Yellow Sea Acoustic Uncertainty Caused by Hydrographic Data Error

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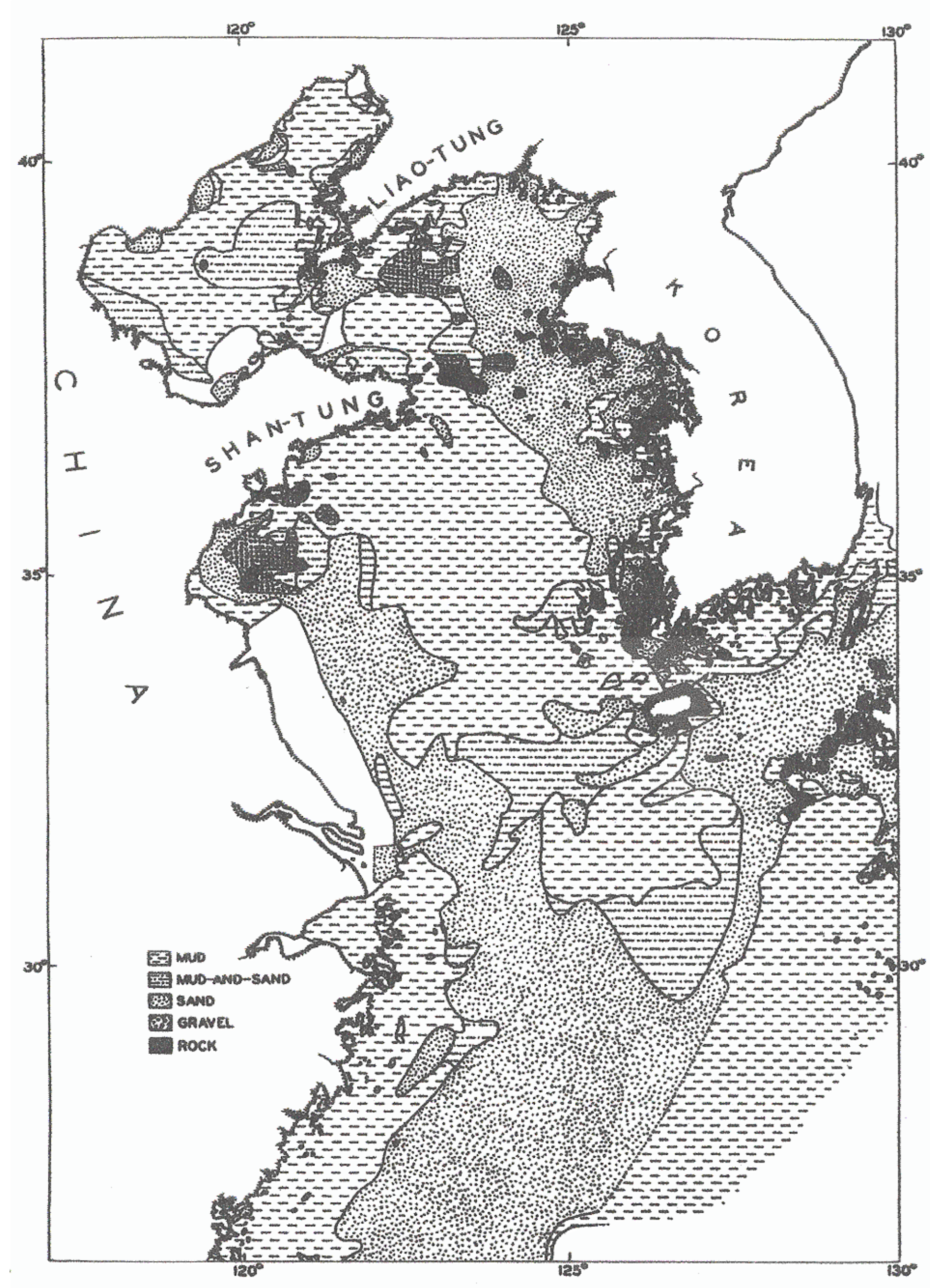
The paper is presented by Prof. Kevin Smith at NPS

