Potentiel scientifique des mesures micro-sonar sur flotteurs profileurs BGC-Argo

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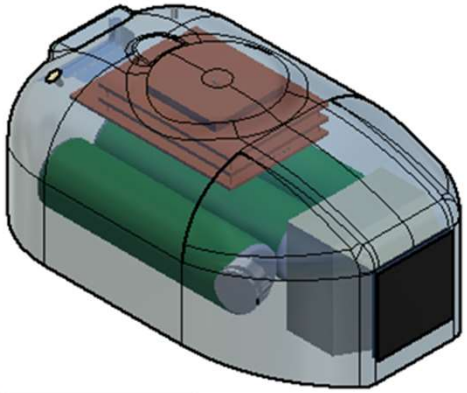
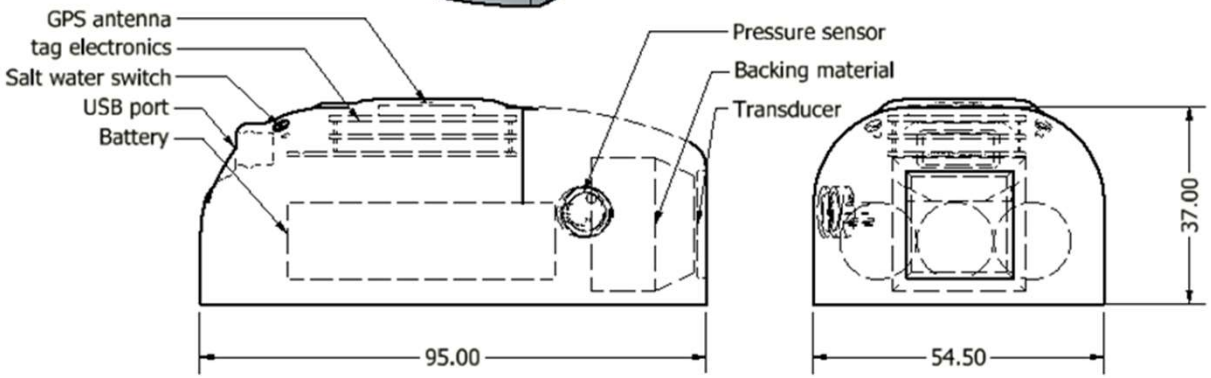
Brest; le 29-30 octobre 2022

Active µ-sonar: collaboration with M. Johnson & P. Goulet, Sea Mammal Research Unit),
Tiphaine Jeanniard du Dot (CEBC)





GOULET P, GUINET C, SWIFT R, MADSEN P. JOHNSON M. (in press). A miniature biomimetic sonar and movement tag to study the biotic environment and predator-prey interactions in aquatic animals. Deep-Sea Research Part 1.

Thèse Pauline Goulet (M. Johnson)

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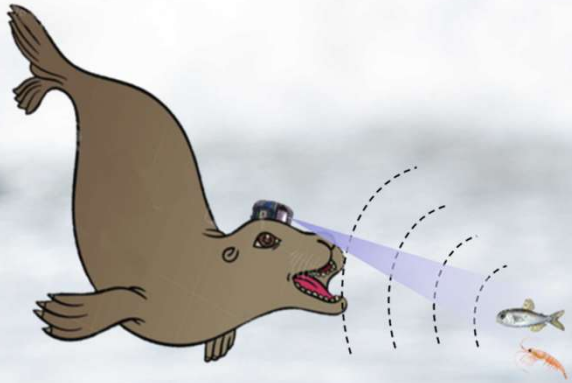


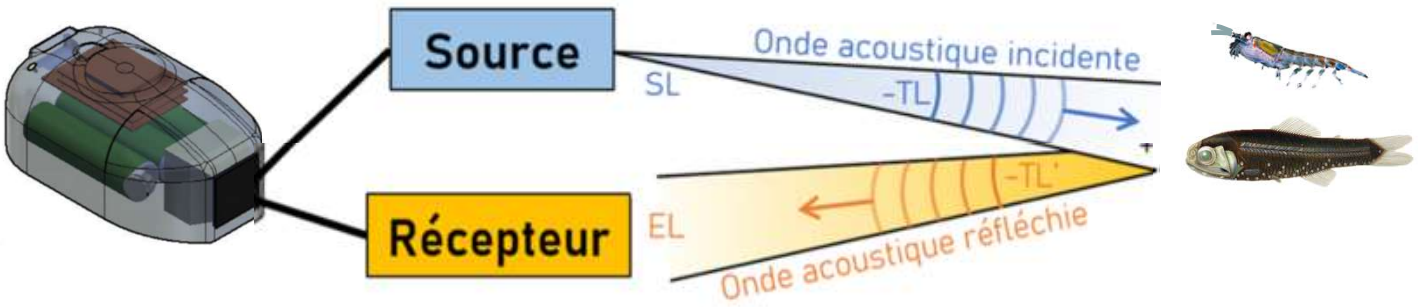
SenSe SENTINELS OF THE SEA ICE

FONDATION BNP PARIBAS

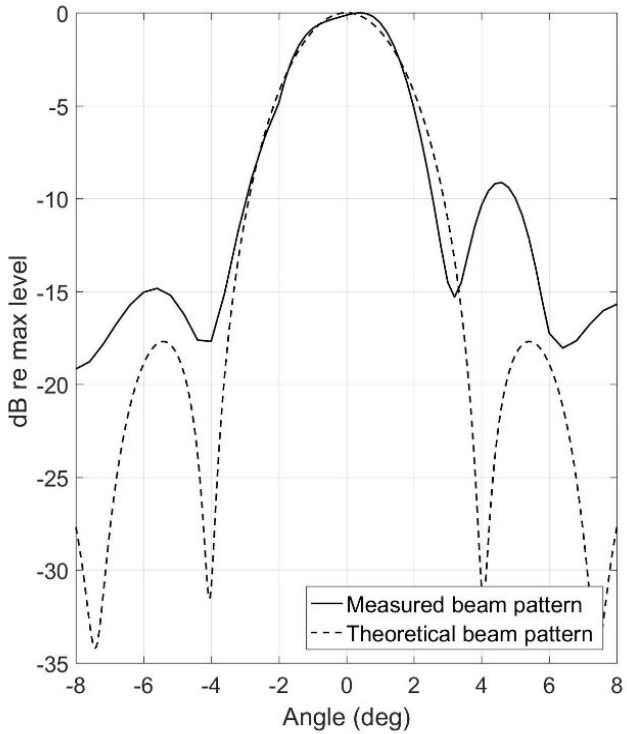
Sous l'égide de la Fondation de France

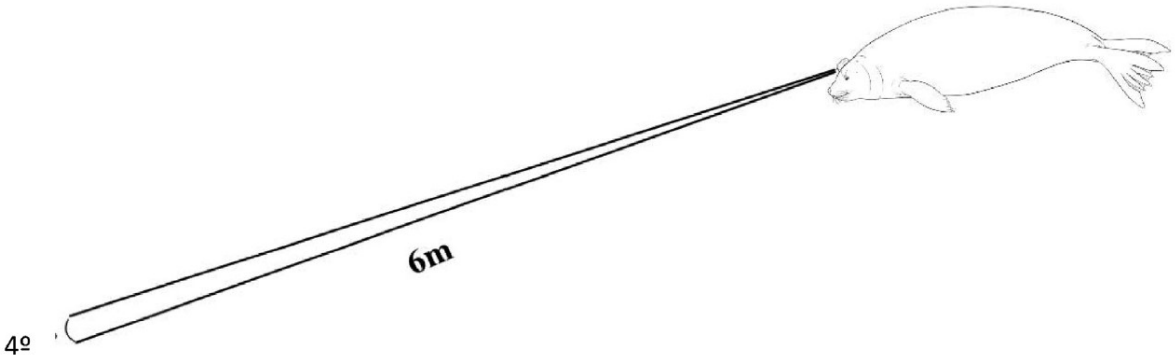
cnes

CENTRE NATIONAL D'ÉTUDES SPATIALES

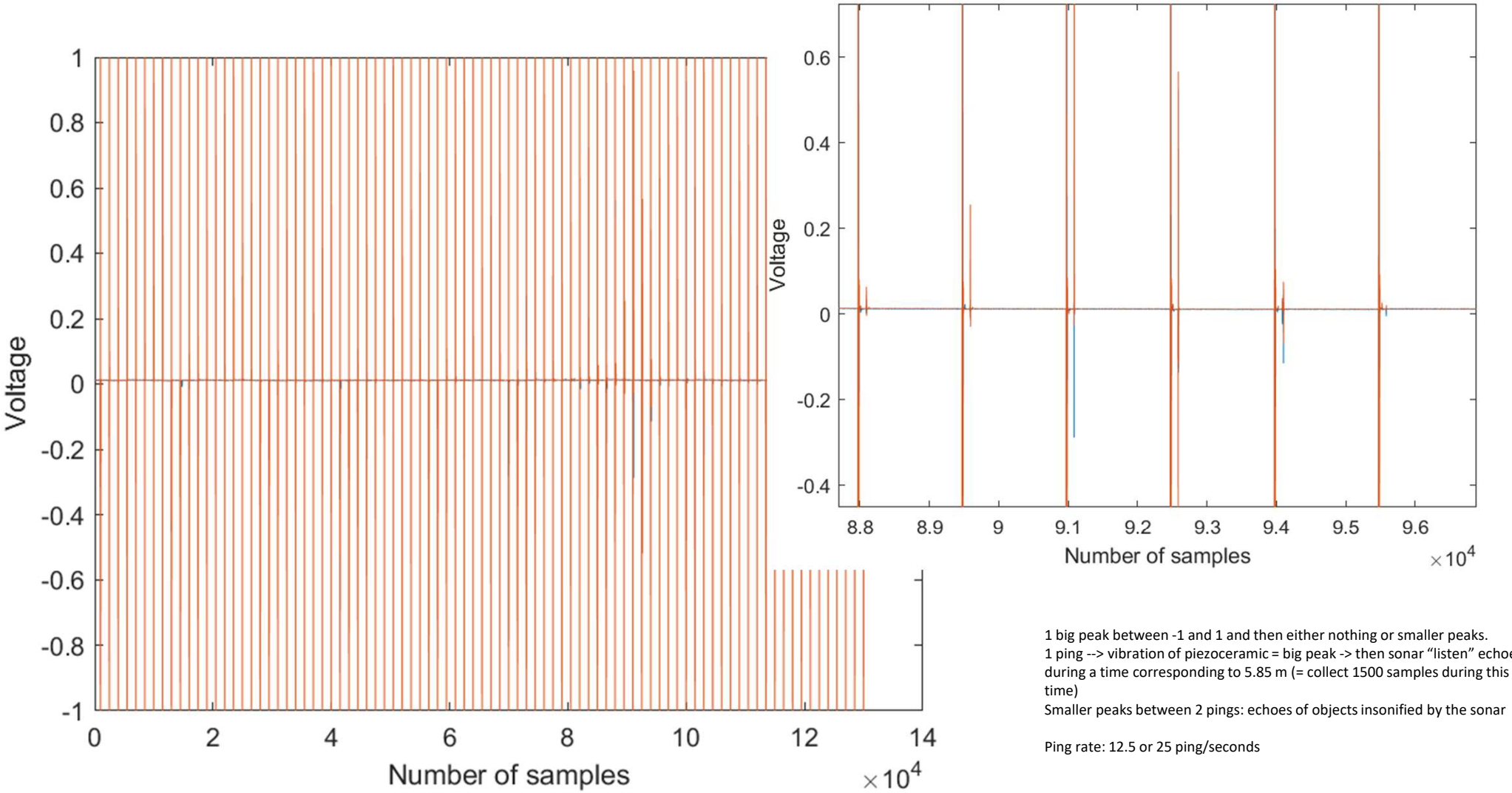


- ✓ échosondeur mono-faisceau et monofréquence
- ✓ <u>fréquence d'émission</u> (onde sonore émise): 1,5 MHz
- ✓ Fréquence d'acquisition : 12,5 ou 25 Hz.
- ✓ Résolution pixel : 3,9 mm
- ✓ <u>taille minimale détectée</u> : 1 à 2 mm



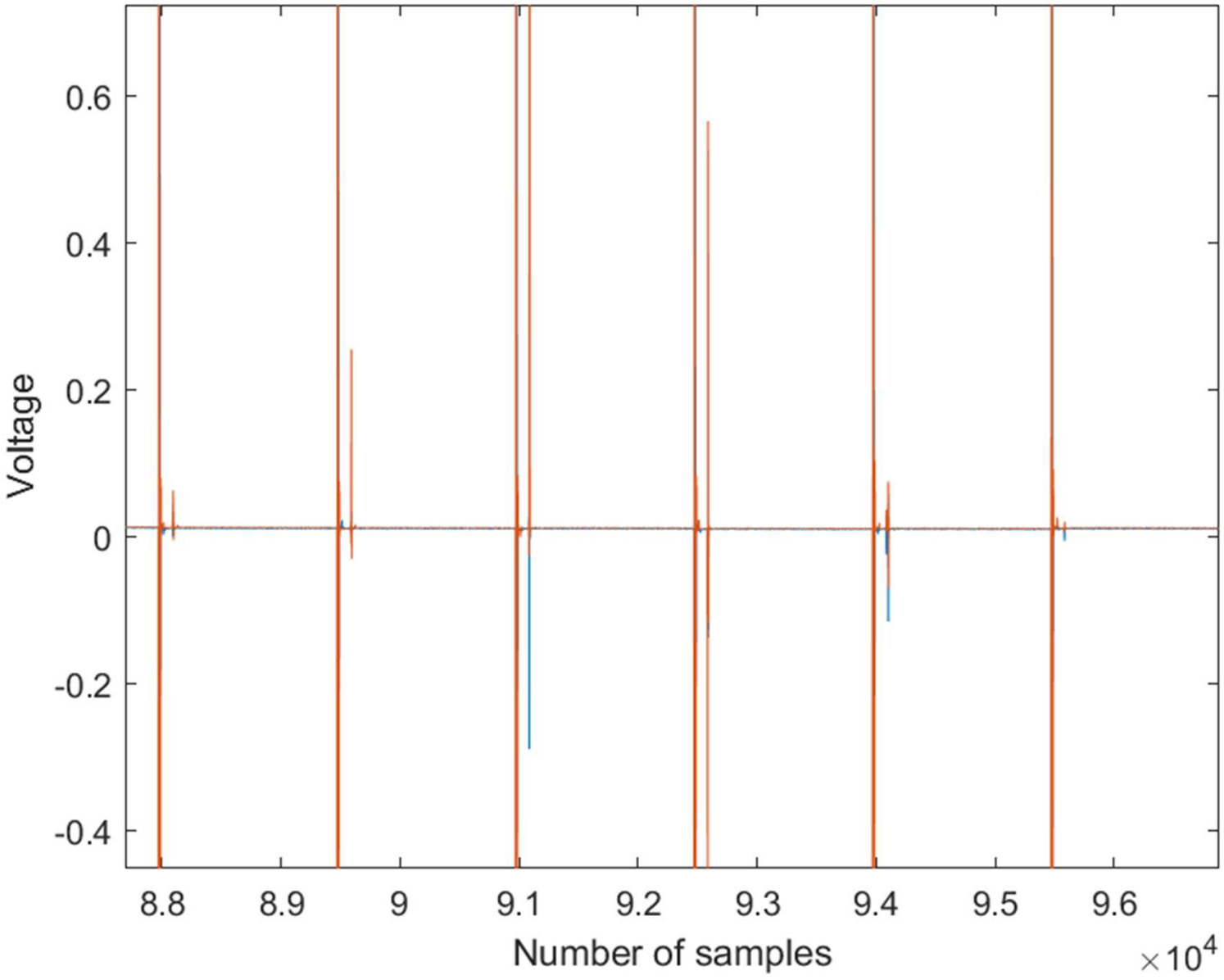


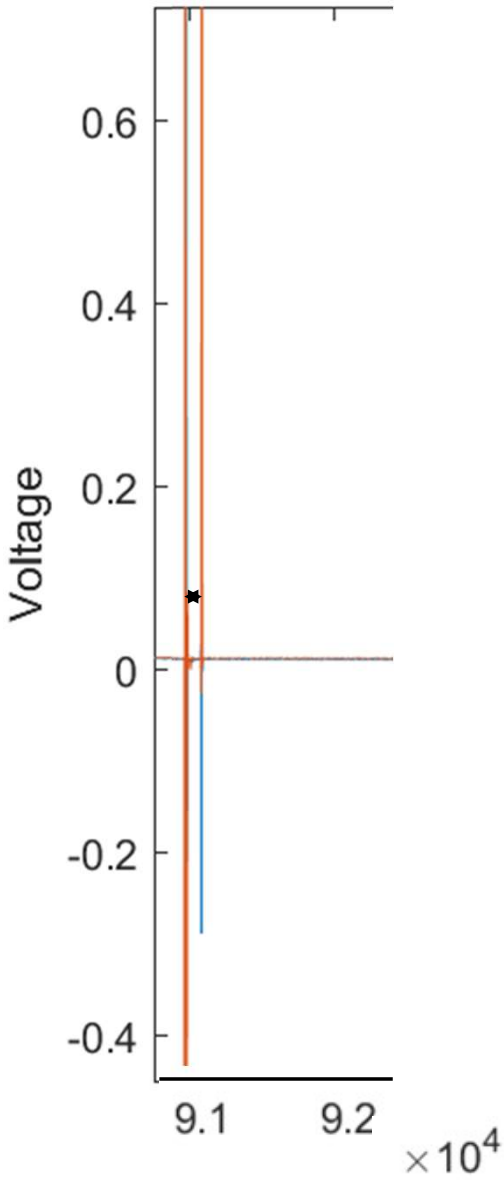
Raw data:



