



# ***Marine Ecosystem Acoustics: A cost-efficient approach to ecosystem information***

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New Technology for a Blue Future  
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# Requirements for Ecosystem approach to management

- Understanding of ecosystem composition and dynamics
- Capabilities to assess status
- Abilities to adequately predict development of system and components (particularly harvested stocks)
- Abilities to handle risks





# Marine Ecosystem Acoustics concept

- Acoustics is the only method that support observations at **spatial and temporal scales** relevant to the processes to be observed
- **Detection, identification and quantifications**

Demand development of the following:

- Technology: Tailor acoustic sensors to the task – **utilize beam and bandwidths**
- Operation: Establish operational capabilities to **put sensors where processes occur**
- Modelling: **Tailor modelling to the opportunities offered by acoustics**



# Ecosystem approach

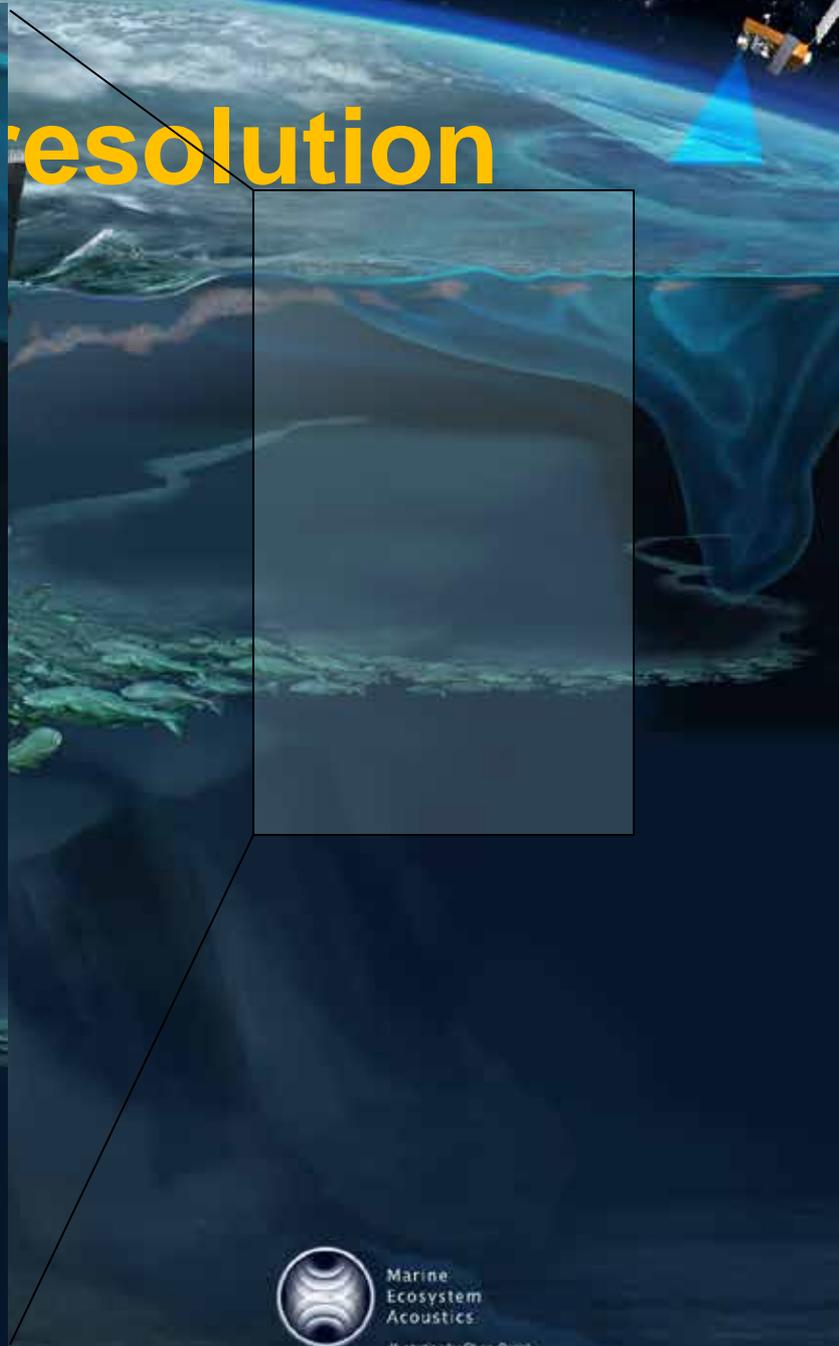
- **Conventional sampling aggregates in time and space**
- **Can not observe details and processes**
- **Acoustics can! And this talk focuses on demonstrating the possibilities**



Marine  
Ecosystem  
Acoustics

Illustration by Ulynn Gorick  
glyn@gorick.co.uk

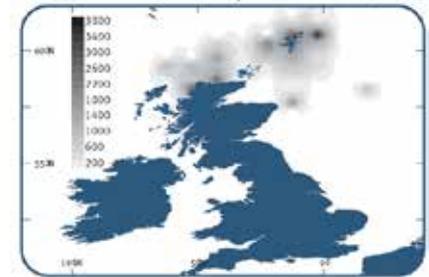
# Resolution



Marine  
Ecosystem  
Acoustics

Illustrator: Glynn Gorick  
glynn@gortek.co.uk

# Time – space resolution from copepods to whales



mm

cm

m

km

Low bass notes

20Hz

Animals and Chemistry

20KHz

Medical and Destructive

Diagnostic and NDE

2MHz

200MHz

Infrasound

Acoustic

Ultrasound

# Exploiting bandwidth -detection

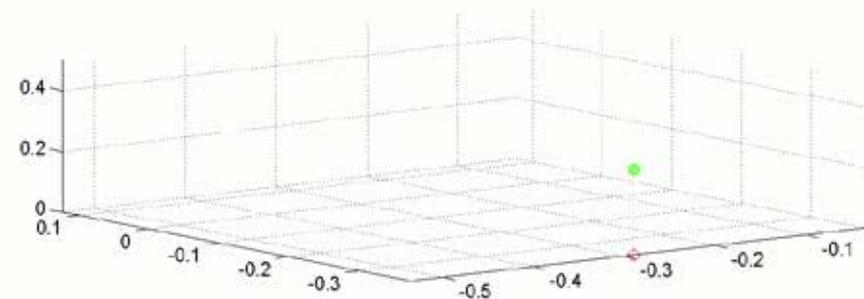
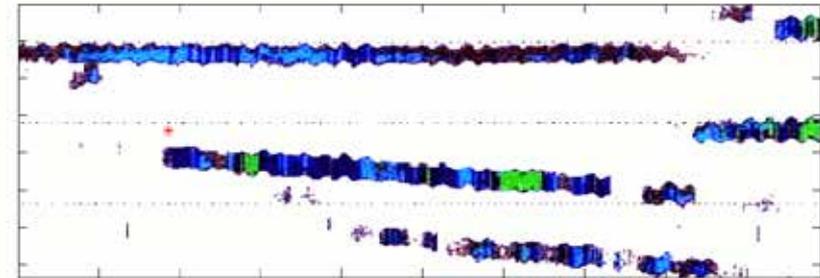
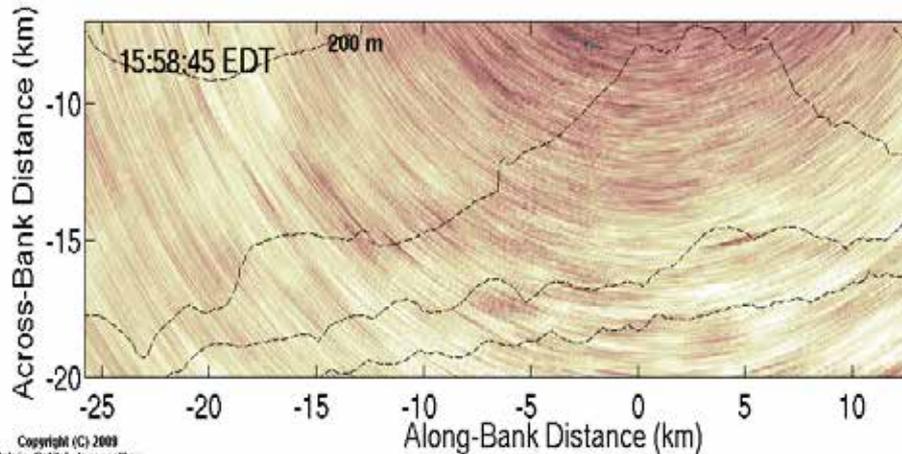
## From individual to population

Herring behaviour at sub  
population scale

Makris et al. 2009

Krill behaviour at cm scale  
Klevjer & Kaartvedt, University  
of Oslo.

Formation and Migration of Herring Shoals on October



# How can we do it?

## Operational challenges

- **Acoustic technology** – utilize beam and bandwidth
- **Platform development** – put sensor where processes occur and combine sensors
- **Operational skills**
- **Modelling** – coordinate and integrate data with variable time – space resolution



# Vessel acoustics

- Geographical coverage
- Multiple freq/Broadband acoustics
- Multibeam acoustics
- Probing systems
- Towed systems
- Vessels are operators of alternative platforms

- Mobile acoustics
  - Vessel
  - UV vehicles
- Stationary acoustics



Marine  
Ecosystem  
Acoustics

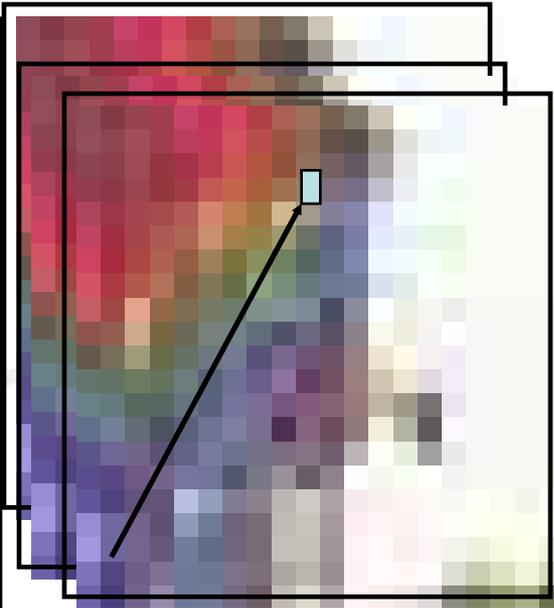
Illustration by Clynie Gorick  
glynn@gorick.co.uk

# Exploiting bandwidth – Identification

Multiple frequencies

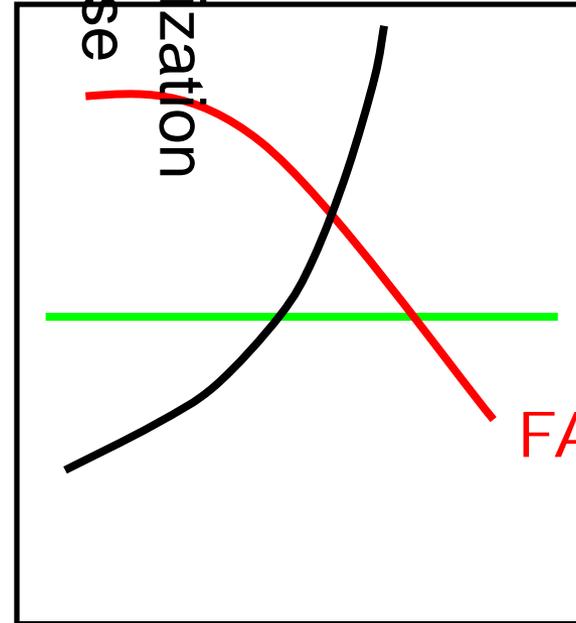


Response by freq.



