Spatial Variability of Seafloor Sediment Properties

John A. Goff
University of Texas Institute for Geophysics

Contributors: Barbara Kraft, Larry Mayer, Steve Schock, Sean Gulick, Hilary Olson, Sylvia Nordfjord, Chris Sommerfield, Homa Lee, Rob Wheatcroft, Dave Drake, Don Swift, Shejun Fan

Data Base Collaboration: Chris Jenkins (CU/INSTAAR), Jeff Williams (USGS)

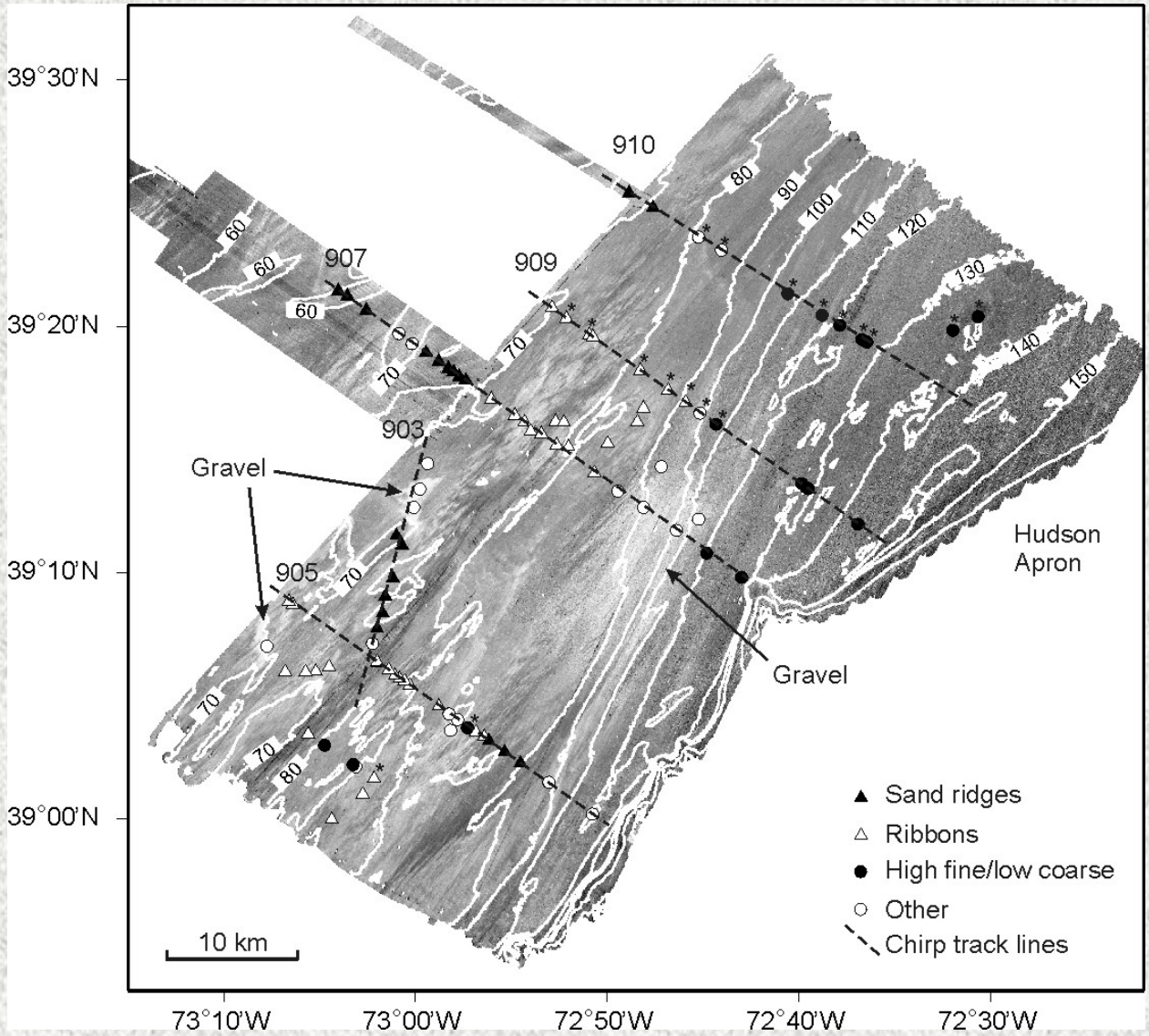
Why is it important to understand spatial variability of sediment properties?

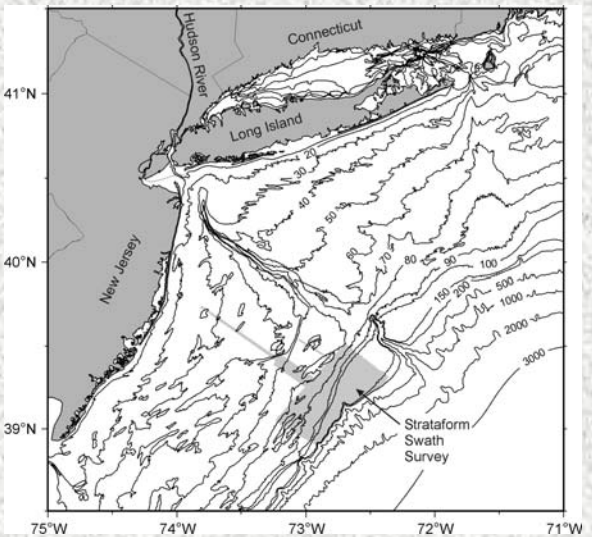
- Answer to the following: if we know seafloor properties at a finite number of sampled locations, what is our best prediction of the seafloor properties at an unsampled location, and what is the uncertainty in that prediction?

- A statistical model can be used to generate any number of independent “realizations” that can be used in Monte Carlo acoustic experiments.

