International Training Centre for Operational Oceanography
(ITCOocean), Hyderabad, India.

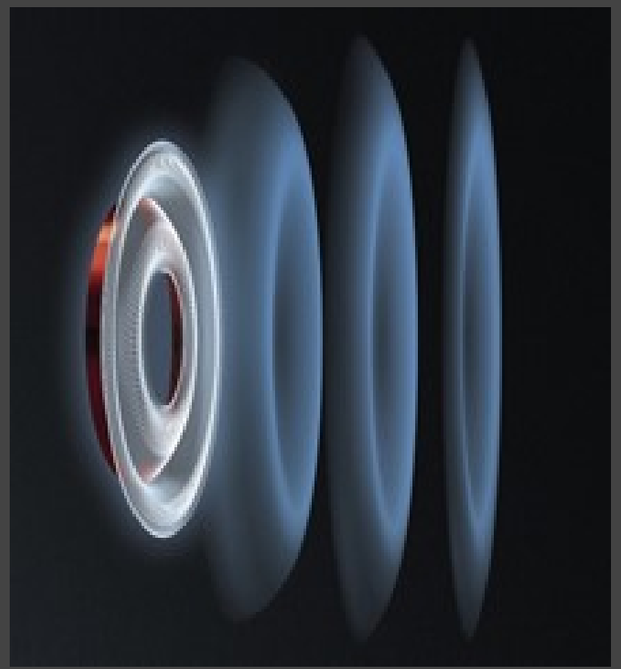
Basics of Underwater Acoustics

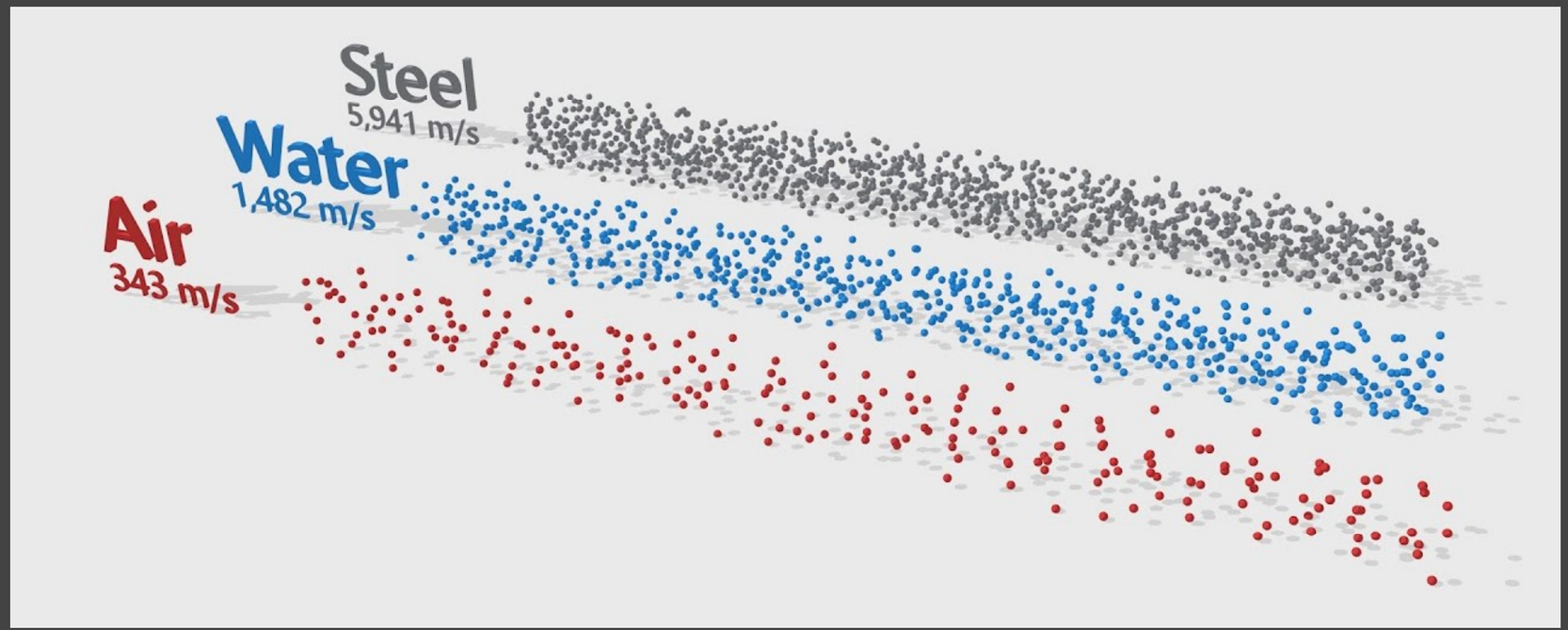
Nimit Kumar, PhD

20 April, 2021

Fishery Oceanography for Future Professionals
19 – 23 April, 2021

What is sound?





Courtesy and animation available at: https://www.youtube.com/watch?v=rkI0Nf6dHjQ

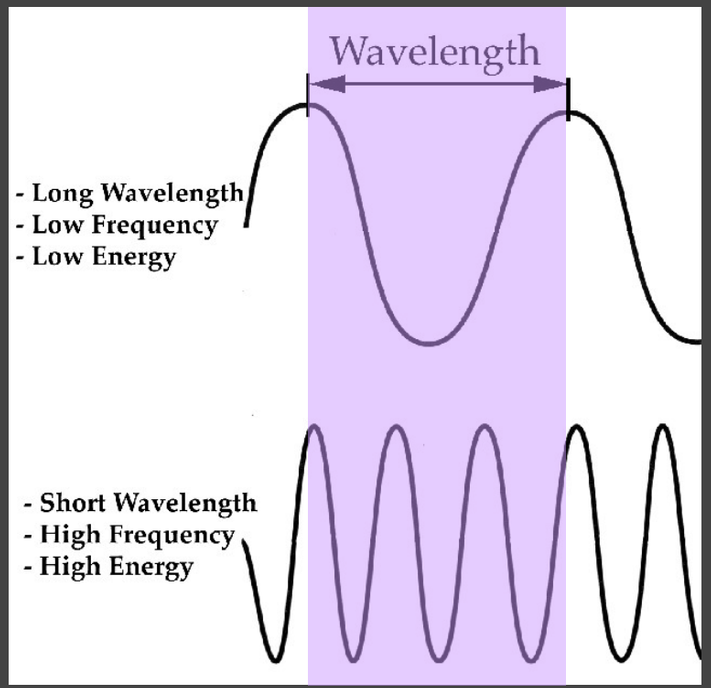
Once upon a time . . .

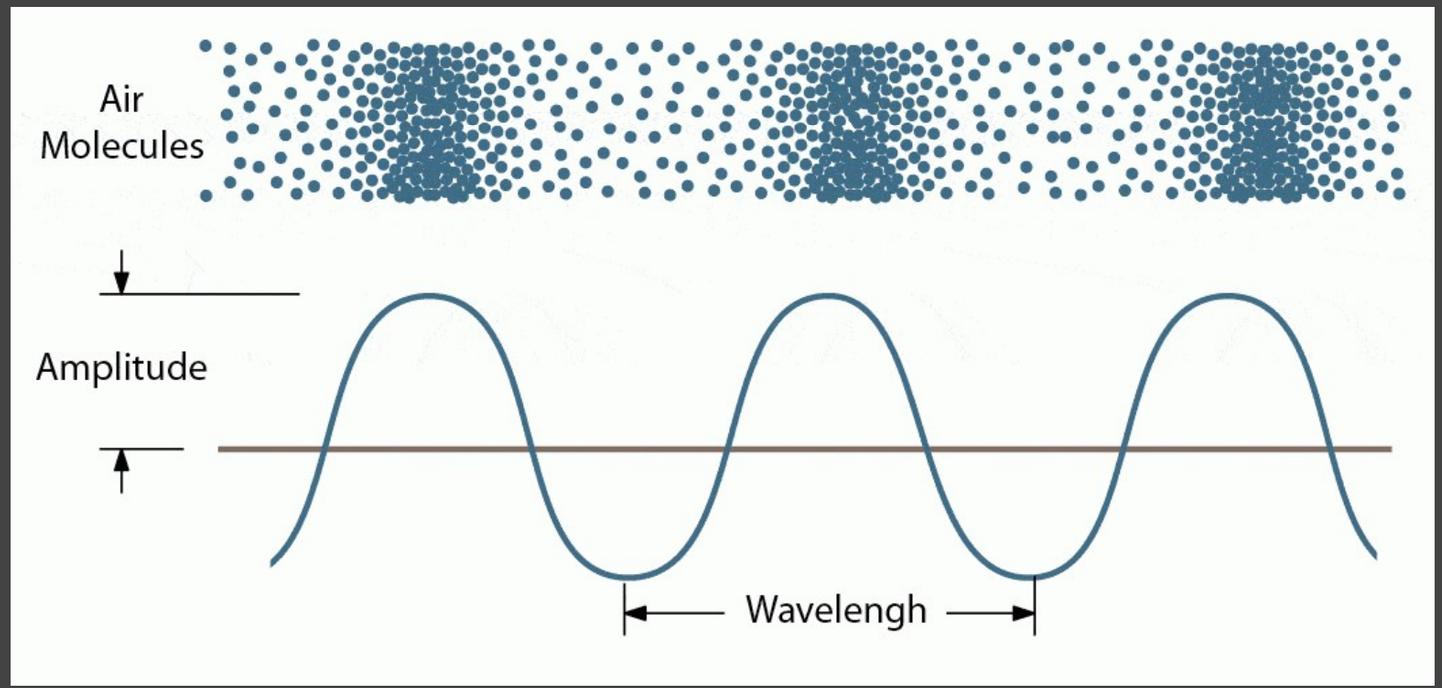
10 Miles

1826. Lake Geneva, Switzerland.
Jean-Daniel Colladon (a physicist) and Charles-Francois Sturm (a mathematician)

Courtesy : Uni. of RI

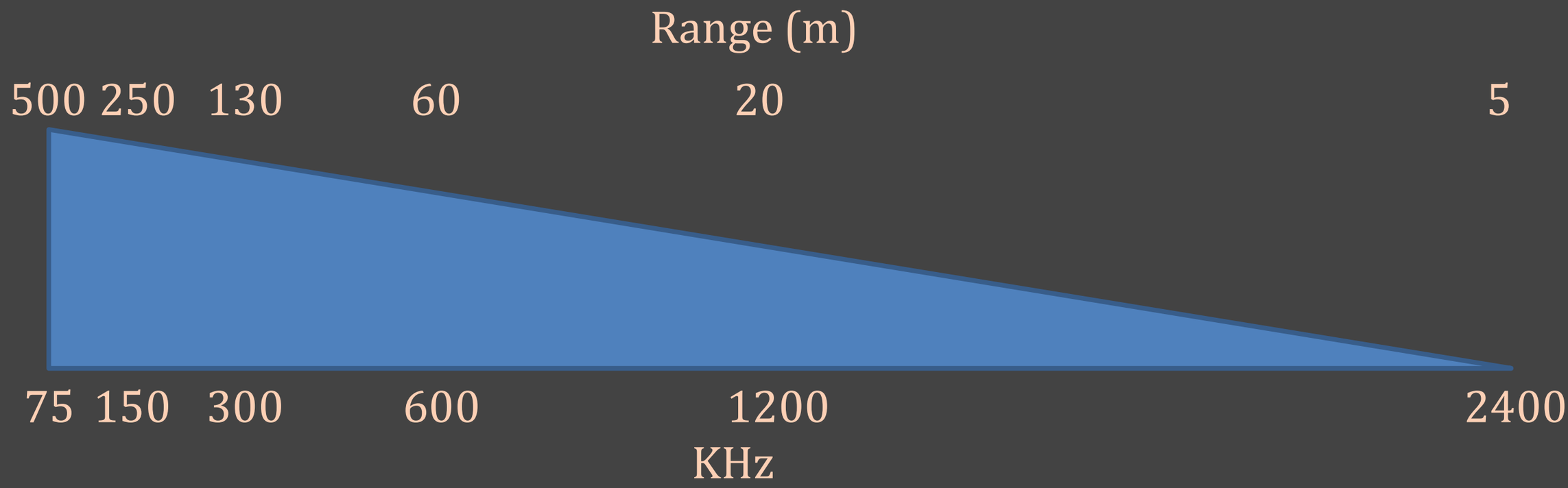
The shape of sound



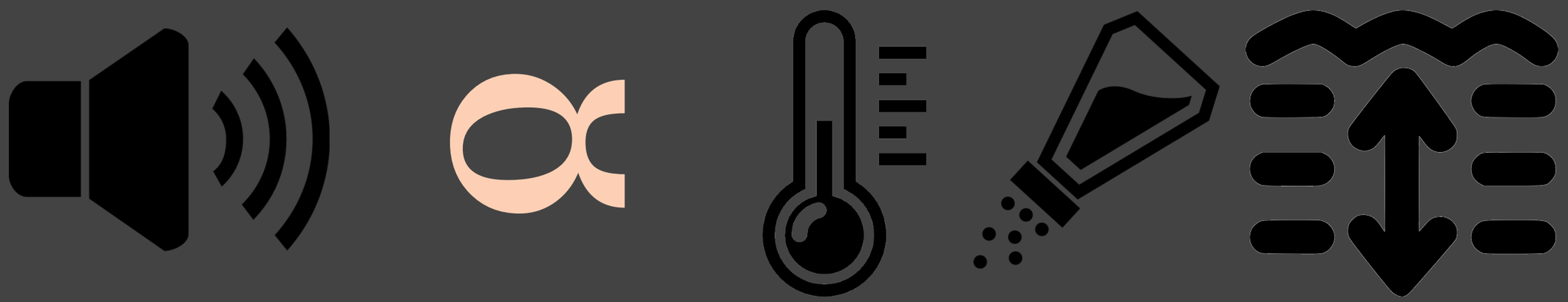


Courtesy : OGMS, and SPC

How far?



