Underwater Sensor Networks: The physical layer

Short tutorial on the physics of sound in underwater environments.

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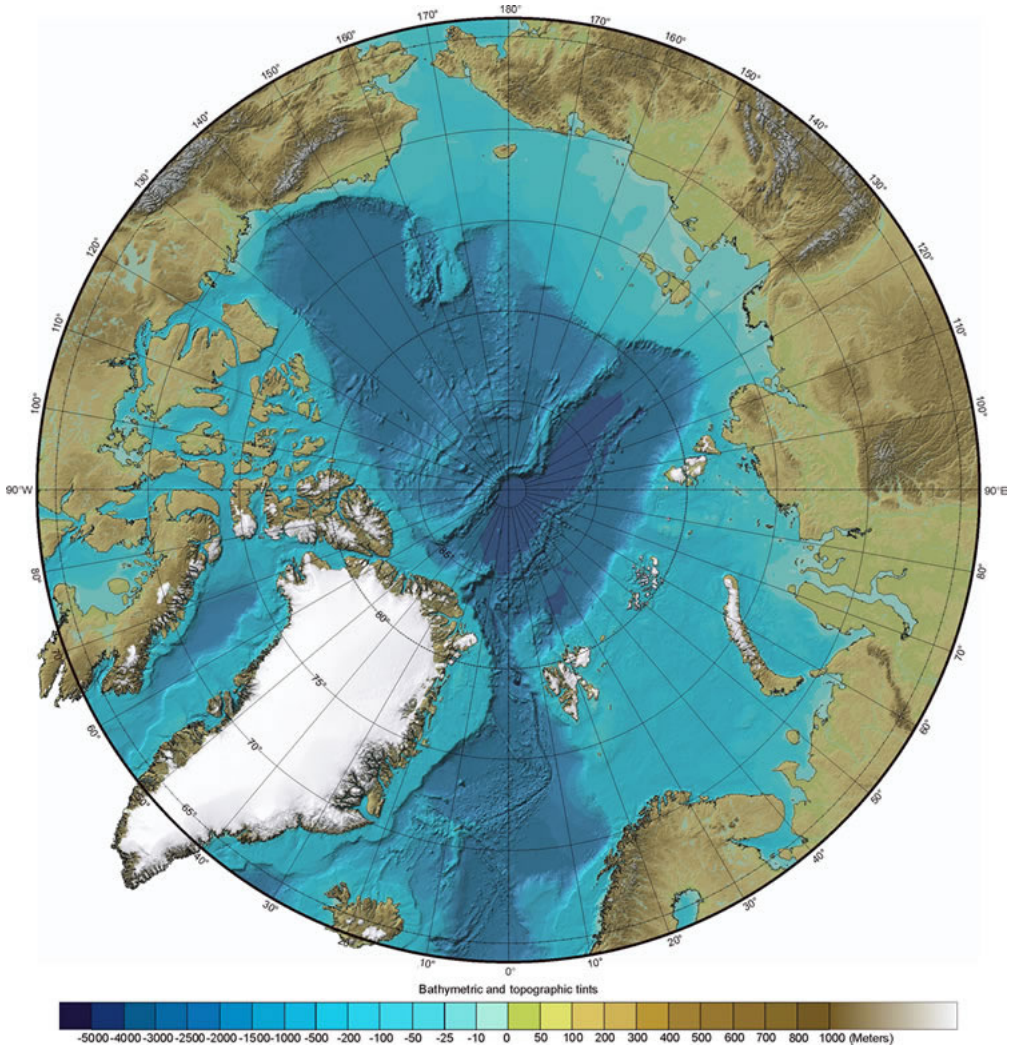
Sensorcom2009 Athens

An overview


Bathymetric and topographic tints
-5000 -4000 -3000 -2500 -2000 -1500 -1000 -500 -200 -100 -50 -25 -10 0 50 100 200 300 400 500 600 700 800 1000 (Meters)

Applications of Marine Acoustics

- Military applications and surveying of coastal areas, vessels and mines.
- Fishery acoustics and abundance estimation of fish and plankton.
- Sea floor acoustics, hydrography and mapping of the topography and structure of the sea floor and sub-bottom.
- Underwater communication
- Underwater navigation and position reference systems.
- Acoustic remote sensing of the oceanic conditions.

