

# A simple unsupervised echoes classification to detect different types of SSL in multispecific ecosystems

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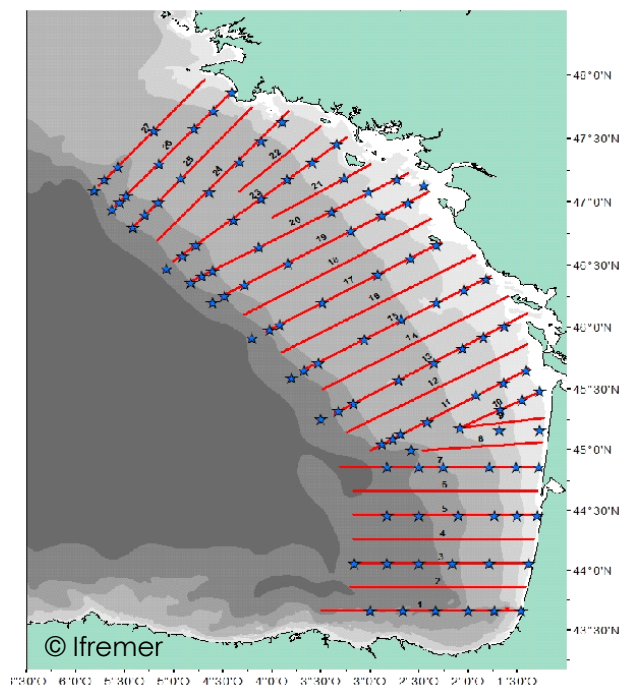
**& Laurent BERGER** <sup>(b)</sup>

*<sup>(b)</sup> Acoustic and Seismic Service, Ifremer, Brest, Fr.*

# Introduction

## Zooplankton and micronekton sampling

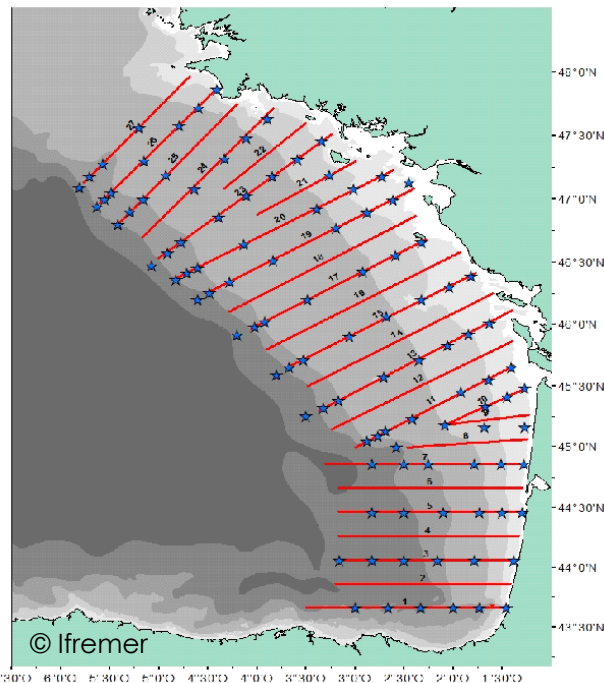
- Planktonic/micronektonic nets
  - Discrete
  - Limited extension



# Introduction

## Zooplankton and micronekton sampling

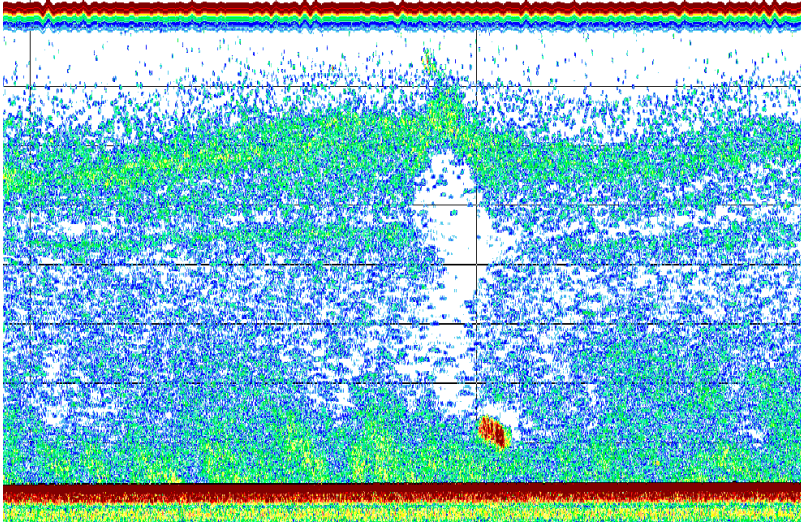
- Planktonic/micronektonic nets
  - Discrete
  - Limited extension



- Hull-mounted multifrequency echosounders
  - Continue
  - Extended geographical areas
  - Processes at fine resolution

# Introduction

## Sound Scattering Layers (SSLs)

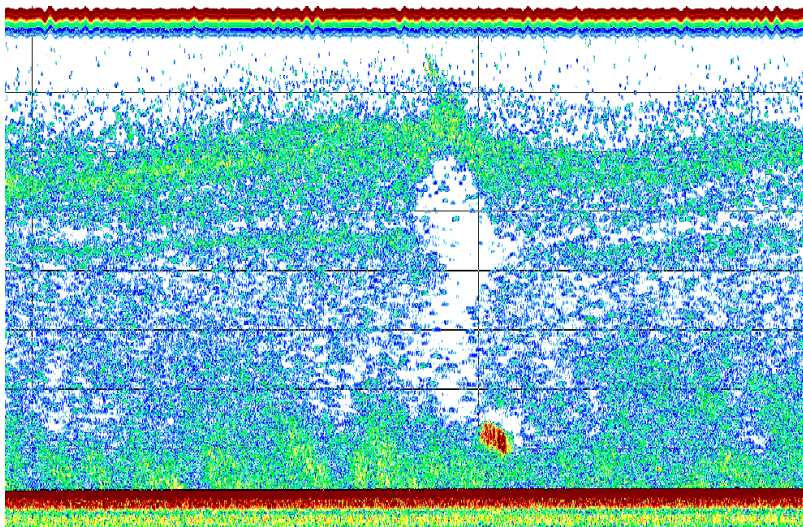


- Composed of a diversity of organisms



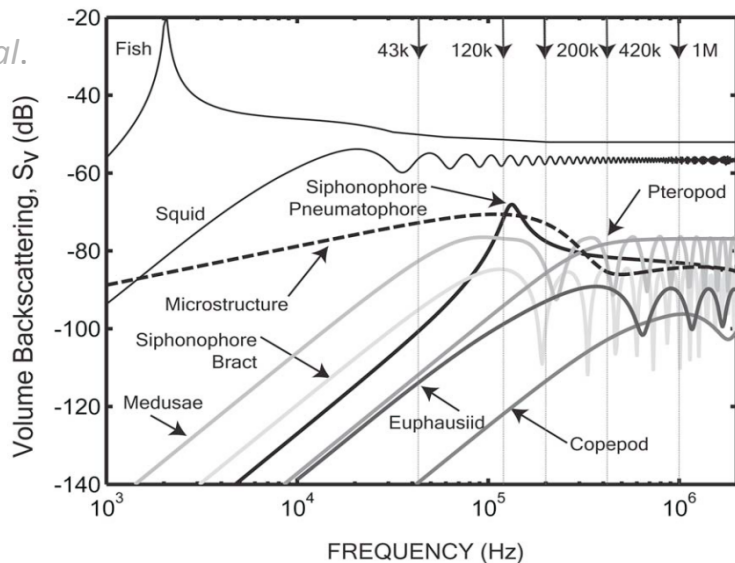
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## Sound Scattering Layers (SSLs)