Yellow Sea Bottom Sediment Chart

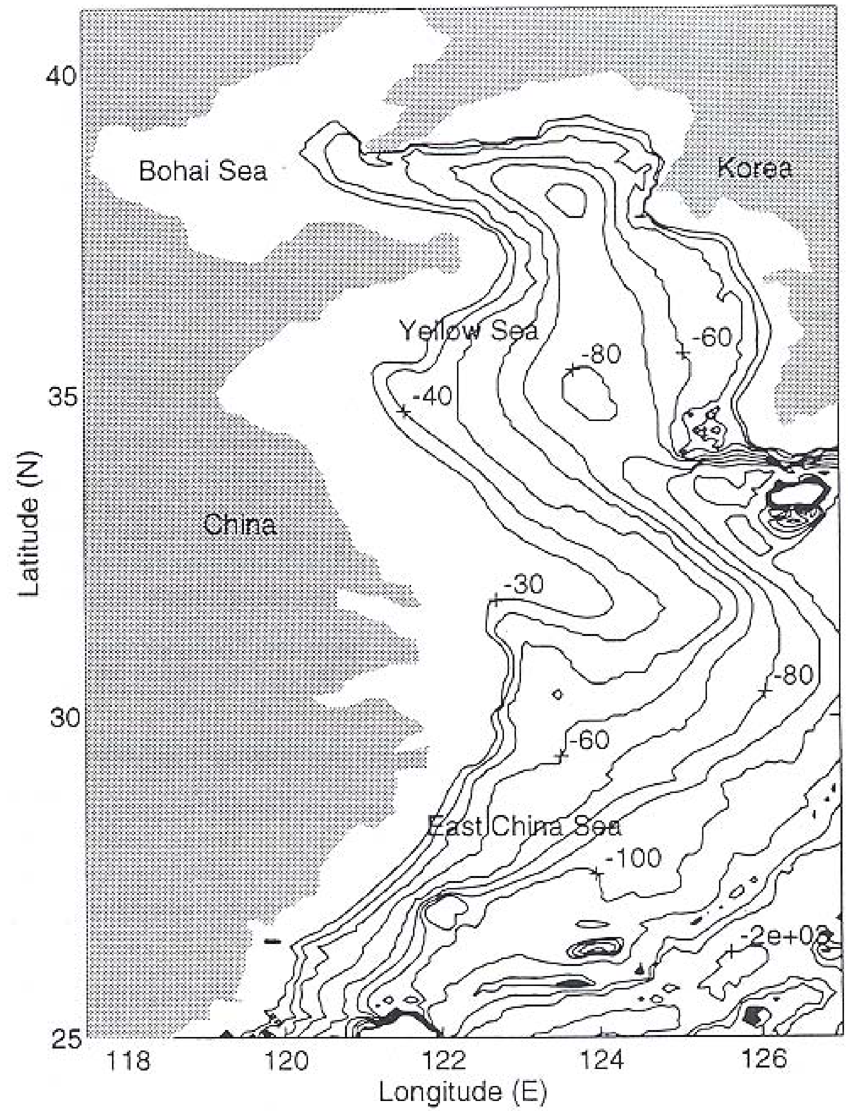
- Four Bottom Sediment types

1. Mud
2. Sand
3. Gravel
4. Rock

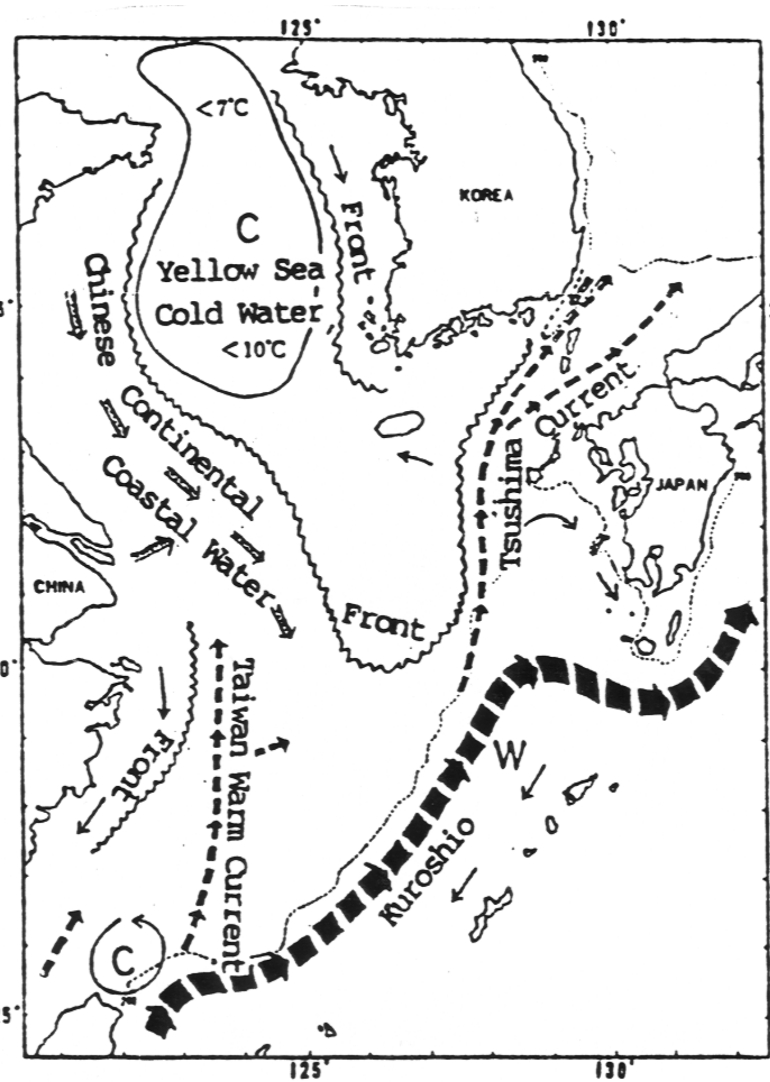


Yellow Sea Bottom Topography

- Water depth in most of the region is less than 50 m.
- Within 50 km of the Korean coastline the average water depth is 20 m.



Water Mass Distribution
(Kondo 1985)



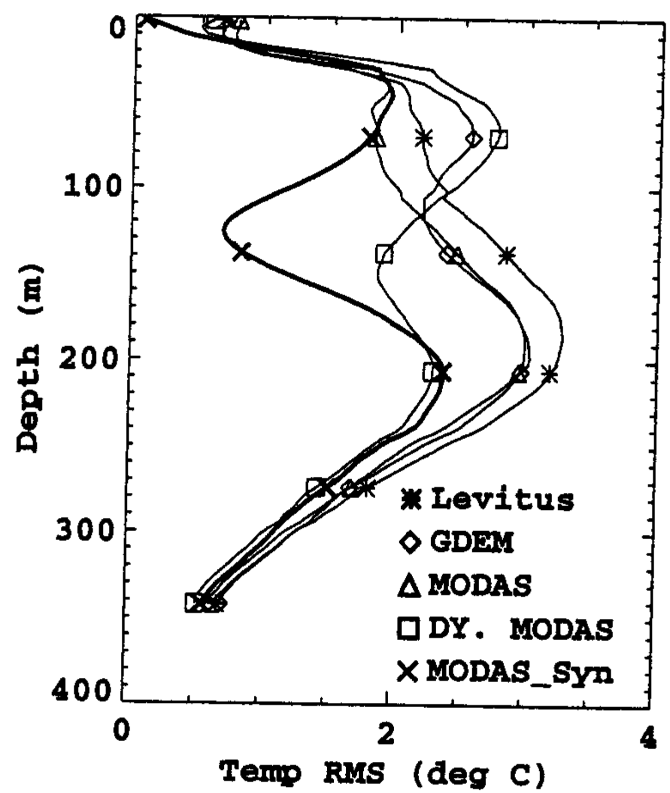
Oceanographic Data Sets

- NODC Monthly Mean Data (Levitus 1994)
- Master Oceanographic Observational Data Set (MOODS)
- Generalized Digital Environmental Model (GDEM)
- Modular Ocean Data Assimilation System (MODAS)