1 big peak between -1 and 1 and then either nothing or smaller peaks.
1 ping --> vibration of piezoceramic = big peak -> then sonar “listen” echoes during a time corresponding to 5.85 m (= collect 1500 samples during this time)
Smaller peaks between 2 pings: echoes of objects insonified by the sonar

Ping rate: 12.5 or 25 ping/seconds

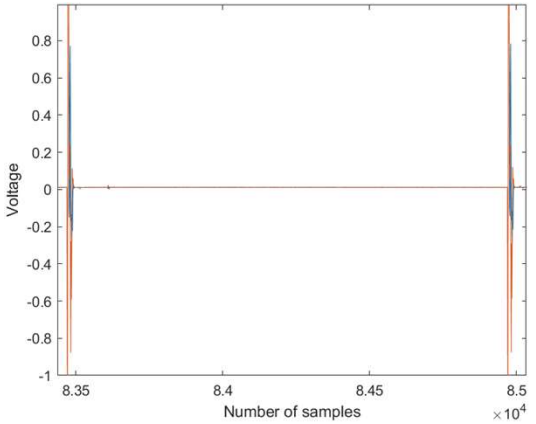

0.6
0.4
0.2
0
-0.2
-0.4
Voltage
8.8
8.9
9
9.1
9.2
9.3
9.4
9.5
9.6
Number of samples
×10^4


0.6
0.4
0.2
0
-0.2
-0.4
Voltage
9.1
9.2
×10^4

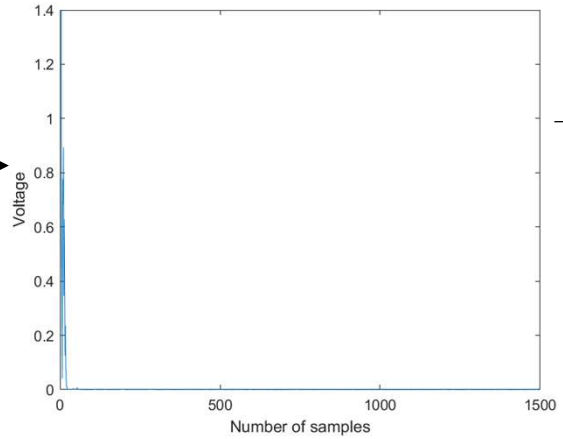
From raw data to echograms:

1. Raw signal, received on two channels

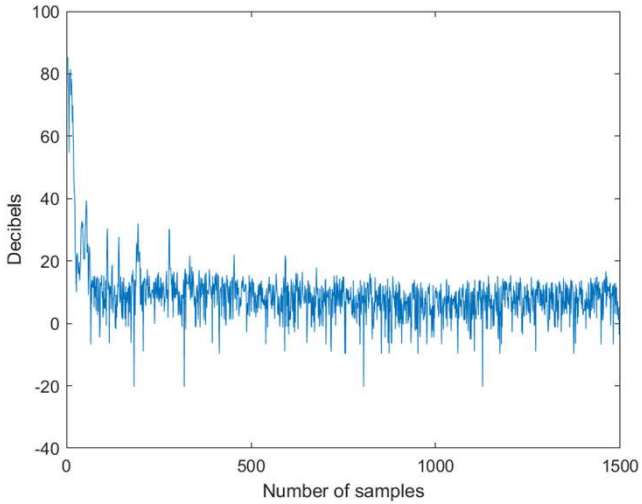
192 000 Hz receiver sampling rate, according to the sound travel speed in water (1500 $m.s^{-1}$) the resolution is 7.8 mm/channel.



2. Signal gathered into one channel (quadratic demodulation) by combining the two channels the resolution increase from 7,8 mm to 3,9 mm (elementary sample or pixel): i.e. Resolution : 256 samples/m (i.e. 3,9 mm/ transducer vibrations). 1500 vibrations recorded by the sonar correspond to 5,85 m



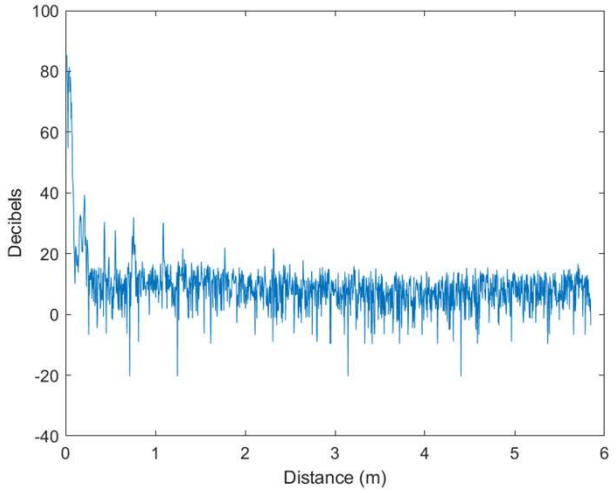
3. Convert voltage into decibels



Then convert voltage V into decibels
dB = 20*log10(V)-NL

Noise Level
NL = 20*log10(10^{th} percentile of voltage of the vibrations (signal)

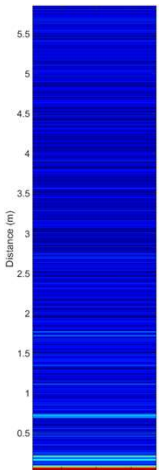
4. Convert number of samples into a distance



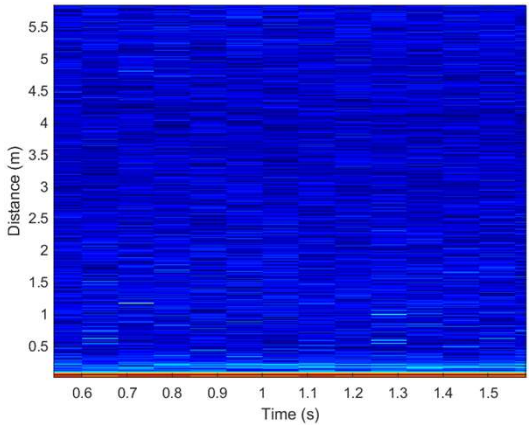
D = v * t
D = round-trip distance travelled by the sound = 2*distance single trip
v = sound speed (1500 $m.s^{-1}$)
t = time of the ping in samples = time of the ping in seconds divided by ping rate

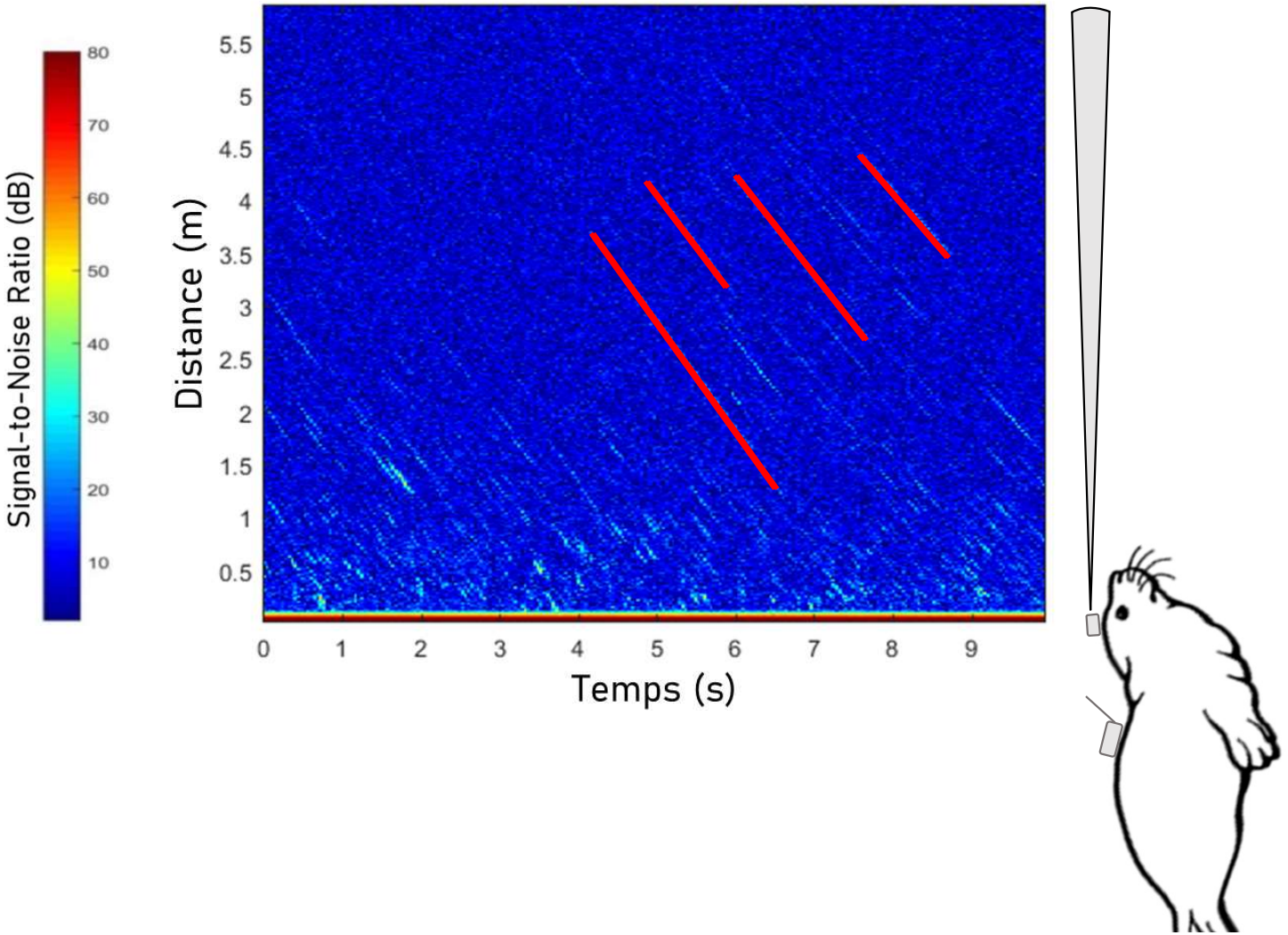
D = (ss * n) / (pr * 2)
n = n° of sample of the ping
ss = sound speed
pr = ping rate

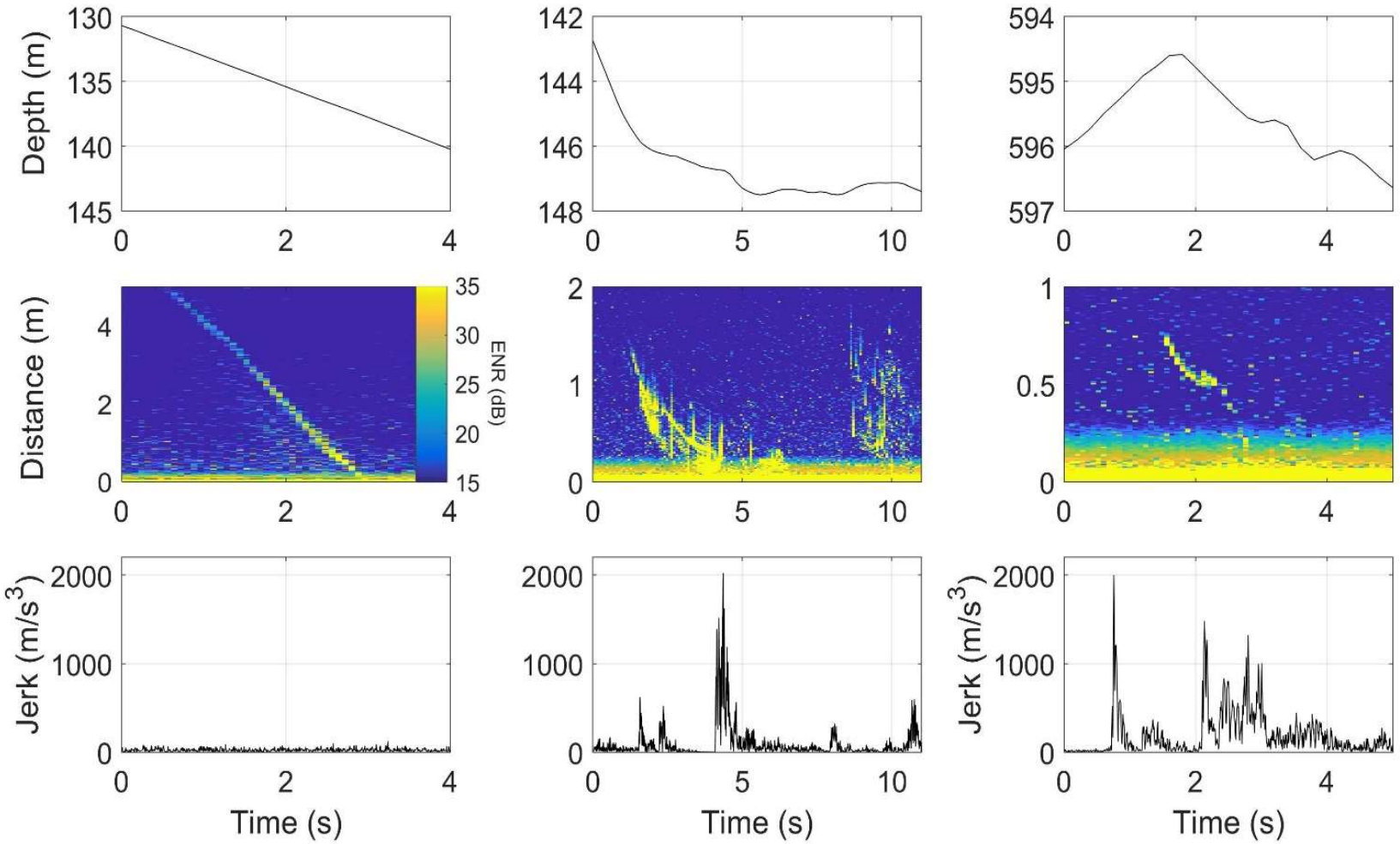
5. Rotate and colour by dB value



6. Stack all pings one after the other to create the echogram (12,5 Hz)



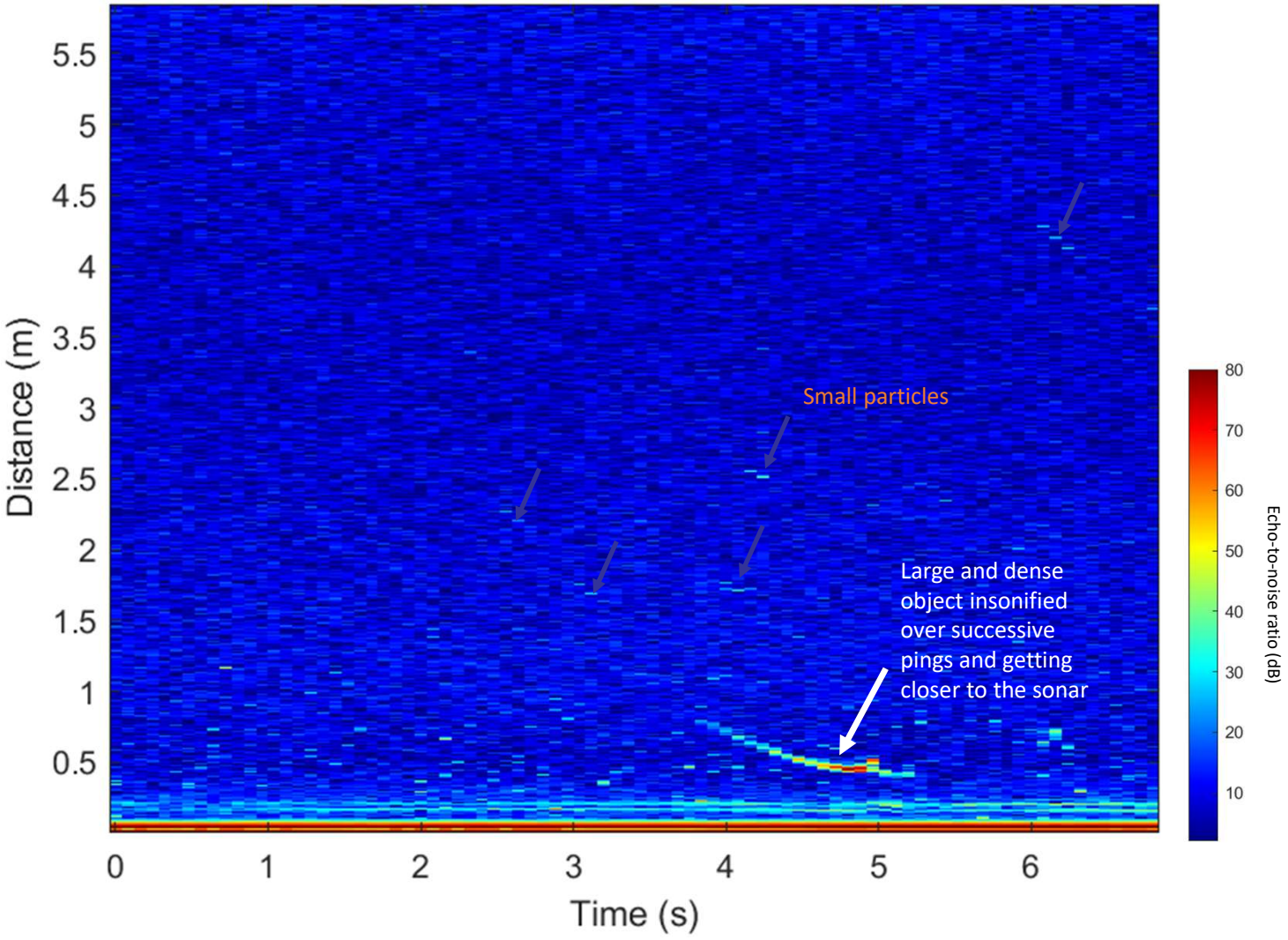

Signal-to-Noise Ratio (dB)
80
70
60
50
40
30
20
10
Distance (m)
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
Temps (s)



