Acoustic Assessment of Sperm Whale Distribution, Habitat, and Habitat Use

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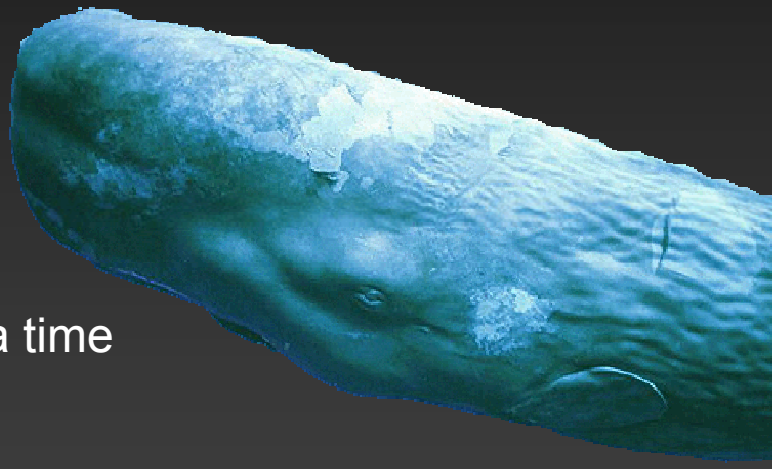
Sperm Whales

- High trophic level predators
- Feed on fish and cephalopods
  - Mesopelagic (200 to 2000 m deep)
  - Bathypelagic (>1000 m deep)
    - Consume several thousand kg prey/day
    - 1000 individual prey items
- Prey resources drive distribution and behavior
- Food linked to
  - Physical processes
  - Distribution of plankton
- Many trophic levels between whales and plankton
  - Temporal and spatial lags between correlations

➔ Must characterize the distribution of fish and squid in the mesopelagic and bathypelagic zones

Characterizing Prey

- Challenges
  - Regular sperm whale dives 1000-meter depth range
  - Highly mobile prey
- Possible approaches
  - Trawling with nets
    - Relatively localized
    - Assess only one depth at a time
    - Net avoidance
  - Acoustic assessment
    - Does not provide taxonomic information
    - Rapid coverage of habitat
    - Cover large vertical range simultaneously
    - High resolution



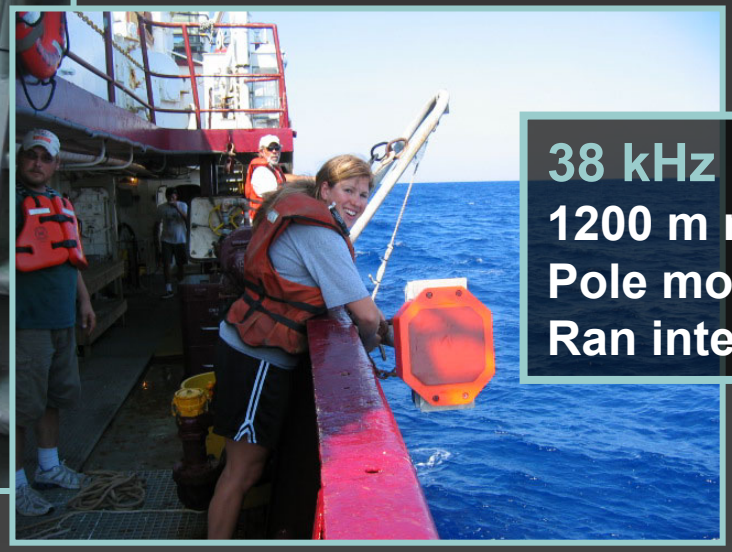
Objectives

- Assess sperm whale potential prey
  - Distribution in space and time
  - Availability
- Prey assessment done in conjunction with
  - Sperm whale visual surveys
  - Sperm whale acoustic surveys
  - Sperm whale tagging
  - Sperm whale passive acoustic tracking
  - Oceanographic sampling (temperature, salinity, fluorescence, ADCP)