Environmental Data Accuracy

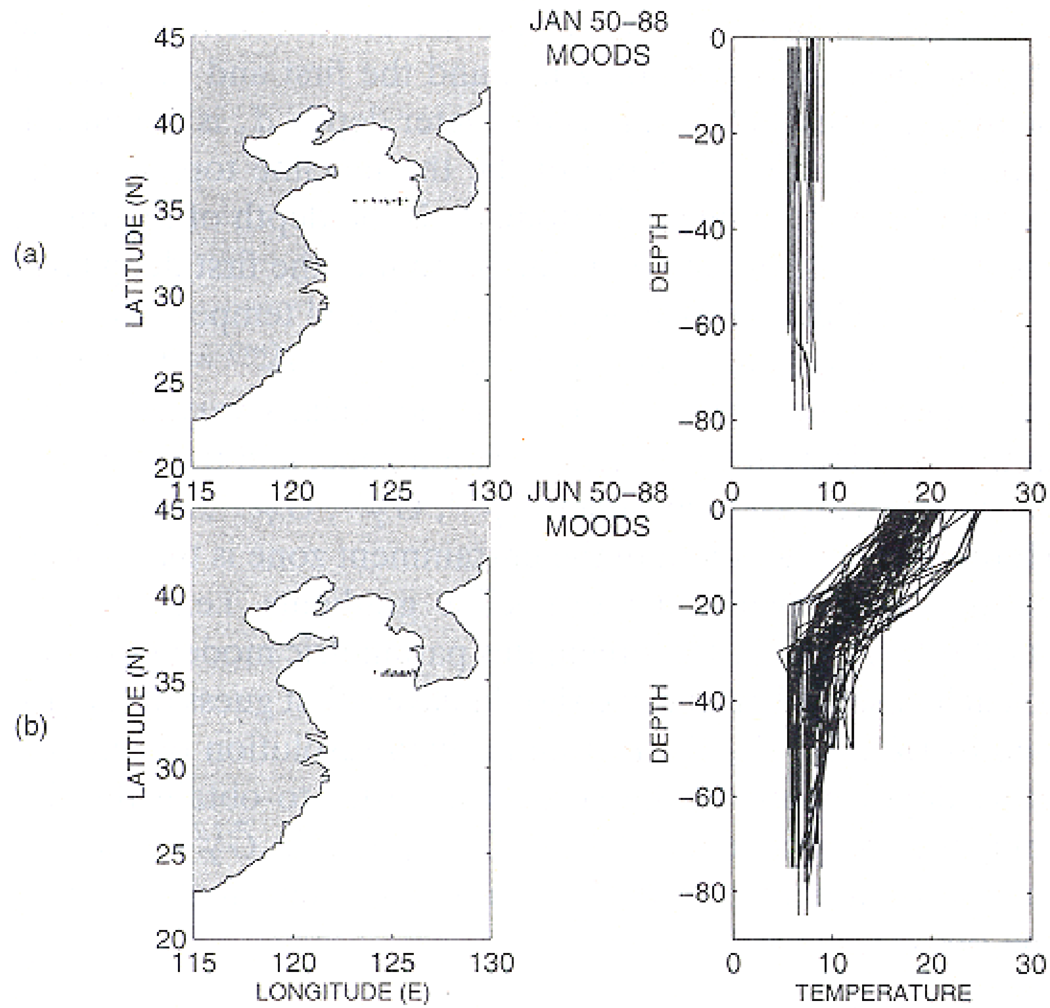
Major Environmental Data Accuracy Compared with SeaSoar profiles in Japan Sea In June 1999

(Fox et al. 2002, JTECH)



Seasonal Temperature Profile Structures

- (a) Winter and Fall Temperature Profile Structure.
  - Isothermal
- (b) Spring and Summer Temperature Profile Structure.
  - Multi-layer
    - Mixed layer
    - Thermocline
    - Deep Layer

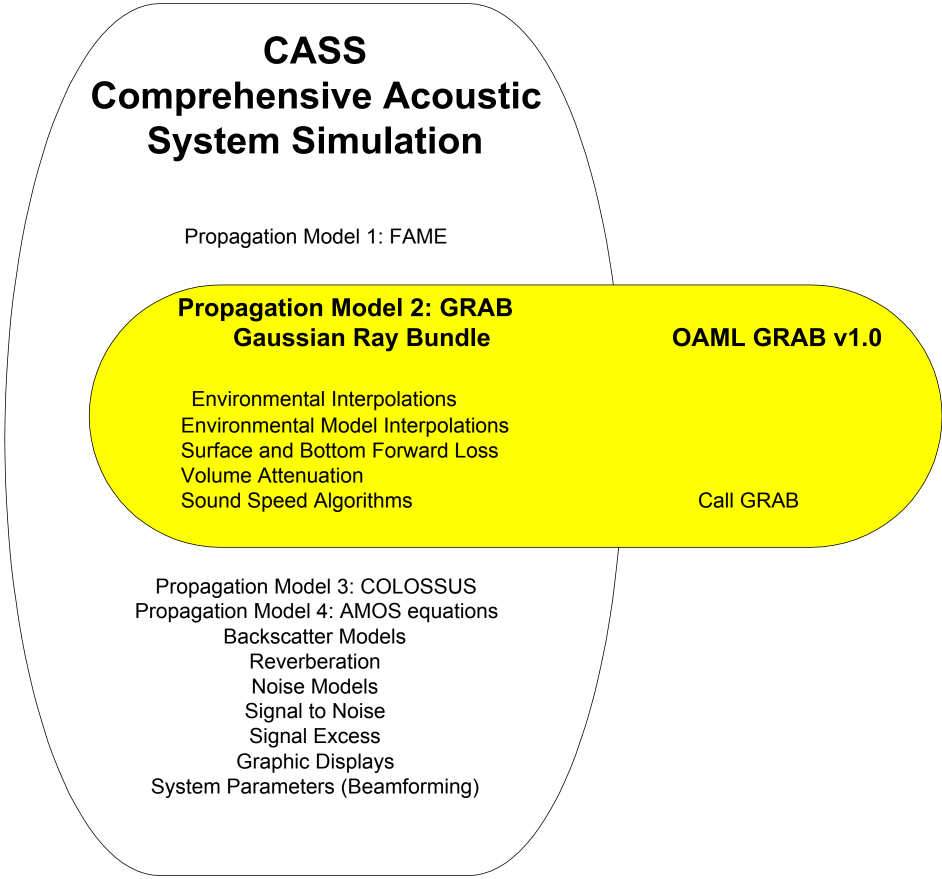


Comprehensive Acoustic Simulation System/Guassian Ray Bundle (CASS/GRAB)

- CASS/GRAB is an active and passive range dependent propagation, reverberation, and signal excess acoustic model that has been accepted as a Navy Standard for the frequency bands of 600 Hz to 100 kHz.