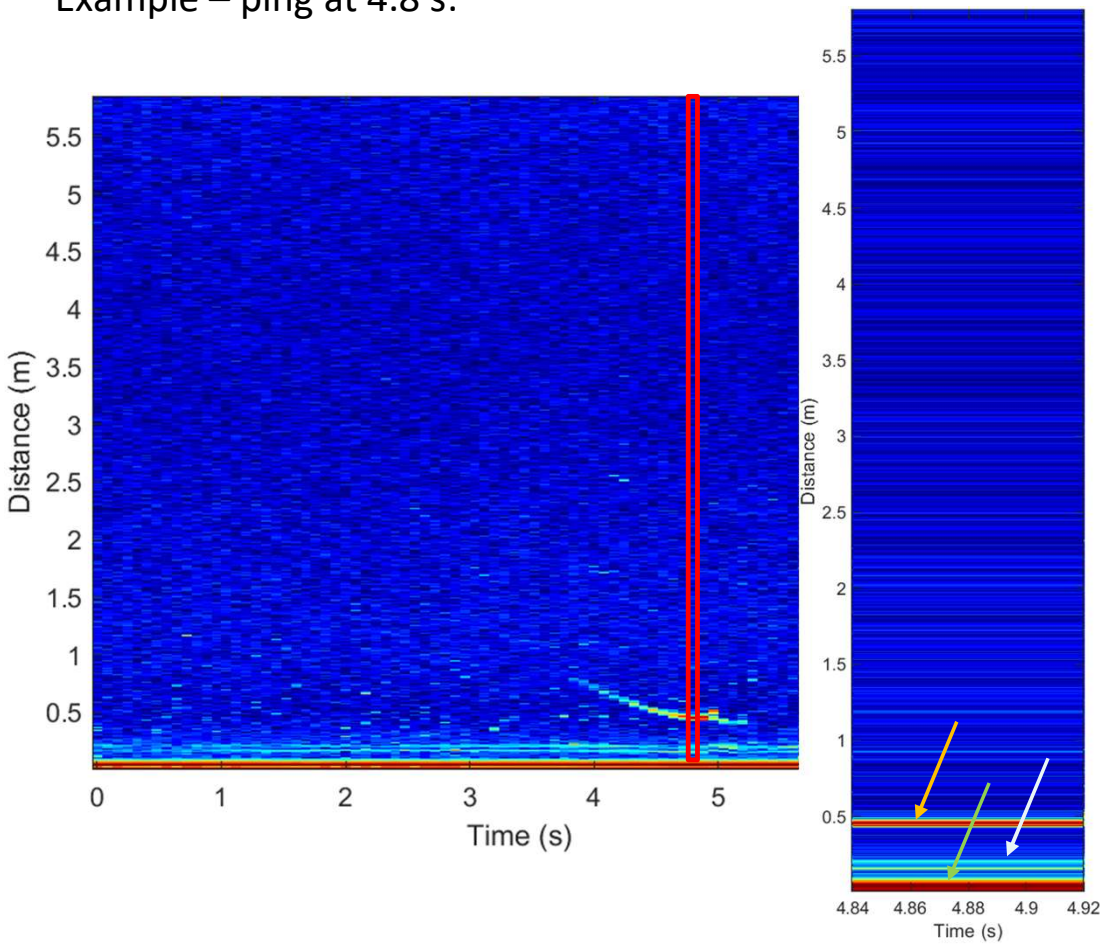
Goulet P, Guinet C, Swift R, Madsen P. Johnson M. (2019). Deep-Sea Research Part 1.

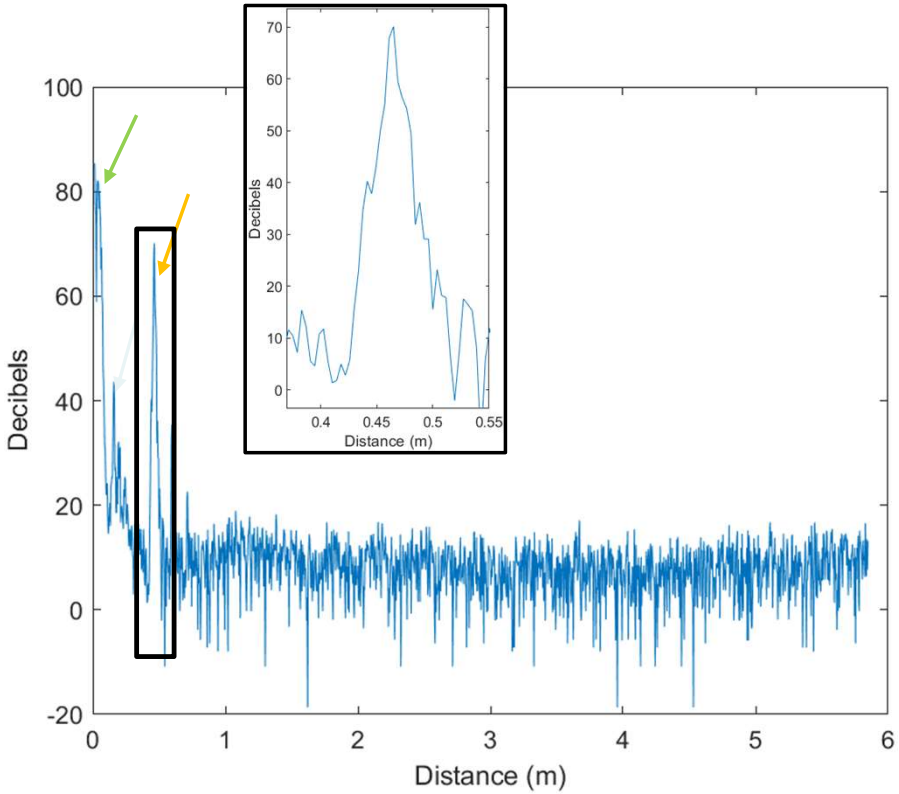
Example of an echogram:

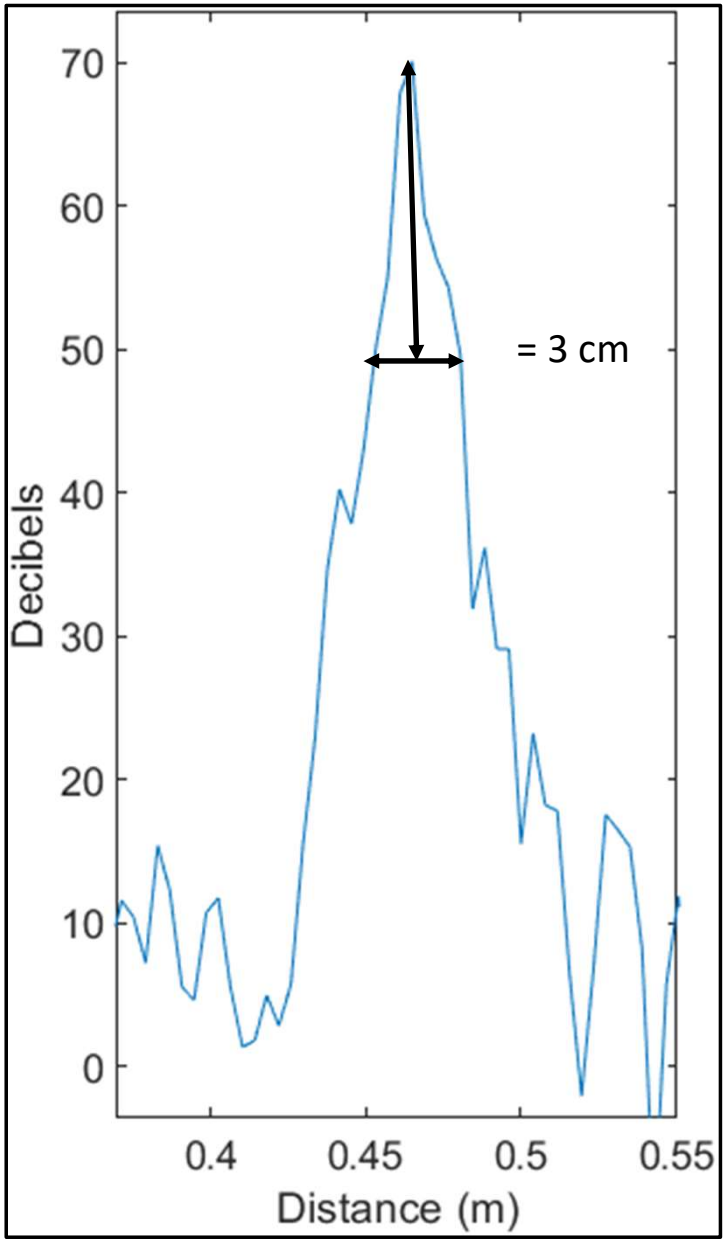
Logger Microsonar: prey field



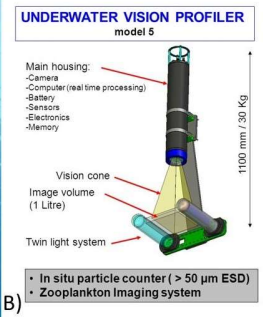
Example – ping at 4.8 s:



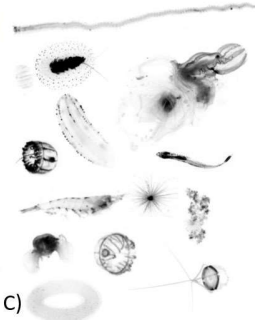



70
60
50
40
30
20
10
0
Decibels
= 3 cm
0.4
0.45
0.5
0.55
Distance (m)

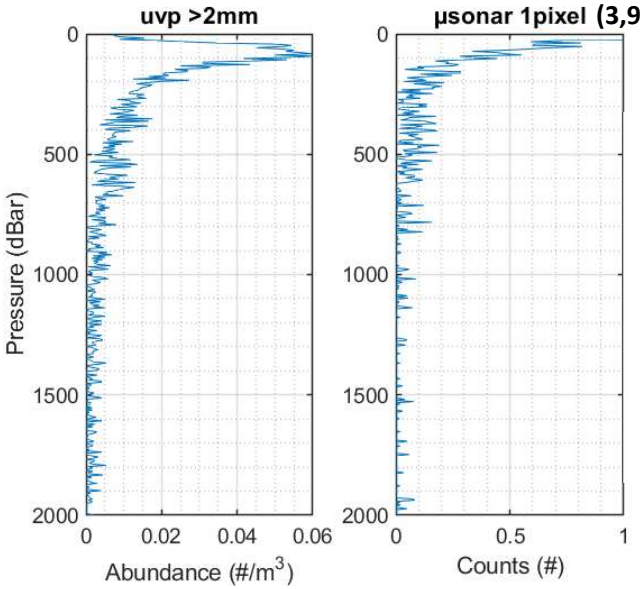
A)

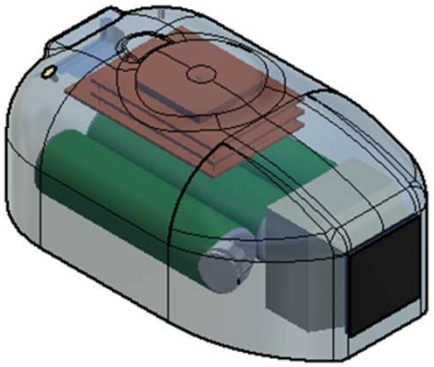


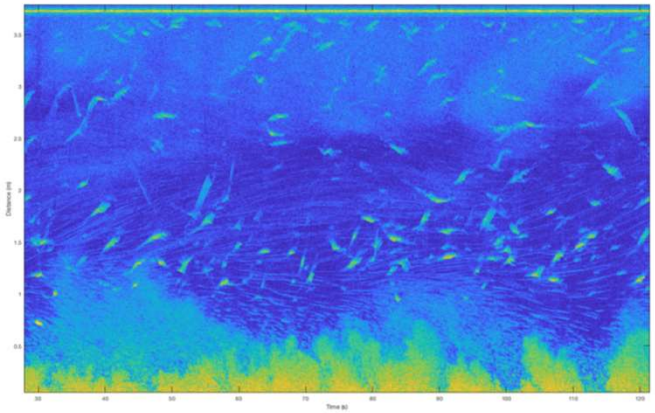
B)



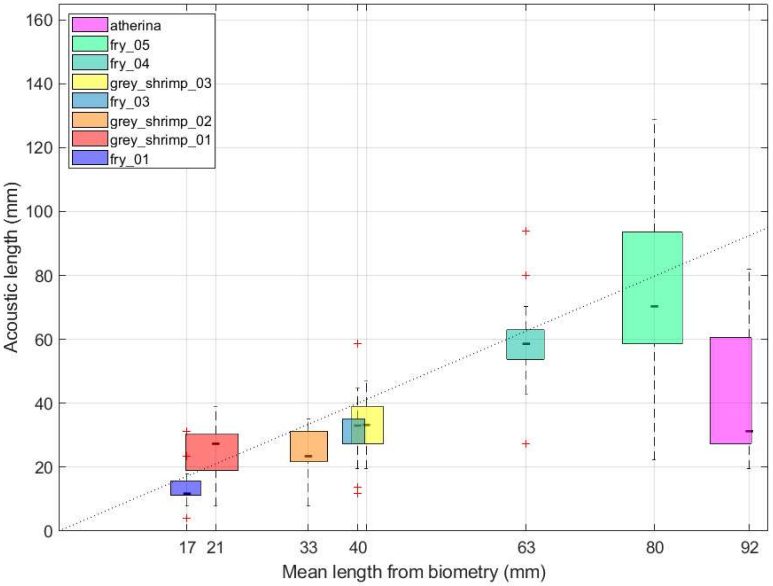
C)



