Clicking to be Counted: using passive acoustic monitoring to estimate the density and abundance of sperm whales in the central Gulf of Alaska

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Objectives

- Obtain 'perpendicular' distances to individual animals (e.g. acoustic localization).
- Derive abundance and density estimates for sperm whales in the Gulf of Alaska (GoA) study area using only acoustic encounters –*Distance Sampling Methods*.
- Compare visual-based estimates with acoustic-based estimates.

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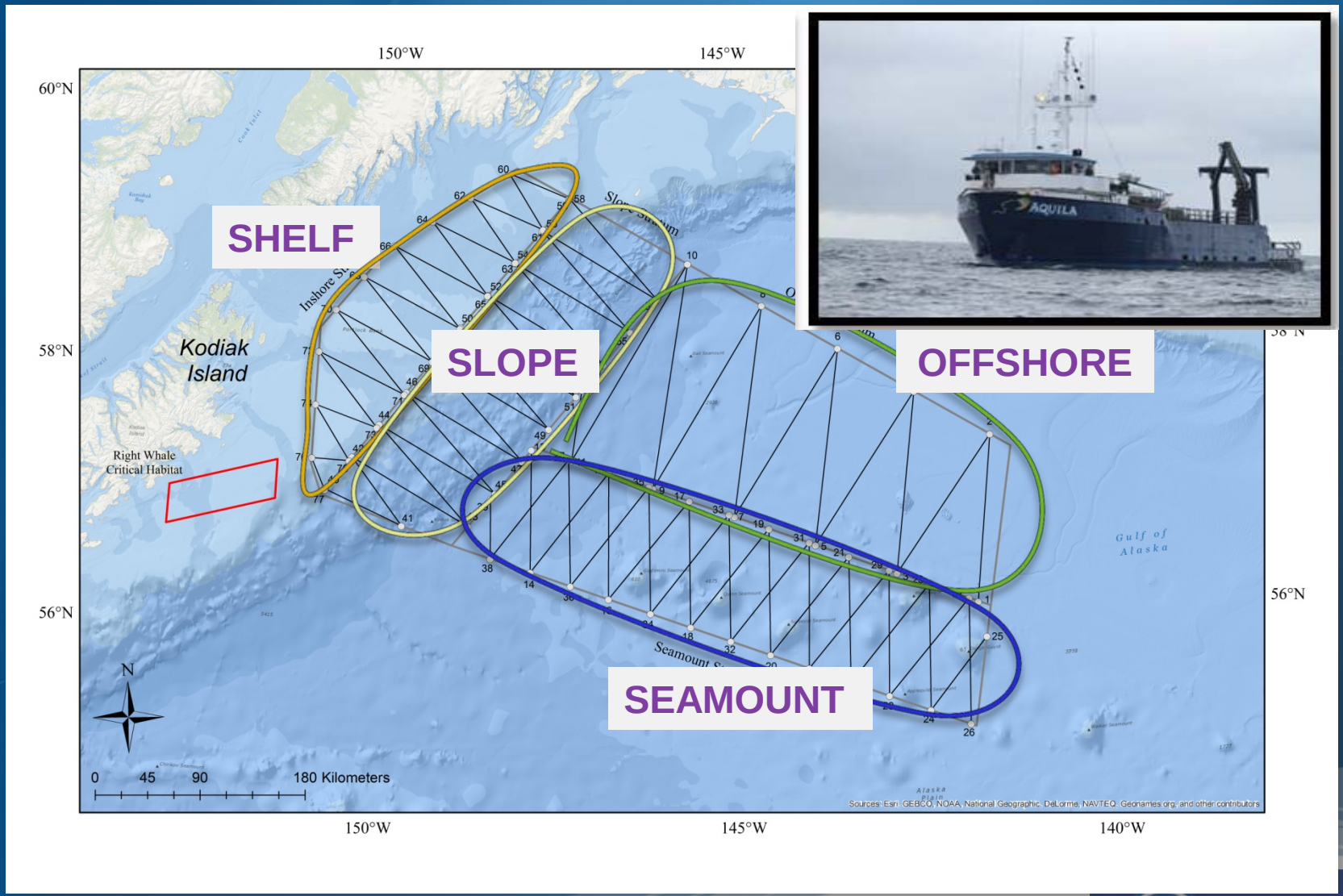
Study Area & Survey Design



