

Ocean Analysis and Prediction for Undersea Acoustics

Passive Sonar Equation

$$SE = SL - PL - LE - RD$$

where:

SE = Signal Excess

SL = Source Level

PL = Propagation Loss

LE = Total Background Noise

RD = Recognition Differential

ASW Success Foundation

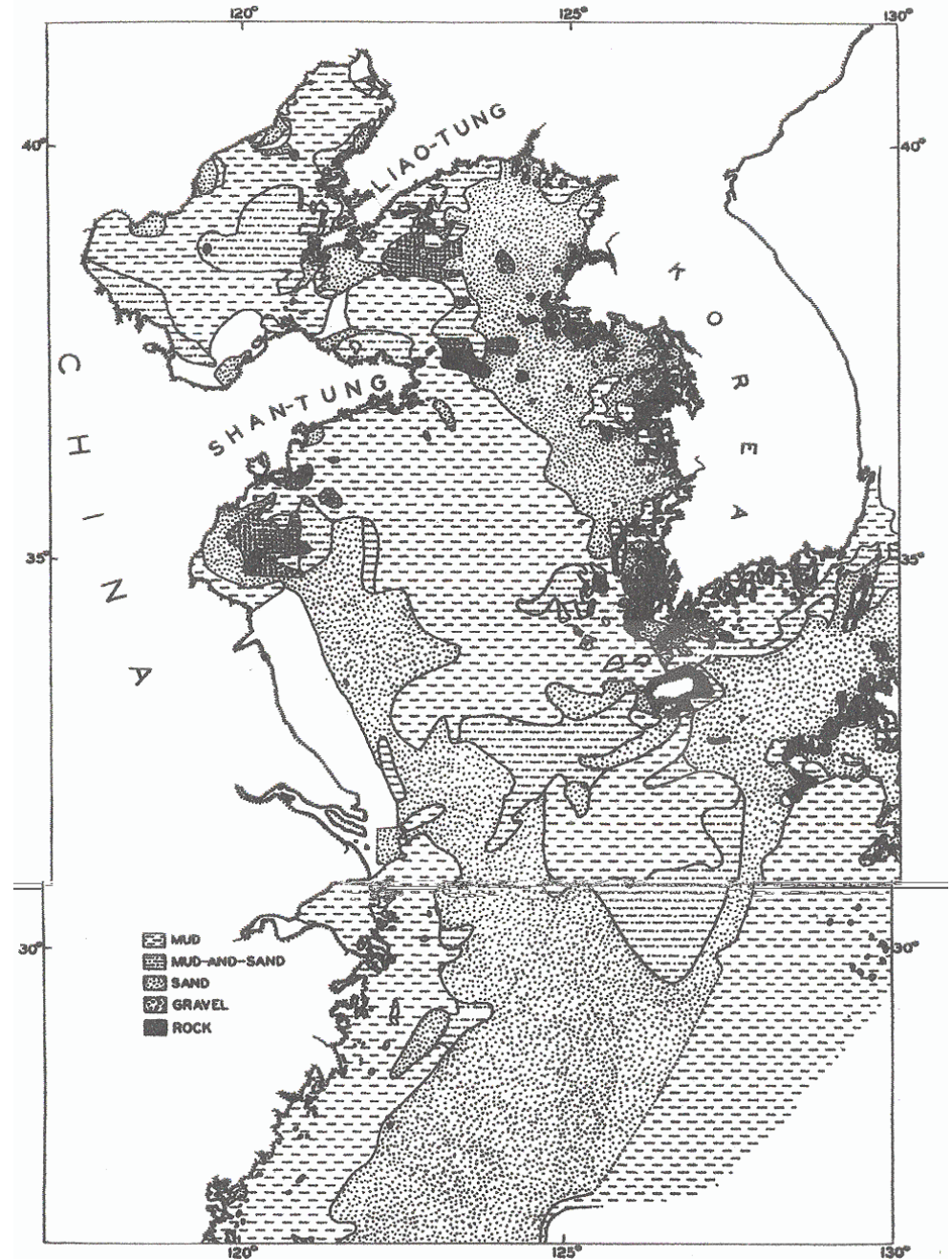


**ASW Success starts with
FOM = SL-LE-RD.**