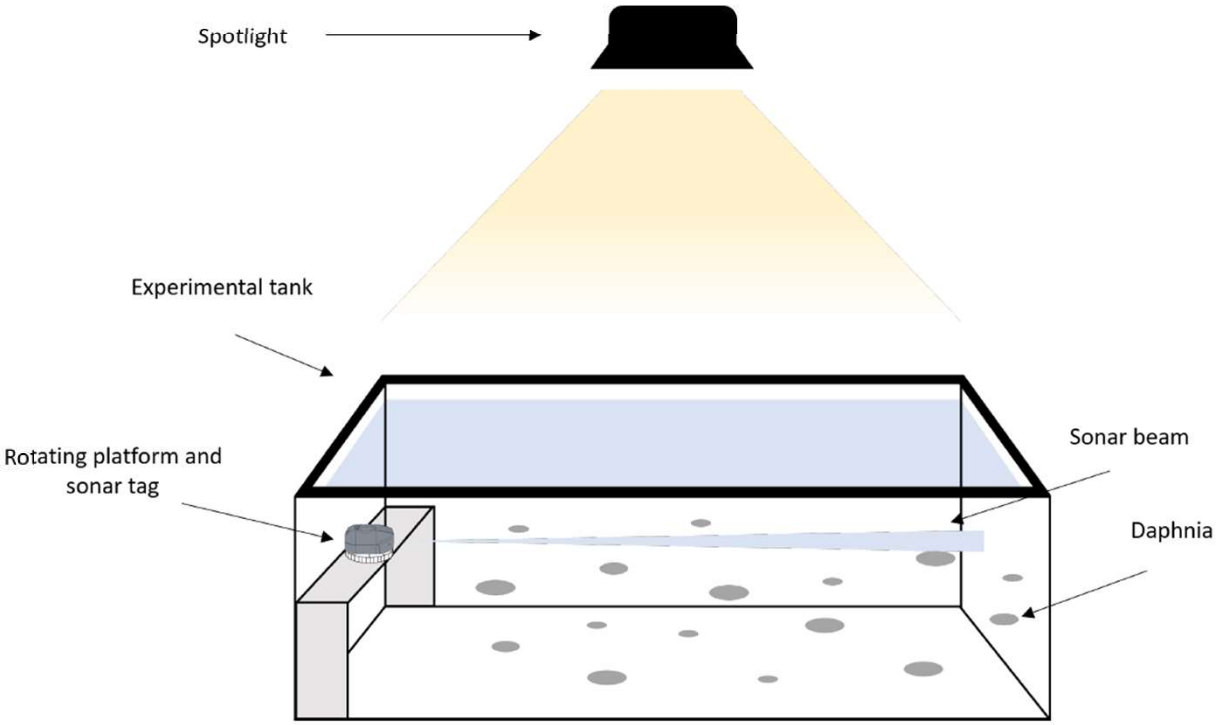




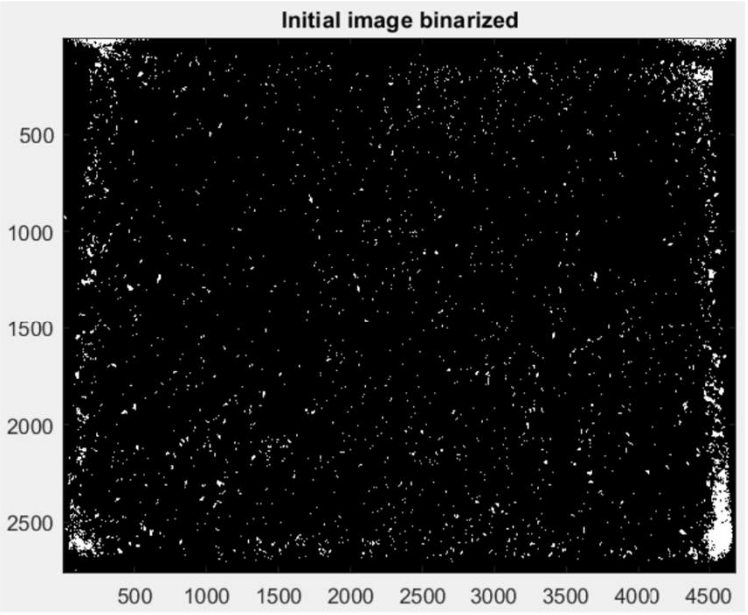
Master 2 WAPE Louis Petiteau

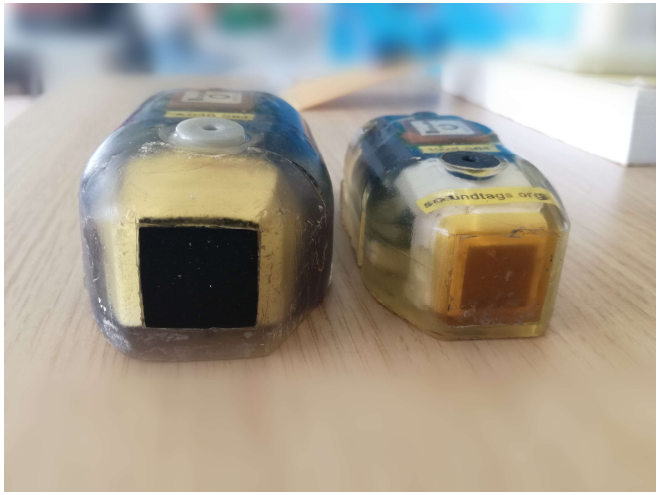


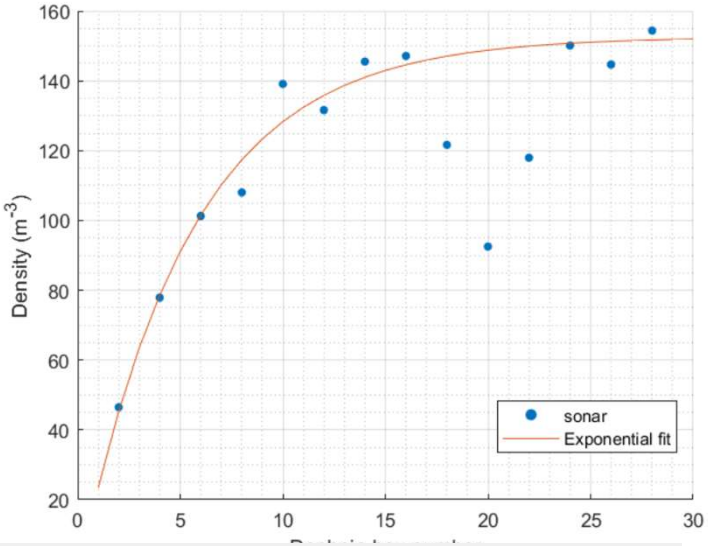
Master 1 Adrien Moinet

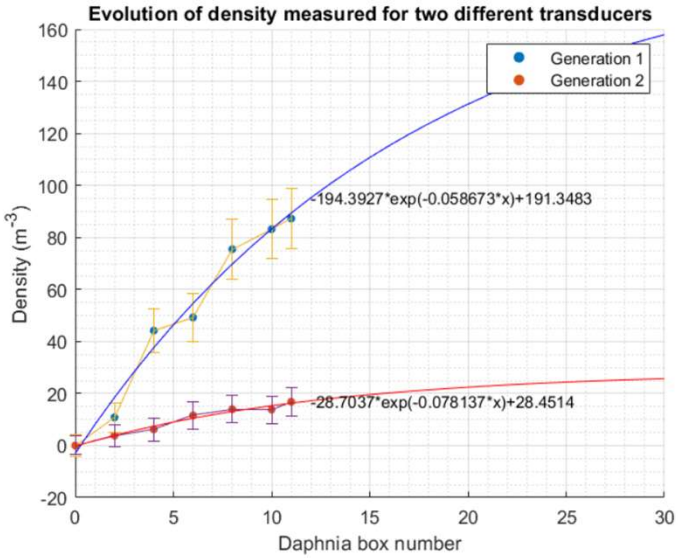


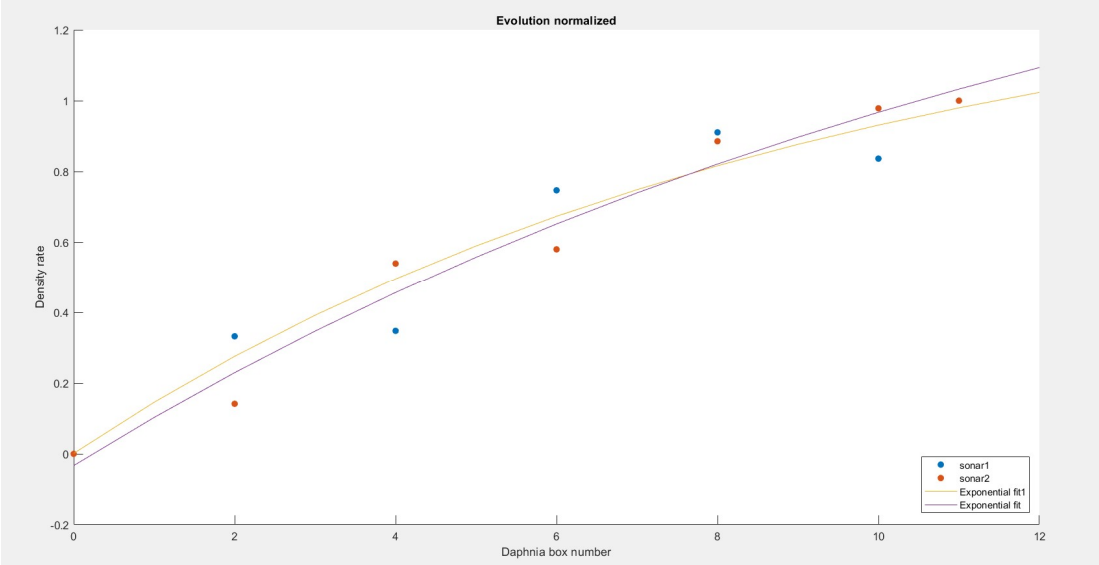
	Number of daphnia per box	Size
Category 1	850	0 to 0.7 mm
Category 2	1700	0.7 to 1.1 mm
Category 3	2700	1.1 to 2.5 mm
Category 4	300	Up to 2.5 mm