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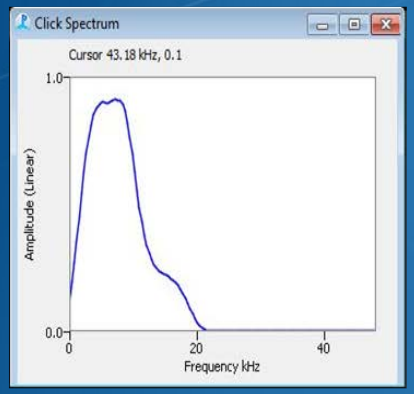
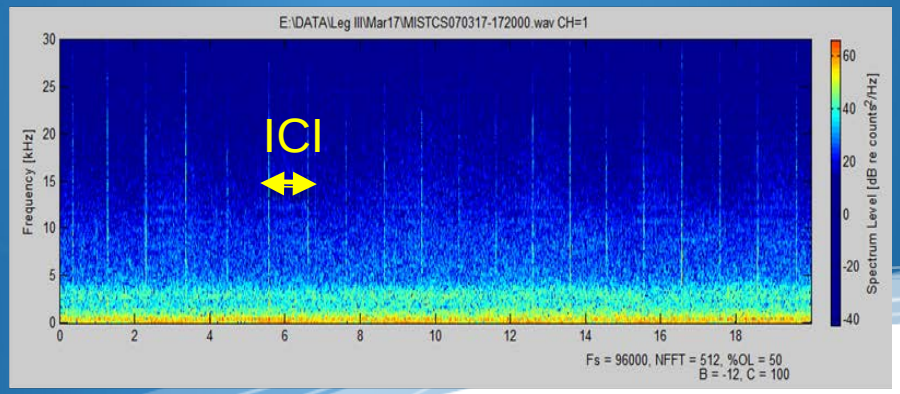
Sperm Whales

- Deep-diving odontocetes
- Endangered (ESA), Depleted (MMPA)
- Cosmopolitan Distribution
- Gulf of Alaska (GoA):
  - Autonomous recorders indicate year round presence in GoA with increased rates in summer
  - No accepted abundance estimates in GoA
- Regular Clicks:





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Methods

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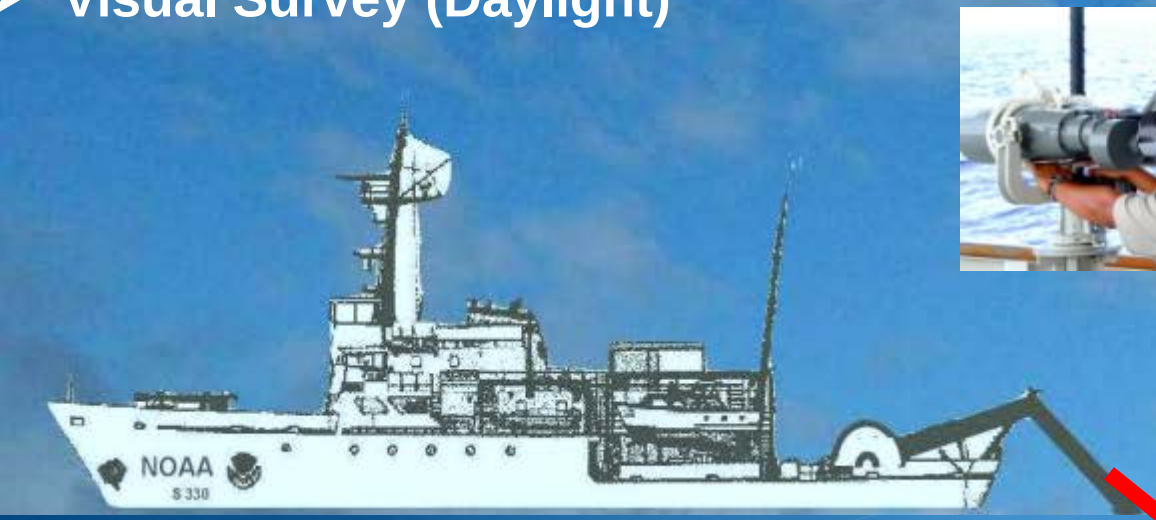
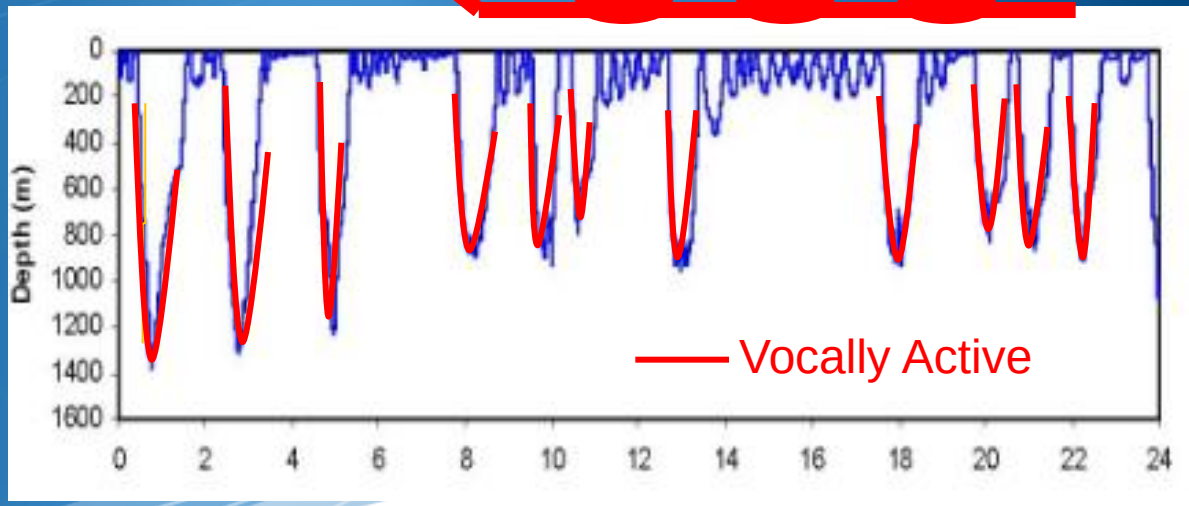
Survey Methods