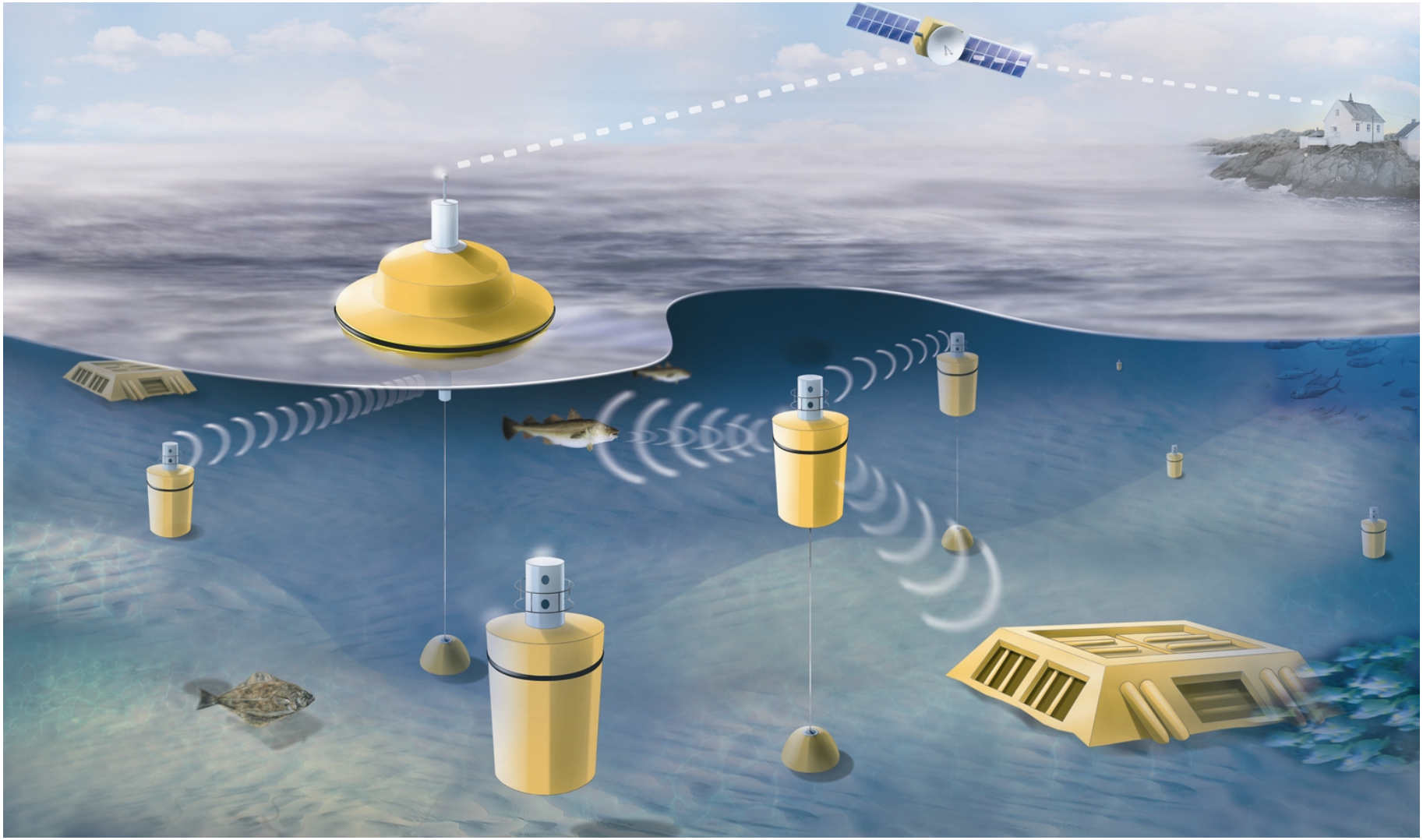
Issues in Acoustic Underwater Communication

Low data rates: Bandwidth limitations, absorption, noise.
Channel characteristics: Range (time) and frequency shift (Doppler). Coherence degradation
Oceanic variability: Significant problem, but the seriousness dependent on positions of the nodes.
Transmitters/receivers: No standards (jet) and limited availability.

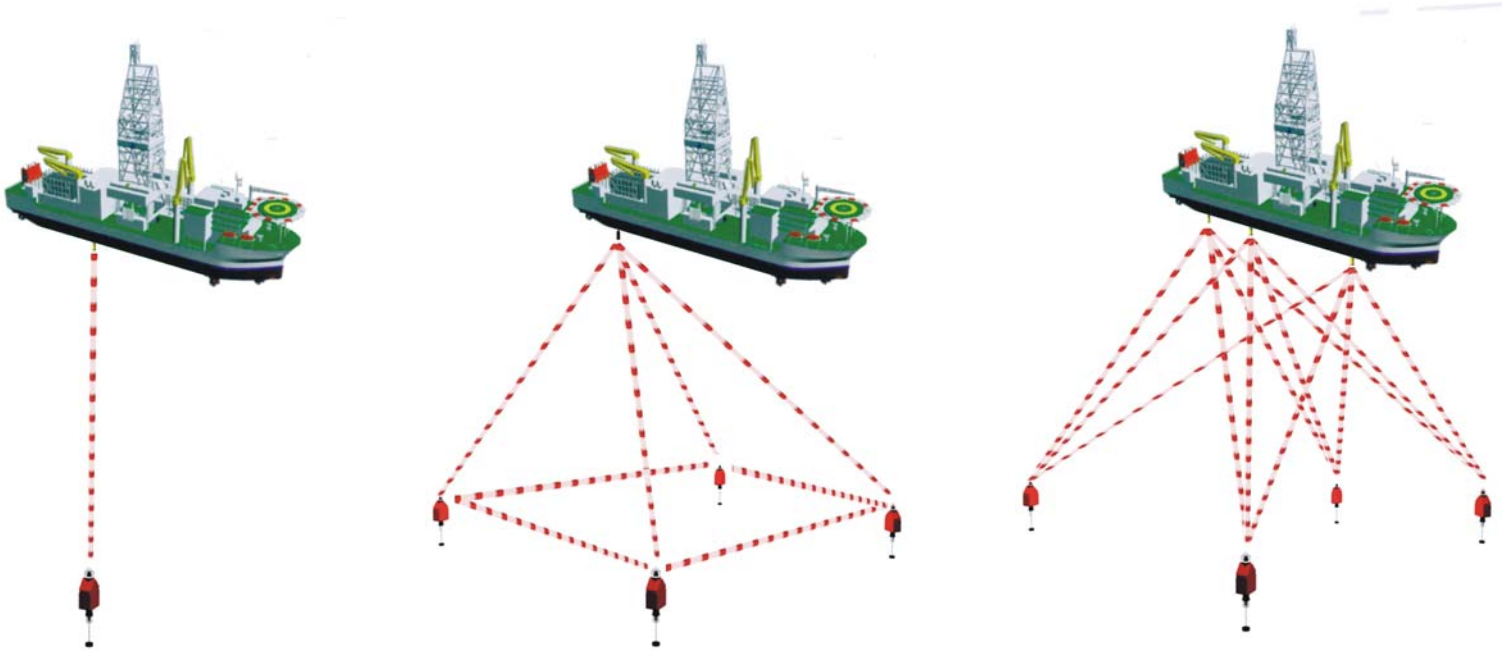
Applications of UAN

- Environmental data: Large area, very low data rates, long lifetimes.
- Protection of critical structures: Harbors, oil and gas pipes, offshore production faclities
- Event driven applications: Oil and gas leakage, pollution monitoring, equipment malfunctioning.
- **Stationary sensor networks**
  (often backup system for other systems)
- **Ad-hoc sensor networks**