CASS/GRAB Model Description

- The CASS model is the range dependent improvement of the Generic Sonar Model (GSM). CASS performs signal excess calculations.
- The Grab model is a subset of the CASS model and its main function is to compute eigenrays and propagation loss as inputs in the CASS signal excess calculations.



Comprehensive Acoustic Simulation System/Guassian Ray Bundle (CASS/GRAB)

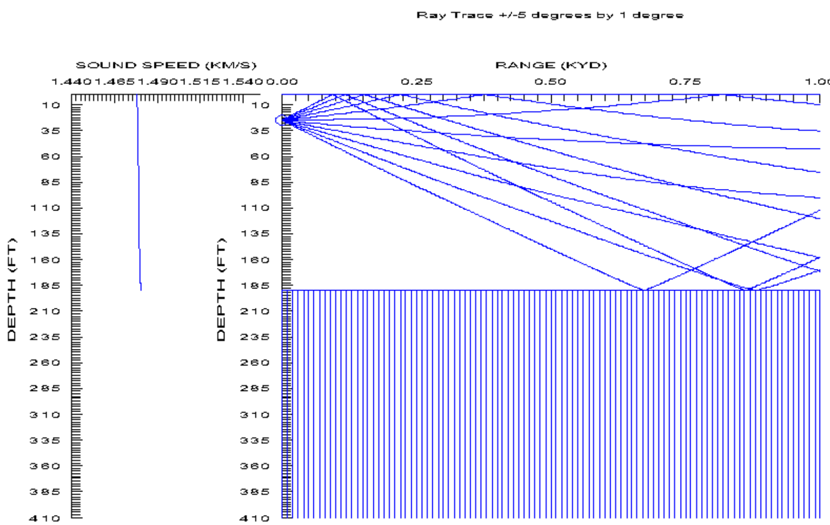
- In the GRAB model, the travel time, source angle, target angle, and phase of the ray bundles are equal to those values for the classic ray path.

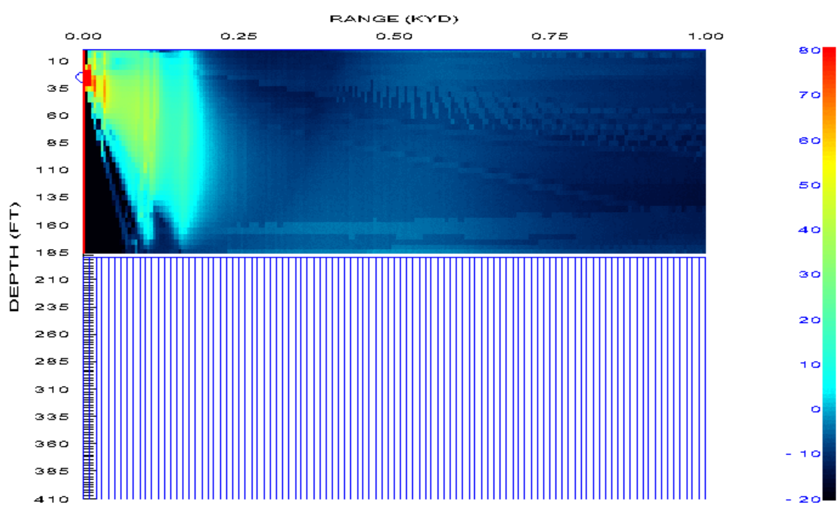
- GRAB calculates amplitude globally by distributing the amplitudes according to the Gaussian equation

$$\Psi_{\nu} = \frac{\beta_{\nu,0}\Gamma_{\nu}^{2}}{\sqrt{2\pi}\,\sigma_{\nu}\,p_{r,\nu}\,r}\exp\left\{-0.5\left[(z - z_{\nu}) / \sigma_{\nu}\right]^{2}\right\}$$