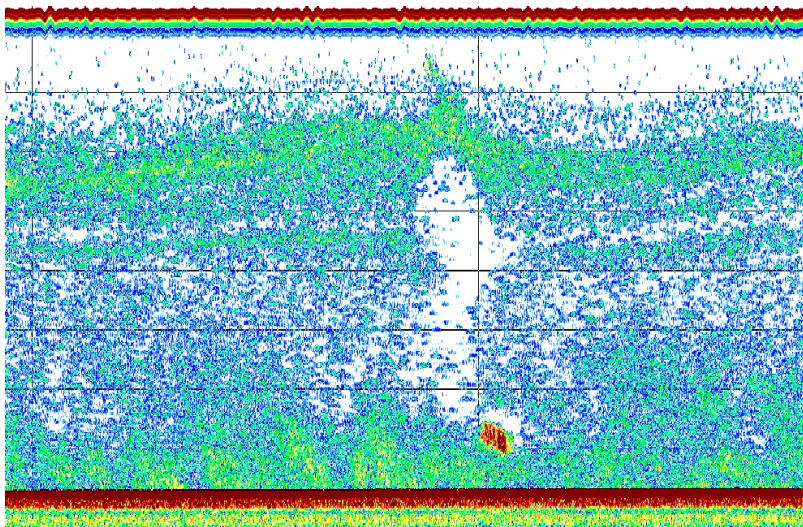
- Composed of a diversity of organisms
- Organisms identity set with frequency response

Lavery *et al.*  
2007



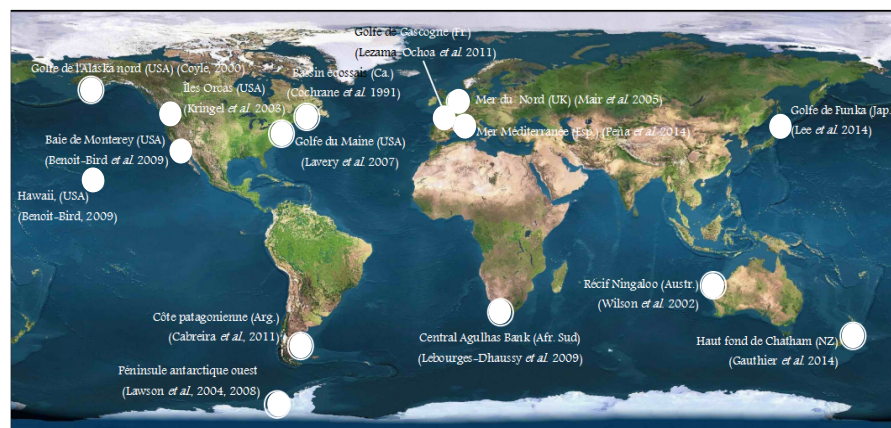
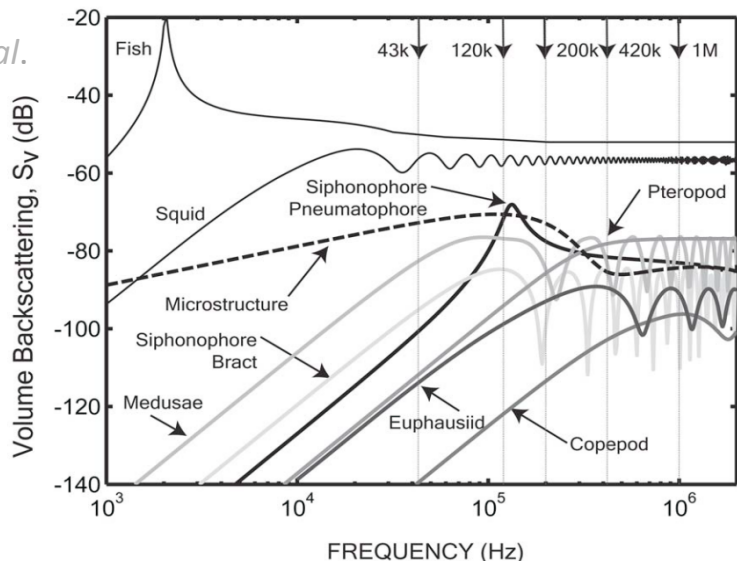
# Introduction

## Sound Scattering Layers (SSLs)



- Composed of a diversity of organisms
- Organisms identity set with frequency response
- Ubiquitous

Lavery *et al.*  
2007



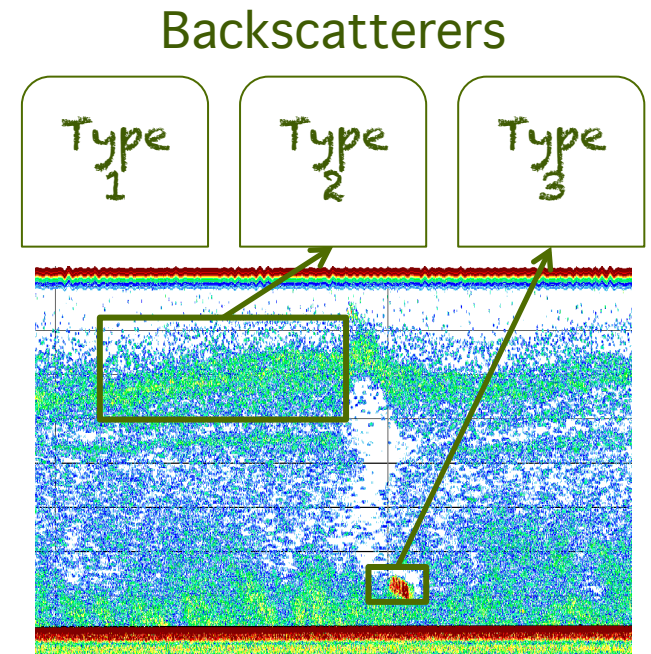
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## Echoes classification

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- Scrutinizing
  - Manual classification
  - Experimented and calibrated operators

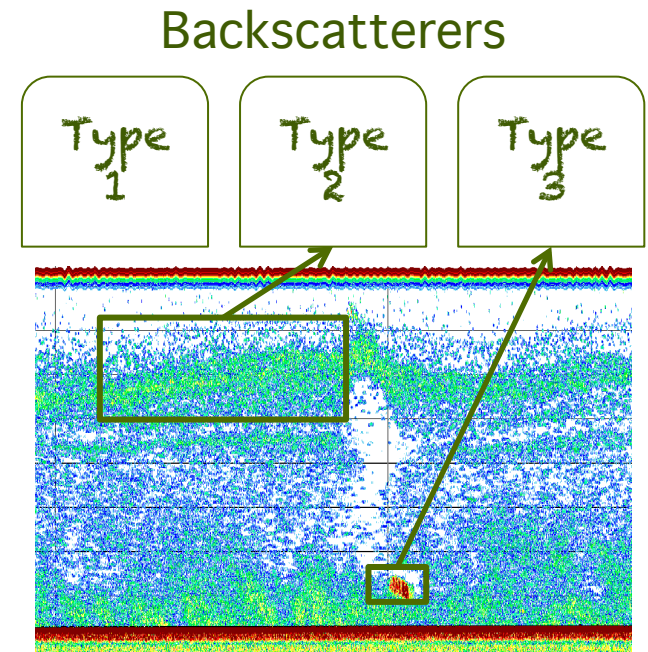




# Introduction

## Echoes classification

- **Scrutinizing**
  - Manual classification
  - Experimented and calibrated operators
- **Supervised classification**
  - Automatic allocation
  - *A priori* knowledge on present backscatterers

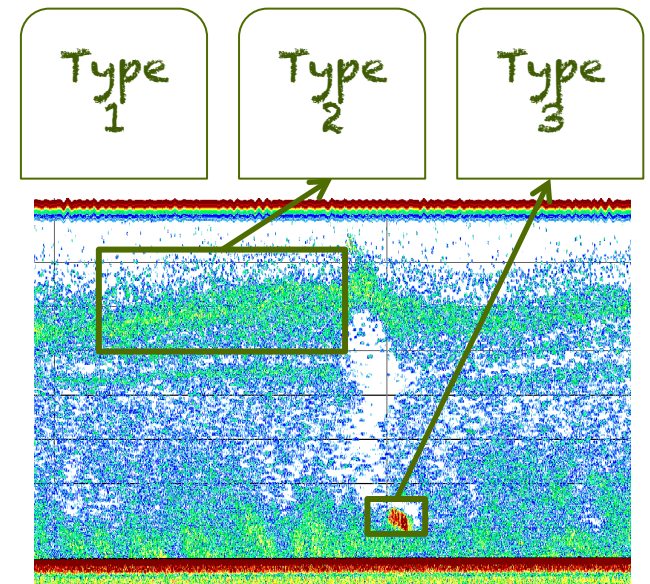


# Introduction

## Echoes classification

- **Scrutinizing**
  - Manual classification
  - Experimented and calibrated operators
- **Supervised classification**
  - Automatic allocation
  - *A priori* knowledge on present backscatterers