Echosounder Set Up

70 kHz
600 m range
In hull
Ran continuously

3–29 June 2005
R/V Gyre



38 kHz
1200 m range
Pole mount over side
Ran intermittently

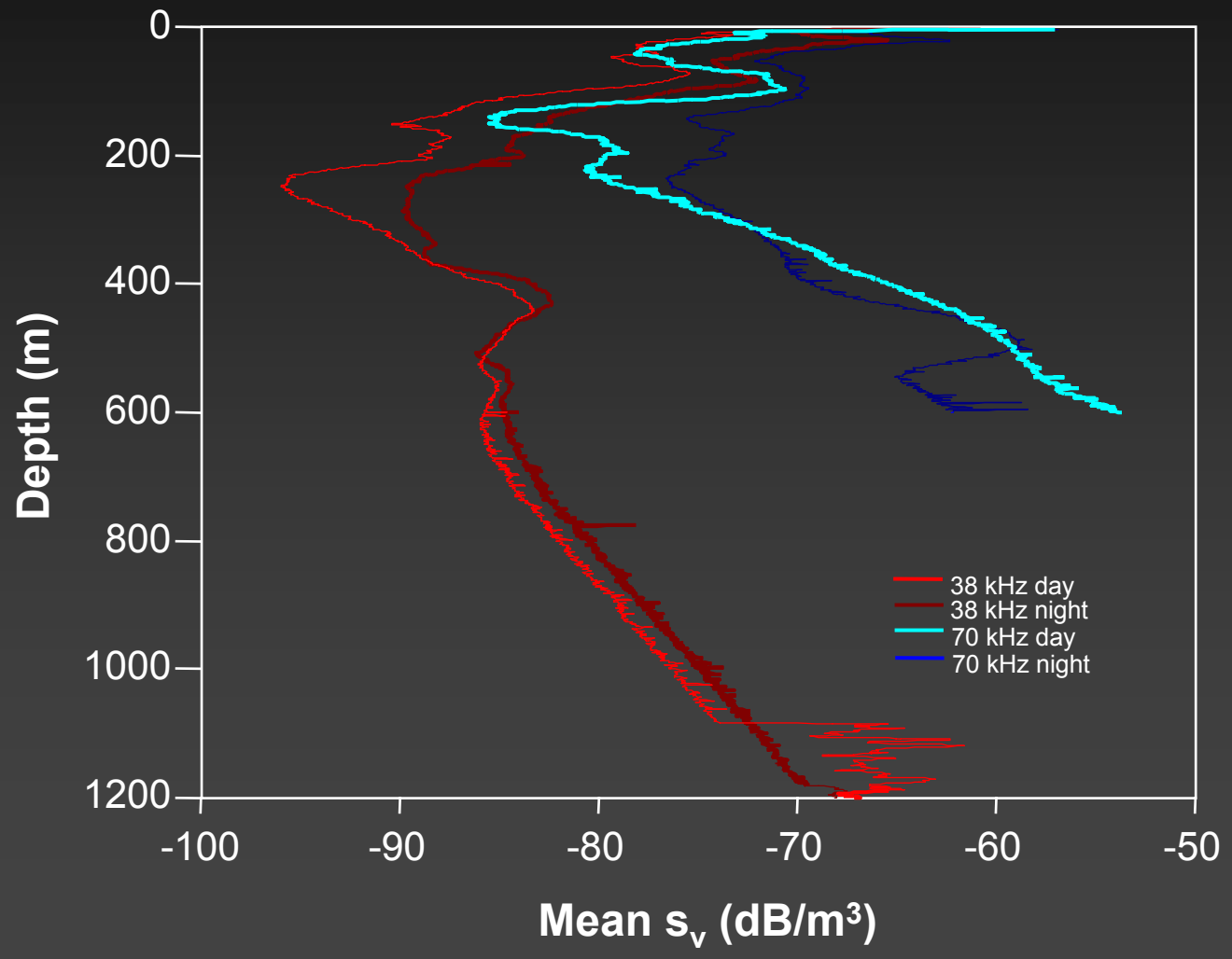
Echosounder vs. ADCP

Backscatter values	Calibrated – absolute	Relative – counts
Vertical resolution	< 1m	16 m
Horizontal resolution	1 sec (~3 m bins at 5 knots) Can measure individual targets	5 min (~775 m bins at 5 knots)