Sound speed and Ocean water

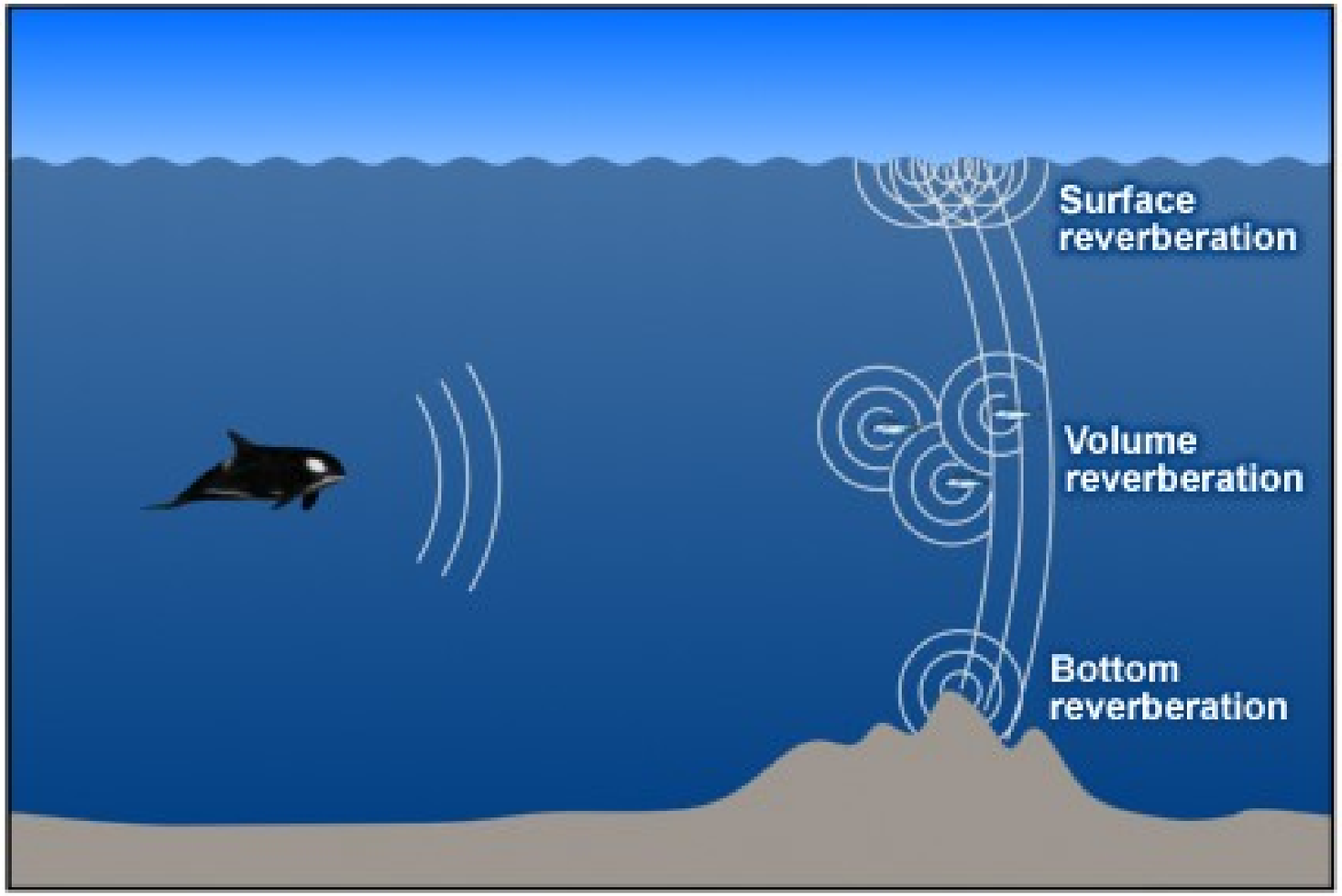


Factors

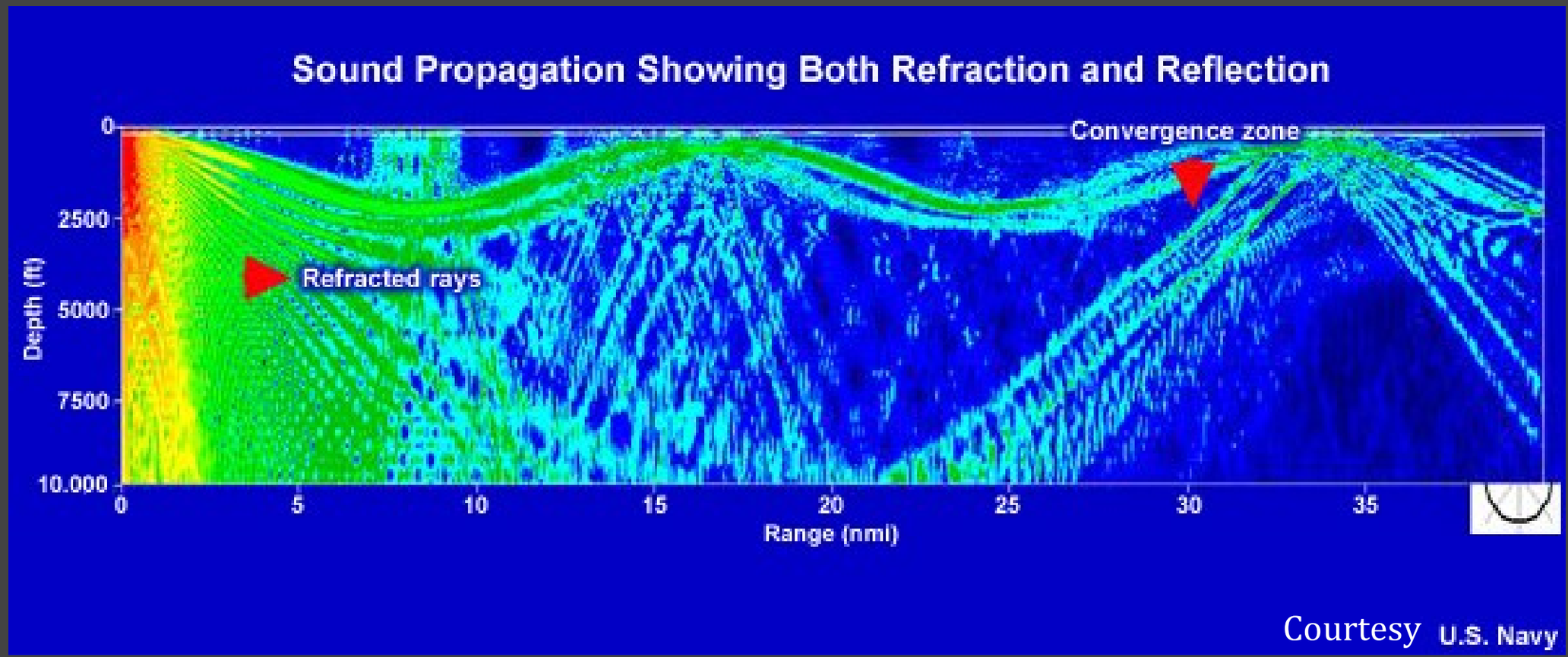
- Surface properties
- Column properties
- Bottom properties

- Fronts
- MLD
- Eddies
- Seasons

Types of Reverberation

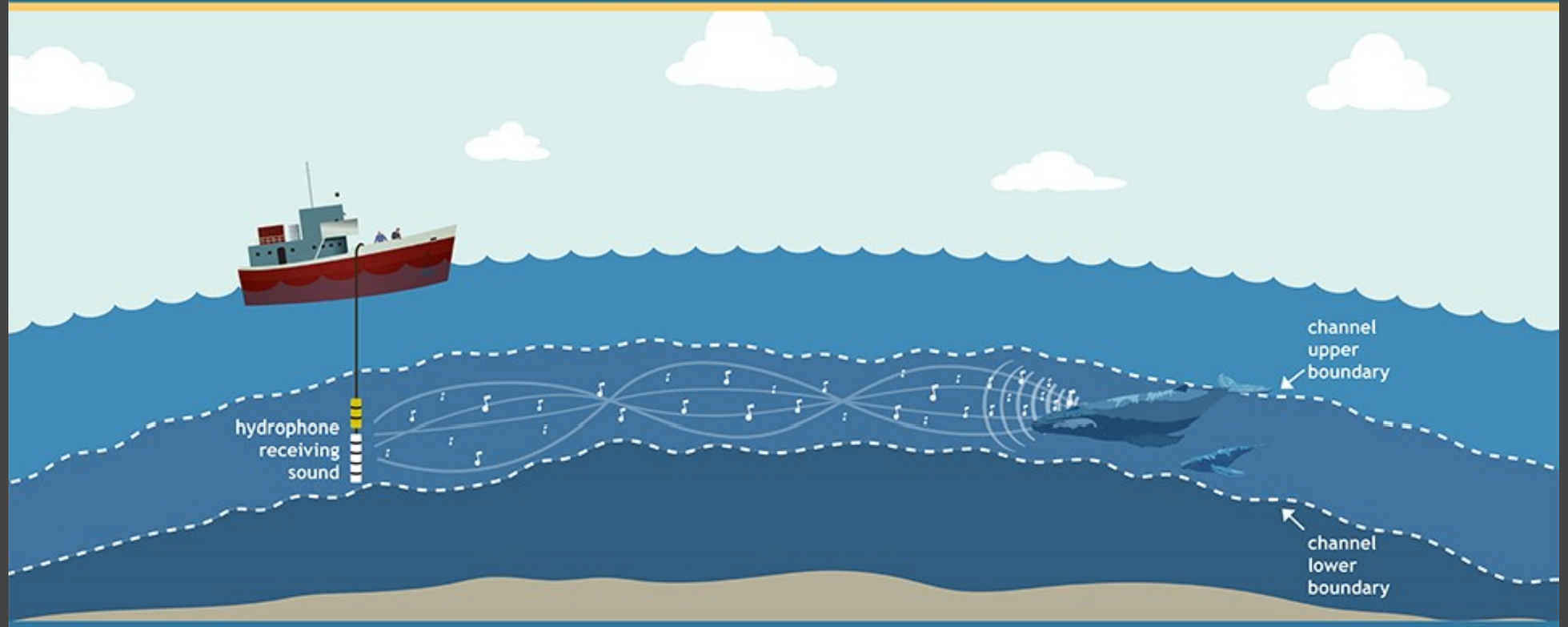


Courtesy ©The COMET Program


Sound Propagation Showing Both Refraction and Reflection
Convergence zone
Refracted rays
Depth (ft)
0
2500
5000
7500
10.000
0
5
10
15
20
25
30
35
Range (nmi)
Courtesy U.S. Navy

What is SOFAR?

