Time domain geoacoustic inversion using back-propagation on SWAMI32 line array

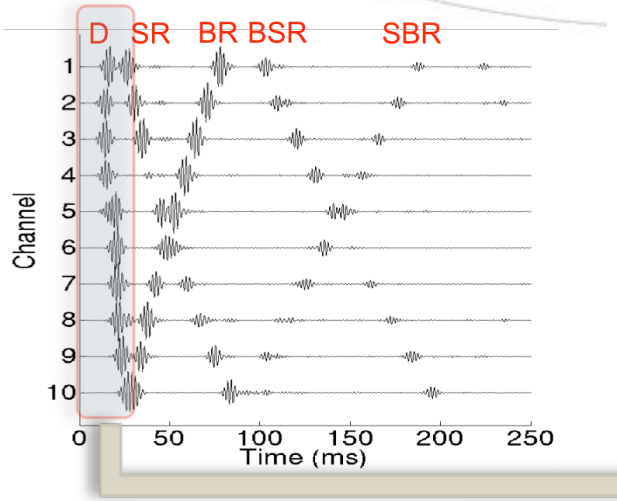
Cheolsoo Park*, Peter Gerstoft, Woojae Seong and William S. Hodgkiss

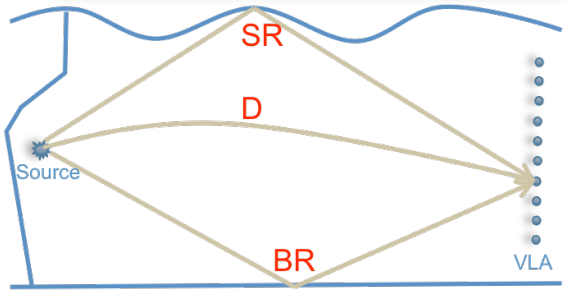
Marine Physical Lab. / SIO

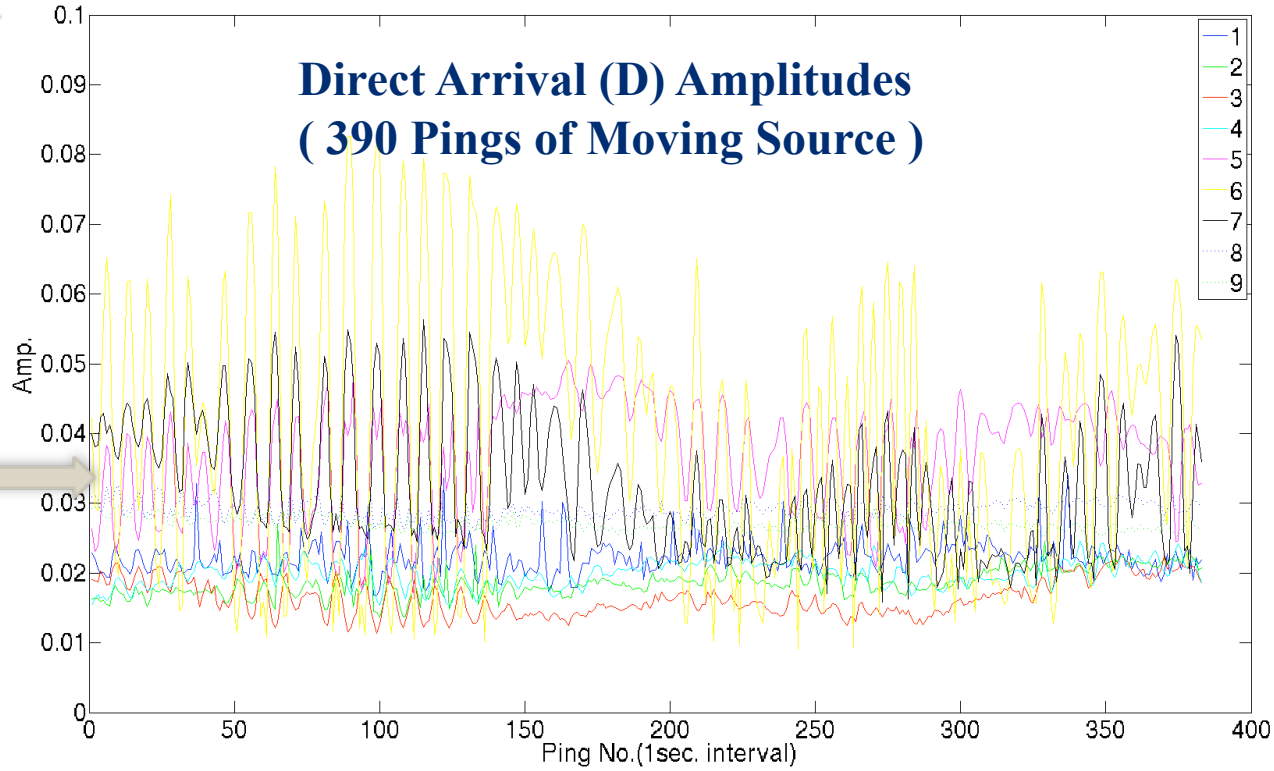
Outline

- Background of the work
- Experiment(SW06)
- Arrival amplitude fluctuation analysis (frequency, variation)
- Arrival amplitude variation (simulation)
- Inversion approach
- Inversion results
- Summary