Yellow Sea Bottom Sediment Chart

- Four Bottom Sediment types

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



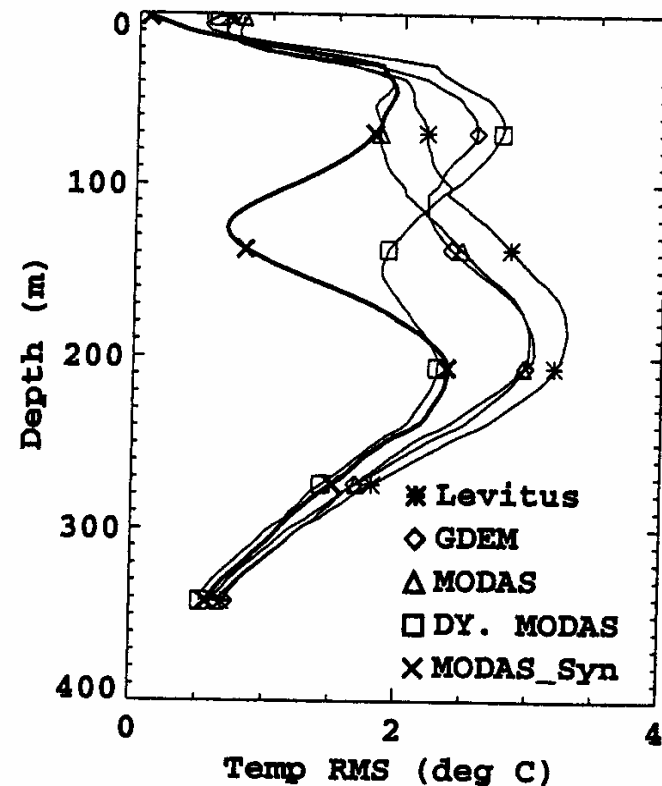
Oceanographic Data Sets

- 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

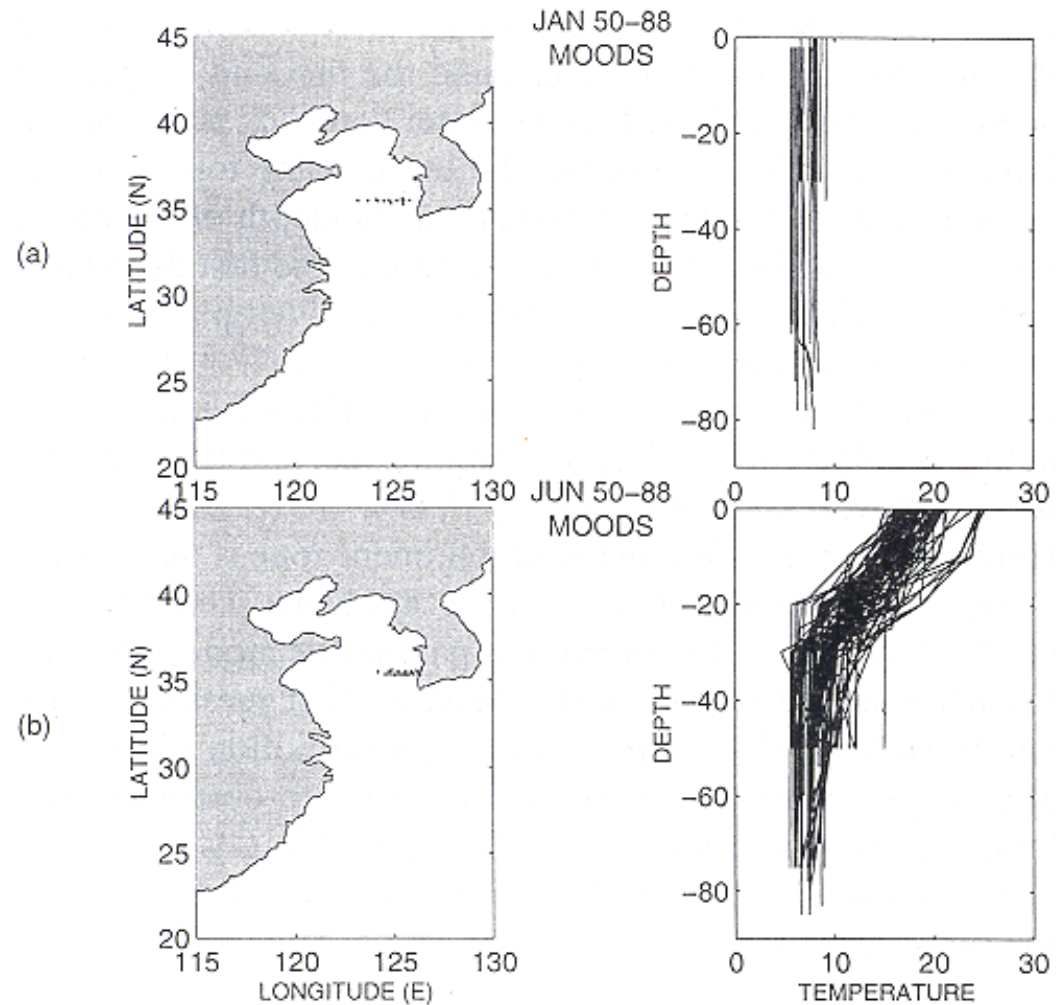
Major Environmental Data
Accuracy Compared with
SeaSoar profiles in Japan Sea
In June 1999