### Backscatterers



Unappropriate for  
ecosystems with high specific  
diversity

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- Classify echoes of a **multispecific** ecosystem
  - Bay of Biscay (France)

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  - No hypothesis on the backscatterers identities



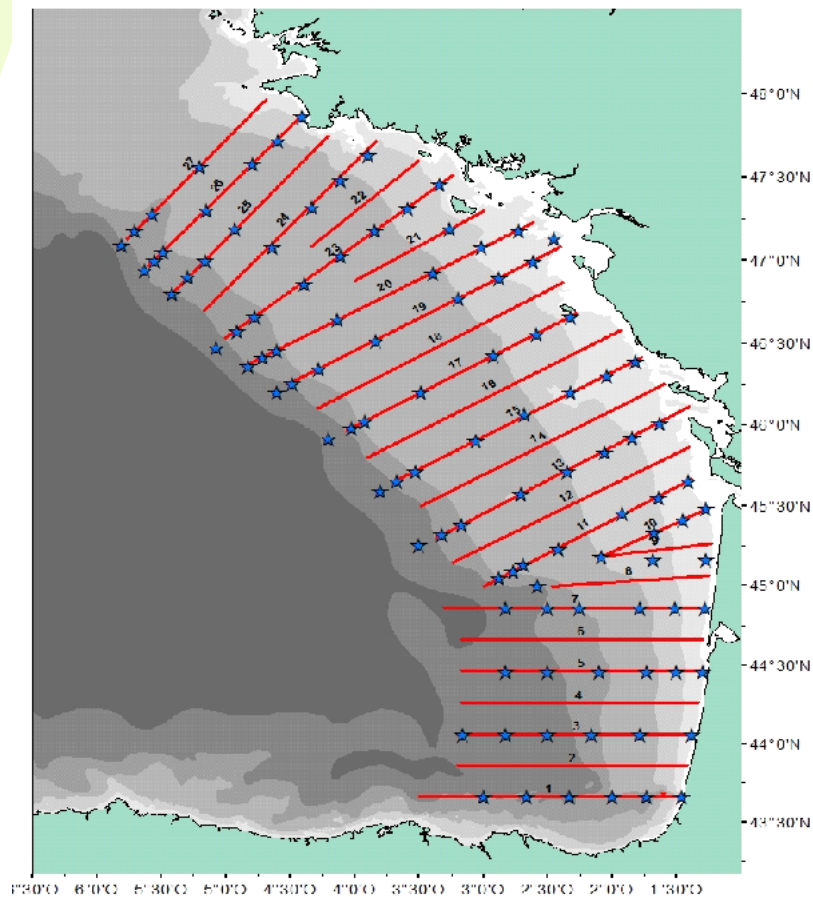
# Introduction

## Objective

- Classify echoes of a **multispecific** ecosystem
  - Bay of Biscay (France)
- **Unsupervised** echoes classification
  - No hypothesis on the backscatterers identities
- **3 criterion**
  - Applicable in quasi-real time at sea
  - Performable on computers with regular compiling power
  - Applicable on any multifrequency dataset

# Method

## Data



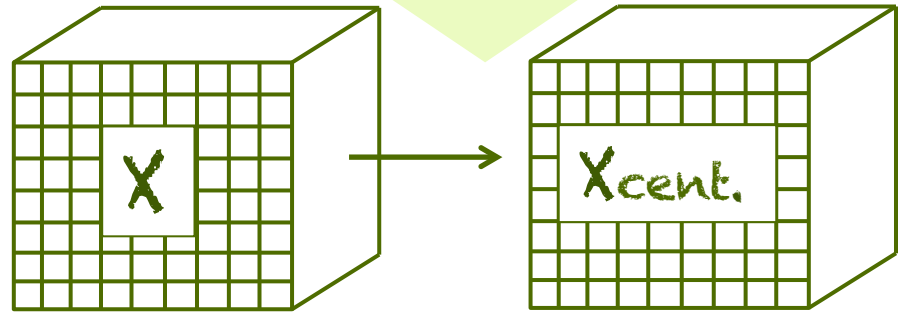
- Ecosystemic acoustic survey PELGAS
  - Bay of Biscay in spring
  - EK60 : 18, 38, 70, 120, 200 kHz

# Method Analysis

1  
Echo-integration

# Method Analysis

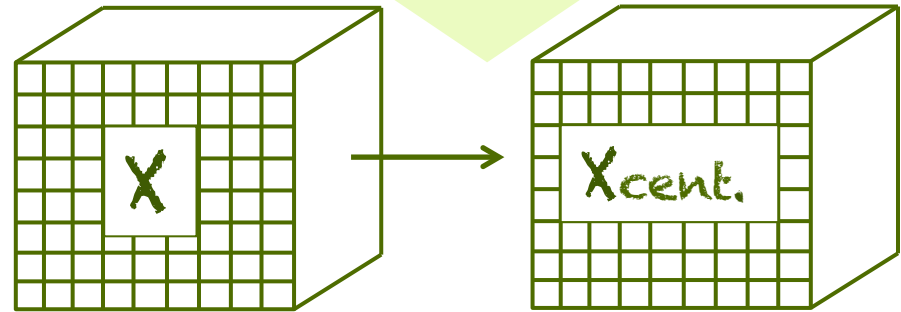
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# Method Analysis

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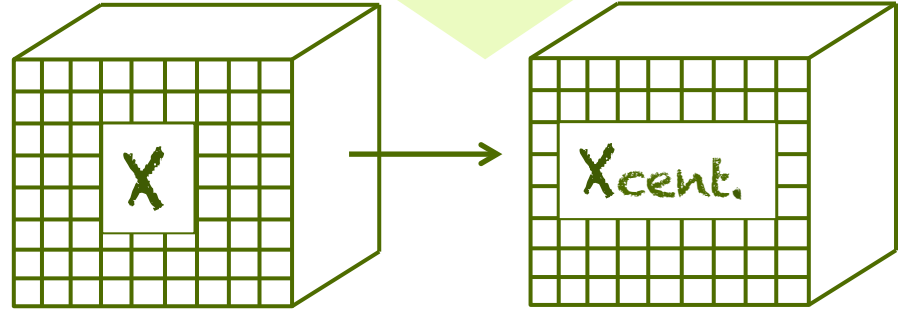


3  
Classes of  $S_v$

$$\left\{ \begin{array}{l} C_1 : S_{v_{..}^{min} cent.} < S_{v_{ij} cent.} \leq i_{sup.}^1 \\ C_2 : i_{inf.}^2 < S_{v_{ij} cent.} \leq i_{sup.}^2 \\ C_3 : i_{inf.}^3 < S_{v_{ij} cent.} \leq i_{sup.}^3 \\ C_4 : i_{inf.}^4 < S_{v_{ij} cent.} \leq i_{sup.}^4 \\ C_5 : i_{inf.}^5 < S_{v_{ij} cent.} \leq S_{v_{..}^{max} cent.} \end{array} \right.$$