(PIXEL)

Characterization by response



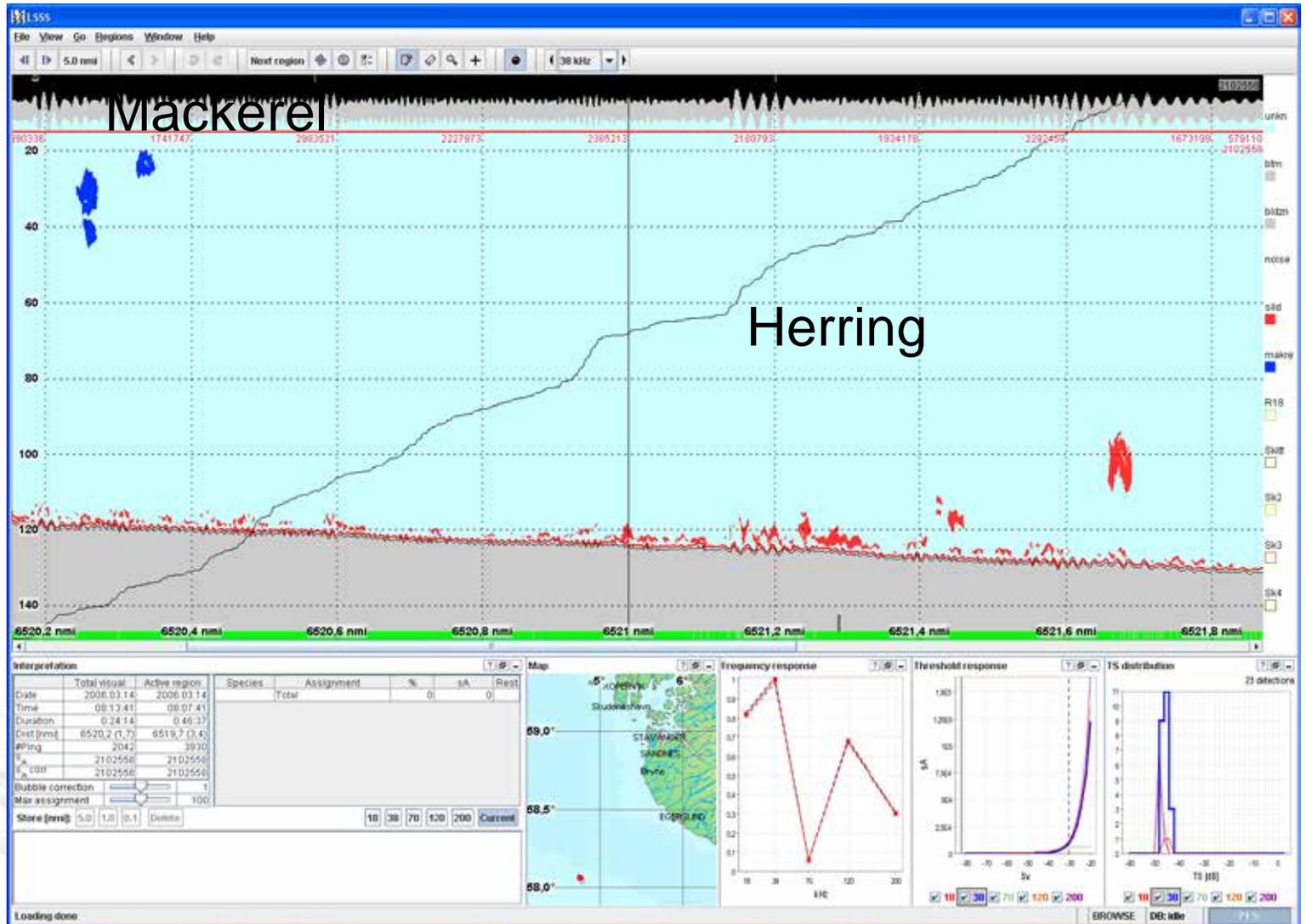
INCREASING

FLAT

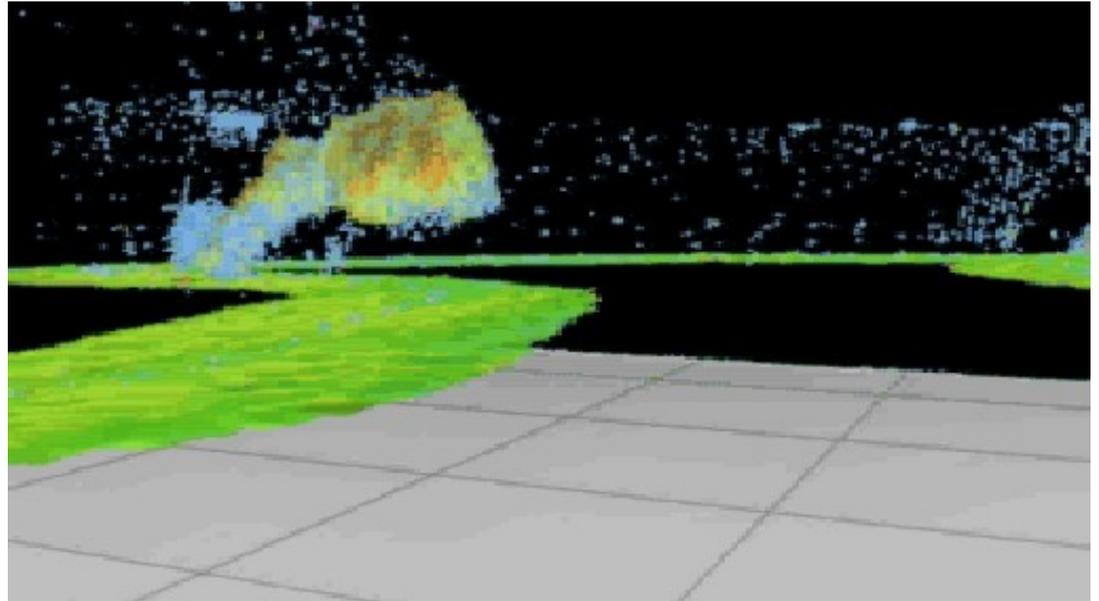
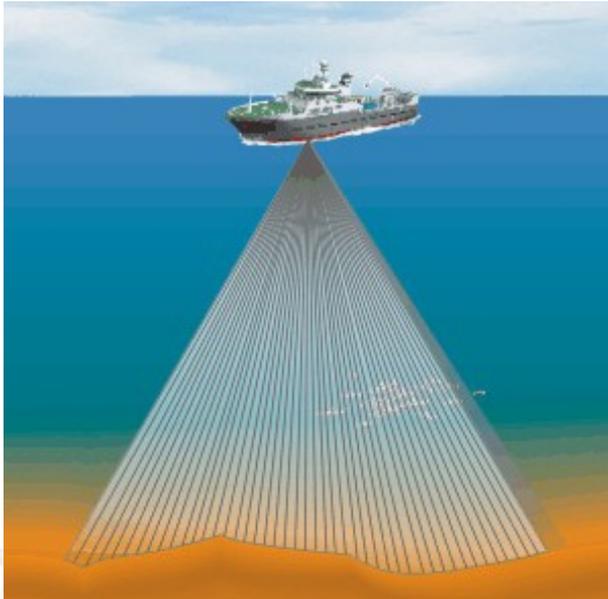
FALLING

FREQUENCY

# NEW SYNTHETIC ECHOGRAM



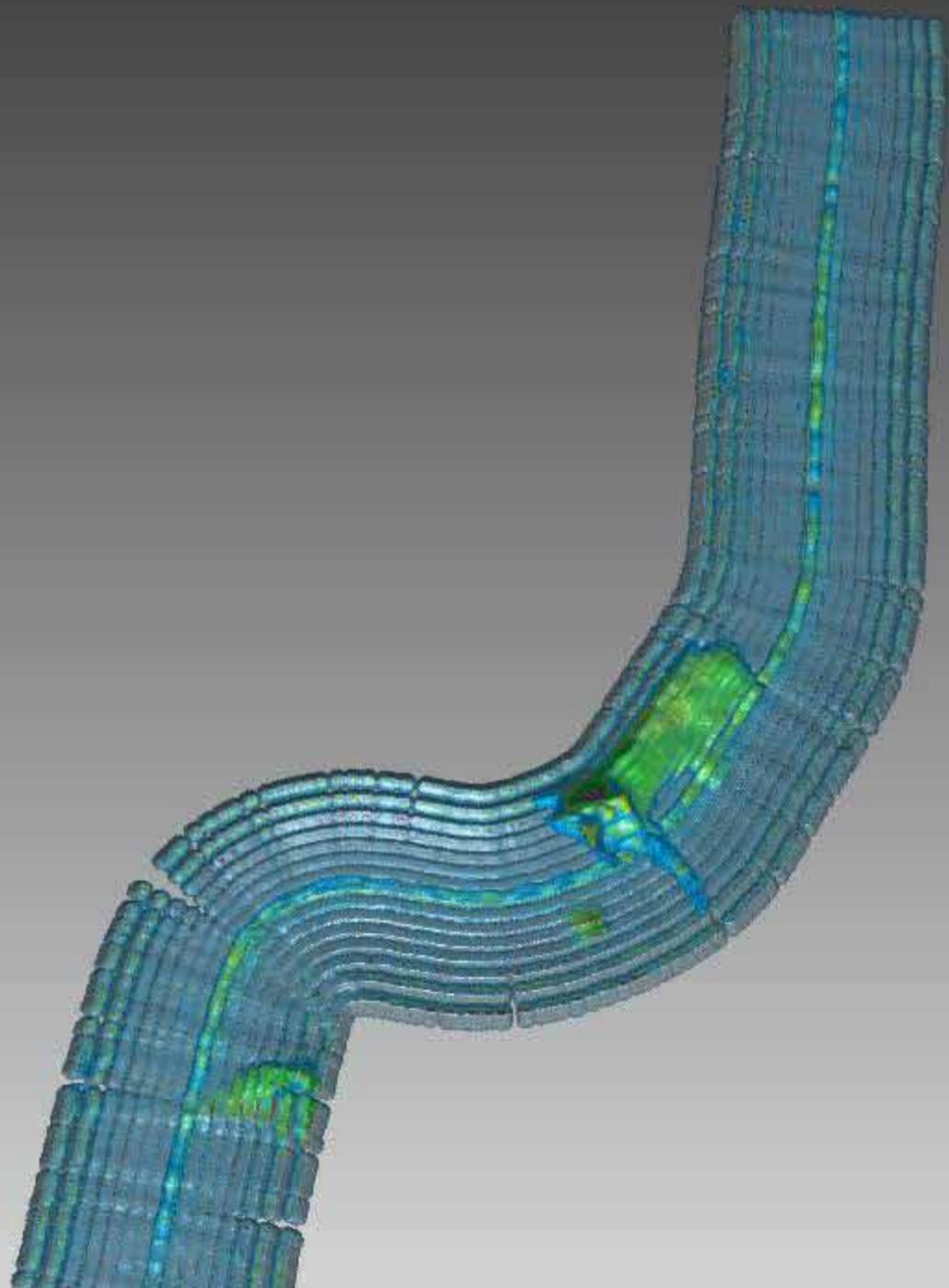
# Quantitative multibeam echo sounder/sonar Simrad ME70/MS70