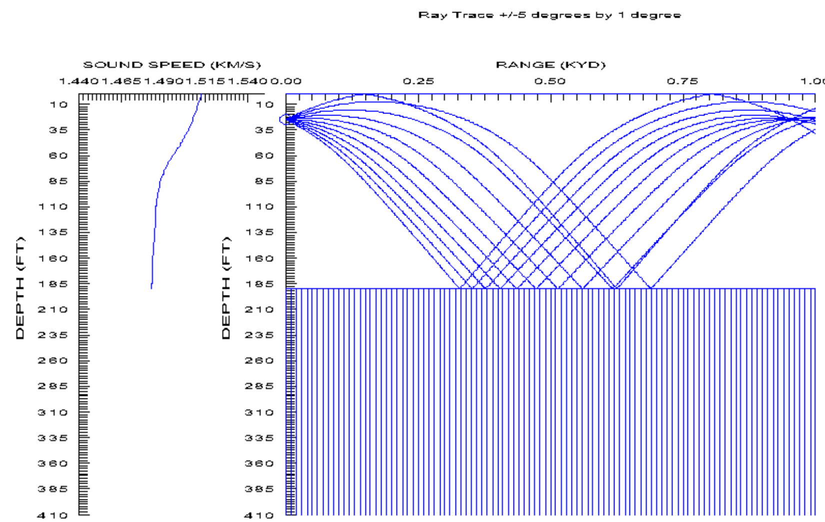
Seasonal Variability for Signal Excess

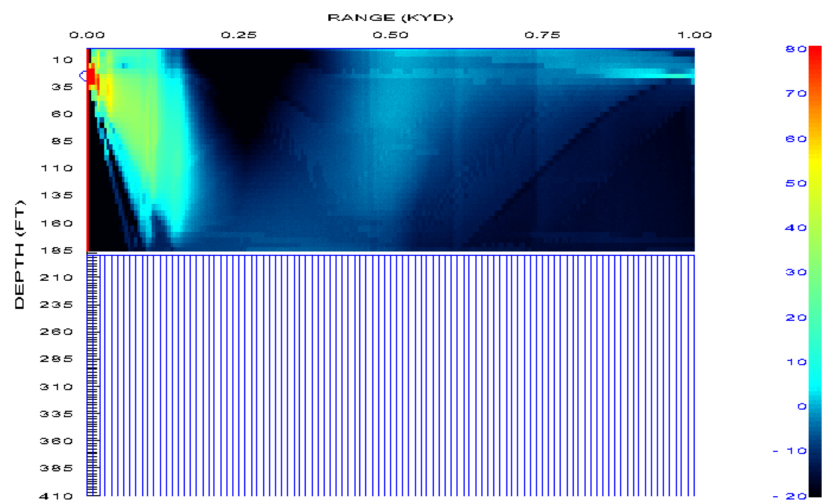
GDEM /January/ Sand/ SD = 25 ft





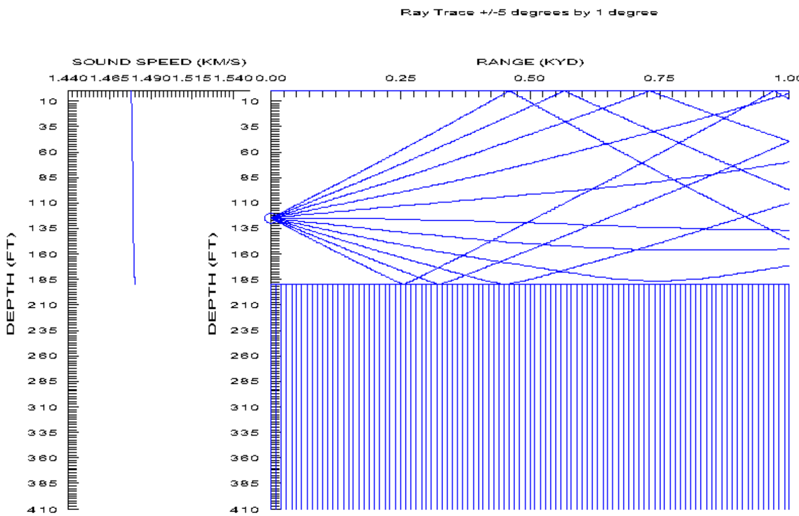
GDEM /June/ Sand/ SD = 25 ft

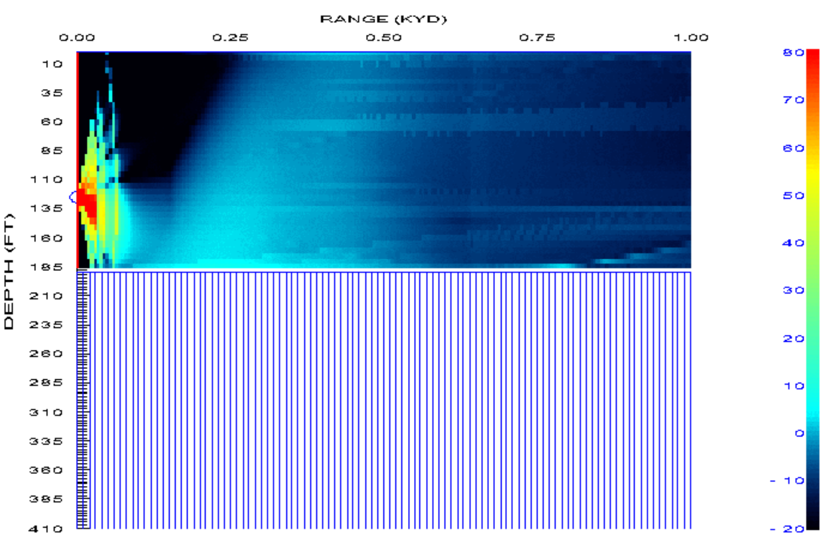




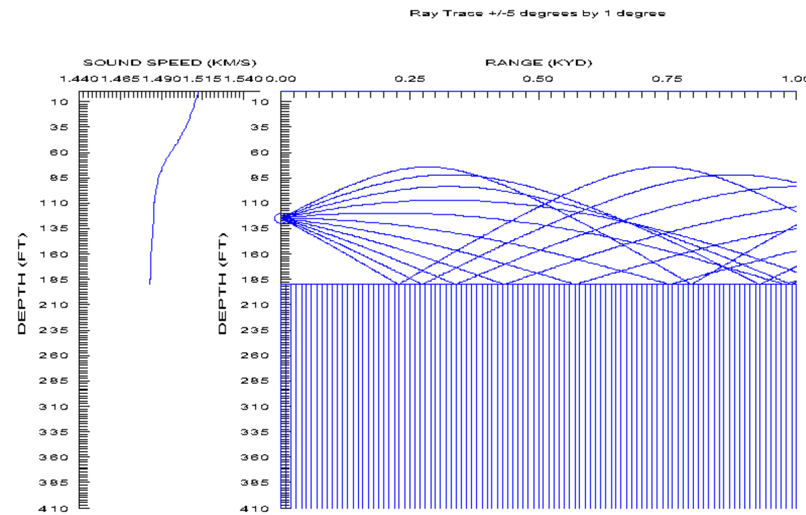
Seasonal Variability for Signal Excess

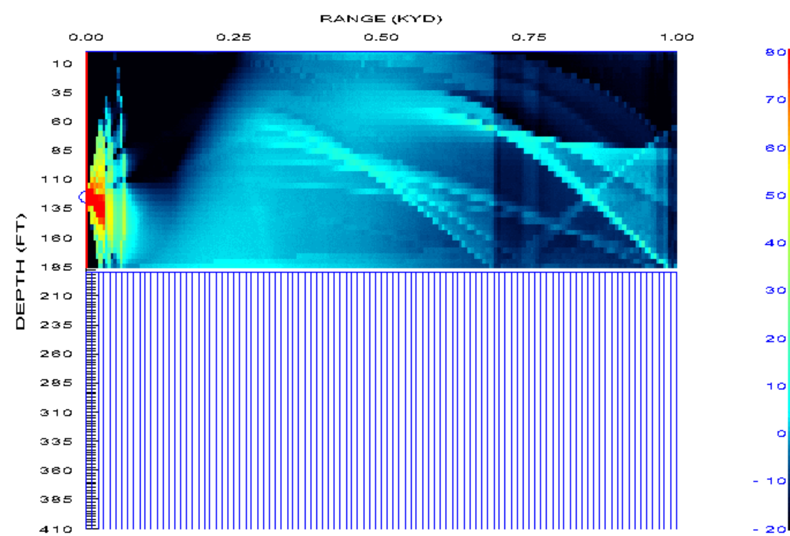
GDEM /January/ Sand/ SD = 125 ft





GDEM /June/ Sand/ SD = 125 ft





What is the acoustic uncertainty caused by hydrographic data uncertainty?