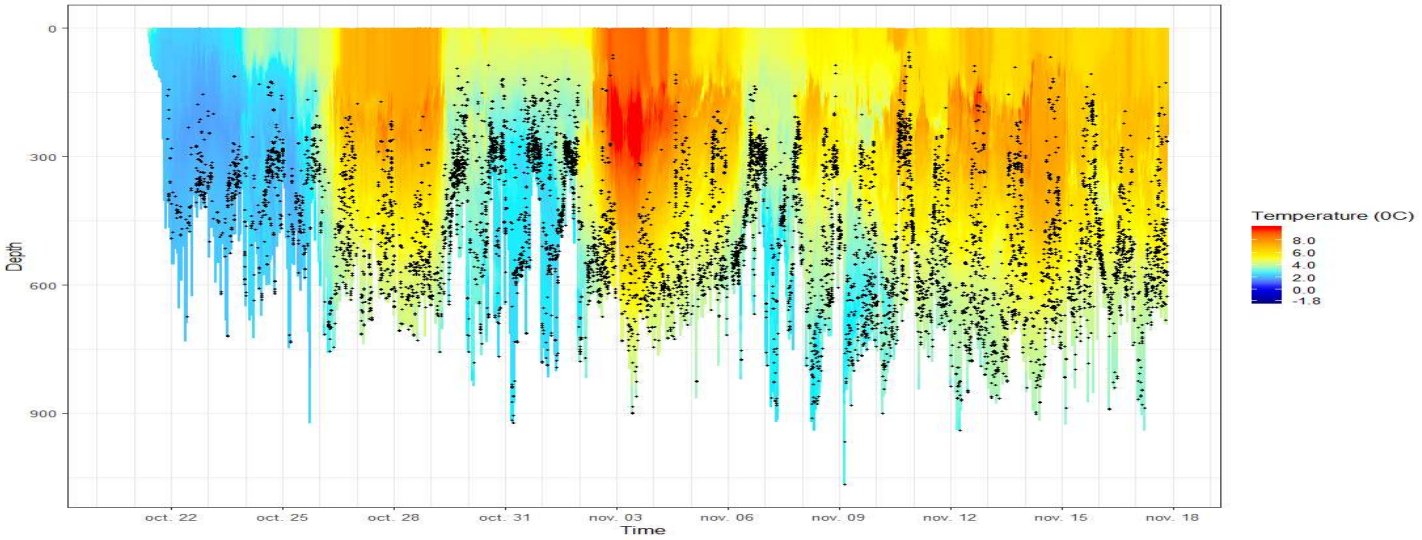


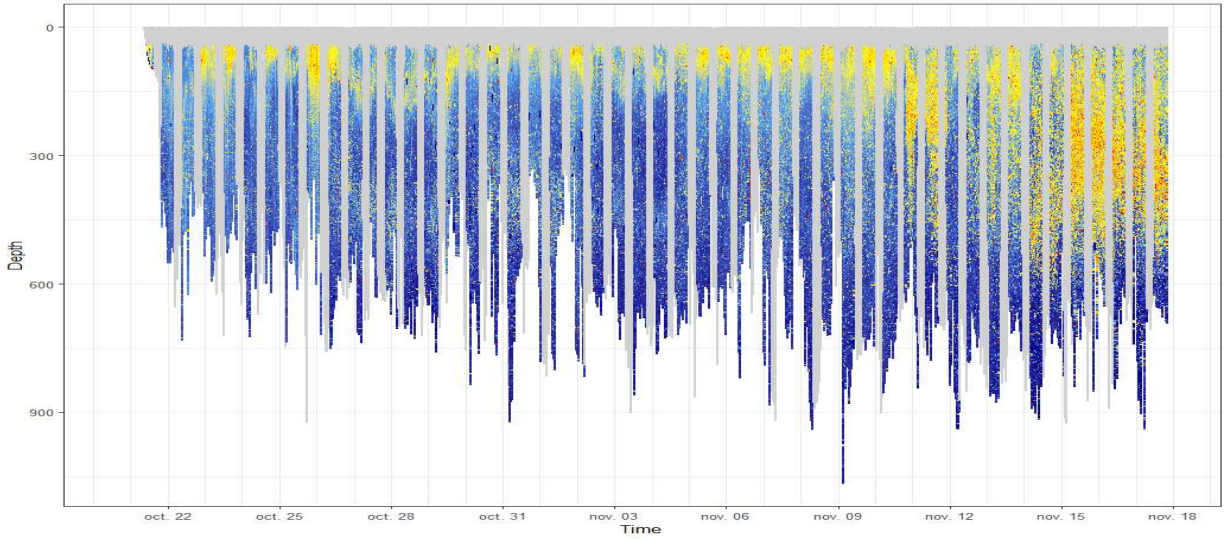


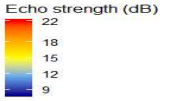




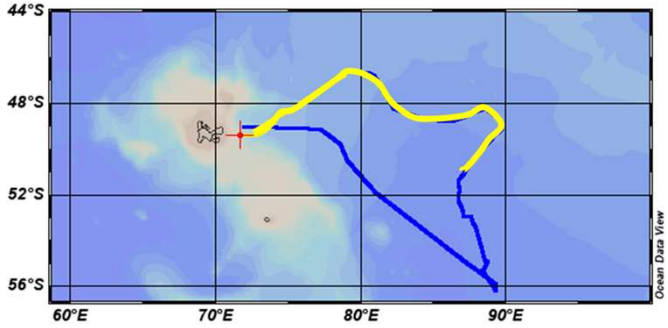
Master 1 Adrien Moinet



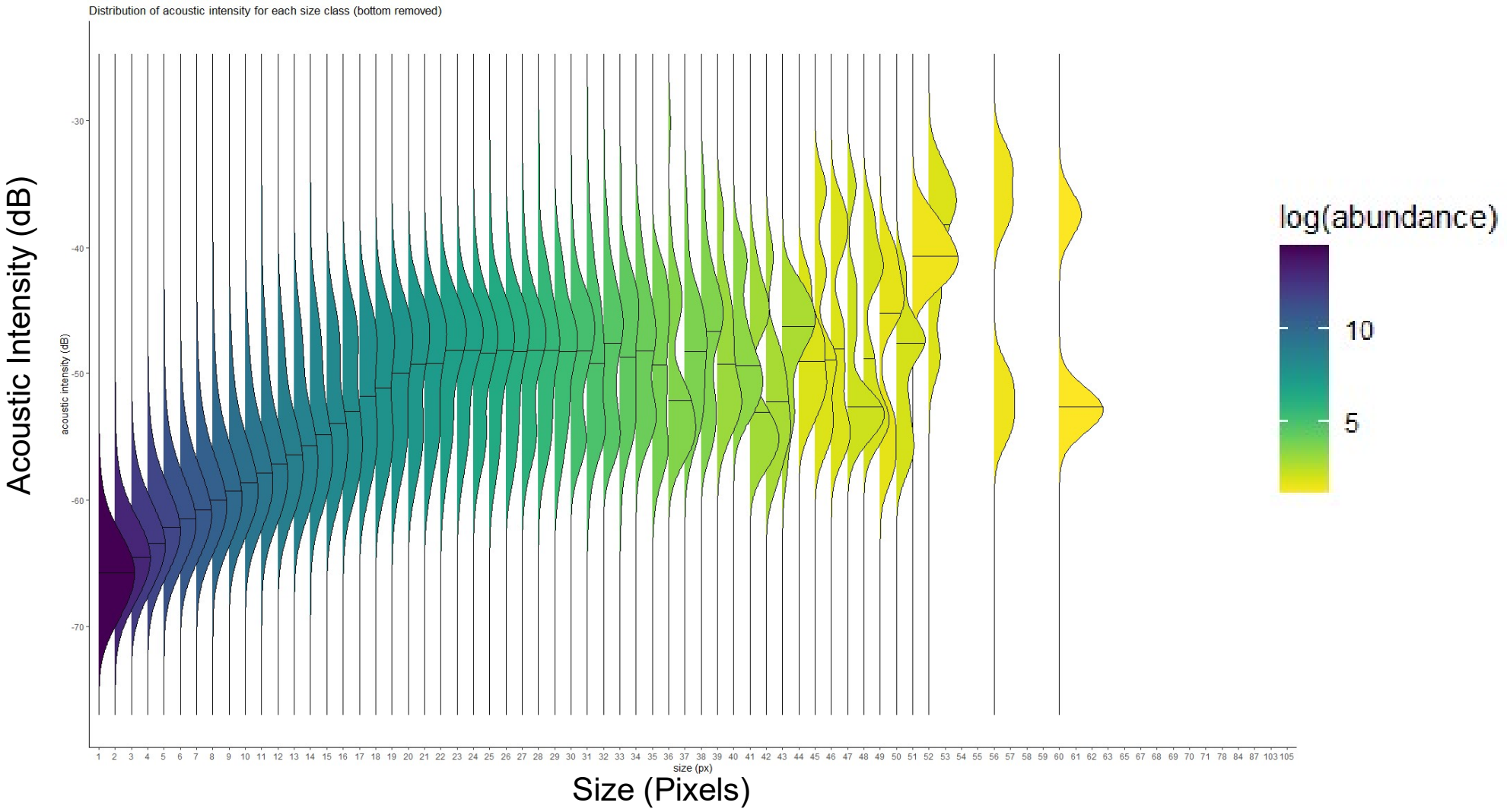




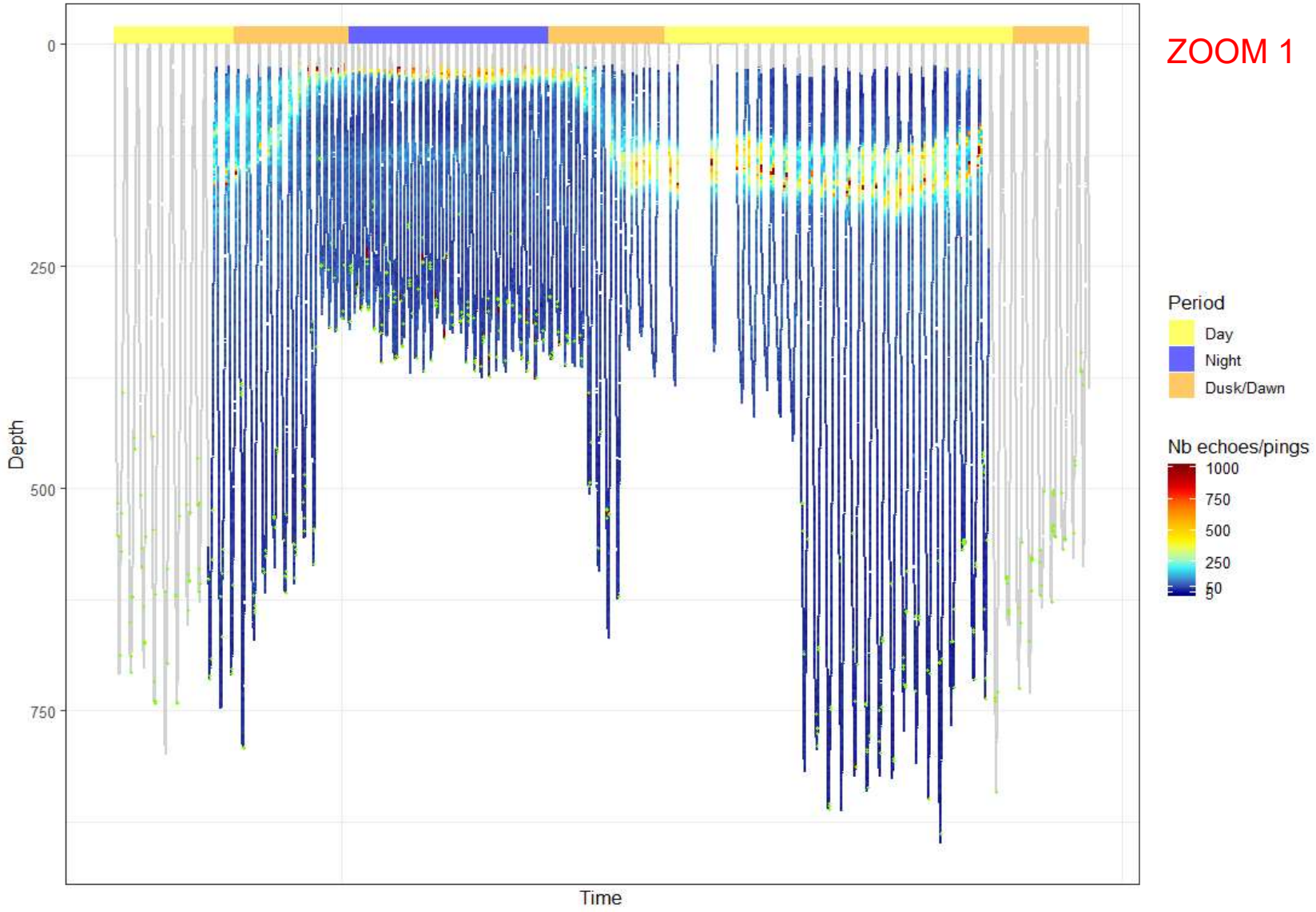
Thèse Martin Tournier (C. Guinet & M. Johnson)



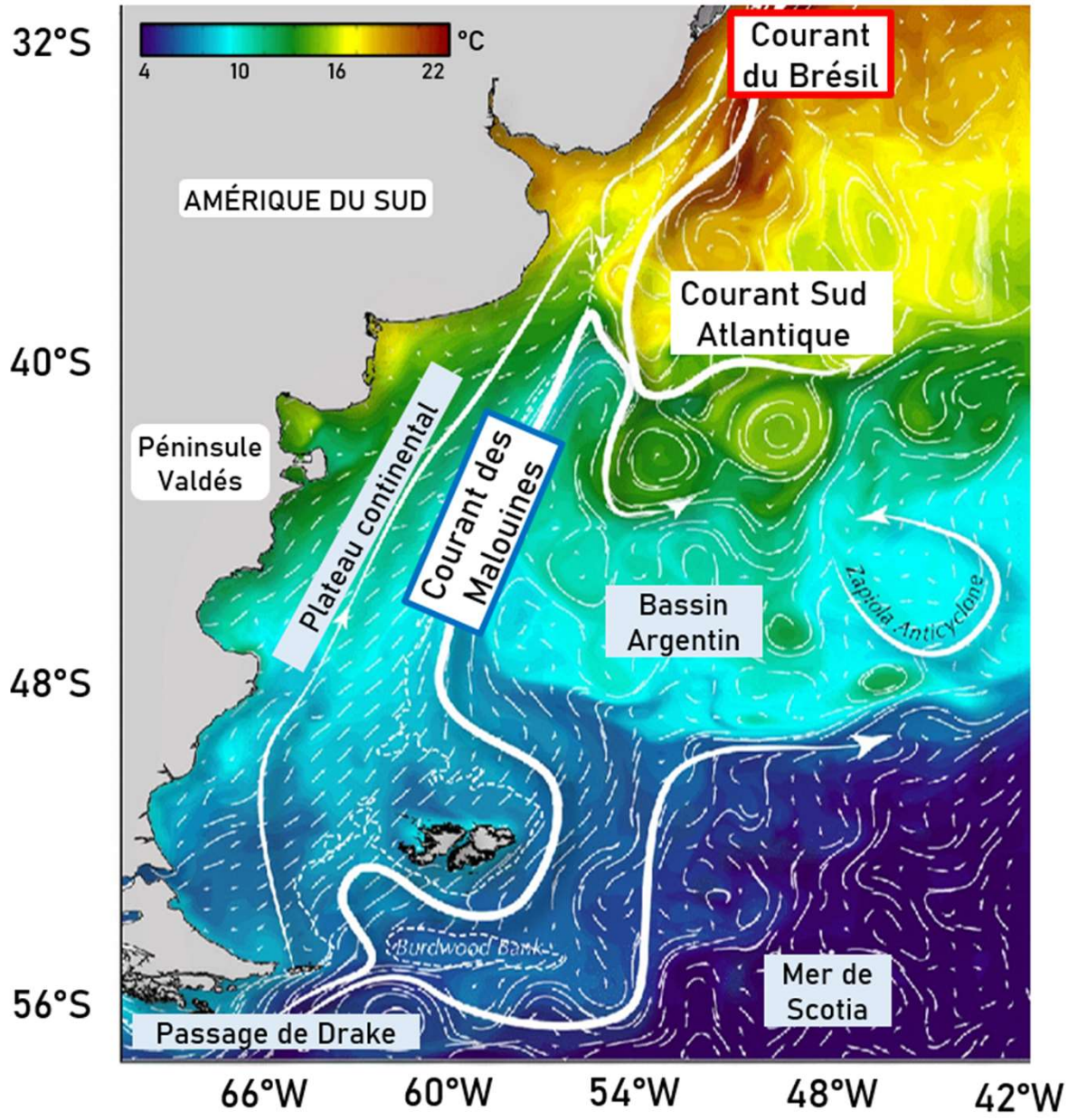
Master 2 Jade Chevassu



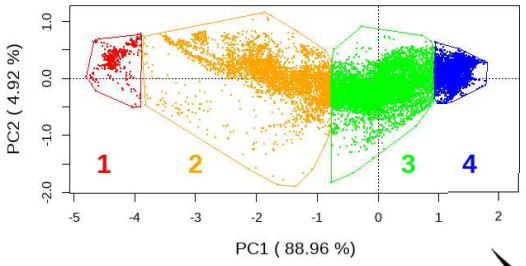
ZOOM 1



Zoom de la densité en echos au 4 Novembre. En vert, les PCA

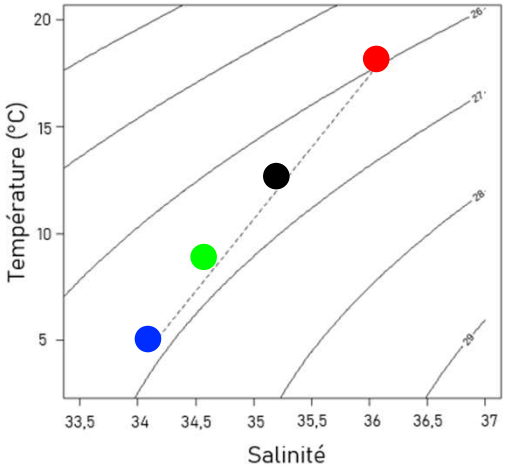

°C
4
10
16
22
Courant du Brésil
AMÉRIQUE DU SUD
Courant Sud Atlantique
Péninsule Valdés
Plateau continental
Courant des Malouines
Bassin Argentin
Zapiola Anticyclone
Burdwood Bank
Mer de Scotia
Passage de Drake
32°S
40°S
48°S
56°S
66°W
60°W
54°W
48°W
42°W

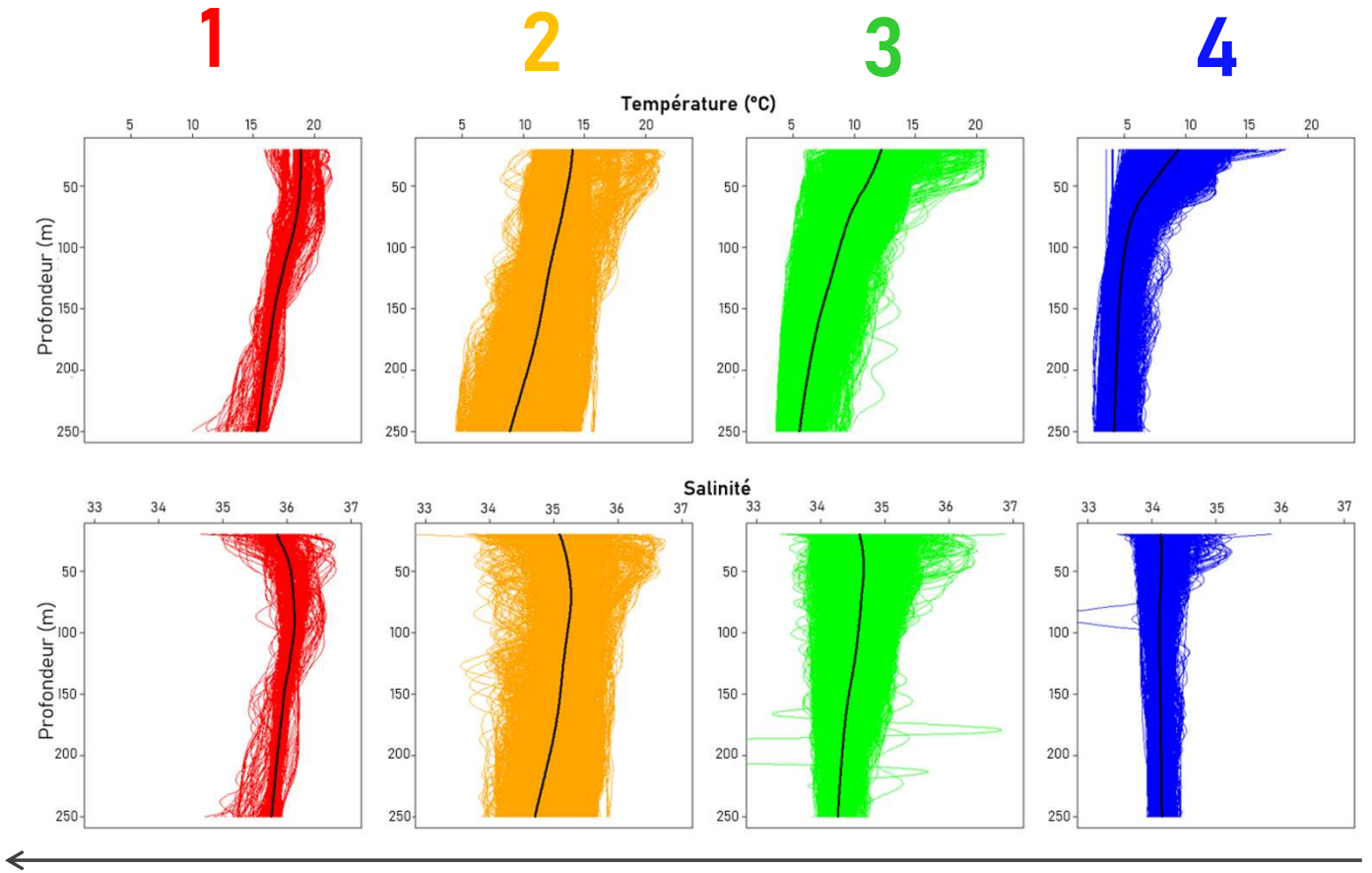
Classification des masses d'eau



(a) **Profils moyens**

(b) **Diagramme T-S**





Profils très chauds et très salés

Profils intermédiaires

Profils très froids et très peu salés

Classification des masses d'eau

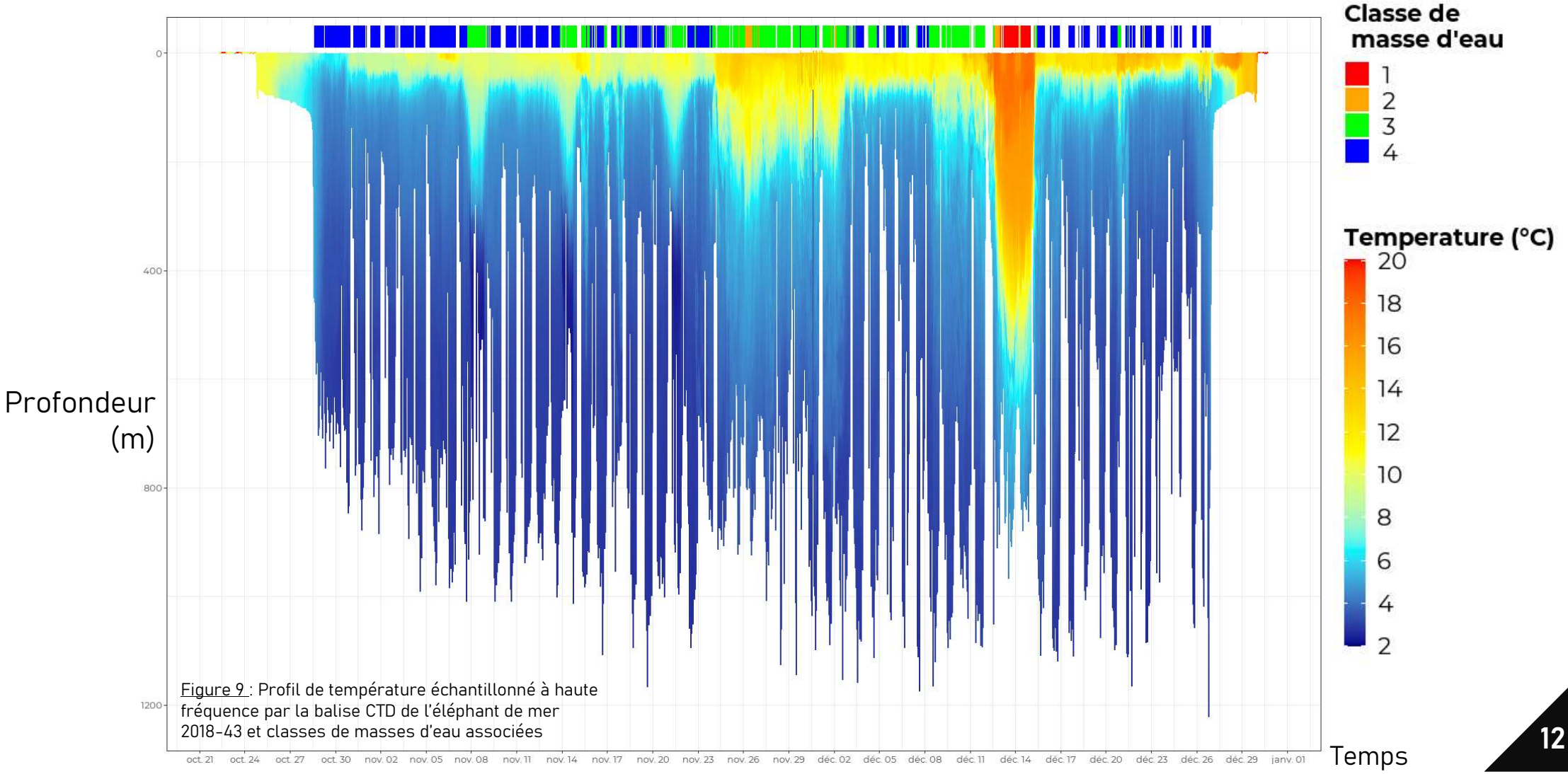


Figure 9 : Profil de température échantillonné à haute fréquence par la balise CTD de l'éléphant de mer 2018-43 et classes de masses d'eau associées