- **Visual Survey (Daylight)**



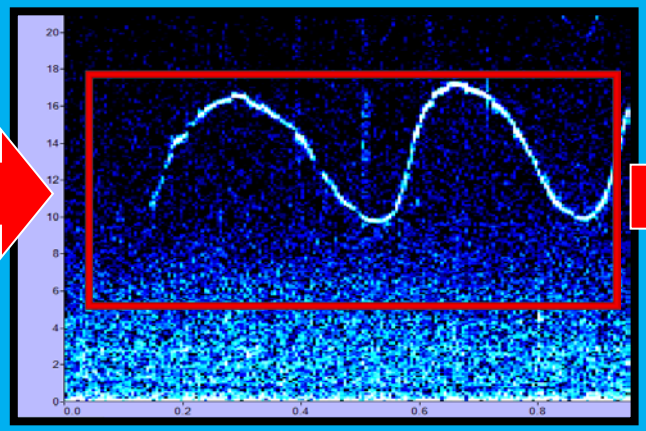
- Acoustic Survey: (24 hrs)



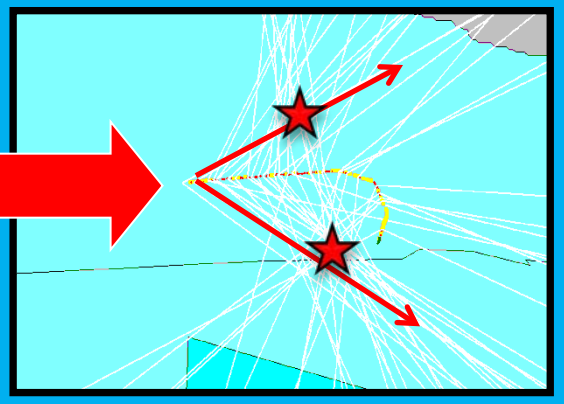
Baird, et al. 2005.