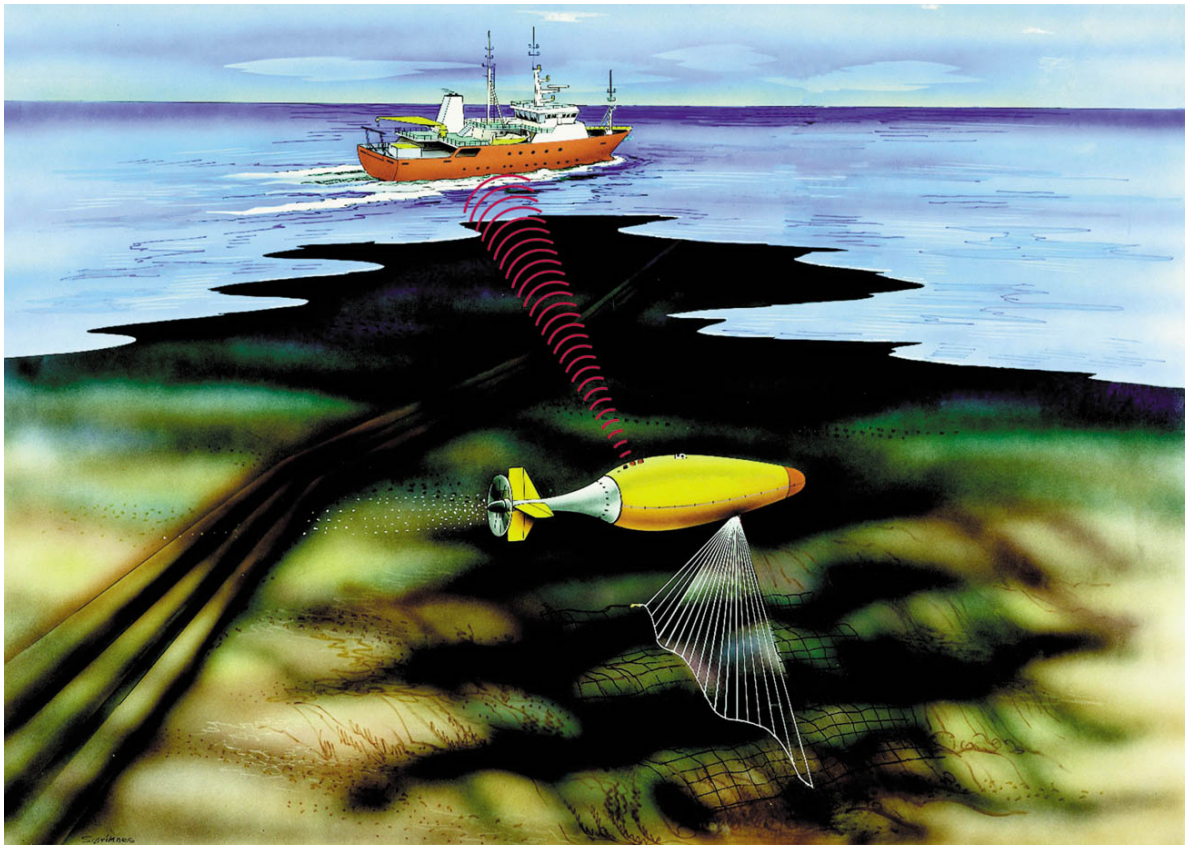
Sensor network



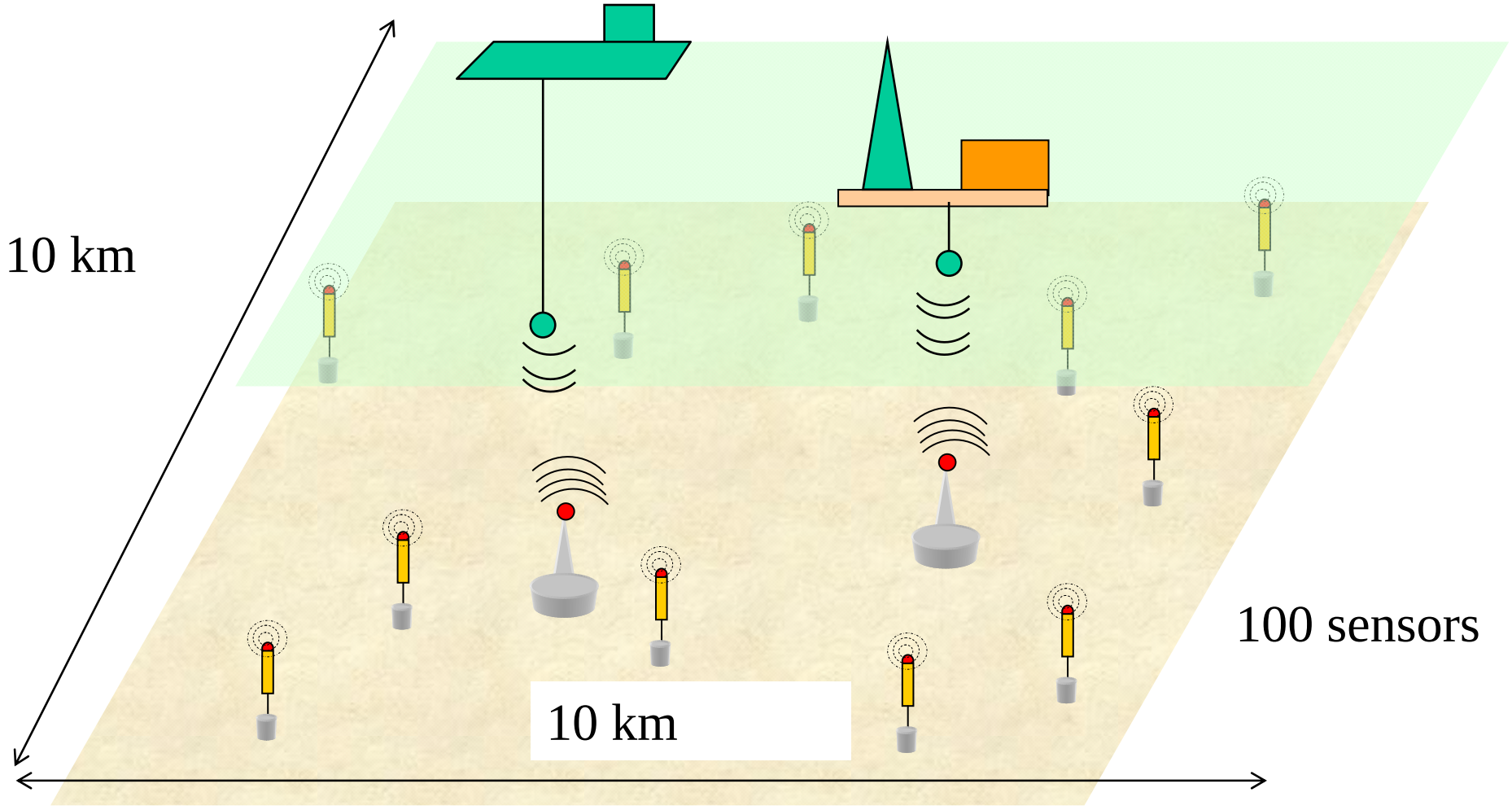
Underwater navigation and positioning



Autonomous Underwater Vehicles



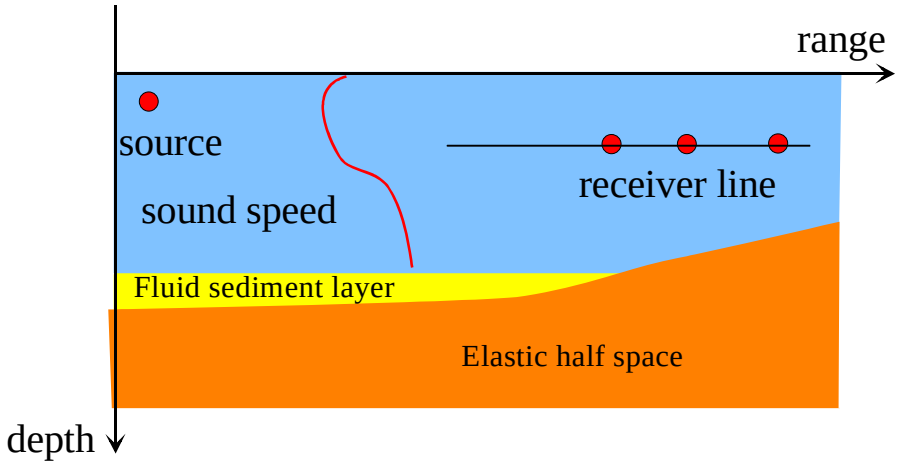
Future sensor network-concept

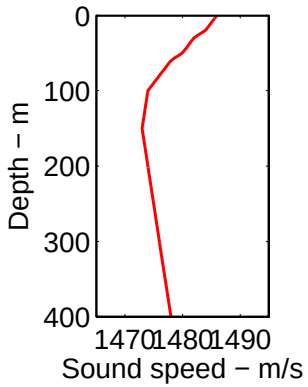


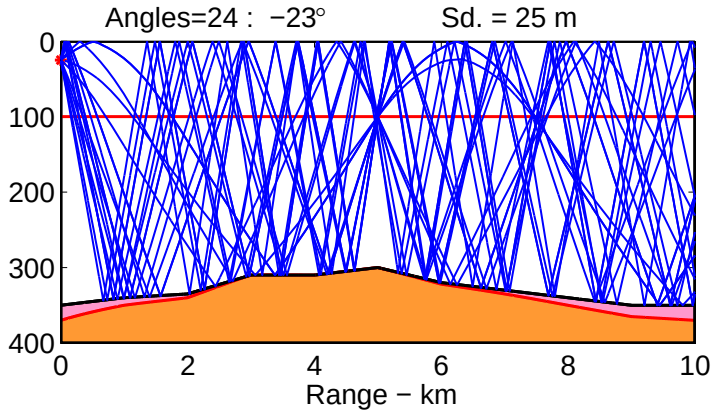
Ray modeling of underwater propagation conditions

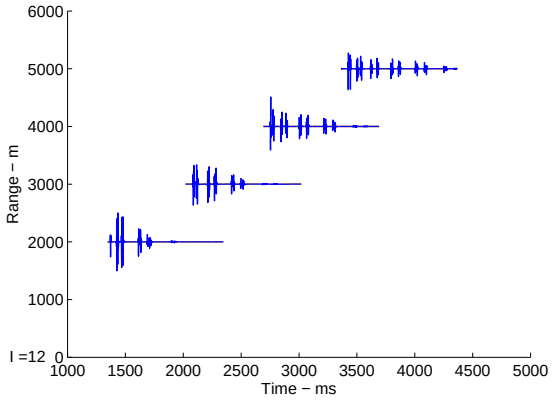
Computes the received field from a source to a number oft receivers located on a horizontal line. The bottom can be a fluid sedimentary layer over an elastic half space and both can be range dependent.

Coherently additions of all multi-path contributions to produce broad band time and frequency field descriptions.

