Utilizing Opportunistic Acoustic Data to Investigate Distributional Changes in Alaska Pollock (Theragra Chalcogramma) Aggregations

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Steller Sea Lion Mitigation Committee

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Overview

- **Data Collection and Processing**
- **Data Verification**
  - Sphere Calibration
  - Opportunistic Intership Calibration
    - Single Vessel
    - Multiple Vessels
- **Analysis and Visualization**
  - Visualization Results
    - Diel Migration
    - Anthropogenic Effects
    - Recurring or Persistent Formations
- **Discussion**
- **Future Direction**
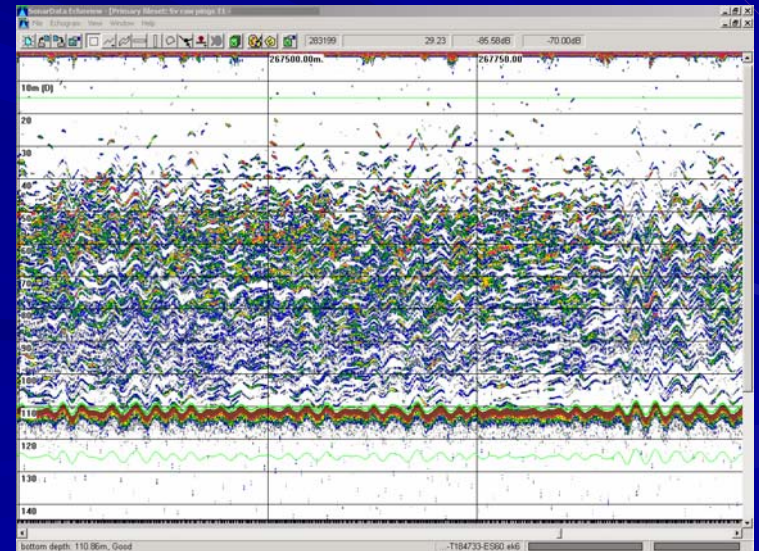
Data Collection

- January 2002 - Present
- Eastern Bering Sea
- At-Sea Processors
- 9 Vessels
- ~32,000 km per Season
- 2.5 Terabytes
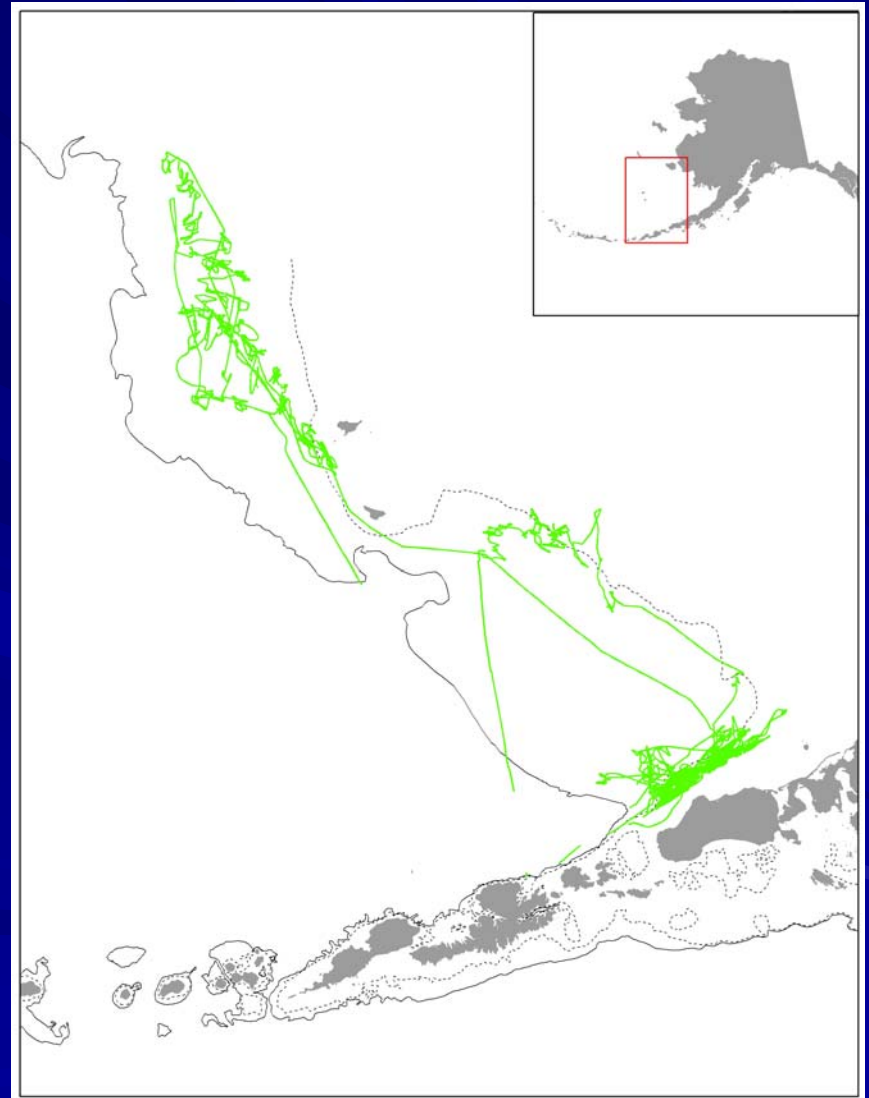
Data Processing

- Echoview Software
  - review data for quality
  - exclude areas that were not readable due to surface interference
  - integrate data from 15 meters below the surface to 0.5 m above the bottom by 100m horizontal by 5m vertical cells