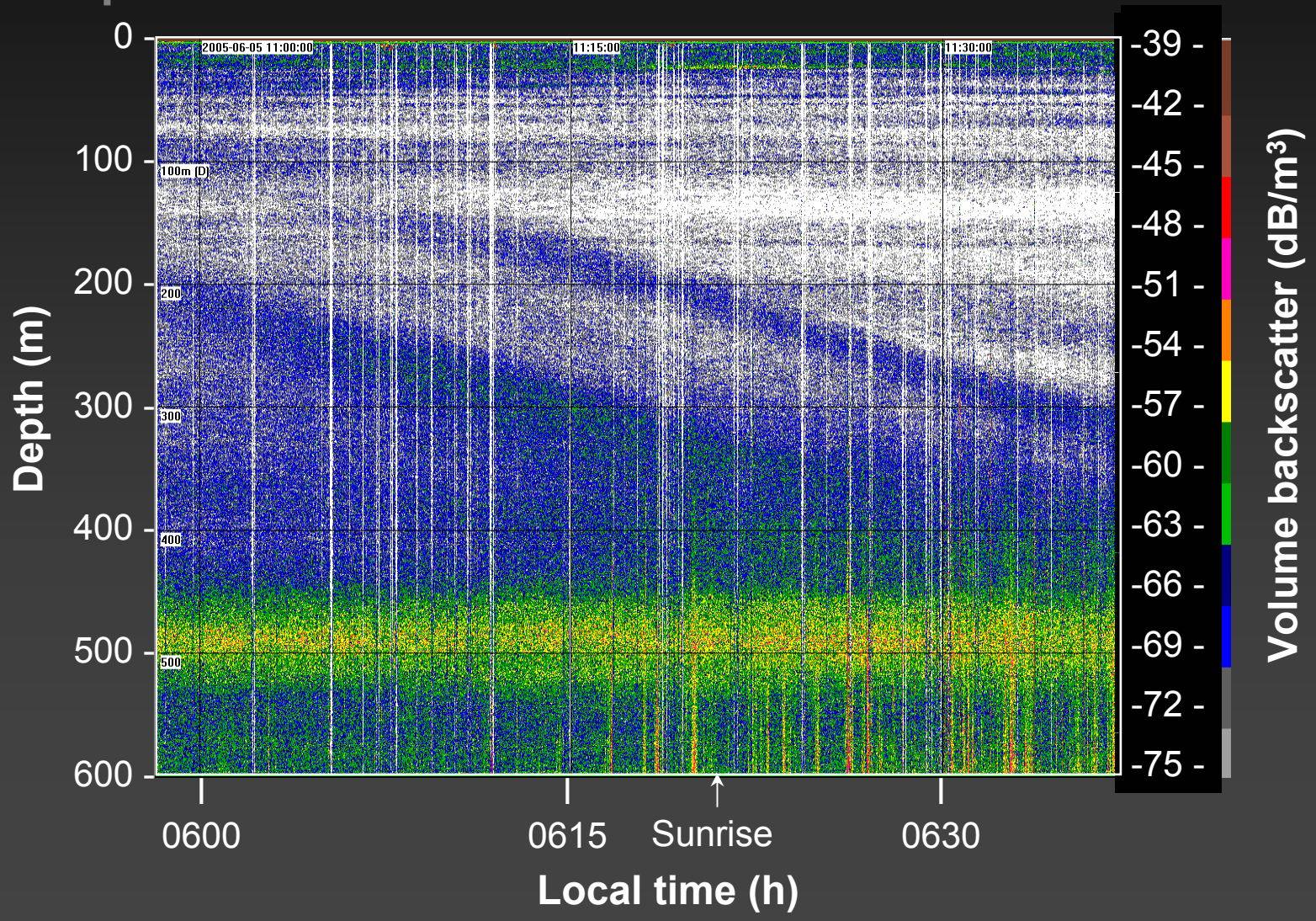
Scattering Layers

- Extensive
- Vertical extent from 1 m to 121 m
  - Mode 4 m
- Many layers showed distinct scattering patterns between the two frequencies
  - Some layers detected only at 38 kHz
  - Others detected only at 70 kHz
- Diel vertical migration in the scattering layers
  - Layers moved up to 200 m in 30 minutes
  - Only some of the animals within layers are migrating
  - Others remain at a constant depth