(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

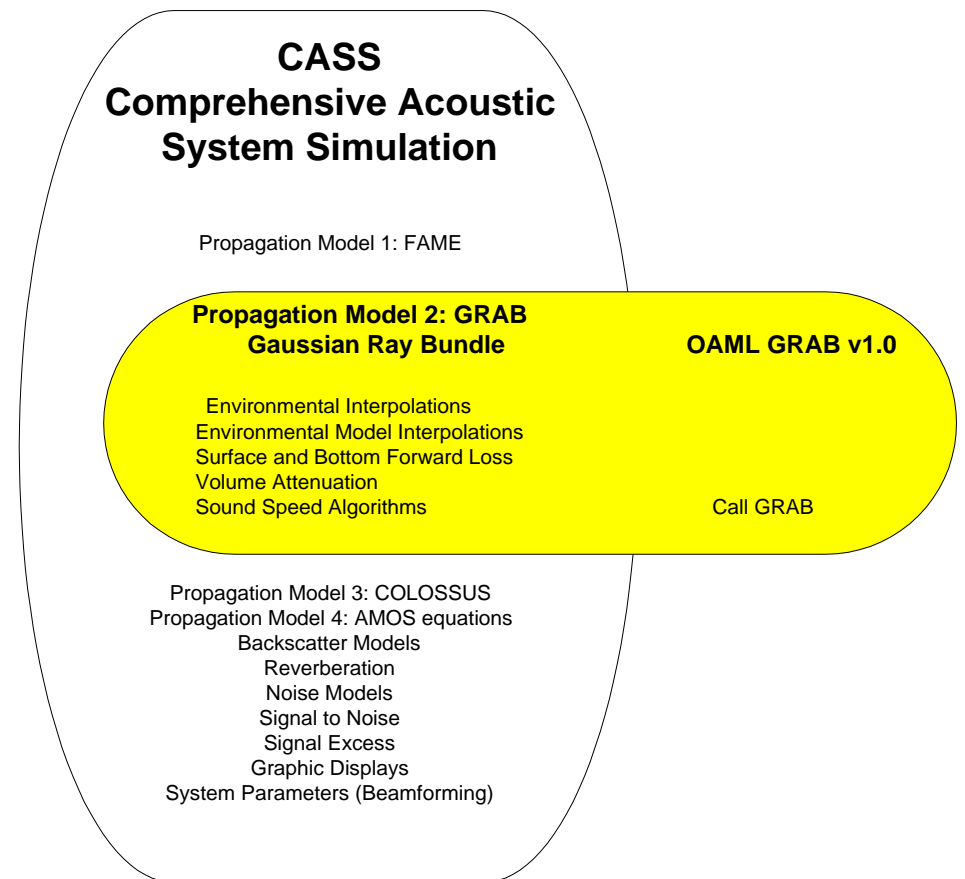


Comprehensive Acoustic Simulation System/Gaussian Ray Bundle (CASS/GRAB)

- 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/Gaussian 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

