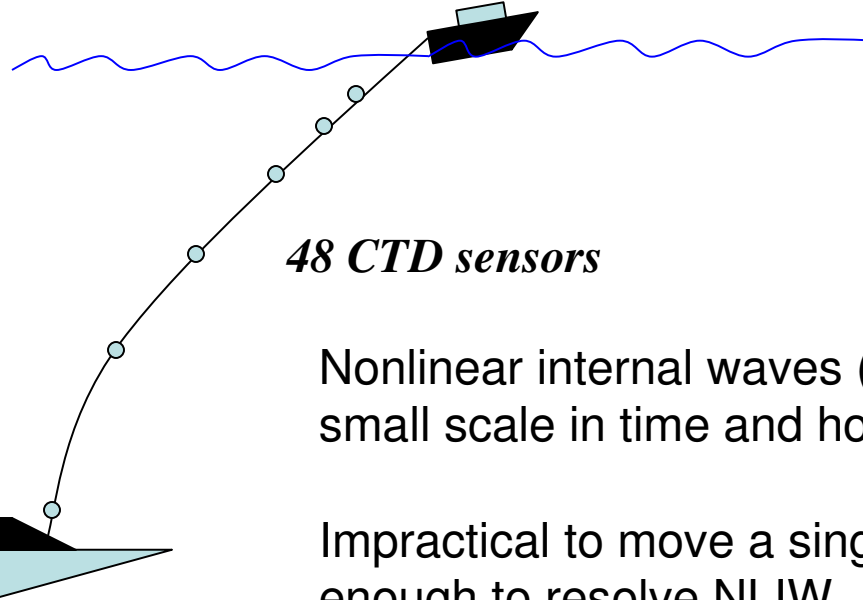


Simultaneous nearby measurements of acoustic propagation and high-resolution sound speed structure containing internal waves

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Washington

Towed CTD chain



48 CTD sensors

Nonlinear internal waves (NLIW's) have a small scale in time and horizontal extent