Background of the work



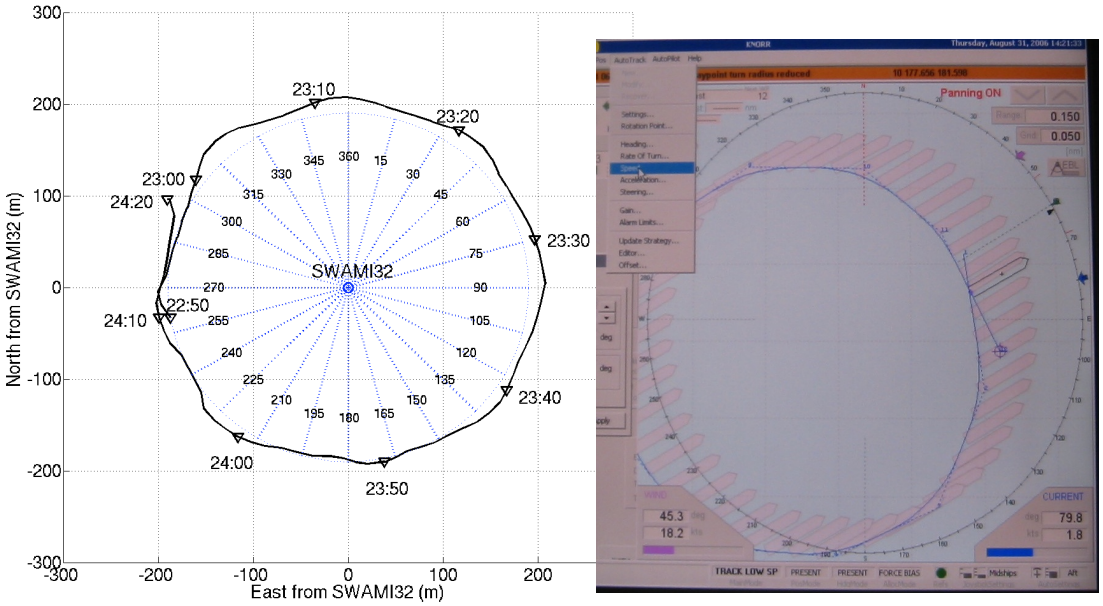




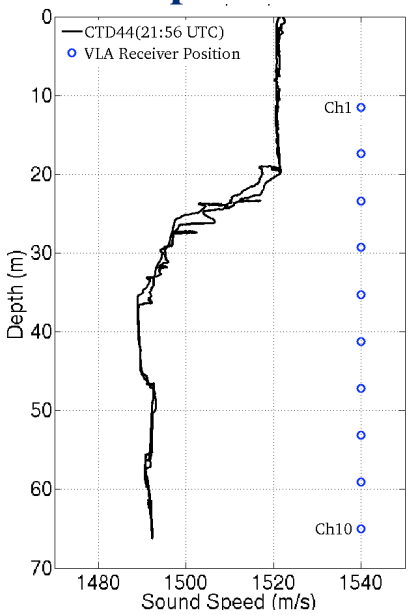
- Severe signal fluctuations were observed !
- **(Q1)** What is the physics in the fluctuations ?
- **(Q2)** Does inversion work for the time-varying data ?

Experiment (SW06)