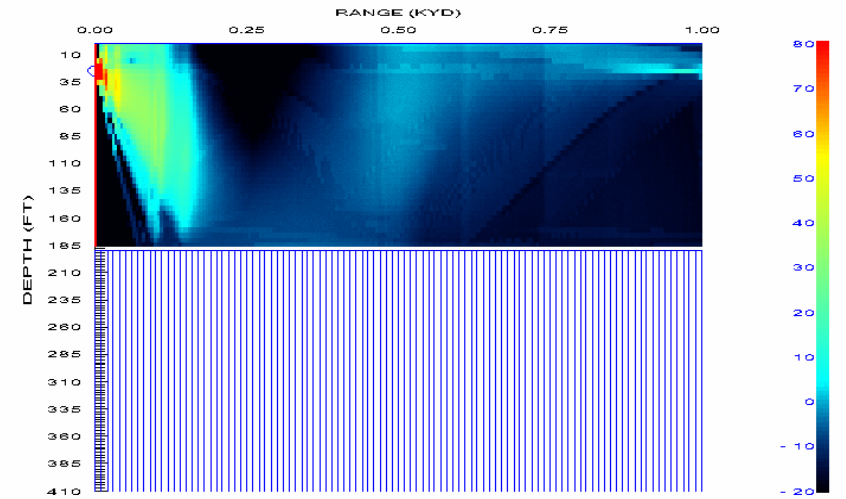
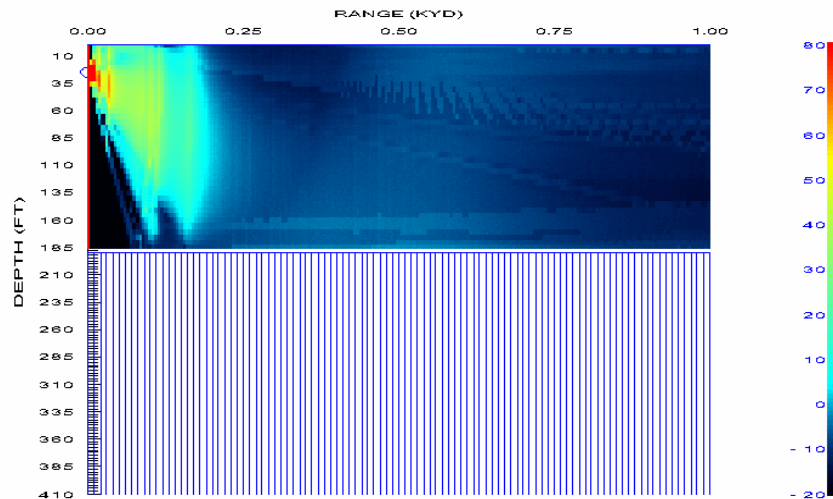
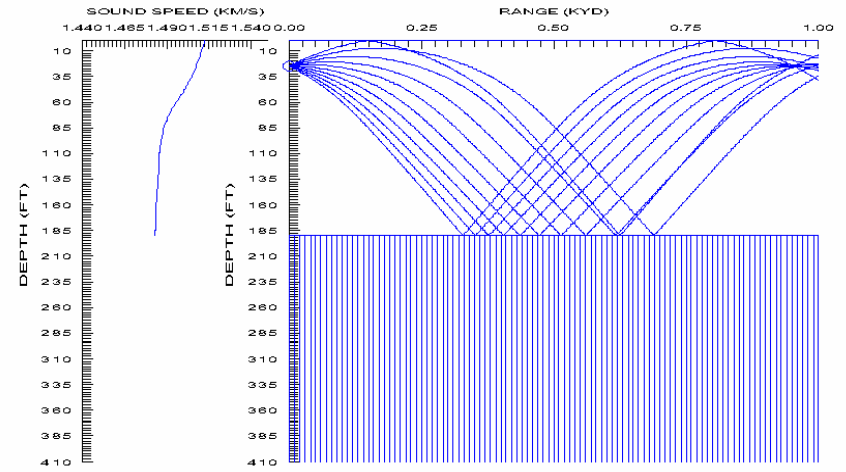
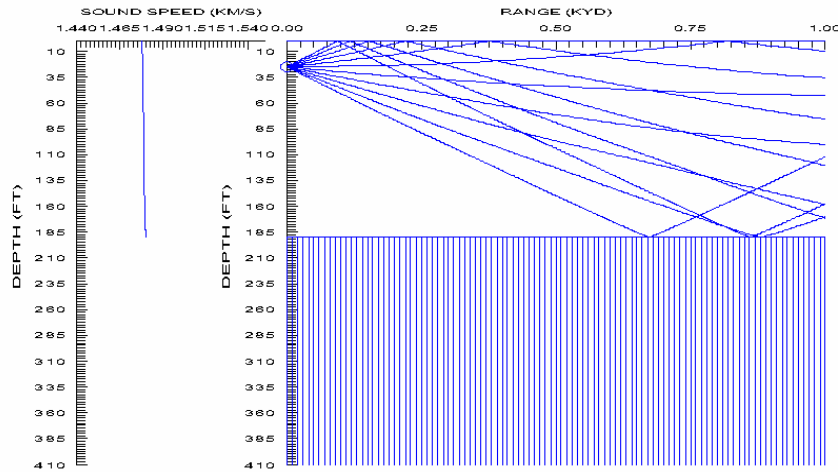
$$\Psi_v = \frac{\beta_{v,0} \Gamma_v^2}{\sqrt{2\pi} \sigma_v p_{r,v} r} \exp\left\{-0.5\left[(z - z_v) / \sigma_v\right]^2\right\}$$