Impractical to move a single CTD fast enough to resolve NLIW

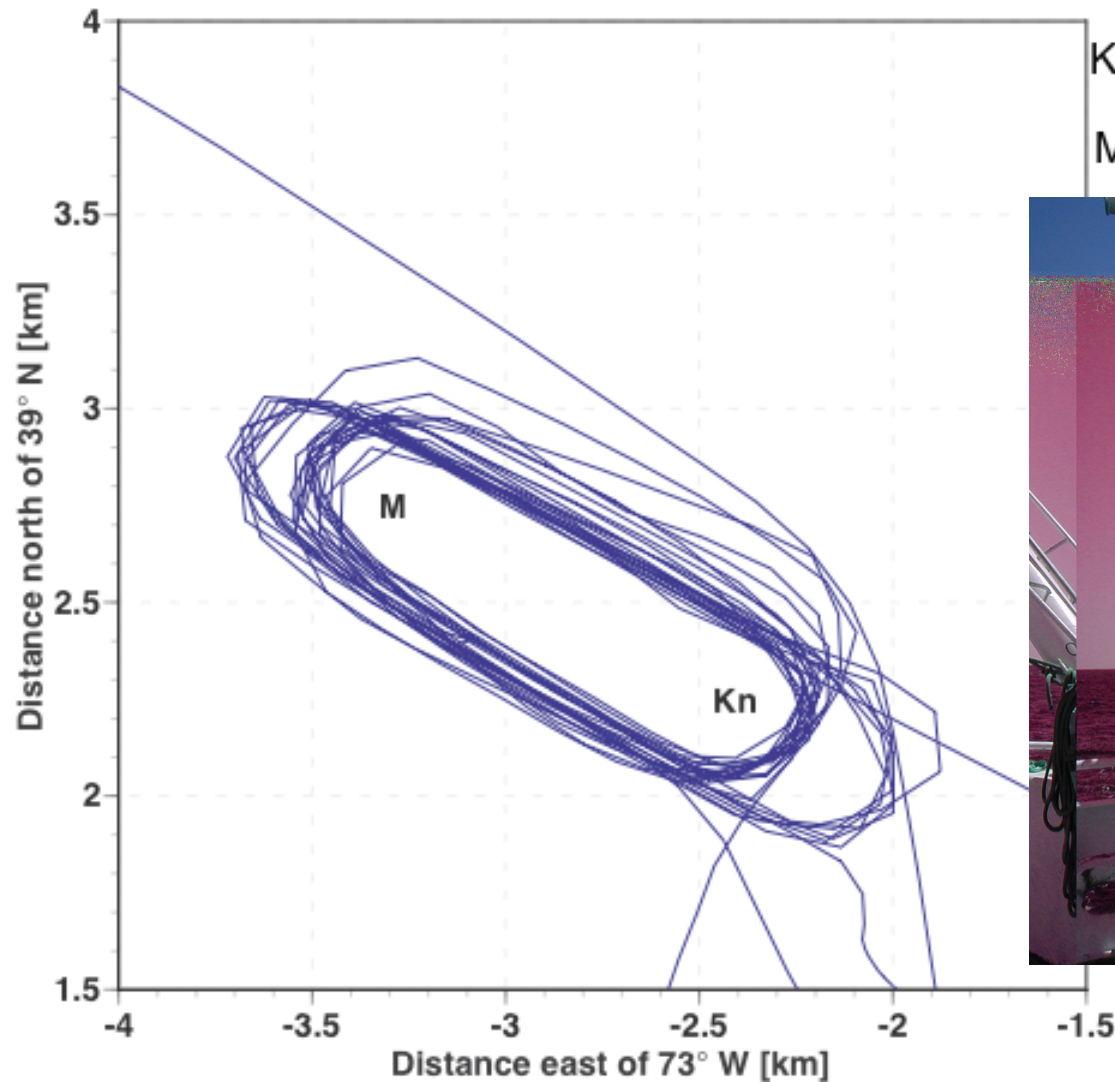
Depressor

The towed chain has the advantage over a mooring that the wave speed and the slow $x - vt$ evolution was measured in SW06 by repeated passes.

Depth, sound speed, and density are extracted from the measurements

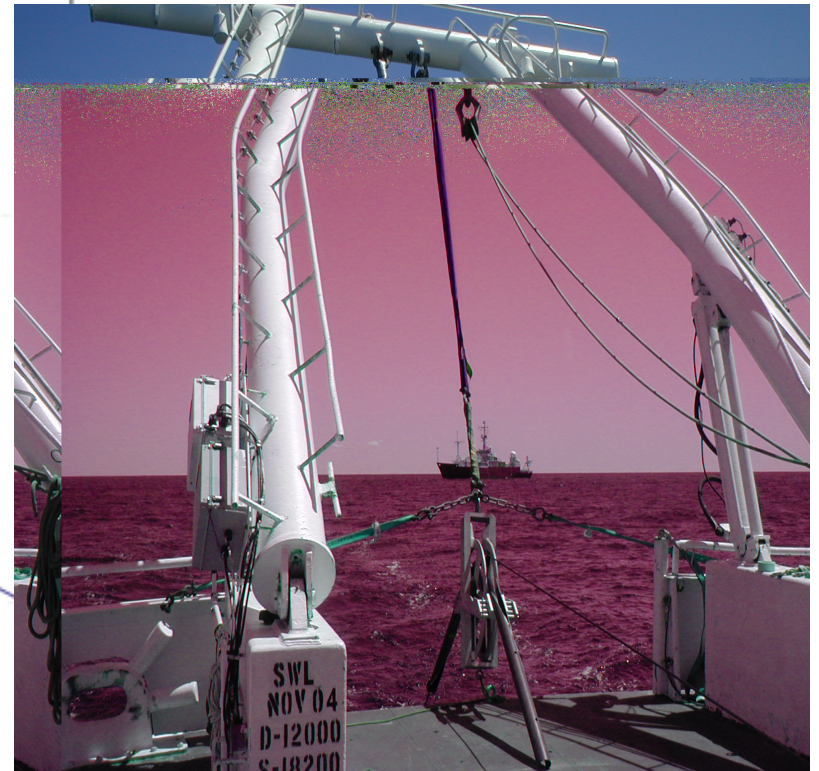
GPS Track of the R/V Endeavor with a towed CTD Chain