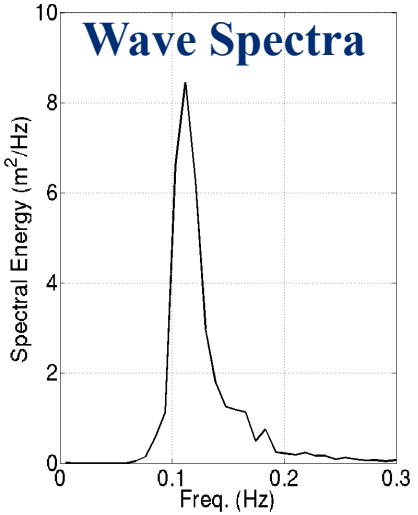
SWAMI 32 circle track



Sound Speed Profile

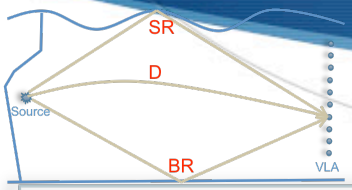


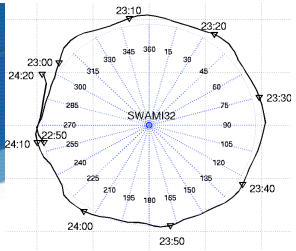
Wave Spectra



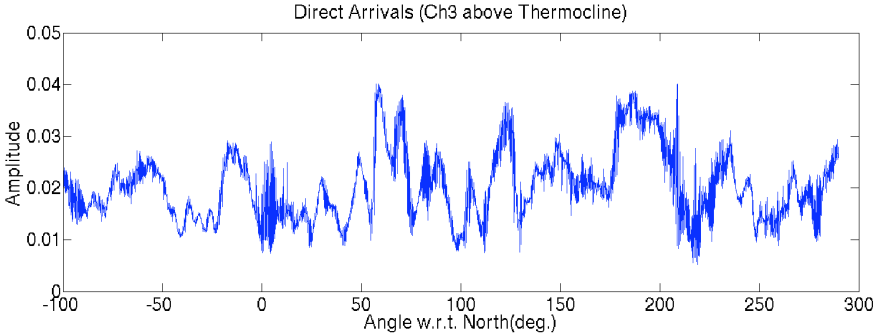
- New Jersey continental shelf break
- Source circle track (R_{circle}=190m, SD=35m)
- Strong thermocline in SSP
- Ocean Wave Peak freq. = 0.12 Hz H ⅓ = 2.2 m

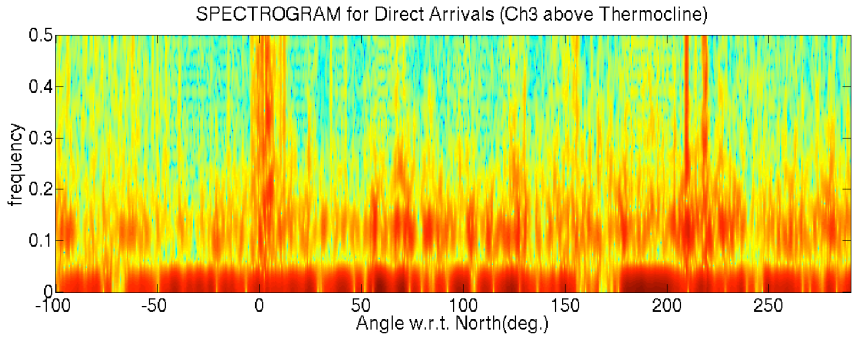
Arrival amplitude frequency analysis





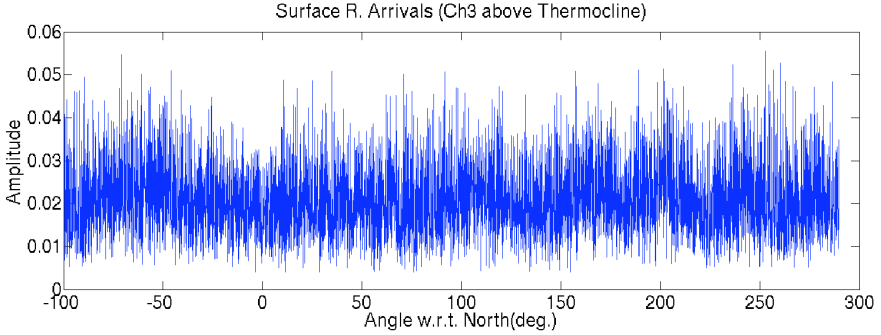
Direct Arrivals (ch.3)

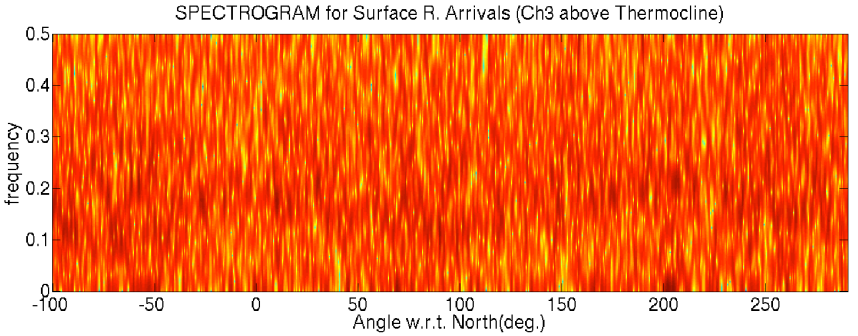




- Amplitude fluctuations with dominant frequency 0.12Hz (8.3s)
- Cf. Surface wave freq. = 0.12 Hz

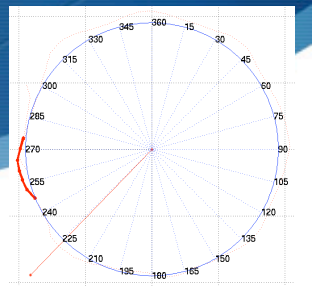
Surface Reflected Arrivals (ch.3)