Manual Detection/Tracking

Ishmael

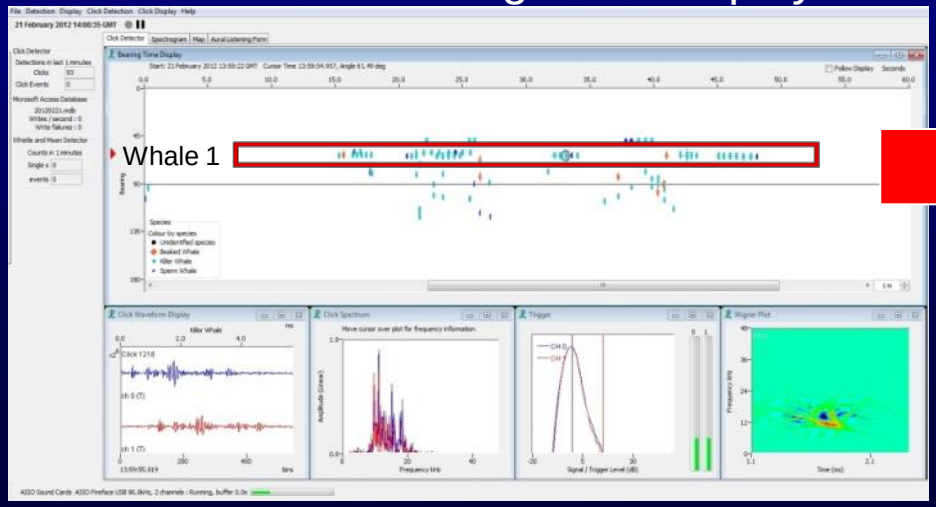


WhalTrak II

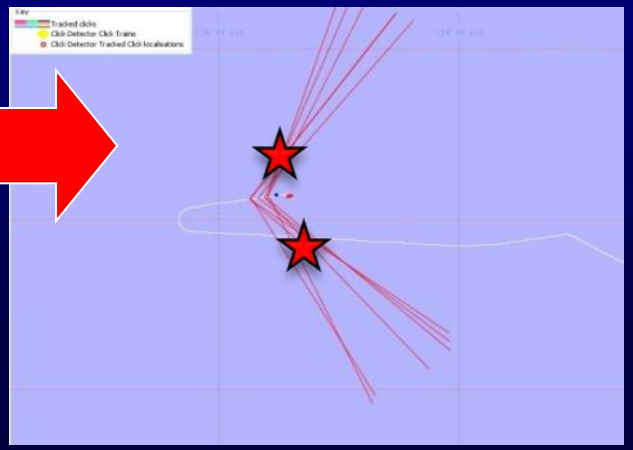


Semi-Automated Detection/Tracking

PAMGuard Bearing Time Display

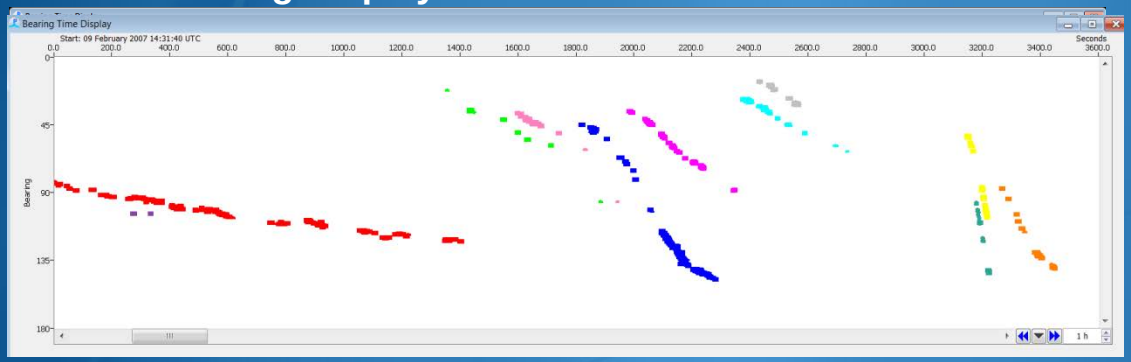


PAMGuard Map Display

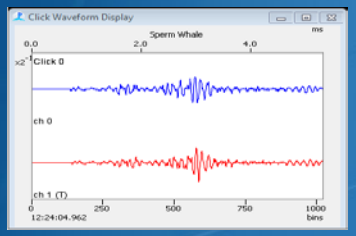


PAMGuard's 'ViewerMode'