Seasonal Variability for Signal Excess

GDEM /January/ Sand/ SD = 25 ft **GDEM /June/ Sand/ SD = 25 ft**

Ray Trace +/-5 degrees by 1 degree

Ray Trace +/-5 degrees by 1 degree

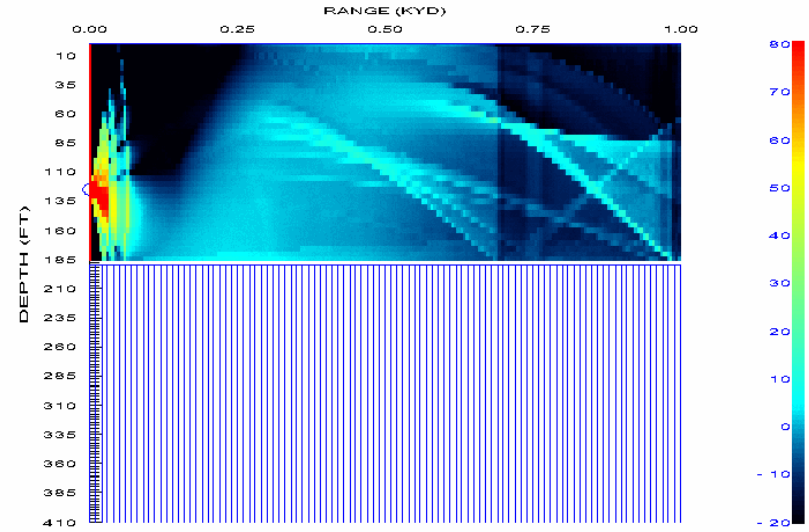
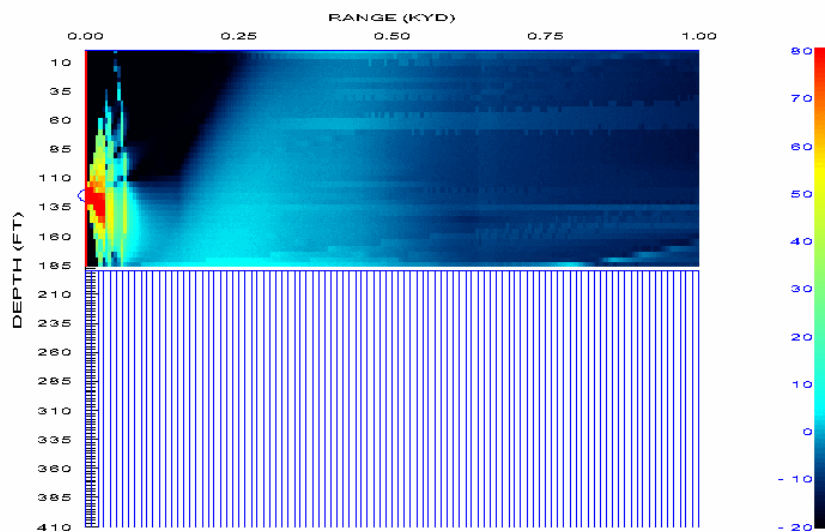
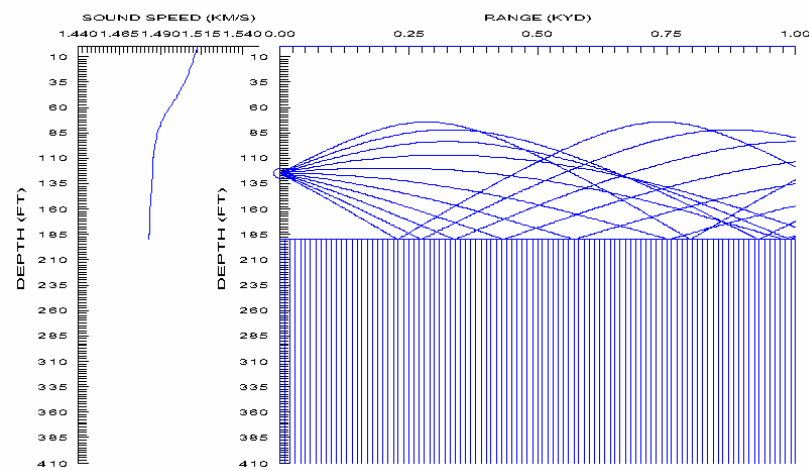
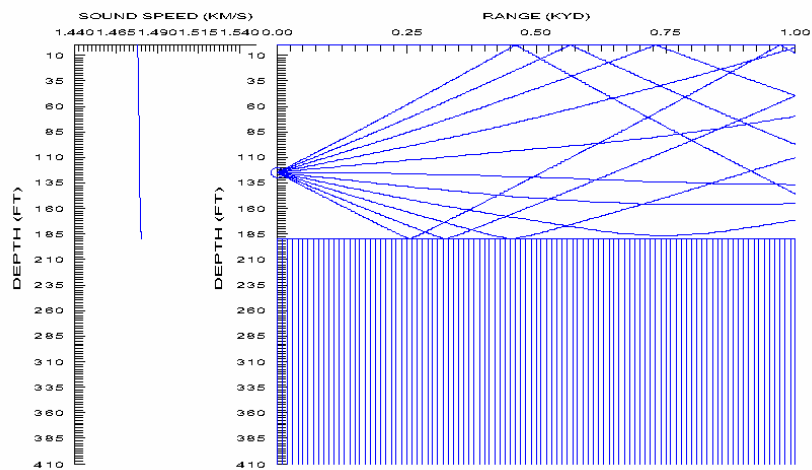


Seasonal Variability for Signal Excess

GDEM /January/ Sand/ SD = 125 ft GDEM /June/ Sand/ SD = 125 ft

Ray Trace +/-5 degrees by 1 degree

Ray Trace +/-5 degrees by 1 degree



What is the acoustic uncertainty
caused by hydrographic data
uncertainty?

Remember all the temperature errors in all
environmental datasets around 1-2° 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