- CFVAD Database
  - Data loaded to an ORACLE database at AFSC
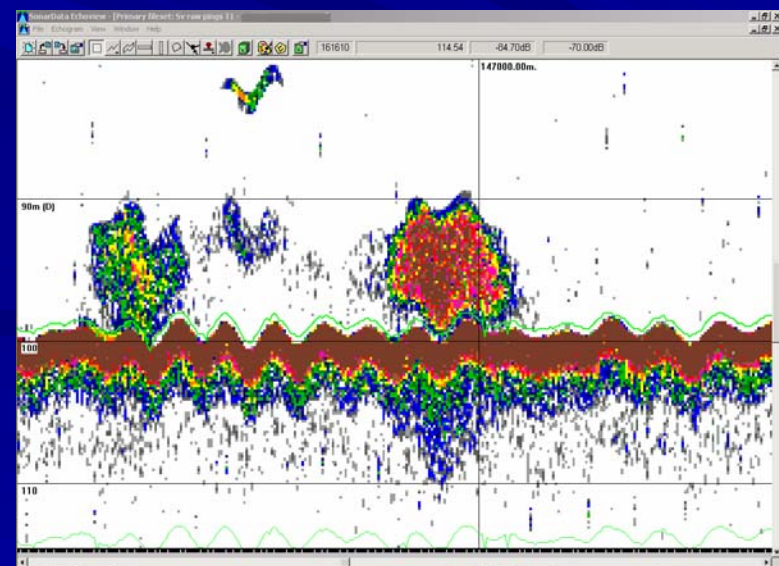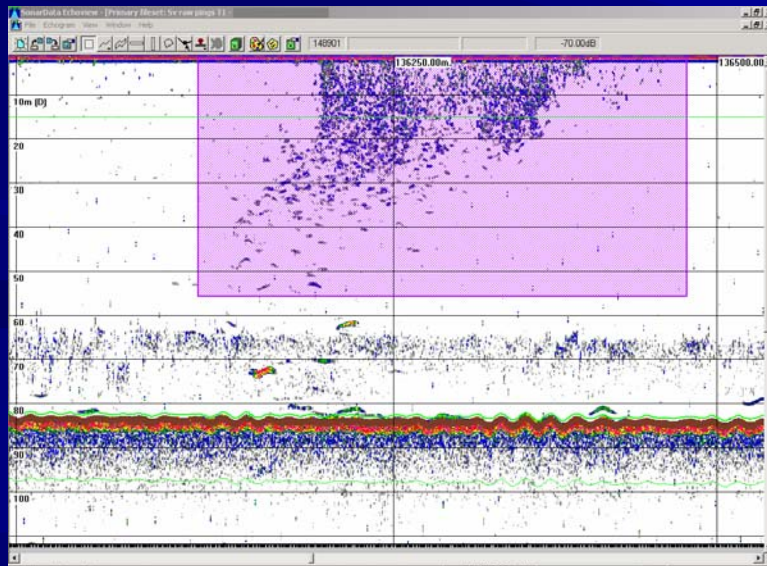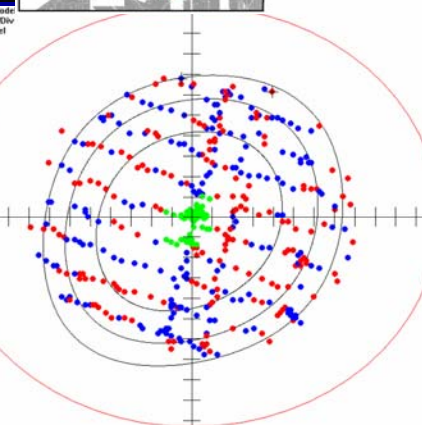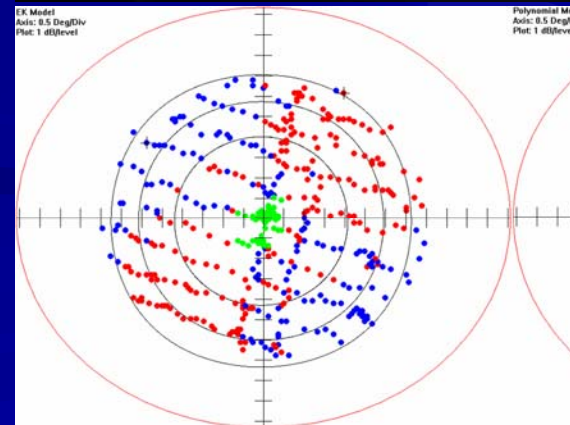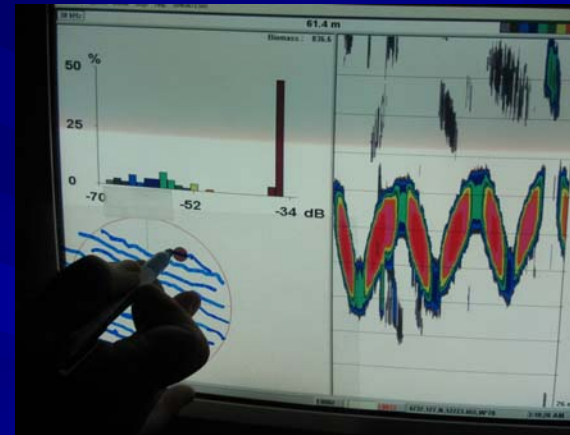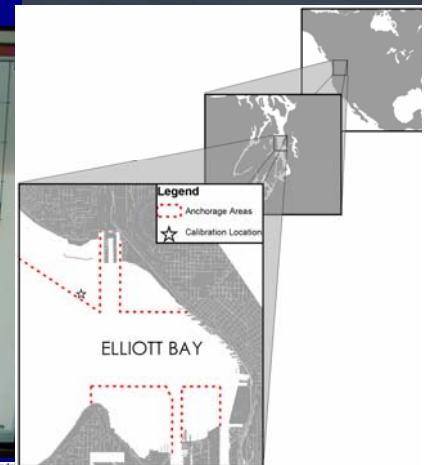
System Calibration of ES-60

- Methods
  - F/V American Dynasty
  - Elliott Bay, Seattle
  - Standard 60mm copper sphere calibrations
  - June and October, 2004
- Results
  - -0.85 dB S_A correction required
  - Beam pattern and calibration correction consistent between two time periods
- Conclusion
  - ES-60 stable and within generally accepted guidelines

Opportunistic Intership Calibration

- Quantitative use of data from multiple vessels requires calibration among vessels

- Analyzed trackline crossing to compare backscatter from multiple vessels at various spatial and temporal scales

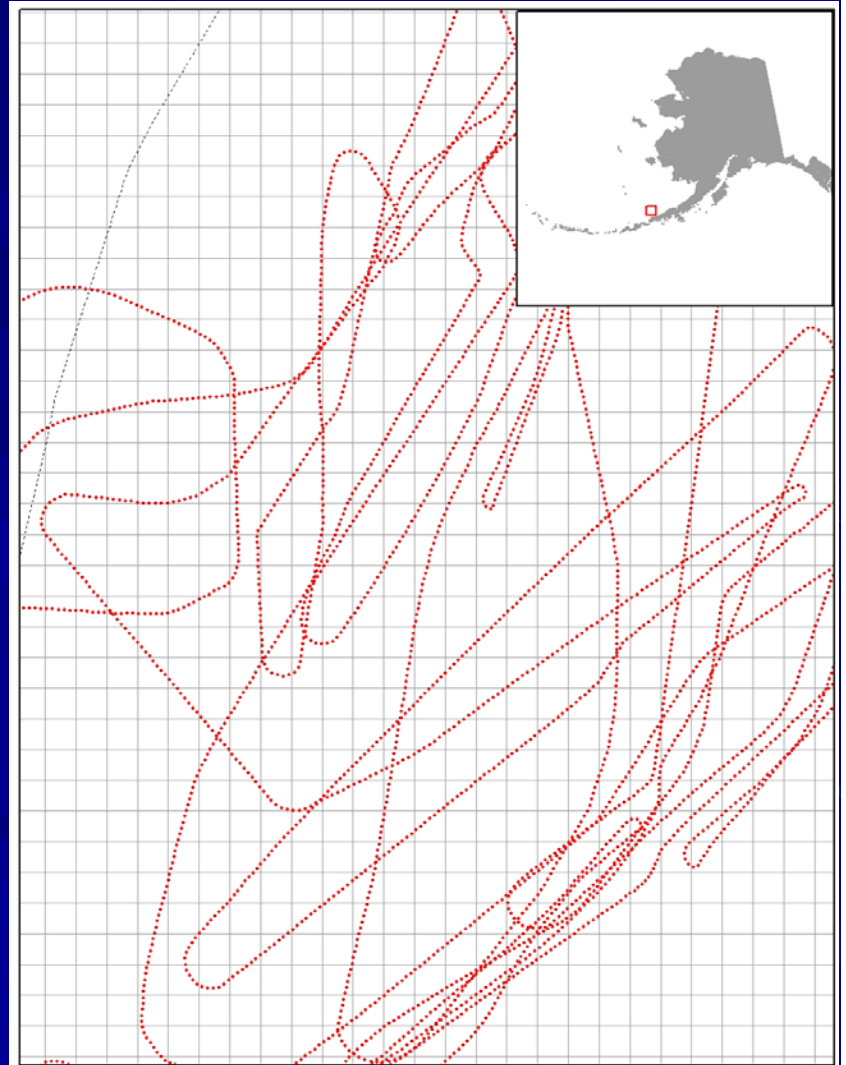- May result in new methodology for intership calibrations of vessel acoustics