Average Backscatter



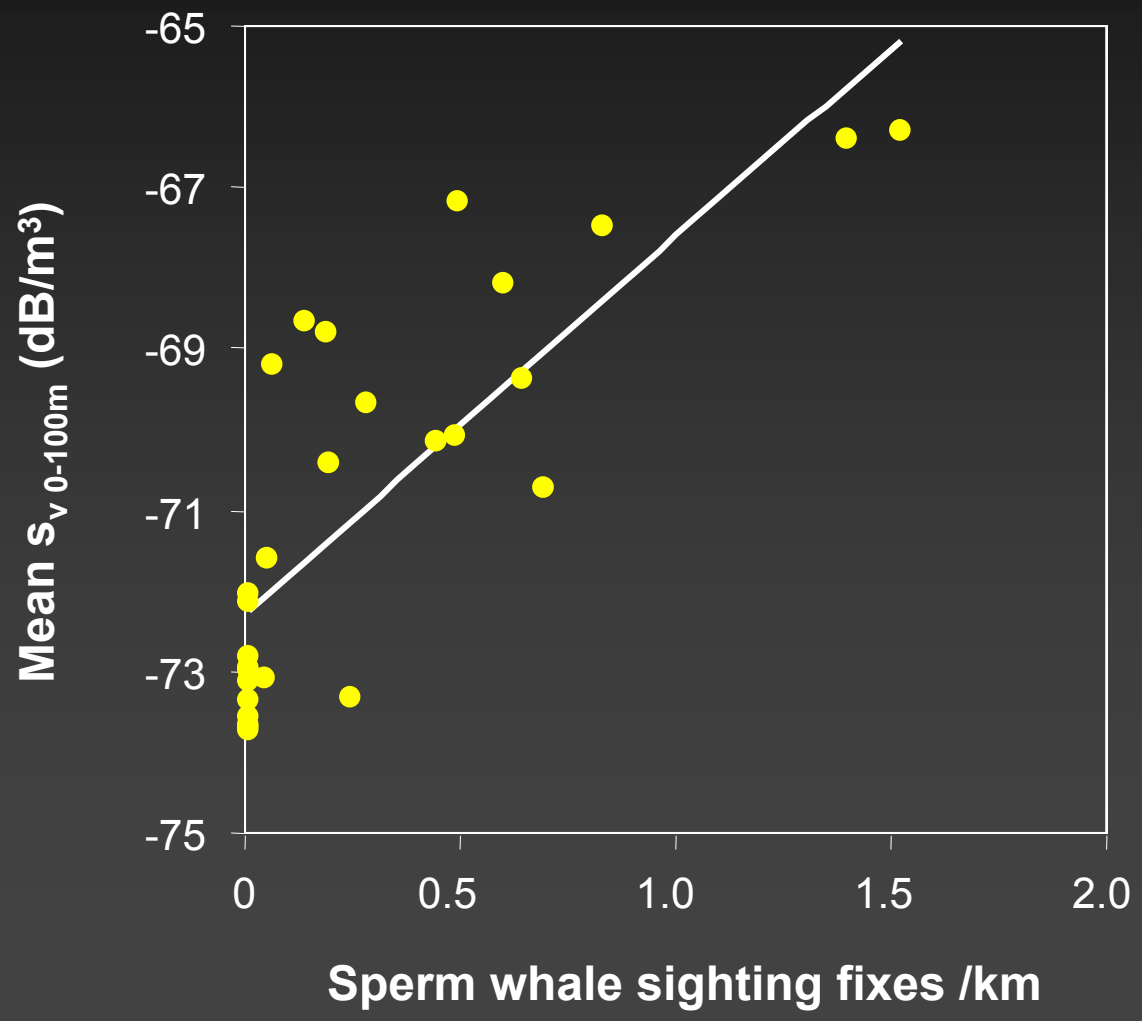
Diel Migration



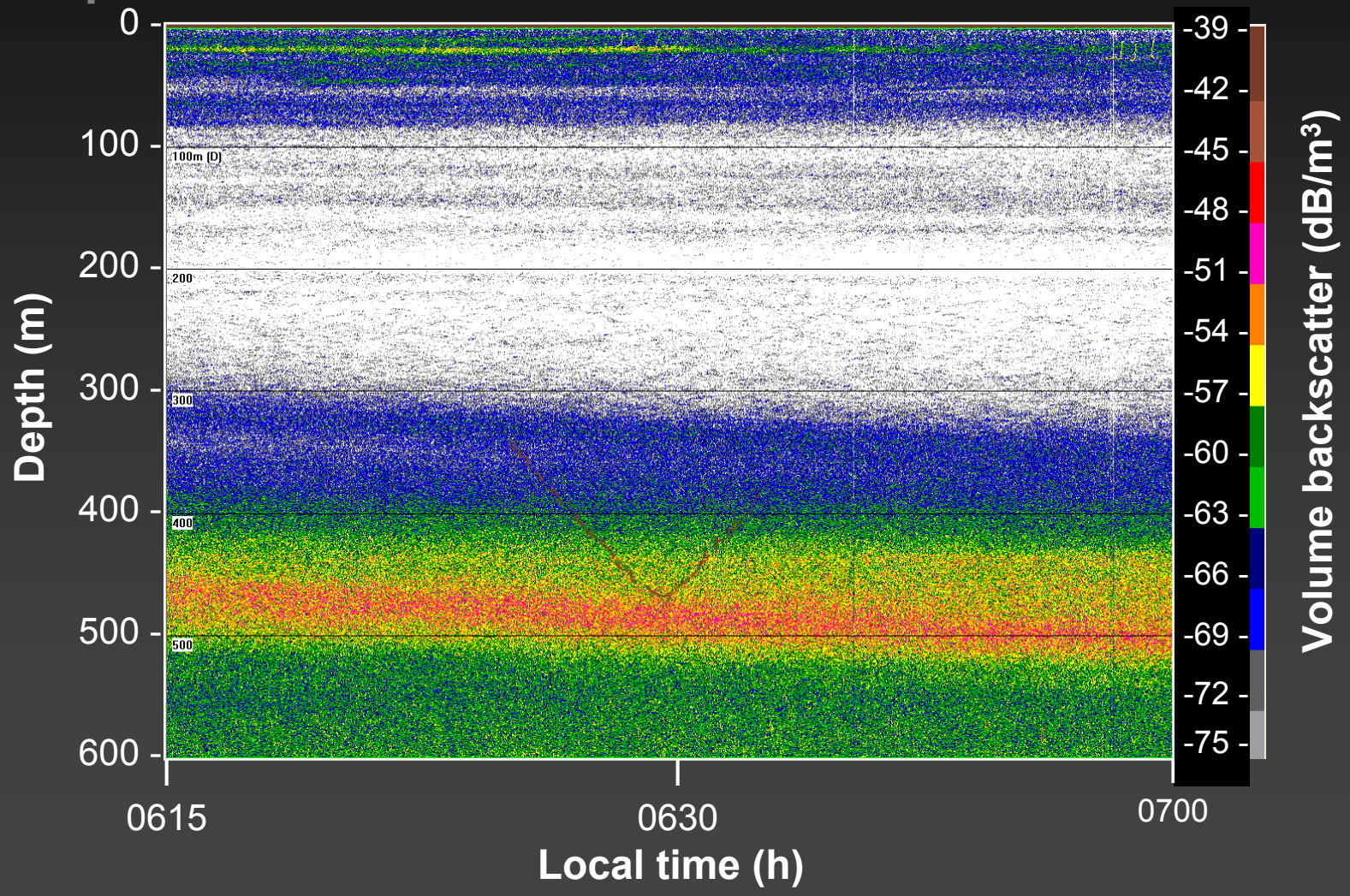
Sightings and Backscatter

- Visual survey results compared with average volume scattering in 100 m depth bins
- 29 visual survey legs
- 3 to 108 km in length (mean=57 km)
- Scattering in the **upper 100 m** of the water column was correlated with the rate of sperm whale locations/survey distance (R=0.80)
- No other depths showed significant correlation