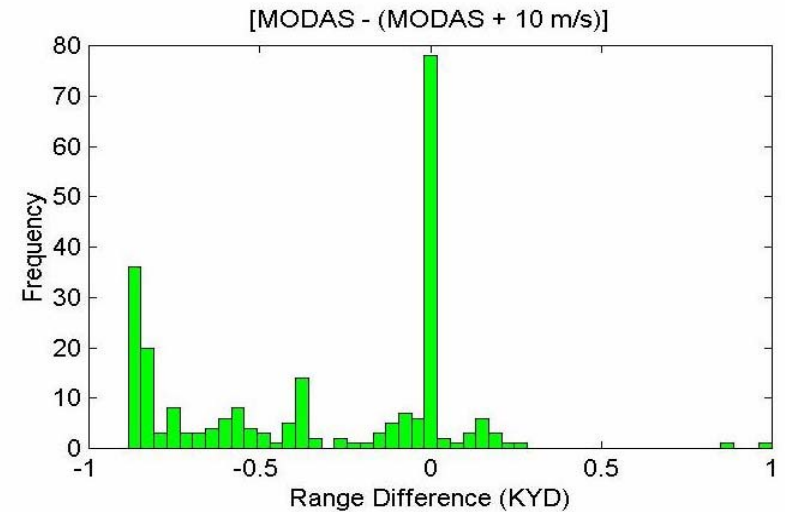
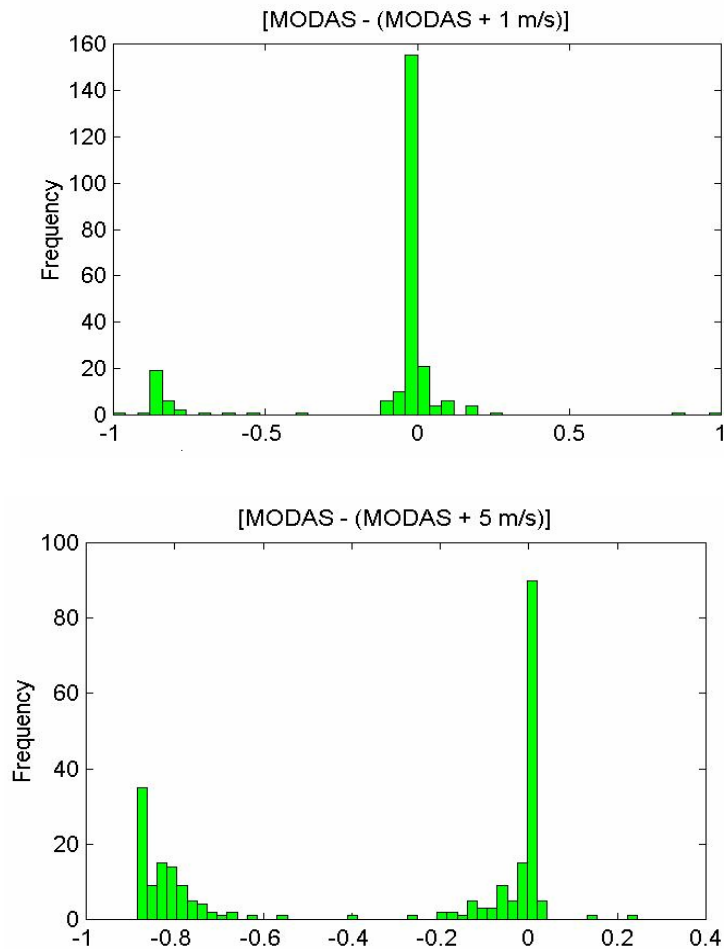
**Gaussian-type errors with zero mean
and different standard deviations in
the sound speed profile at the sound
source depths (25 and 125 ft)**

1. $SDV = 1 \text{ m/s}$

2. $SDV = 5 \text{ m/s}$

3. $SDV = 10 \text{ m/s}$

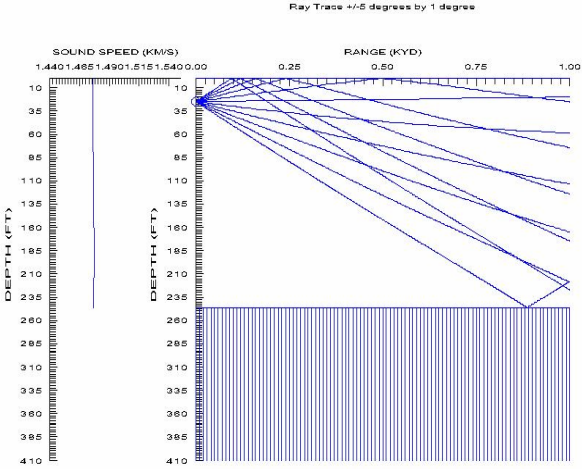
Detection Range difference for sound source at 25 ft



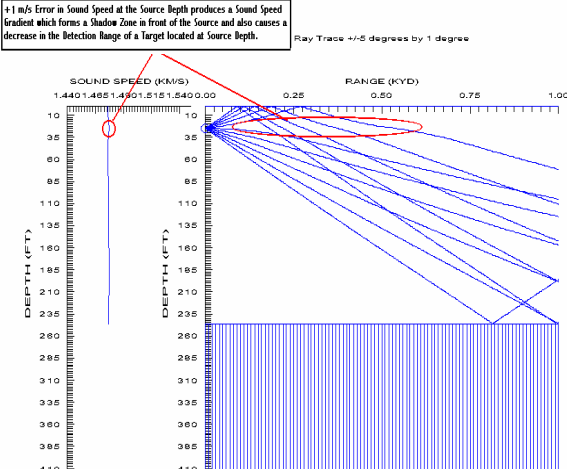
Gaussian-type errors in sound speed profiles cause non-Gaussian-type errors in acoustic transmission.