Remember all the temperature errors in all environmental datasets around 1-2^{o} C

Sound speed from MODAS on February 15, 2000, at 36.4° N, 124.4° E, mud bottom

Depth (Feet)	Sound Speed (M/S)
0.00	1479.90
8.20	**1479.70**
24.60	**1479.80**
41.00	**1479.80**
57.40	1480.00
82.00	1480.00
106.60	1480.10
131.20	1480.30
164.00	1480.50
205.00	1480.40
246.00	1480.40

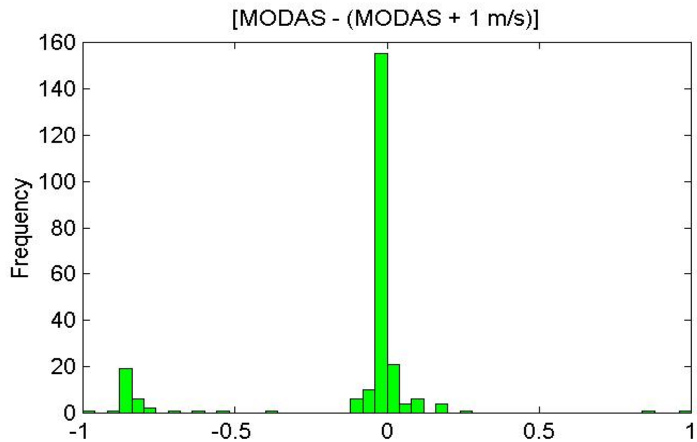
Gaussian-type errors with zero mean and different standard deviations in the sound speed profile at the sound source depths (25 and 125 ft)

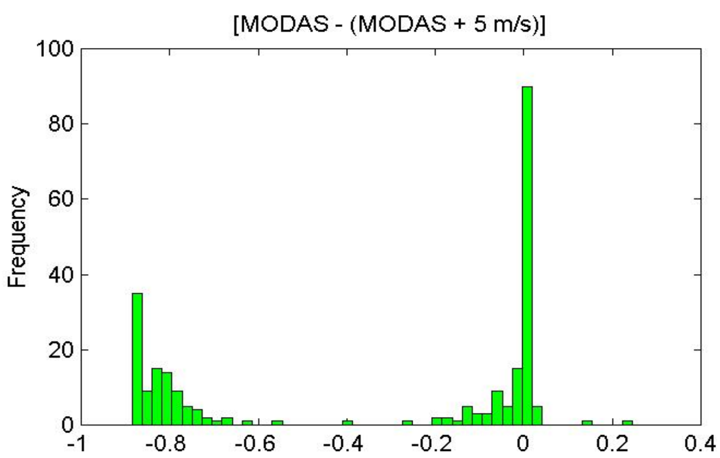
1. SDV = 1 m/s

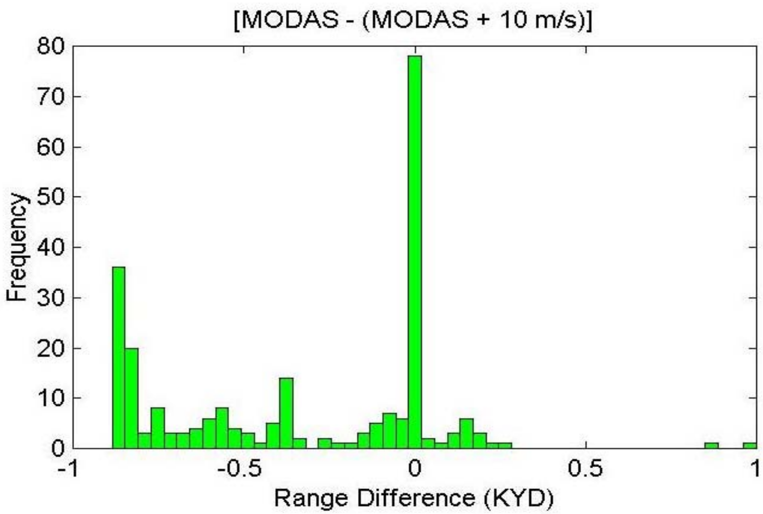
2. SDV = 5 m/s

3. SDV = 10 m/s

Detection Range difference for sound source at 25 ft



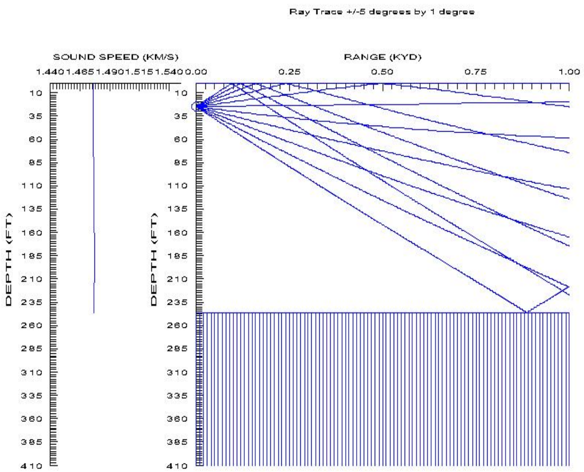


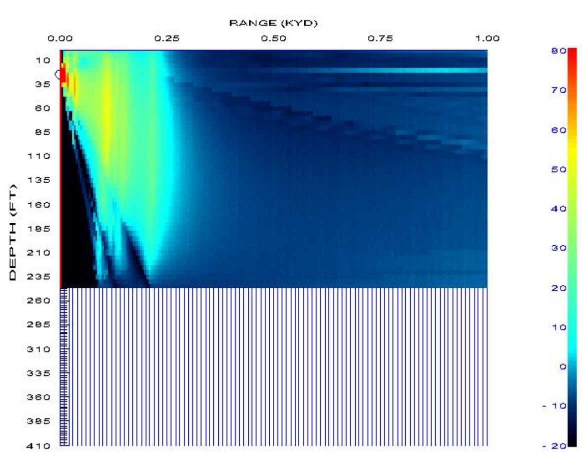


Gaussian-type errors in sound speed profiles cause non-Gaussian-type errors in acoustic transmission.