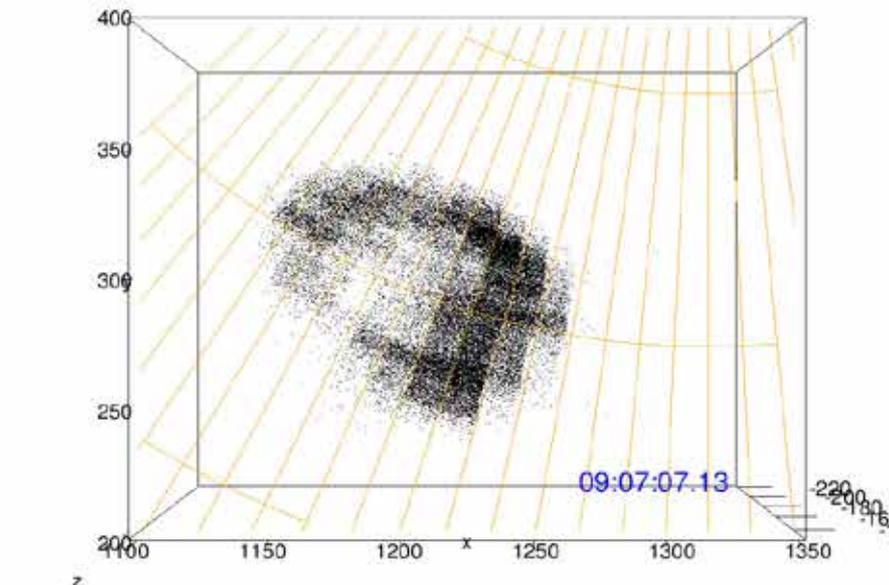
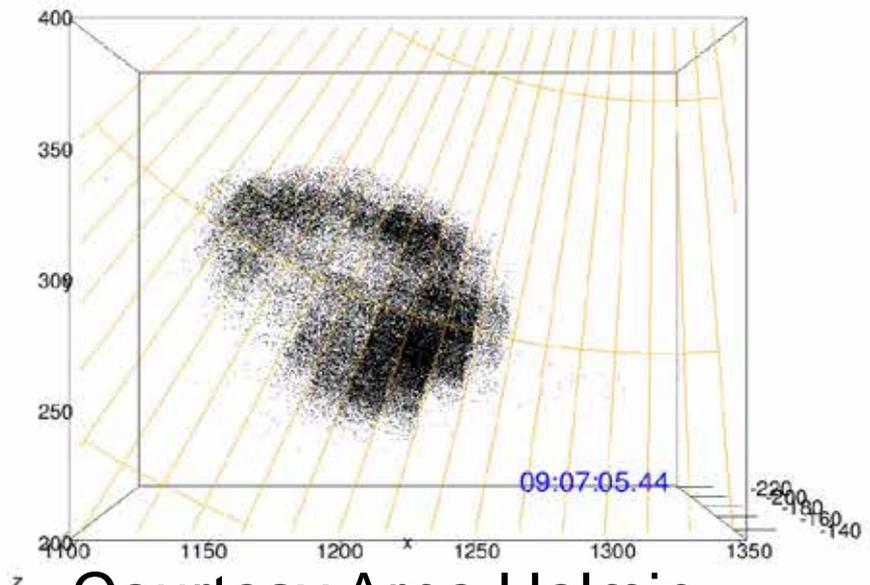
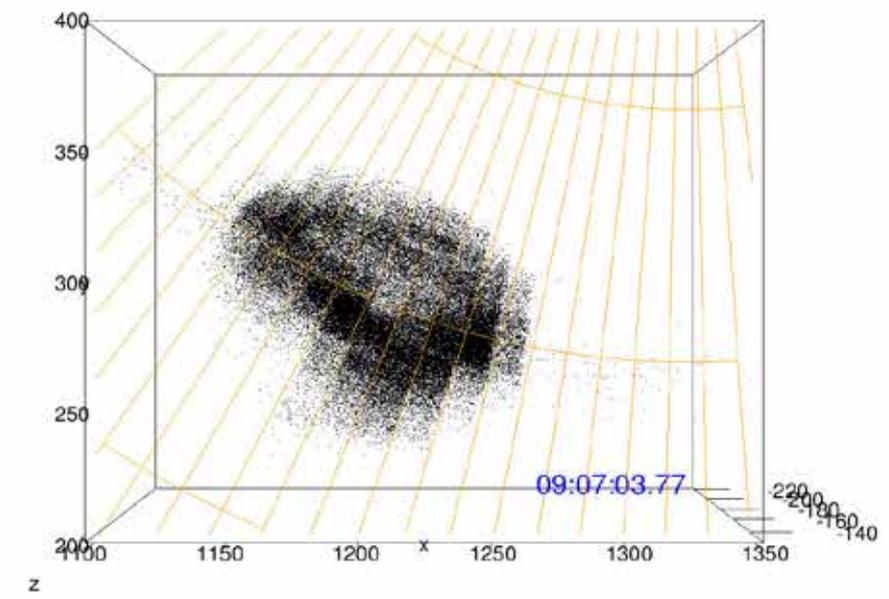
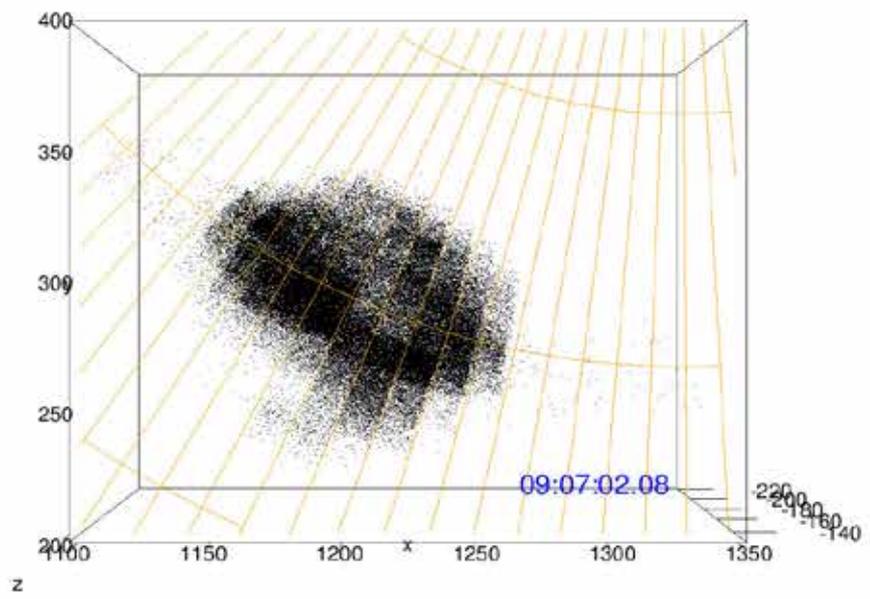


Expanding beam width  
45 stabilized split beams  
2D-3D  
Near bottom detection

- 3D image of a school of
- Sand eel using ME70
- Reduce uncertainty of behaviour and density estimates