Aug 11 & 13, 2006



Kn -- Acoustic source on R/V Knorr

M -- Moray receiving mooring



Acoustic measurements

2-10 kHz; various pulse types

1 km propagation path

Repeated every 20 s

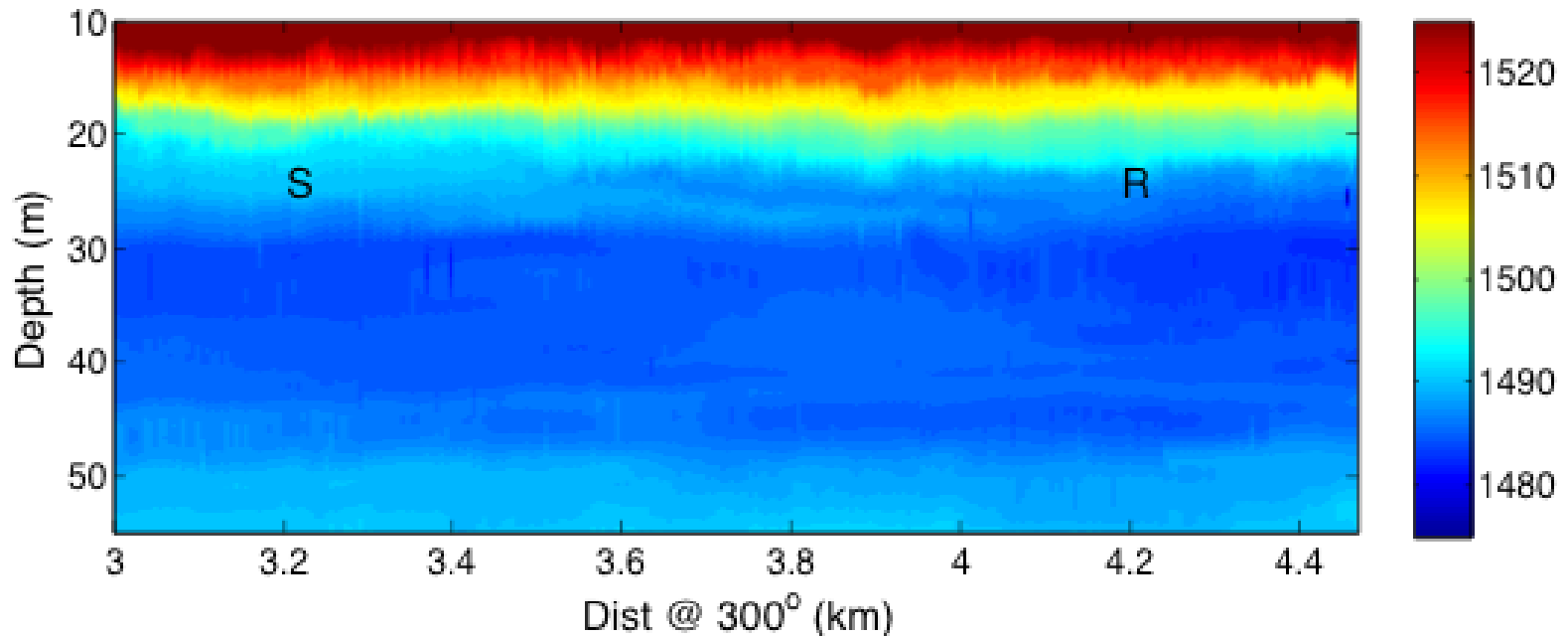
Source at 30 m

Receivers in clusters near 25 m and 50 m

S/N = 45 dB after fm pulse compression

Aug 11

Sound speed extracted from towed CTD data one leg



No large waves

Note the higher sound speed near bottom -- the sound channel shields acoustic energy from the sediments.

Acoustics on Aug 11

Large fluctuations in intensity

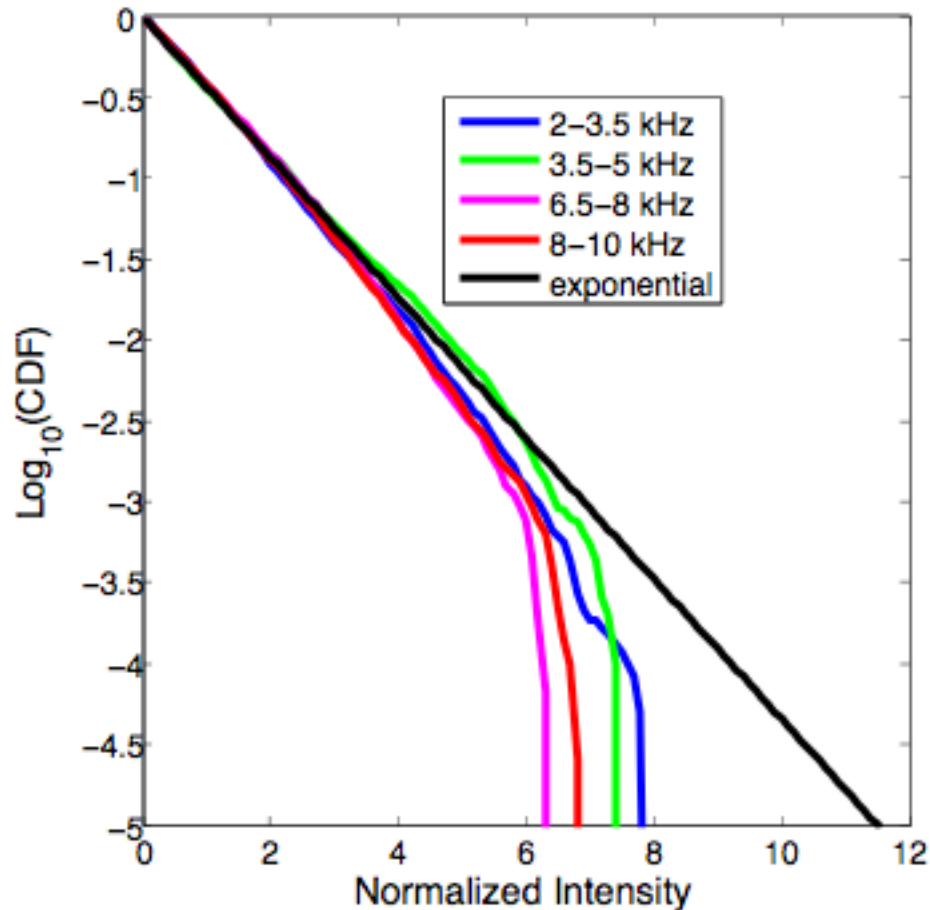
The mean field is fit by spreading loss + seawater absorption with random phase modes. The mode cutoff is assumed to be at the bottom critical angle.