SOFAR, or Sound Fixing and Ranging Channel, is a naturally-occuring ocean "channel" that allows sound to carry great distances



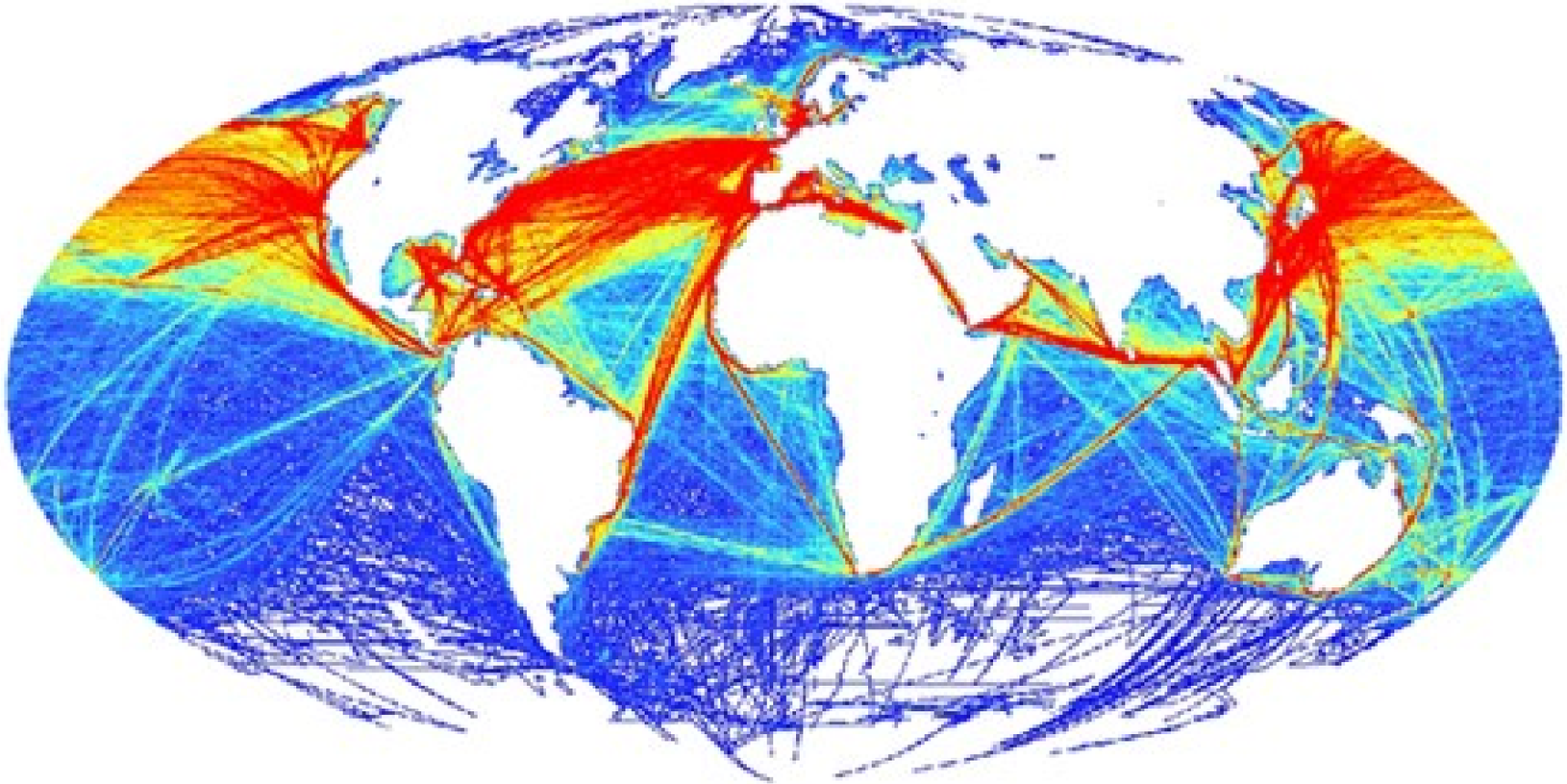
Courtesy : NOAA

Applications

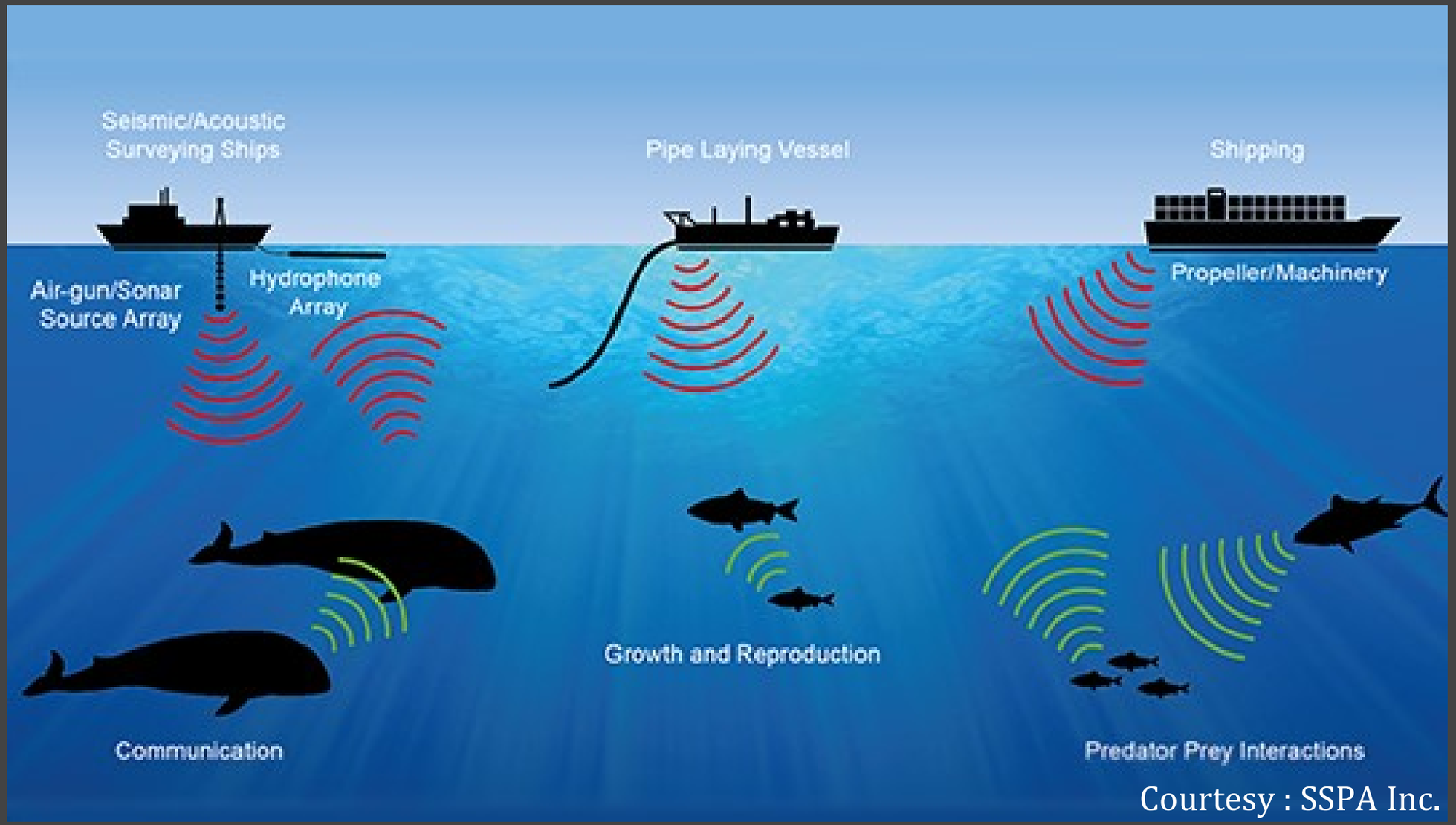
- Noise, PAM

- SONAR, ADCP, Surveys
- Bioacoustics
- Fishery Acoustics
- Acoustic and Hybrid telemetry