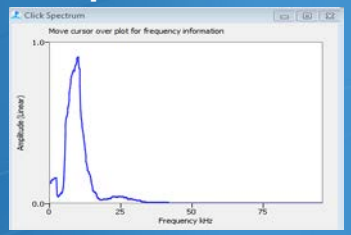
I. Time/Bearing Display



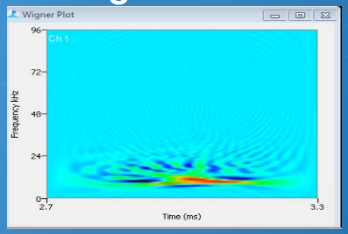
II. Waveform



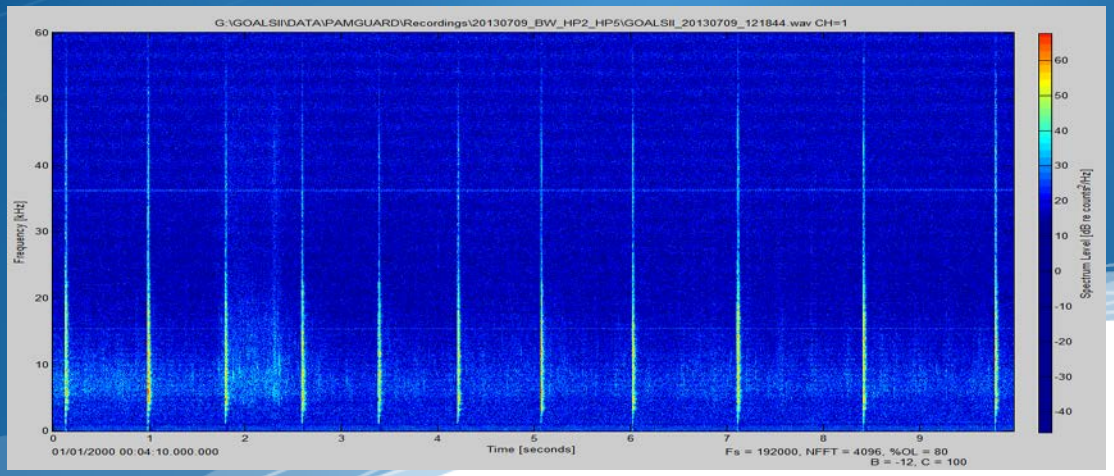
III. Spectrum



IV. Wigner



V. Spectrogram



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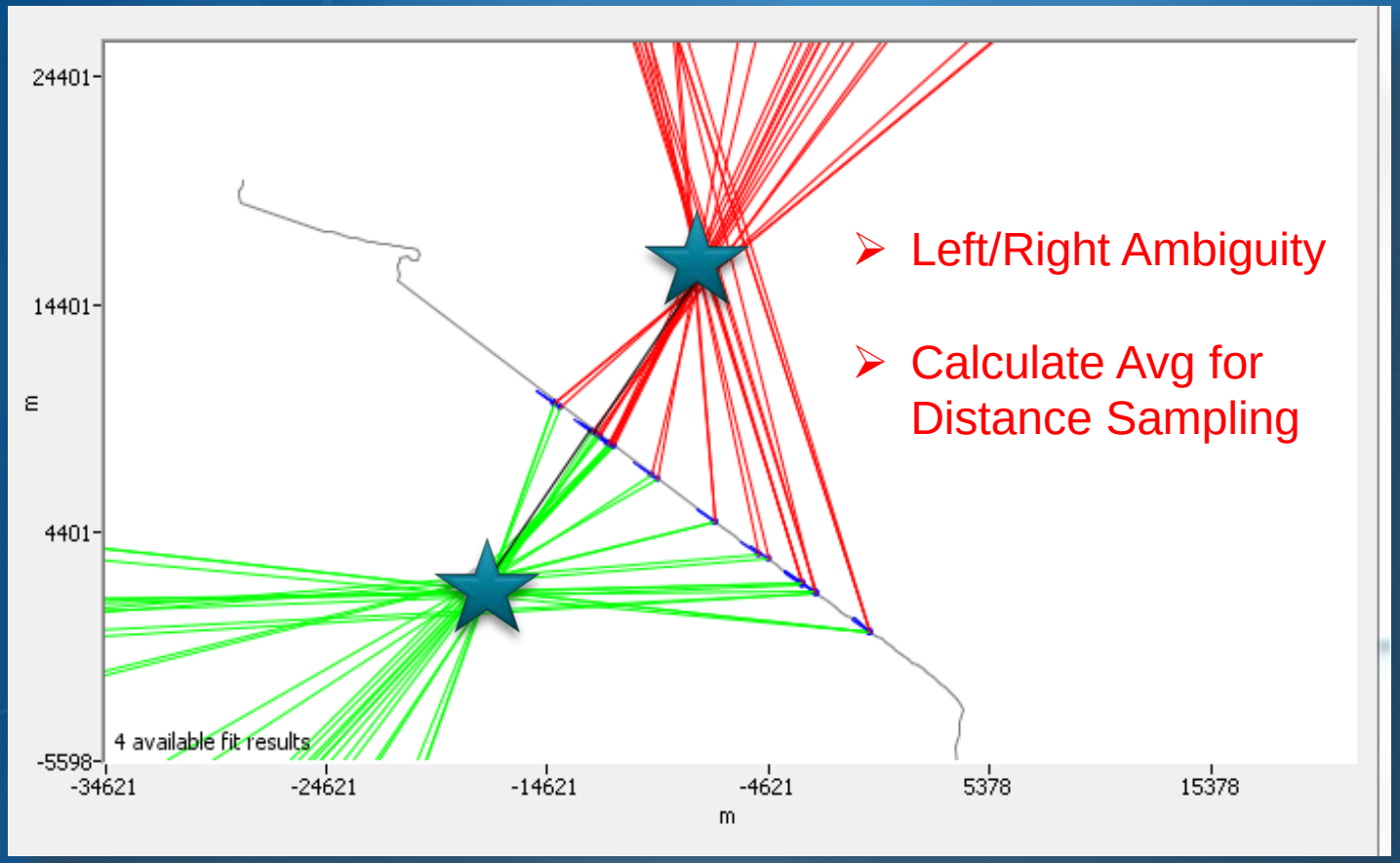
Target Motion Analysis



- Left/Right Ambiguity
- Calculate Avg for Distance Sampling

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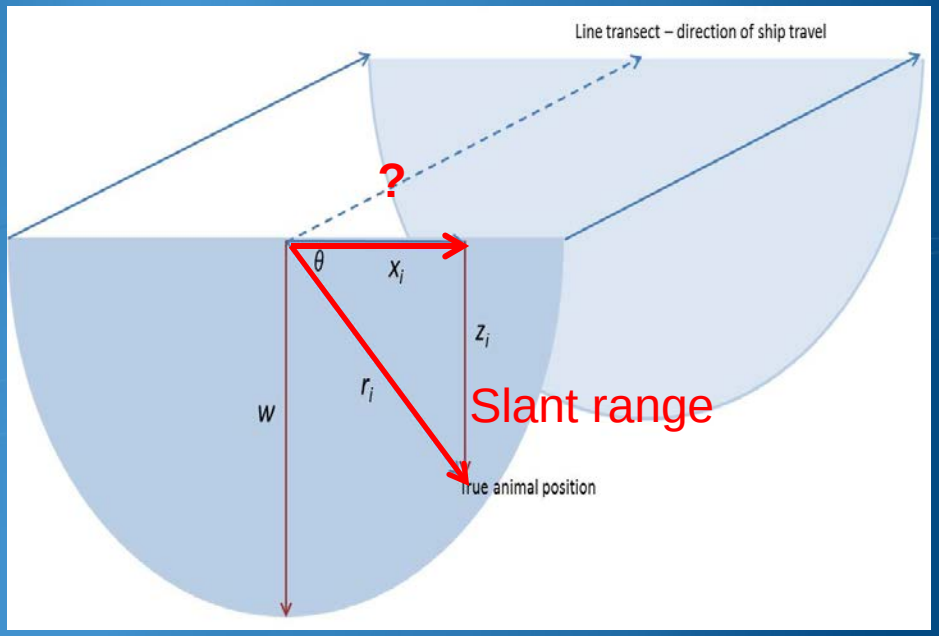
The Problem with Deep Divers

- Unknown animal depth = unknown **horizontal** distance.
- Problem for any species where **dive depths are similar to the detection range.**
- Ignoring the problem overestimates distances and **underestimates** density.