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1 Echo-integration

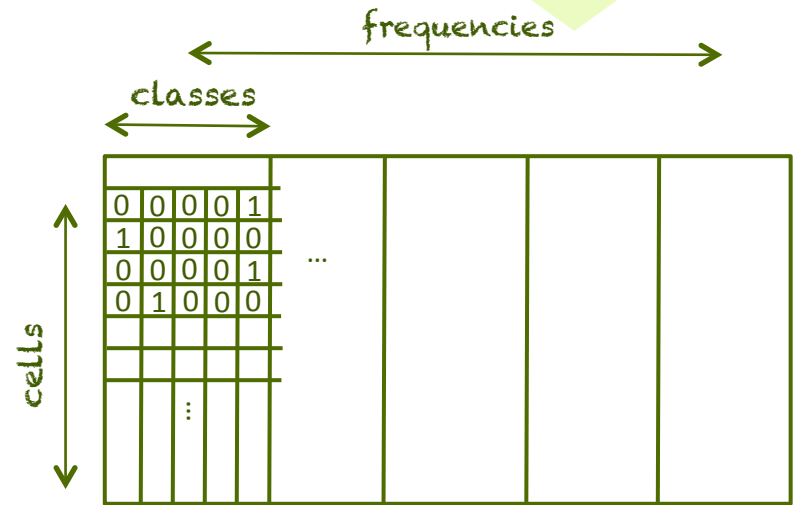


2 Standardization

3 Classes of  $S_v$

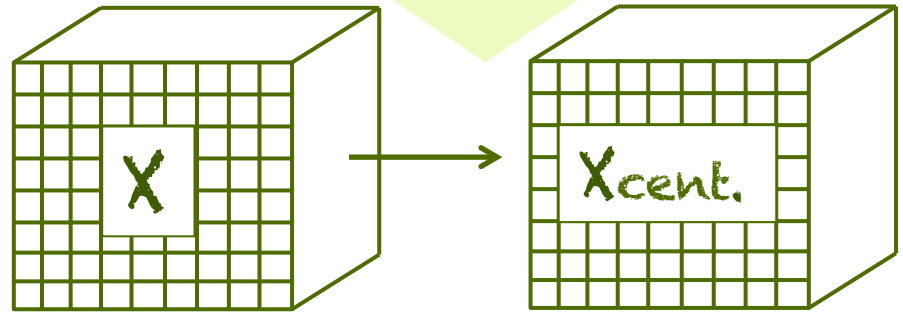
$$\left\{ \begin{array}{l} C_1 : S_{v_{..}^{min} cent.} < S_{v_{ij} cent.} \leq i_{sup.}^1 \\ C_2 : i_{inf.}^2 < S_{v_{ij} cent.} \leq i_{sup.}^2 \\ C_3 : i_{inf.}^3 < S_{v_{ij} cent.} \leq i_{sup.}^3 \\ C_4 : i_{inf.}^4 < S_{v_{ij} cent.} \leq i_{sup.}^4 \\ C_5 : i_{inf.}^5 < S_{v_{ij} cent.} \leq S_{v_{..}^{max} cent.} \end{array} \right.$$

3 Calculation of a complete disjunctive table



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Echo-integration



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Classes of  $S_v$

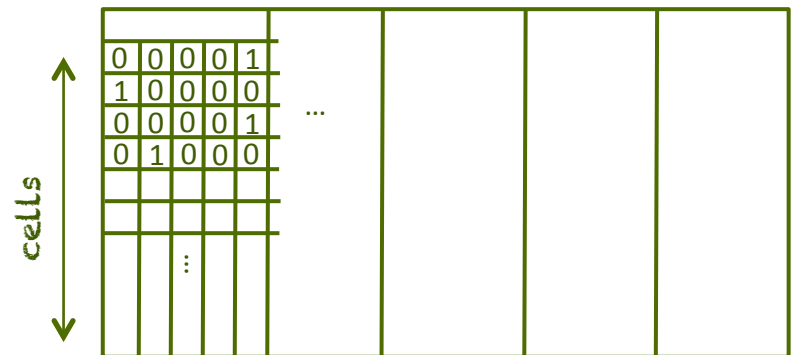
3

Calculation of a complete disjunctive table

$$\left\{ \begin{array}{l} C_1 : S_{v_{..}^{min} cent.} < S_{v_{ij} cent.} \leq i_{sup.}^1 \\ C_2 : i_{inf.}^2 < S_{v_{ij} cent.} \leq i_{sup.}^2 \\ C_3 : i_{inf.}^3 < S_{v_{ij} cent.} \leq i_{sup.}^3 \\ C_4 : i_{inf.}^4 < S_{v_{ij} cent.} \leq i_{sup.}^4 \\ C_5 : i_{inf.}^5 < S_{v_{ij} cent.} \leq S_{v_{..}^{max} cent.} \end{array} \right.$$