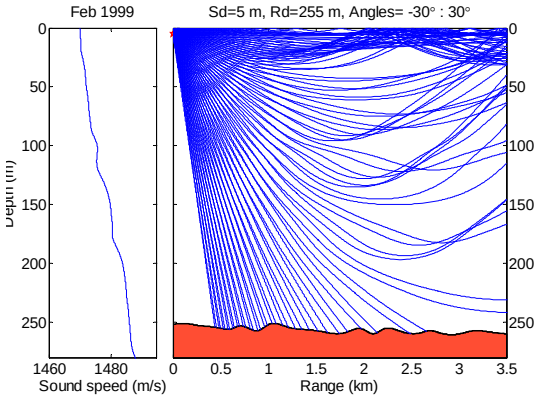


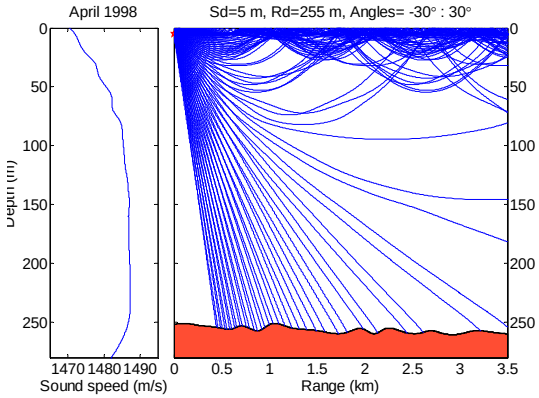


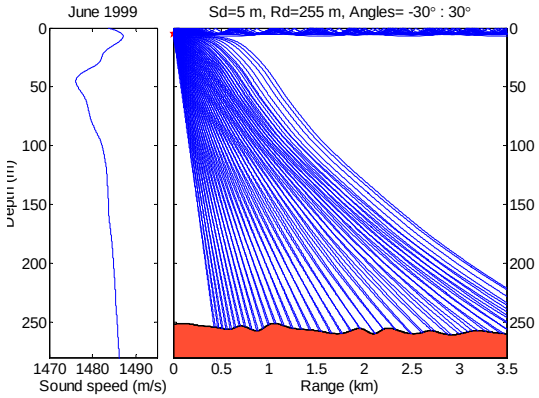


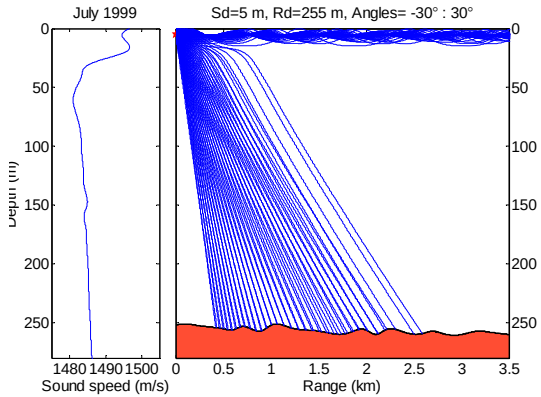


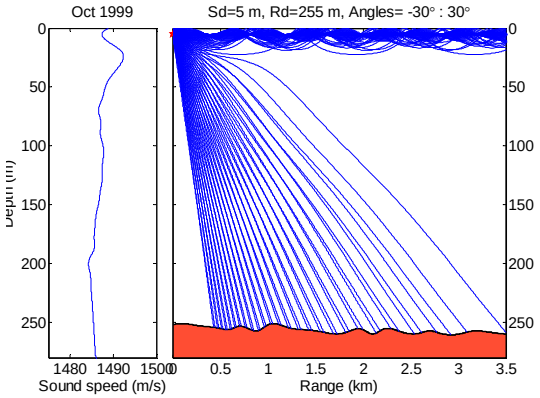
Seasonal variations in sound propagation