Unimak Island
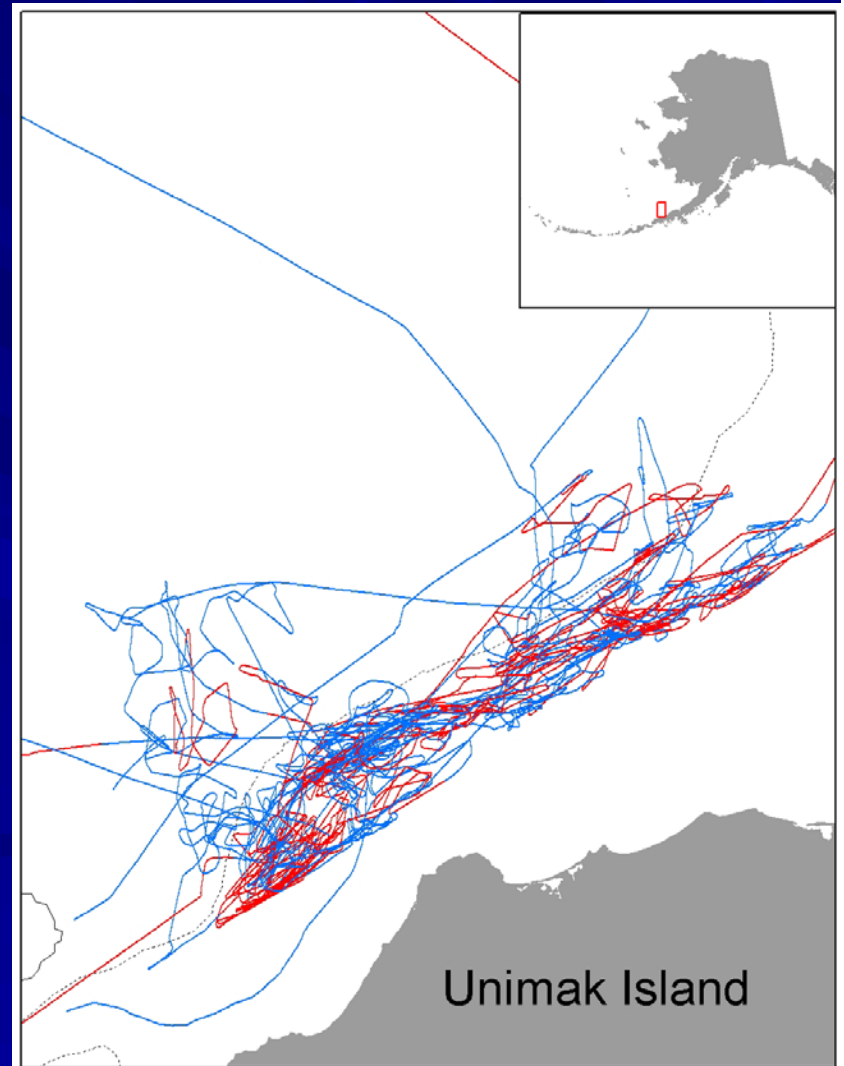
Preliminary: Single Vessel Analysis

- Temporal stability of pollock aggregations
- First 20,000 data points
- $500m^2$ cell spatial resolution
- Temporal Variogram

$$\gamma = \frac{\sum\limits_{i=1, j=1}^{h}\left(x_{ci} - x_{cj}\right)^2}{2N_h}$$

- Temporal Correlogram
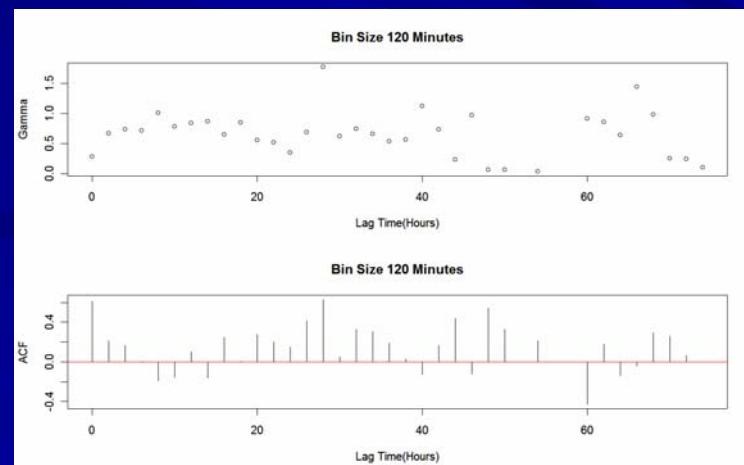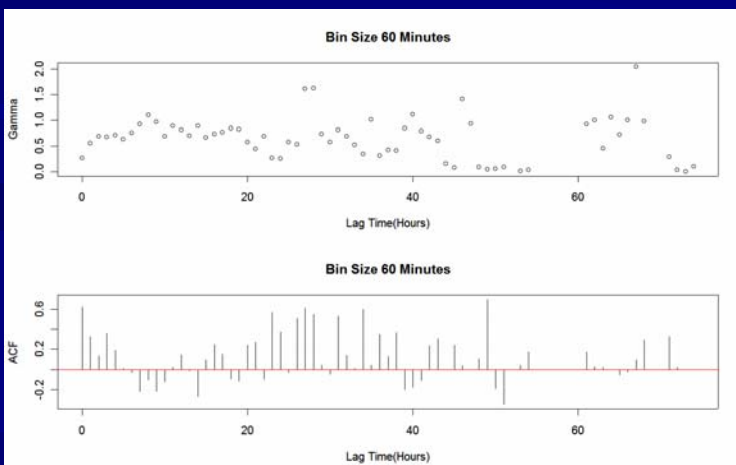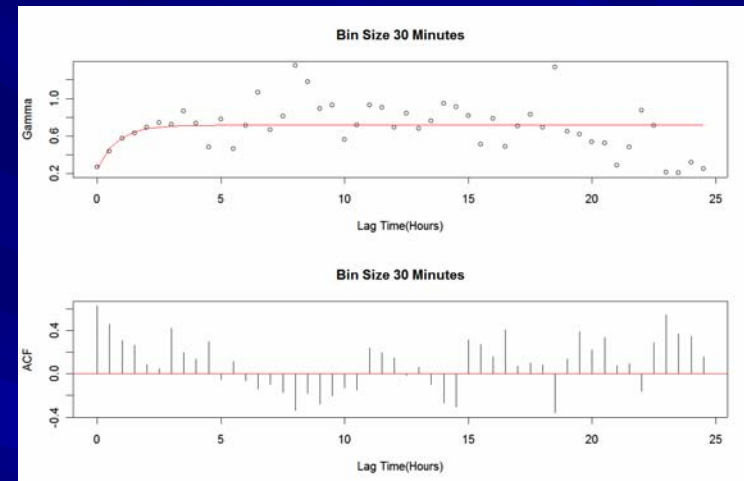
$$\rho = \frac{\dfrac{1}{N_h}\sum\limits_{i=1, j=1}^{h}\left[\left(x_{hci} - \bar{x}_{hc}\right)\left(x_{hcj} - \bar{x}_{-hc}\right)\right]}{\sigma_{hc}\sigma_{-hc}}$$