frequencies

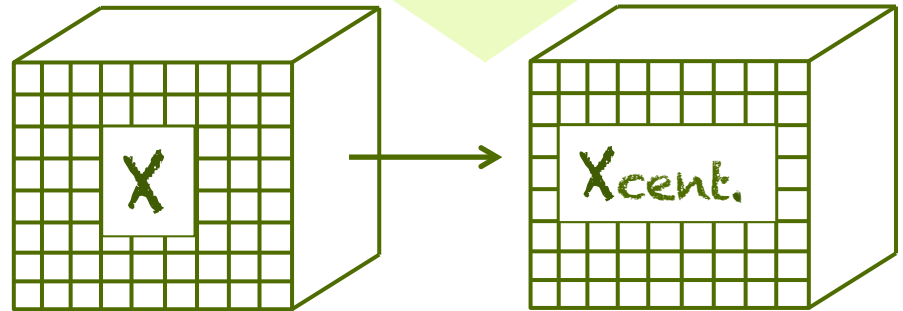
classes



4  
PCA

# Method Analysis

1  
Echo-integration

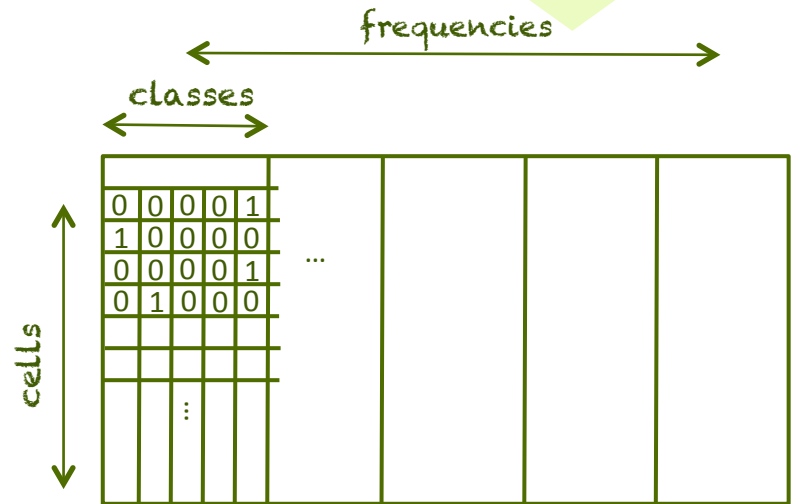


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5  
Kmeans clustering

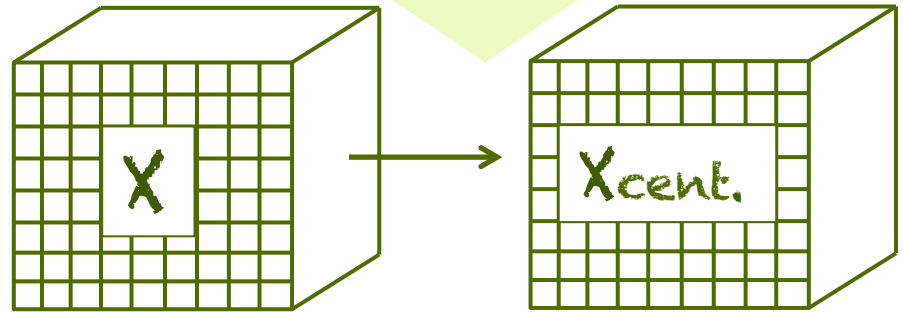
4  
PCA





# Method Analysis

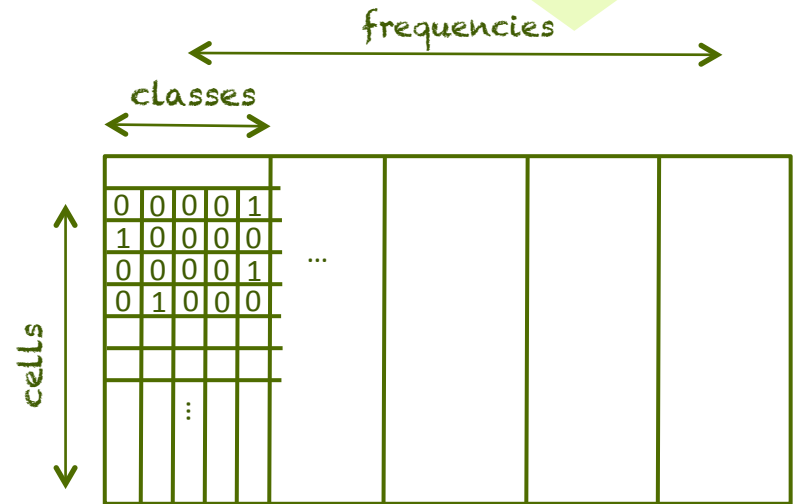
1 Echo-integration



3 Classes of  $S_v$

$$\begin{cases} C_1 : S_{v_{..}^{min} cent.} < S_{v_{ij} cent.} \leq i_{sup.}^1 \\ C_2 : i_{inf.}^2 < S_{v_{ij} cent.} \leq i_{sup.}^2 \\ C_3 : i_{inf.}^3 < S_{v_{ij} cent.} \leq i_{sup.}^3 \\ C_4 : i_{inf.}^4 < S_{v_{ij} cent.} \leq i_{sup.}^4 \\ C_5 : i_{inf.}^5 < S_{v_{ij} cent.} \leq S_{v_{..}^{max} cent.} \end{cases}$$

3 Calculation of a complete disjunctive table



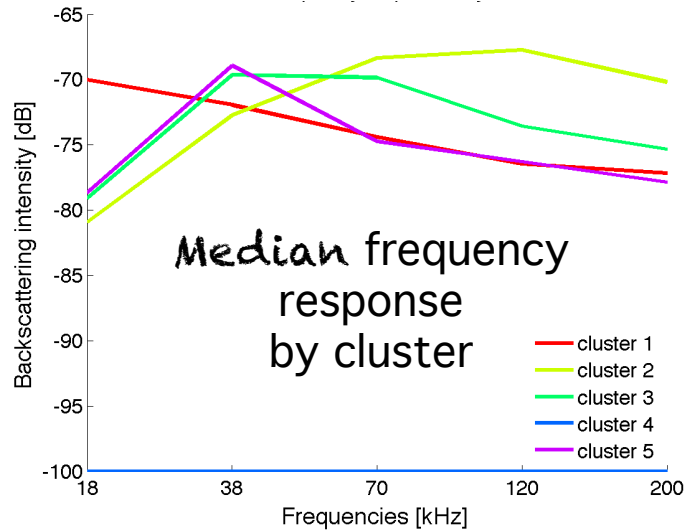
6 Median frequency responses by cluster

5 Kmeans clustering

4 PCA

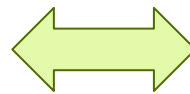
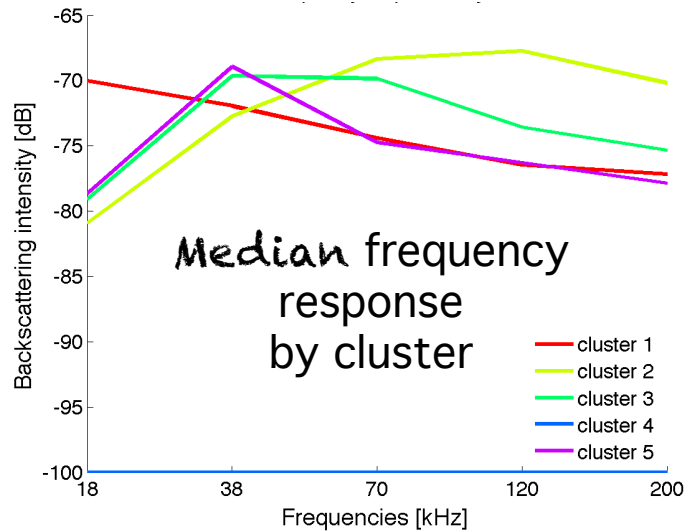
# Results

## PELGAS2014 dataset



# Results

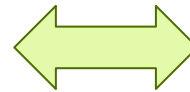
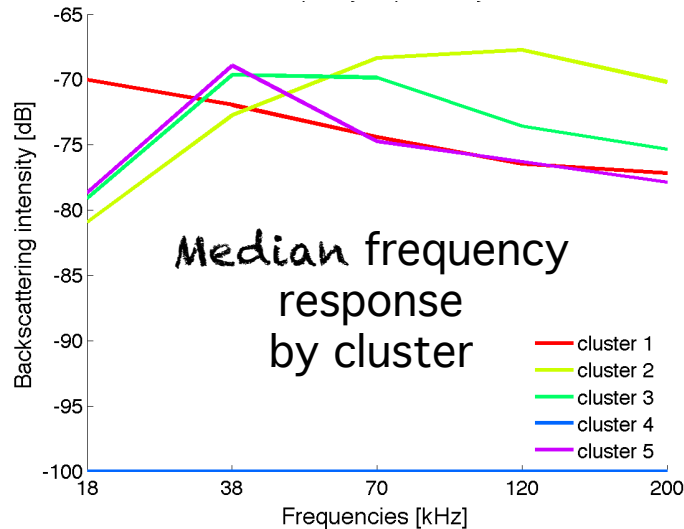
## PELGAS2014 dataset



Theoretical frequency responses

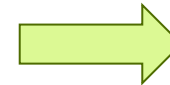
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Theoretical frequency responses

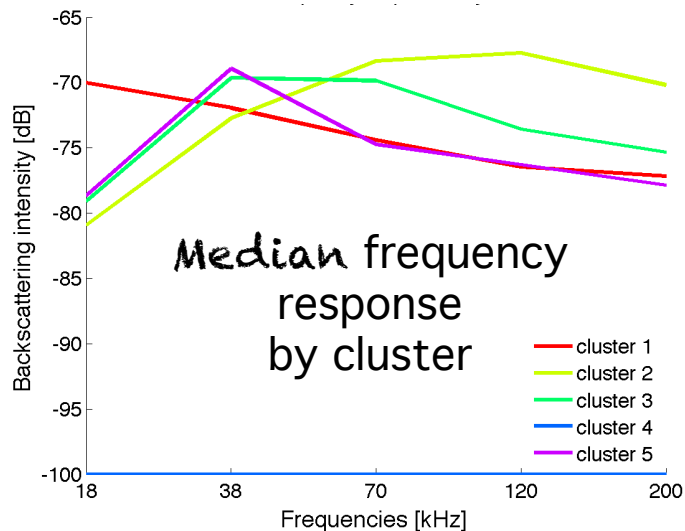
- Peaks of resonance
  - Cluster 1 : < 18 kHz
  - Cluster 3 : 38-70 kHz
  - Cluster 5 : 38 kHz



Gas-bearing organisms

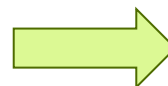
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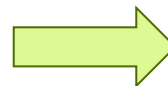


Theoretical frequency responses

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  - Cluster 3 : 38-70 kHz
  - Cluster 5 : 38 kHz
- Cluster 2 : increase with frequency



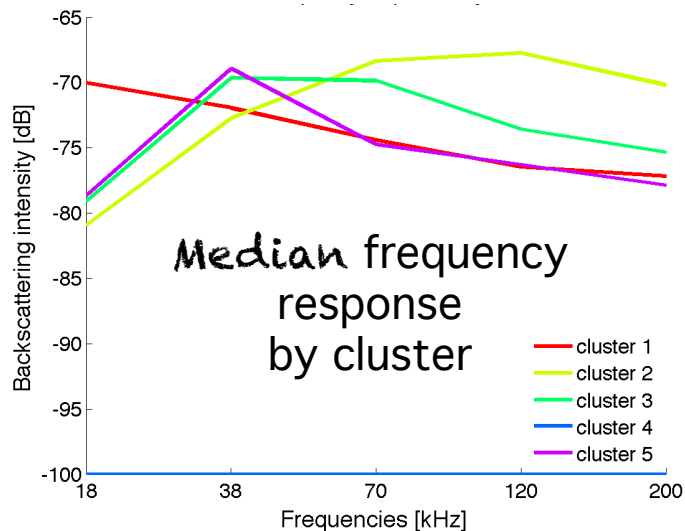
Gas-bearing organisms



Fluid-like organisms

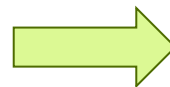
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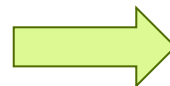