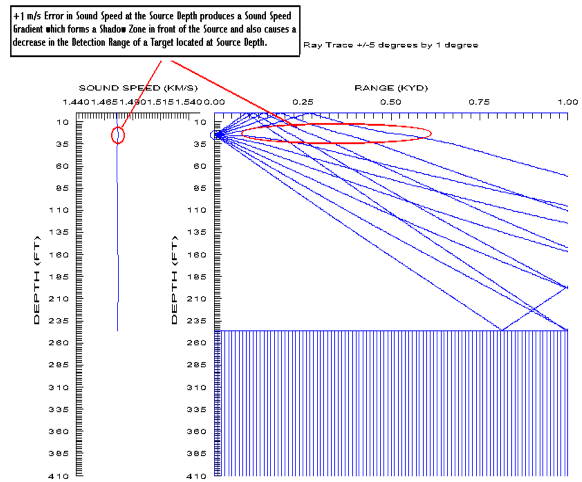
Effect of Sound Speed Error at Source Depth (25ft)

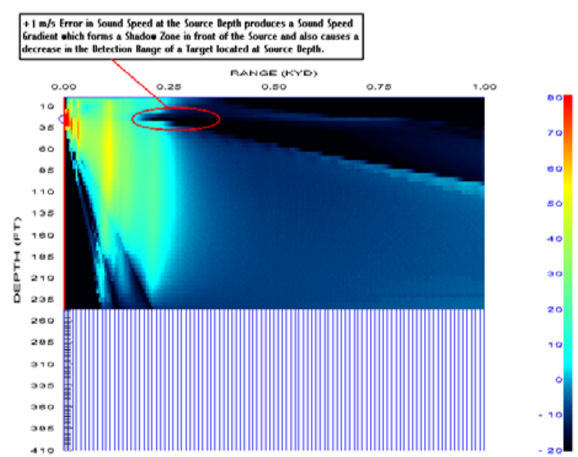
No Error



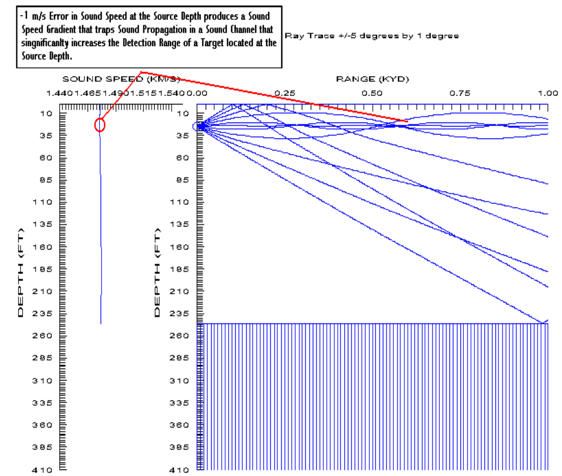


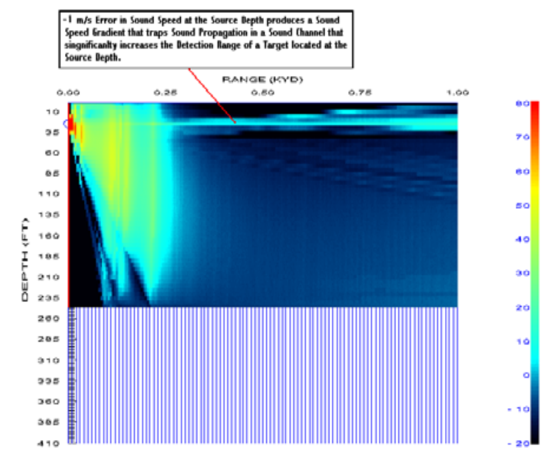
+1 m/s Error



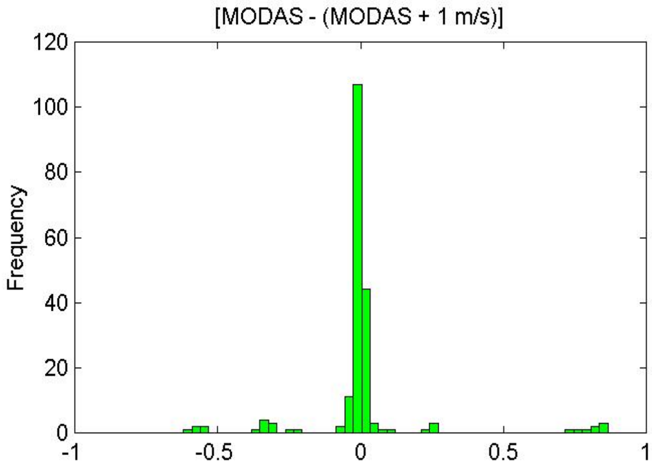


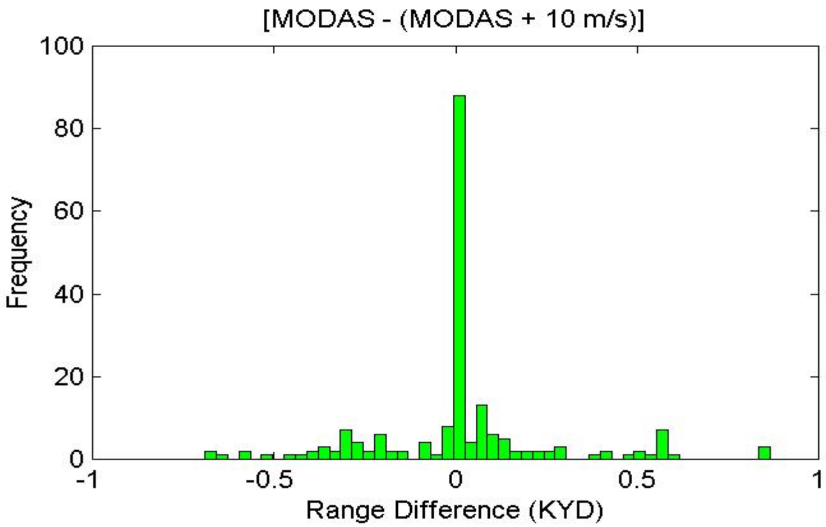
-1 m/s Error

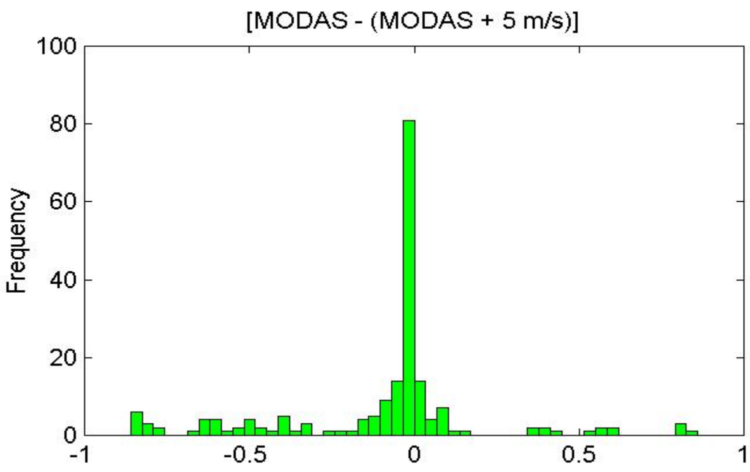




Detection Range difference for sound source at 125 ft

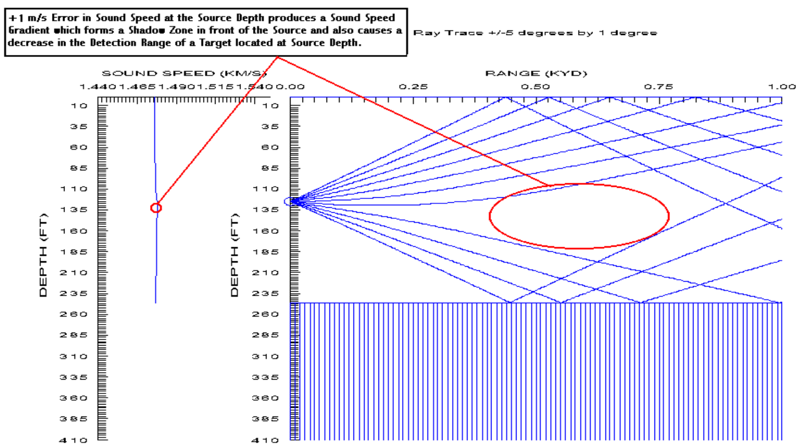


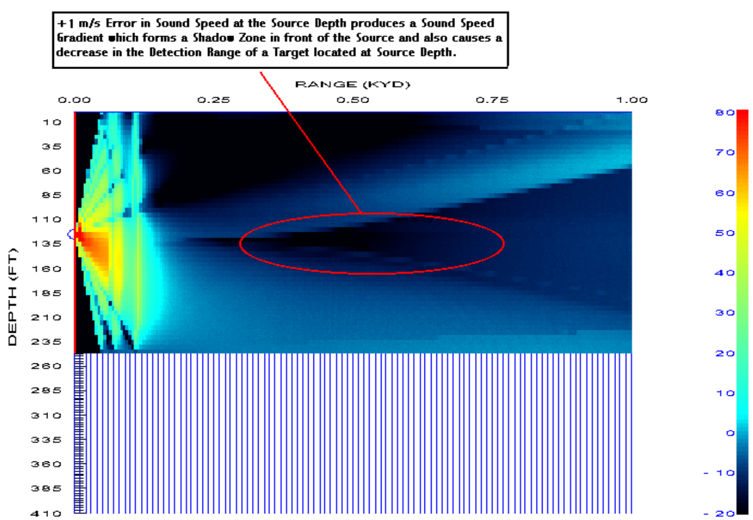




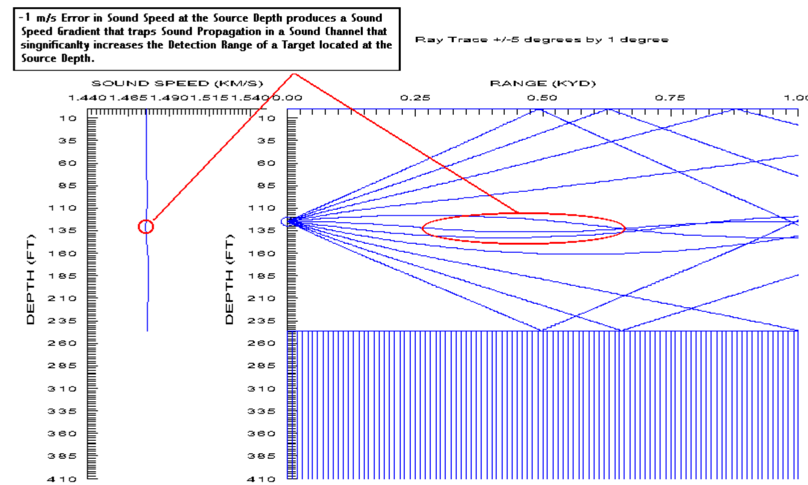
Effect of Sound Speed Error at Source Depth (125ft)

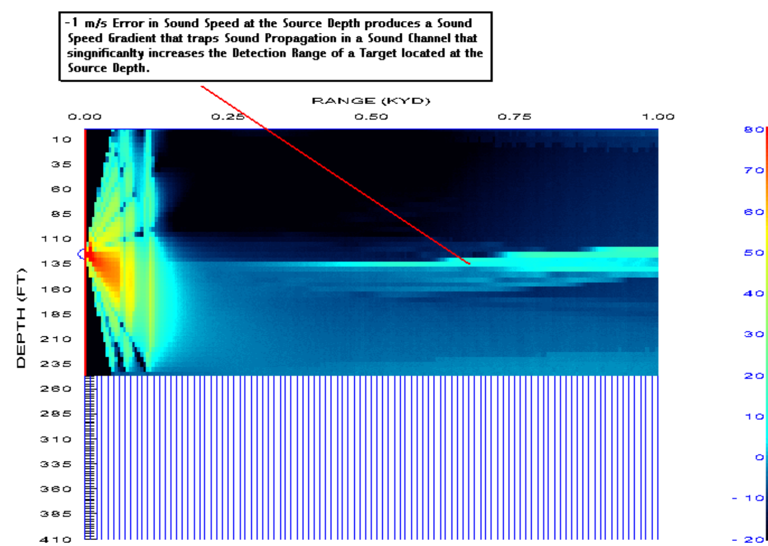
+1 m/s Error





-1 m/s Error





Conclusions

- Strong seasonal variability in thermohaline structure
- Strong seasonal variability in acoustic transmission (detection range, signal excess)
- Acoustic uncertainty due to error in sound speed profiles depends on location of that error relative to the sound source.
- An error (+1 m/s) into the sound speed profile at the source depth can cause a shadow zone in front of the source that significantly decreases the detection ranges at that depth.
- An error (–1m/s) was added into the sound speed profile at the source depth can cause a strong sound channel formed that dramatically increased detection ranges at that depth.