There is no large random attenuation to explain the fluctuations
Not fish.

Not Creamer mechanism -- most likely suppressed by the high-c layer near the bottom.

Intensity distribution

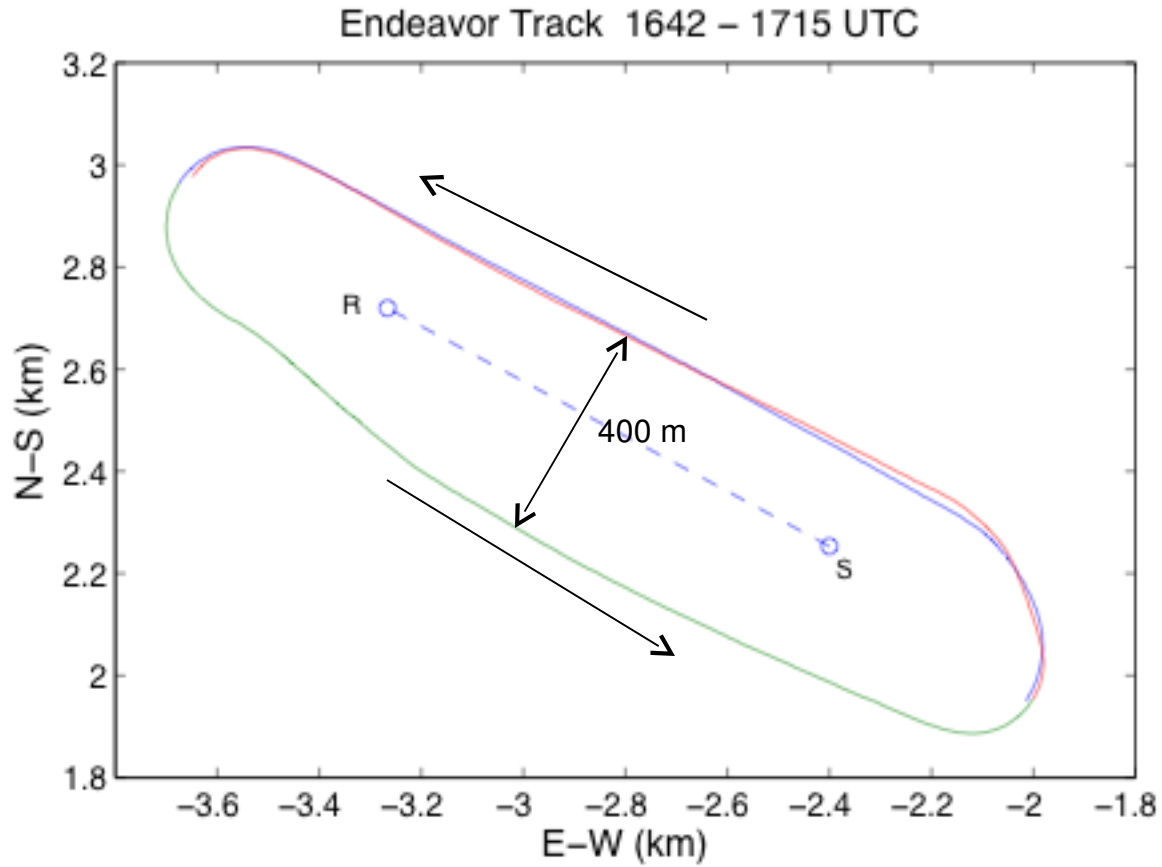
High-tail cumulative distribution function