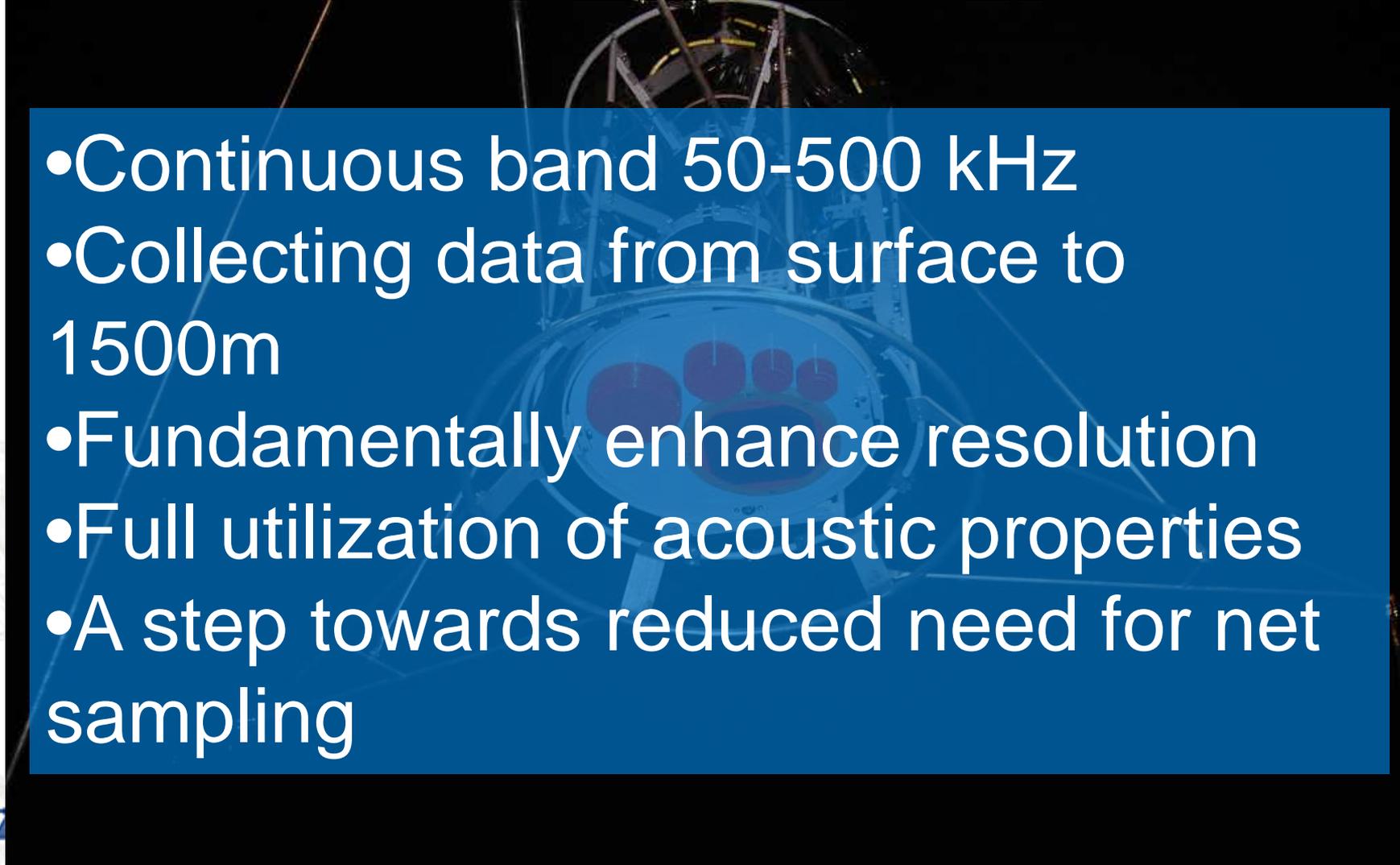


Courtesy Arne Holmin

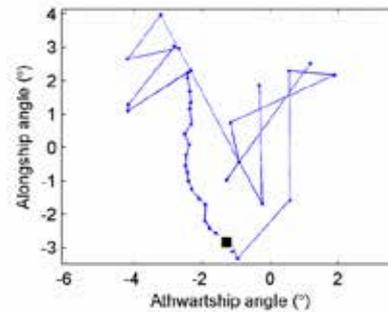
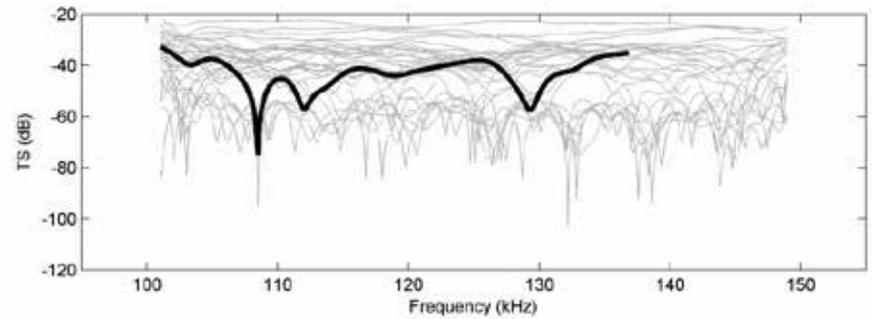
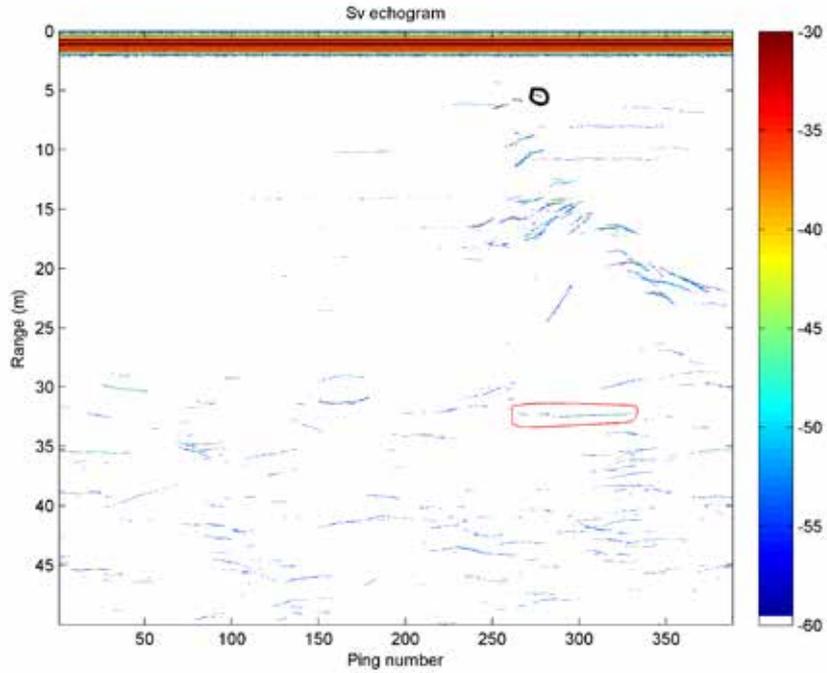


# The broad band acoustic probe

## 38, 70, 120, 200, 333 kHz

- 
- Continuous band 50-500 kHz
  - Collecting data from surface to 1500m
  - Fundamentally enhance resolution
  - Full utilization of acoustic properties
  - A step towards reduced need for net sampling

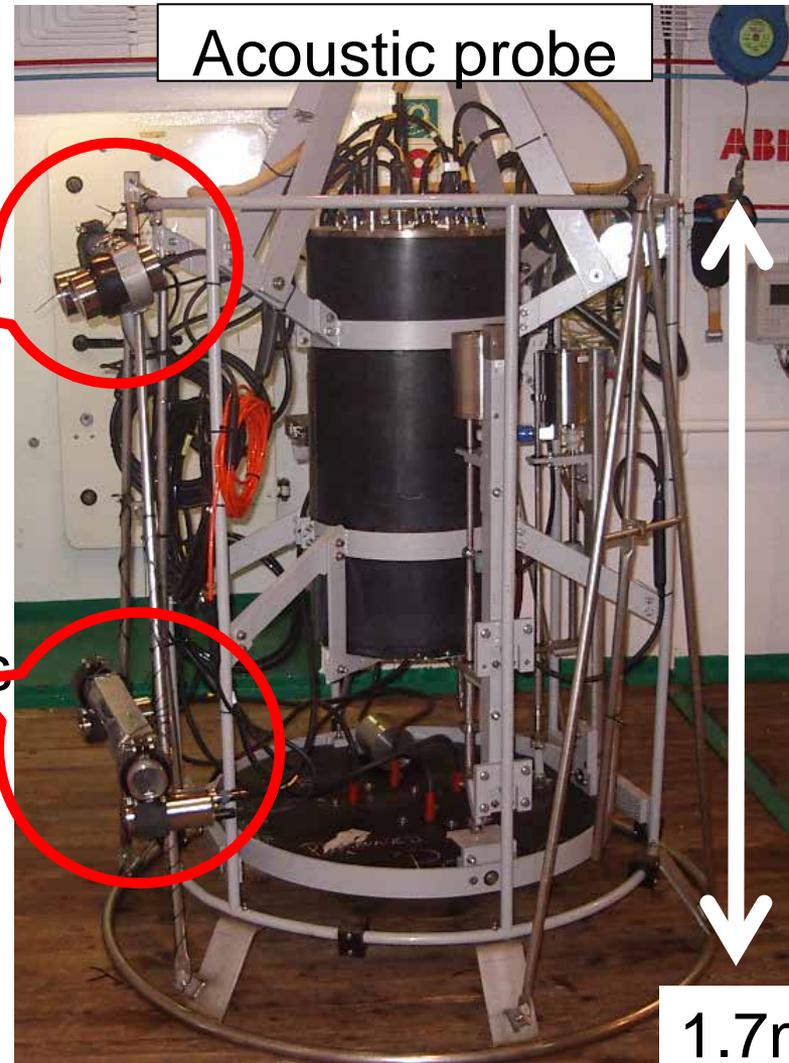
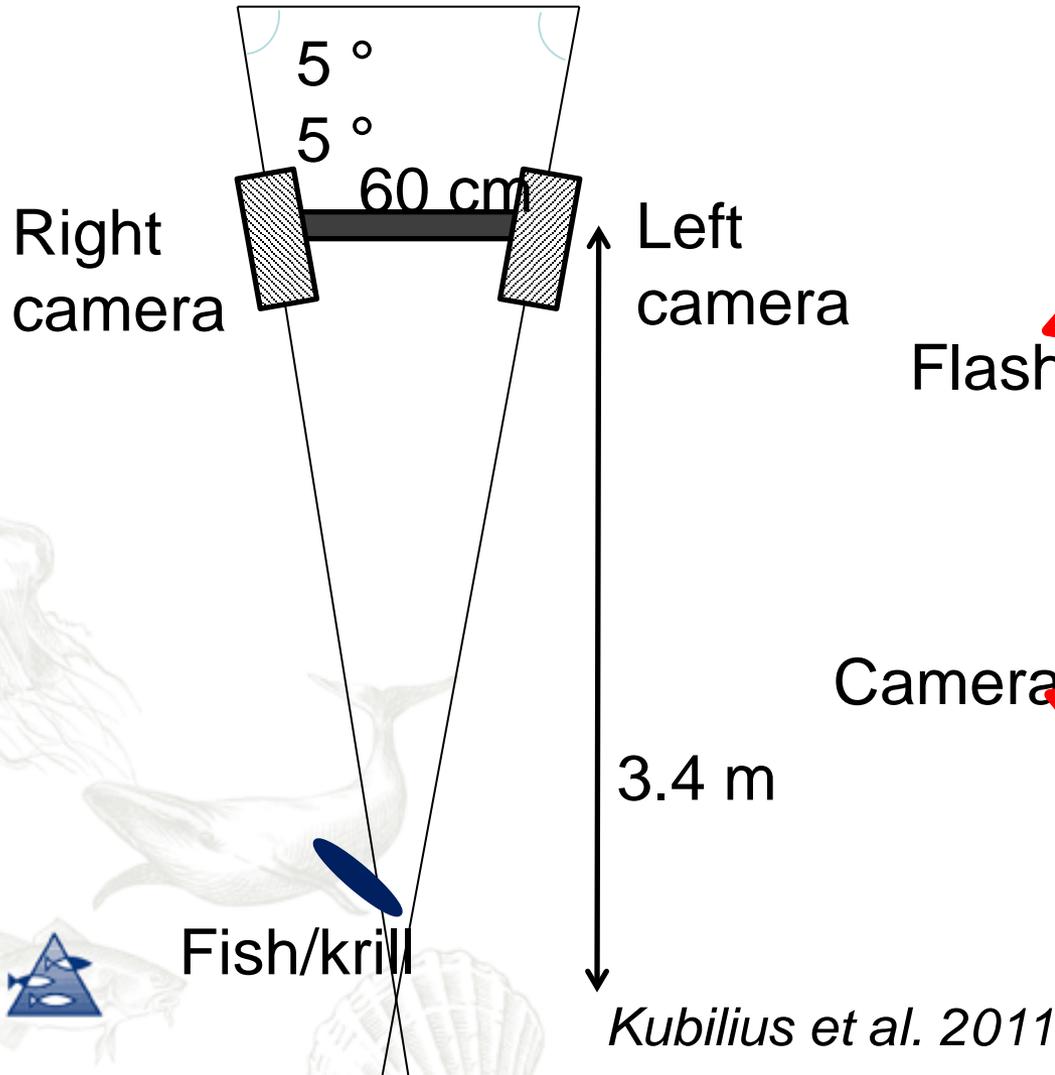
# Real targets