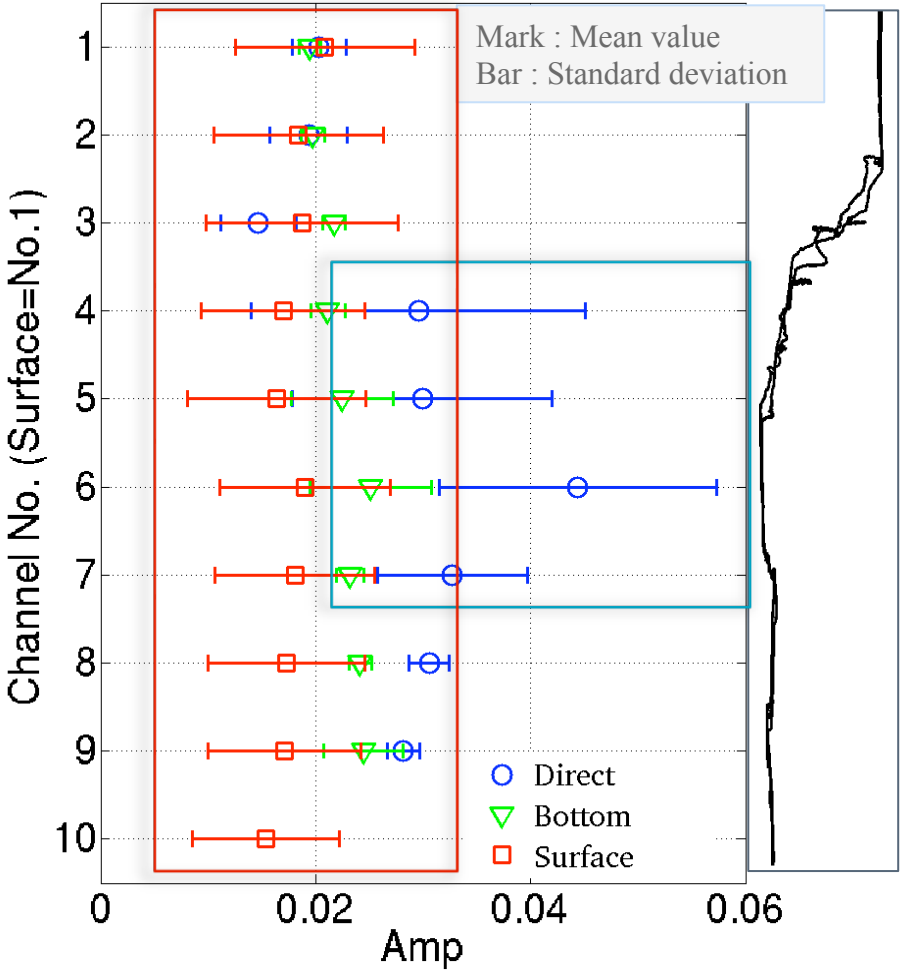


- Almost random fluctuation
- Weak dominant frequency variation (0.1~0.25 Hz)

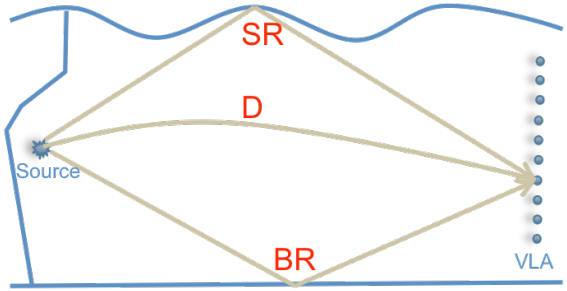
Arrival amplitude variations



Amplitude Variations w.r.t Channel



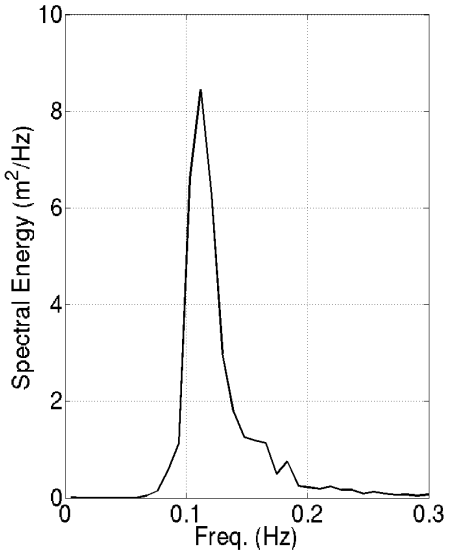
- Largest direct arrival fluctuation at channels 4-7 below strong thermocline
- Large surface R arrival fluctuation at all channels with similar amounts of variation
- Stable bottom R arrival



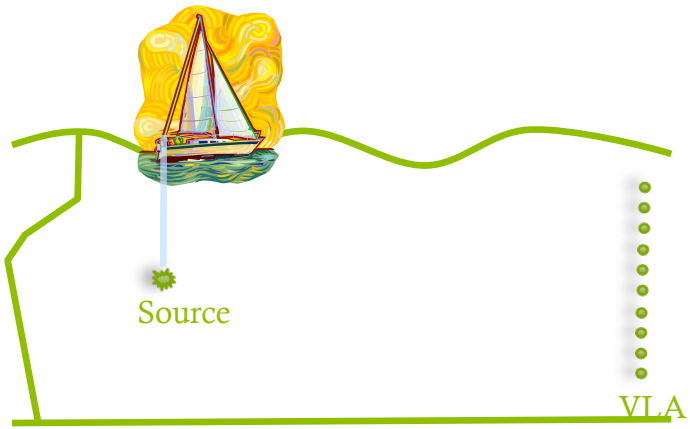
Arrival fluctuation due to ocean waves

(Q1) What is the physics in the fluctuations ?