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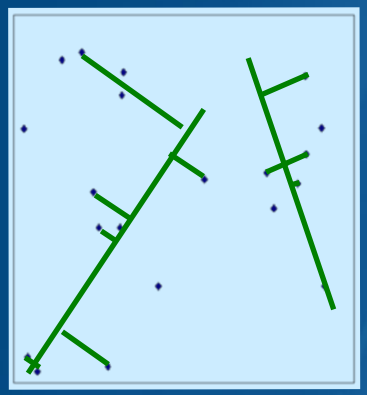
Distance Sampling

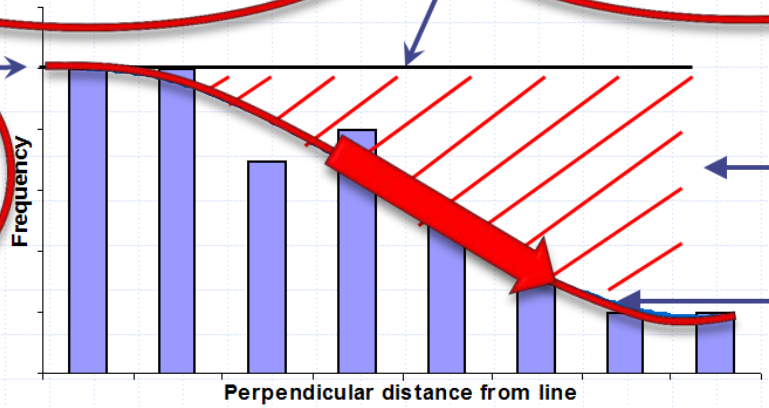


$$P_a = \frac{\text{area under curve}}{\text{area of rectangle}}$$

if you saw everything at all distances, on average the histogram bars should be here

assume you see everything at zero distance

G(0) = 1



these animals are missed

Some function g(x)

$$\hat{D} = \frac{n}{a\hat{P}_a}$$

Slide images courtesy of: http://warnercnr.colostate.edu/~gwhite/fw663/DistanceSampling.ppt

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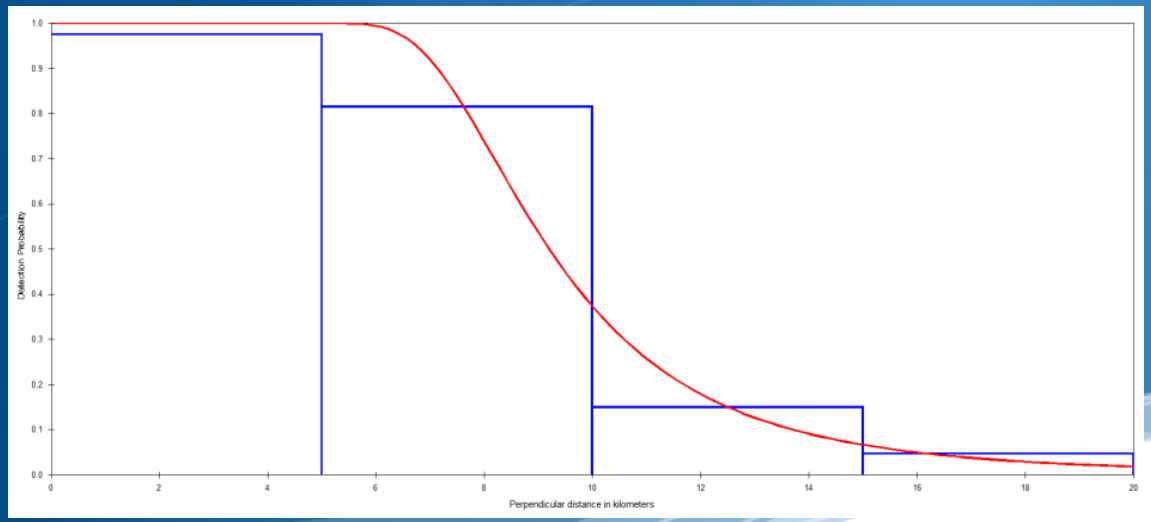
Models

- Stratified Analysis
- Global detection function estimated
- 20 km Truncation
- Binned Data and used AIC to select best model