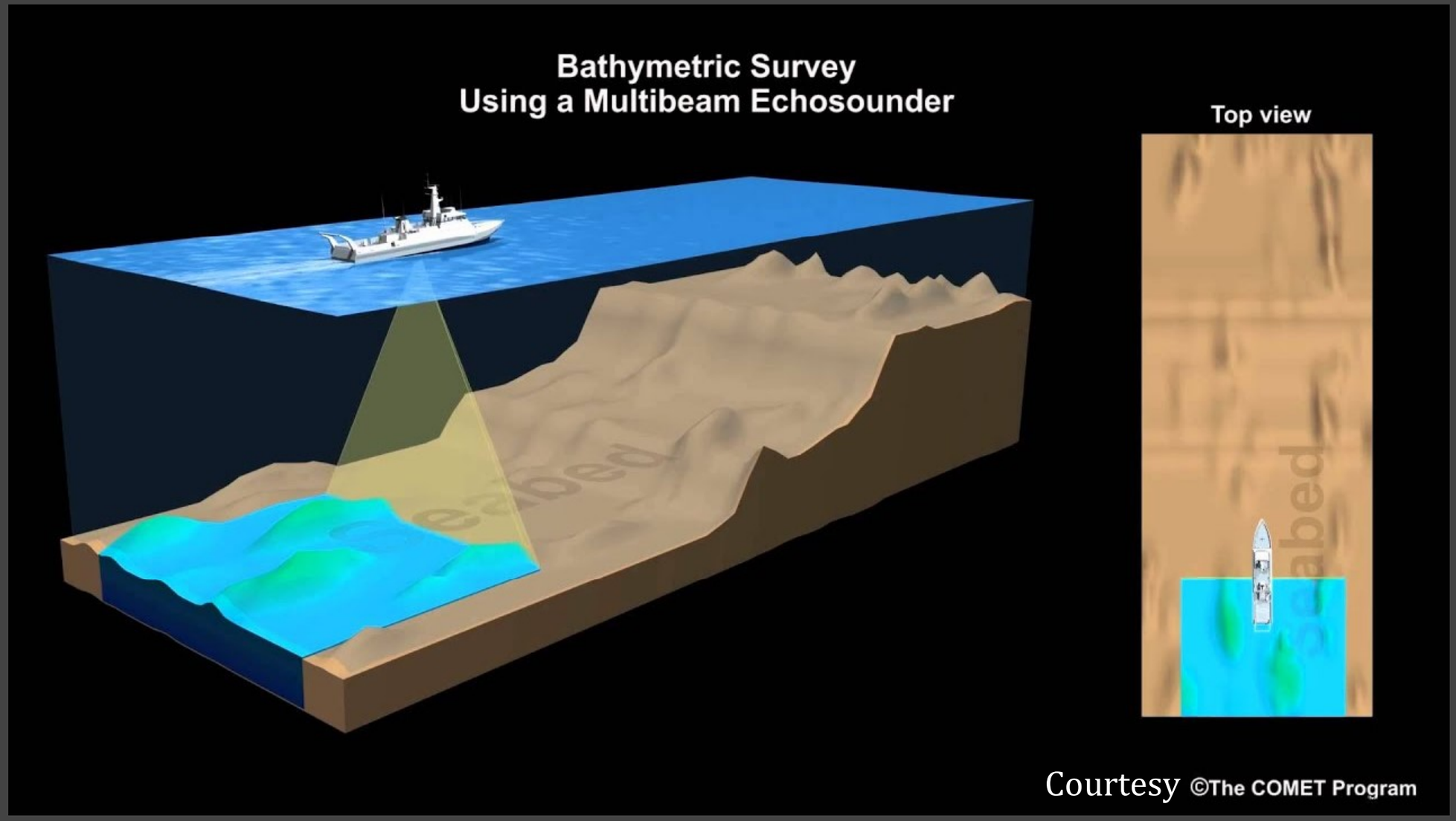
Global Shipping Activity

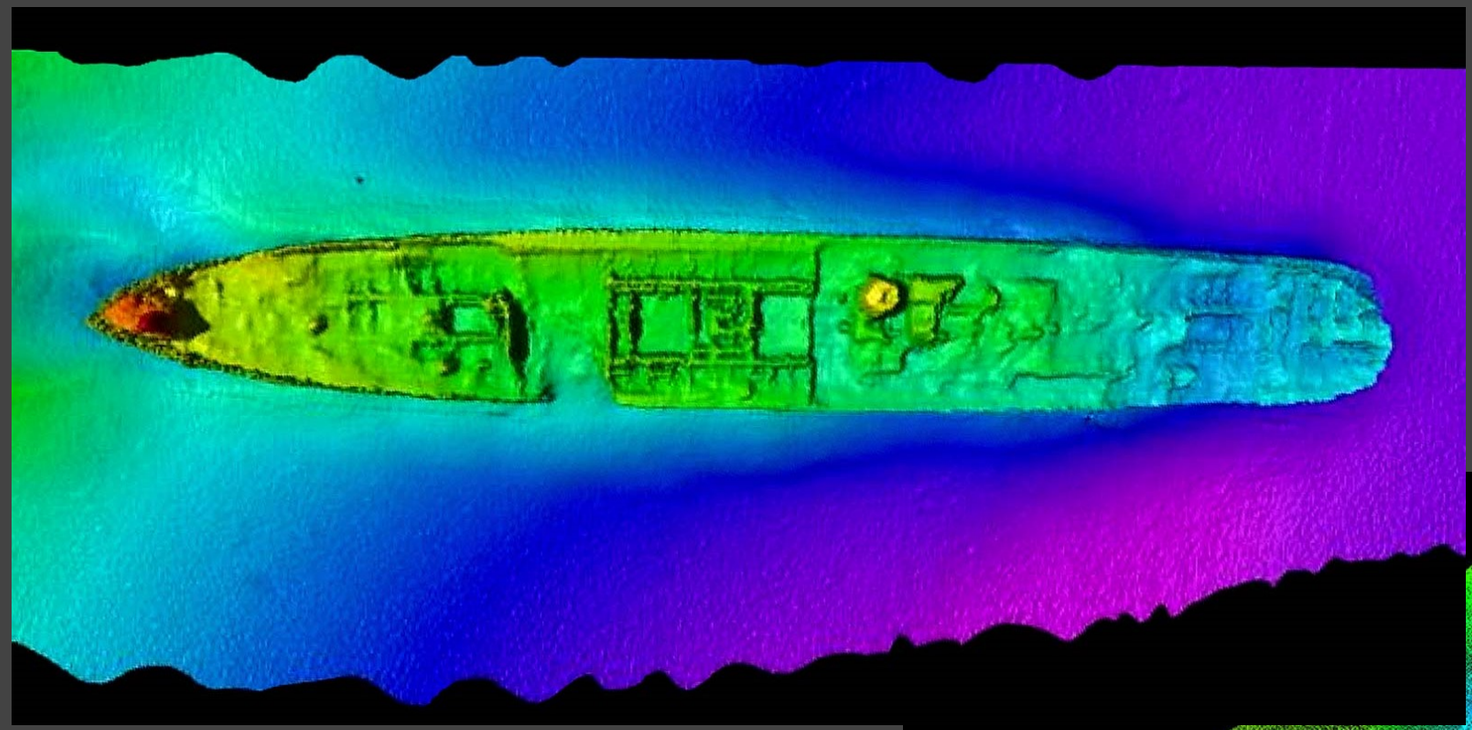


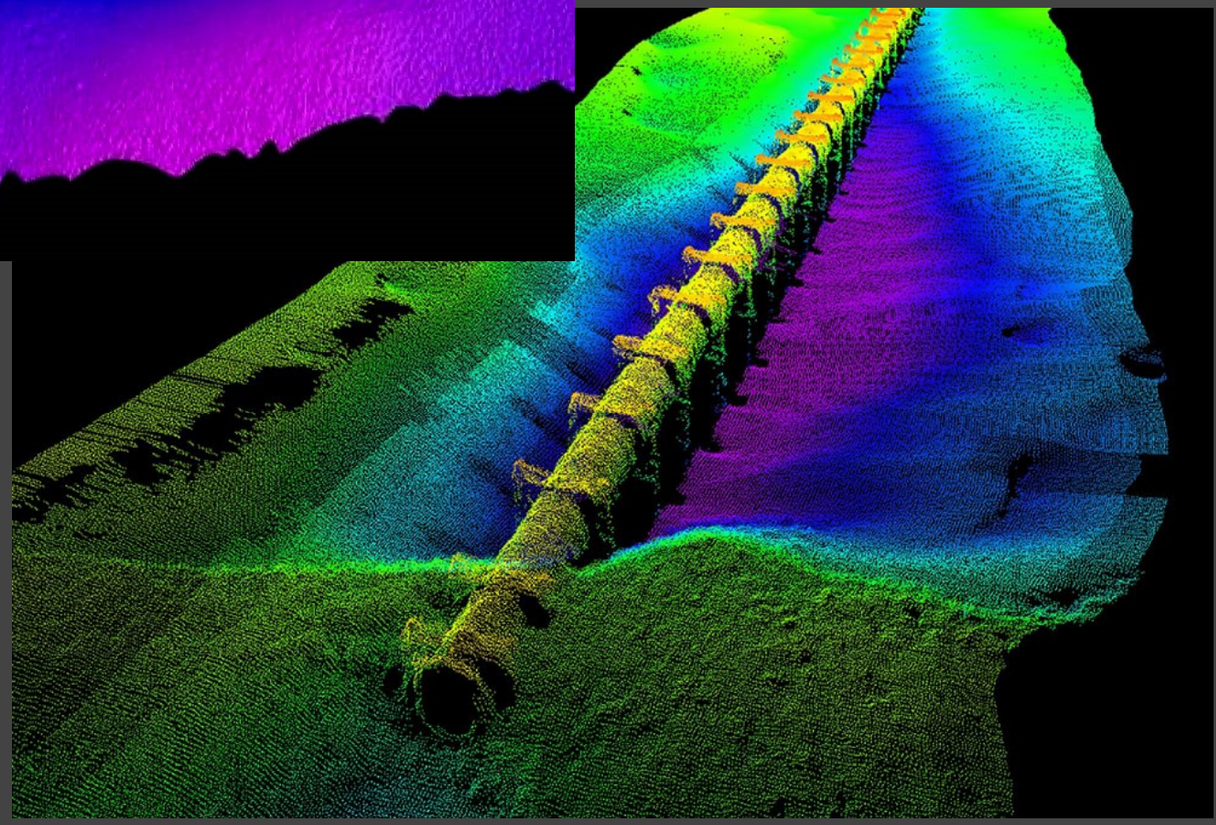
Courtesy National Center for Ecological Analysis and Synthesis



Courtesy : SSPA Inc.

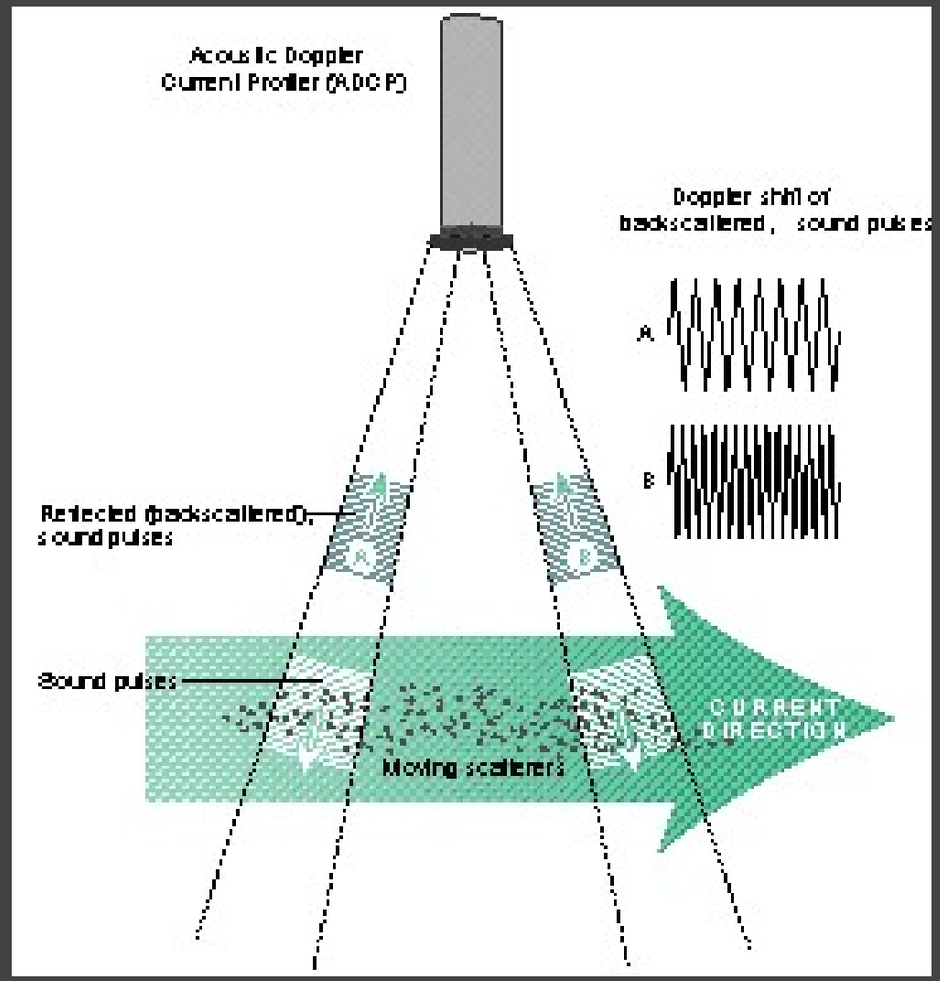

Bathymetric Survey
Using a Multibeam Echosounder
Top view
Seabed
Courtesy ©The COMET Program