SI = 1.0

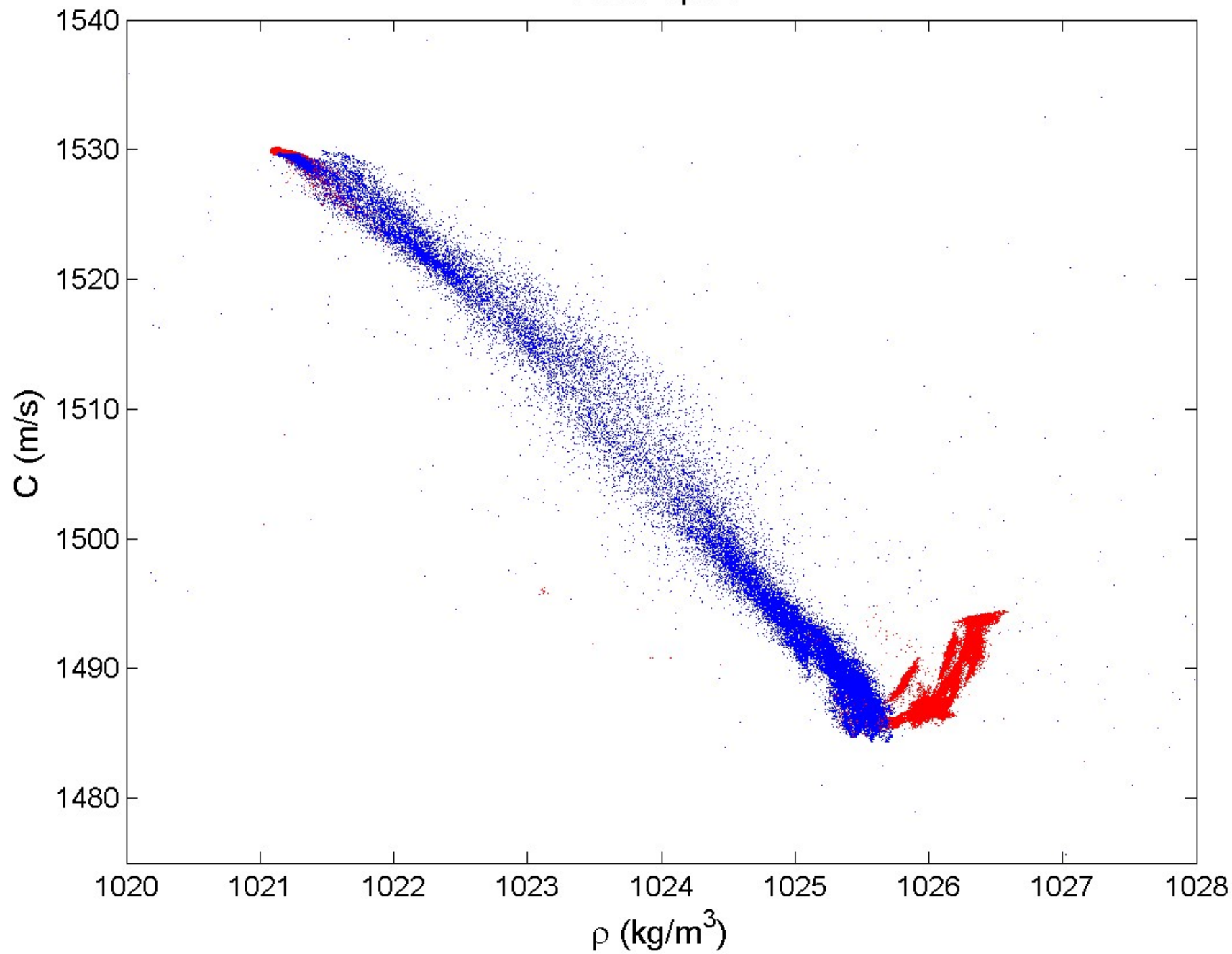
Nearly saturated

Aug 13

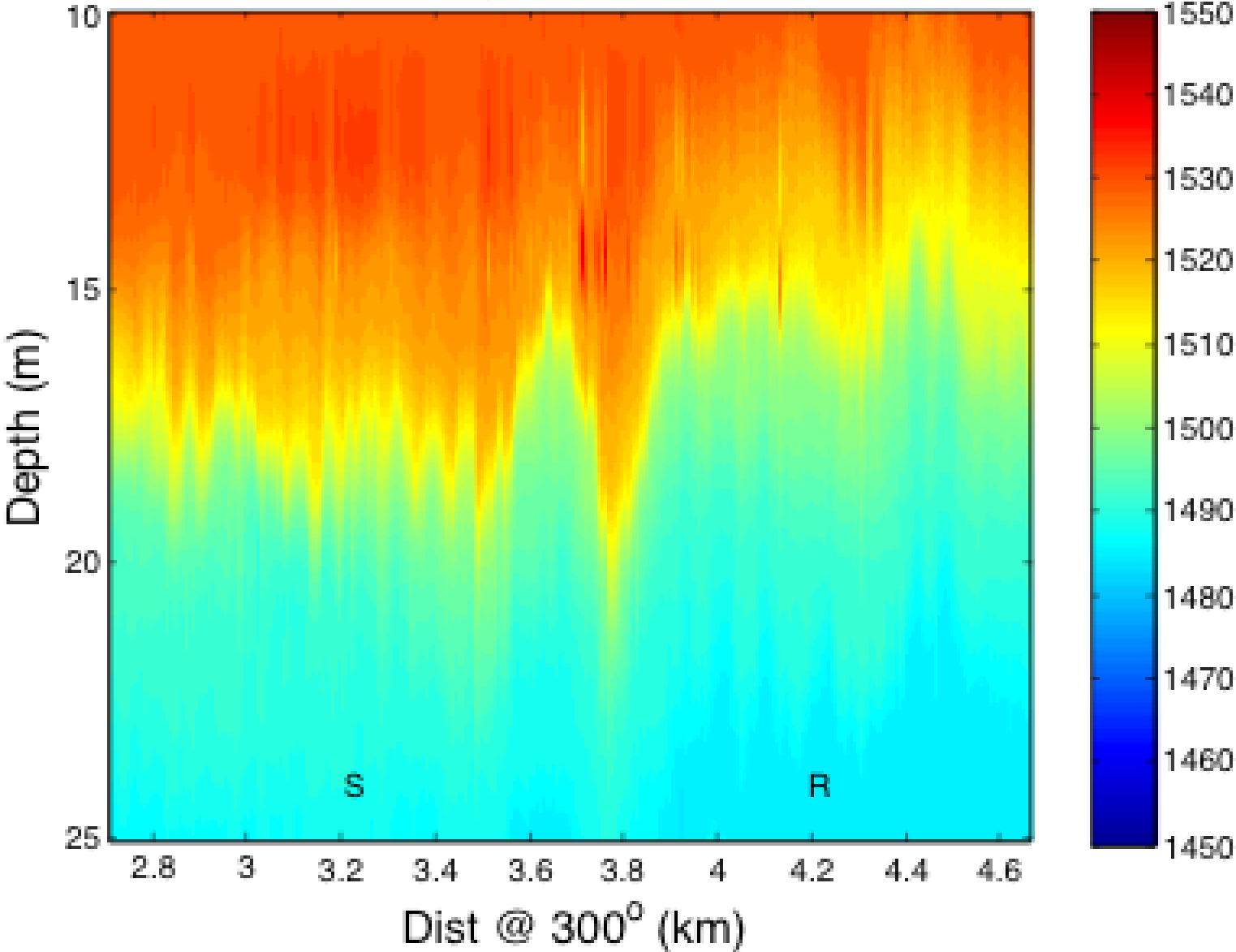