- Variability is tied to geologic processes

New Jersey Backscatter Data





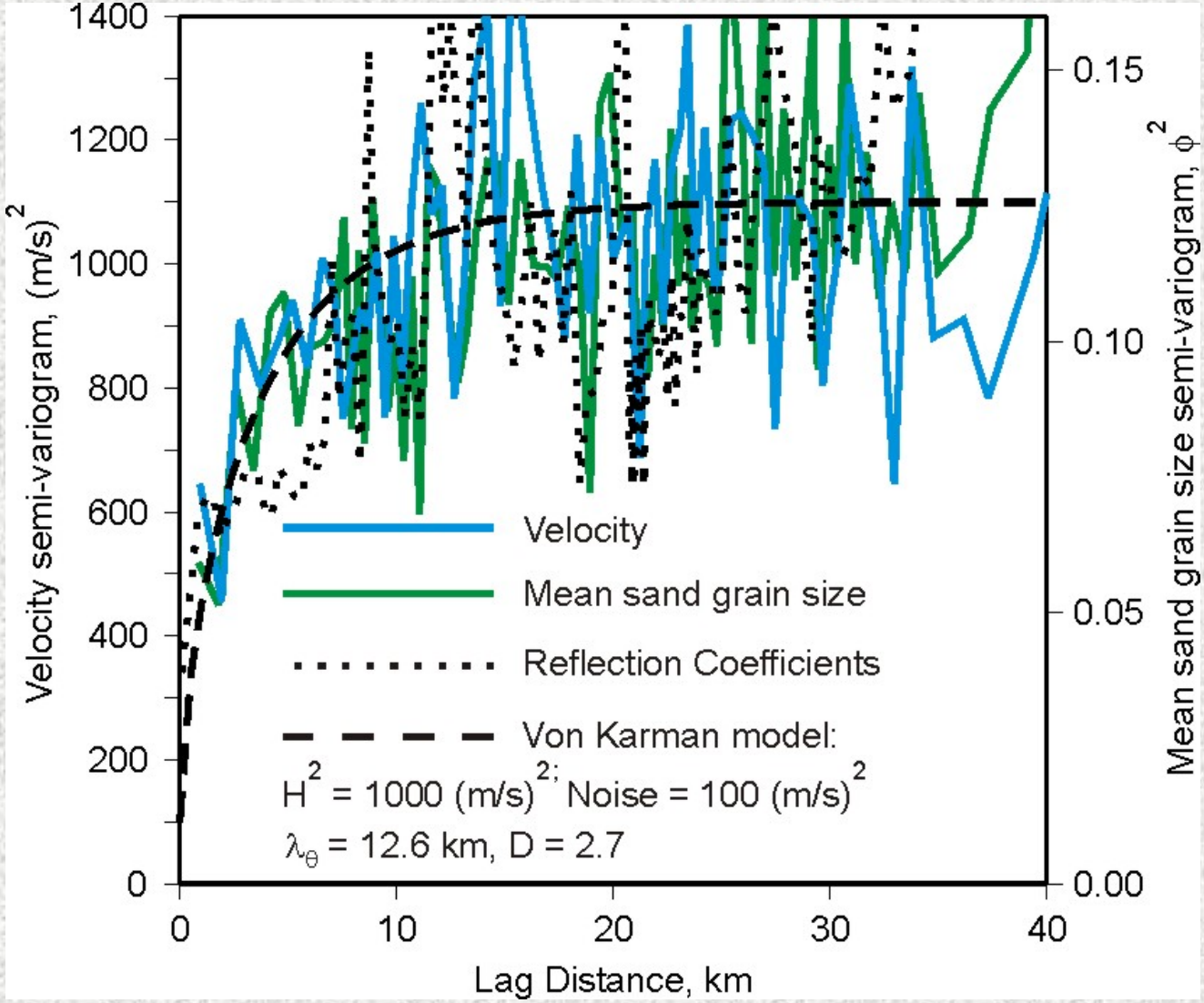
Goals:

1) Investigate seabed variability using point data (grain size, *in situ* velocity and attenuation).

2) Correlate remotely sensed data (backscatter, acoustic impedance) to seabed properties.

Goff et al., in press

NJ Semi-Variogram Analysis



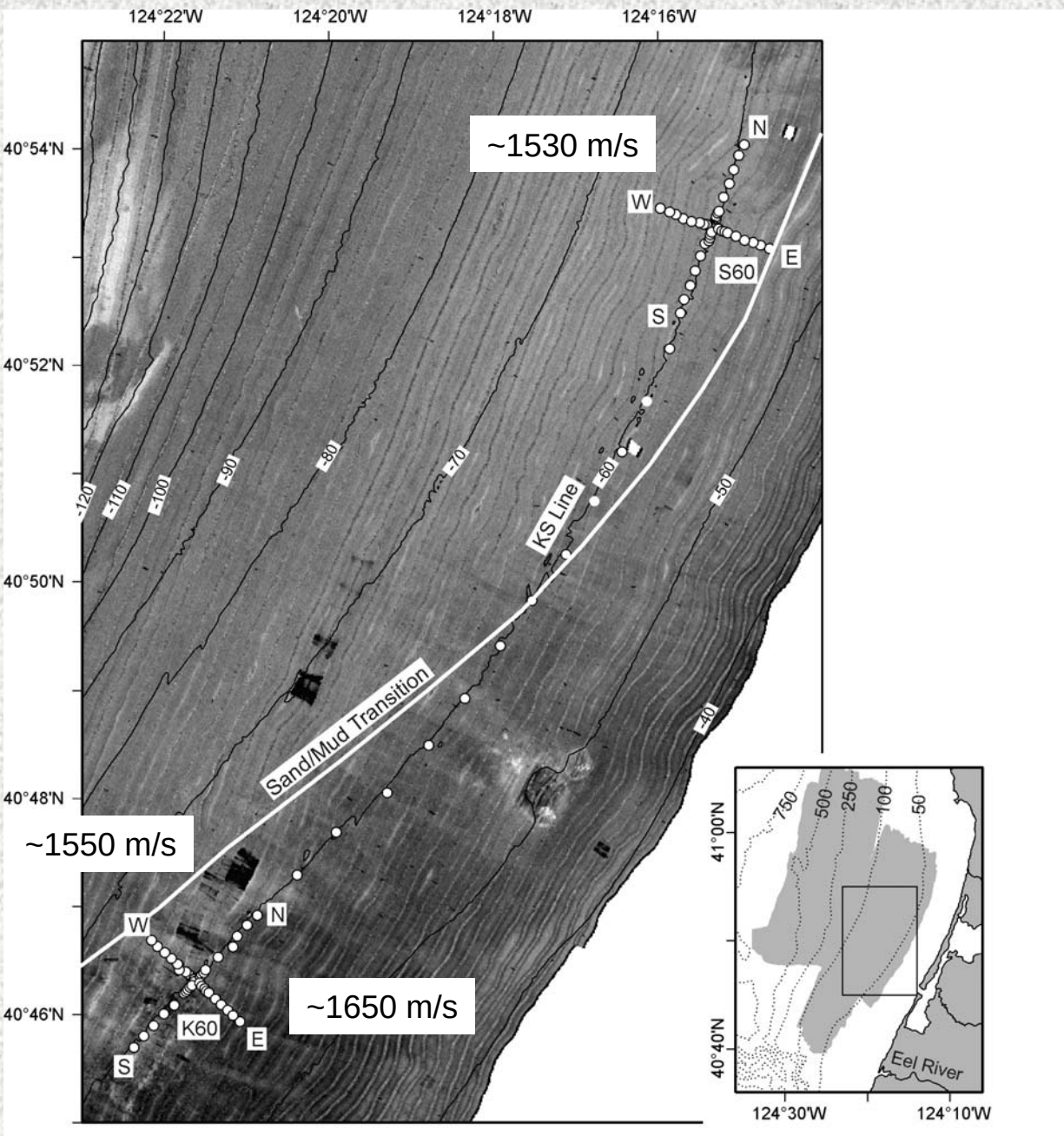
Mean Velocity = 1728 m/s

Backscatter Data: Eel Margin, N. California

Primary Data:

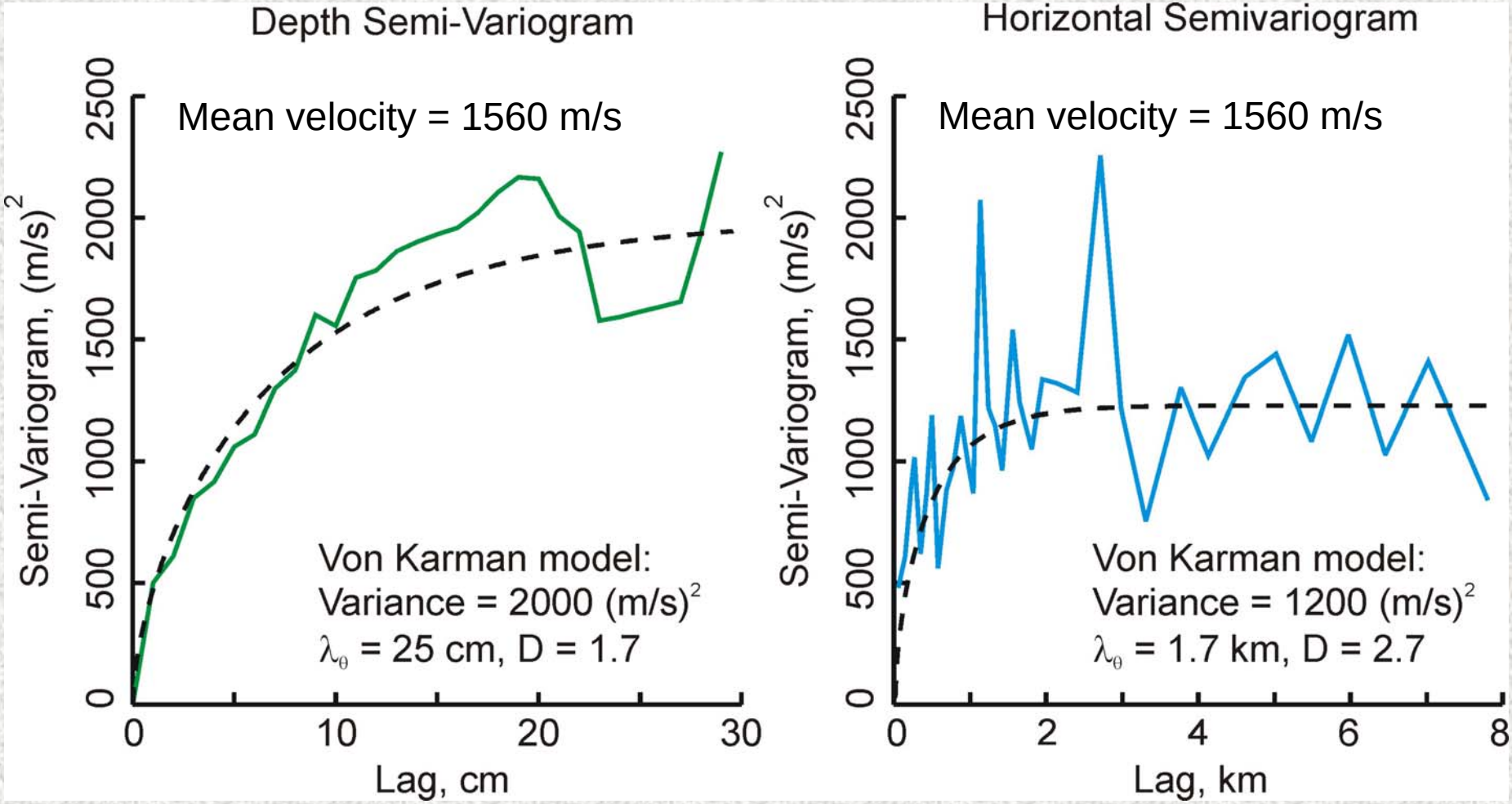
Box cores (~50 cm max penetration) logged for velocity, density, and porosity).

Backscatter displays an inverse correlation with grain size and velocity: remotely sensed data require ground truth!