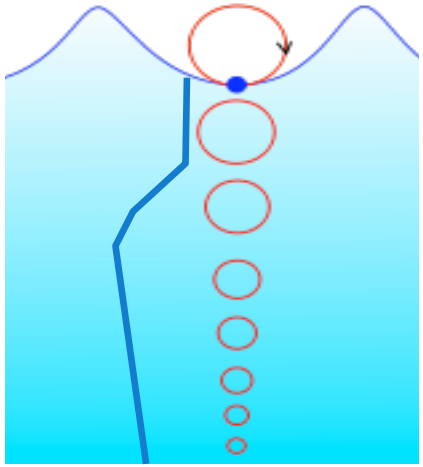
- (1) Measured ocean wave frequency : 0.12 Hz, H⅓ : 2.2 m
- (2) Significant source depth oscillation riding ocean waves (±1.1m)
- (3) Small thermocline oscillation by water particle circulation (R= 0.2m @ 25m)



(1) Wave Spectra



(2) Source movement riding waves

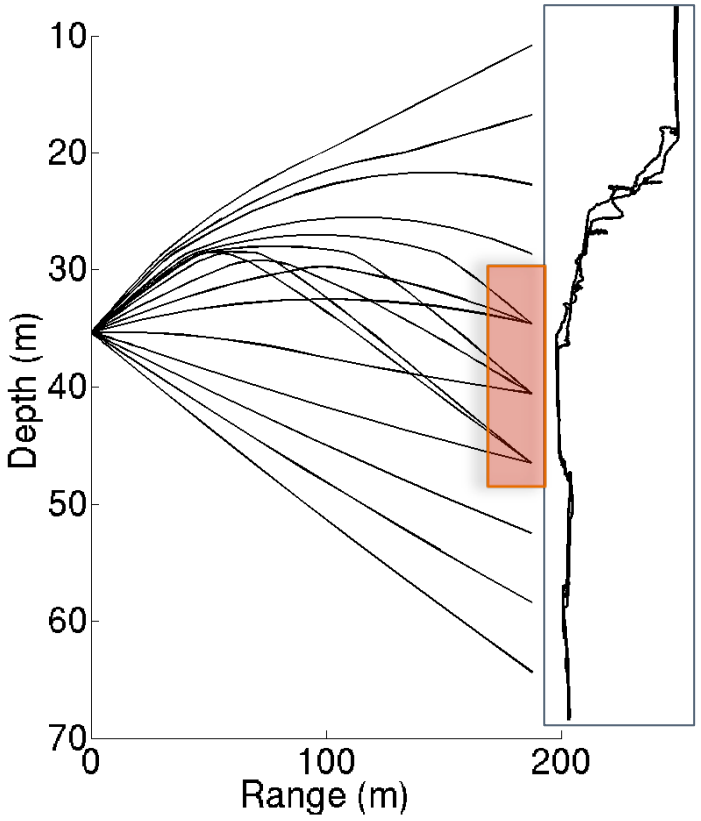


(3) Water particle trajectory

Arrival fluctuation due to thermocline

(Q1) What is the physics in the fluctuations ?

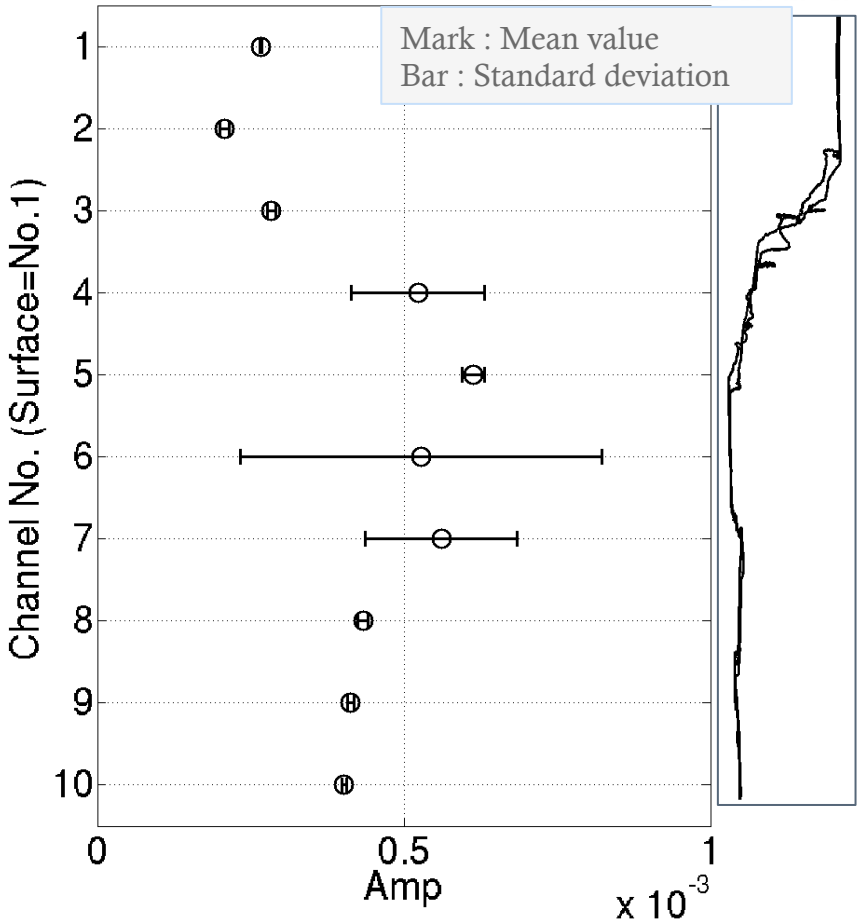
- Downward refracting rays due to thermocline
- Direct arrival interference causing amplitude variation (Y.-M. Jiang and N. R. Chapman, JASA EL, 2008)