Theoretical frequency responses

- Peaks of resonance
  - Cluster 1 : < 18 kHz
  - Cluster 3 : 38-70 kHz
  - Cluster 5 : 38 kHz
- Cluster 2 : increase with frequency
- Cluster 4 : no information cells



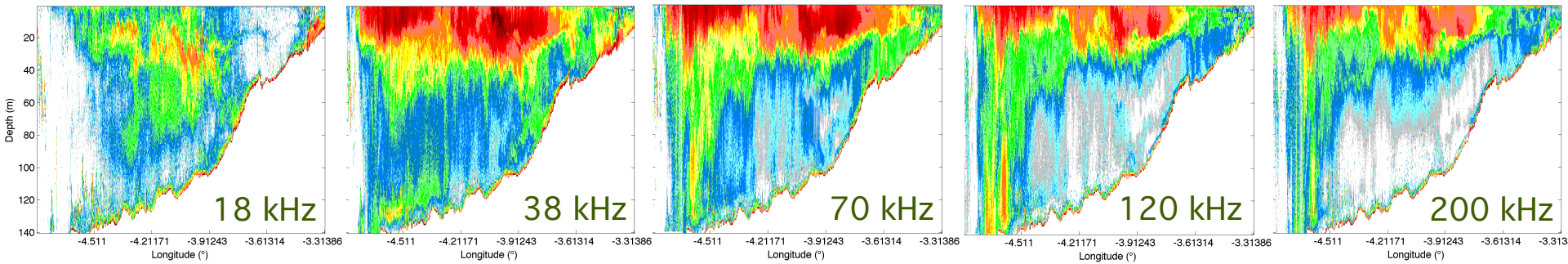
Gas-bearing organisms



Fluid-like organisms

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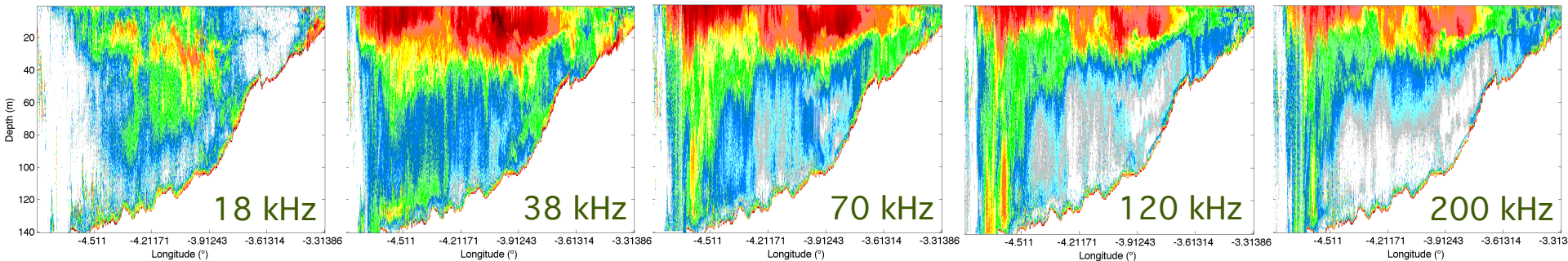
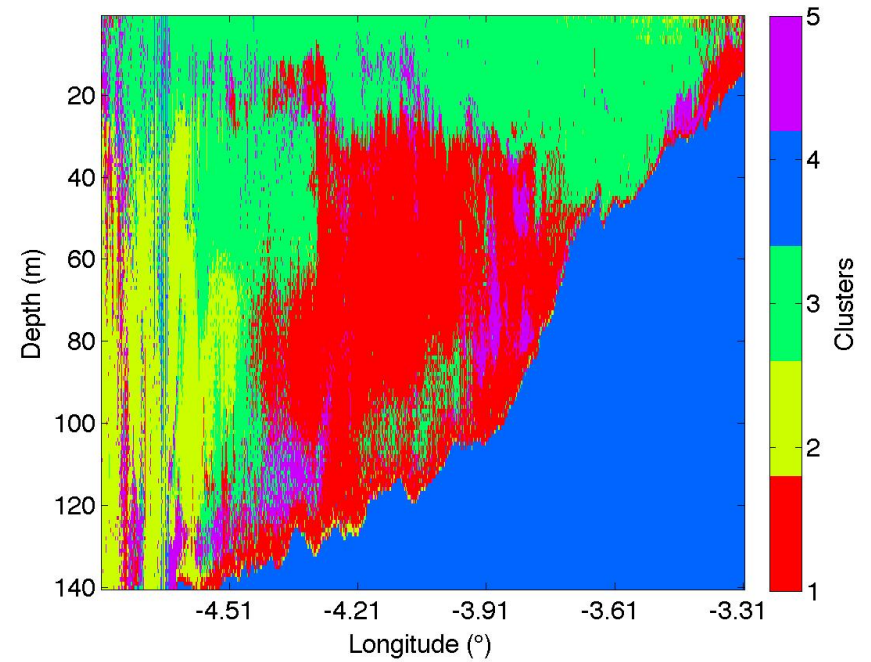