Goff et al., 2002

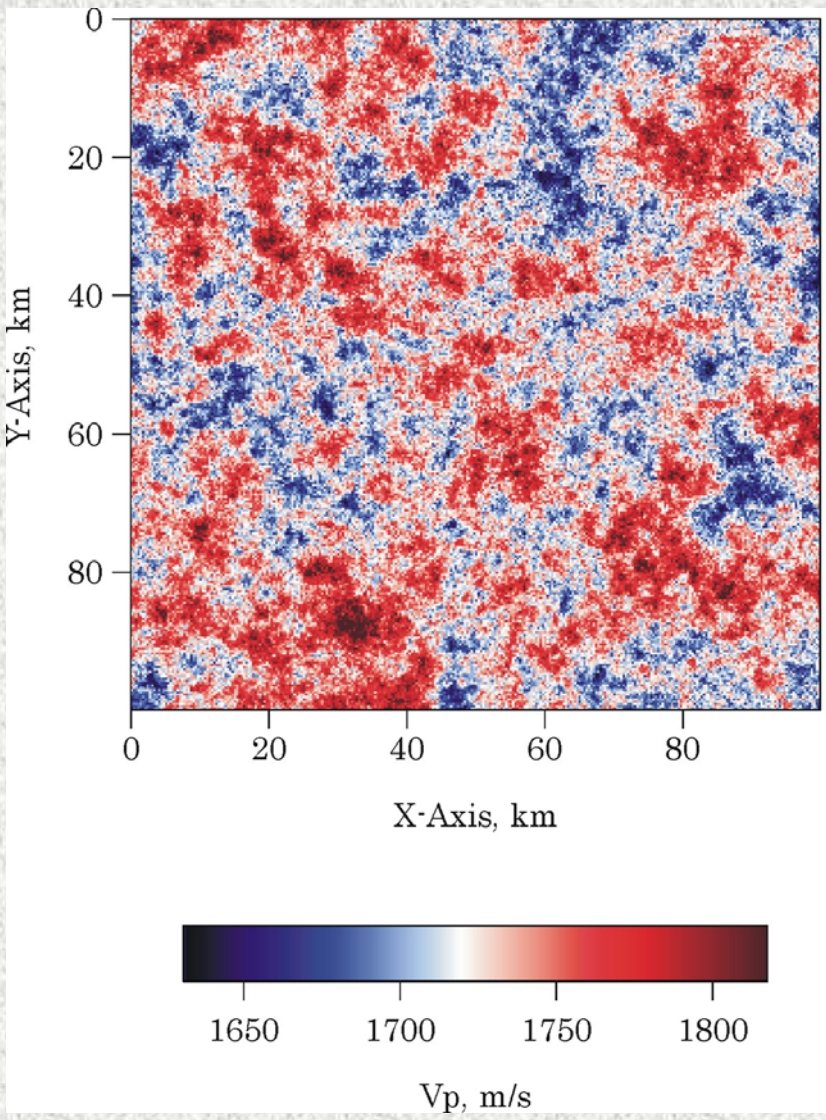
Eel Margin Semi-Variogram Analysis



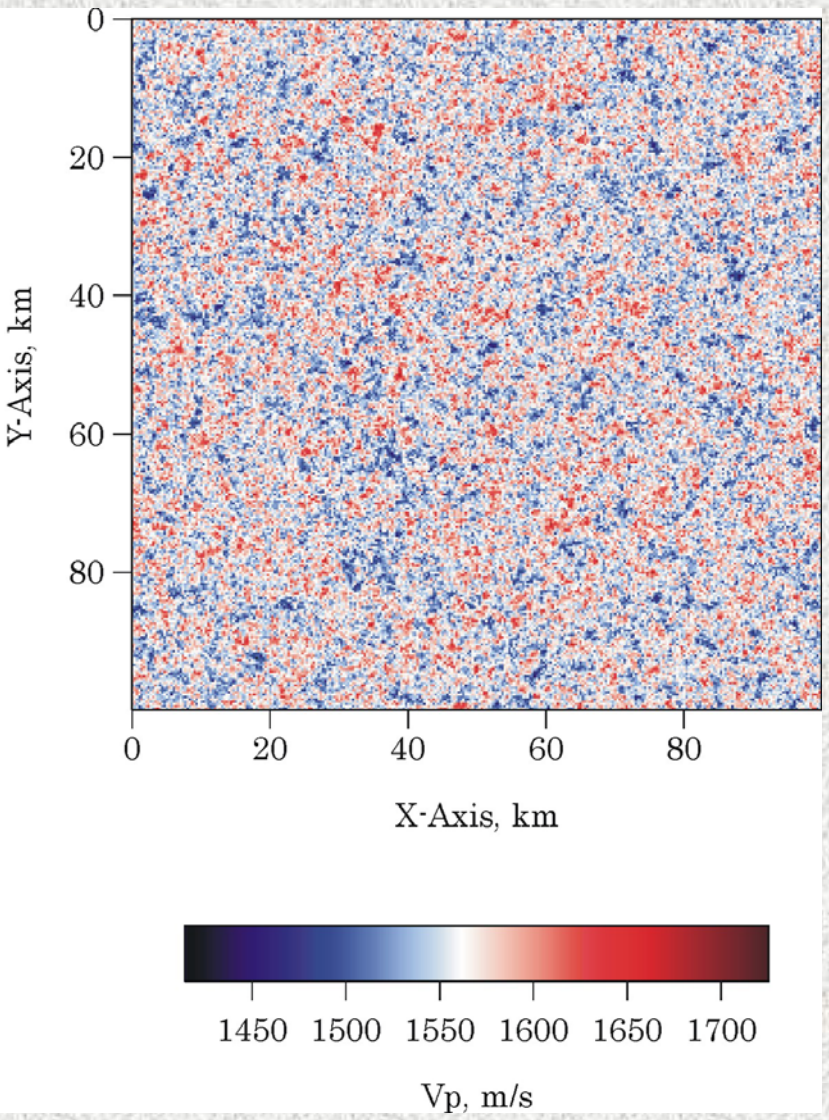
Horizontal model for NJ shelf: Variance = 1000 (m/s)^2
λ_θ = 12.6 km, D = 2.7 Mean velocity = 1728 m/s

Synthetic Velocity Fields – 2-D Horizontal

New Jersey Margin



Eel Margin



Limitations of Seabed Variability Studies

- “Postage stamp” areas – variability determined in these studies will, in general, not be applicable to other geographic settings, environments, depths, etc.

- Small numbers – ability to determine the functionality of variability with scale is constrained by the number of paired measurements that fall within a lag bin. Small numbers force a trade-off between resolution of scale and variance.

We need more data!

usSEABED Data Base

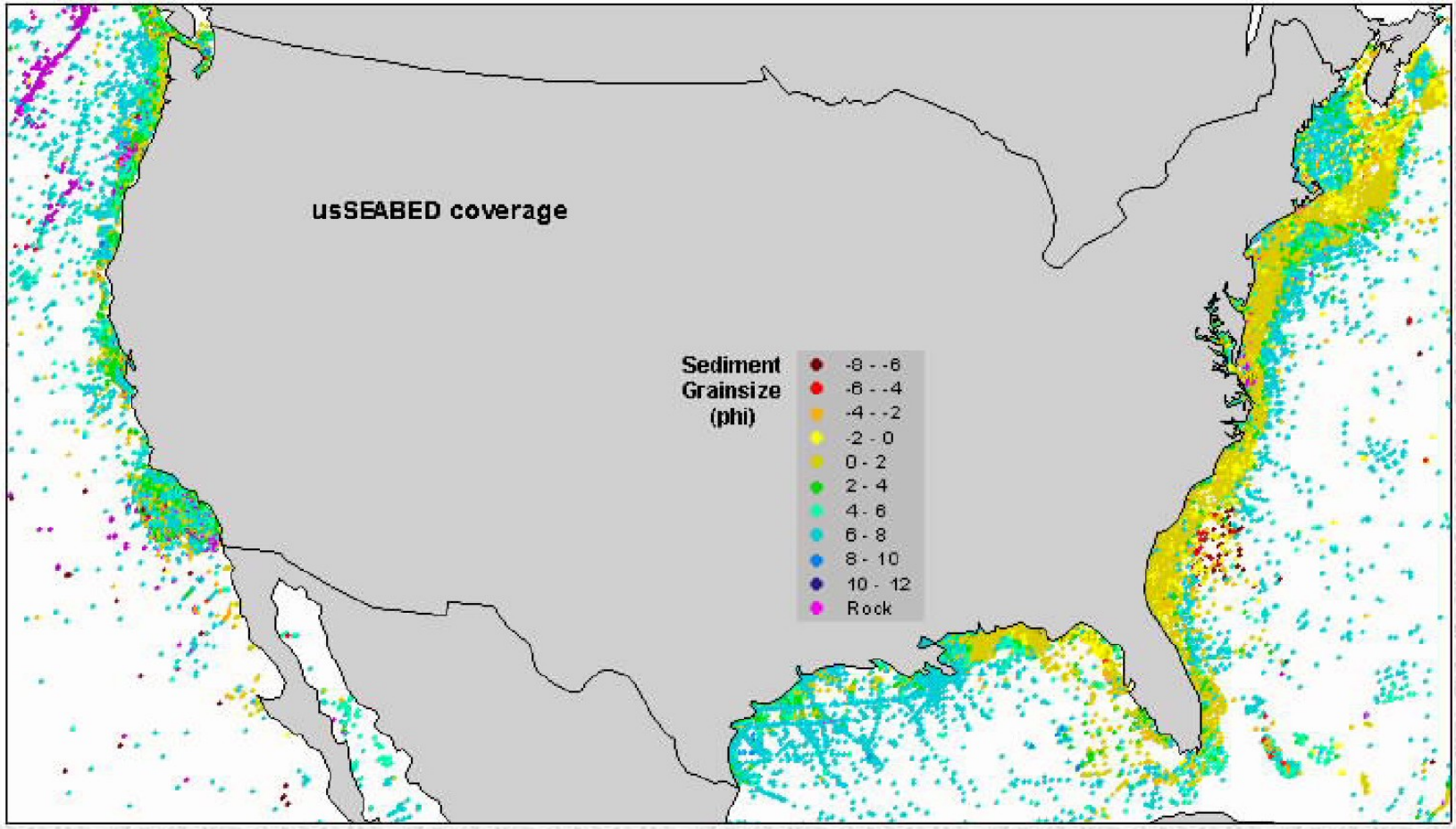


Image courtesy of USGS and CU (Williams et al., 2004, New digital maps of the US continental margins: Insights to seafloor sedimentary character, aggregate resources and processes).