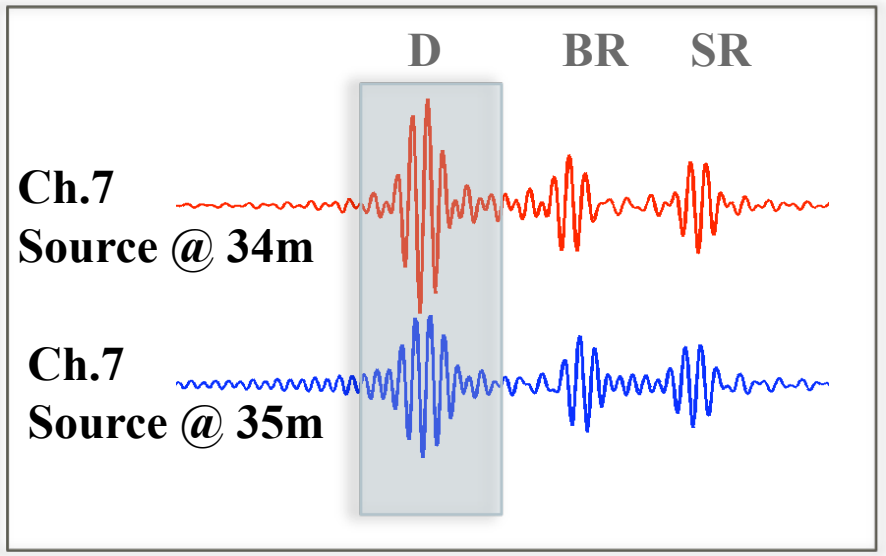
Ray Path Diagram

Direct arrival amplitude variation : simulation

Direct Amplitude Variations Simulation



- Up-down source oscillation
  depth : 35 ± 1 m @ 0.12 Hz
- Water column SSP fixed (CTD 44)
- Variations reproduced

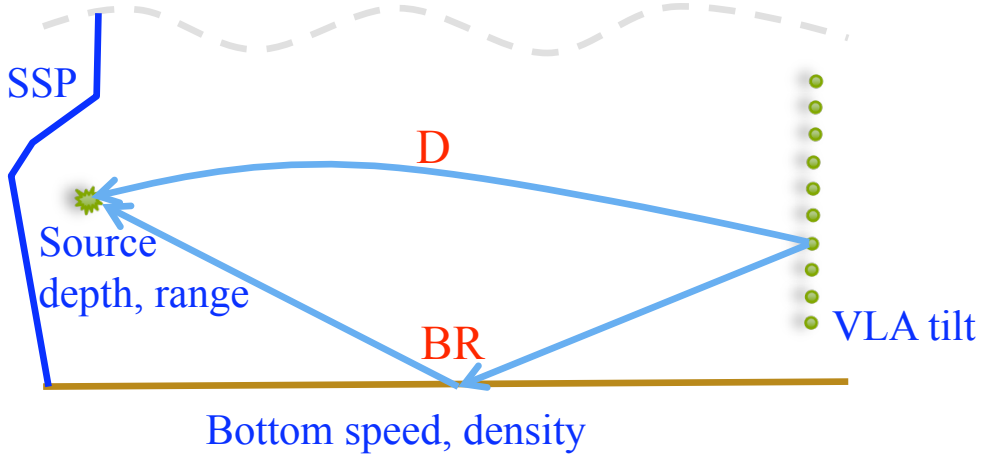


(Q1) What is the physics in the fluctuations ?

