



Using on-animal sensors to study the Ocean and its inhabitants



Journées « Drones et Capteurs » - Sept 2021



cnes

CENTRE NATIONAL D'ÉTUDES SPATIALES

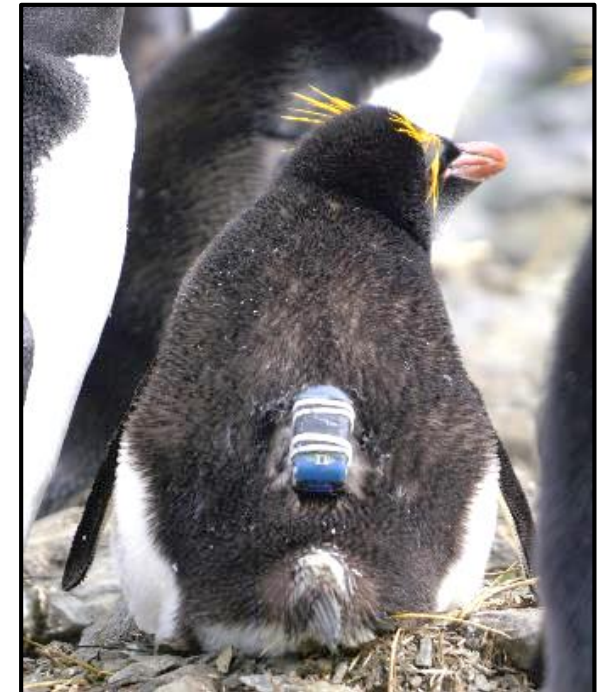


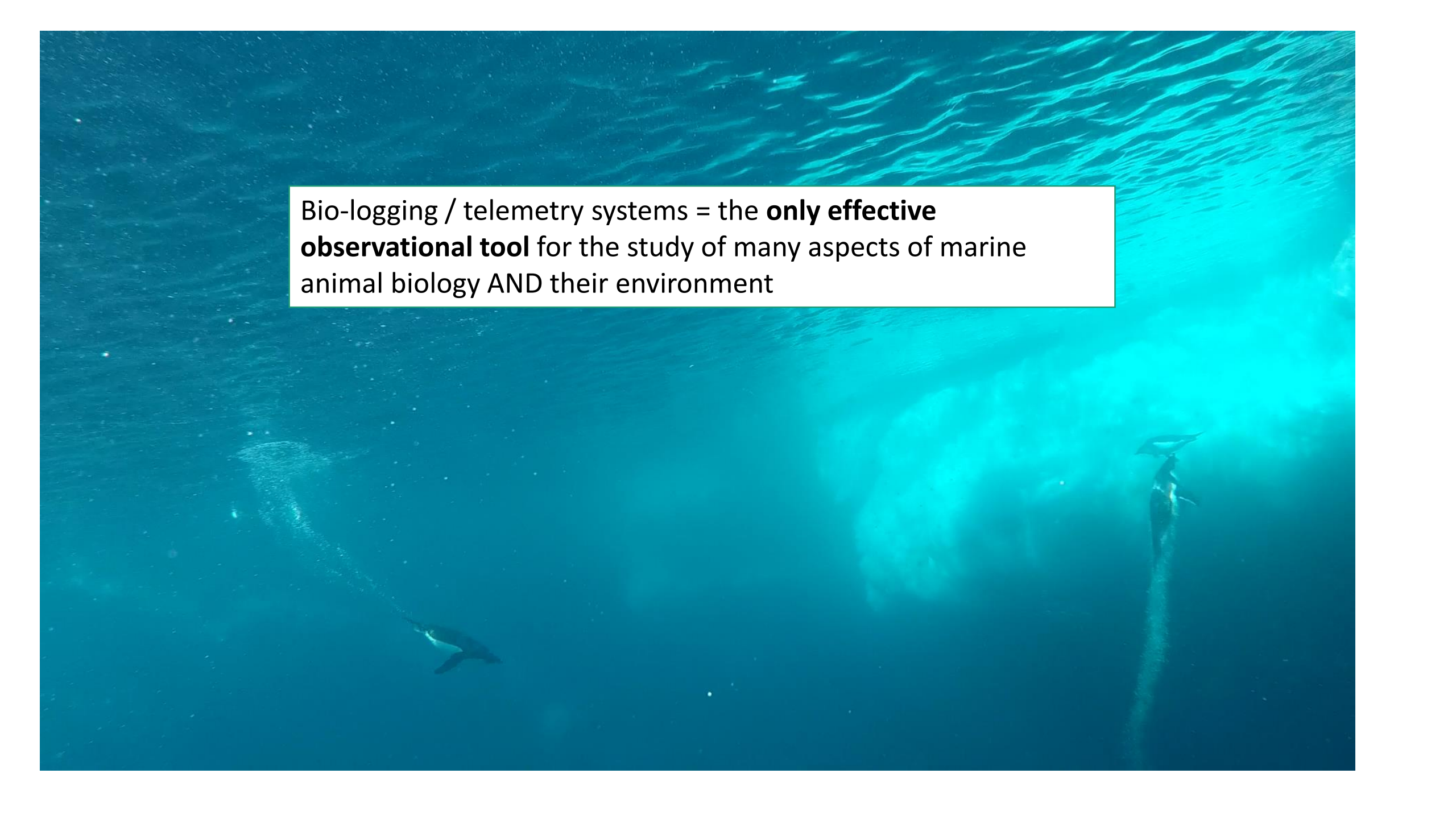
Pauline Goulet,
on the behalf of Yan Roper-Coudert and Christophe Guinet



« Bio » « logging »?

- Refers to animal-attached remote sensing methods
- Biologging versus telemetry: Greek *tele* meaning far and *metros* meaning measurement
- Started with marine animals: most behaviour happens underwater → challenging to observe and follow!




An underwater photograph showing two sharks swimming in clear blue water. One shark is in the lower left, and another is in the lower right. The water is bright blue with some light rays visible. A white text box is overlaid on the upper left portion of the image.

Bio-logging / telemetry systems = the **only effective observational tool** for the study of many aspects of marine animal biology AND their environment

History

1940s

P. Scholander  using a capillary depth gauge* on a freshly-harpooned bowhead whale records the first diving activity in the wild.

* Based on the principle of capillarity proposed by Lord Kelvin in the 19th century, to measure the depth of the seabed from ships

Discovery of the extraordinary diving ability of animals

SPERM WHALE
(*Physeter macrocephalus*)

2085m



SOUTHERN ELEPHANT SEAL
(*Mirounga leonina*)

1653m



NORTHERN BOTTLENOSE WHALE
(*Hyperoodon ampullatus*)

1453m



LEATHERBACKS
(*Dermochelys coriacea*)

1300m




EMPEROR PENGUINS
(*Aptenodytes forsteri*)

564m



History

1960s

G Kooyman  developed the 1st time-depth recorder* to measure diving activity as a function of time.

* Using a kitchen timer in tandem with a pressure sensor. Cheap trick for big results! Since then the research grants in this domain have considerably increased.

First ecophysiological approach of diving activity.