goSEABED Global Data Base

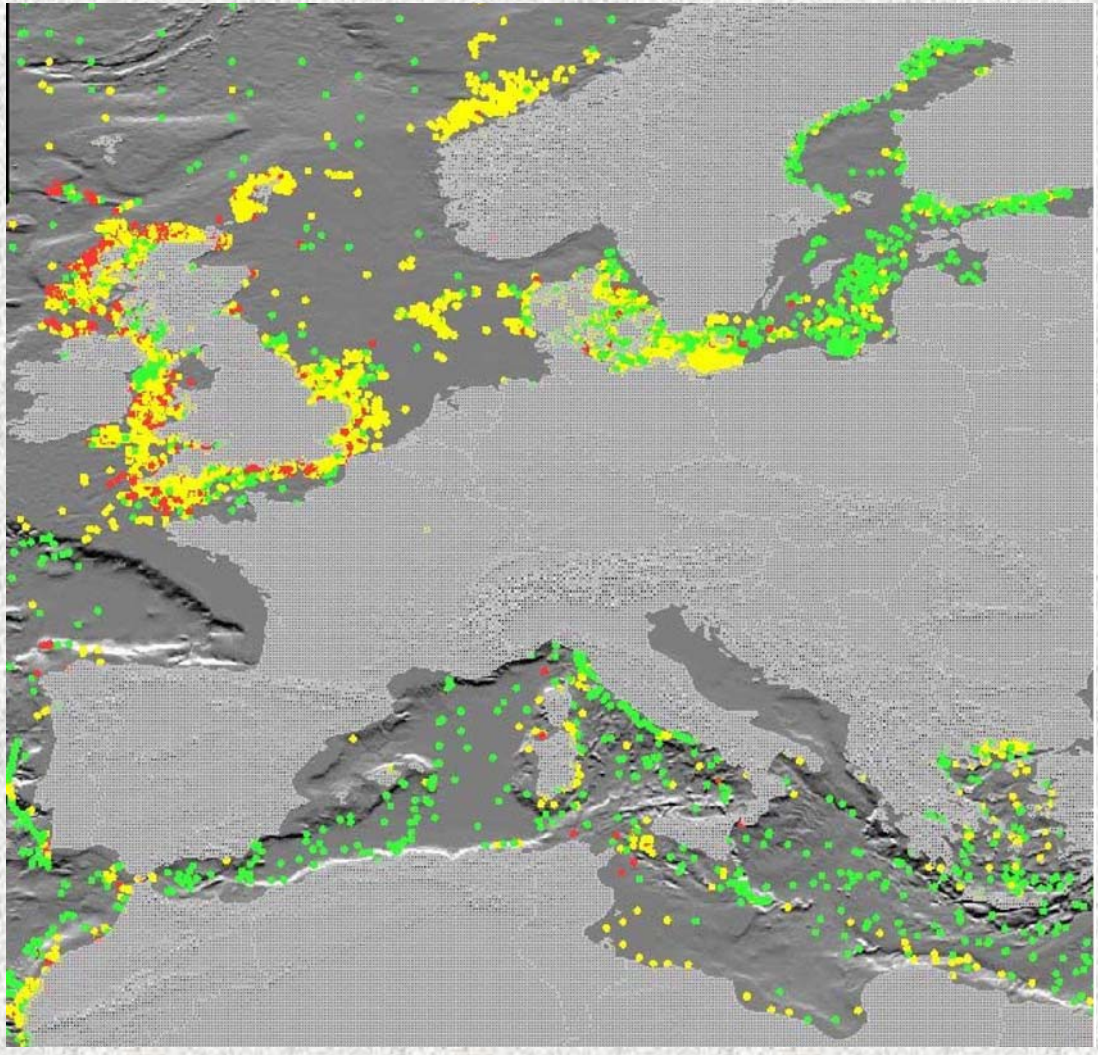


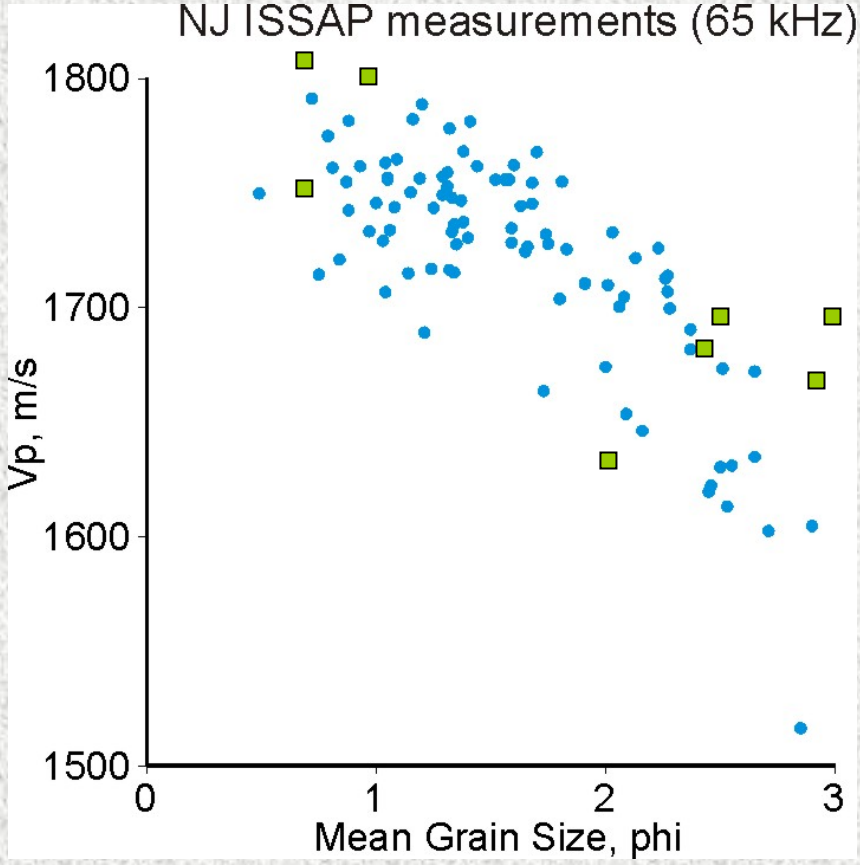
Image courtesy of Chris Jenkins: World Seabed Data Browser,
http://instaar.colorado.edu/~jenkinsc/dbseabed/goseabed/interactive/