Source oscillation + Thermocline => Direct Arrival fluctuation

Inversion Approach

- Inversion Model



- Multi-step optimization

(1) Preliminary SD & VLA tilt using all channels

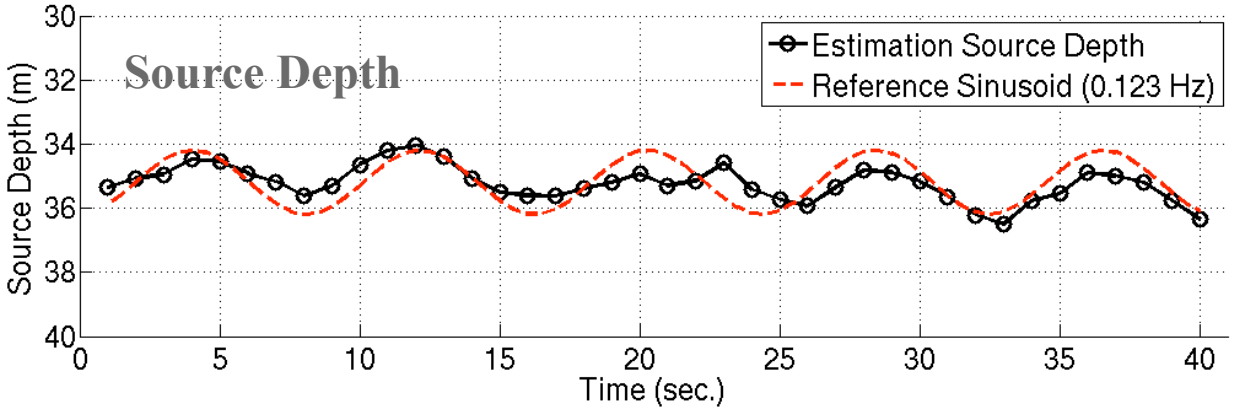
(2) SSP in thermocline zone using ch. 3 ~ 7

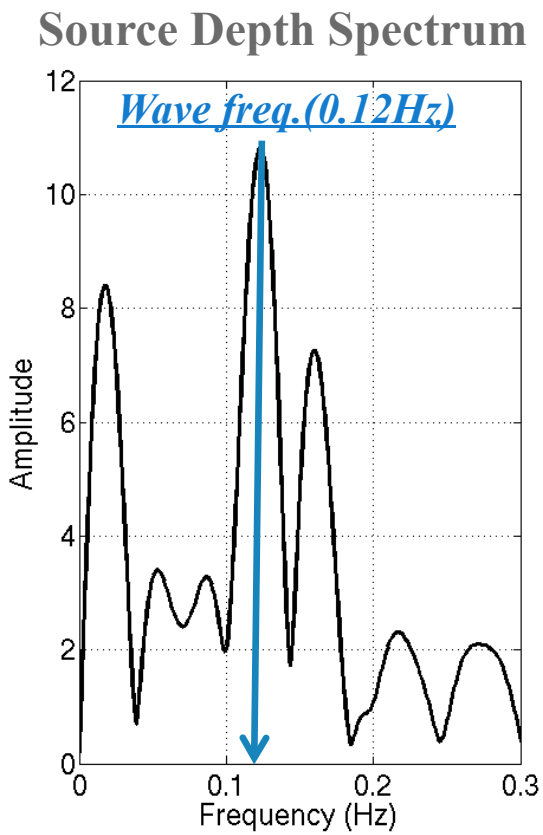
(3) SD, VLA tilt, and remaining SSP using all channels

(4) Bottom parameters (sound speed, density)

Inversion Results (1)

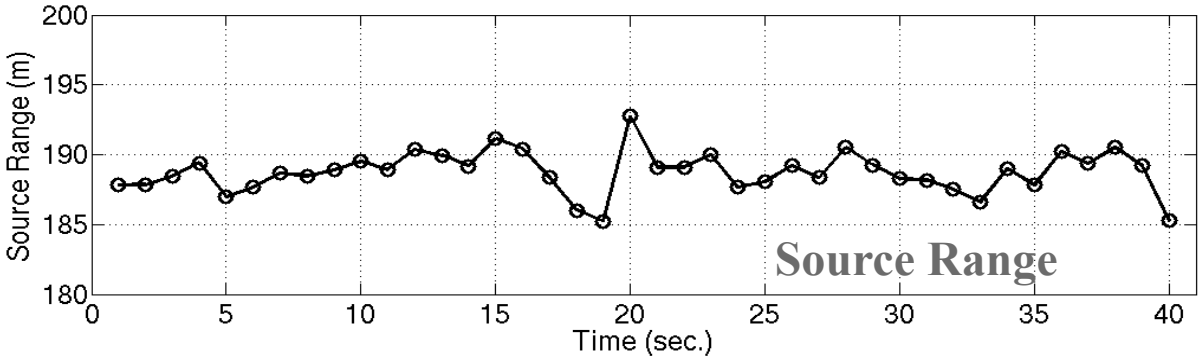
(Q2) Does inversion work for the time varying data ?