Classification des masses d'eau

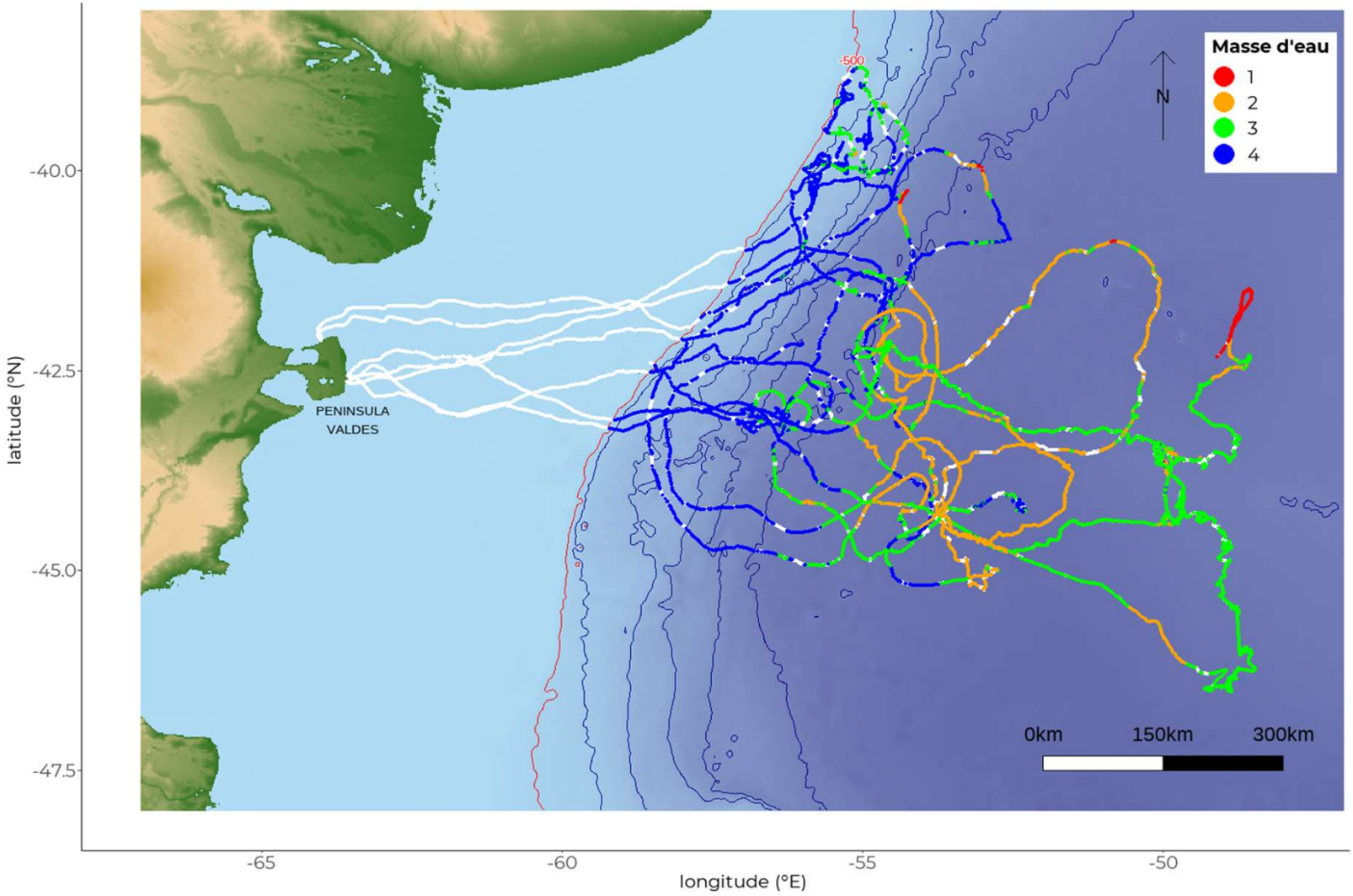
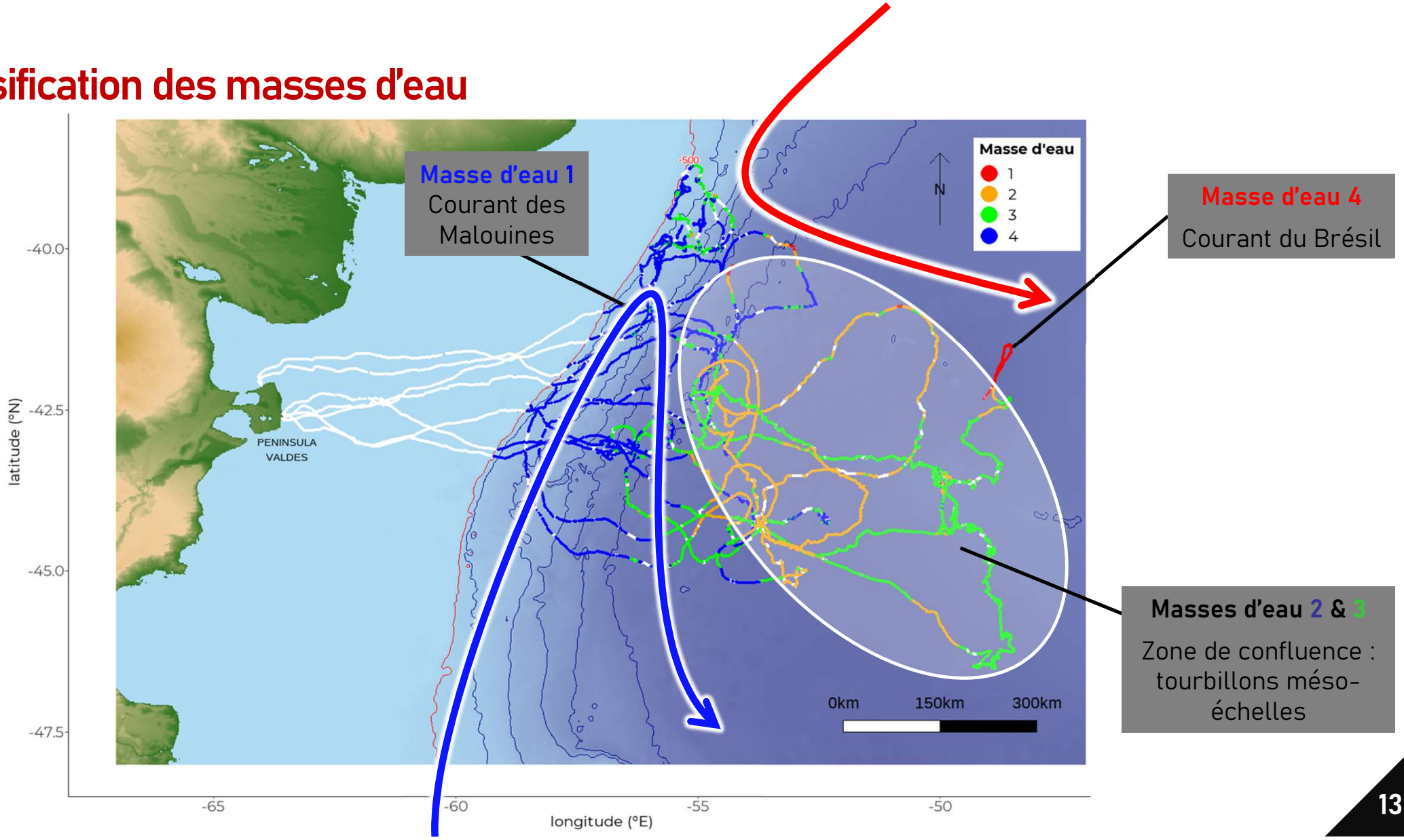
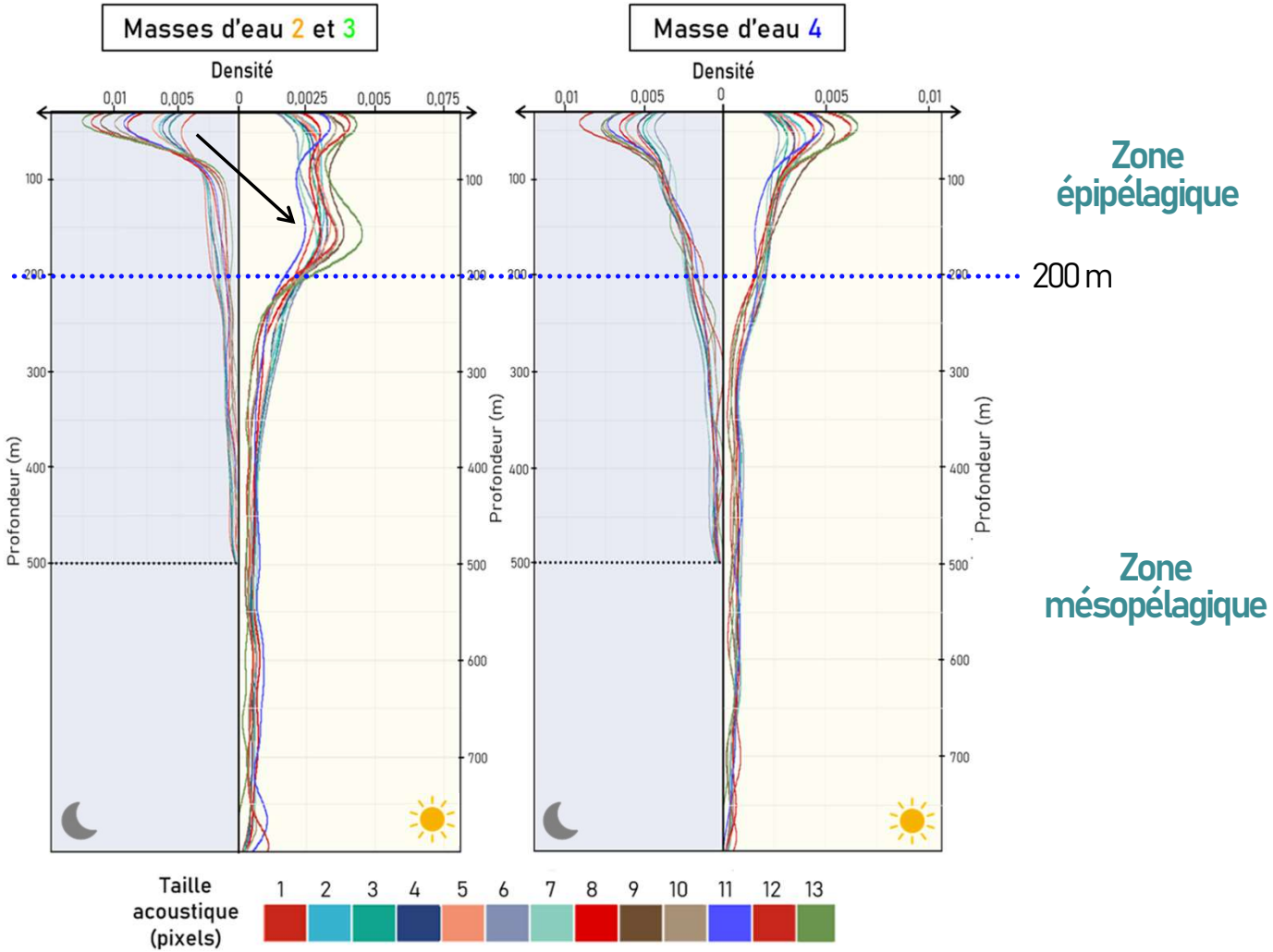


Figure 10 : Trajectoires des voyages post-reproduction des sept éléphants de mer femelles équipés sur la péninsule Valdés en 2018 et 2019, et classes de masses d'eau associées.

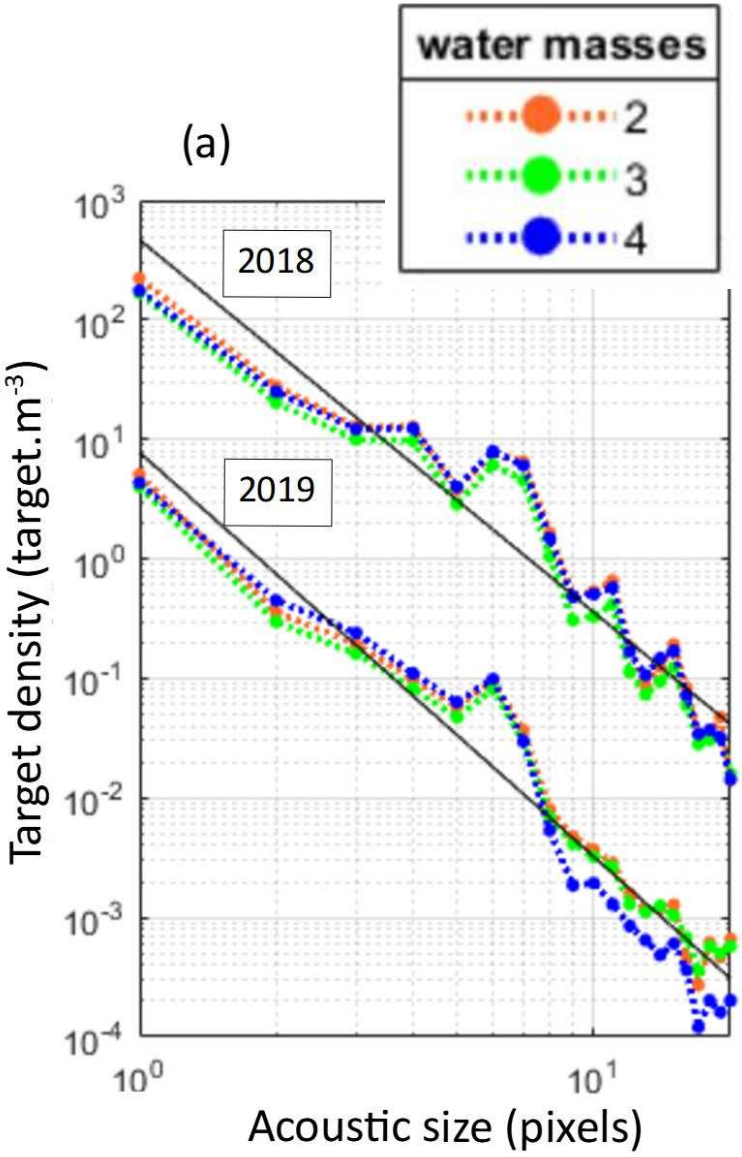
Classification des masses d'eau



Distribution verticale des cibles acoustiques



Master 2 Clément Castrec

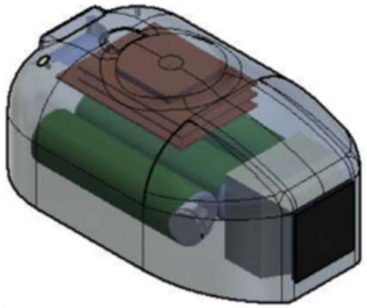


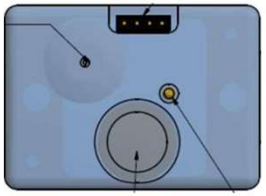
L'A2V-µCam : un système unique

dédié à l'observation des animaux aquatiques en contrôlant la prise de vue par la détection par acoustique




Bio-logging : concepteurs et utilisateurs



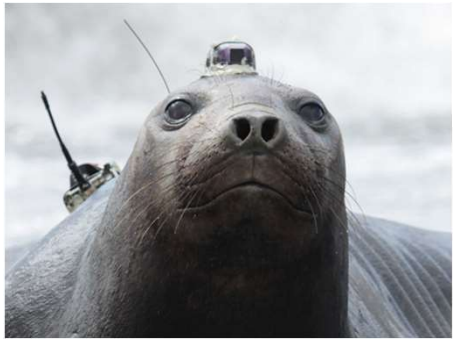


Led: flashes

Module photographique haute résolution

Capteur CMOS HD

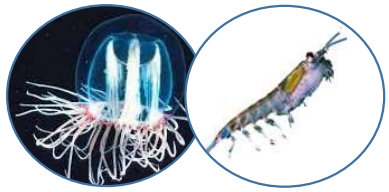
Une information **qualitative** (capacité de 50 000 images, 100 Go)



Une information **quantitative** (longue durée, semaines)

- **Mesure continue**
- **Taille** des organismes
- **Intensité** acoustique
- **Densité** (nombre par unité de volume)

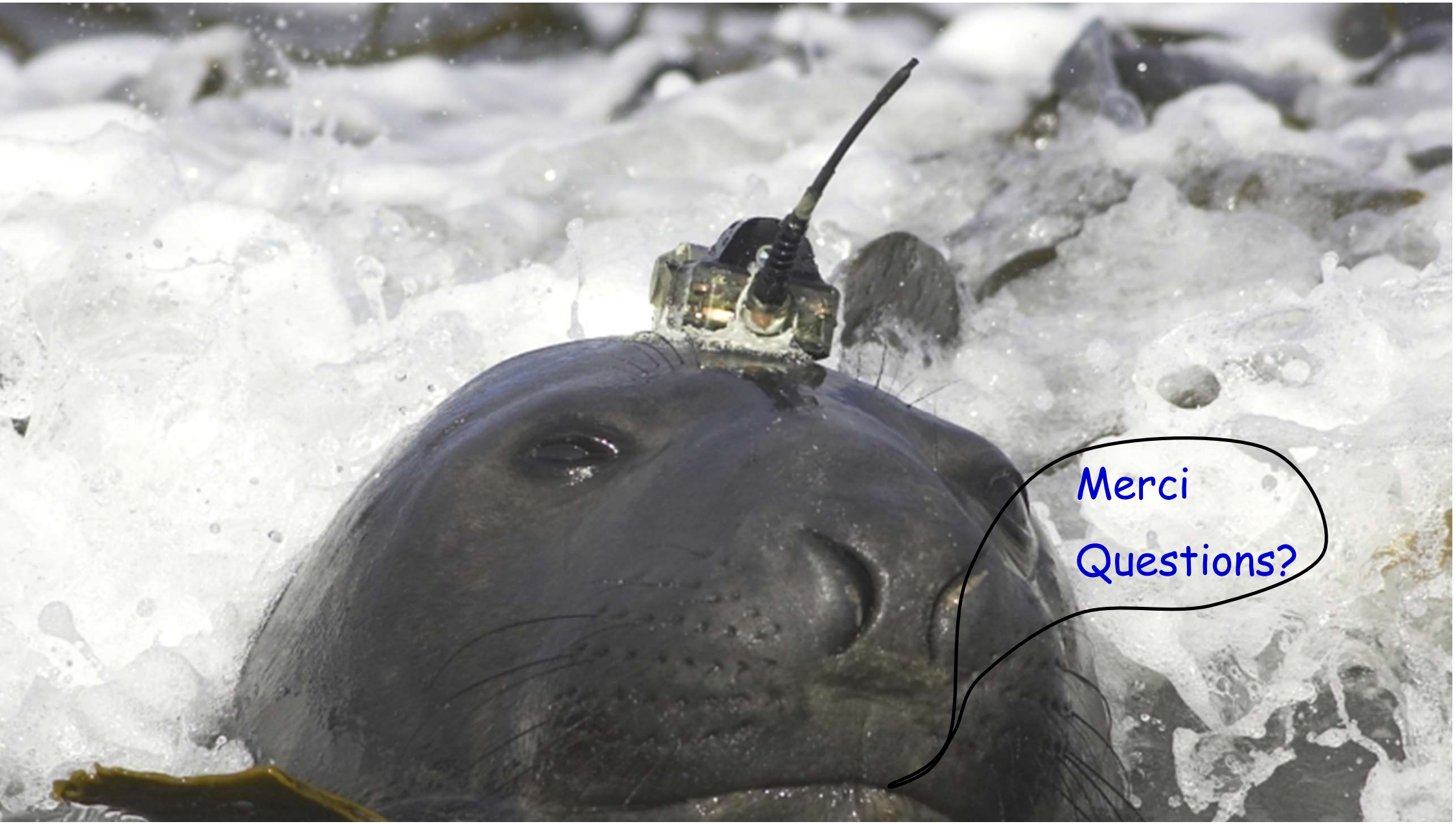
- **Identification** des organismes (famille/espèce)
- ***Biovolume*** *(images stéréoscopiques)*