WEDDELL SEAL

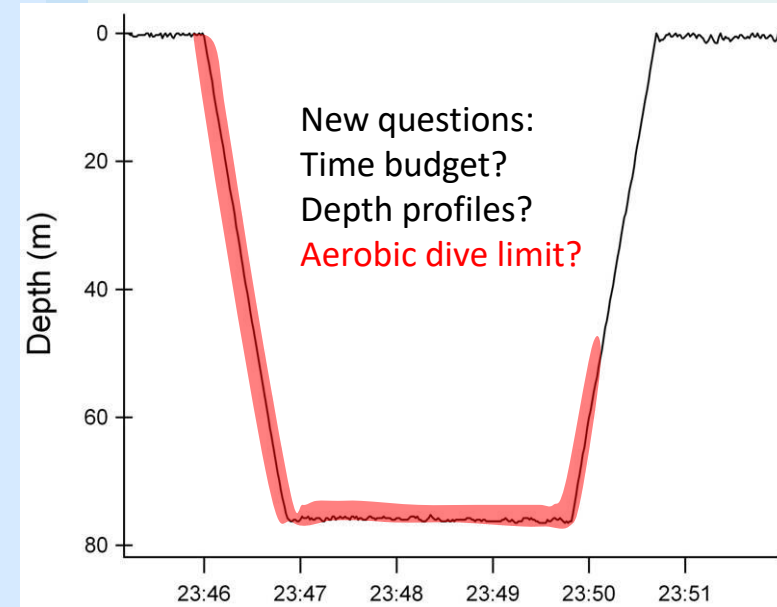
(*Leptonychotes weddellii*)

Maximum depth: 600 m

Maximum duration: 43 min 20 s

AUSTRALIAN FUR SEAL

(*Arctocephalus pusillus*)



1980-

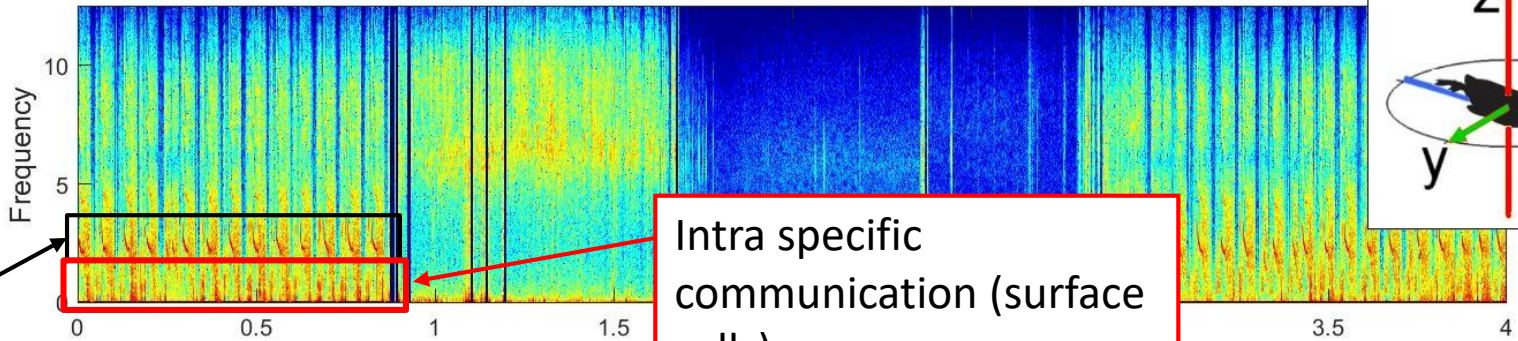
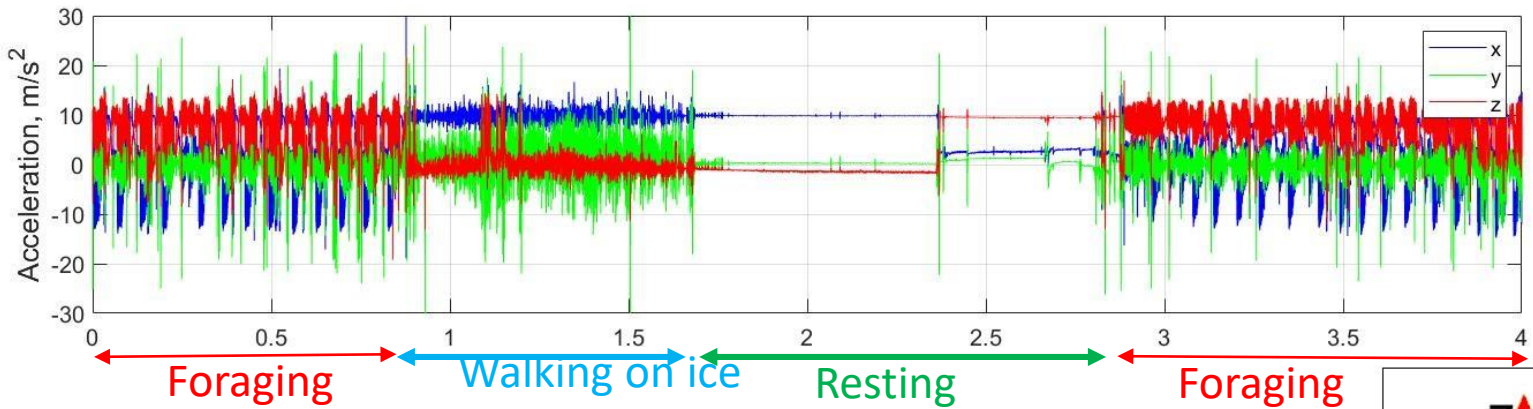
From Mechanical to Digital

Explosion & radiation: New sensor*, new data and new questions are booming all over the

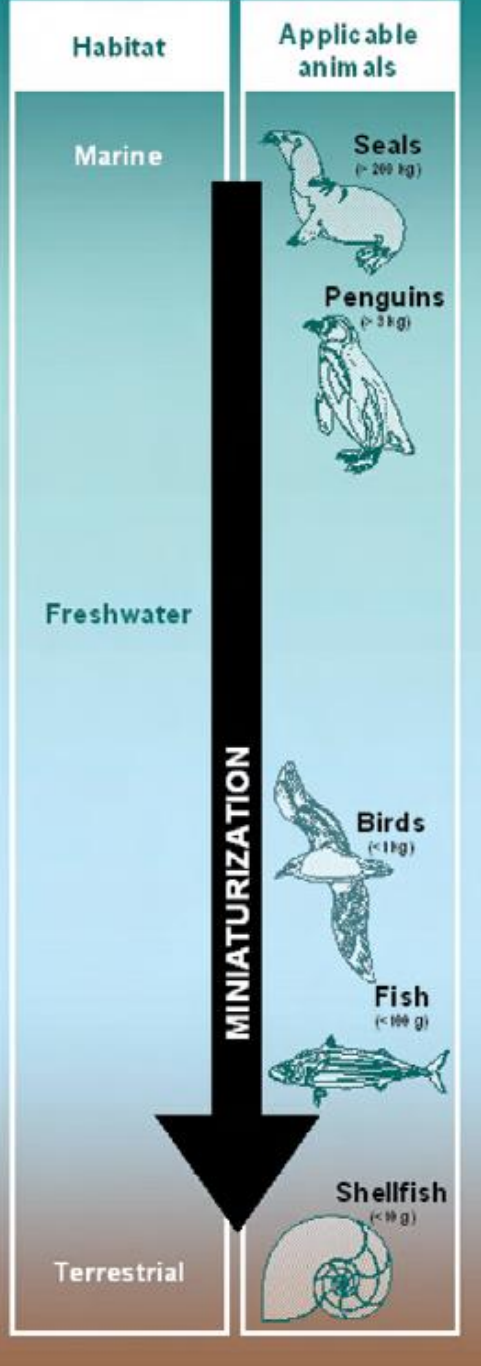
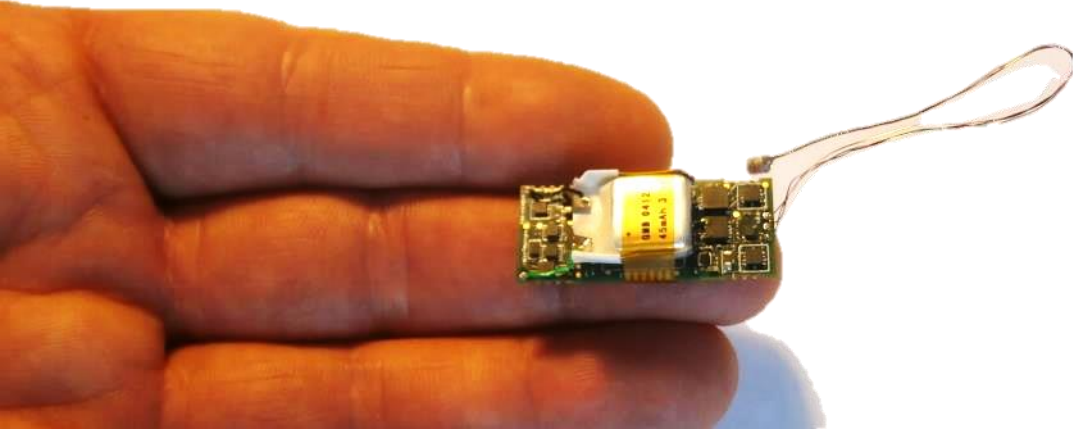
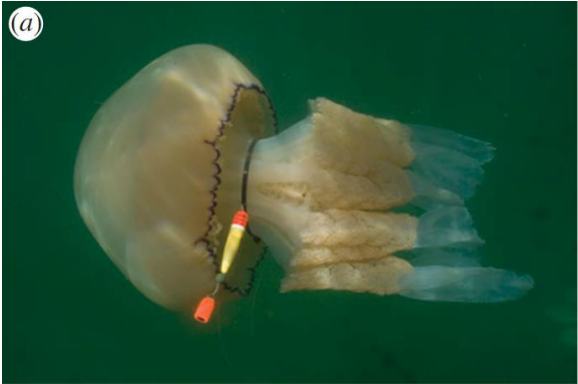