(Distances from 73°W, 39°N)

Little Spice

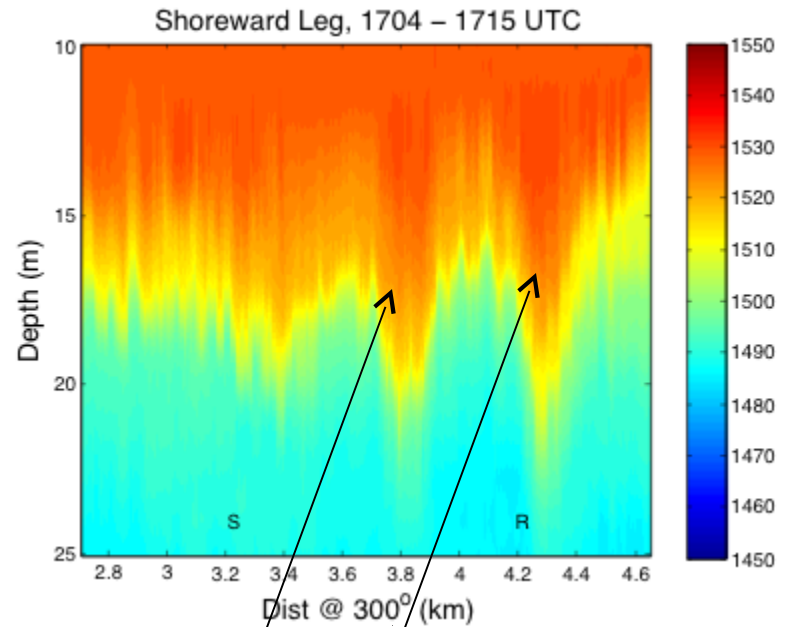
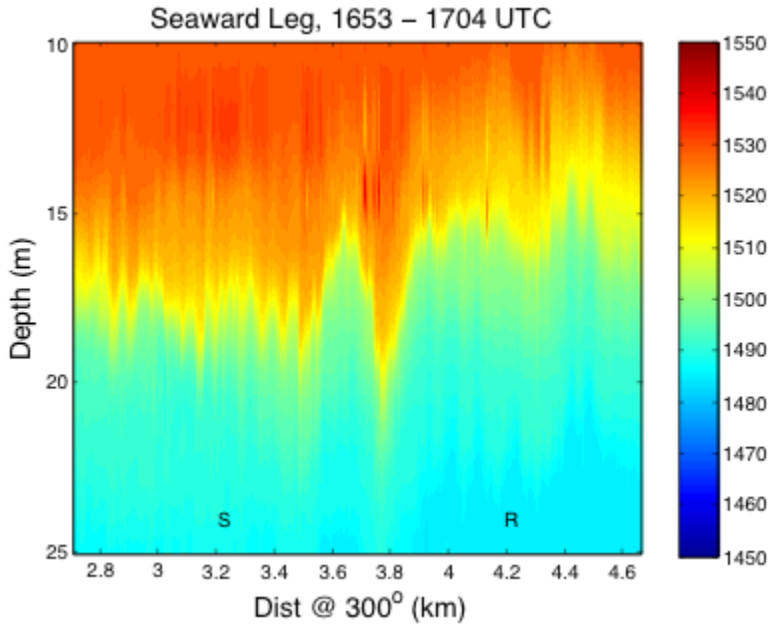