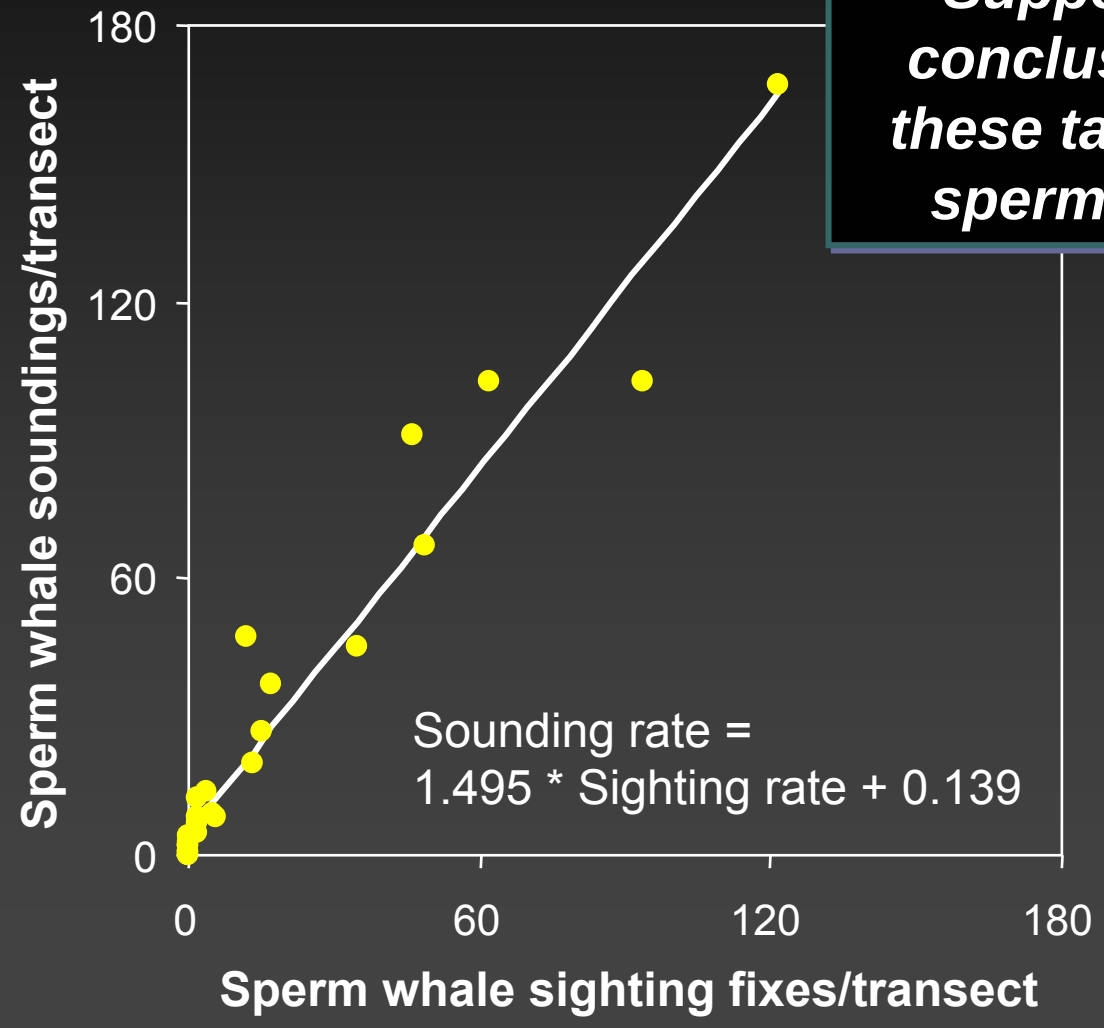
Sightings and Backscatter



Acoustic Whale Detections



Sightings vs. Soundings

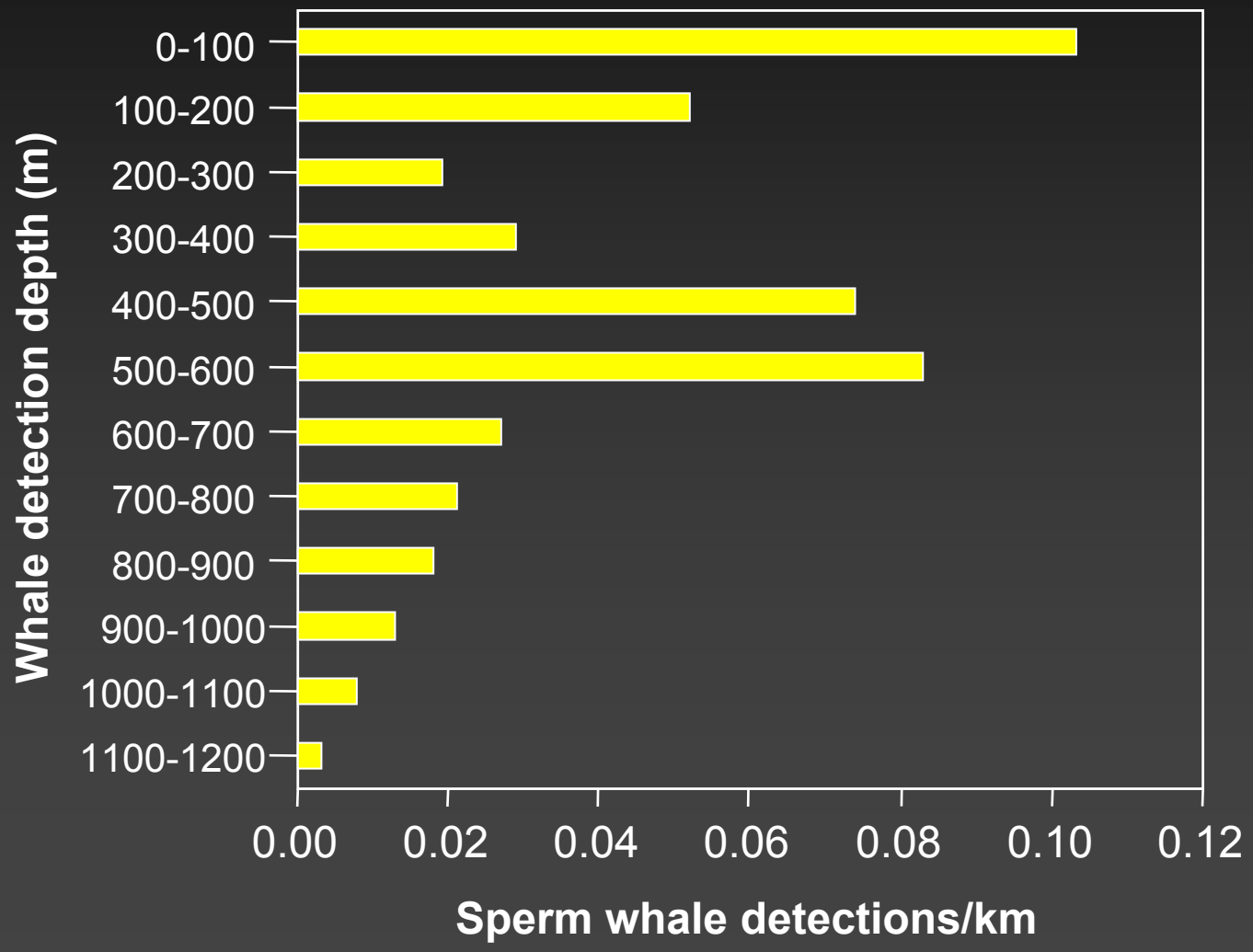


Supports the conclusion that these targets are sperm whales

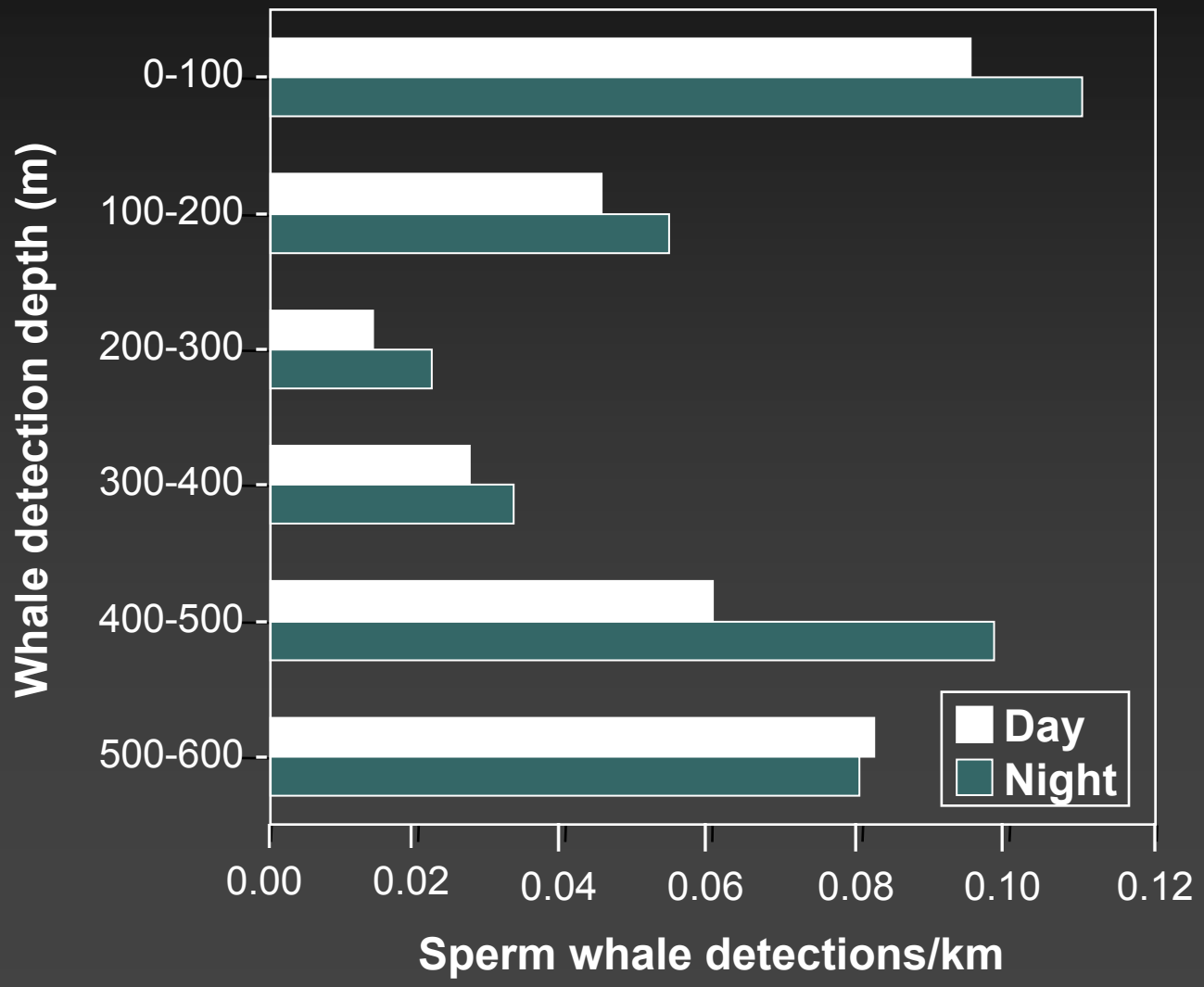
Acoustic Whale Detections

- 70 kHz echosounder (600 m depth range)
  - 2781 sperm whales
  - Average detection rate of 0.36 whales/km surveyed
- 38 kHz echosounder (1000 m depth range)
  - 2112 sperm whales
  - Average detection rate of 0.45 whales/km surveyed