Best-fit Model: hazard-rate + hermite with right-truncation at 20km



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Results

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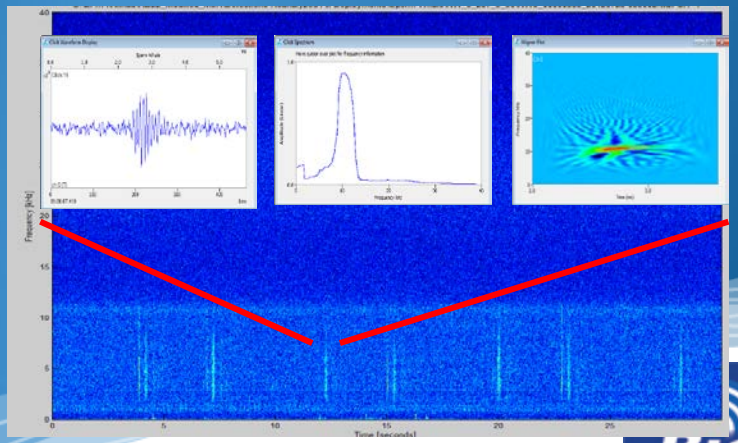
Survey Results

- Survey Effort included:
  - Acoustic Effort: 6,304 km, 426 hours
  - Visual Effort: 4,155 km
- Sperm whale encounters included:
  - Acoustic Encounters: 241, (174 localized individuals)
  - Visual Encounters: 19 (22 individuals)



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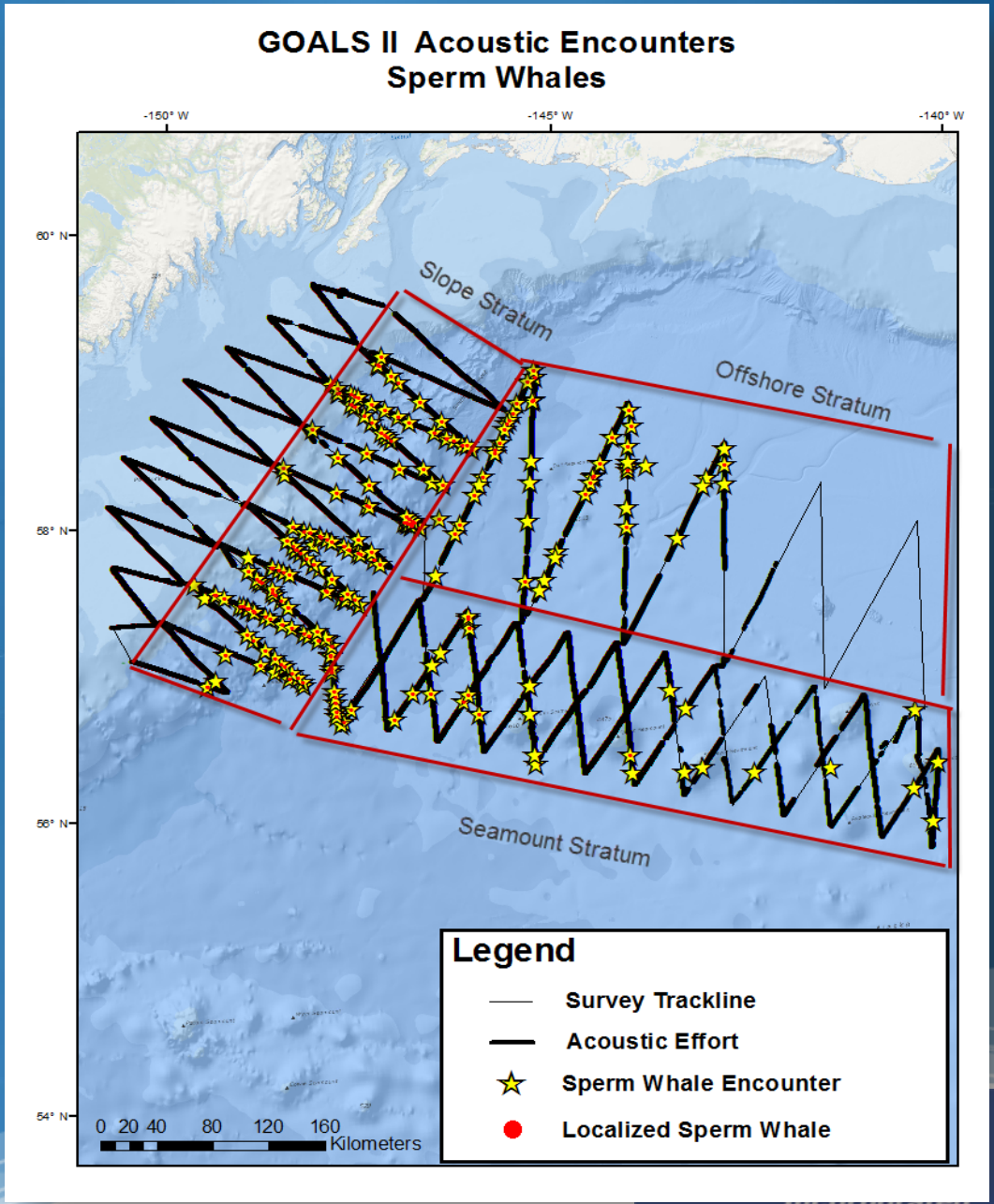
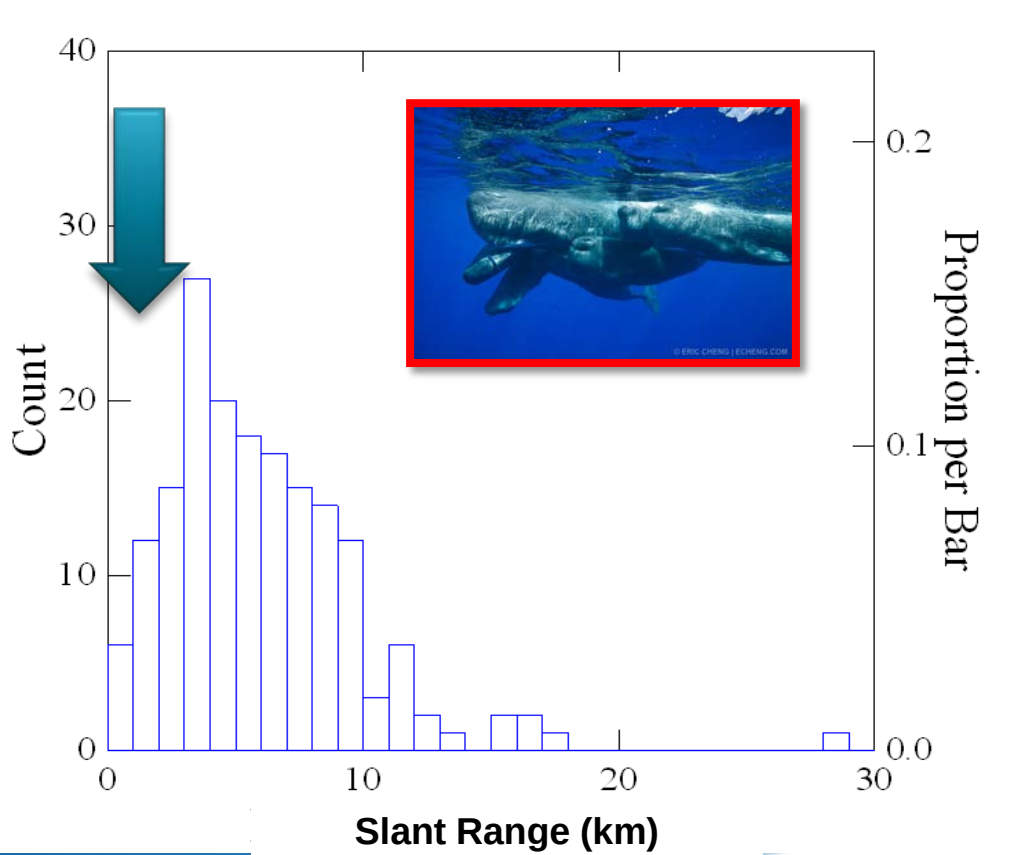
Results