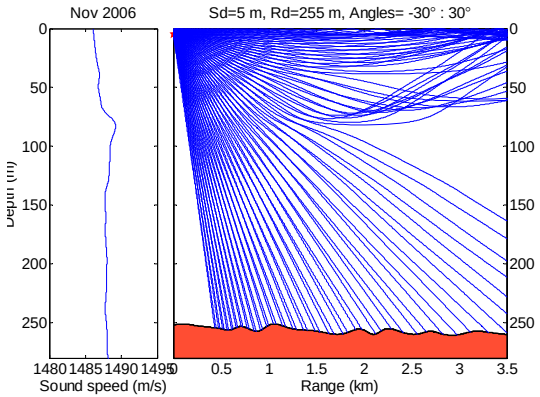




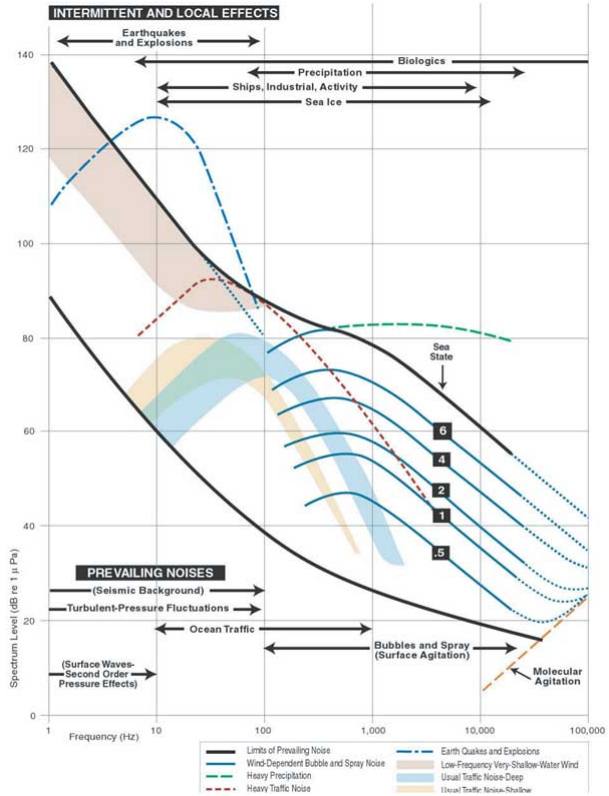






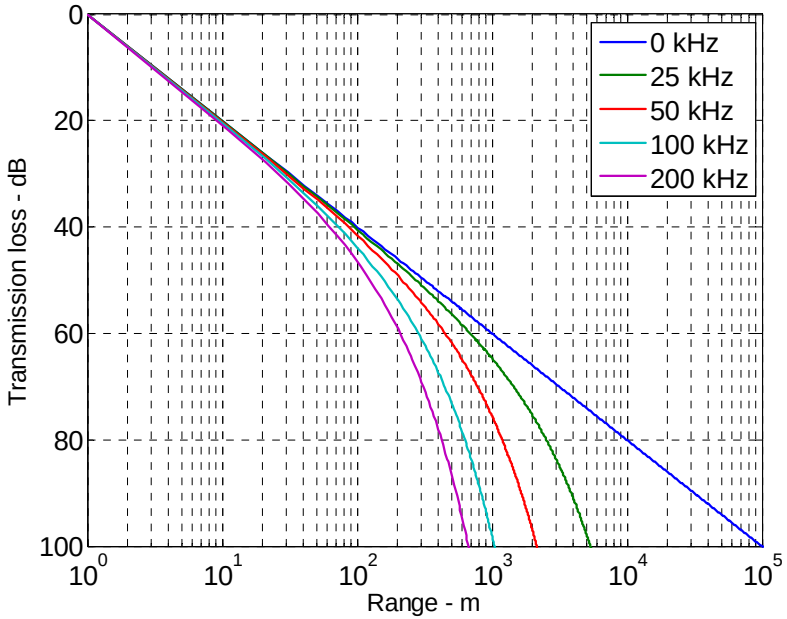


Ambient noise



Range limitations

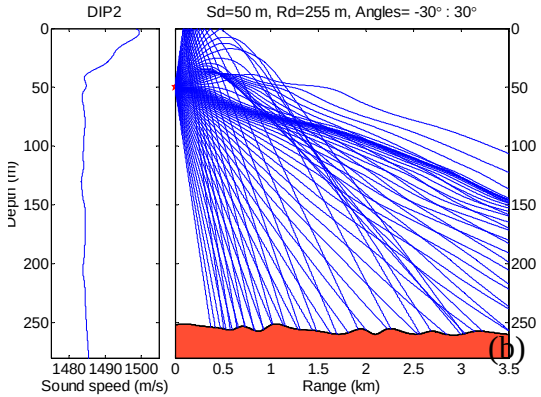
Spherical spreading loss and salt water attenuation



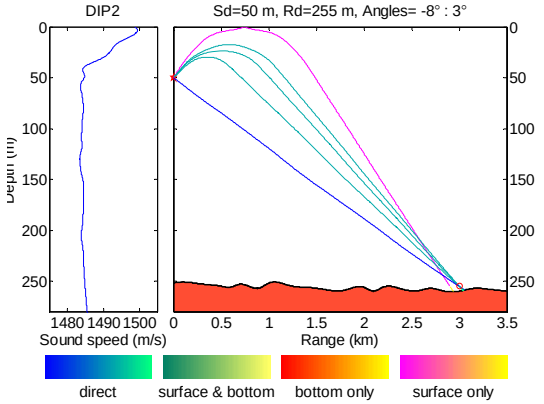
Frequency (kHz)	Range (m)	Bandwidth (Hz)	
12	5000	180	
25	2500	375	
50	1000	750	
100	600	1500	

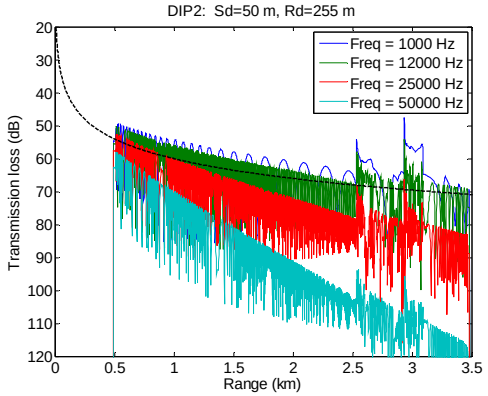
Modeling the communication link from platform to a bottom production unit

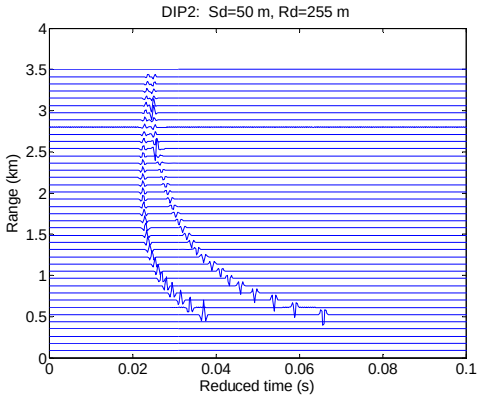
(a)