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

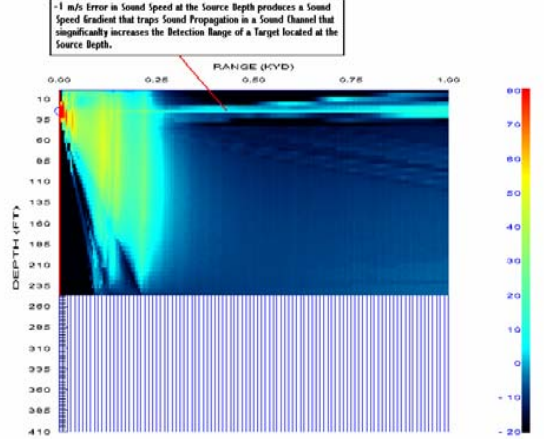
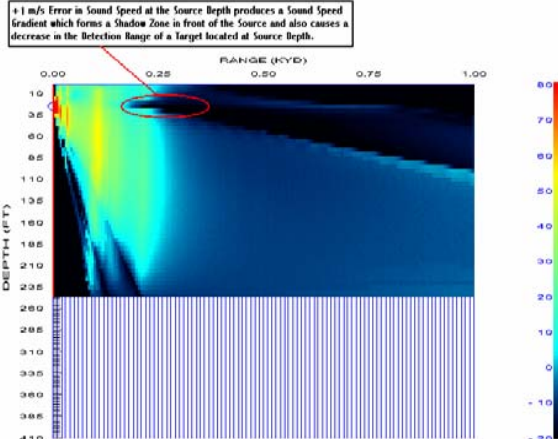
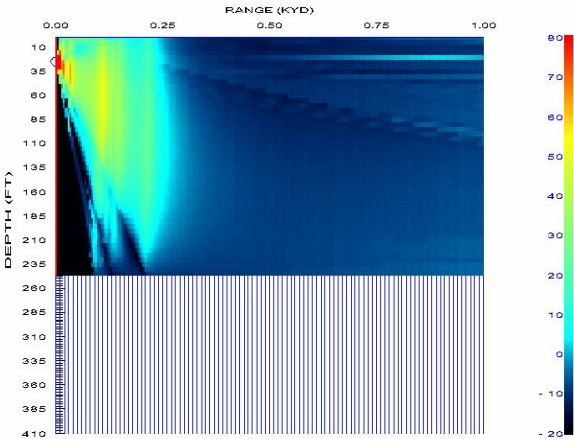
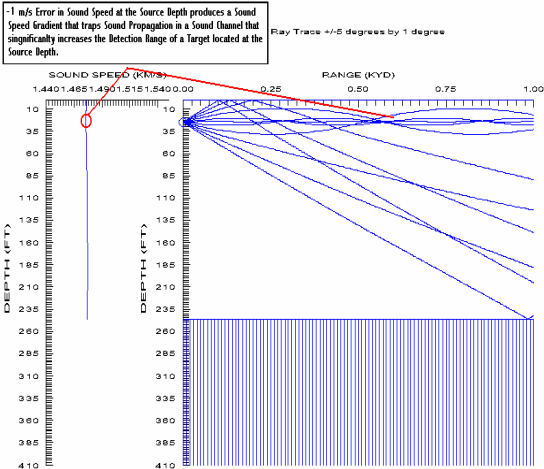
No Error