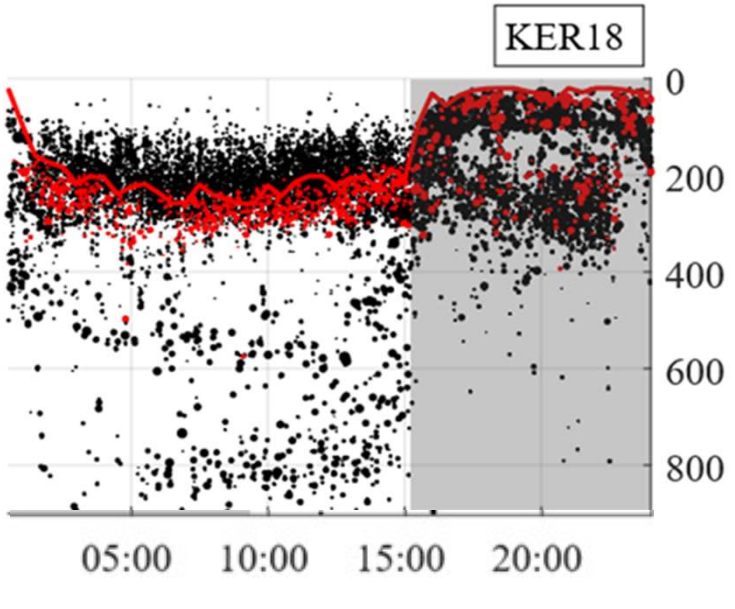


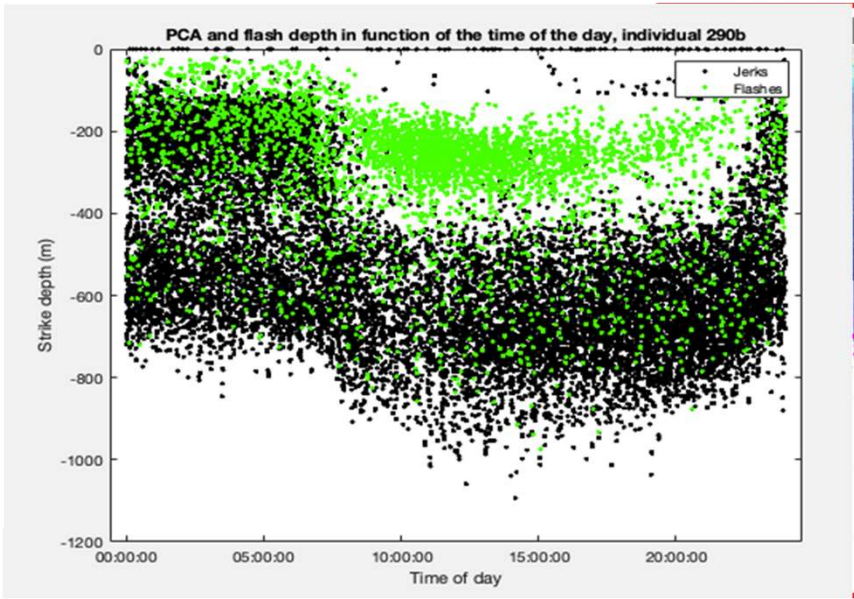
Zooplancton

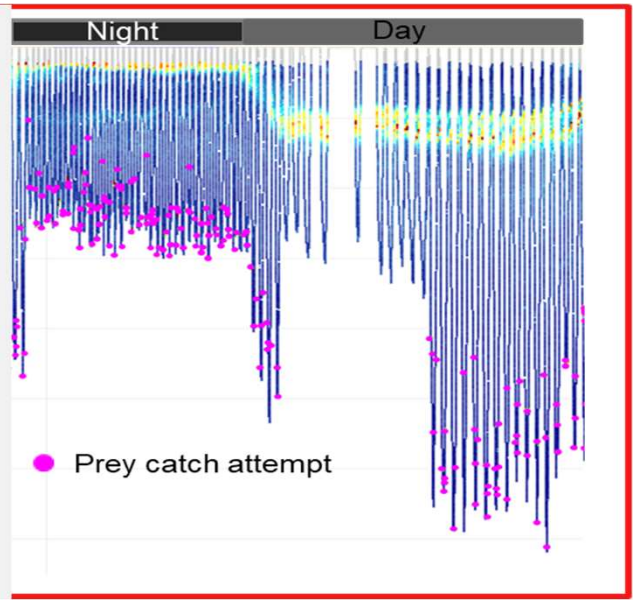
Poissons & Calama

(Goulet et al., 2019; Petiteau, 2020; Tournier et al, 2021.)

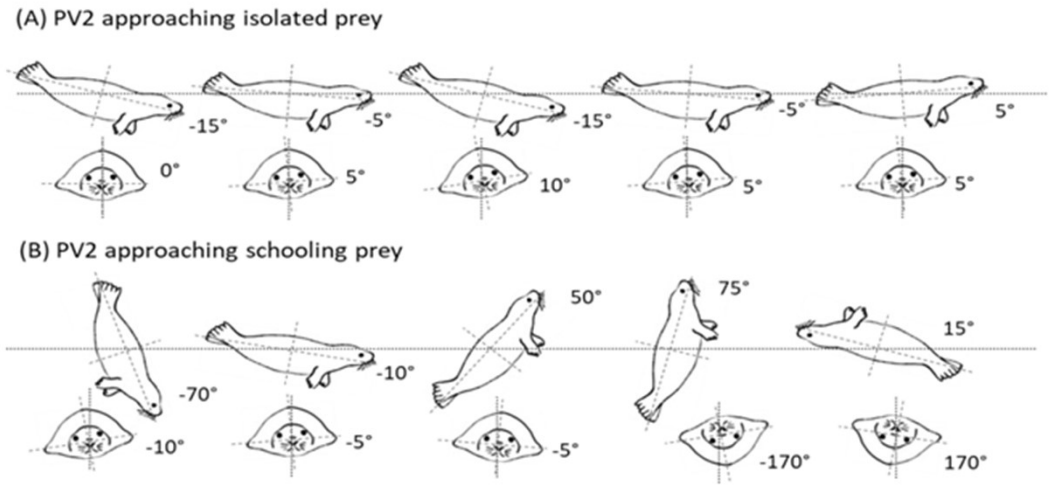

Merci
Questions?





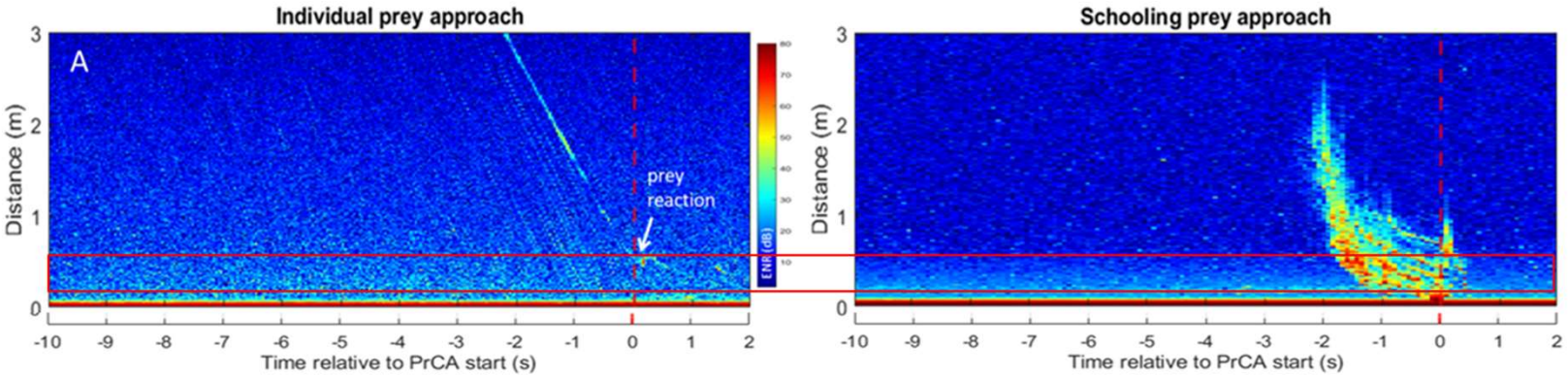


Yakov Uzan, L3, CRI-Paris

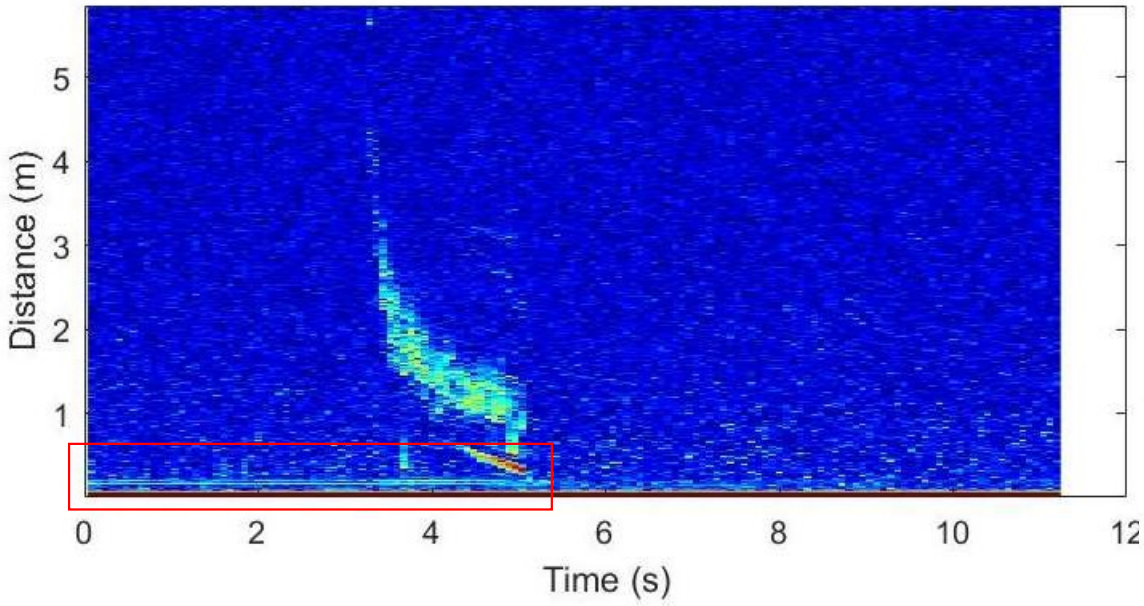


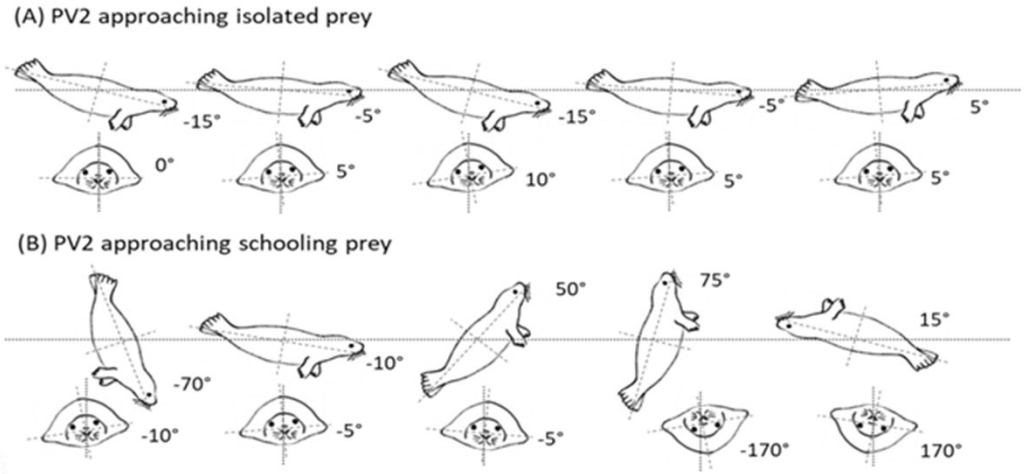
Proies Isolées

Proies en Banc

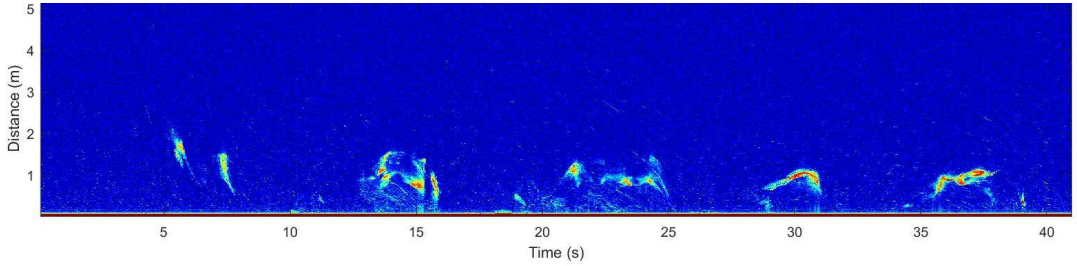


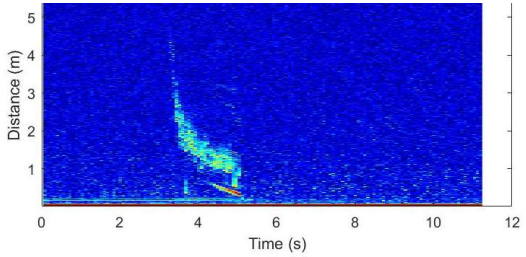
Mathilde Chevallay, M2, 2020, UBO

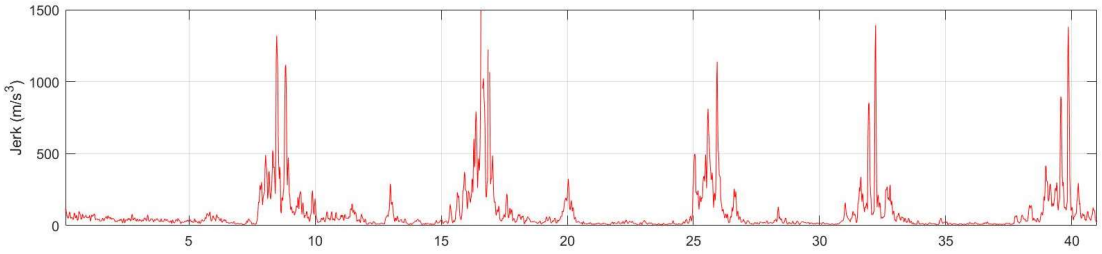


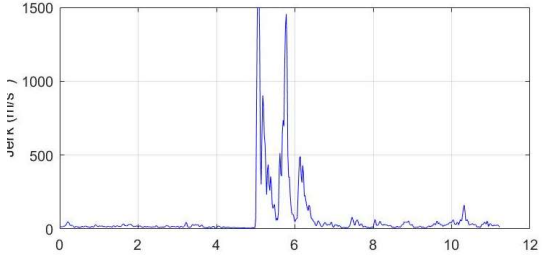


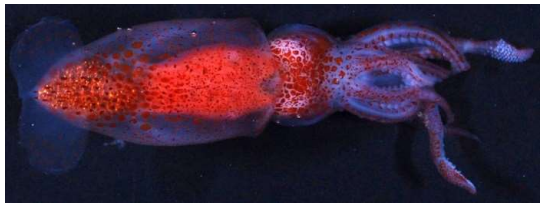
Thèse Mathilde Chevallay & Pauline Goulet



