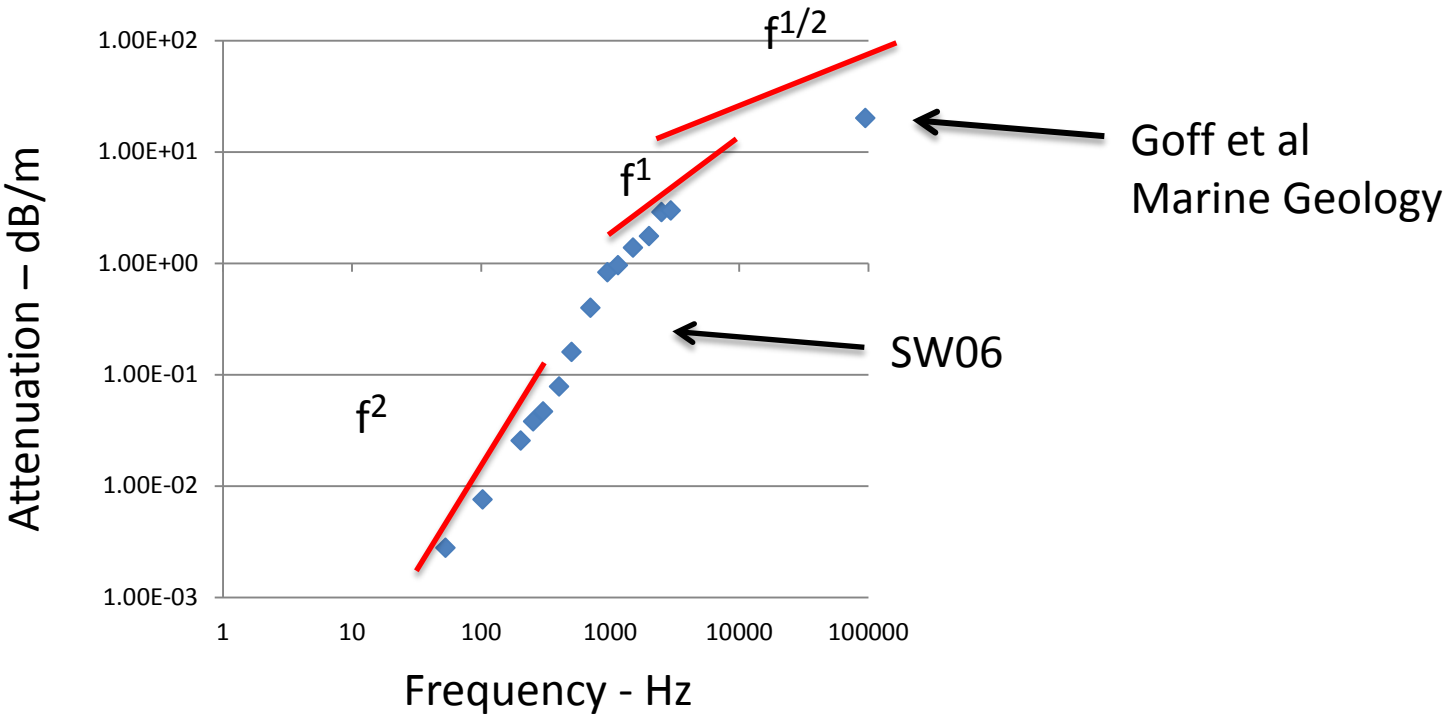
Research Goals

- Measurement via statistical inference[1] of attenuation dispersion over large bandwidth in variety of sediment types (in collaboration with Ross Chapman)
  - Link to measurement of roughness spectrum
- Inference of volume scattering physics in soft sediments
- Statistical inference of seabed parameters that includes 3-D variability (in collaboration with Jim Lynch and Dag Tollenfsen)
- Use "unified model"[2] for propagation and scattering in analysis and statistical inference for model parameters

1 D. P. Knobles and J. D. Sagers, "Maximum entropy approach for statistical inference in an ocean acoustic waveguide," J. Acoust. Soc. Am **131** 1087-1101 (2012).

2 D. P. Knobles and J. D. Sagers, "A nonlocal effective operator for coupling forward and backward propagating modes in inhomogeneous media," J. Acoust. Soc. Am. **130** 2673-2680 (2011).

The need for large bandwidth



Biot goes from f^2 to $f^{1/2}$ from very low to very high frequencies

D. P. Knobles, P. S. Wilson, J. A. Goff, and S. E. Cho, "A seabed acoustics experiment on a sand ridge on the New Jersey continental shelf," J. Acoust. Soc. Am. **124**, EL151-EL156 (2008).