LINESERIES

Athwart: -1.3  
Along: -2.8  
Angle off axis: 31024

# Camera setup



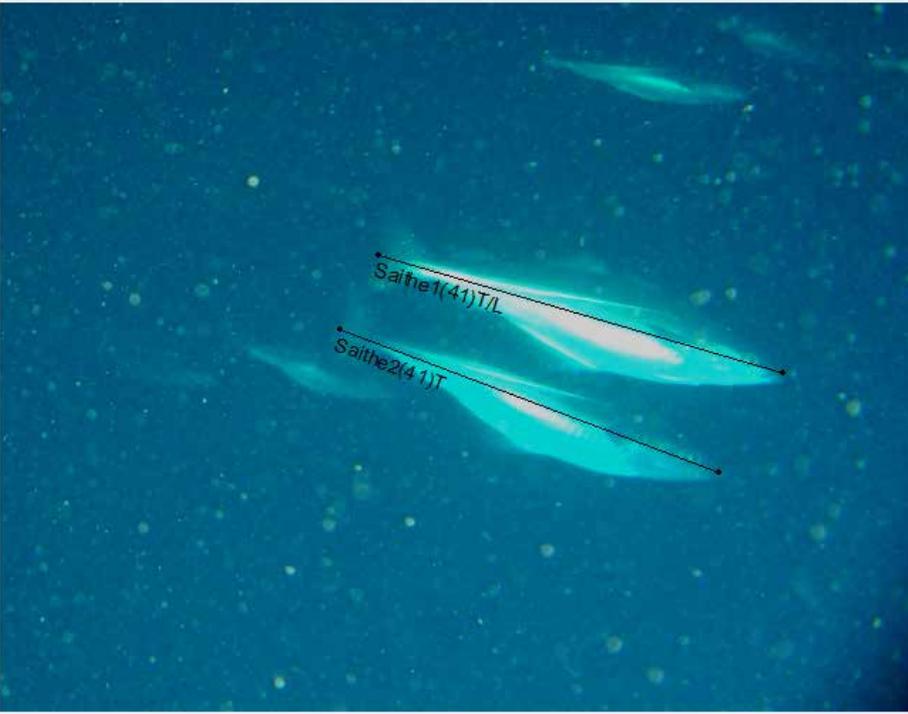
# Measurement - fish

Lengths (IMR Rotated)      Length      Tilt

| Name           | Length (mm) | Precision (m... | Range (mm) | sRange (...) | Horz dir (d... | sHorz dir ... | Vert dir (degrees) | sVert dir (...) |
|----------------|-------------|-----------------|------------|--------------|----------------|---------------|--------------------|-----------------|
| Saithe1(41)T/L | 511.3379    | 2.2495          | 3512.8266  | 3.0398       | 16.4666        | 0.6924        | -12.1324           | 0.1109          |
| Saithe2(41)T   | 606.5187    | 4.4995          | 4301.7711  | 4.5131       | 26.6844        | 0.8227        | -14.4625           | 0.1665          |

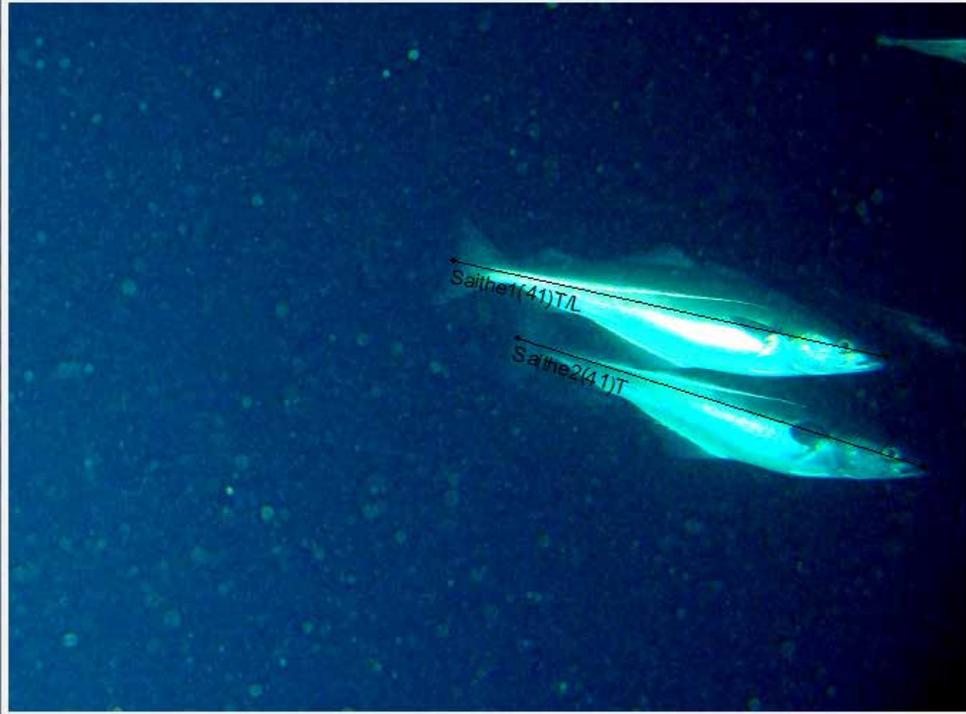
Camera 1 : Left\_Cam1\_11.21\_0041.jpg

Picture Camera  
Zoom 2 Refresh Measurements window  Show measurements



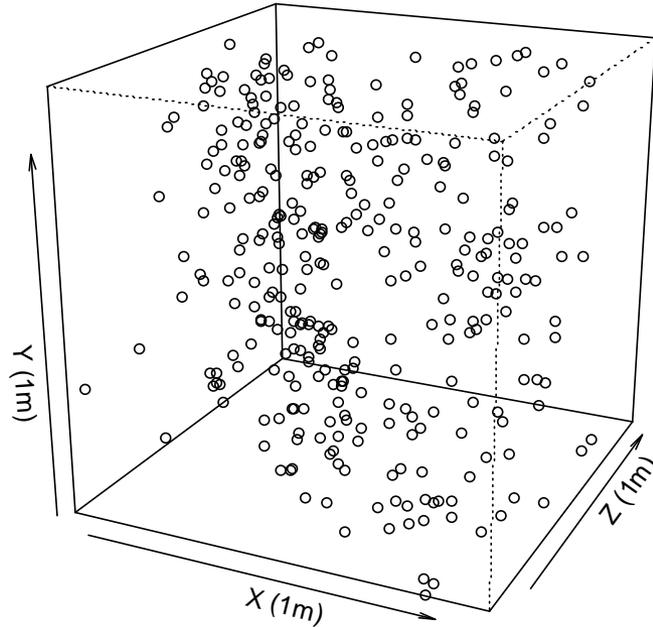
Camera 2 : Right\_Cam2\_11.21\_0041.jpg

Picture Camera  
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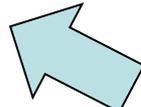
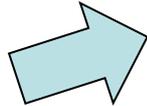


# Volume density - Antarctic krill

(example)

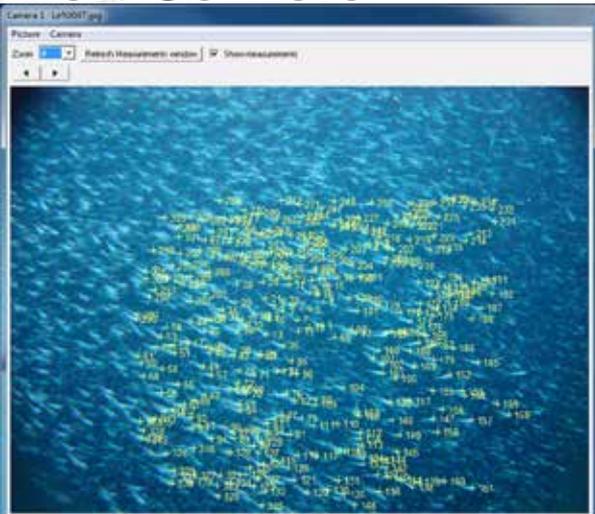


$326/m^3$



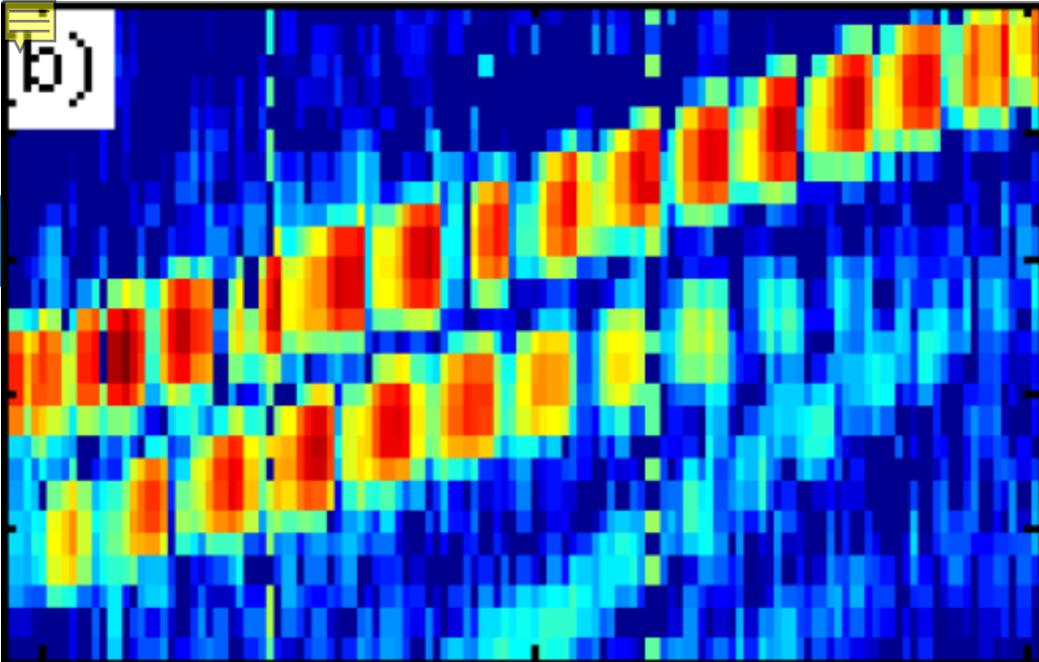
Left Camera

Right Came



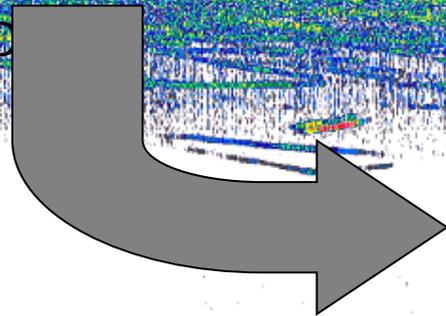
R/V G.O.Sars (2008)  
Antarctic ocean (~30m depth)