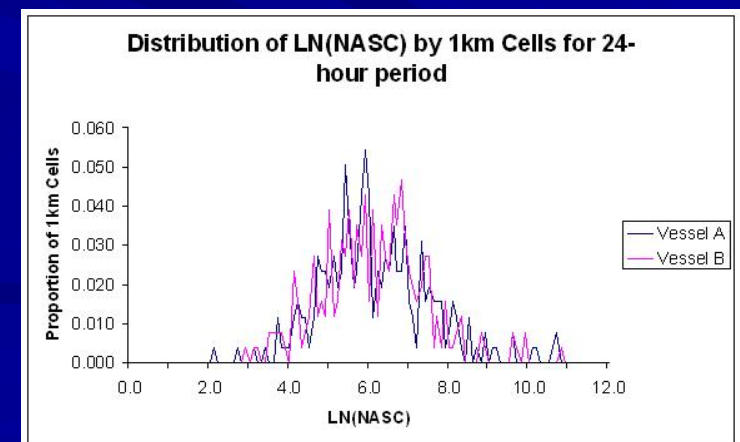# Preliminary: Single Vessel Analysis

- Results
  - ~1,200 Self crossings
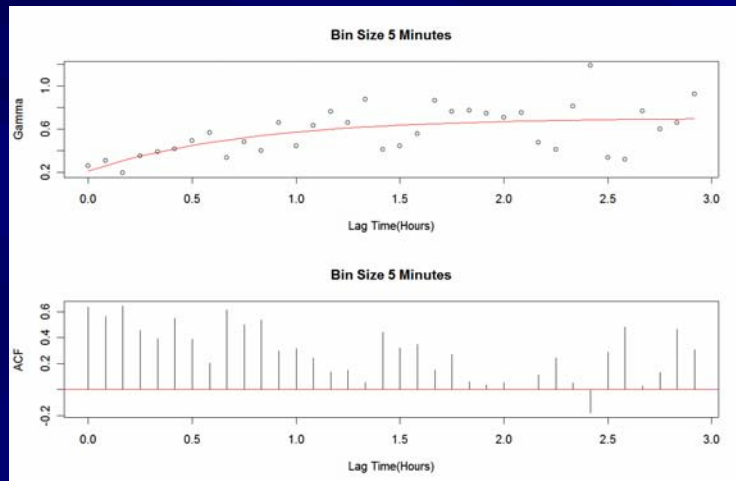
Preliminary: Multi-vessel Comparison

- February 18, 2003
- 2 Sister ships fishing 40km^2
- Analysis
  - Grid data to 1km cells
  - Calculate mean backscatter and variance of the backscatter for each vessel for entire data set and for each 1km cell
  - Statistically compare means and variances for all cells and all common cells
  - Test for significant difference with alpha=0.05

- Conclusions
  - For these two vessels during this 24- hour period the mean log transformed NASC and variance of the log transformed NASC were not statistically discernable for all data, all cells, and all shared cells.

Legend
Vessel A
NASC
- 0.0 - 197.0
- 197.0 - 110000.0
Vessel B
NASC
- 0.0 - 197.0
- 197.0 - 110000.0

Distribution of LN(NASC) by 1km Cells for 24-hour period
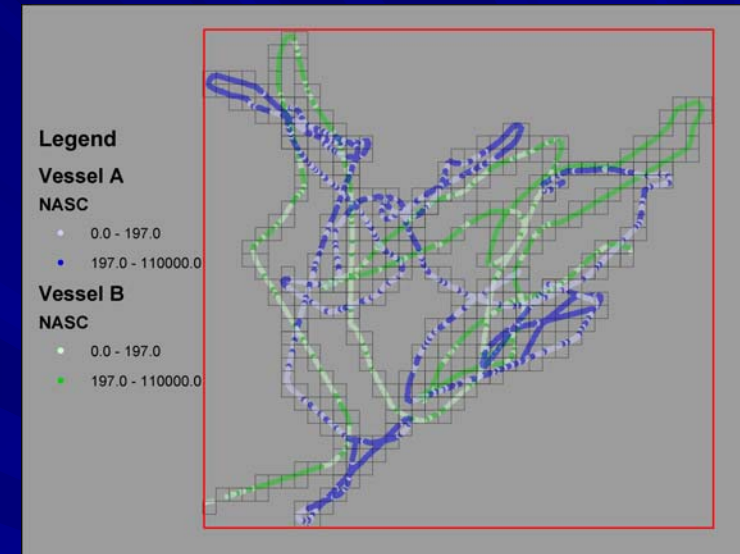
# Exploration and Visualization of Opportunistic Acoustic Data

- **Study area**
  - Limited to a 70km × 40km area in southeastern Bering Sea
- **Data**
  - Opportunistic Acoustic data
  - VMS Data
  - Observer Data
- **Analysis and Visualization**
  - 3-dimensional Kriging and visualization using EVS-Pro
    - Unique 3-d EVS model allowing asymmetrical weighting of the horizontal and vertical axes
    - 5,000 m range used for all semi-variograms
    - 10× weighting difference for vertical vs. horizontal
    - 75× vertical exaggeration of the model
    - Display only model points with > 80% confidence