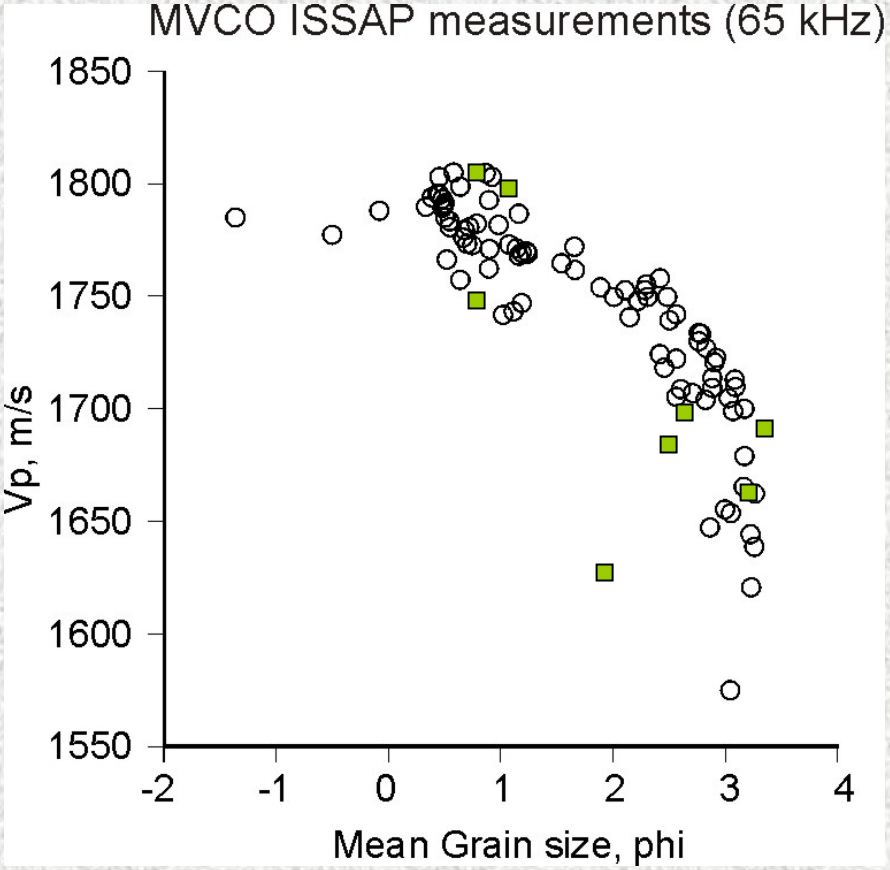
usSEABED, its international counterpart goSEABED, and their underlying software system dbSEABED, are an ongoing project by the USGS and the University of Colorado (INSTAAR) to compile all physical descriptions of seafloor samples into a unified data base

- Data fields of interest include: latitude, longitude, water depth, mean grain size.
- Analytic measurements of mean grain size where available.
- Word-based descriptions (e.g., fine, medium or coarse sand, muddy sand, clayey-silty-sand) converted to estimates of mean grain size.

To make full use of the SEABED data bases, we need to (1) assume a correlative relationship between mean grain size and velocity and (2) assess the accuracy of word-based estimates of mean grain size.

In Situ Velocity vs. Mean Grain Size

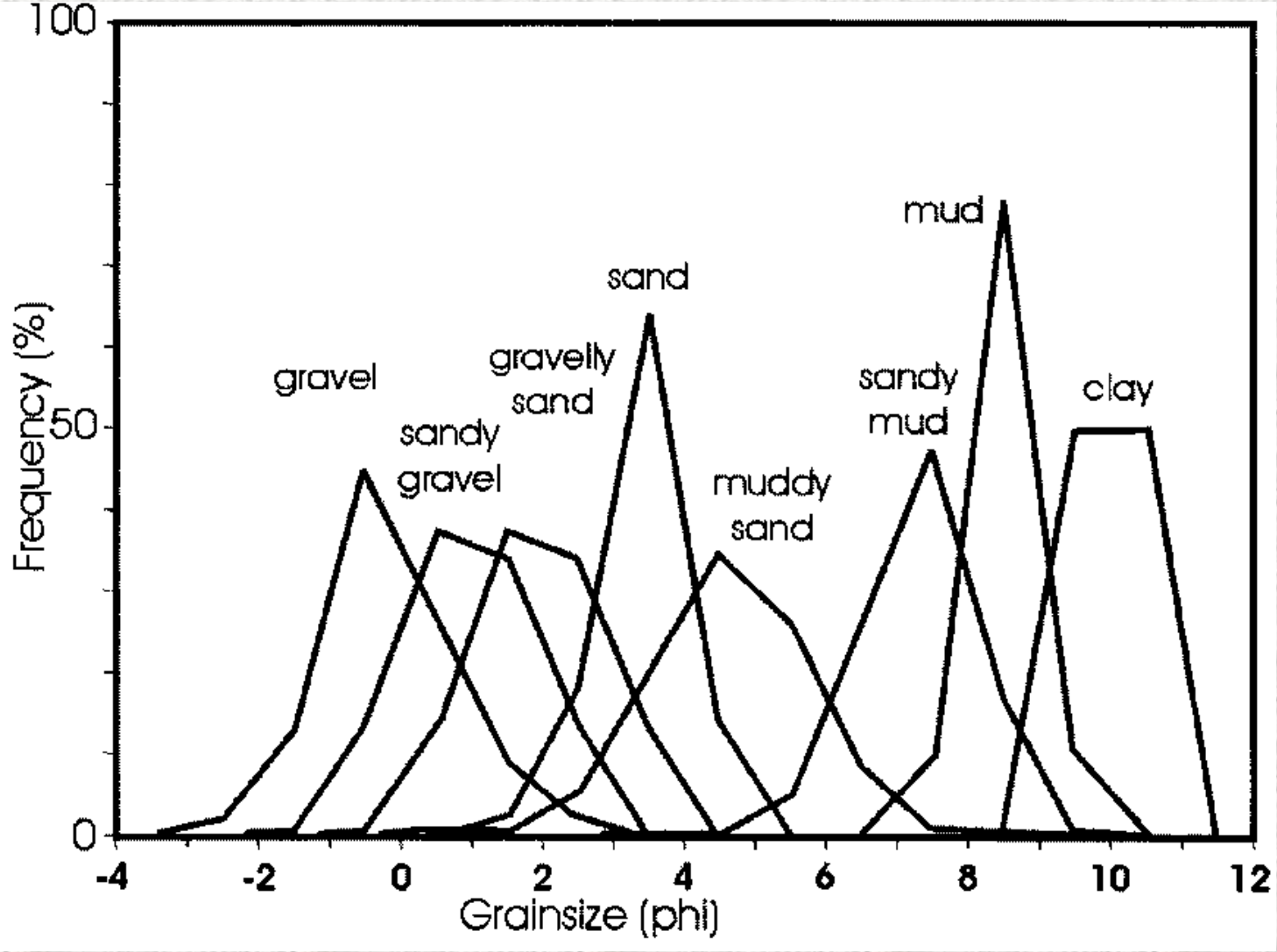




- *In situ* measurements by Hamilton, 1972 (3.5-100 kHz)