* Among which: swim speed, dive angle, body posture, heart rate, internal and external temperature, micro-movements, heading, etc.

Several aspects of the biology of an animal are studied simultaneously.



Miniaturisation



Robert-Coudert & Wilson 2005

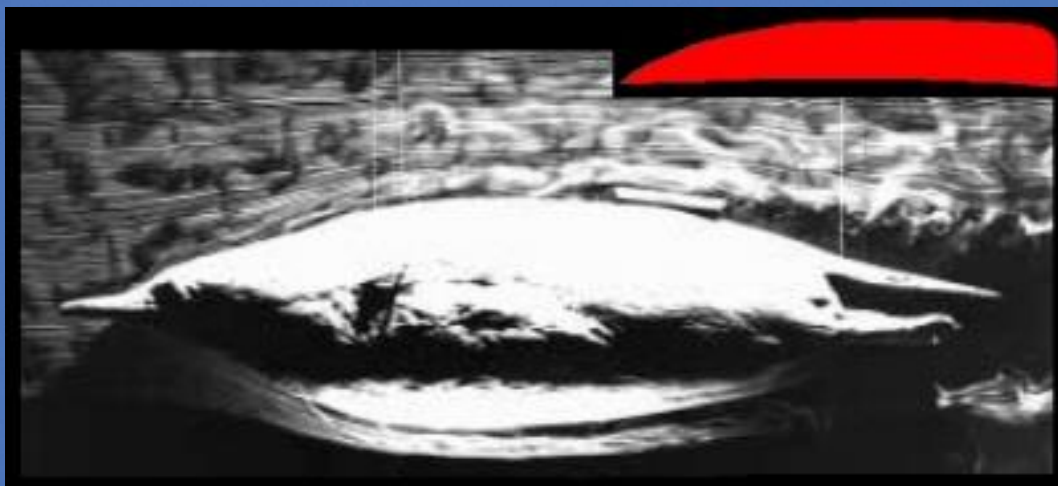
LIMITING THE IMPACT

The 3% rule for airborne models

Respecting the streamlining of divers: the 1% cross-section rule



End of 1990's



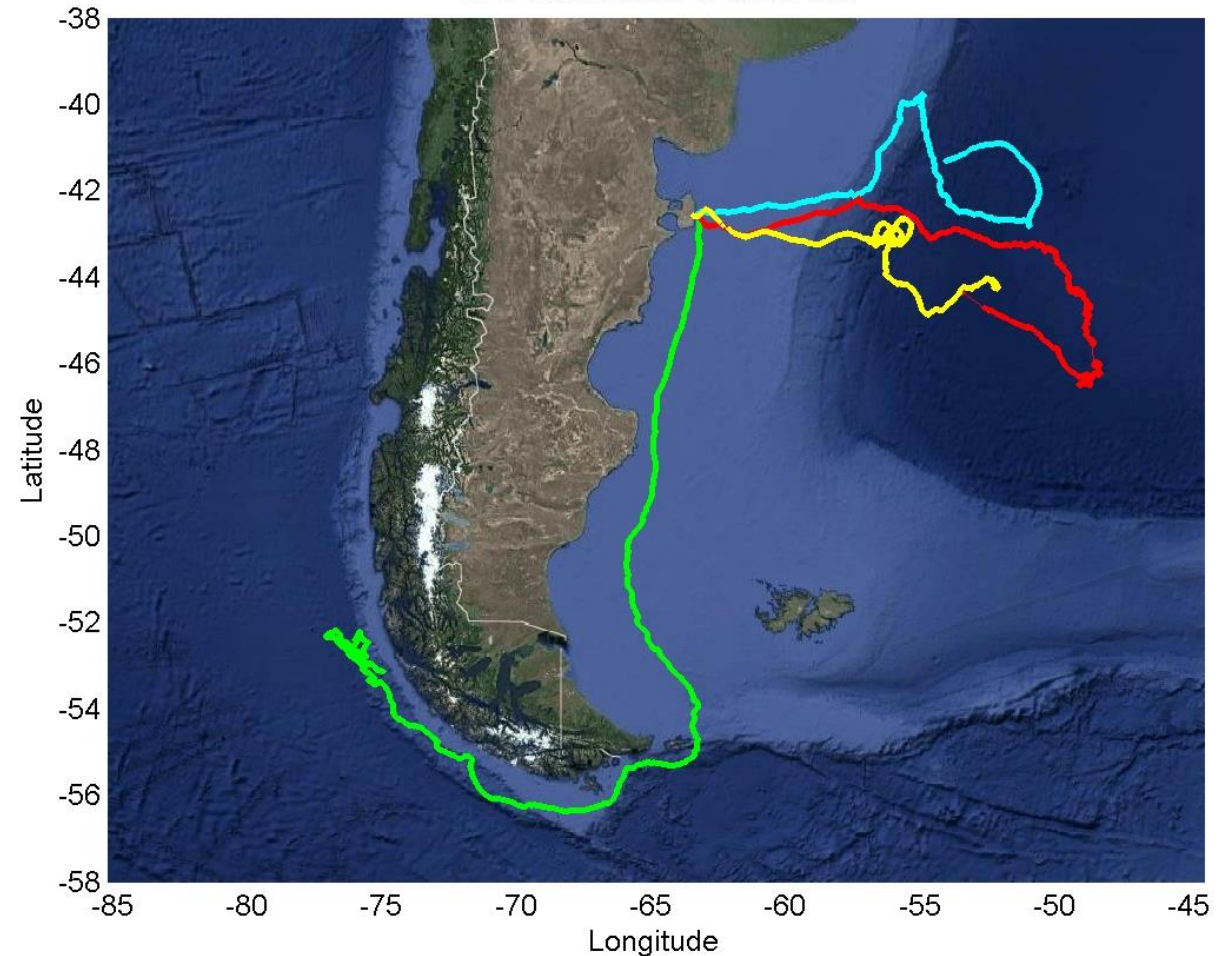
Today

Case study: the elephant seal



- Large animal – good to deploy devices
- Always comes back to the same place – good to retrieve devices
- Regular and (almost) continuous diving
- Deep diver (regularly to 1000m)= good sampler
- Long distances during post-breeding and post-moult feeding trips