Results

- Visualization of Diel Migration Pattern

- Anthropogenic Effects on Distribution

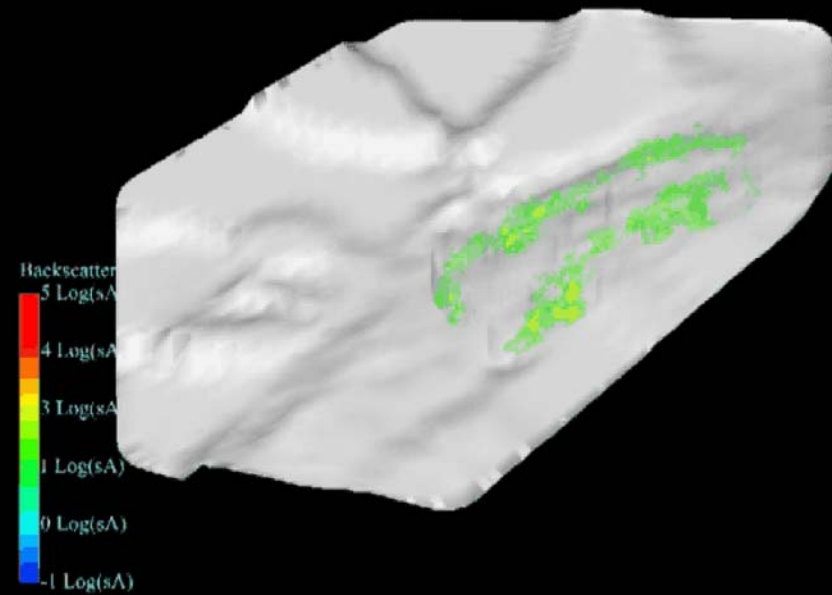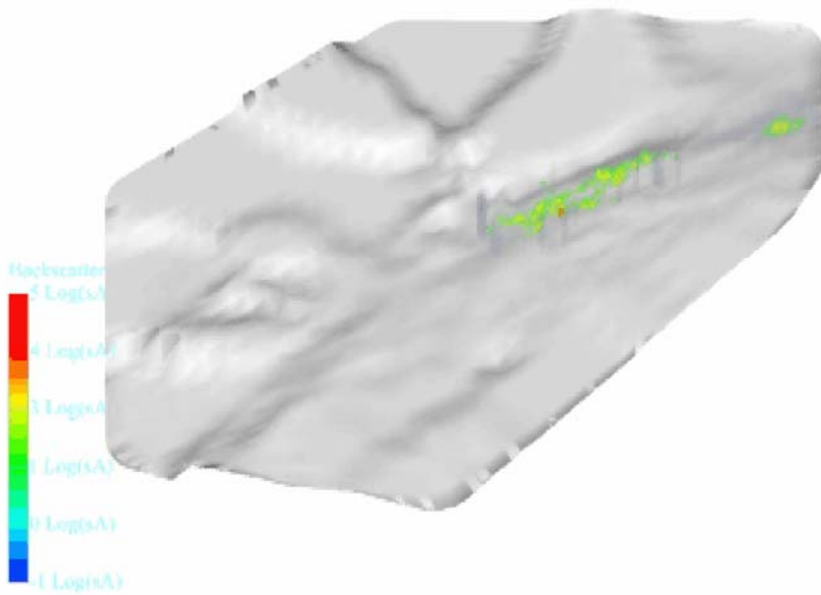- Recognition of Persistent or Recurrent Formations

Diel Migration
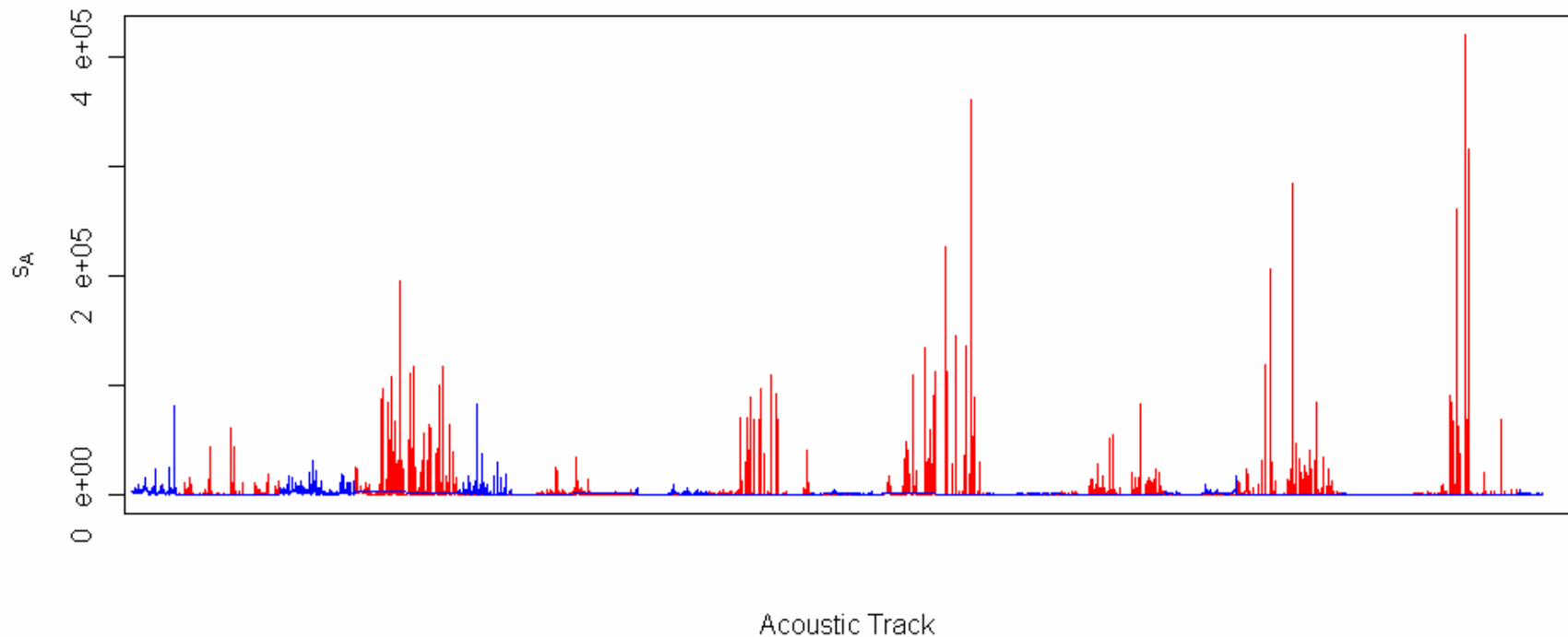
- s_A along the acoustic track for 17 - 24 February