*Kubila et al. 2011*

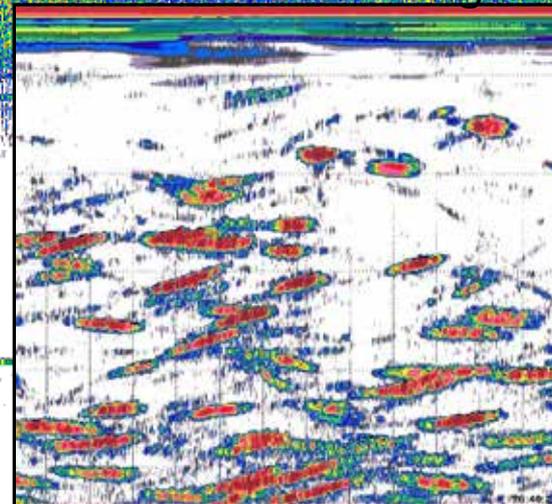


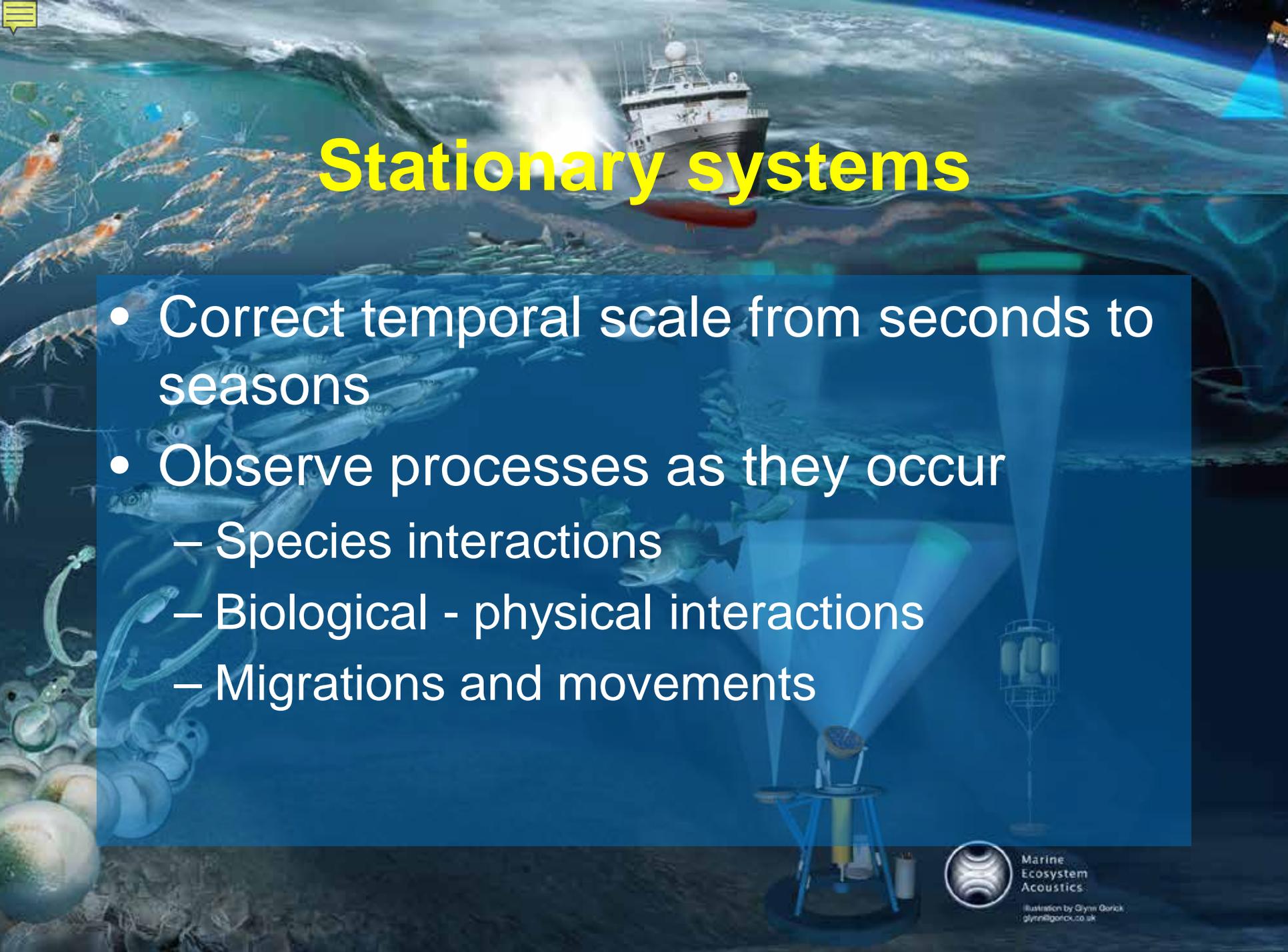
# Probing a herring school to observe individuals

Lowering the transducer\* into the school



Within school echogram





# Stationary systems

- Correct temporal scale from seconds to seasons
- Observe processes as they occur
  - Species interactions
  - Biological - physical interactions
  - Migrations and movements



Marine  
Ecosystem  
Acoustics

Illustration by Glynn Gorick  
glynn@gorick.co.uk

# Interactions

## Stationary acoustics

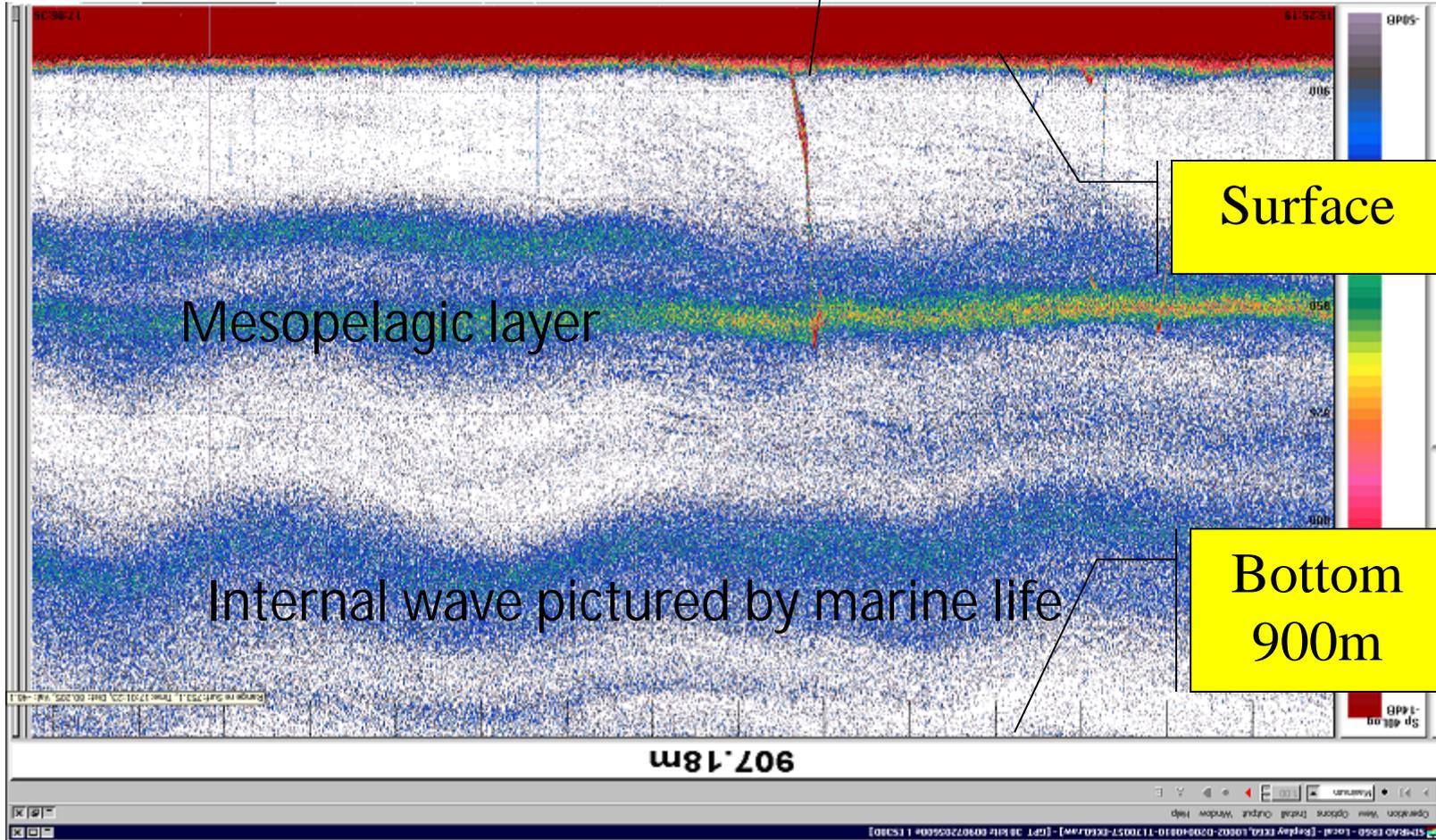
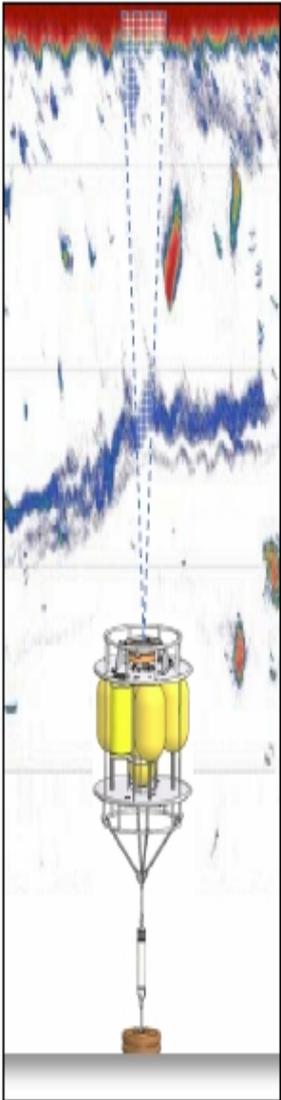
Whale feeding behaviour