GPS tracks from 2018 DTAGs





SMRU CTD tag

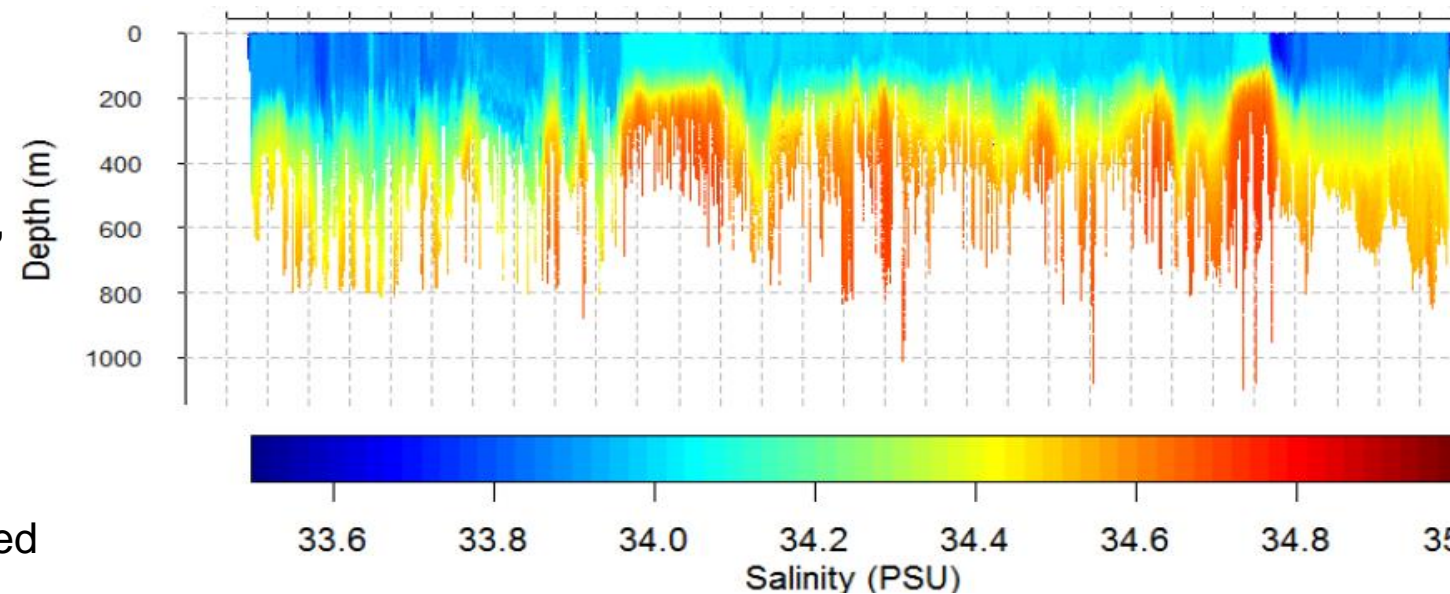
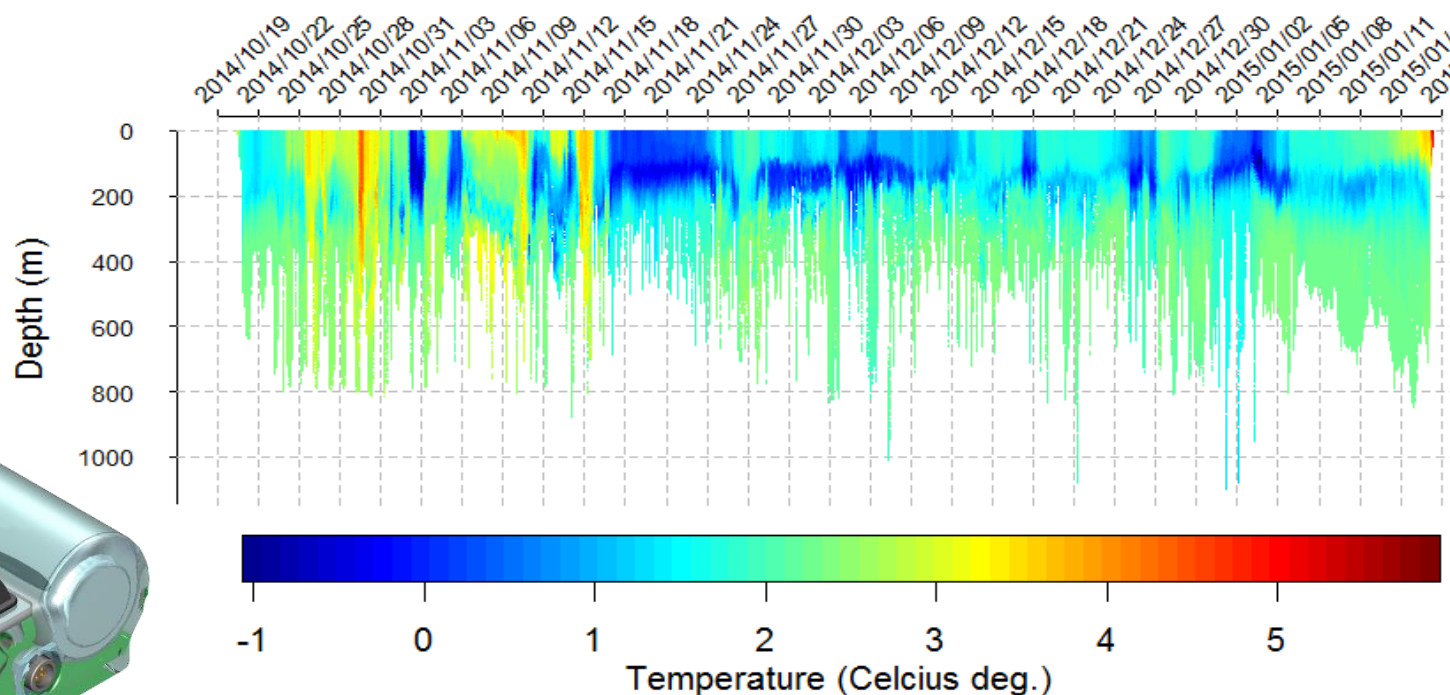
- Depth (0.5 Hz)
- Temperature (0.5 Hz, 0.02°C)
- Salinity (0.5 HZ, 0.03 PSU)
- Fluorescence, (0.5Hz, 4/profiles per day)
- Dissolved oxygen (0.5 Hz, 4 profiles per day)
- Light (0.5 Hz)
- Accelerometer (12 Hz)

Argos Transmitted Summary:

- 2-4 profiles/day
- 24 T/S points/profile,
- real time

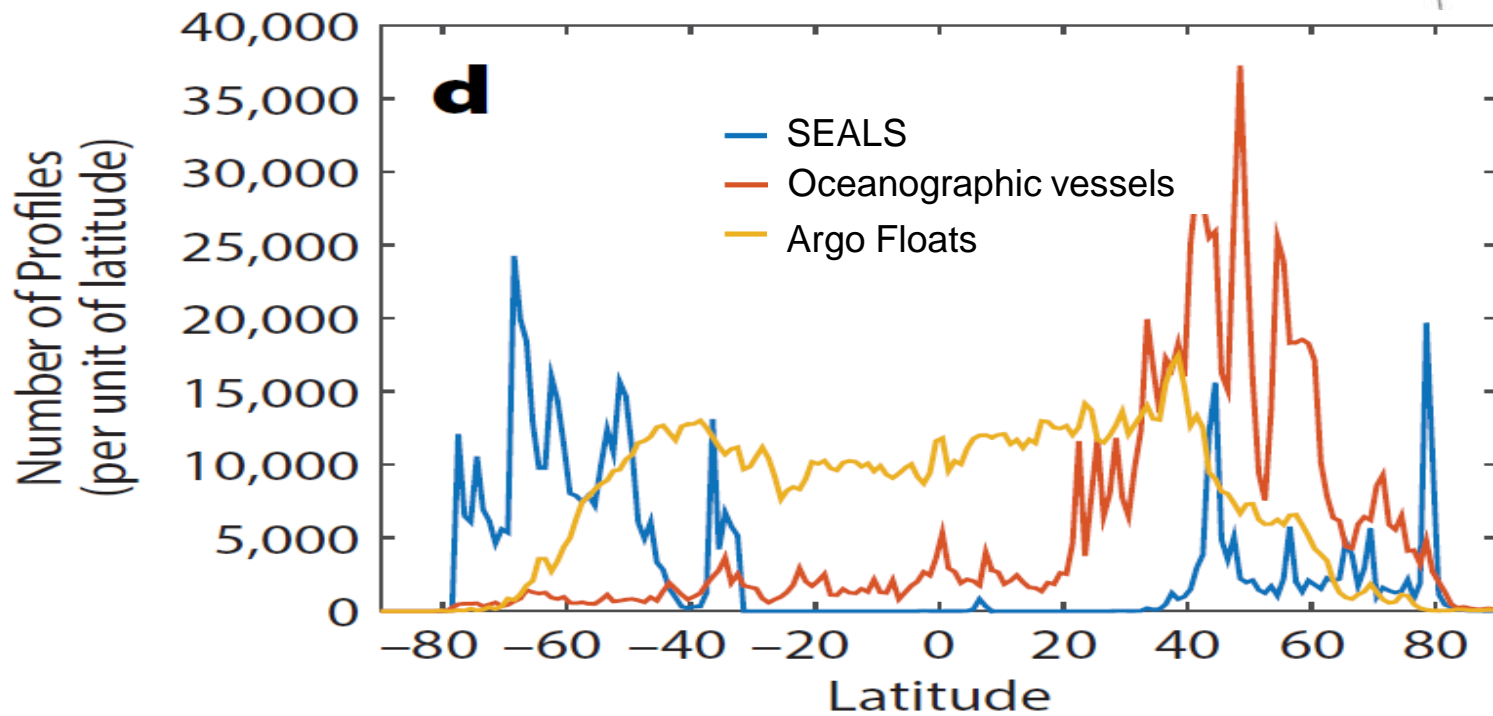
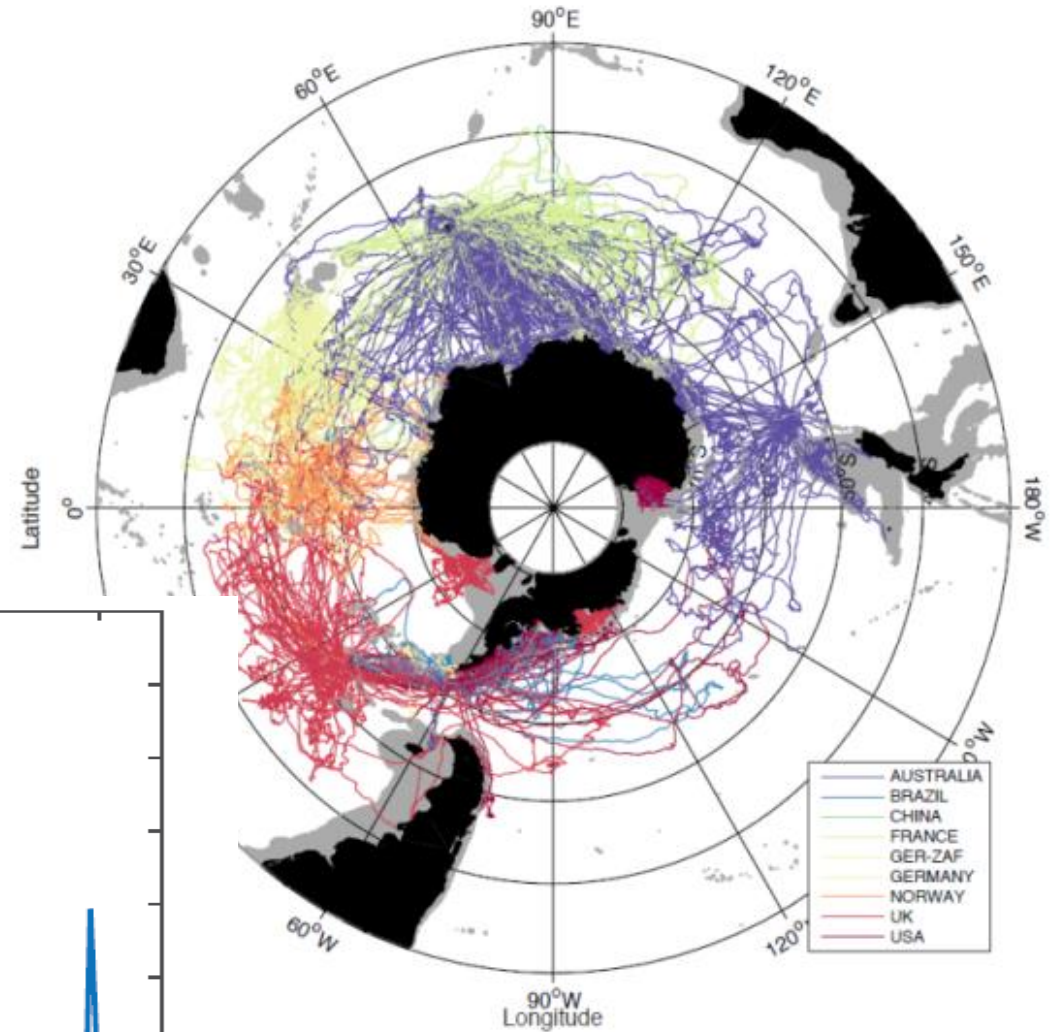
Archived/Differed:

- High res data
- Entire dataset
- needs to be recovered



98 % of the profiles within antarctic sea-ice

www.meop.net

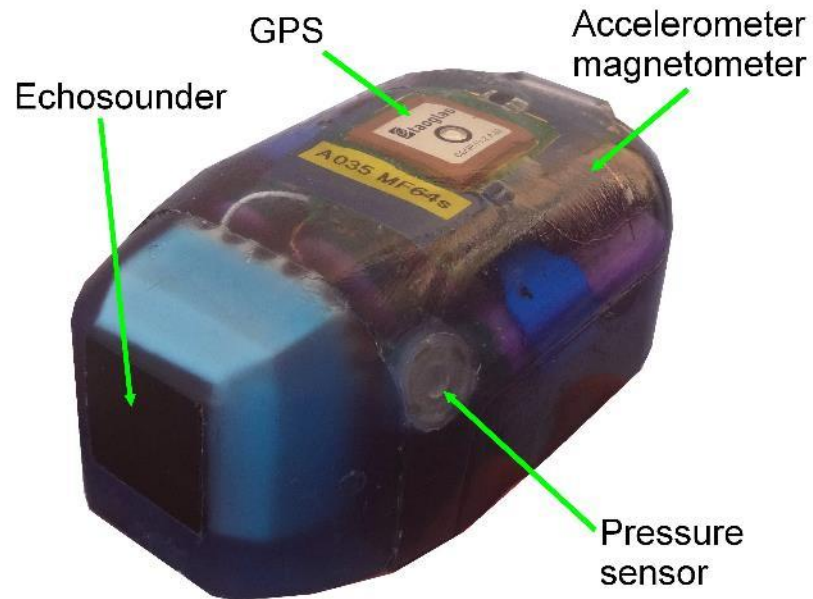
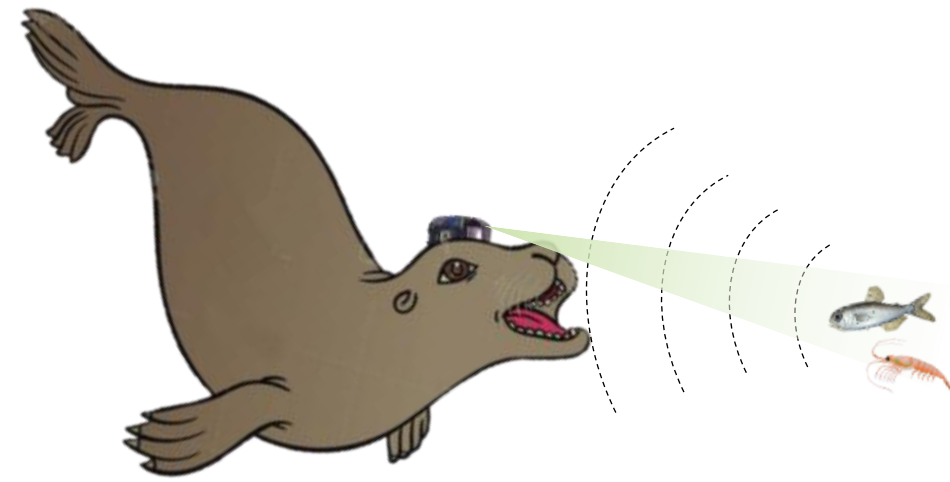


Observing the biotic environment of animals:
using a sonar



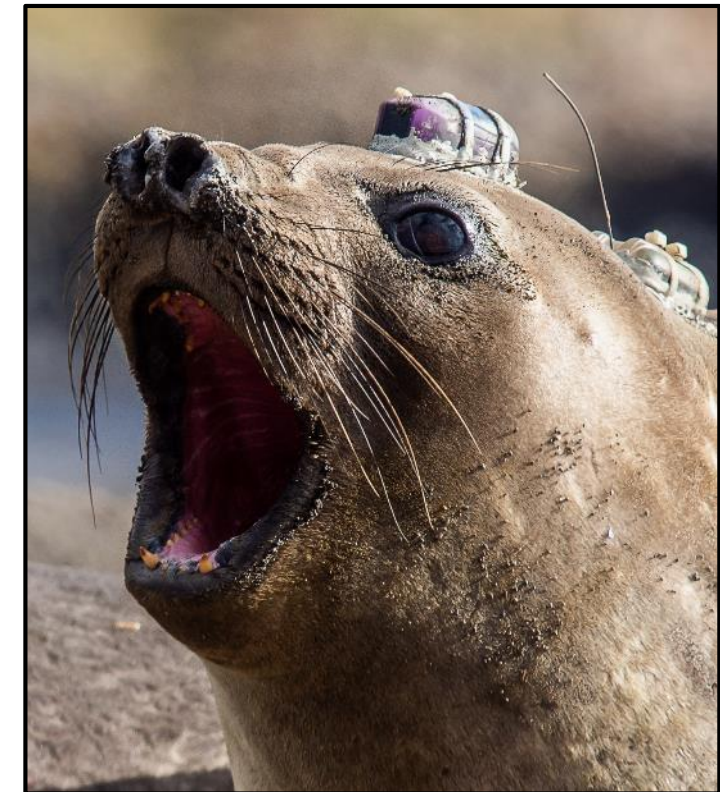
The sonar tag

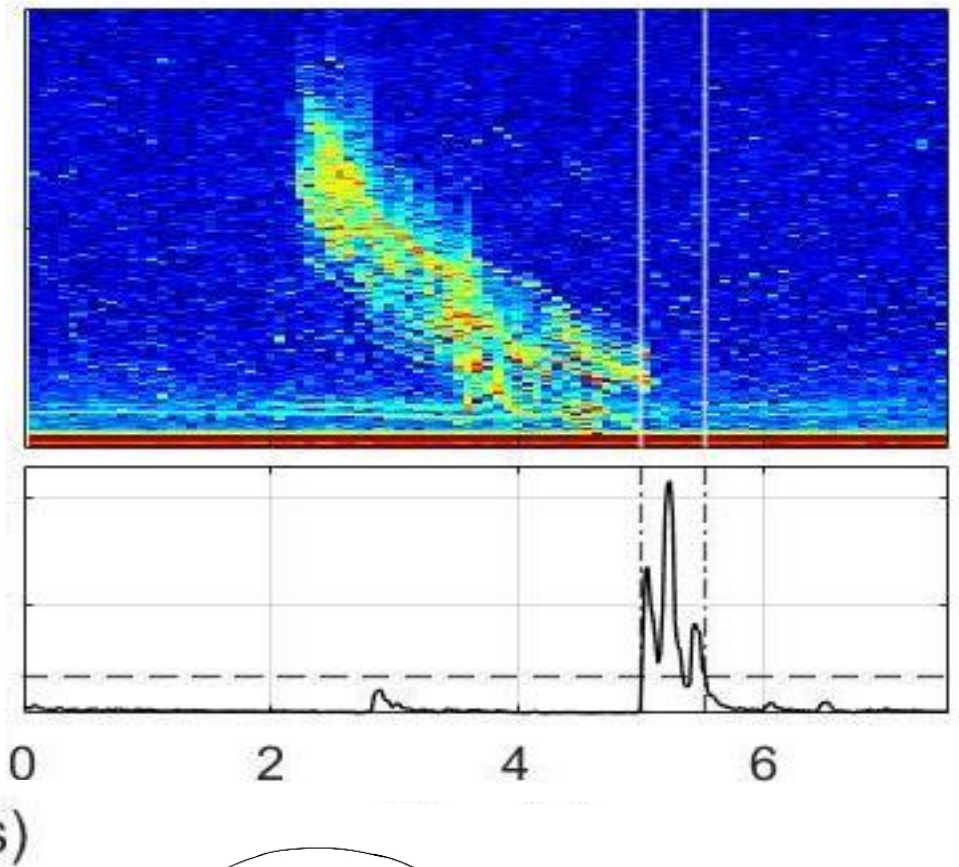
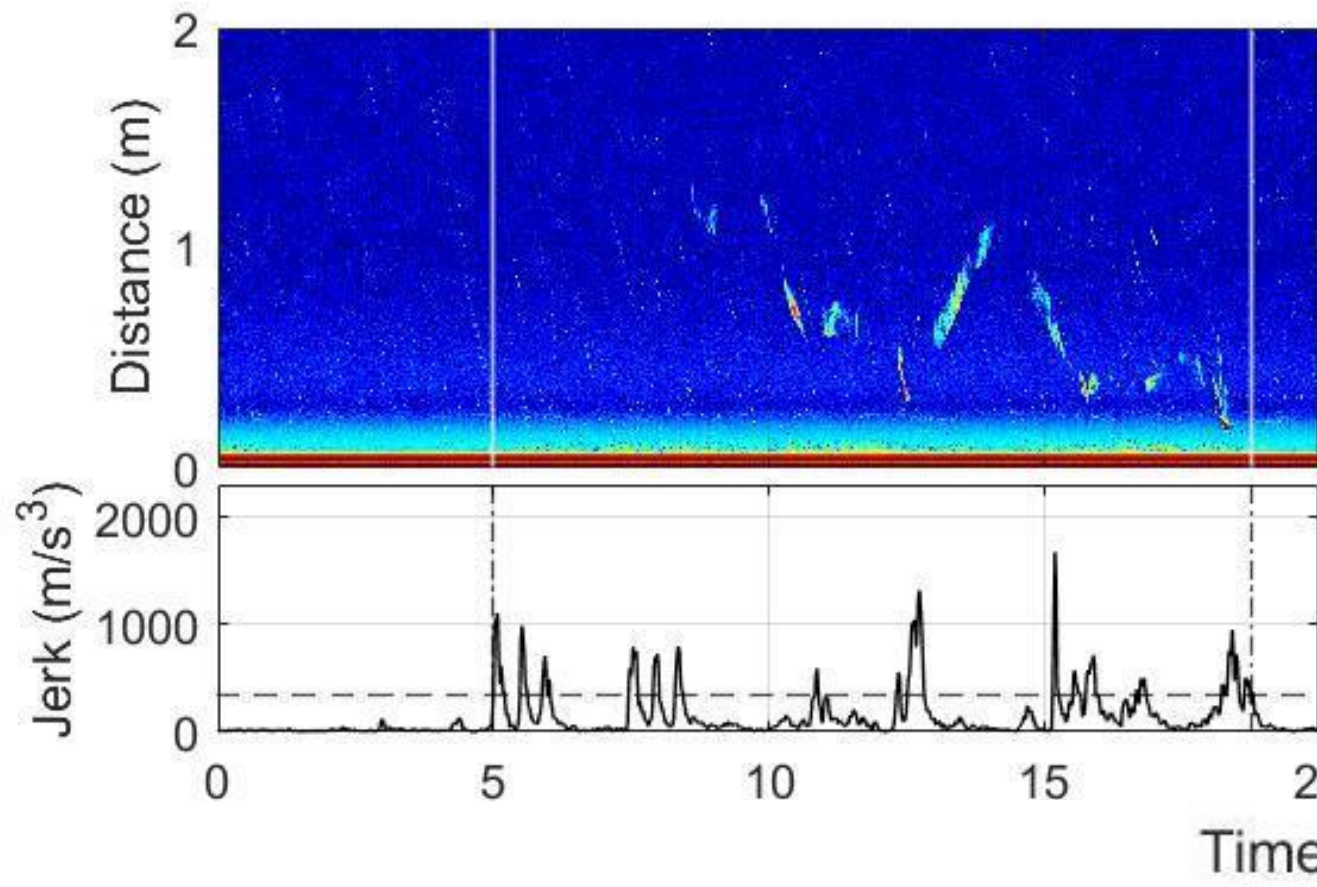
- High frequency position (GPS) and movement sensors (accelero, magneto, depth)
 - **Miniature active sonar:**
 - 1.5MHz → min object size 3 mm
 - up to 7m range,
 - up to 50Hz ping rate