Whale Depth Distribution



Diel Whale Depth Distribution



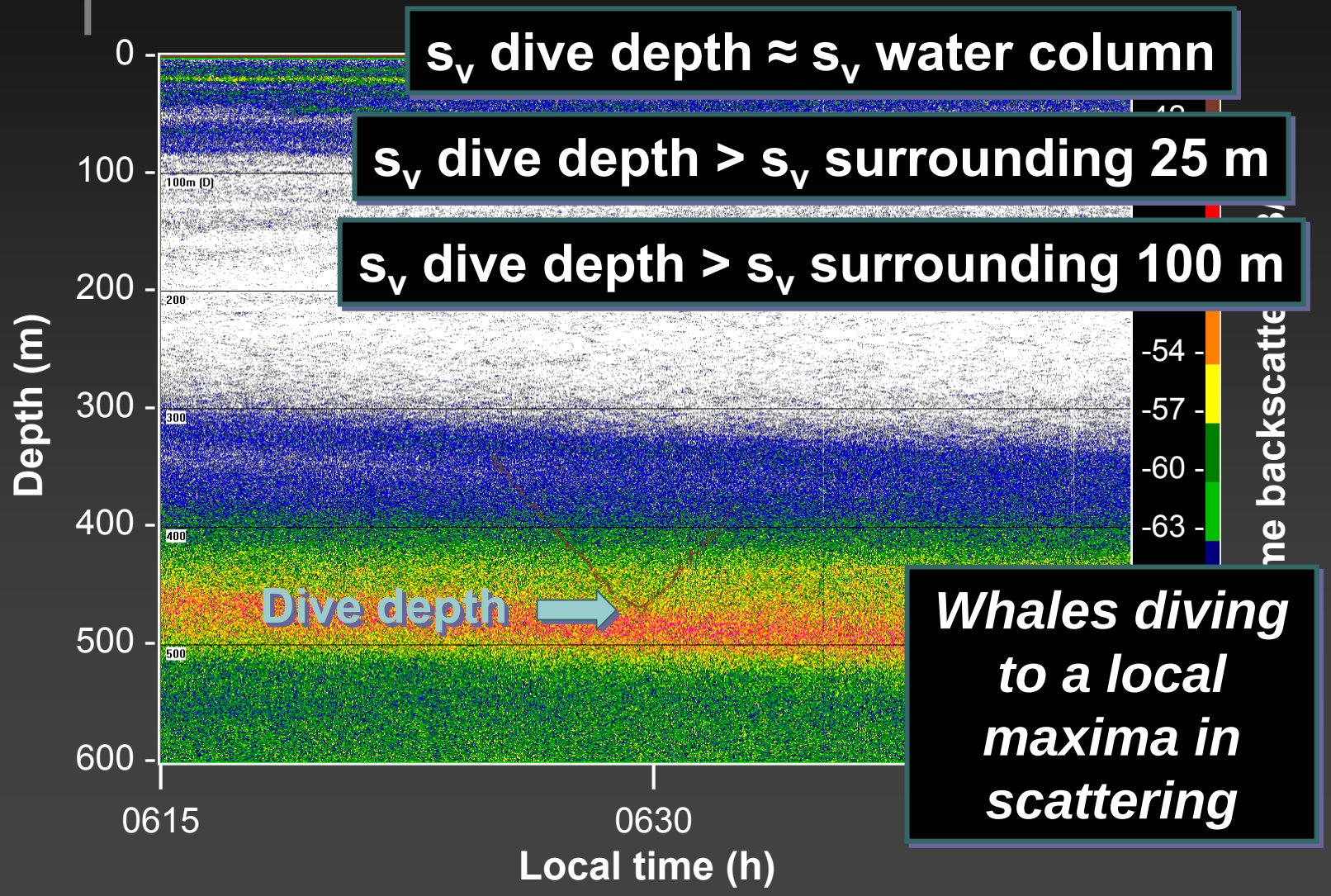
Horizontal Scale

Detecting changes in the habitat at horizontal scales of tens of kilometers

38 kHz	100 km	50 km	25 km	10 km	5 km	1 km
n whales/total n	24/46	47/94	88/187	203/468	375/937	1781/4687
0-100m	✓	✓	✓	✓	✓	✓
100-200m	X	X	X	X	X	X
200-300m	X	X	X	X	X	X
300-400m	X	✓	✓	✓	✓	✓
400-500m	✓	✓	✓	✓	✓	✓
500-600m	X	✓	✓	✓	✓	X
600-700m	X	X	✓	✓	✓	X
700-800m	X	X	✓	✓	✓	X
800-900m	X	✓	✓	✓	✓	X
900-1000m	X	X	X	✓	✓	X
1000-1100m	X	X	X	X	X	X
1100-1200m	X	X	X	X	X	X

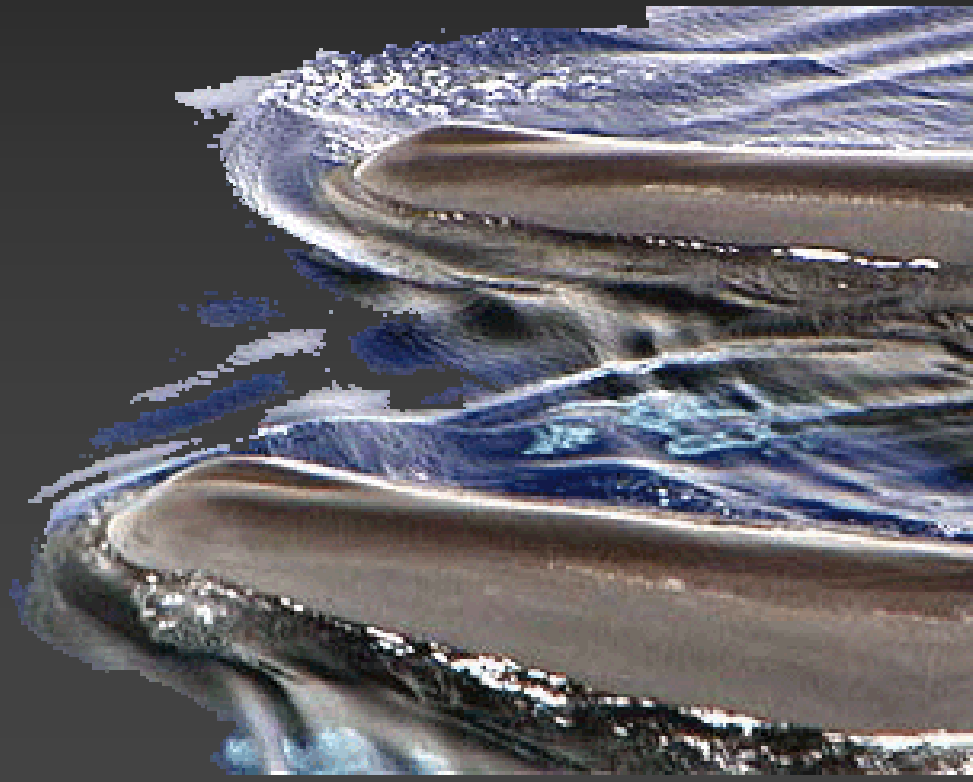
Vertical Scale

Whale dive depth (N=1973)



Conclusions

- First calibrated acoustic data of potential prey in the GOM
  - High-resolution information on the distribution of prey
  - Simultaneous observations of diving sperm whales
- Sperm whales
  - Correlated with scattering above 100 m and below 400 m
  - Appear to select stronger scattering at
    - 5–25 km scale horizontally
    - 1 m scales vertically
- Resource distribution has a strong impact on the distribution of sperm whales in the GOM
- Future needs
  - Identify prey animals in these depth intervals
  - Acoustic measurements of prey for inversion approaches to identify prey remotely

Acknowledgments

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