Diel Migration

Daytime Distribution
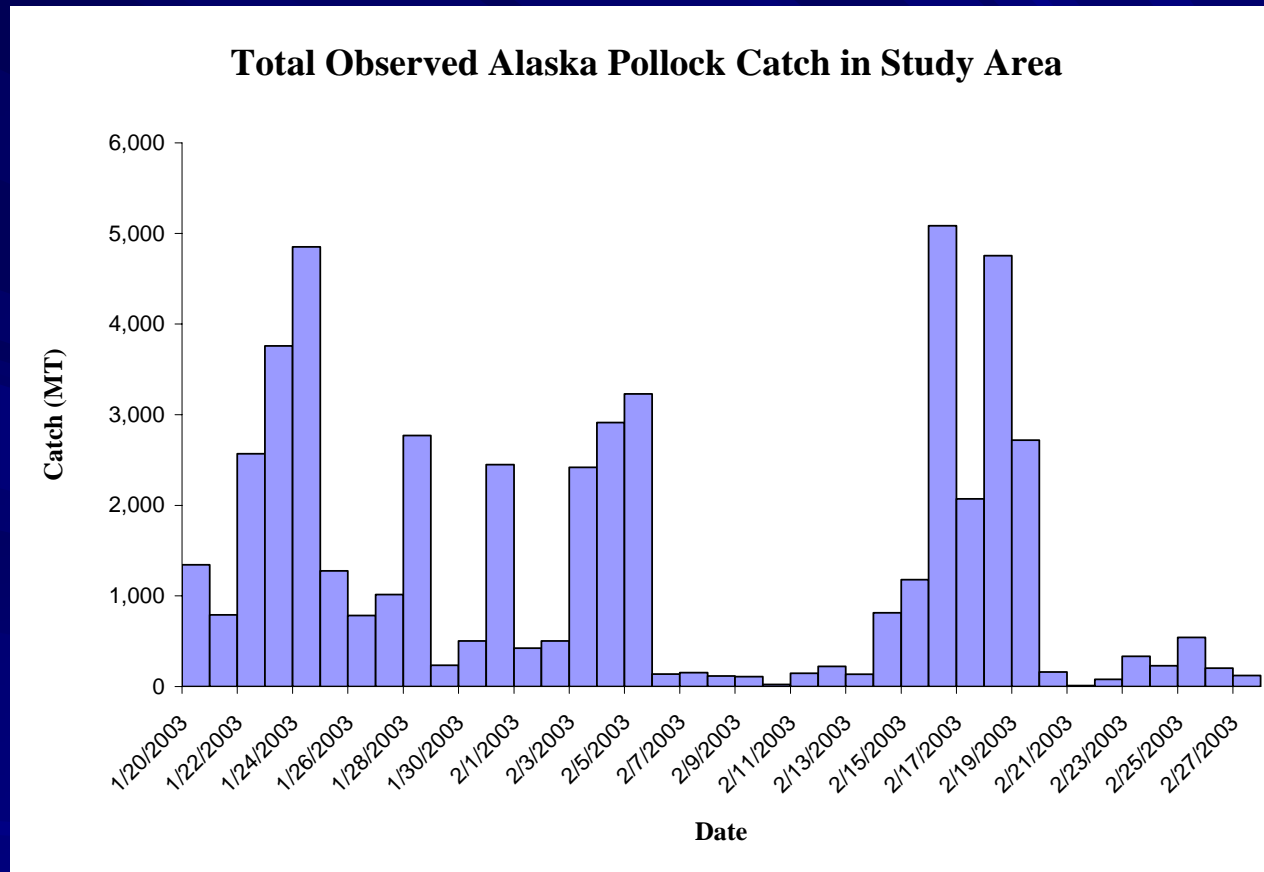21 January

Nighttime Distribution
21-22 January

Anthropogenic Effects

- Local depletion of fished aggregations immediately following fishing due to removal or avoidance

- Depletion of the fish population over duration of the fishery

Anthropogenic Effects

Total Observed Alaska Pollock Catch in Study Area

- **51,200 t harvested from 70km × 40km study area**

- **Two fishing pulses**

Anthropogenic Effects

Catcher/Processor Catch per Unit Effort and Mean Backscatter from Study Area Versus Alaska Pollock Cummulative Catch
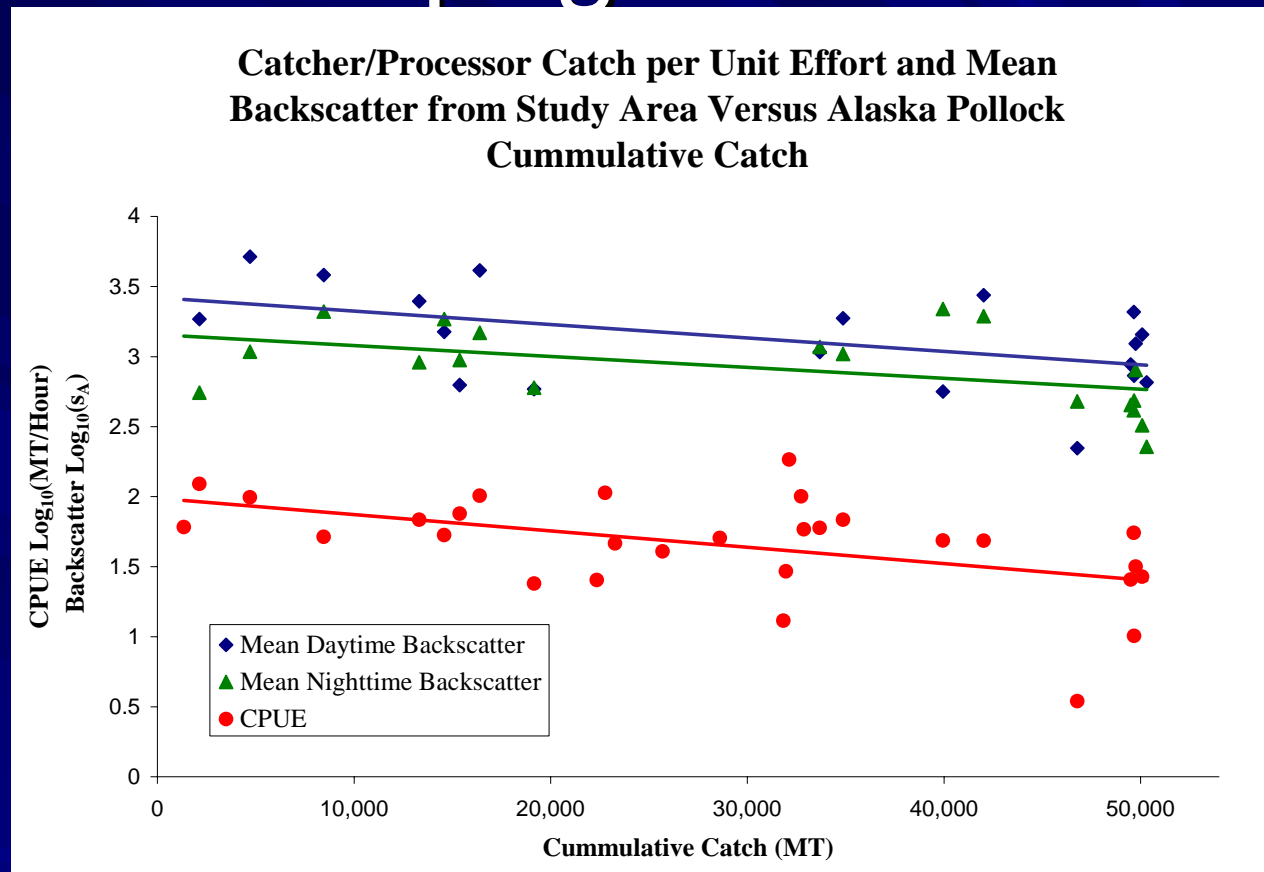
- Decline in CPUE over cumulative catch