Surface

Bottom  
900m

Mesopelagic layer

Internal wave pictured by marine life



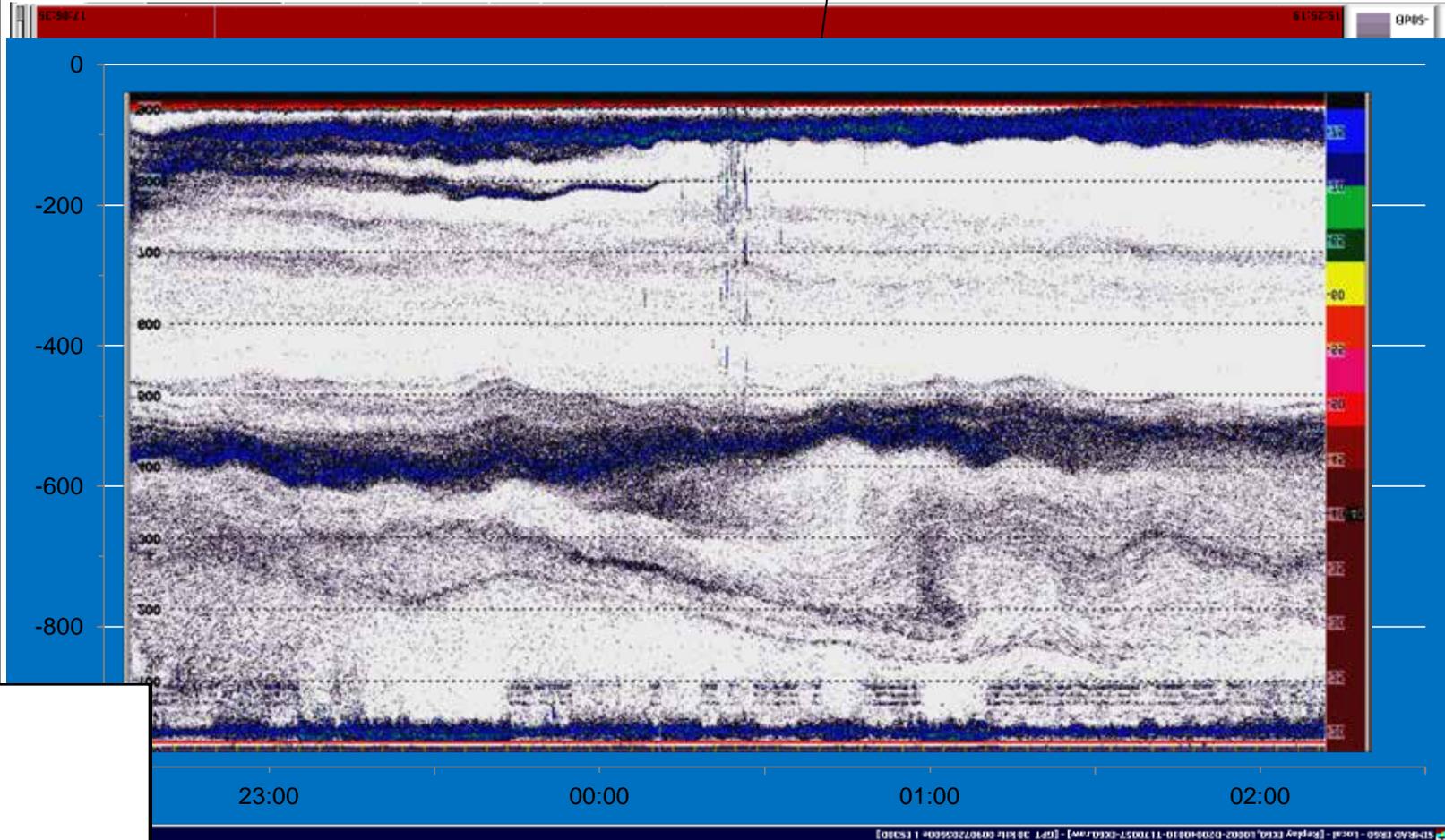
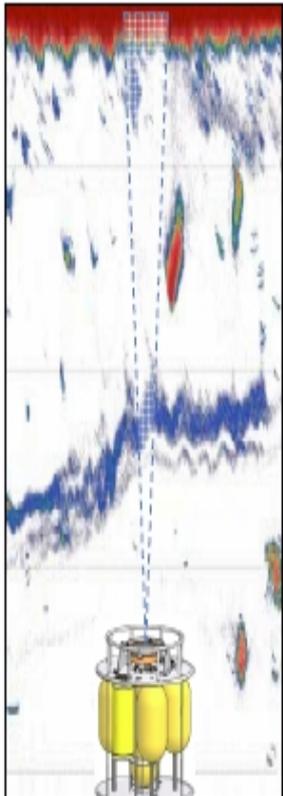
*Godø et al in prep*



# Interactions

## Stationary acoustics

Whale feeding  
behaviour

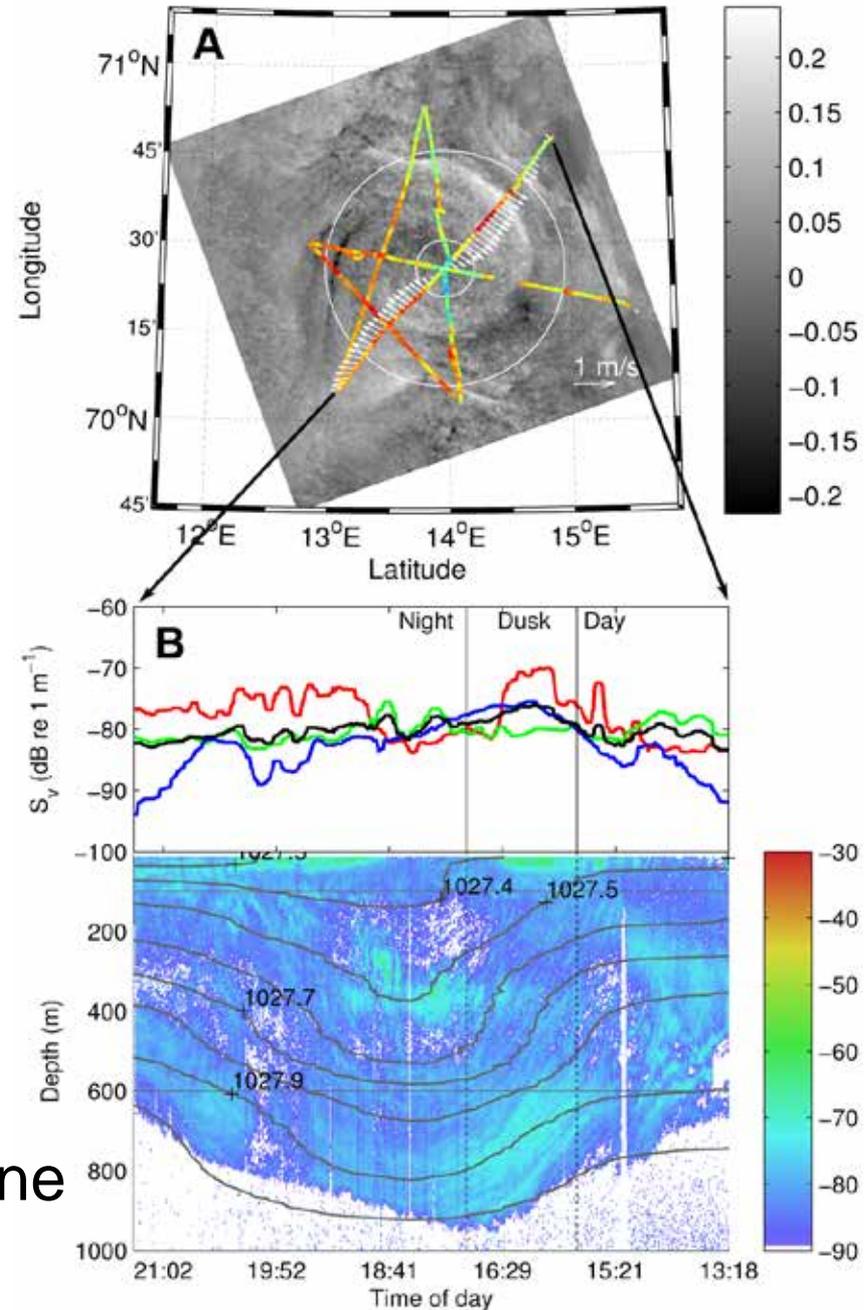


*Godø et al in prep*



# Biophysical interactions eddies

1. Biomass concentration along density gradients
2. Extending to surface
3. Blue whiting feeding at surface



Godø et al. 2012. Plos One

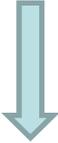


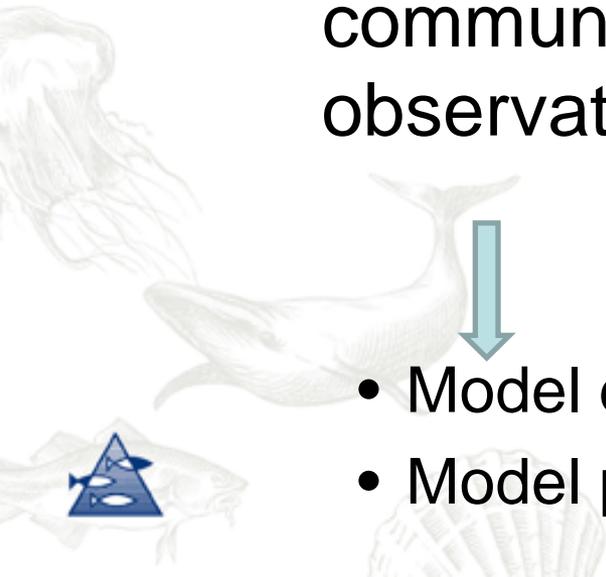
# The key role of modelling

- Modelling

- Modelling tailored to the acoustic data stream
- Tools for seamless two ways' communication between acoustic observations and modelling results