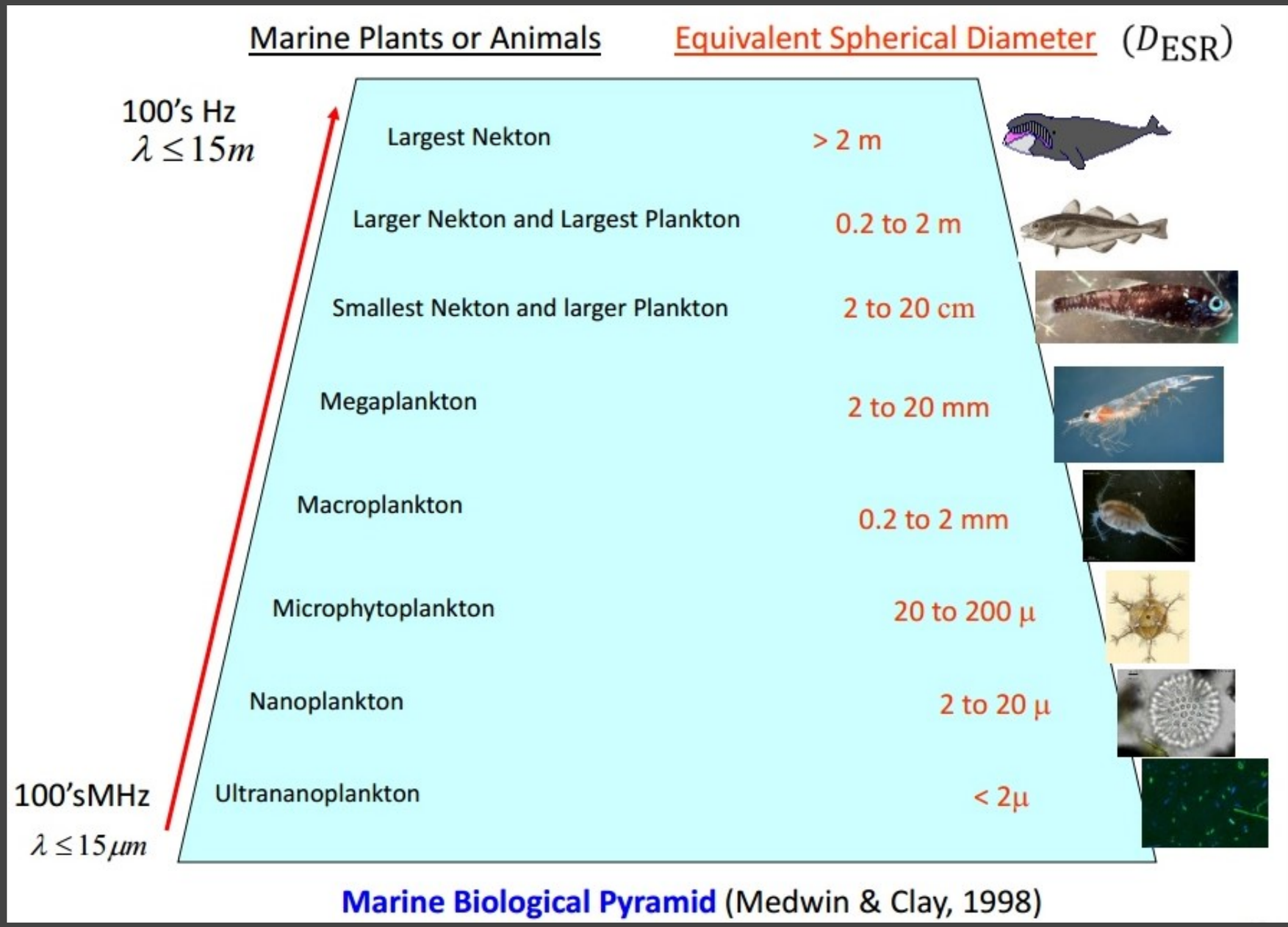


Courtesy: BlueNomads, Aspect Surveys

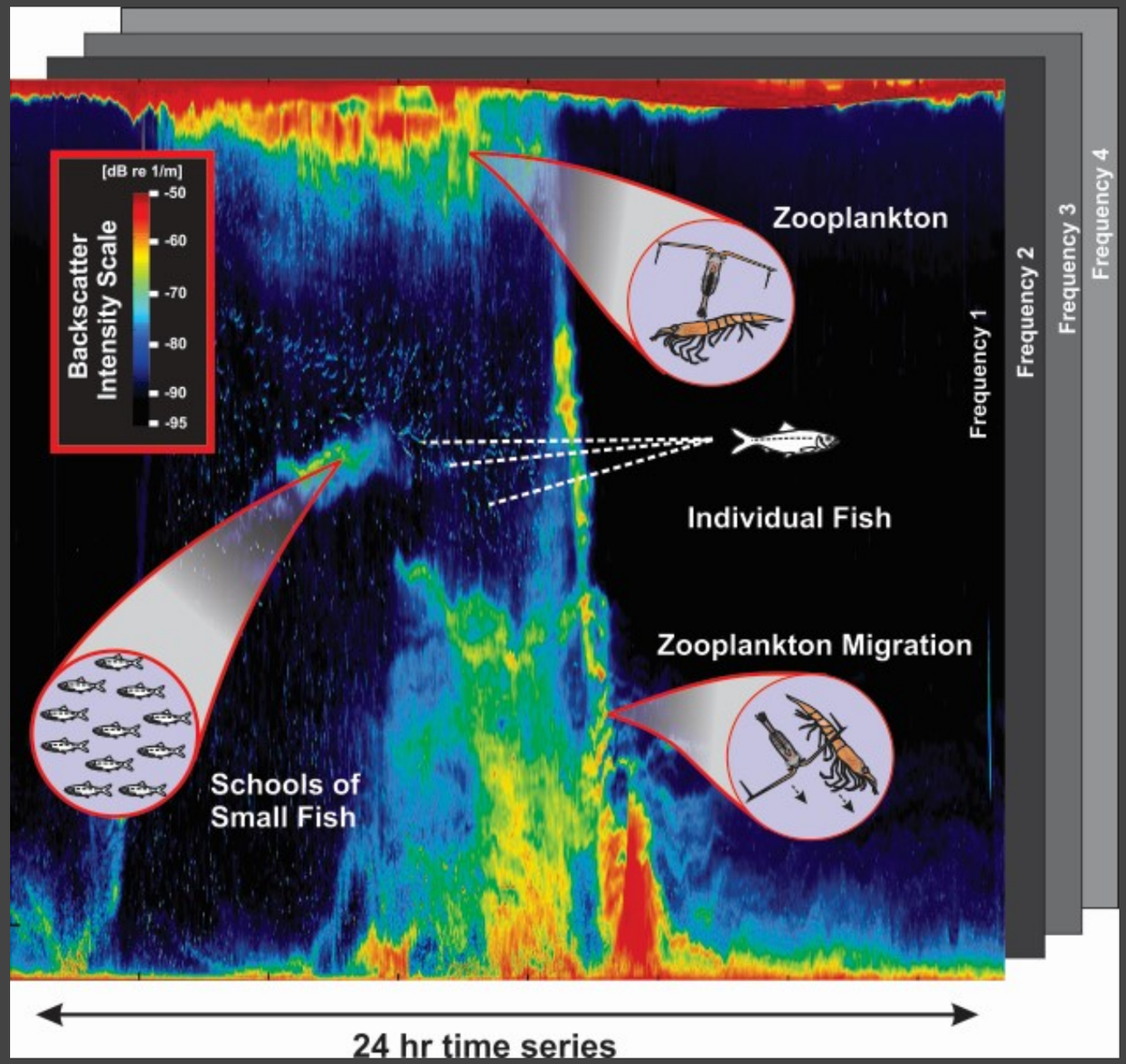
Tracking particles with sound



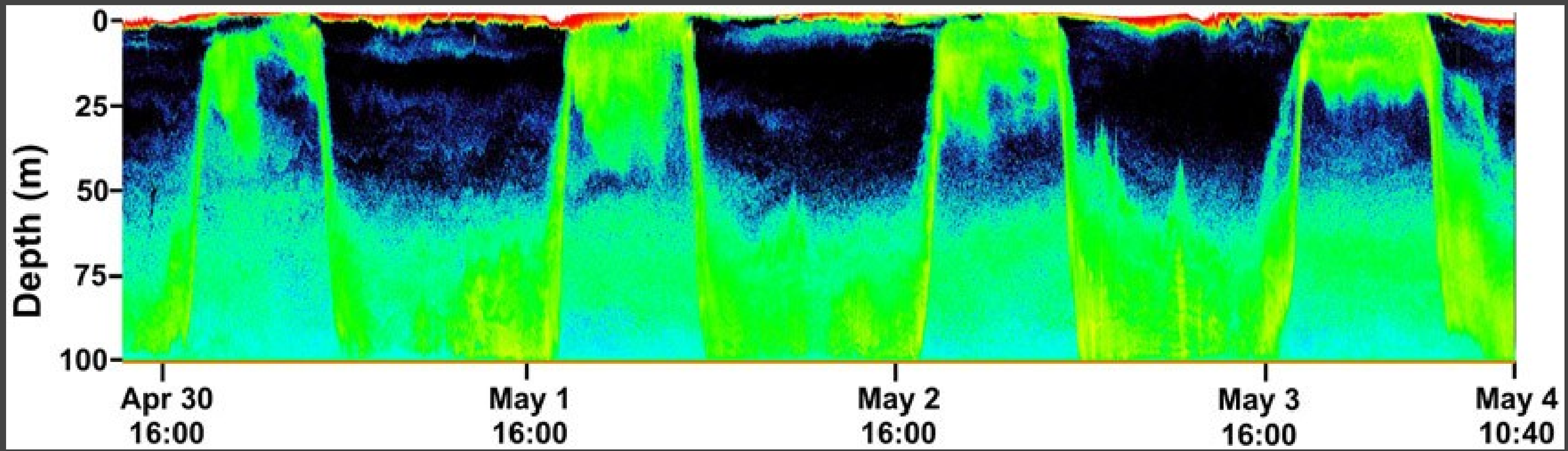
Courtesy: Teresa K. Chereskin, SIO, UCSD



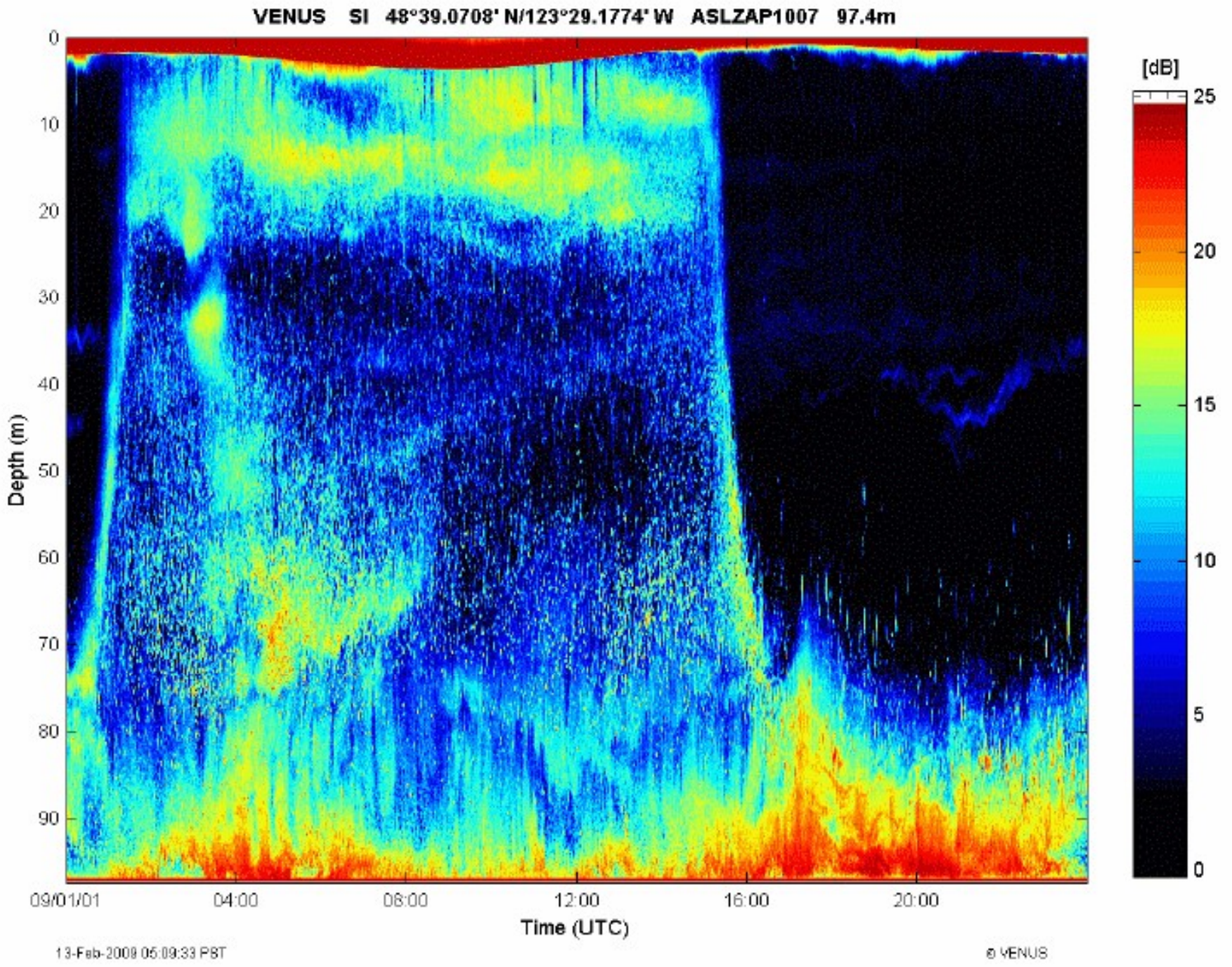
Marine Biological Pyramid (Medwin & Clay, 1998)