- Decline in s_A over cumulative catch

Anthropogenic Effects
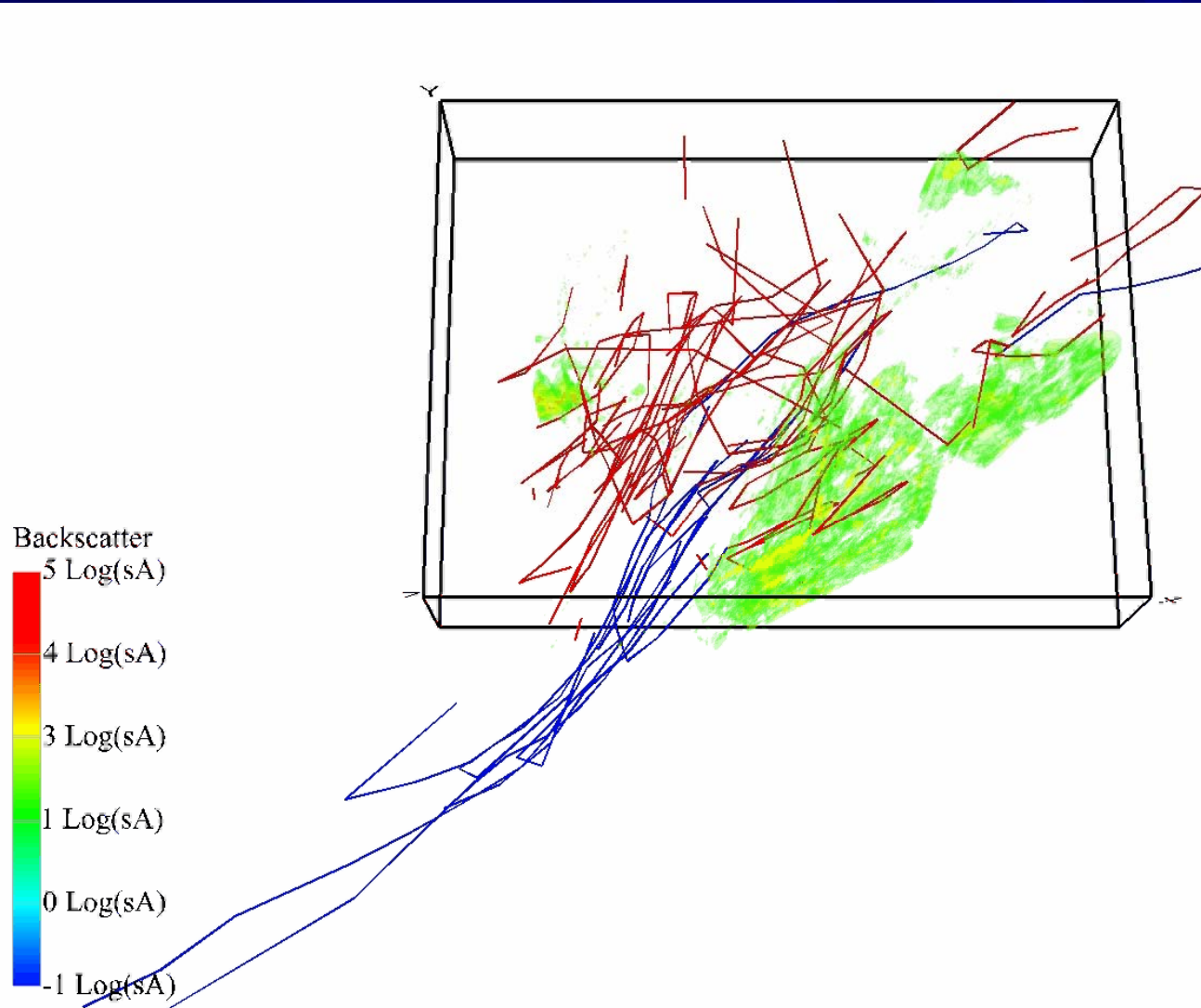
Anthropogenic Effects
21 Jan, 24 Jan, 15 Feb, 18 Feb, and 22 Feb

Persistent or Recurrent Formations

22 - 23 January   14 - 15 February

- Evidence against persistent localized depletion?