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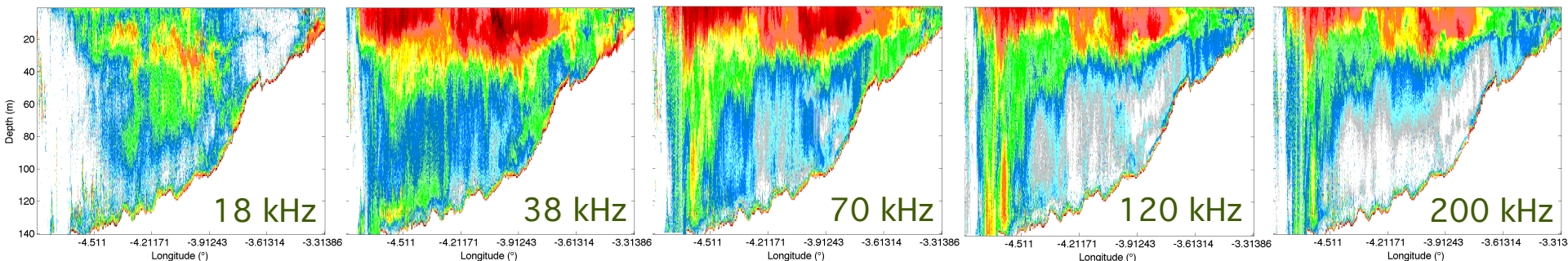
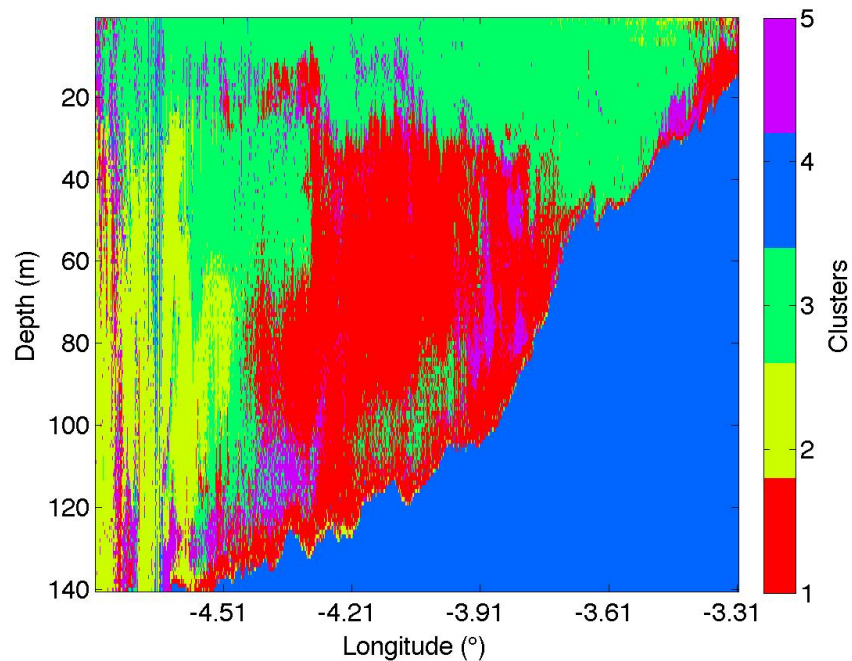
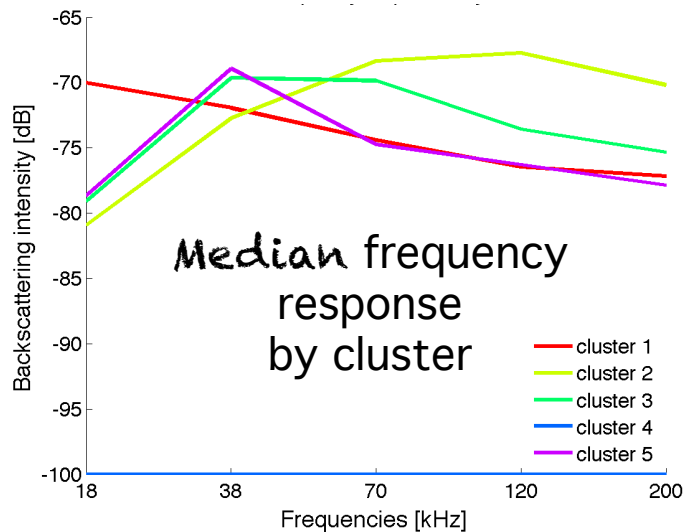
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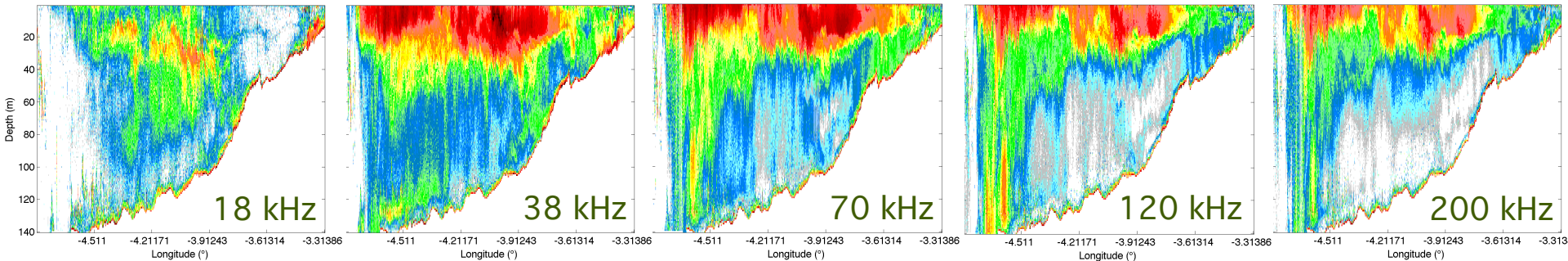
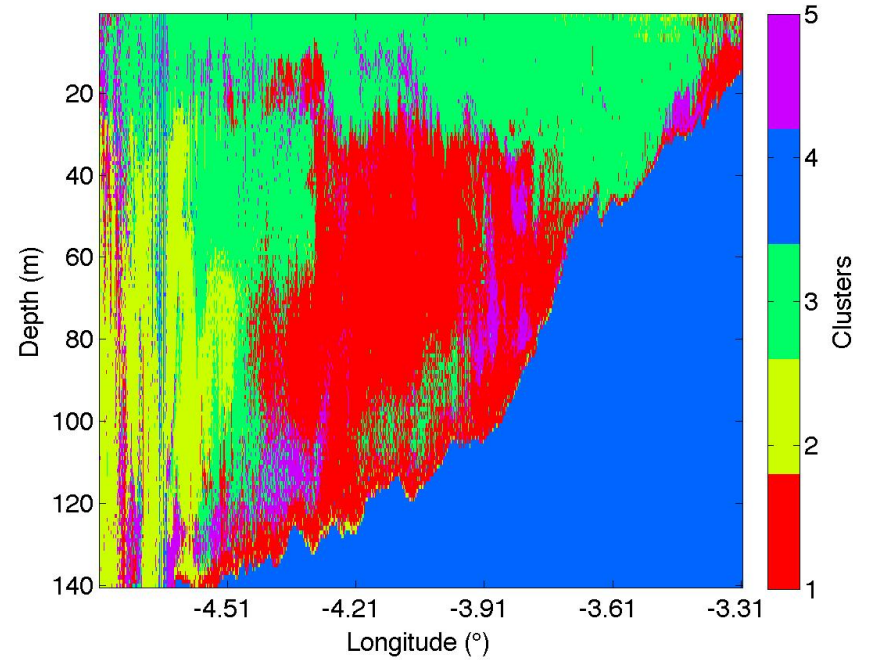
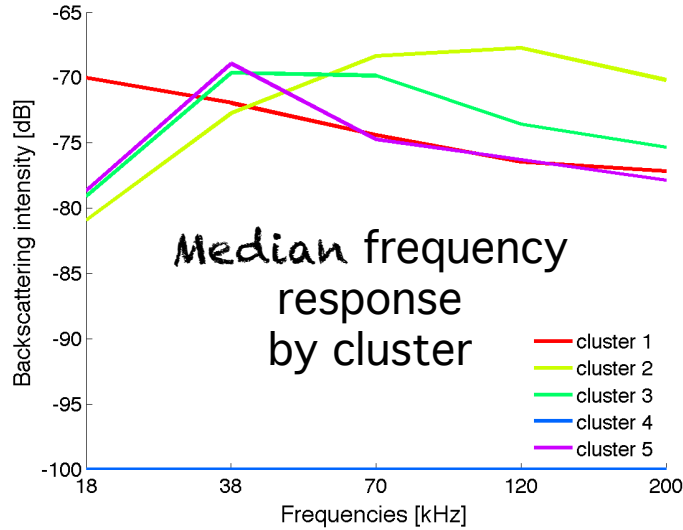
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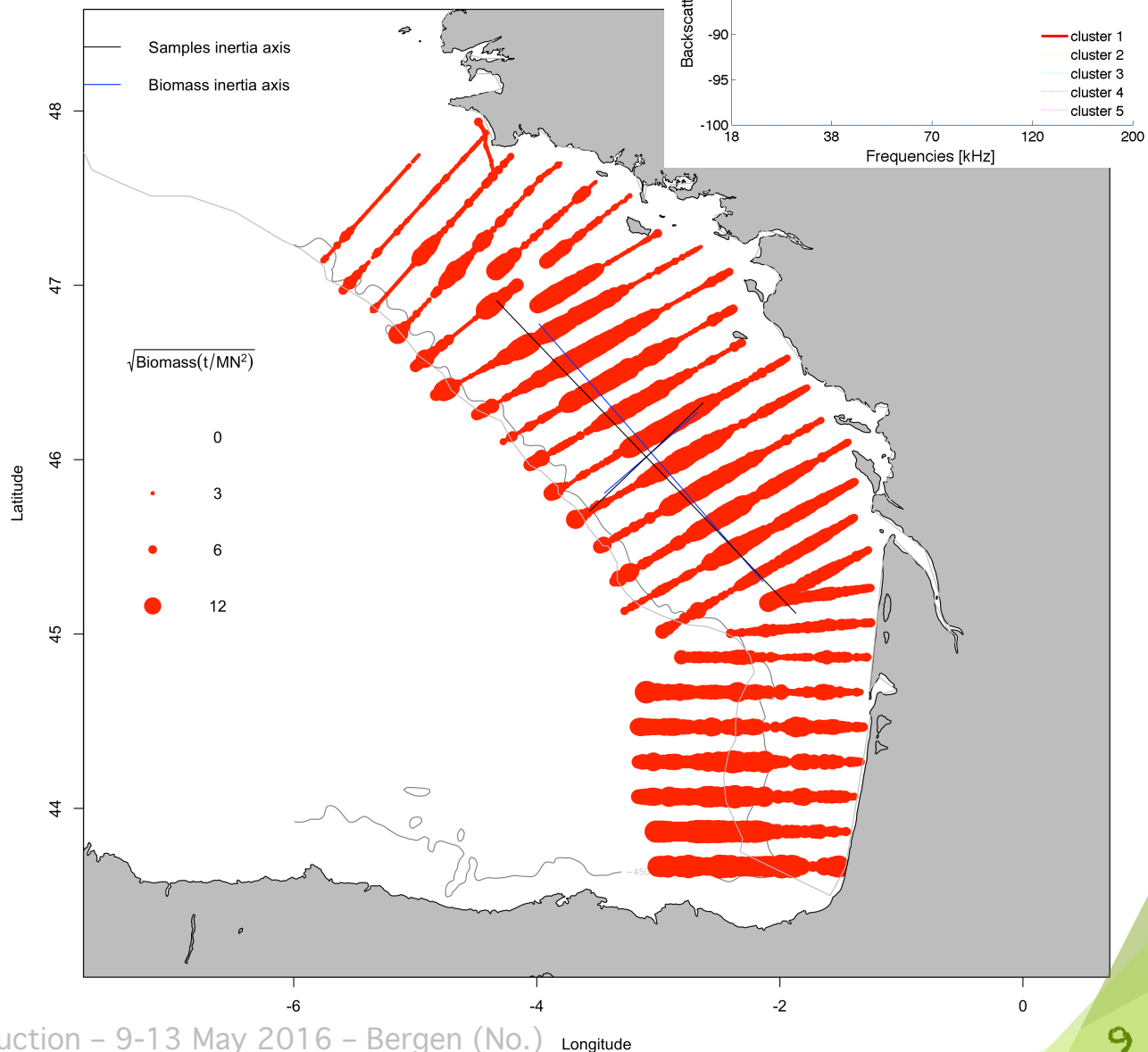