Courtesy : ASL Env. Sc., Ca

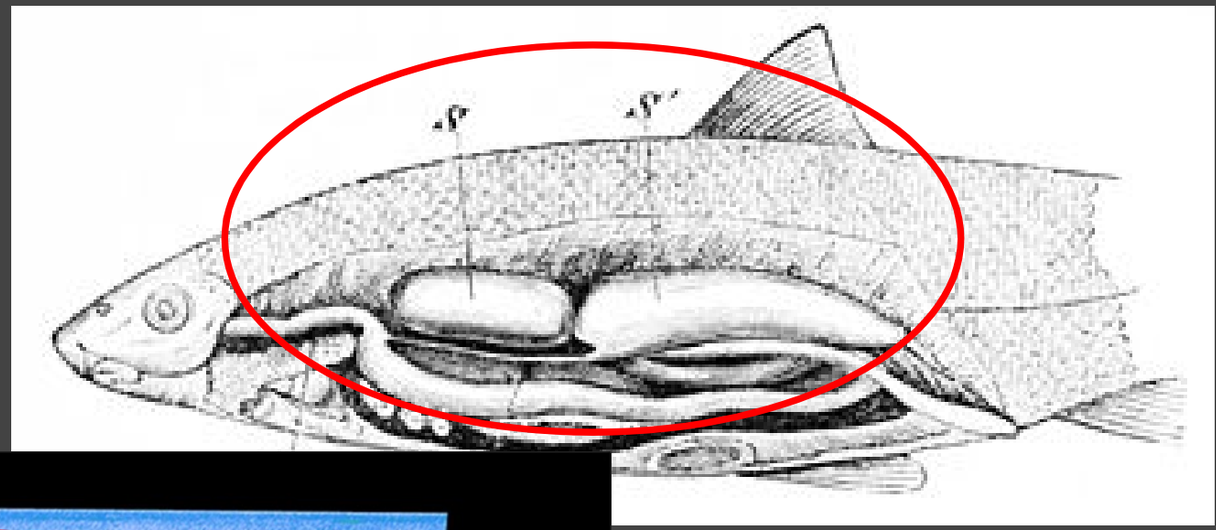


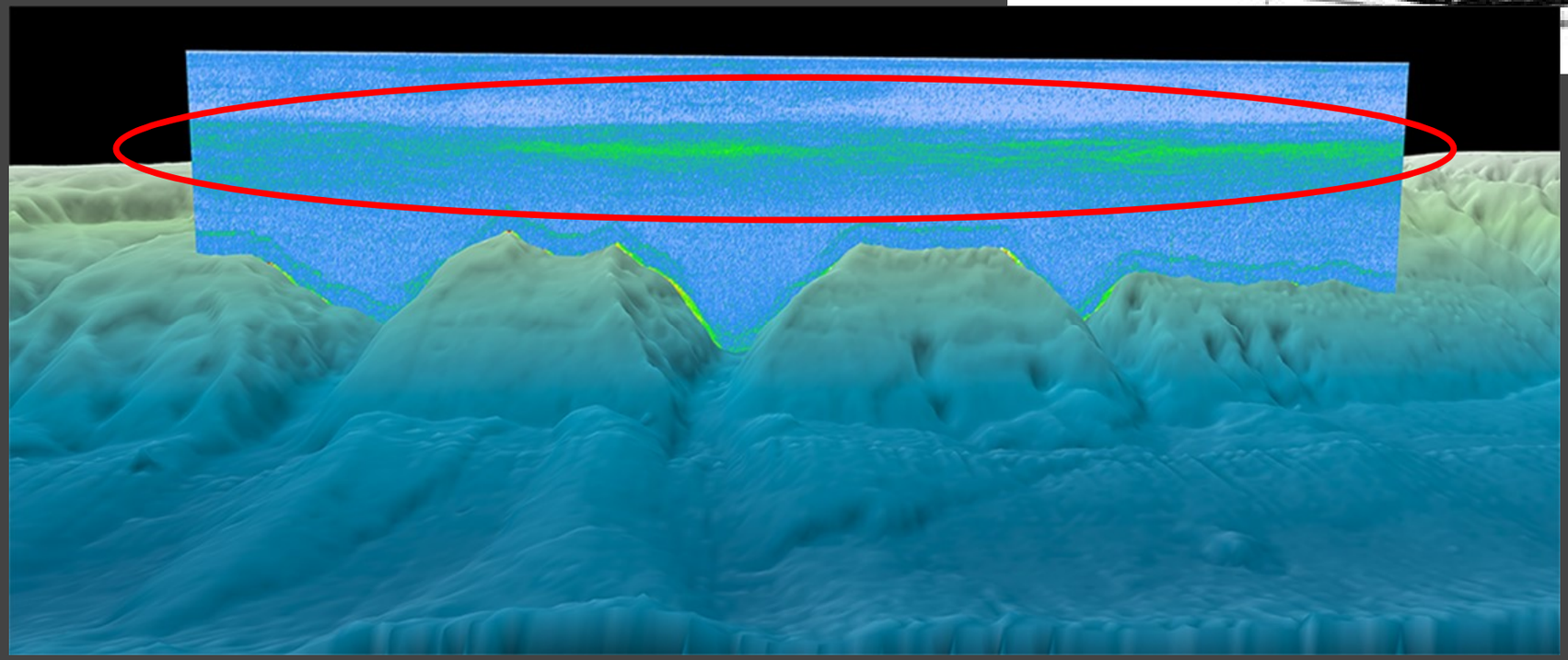
•Courtesy : ASL Env. Sc., Ca



Courtesy : ASL Env. Sc., Ca

Fish detection

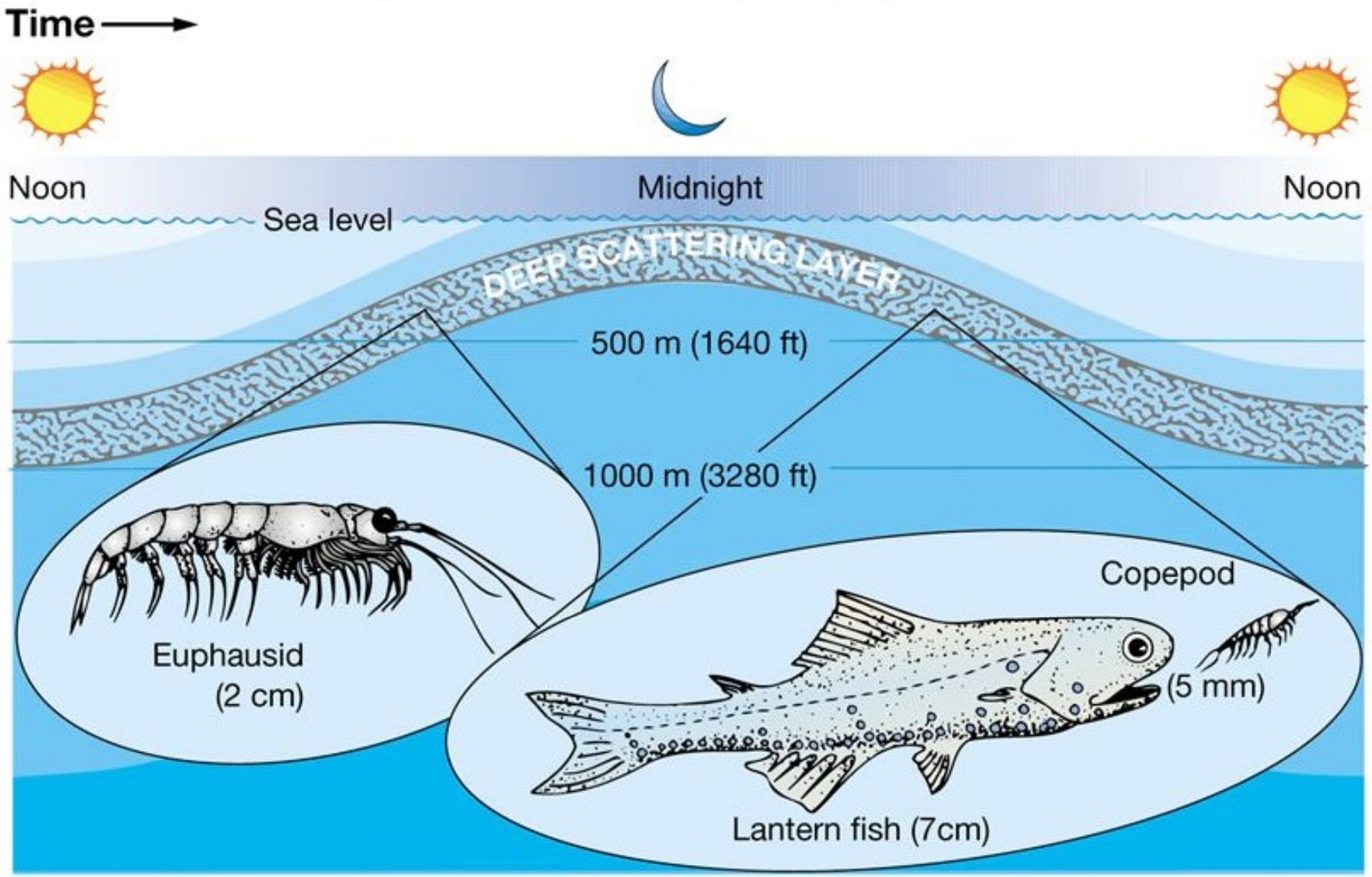




Courtesy :

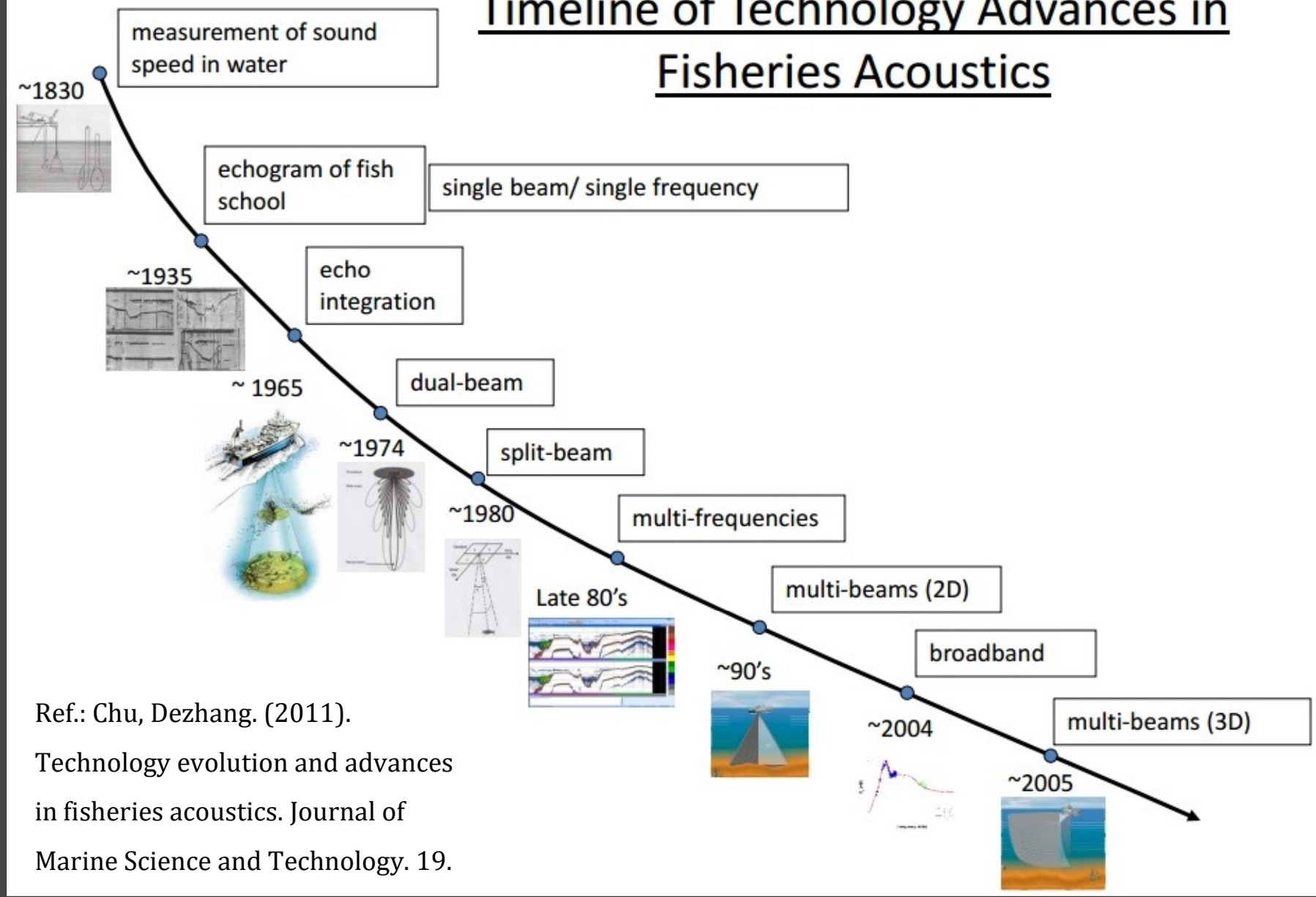
WikiMedia Commons

Deep scattering layer



Courtesy &

Timeline of Technology Advances in Fisheries Acoustics



Ref.: Chu, Dezhang. (2011). Technology evolution and advances in fisheries acoustics. Journal of Marine Science and Technology. 19.