Discussion

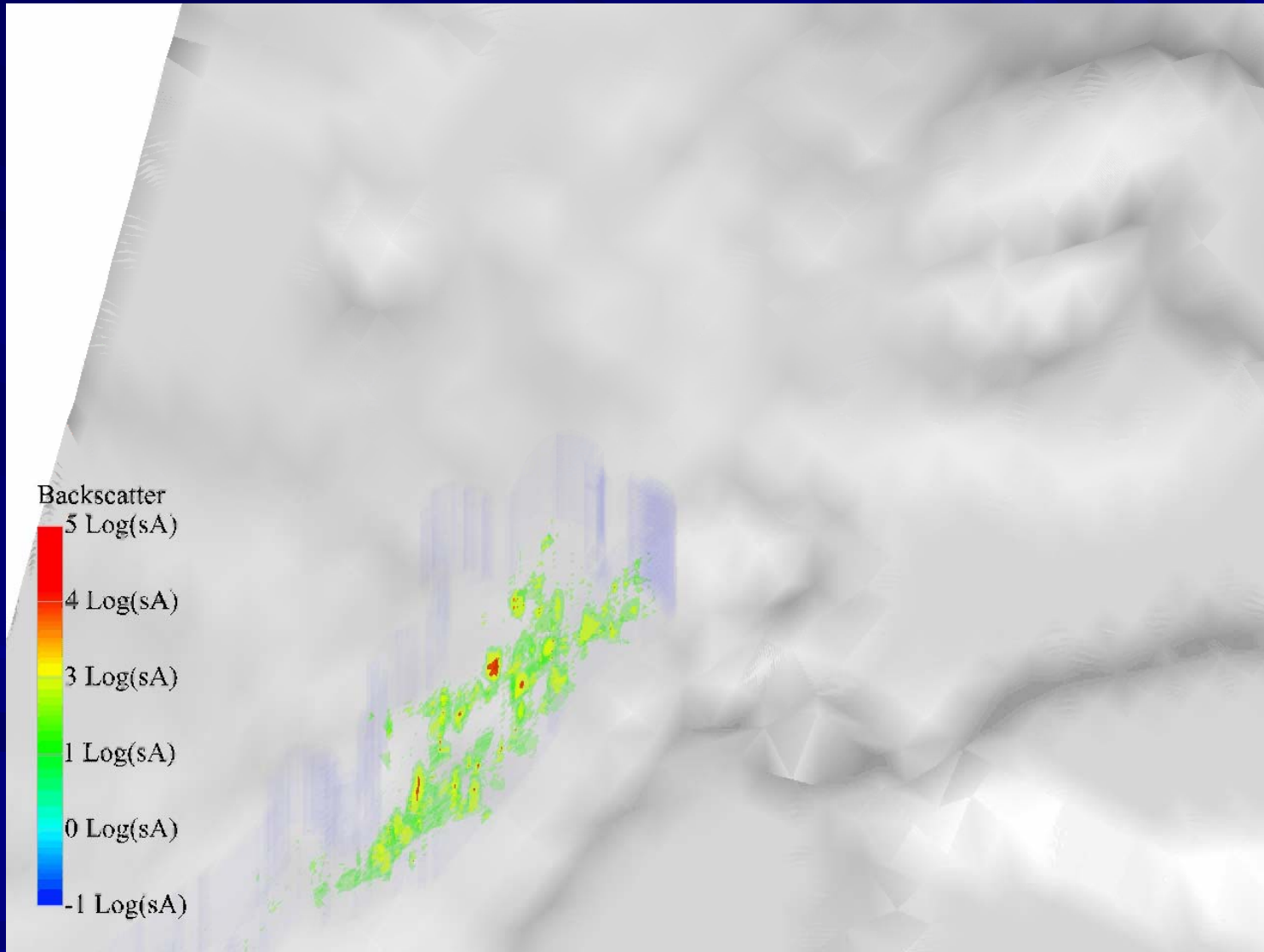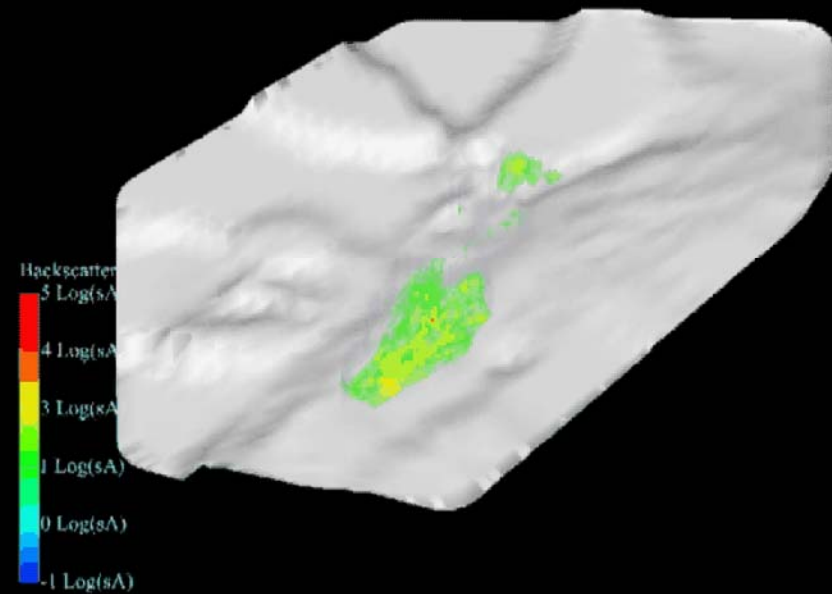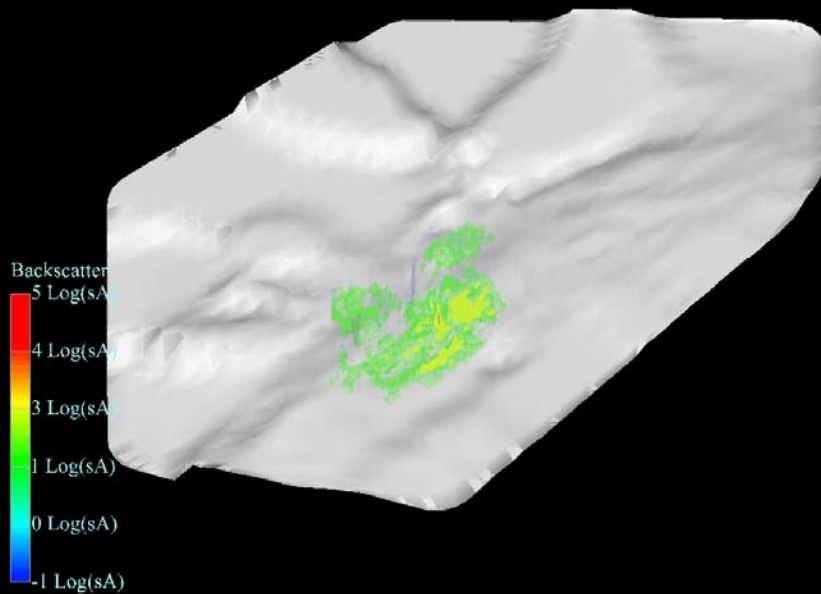- Commercially available echosounders now provide the opportunity for researchers to collect high resolution spatially and temporally referenced data sets from commercial fishing vessels during normal fishing operations, unfortunately development of techniques to make sense of these complex data sets has lagged behind.

- Preliminary calibration results suggest that these data are of sufficient quality to be used in quantitative research

- Development in methods for intership calibration may facilitate the quantitative use of opportunistic data collected from multiple vessels

- Methods are proposed in this study that allow visualization of acoustic and other spatially and temporally explicit data sets concurrently in three and four dimensions. Thus rendering the complex data into a form that can be readily examined for anomalies and possible trends.

- Three- and four-dimensional visualizations are used here as tools for data exploration, allowing us to conceptualize fish distribution and the relationship between fishing and fish aggregations.

- These methods also provide a means to identify persistent or recurrent aggregation formations that otherwise may not have been discovered.

- Further statistical analysis and modeling is needed to quantify the possible relationships between fishing and fish distribution observed in this study.

Future Research

- Sphere calibrations of all study vessels

- Refinement of Intership calibration work

- Examination of data surrounding study area to ascertain possible migration into and out of the area

- Development of Kriging models to explicitly take into account variance in distributions due to diel and seasonal migration

- Development of more accessible modeling algorithms and visualization development

- Exploration of spatially explicit Depletion models

Acknowledgements

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- North Pacific Groundfish Observers