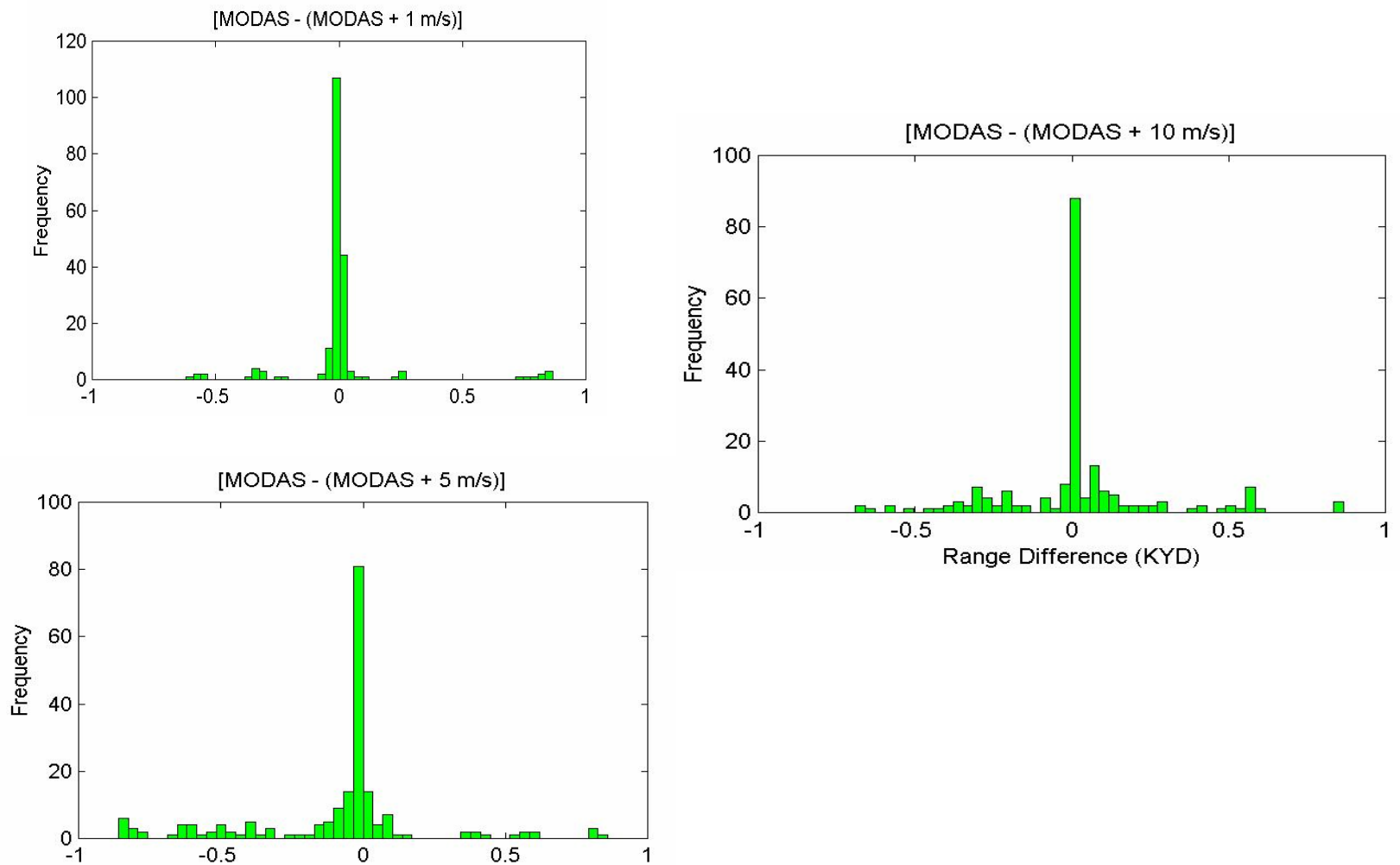
+1 m/s Error



-1 m/s Error



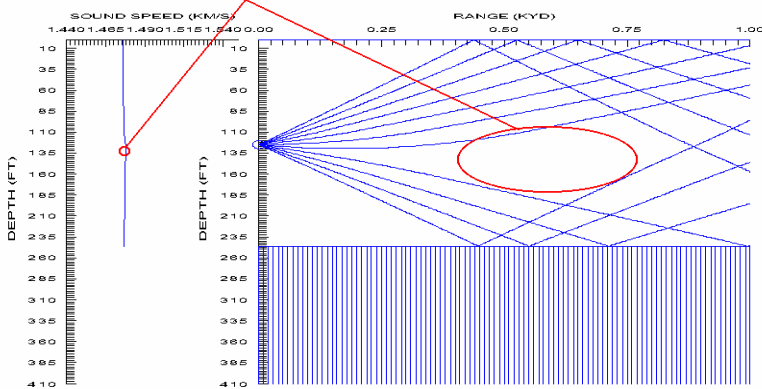
Detection Range difference for sound source at 125 ft



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

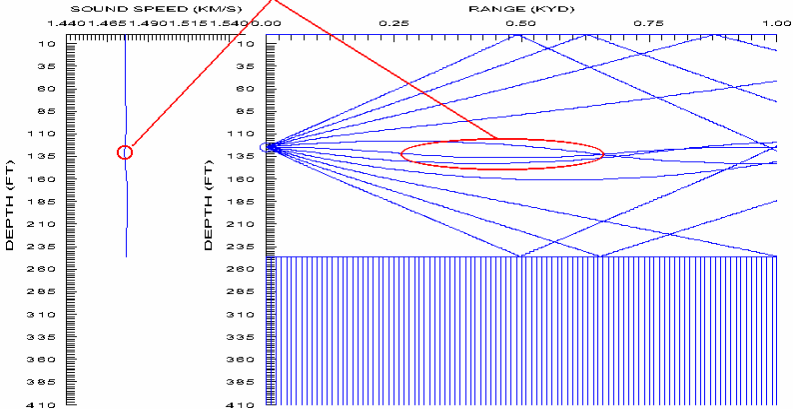
+1 m/s Error

+1 m/s Error in Sound Speed at the Source Depth produces a Sound Speed Gradient which forms a Shadow Zone in front of the Source and also causes a decrease in the Detection Range of a Target located at Source Depth.

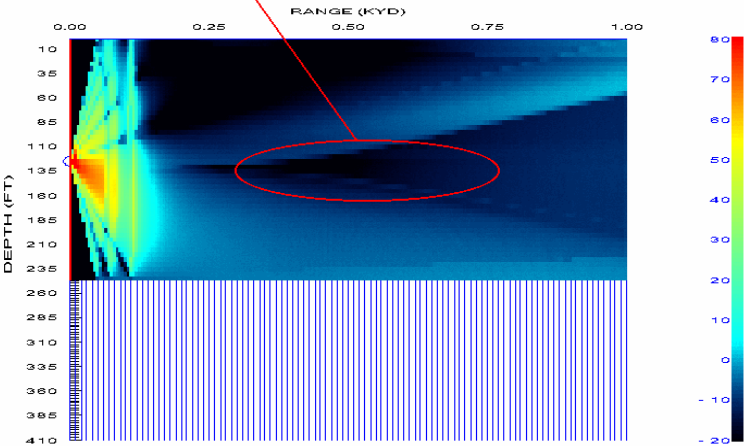


-1 m/s Error

-1 m/s Error in Sound Speed at the Source Depth produces a Sound Speed Gradient that traps Sound Propagation in a Sound Channel that significantly increases the Detection Range of a Target located at the Source Depth.



+1 m/s Error in Sound Speed at the Source Depth produces a Sound Speed Gradient which forms a Shadow Zone in front of the Source and also causes a decrease in the Detection Range of a Target located at Source Depth.



-1 m/s Error in Sound Speed at the Source Depth produces a Sound Speed Gradient that traps Sound Propagation in a Sound Channel that significantly increases the Detection Range of a Target located at the Source Depth.