- 
- Model design
  - Model parameters

- 
- Sensor design
  - Platform development
  - Survey/sampling design

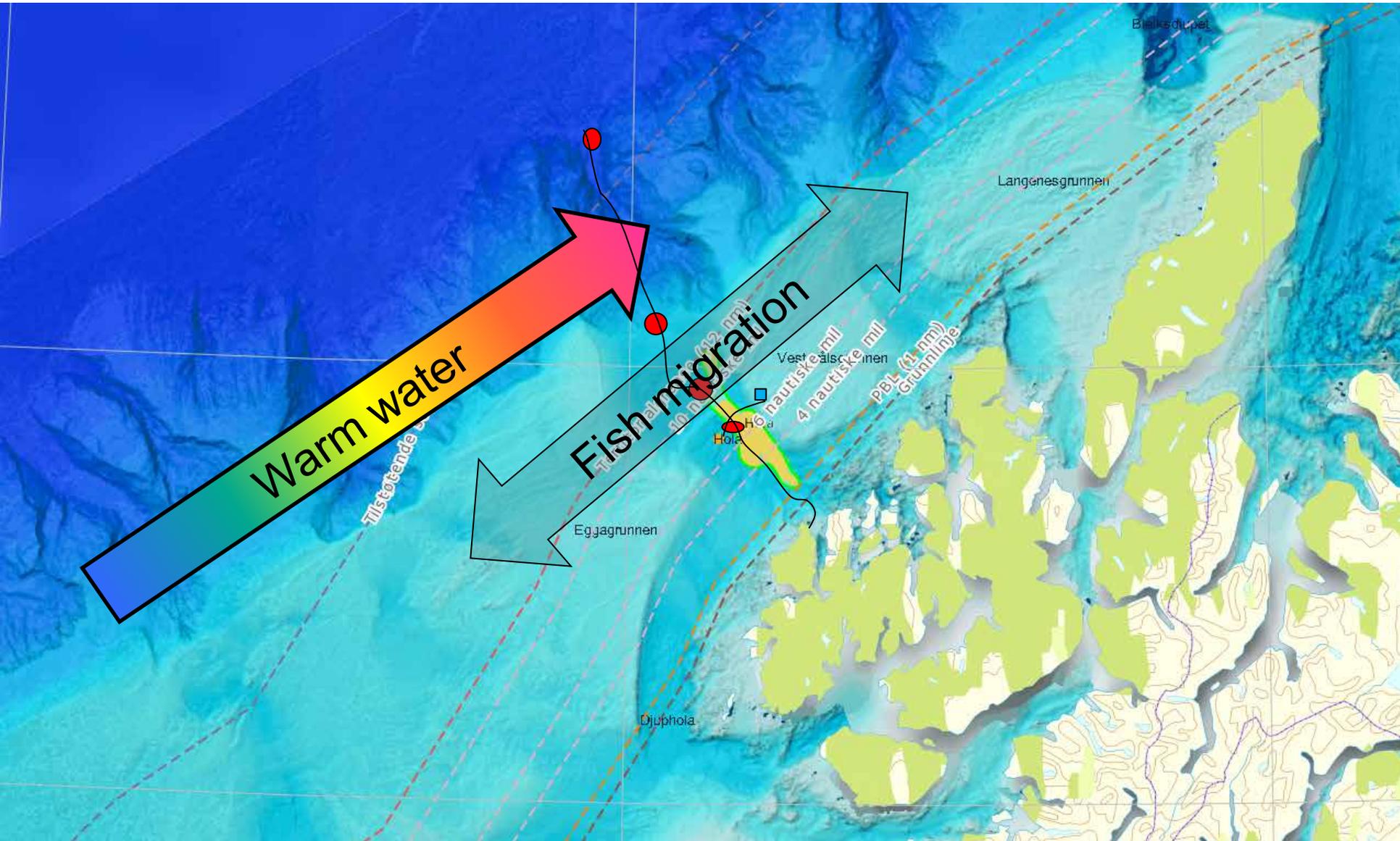


# Acoustics support ecosystem based management

- **Observation** – acoustics collect data at spatio-temporal scales at which processes occur
- **Understanding** – cross scale data support and is mandatory for understanding
- **Prediction** – depends on realistic modelling. MEA support coordinated and integrated development of technology and modelling

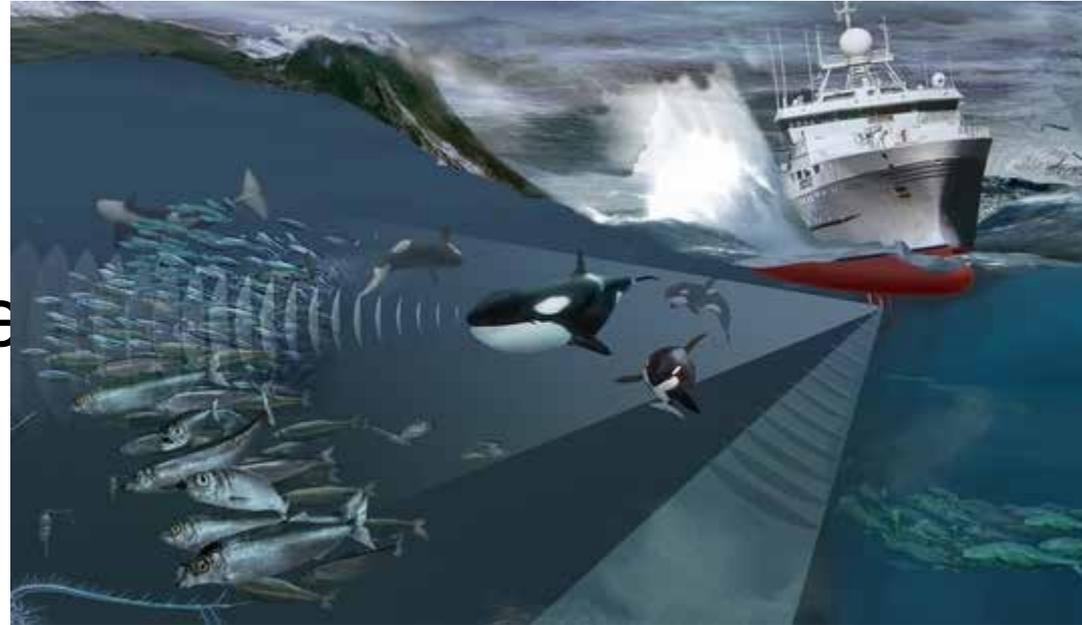


# Observatory plan

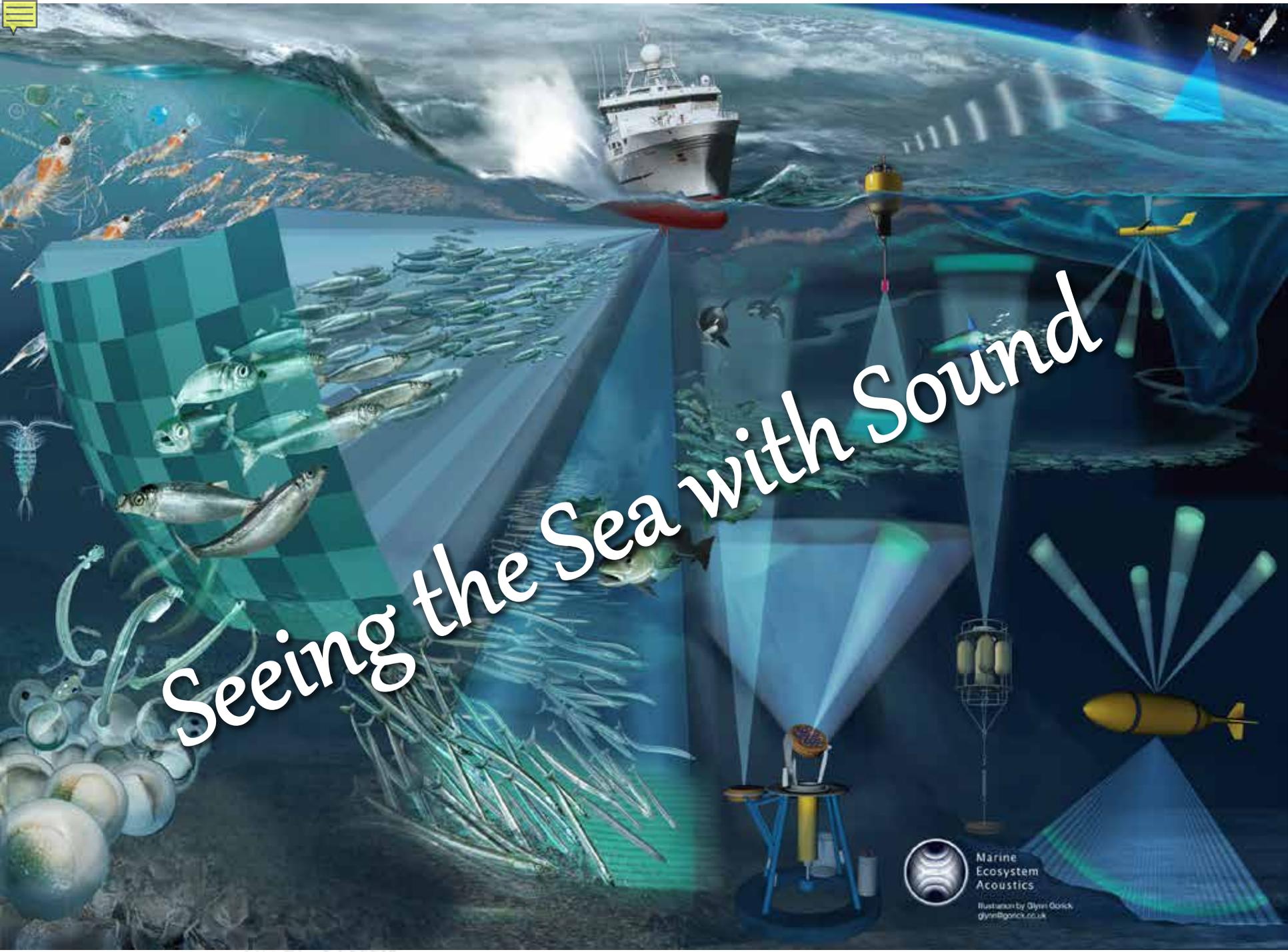


# Are we the first ones?

- Whales have developed acoustics on an evolutionary scale
- Our vision is to get at least as good as the whales



# Seeing the Sea with Sound



Marine  
Ecosystem  
Acoustics

Illustration by Olyvia Oorick  
olyvia@oorick.co.uk