ISSAP: University of New Hampshire's *in situ* sound speed and attenuation probe

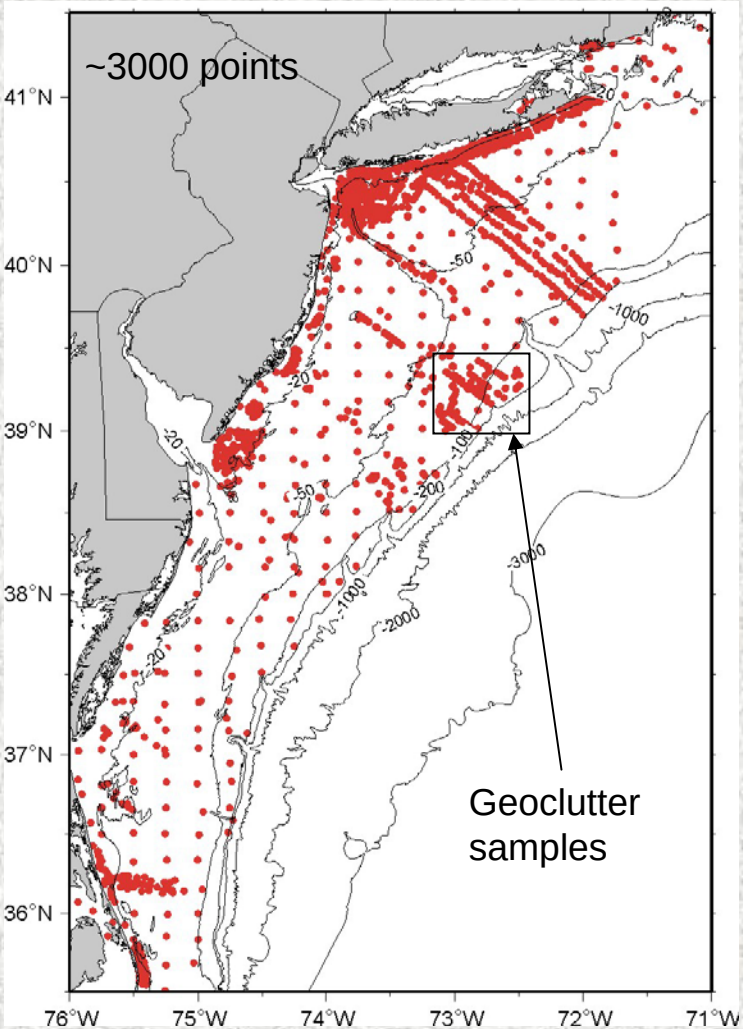
Calibration of Word-Based Descriptions



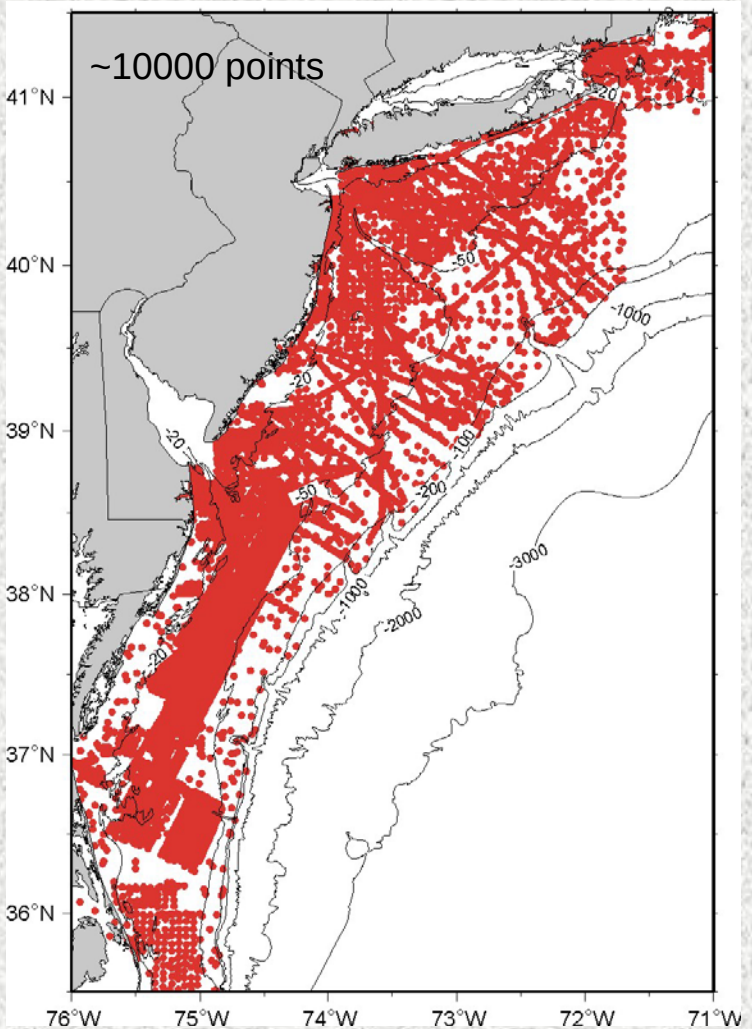
Jenkins, C., submitted to *Continental Shelf Research*