Seaward Leg, 1653 – 1704 UTC

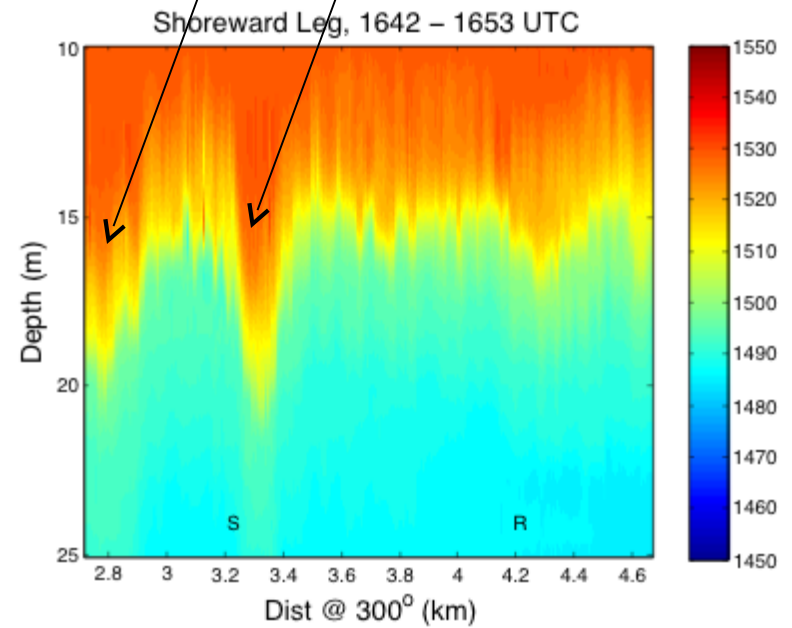


Simple example of interpolation

Corrections not needed



$$\frac{v}{\cos q} = 0.6 \text{ m/s}$$



Ship speed = 3.5 m/s
 Spacing on shoreward legs = 500 m – 86 m = 414 m
 Spacing on seaward leg = 300 m + 52 m = 352 m

Difference = 62 m
 Distance between legs = 400 m

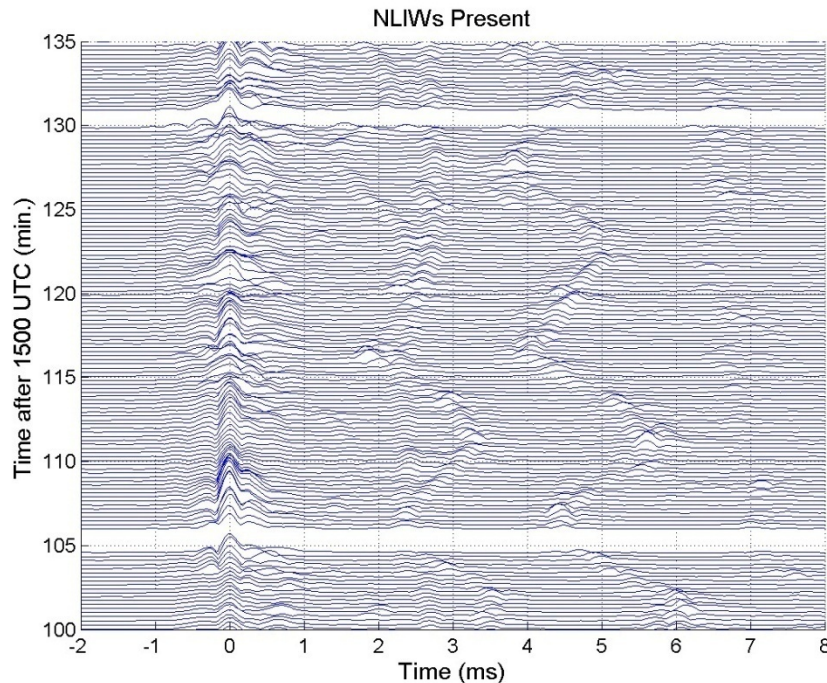
Angle between waves = 9°

Estimate from radar image on Knorr = 10°

By such interpolation, the waves on the acoustic path can be reconstructed.