- Encounter rates varied by strata
  - Slope strata contained majority of encounters
- Samples by strata
  - Offshore = 28
  - Seamount = 17
  - Slope = 129



Results

- Histogram showing distribution of slant range distances in 1 km bins



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Acoustic & Visual Estimates

	Visual	Acoustic
obs	22	173
D/1000km	1.5	1.5
N	220	216
CV	51%	18%

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Discussion/Conclusions

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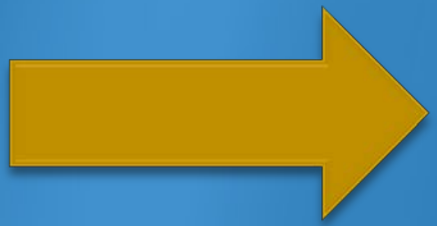
Discussion - Caveats

- Time spent vocalizing
  - Animals are not available for detection 100% of the time
  - g(0) = 1 ?
- Localizations close to the trackline
  - Lower than expected
  - Possible causes:
    - Measurement Error
    - Slant Range Issue
    - Evasive movement



Underestimation Of Density

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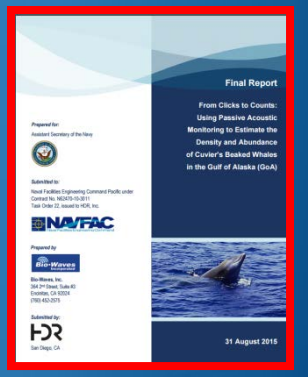
Conclusions



- Acoustic monitoring methods
  - Valuable resource for estimating deep-diving, continuously clicking species.
  - Provided first sperm whale density estimates for this region.
  - Hot off the Press: We have recently used these same methods to produce the first ever line-transect acoustic-based density estimates for Cuvier's beaked whales in the GoA.

http://www.navymarinespeciesmonitoring.us/files/4514/4226/1871/GOALS_BeakedWhaleDensityEstimation_Final_Report_31AUG2015.pdf

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Thank you!

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