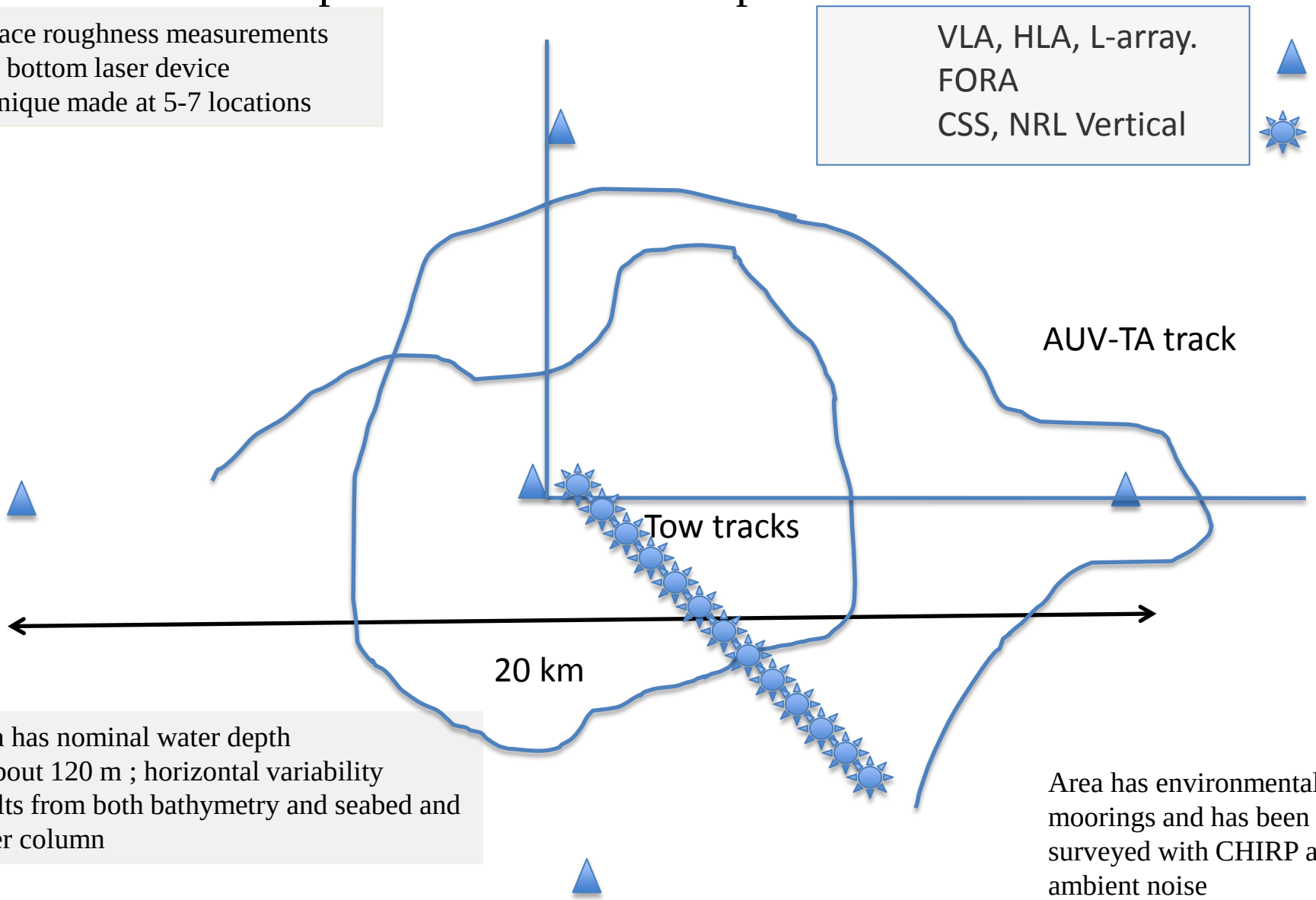
- Model that treats forward propagation and scattering within a single unified theory (non-Born approach)
  - D. P. Knobles and J. D. Sagers, “A nonlocal effective operator for coupling forward and backward propagating modes in inhomogeneous media,” J. Acoust. Soc. Am. **130** 2673-2680 (2011).
- Bandwidth generated by CSS and multiple towed sources (MPL mid frequency source and perhaps NRL source)
- Inferred or computed attenuation dispersion for different seabed models – KK relationships
- AUV-TA created multiple data samples in geographical area. Compute ME constraint or variance within a Bayesian method to compute marginal pdfs. Model space includes horizontal and azimuthally variability of seabed

Statistical inference of seabed parameter values that includes 3-D variability (WHOI and ARL:UT collaborative effort)

- Measurements made by AUV-TA in 20 km^2 box that has seabed and bathymetry variability
- Multiple tracks create data ensemble
- Uncertainty (relevant for an operational area) can then be computed with several statistical inference methods (ex. Bayesian, MaxEnt)
- Relevant 3-D models needed to create model space previously demonstrated by M. Ballard et al.
- Already, in simple 2-D track experiments, multiple effective seabed representations give equivalent fits to measured data and Occam's razor is already problematic
  - As we add more parameters to account for 3-D variability how can experiment be designed to obtain something other than uniform marginal distributions for seabed parameter values?

AUV-TA (WHOI and ARL:UT) Uncertainty and variability of seabed parameter values in operational area

Surface roughness measurements with bottom laser device technique made at 5-7 locations



Area has nominal water depth of about 120 m ; horizontal variability results from both bathymetry and seabed and water column

Area has environmental moorings and has been surveyed with CHIRP and ambient noise inversion (Siderius/Gerstoft)

Experimental apparatus and measurements

- What I have access to
  - CSS omni and various towed sources
  - Three 2-D fixed arrays up to 3-4 kHz bandwidth
  - AUV-TA
  - Measurement of seabed roughness spectrum over large wave number band
  - Raman device (Fink et al.)
- What I need/want or can beg/borrow/collaborate/steal
  - Layering ground truth (down to 50-100 m) and sediment cores at multiple (50-125 m water depths)
  - Sediment porosity, grain size distributions, and other physical properties of sediment
  - MPL 1-4 kHz source
  - NRL source
  - ASIS surface buoy
  - Other fixed arrays
  - CTDs ; fixed and mobile