Summarize the multifrequency information



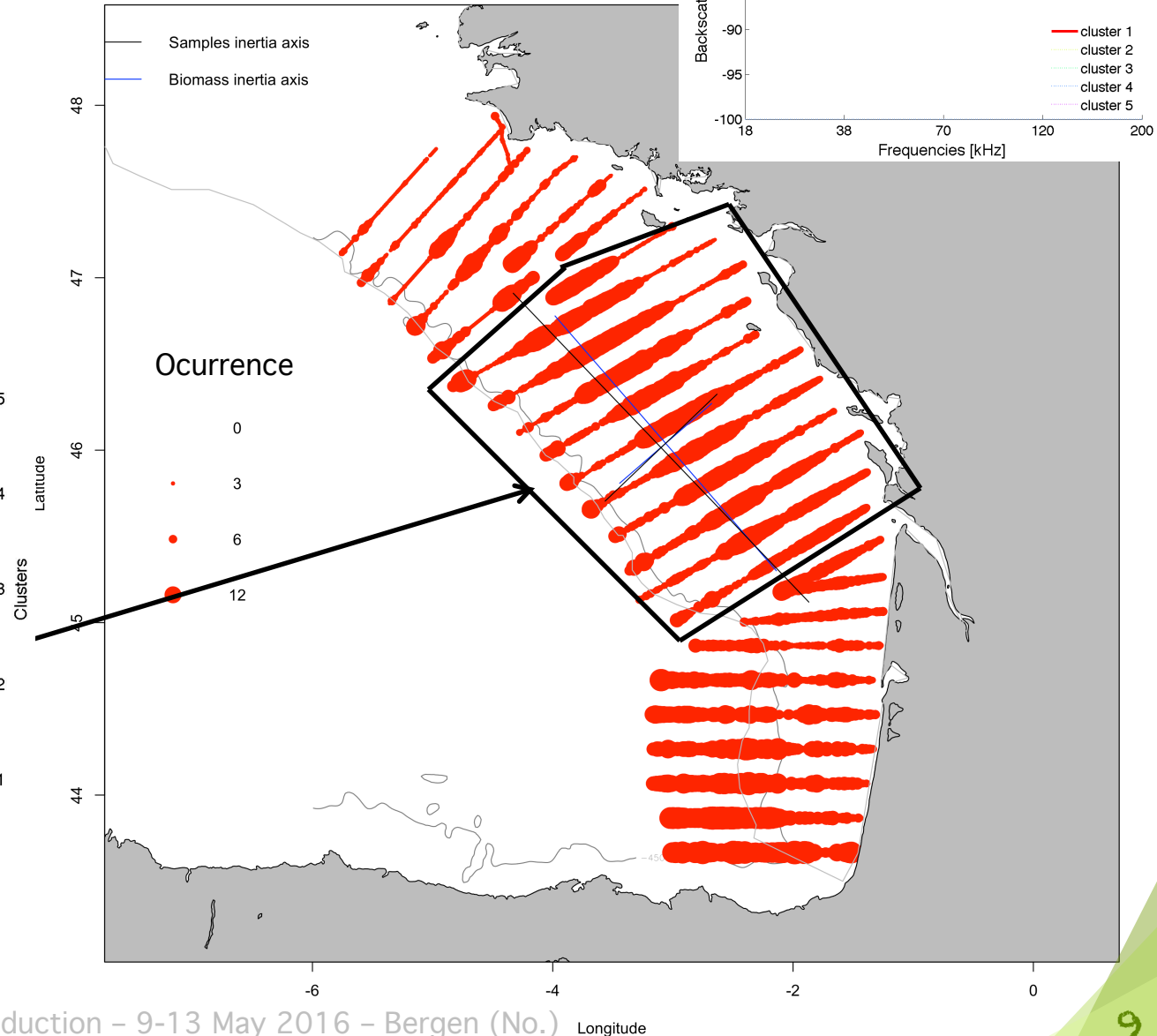
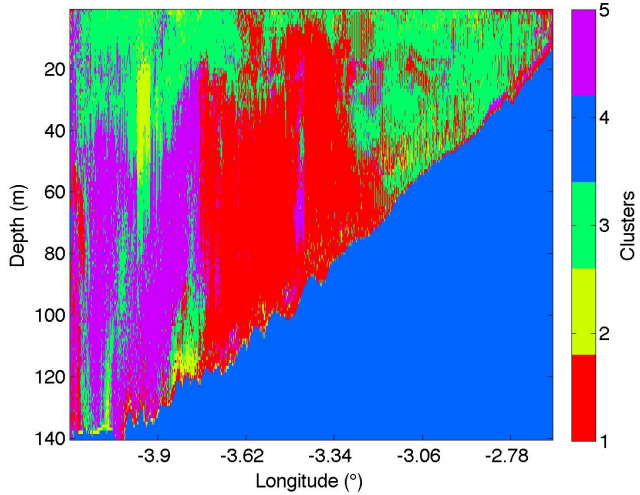
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# Discussion

## About the classification

- **Generic method**
  - Easy to perform
  - Relationship with the types of backscatterers *a posteriori*

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- **Generic method**
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  - Relationship with the types of backscatterers *a posteriori*
- **Limits**
  - Application scale
  - Mapping of the **dominant** backscatterers



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## About the classification

- **Generic method**
  - Easy to perform
  - Relationship with the types of backscatterers *a posteriori*
- **Limits**
  - Application scale
  - Mapping of the **dominant** backscatterers
- **Description of acoustic landscapes**
  - Non-random spatial patterns
  - Acoustic response of **gas-bearing organisms** is dominant
    - Mask fluid-like

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## Perspectives

- Application to other **PELGAS** datasets
  - Comparison of median frequency responses
  - Comparison of clusters' spatial patterns

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- Application to other **PELGAS** datasets
  - Comparison of median frequency responses
  - Comparison of clusters' spatial patterns
- Application to other multifrequency dataset
- Statistical and acoustic analysis
  - Need *biological validation*