The future norm

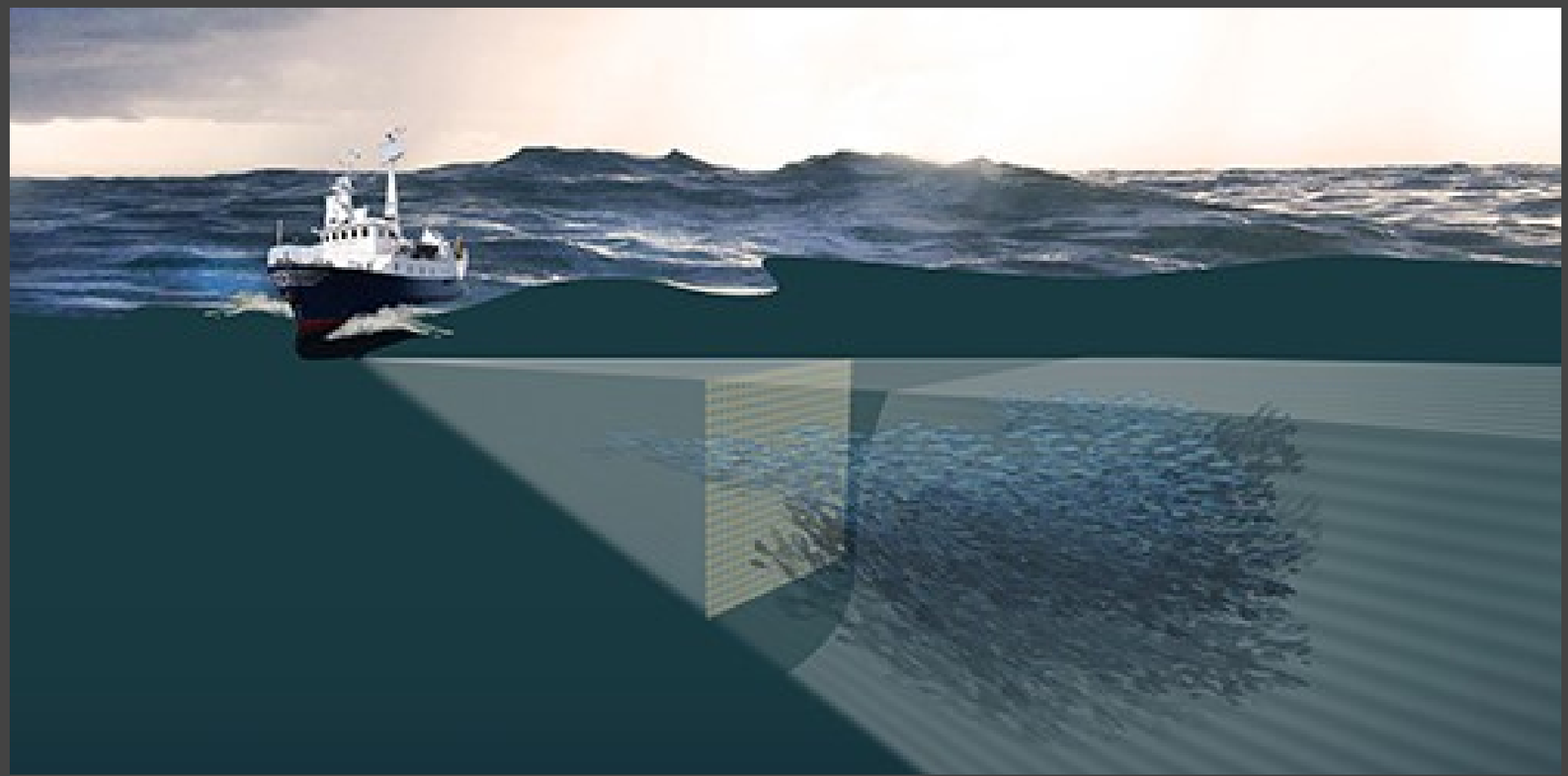
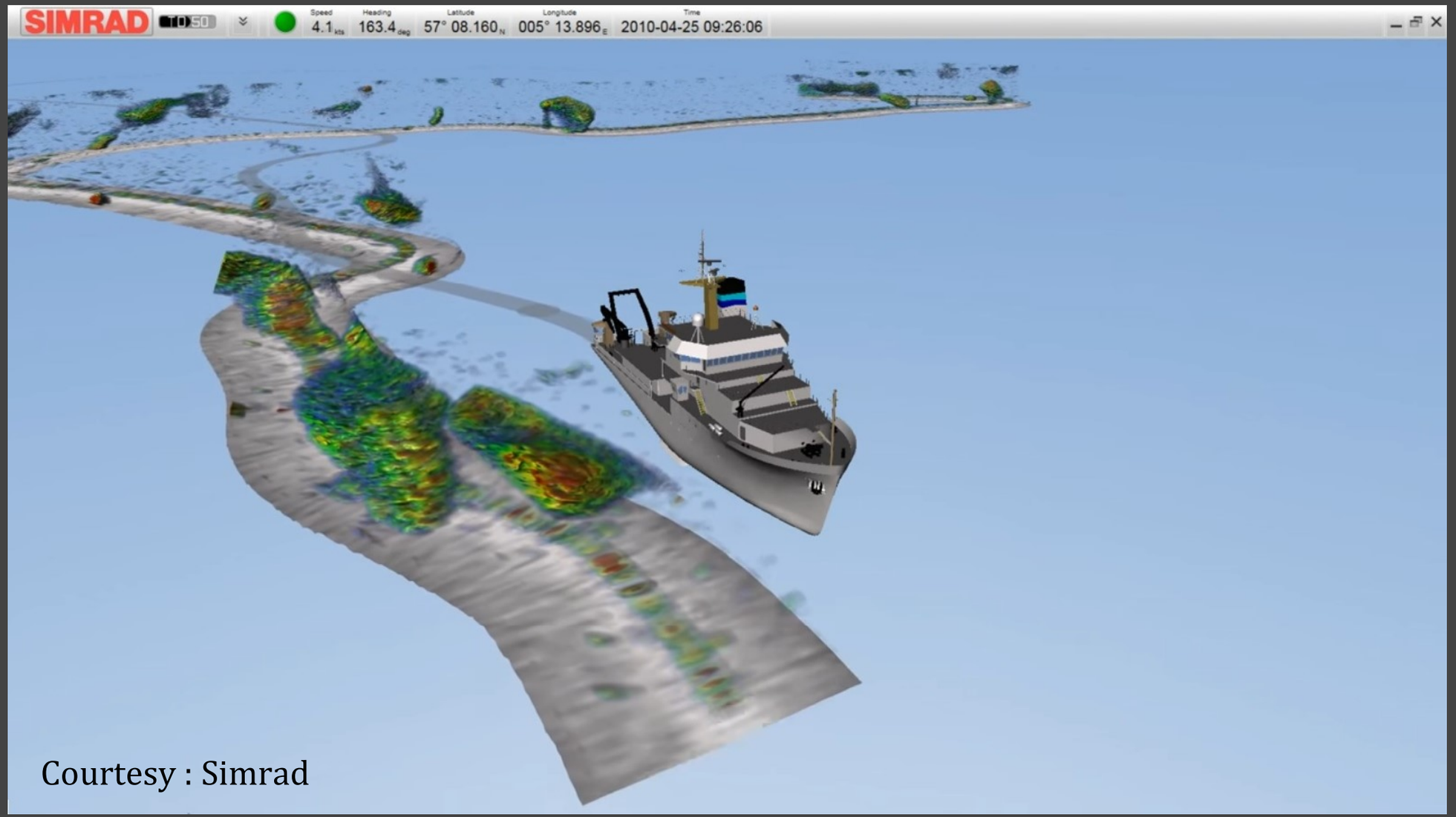


Photo Courtesy : Simrad

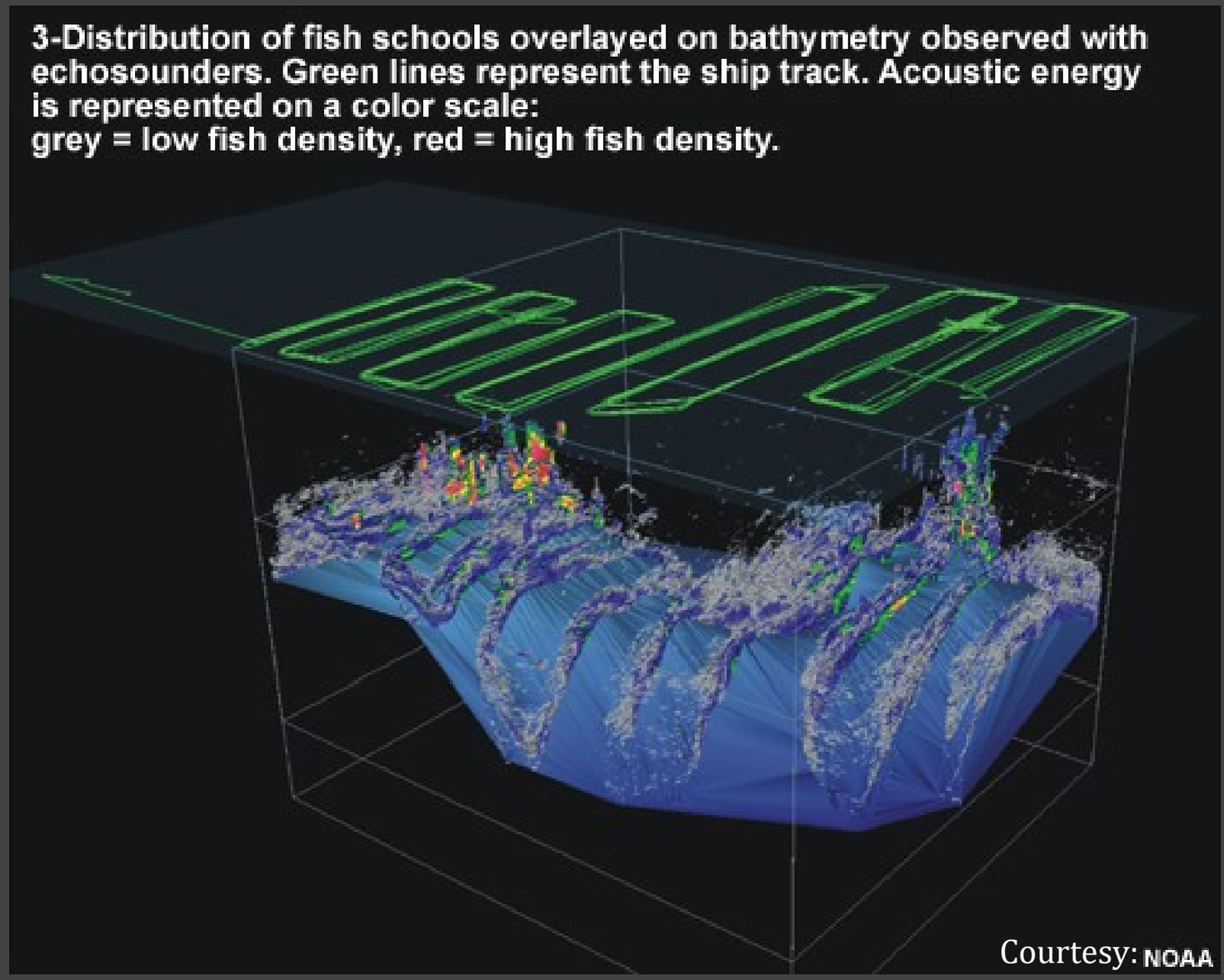


Acoustic data sample, color indicates backscatter intensity (i.e. biomass)

Advantages

- Conventional being used by fishermen
- Qualitative estimation of fishing location
- Scientific surveys go step further, quantify biomass
- Non-intrusive, advanced capability to map fish density
- Continuous, on-the-go, no need for stopping the ship
- Ideal for habitat-scale scientific studies
- **1400 times more volume coverage** than to the trawling (in unit time)
- Holistic approach to study the species along with other parameters
- Adopted as SOP by NOAA Fisheries