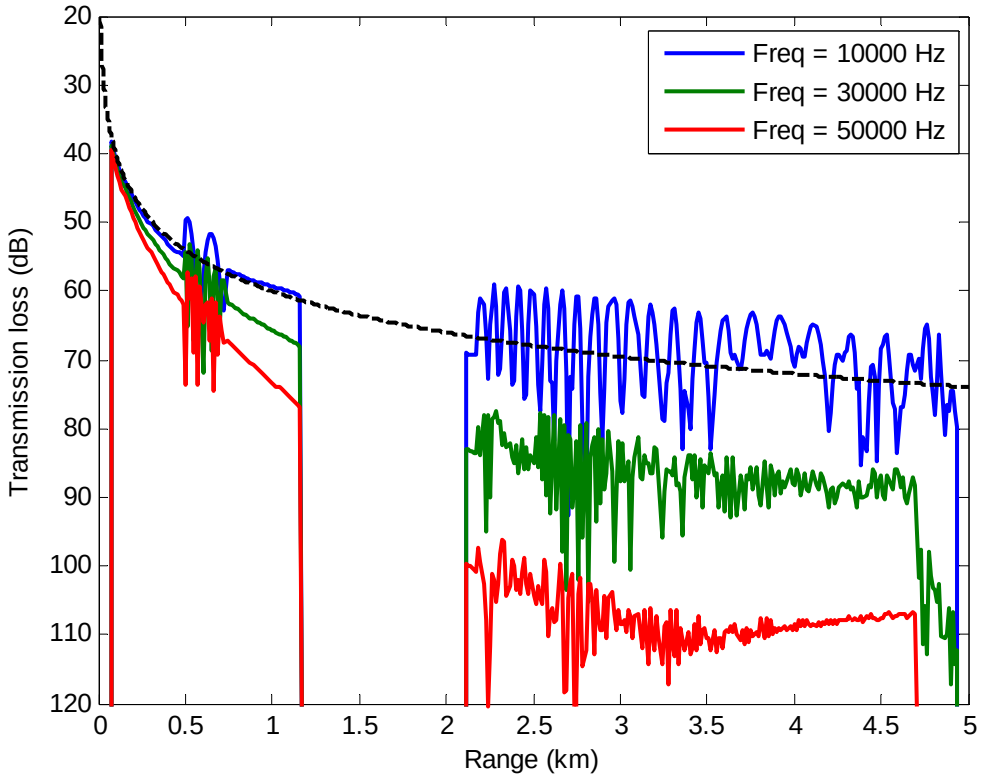
(b)