To study

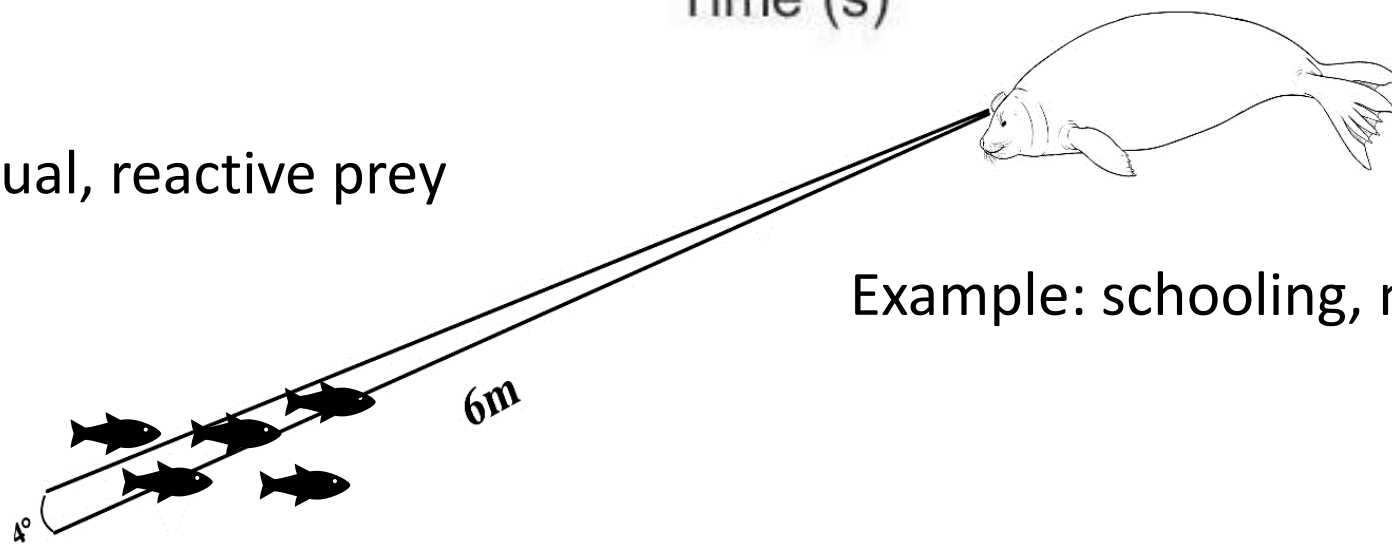
- biotic environment, prey field
- detailed information on prey