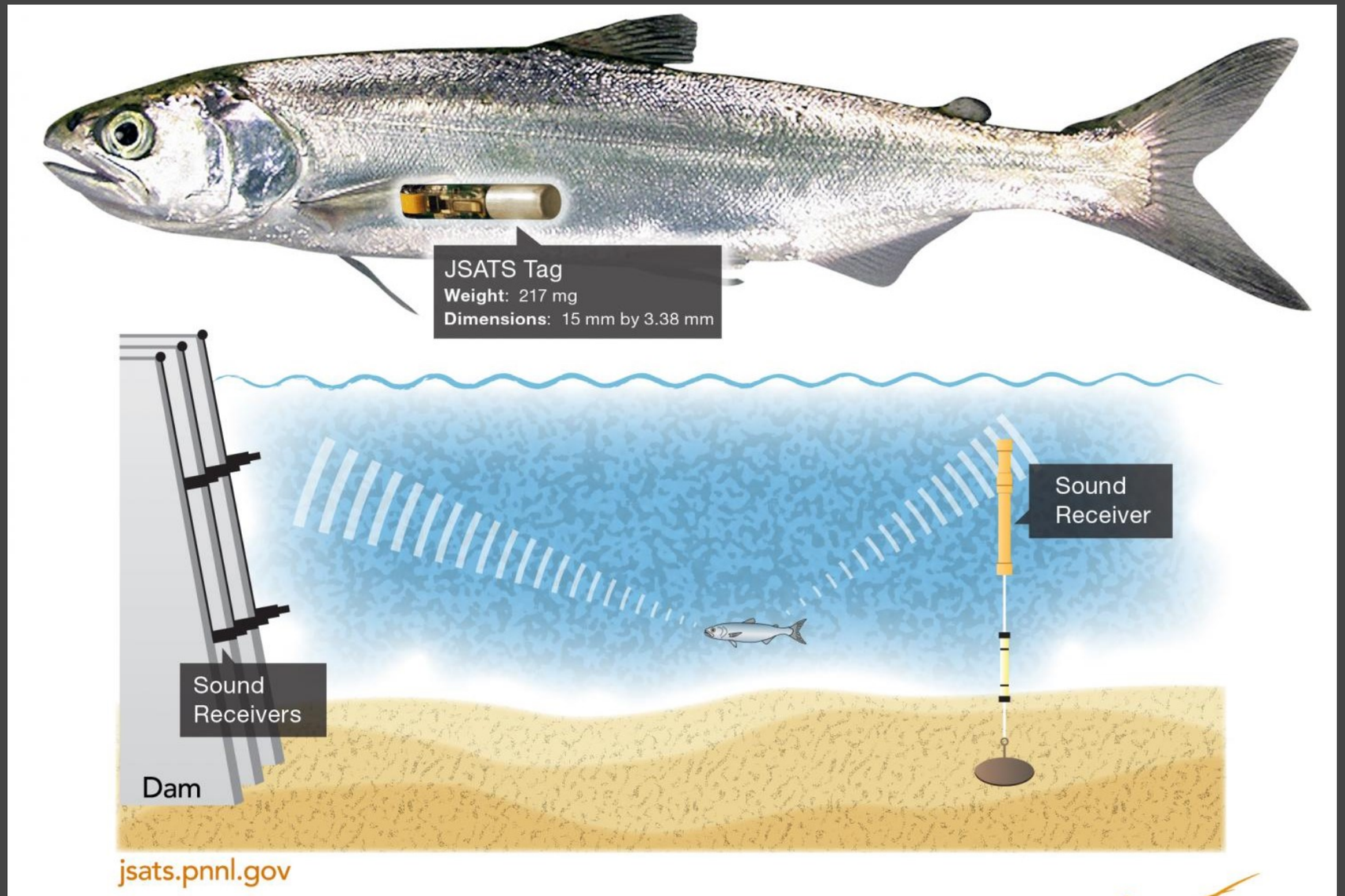
3-Distribution of fish schools overlayed on bathymetry observed with echosounders. Green lines represent the ship track. Acoustic energy is represented on a color scale:
grey = low fish density, red = high fish density.



Courtesy: NOAA

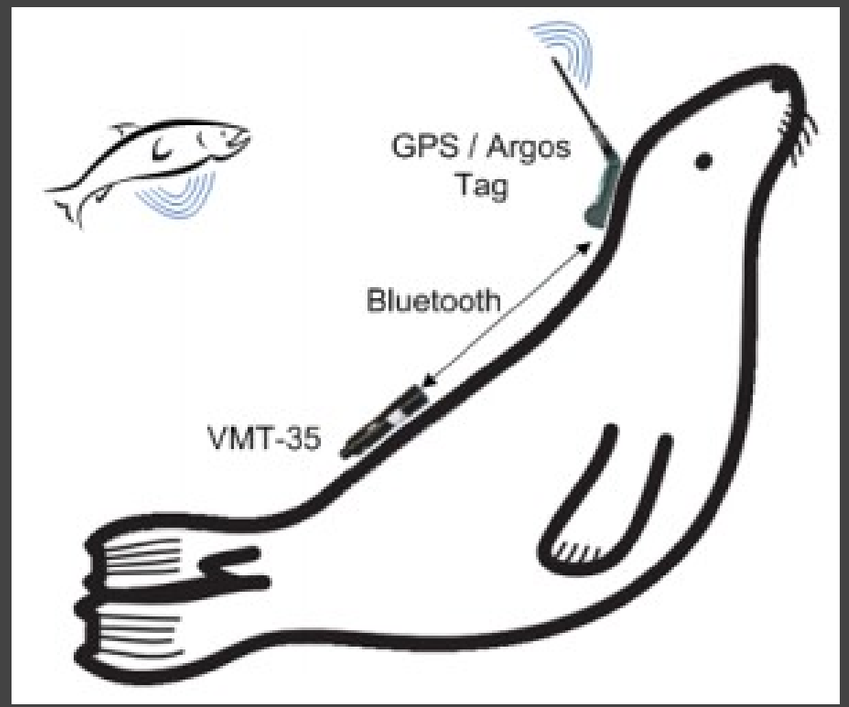
Acoustic Telemetry

•Courtesy: RSMAS, Uni. of Miami

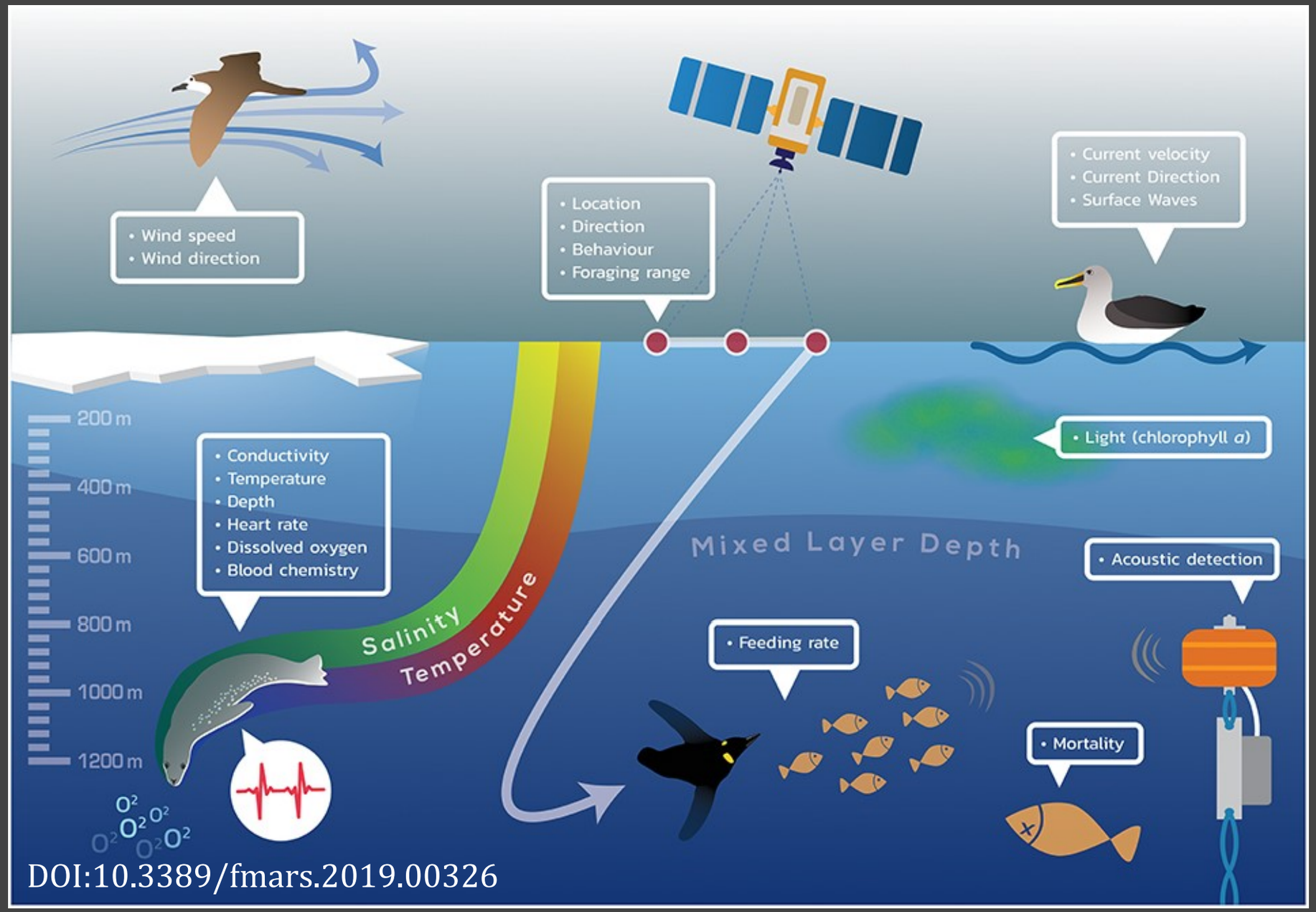


Courtesy: PNNL

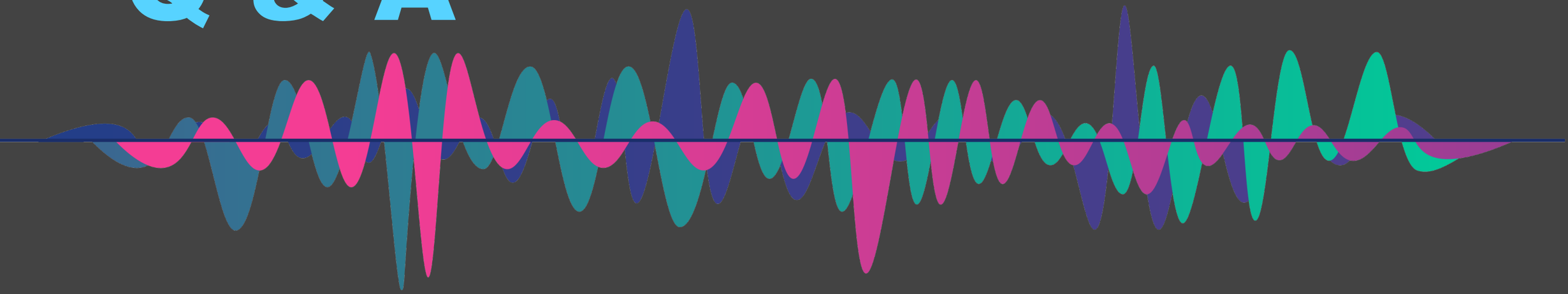
Difficult study-area?



Courtesy: SMRU and Vemco


• Wind speed
• Wind direction
• Location
• Direction
• Behaviour
• Foraging range
• Current velocity
• Current Direction
• Surface Waves
200 m
400 m
600 m
800 m
1000 m
1200 m
• Conductivity
• Temperature
• Depth
• Heart rate
• Dissolved oxygen
• Blood chemistry
Salinity
Temperature
• Light (chlorophyll a)
Mixed Layer Depth
• Acoustic detection
• Feeding rate
• Mortality
DOI:10.3389/fmars.2019.00326

Q & A



nimitkumar.j@incois.gov.in