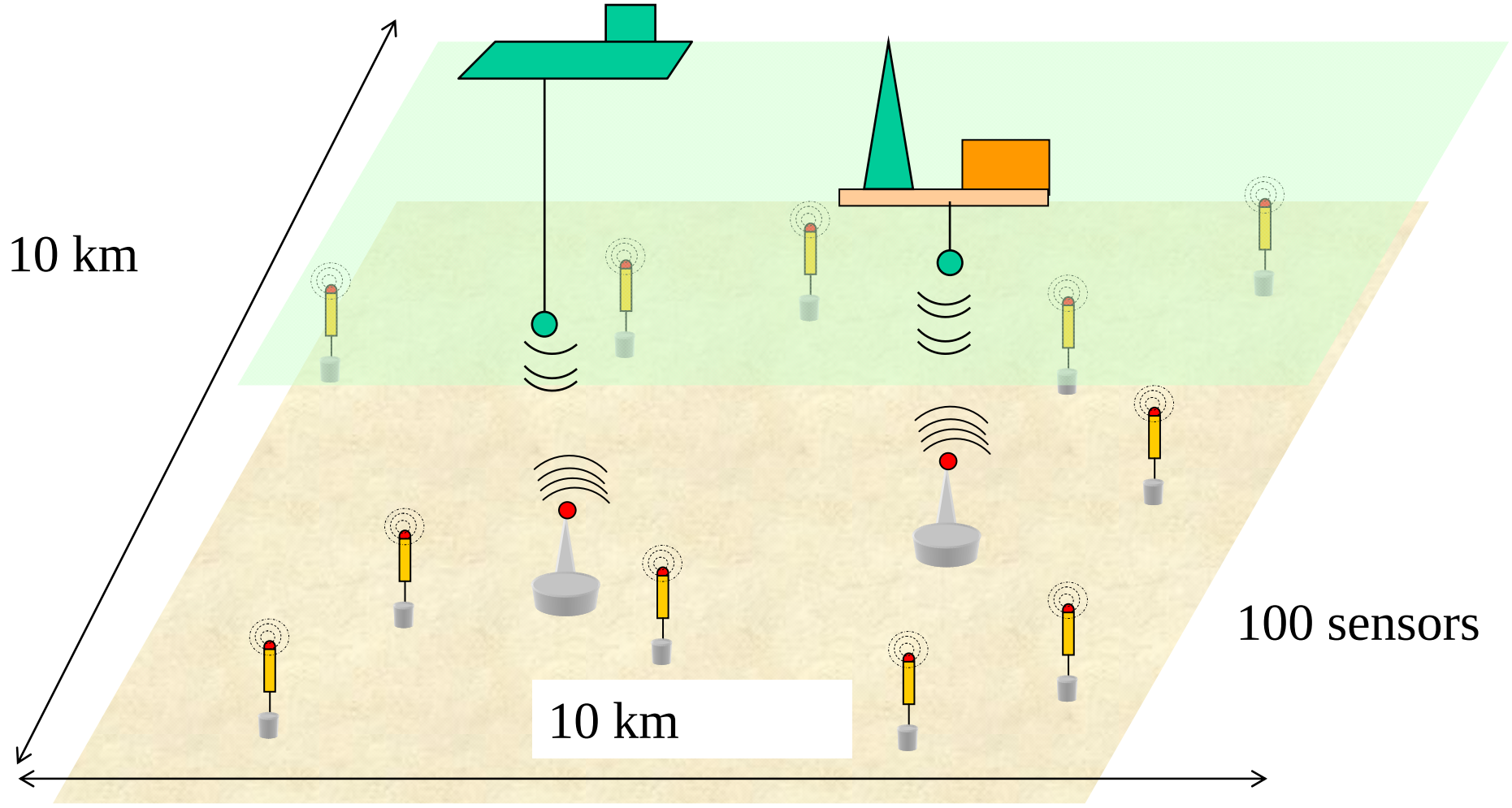


Transmission losses as function of frequency and range

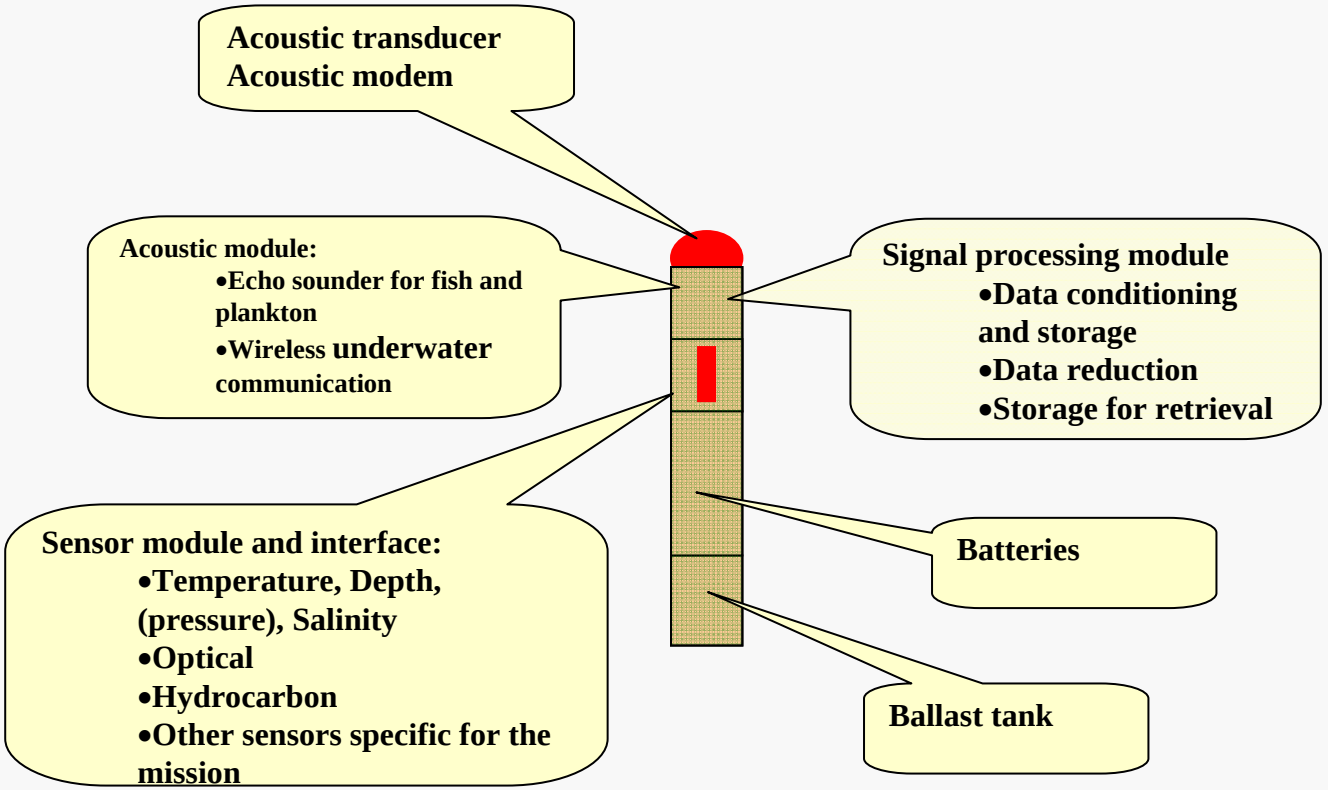


Source and receiver at 290 m, 10 m above the bottom.

Sensor network-concept



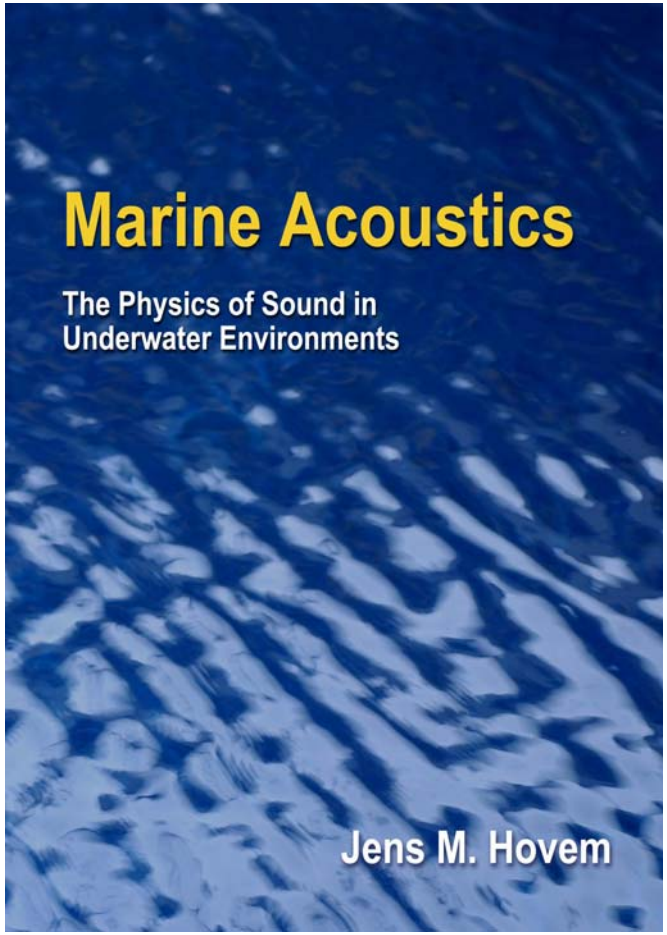
Generic Marine Sensor Unit (GMSU)



Conclusion and recommendations

- We (the underwater people) have a lot to learn from you (the earth people)
- If you want to be successful and useful in our field, you need to understand our problem

What to learn more….?



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