Middle Atlantic US usSEABED Records

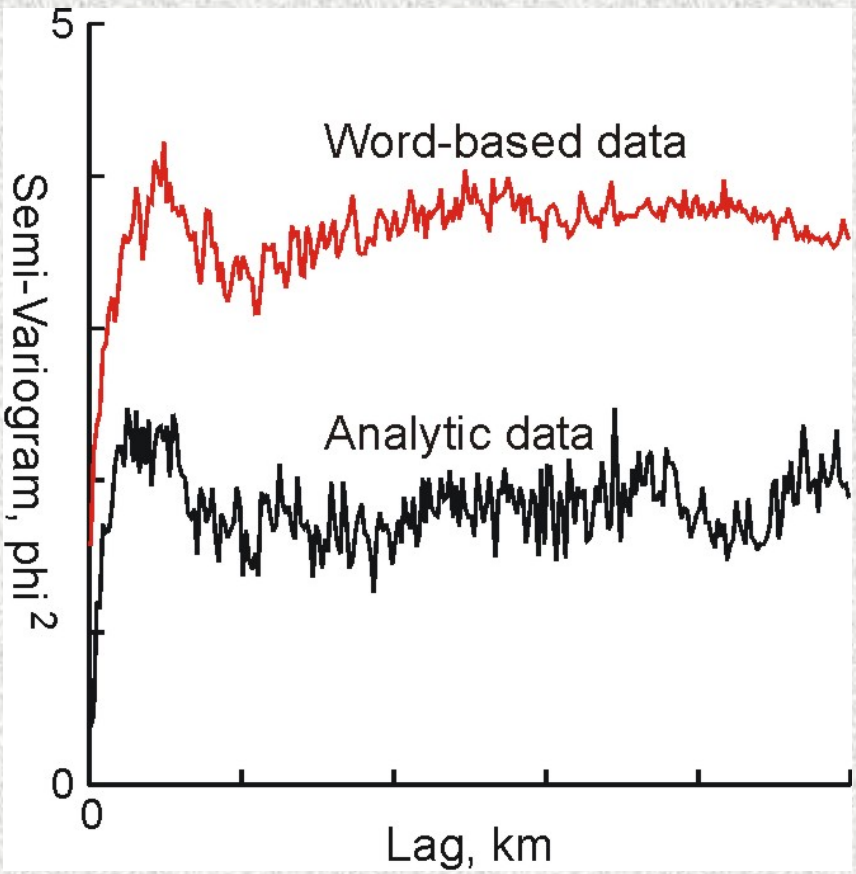
Analytic Mean Grain Size

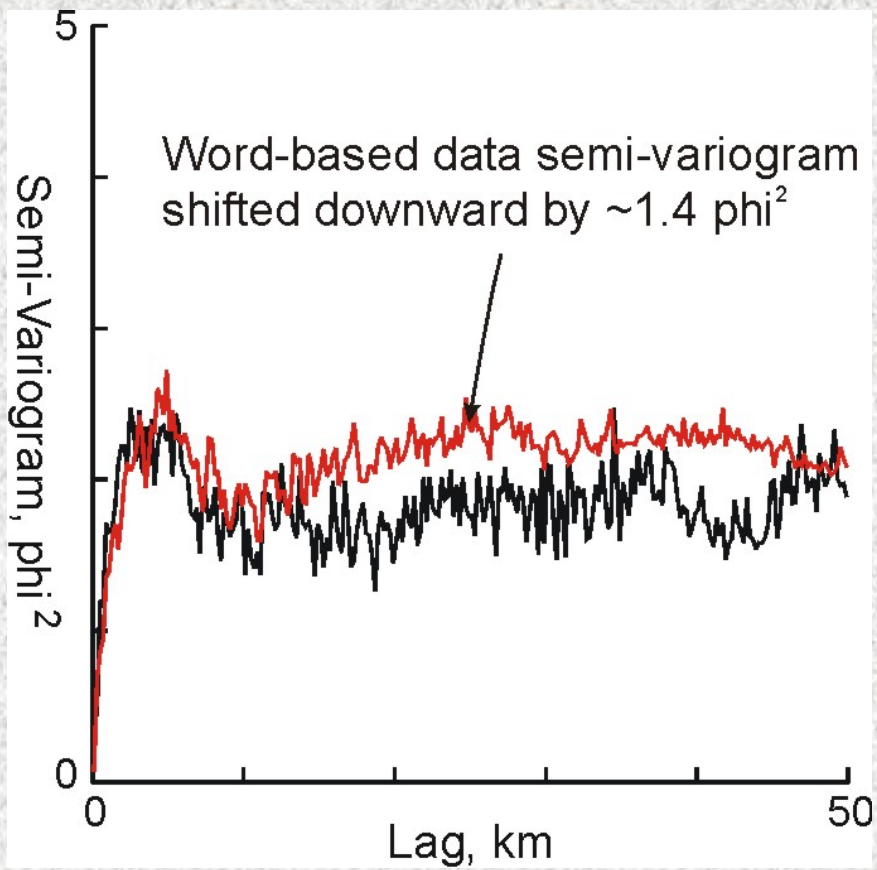


Word-Based Mean Grain Size



Semi-variograms for 0-150 m water depth

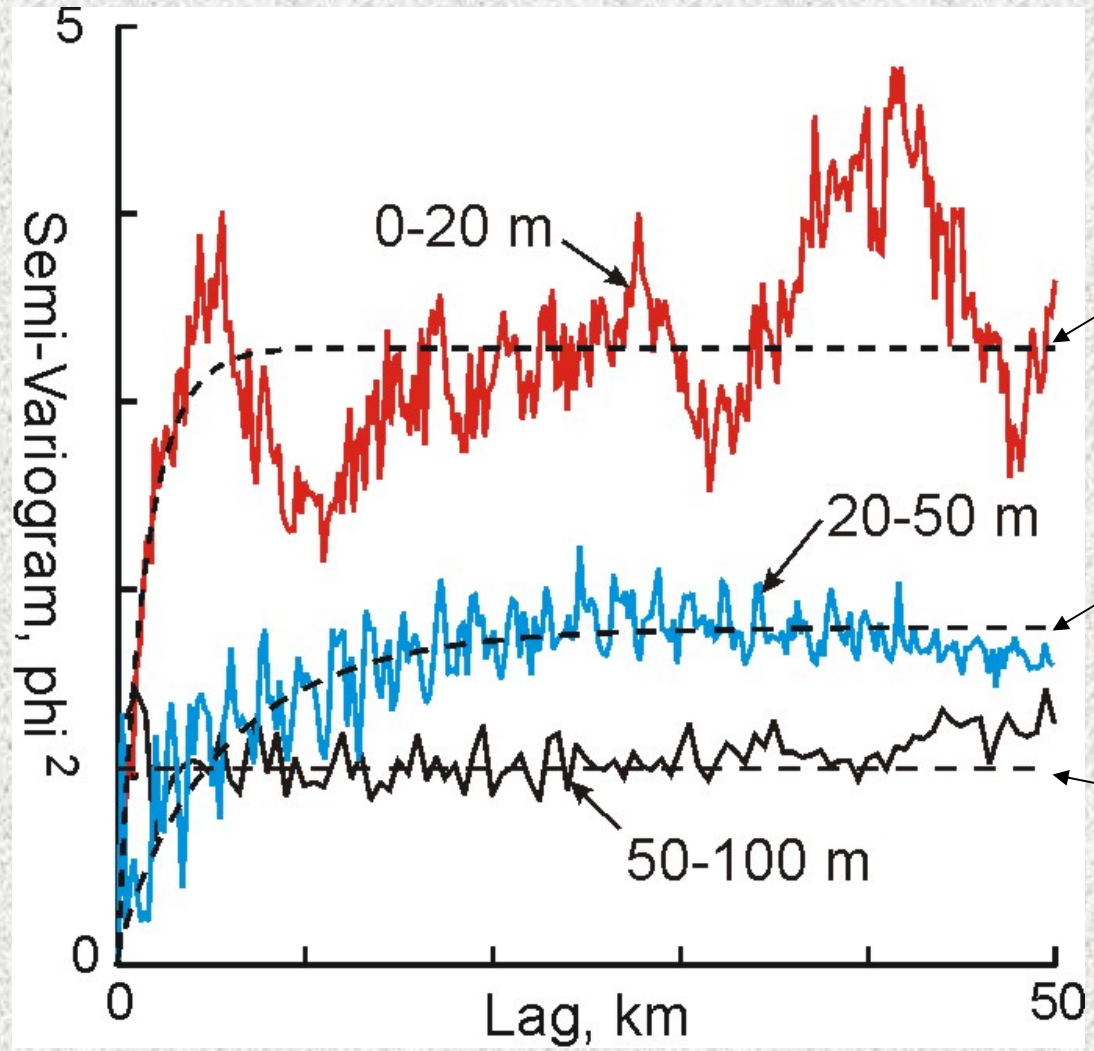




Word-based grain size values may be considered simply as a noisy measurement of the true grain size.

Semi-variograms by depth range

Word-based data, shifted to remove noise spike



Von Karman Model
RMS: 1.8 phi
Characteristic scale: 4.5 km

Von Karman Model
RMS: 1.3 phi
Characteristic scale: 18 km

“White Noise”
RMS: 1.0 phi

Principal Results to Date

- Point and core measurements of velocity have been used in two cases (one sandy, one muddy) to derive statistical model of seafloor variability. Such models can be used to predict sediment properties at unsampled locations from surrounding samples, estimate uncertainty in that prediction, and generate random realizations.

- It may be possible to employ remotely sensed data (e.g., backscatter, vertical-incidence seismic data) to derive models for spatial variability in seafloor velocity, if carefully ground-truthed. This is still work in progress.

- National and international data bases of seafloor sample observations, with both analytical and word-based estimates of grain size, could be used to infer spatial variability in seabed velocity in many parts of the world.