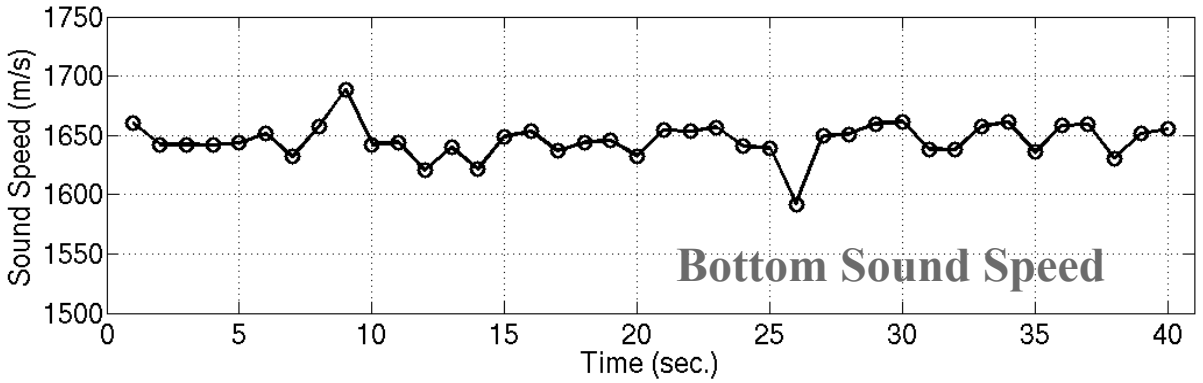


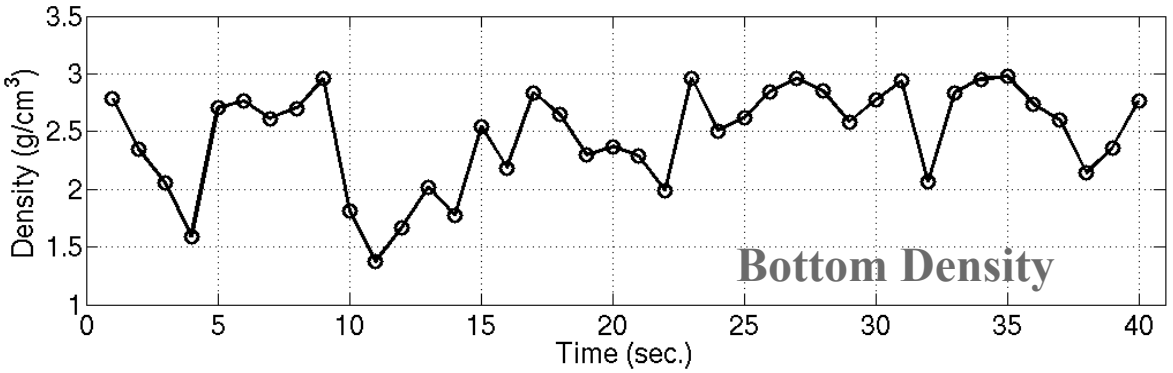


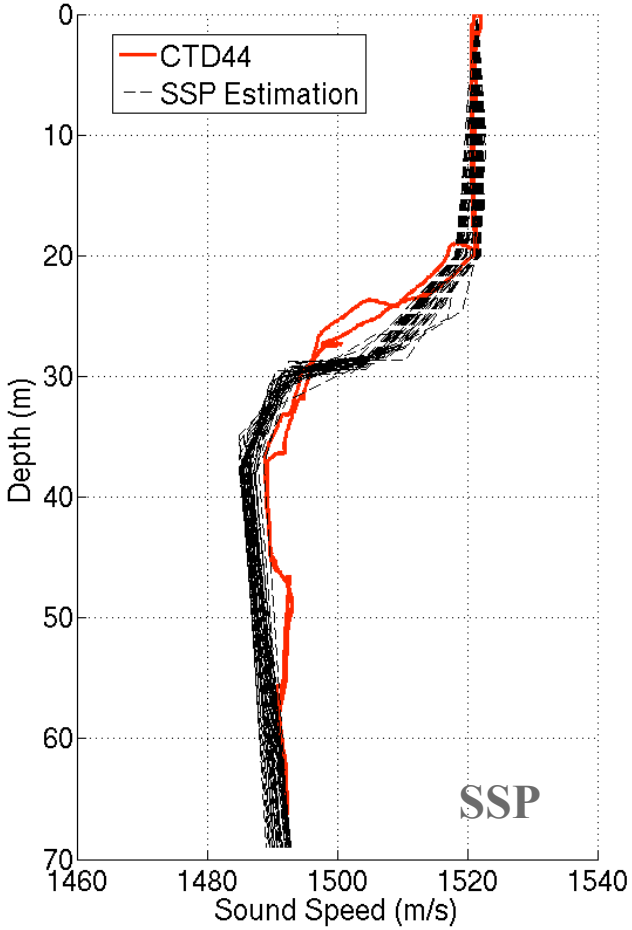
- Source depth oscillation clearly detected
- Source depth variation frequency (0.123Hz) exactly agrees with ocean wave freq.(0.12Hz)
- Variations amplitude (0.9m) agrees with ocean wave amp.(1.1m)

Inversion Results (2)









Summary

- Severe signal fluctuations were observed in SWAMI32 acoustic data.
- Ocean surface wave + theromcline can explain the direct arrival fluctuation.
- Geoacoustic inversion using back-propagation with direct and bottom reflections works successfully.