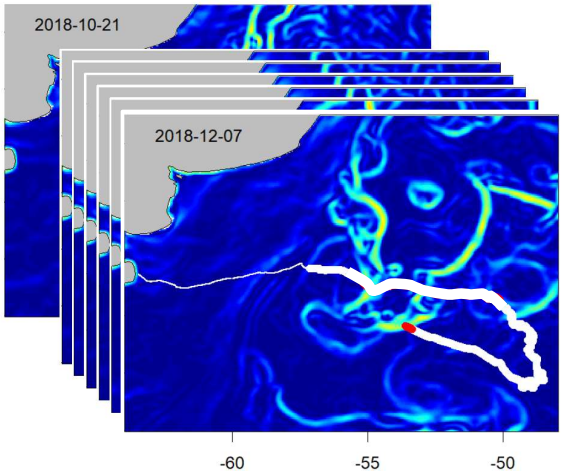




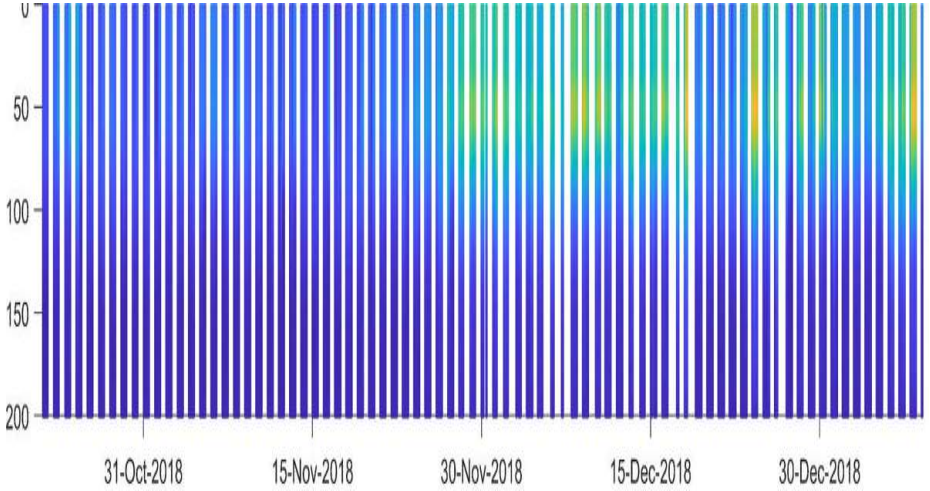


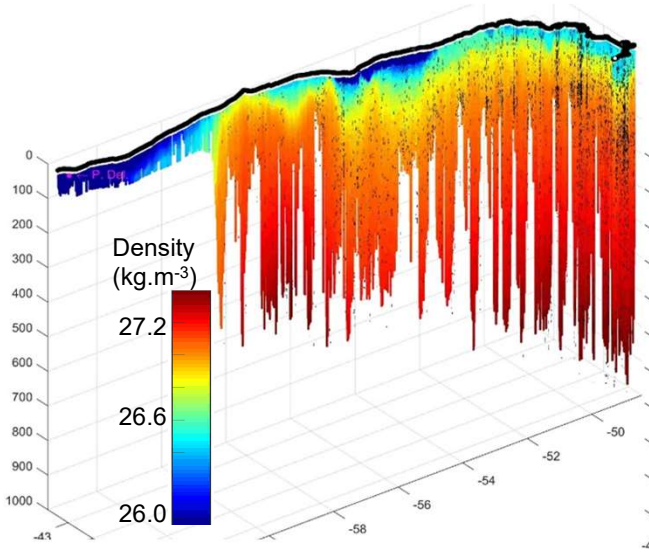


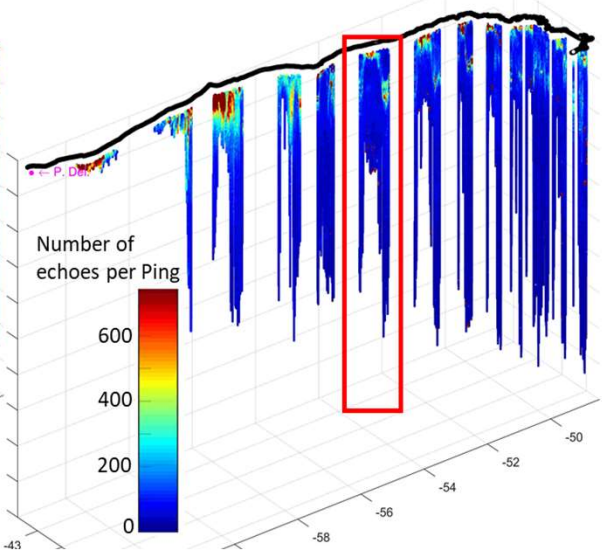
- **Prey size**: larger versus smaller prey → different prey types?

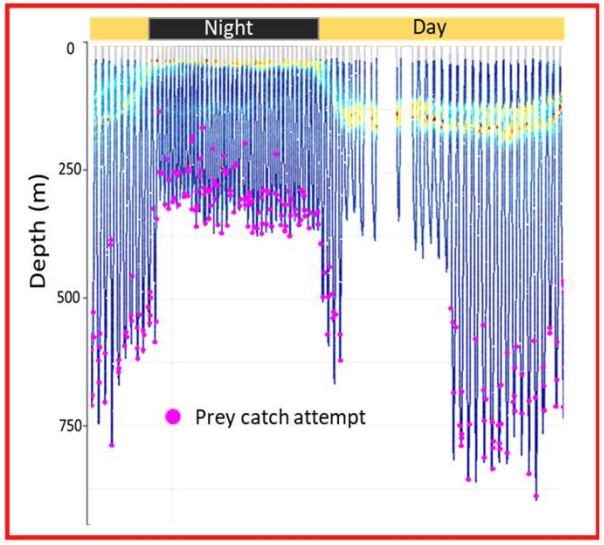


[Chl-a] lumière



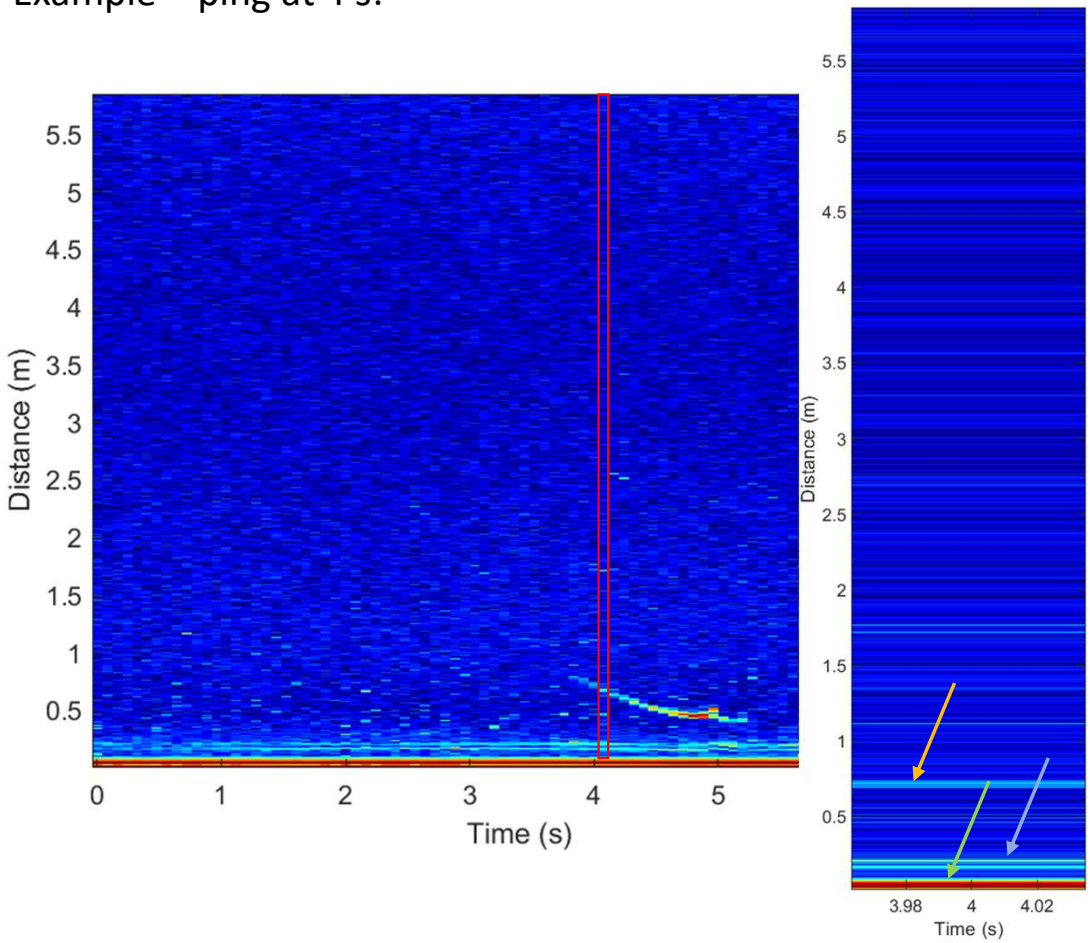


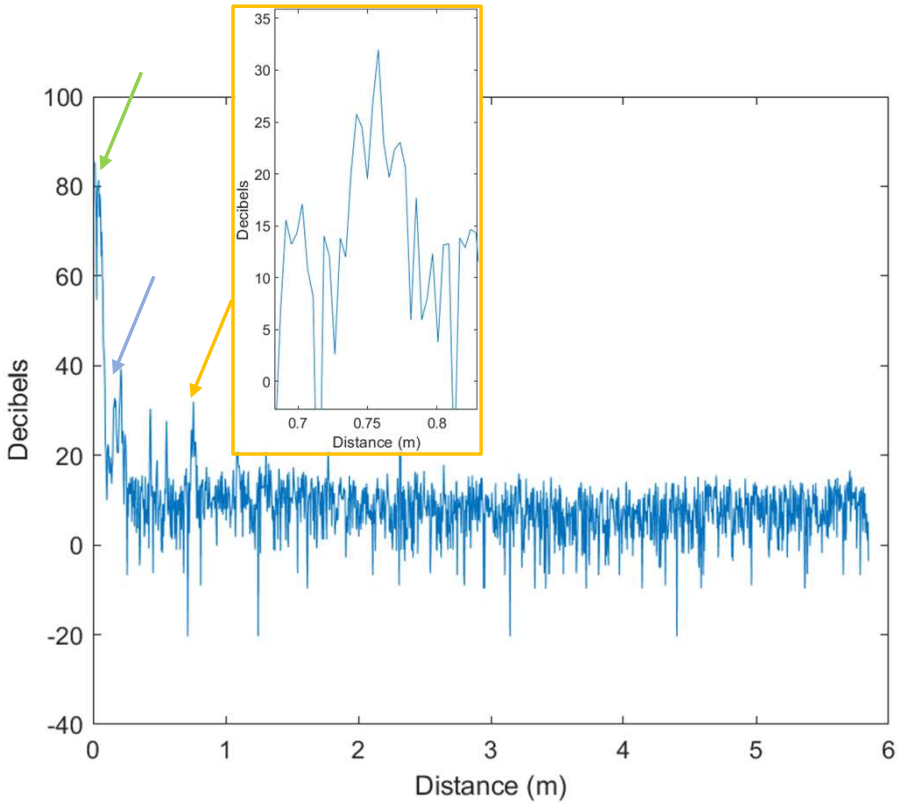




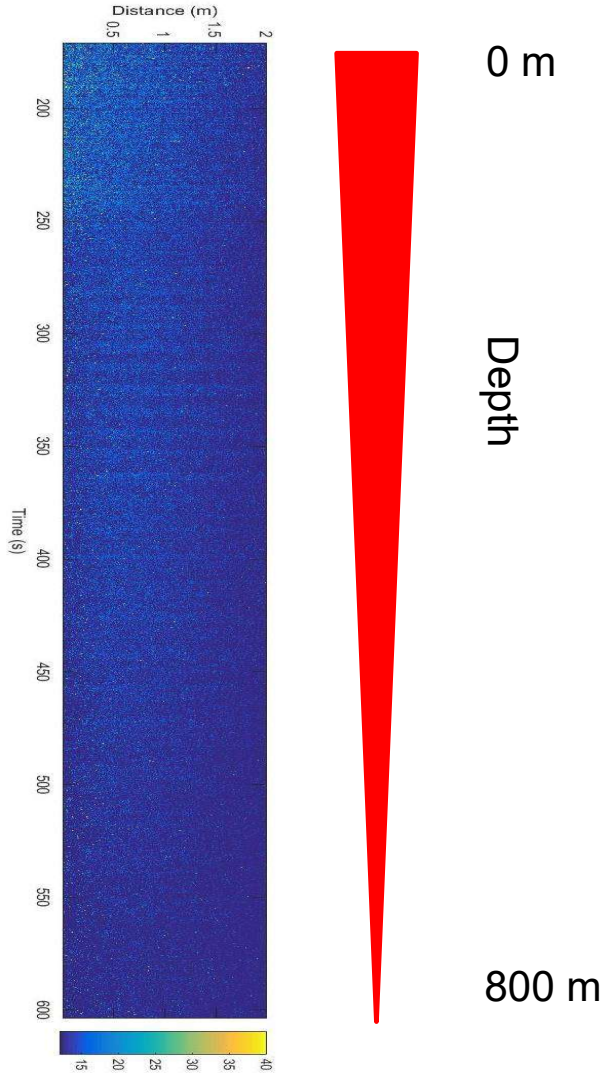
Thèse : Nadège Fonvielle D. Nerini (MIO)-C. Guinet

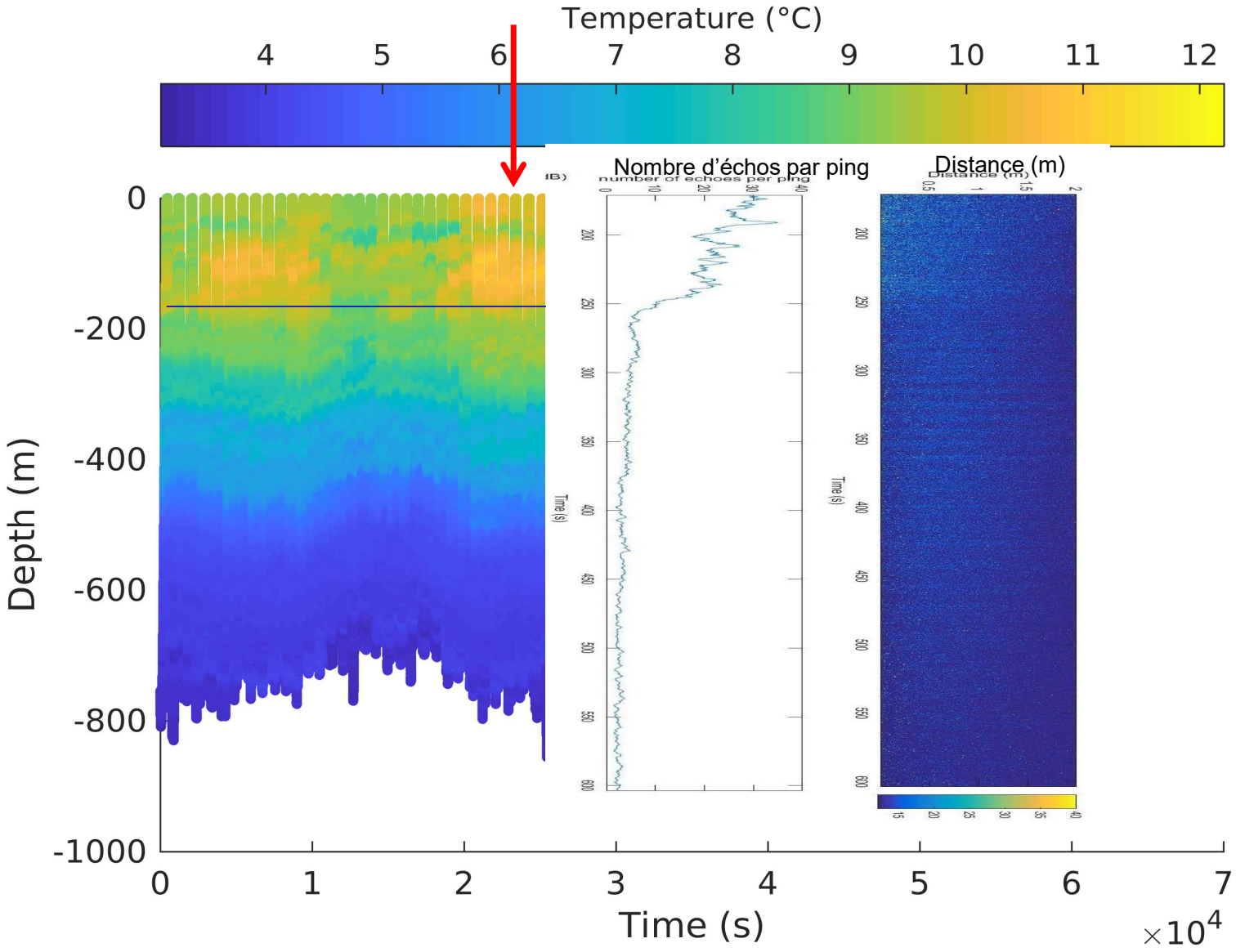
Example – ping at 4 s:





Logger Microsonar: Biological field




Temperature (°C)
4
5
6
7
8
9
10
11
12
Nombre d'échos par ping
number of echoes per ping
Distance (m)
Distance (m)
Depth (m)
0
-200
-400
-600
-800
-1000
Time (s)
0
1
2
3
4
5
6
7
×10^4
Time (s)
Time (s)