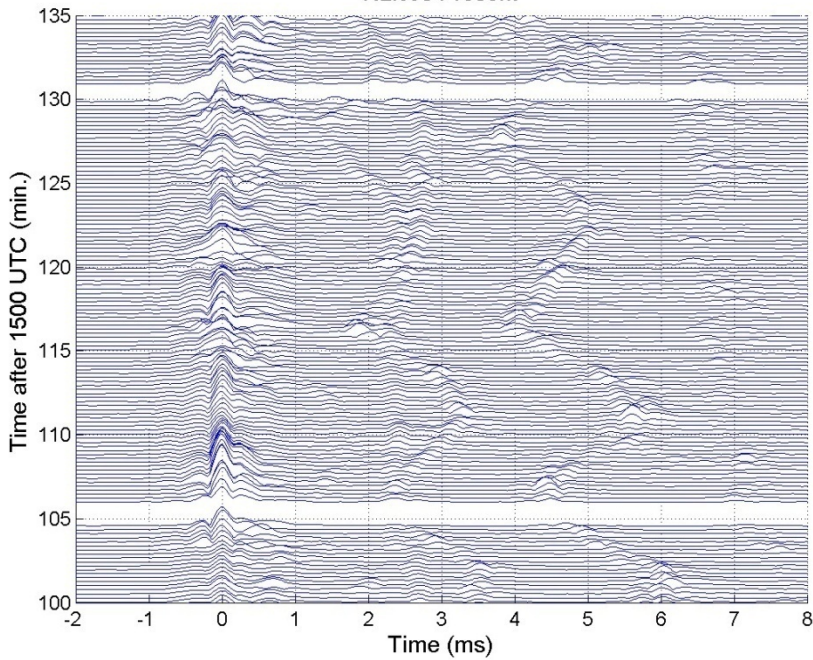
The resulting sound speed field can be used in an acoustic propagation code.

The predicted acoustics can be compared to the measured acoustics



Time relative to first arrival (source position uncertain & changing)

NLIWs Present

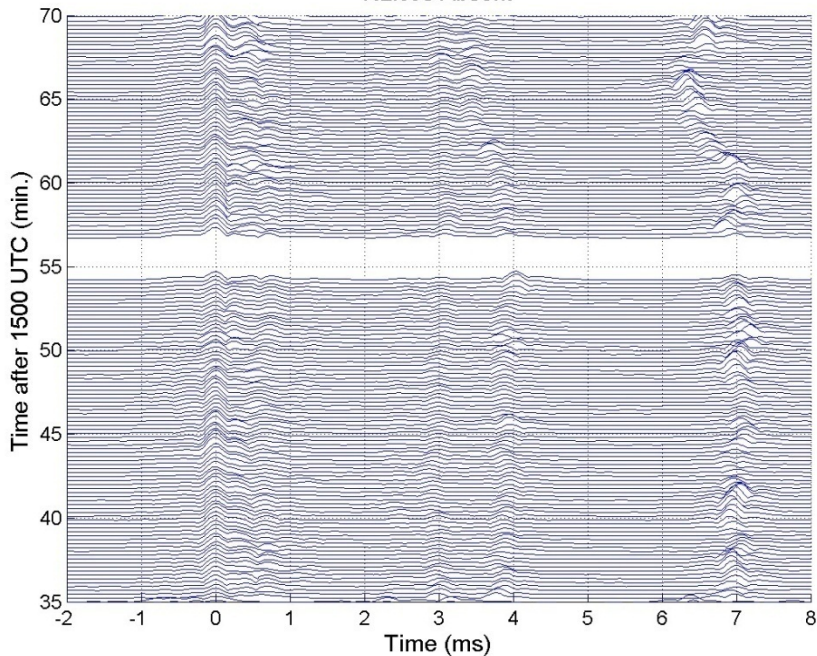


With NLIW's present:

Relative times change
between no-wave & wave
within wave event

First arrival scintillates much more
Relative intensity changes

NLIWs Absent



Arrival time is very sensitive to SSP

Acoustic field with internal solitary wave

2 kHz, absorbing layer at 60 m, source at 30 m

QuickTime^a and a
decompressor
are needed to see this picture.

Summary

- Acoustics (at 1 km) depends strongly on water column properties
- Scattering by small internal waves studied stochastically
- When NLIW's are in the acoustics path, received signals are dramatically different from those when no NLIW is present
- Scattering of sound by NLIWs will be studied deterministically.