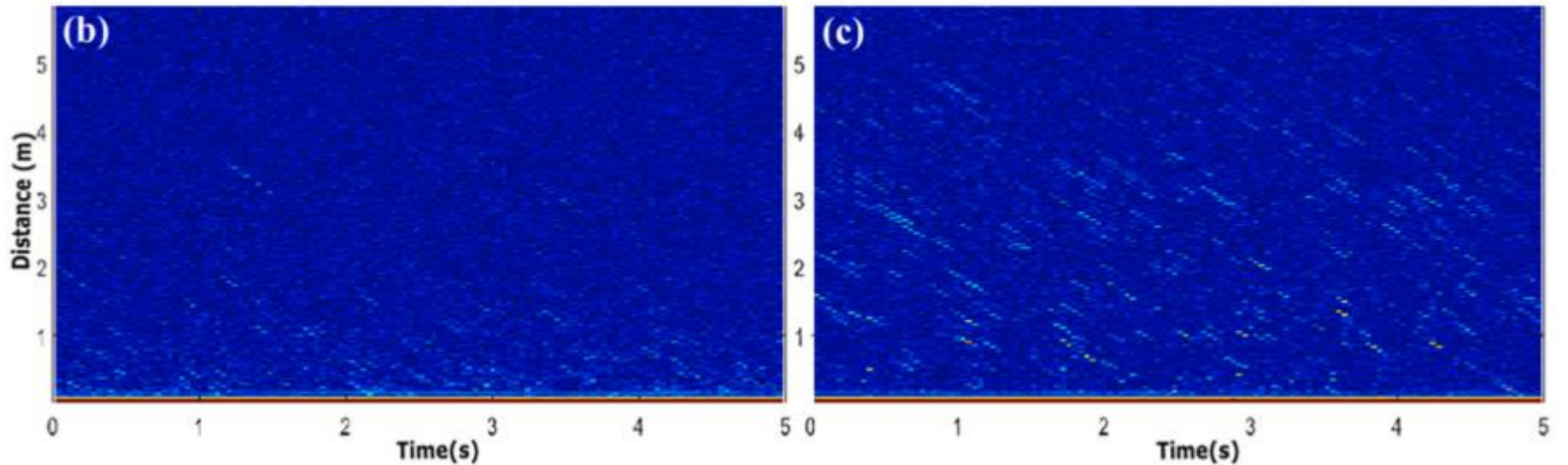
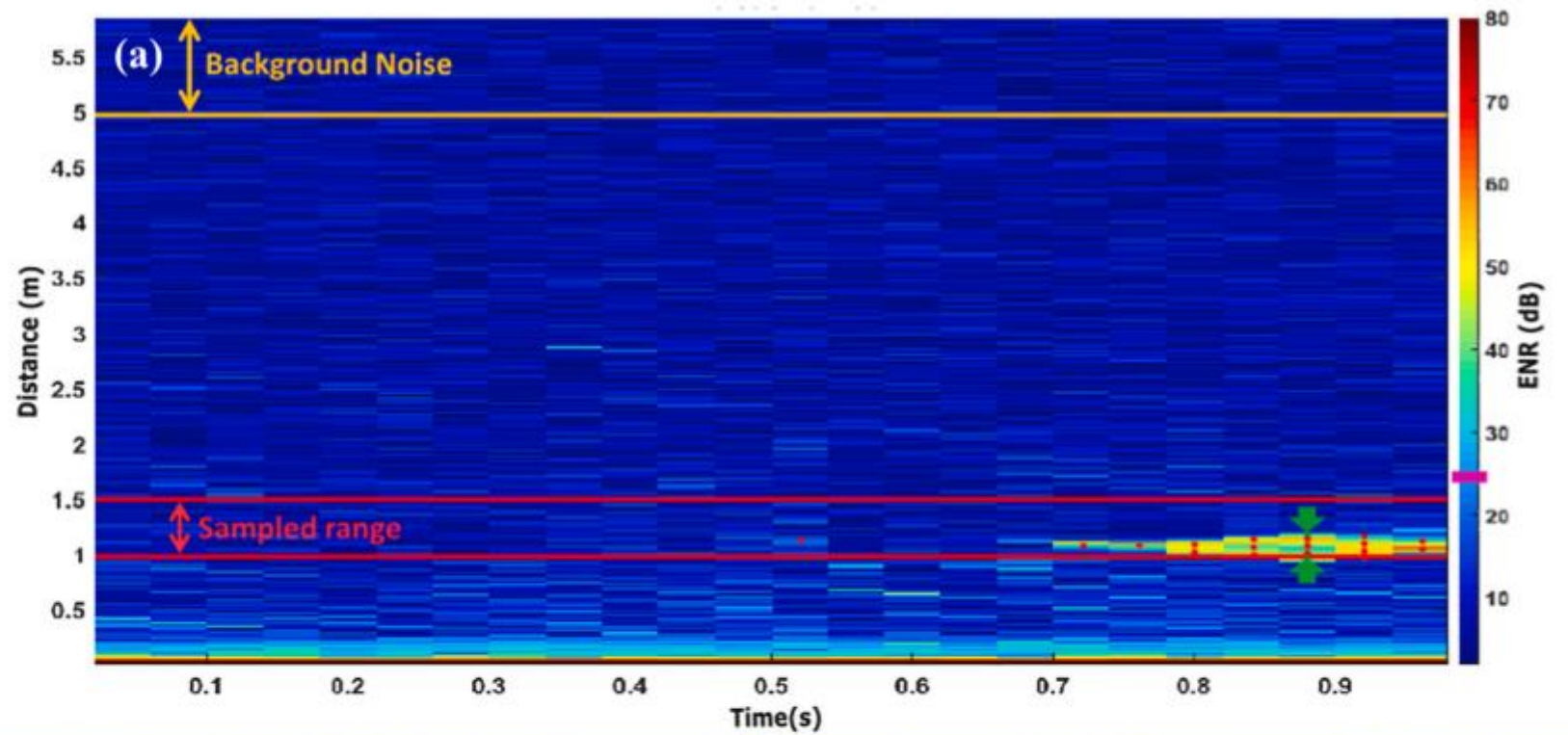
Example: individual, reactive prey

Example: schooling, non reactive prey



Sampling the biotic environment

Tournier et al., (2021) A novel animal-borne miniature echosounder to observe the distribution and migration patterns of intermediate trophic levels in the Southern Ocean (Journal of Marine Systems)

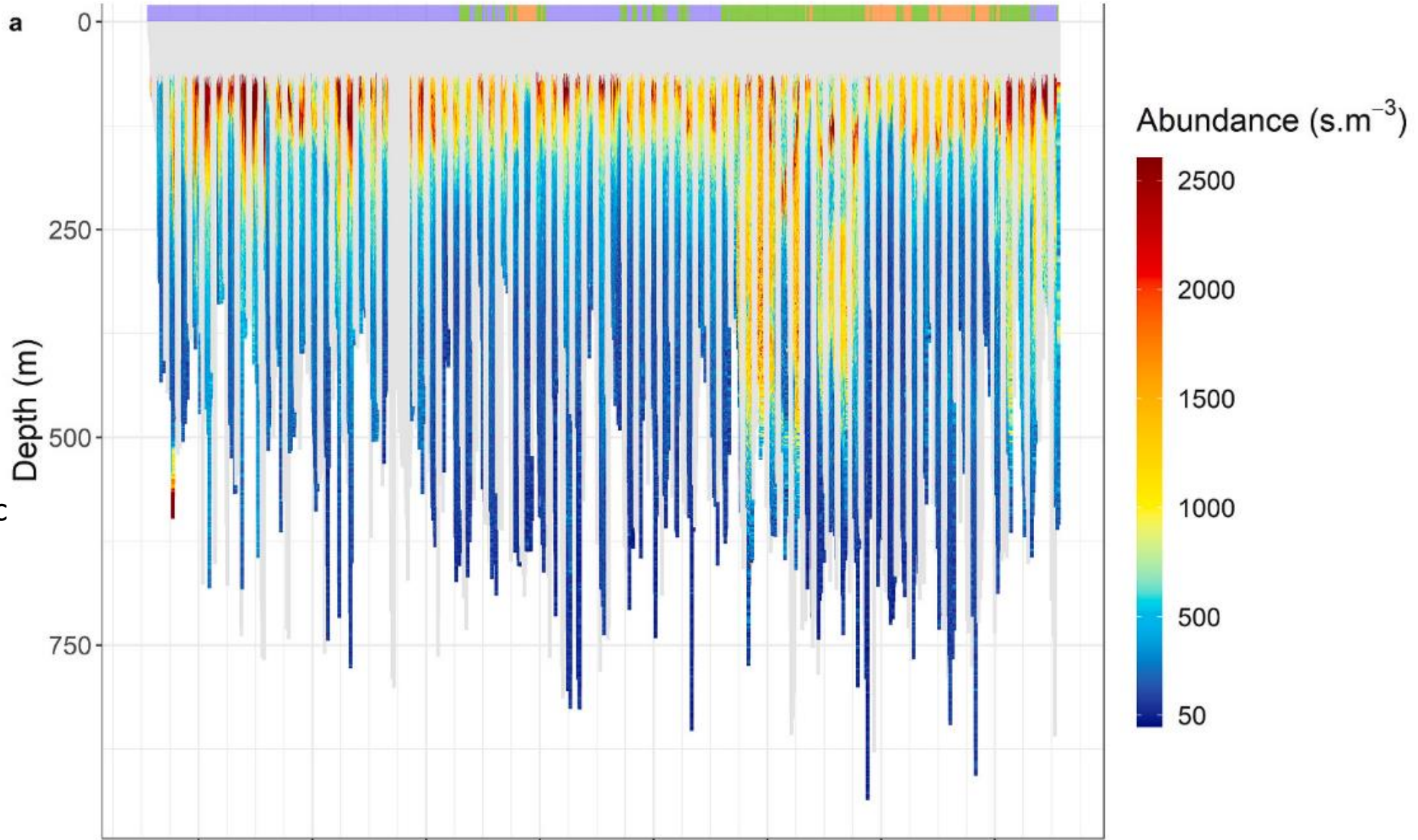


Sampling the biotic environment

Marine snow at Kerguelen

Passive sinking of biological detritus

(Major contribution to biological pump that exports particulate organic carbon (POC) to depth)

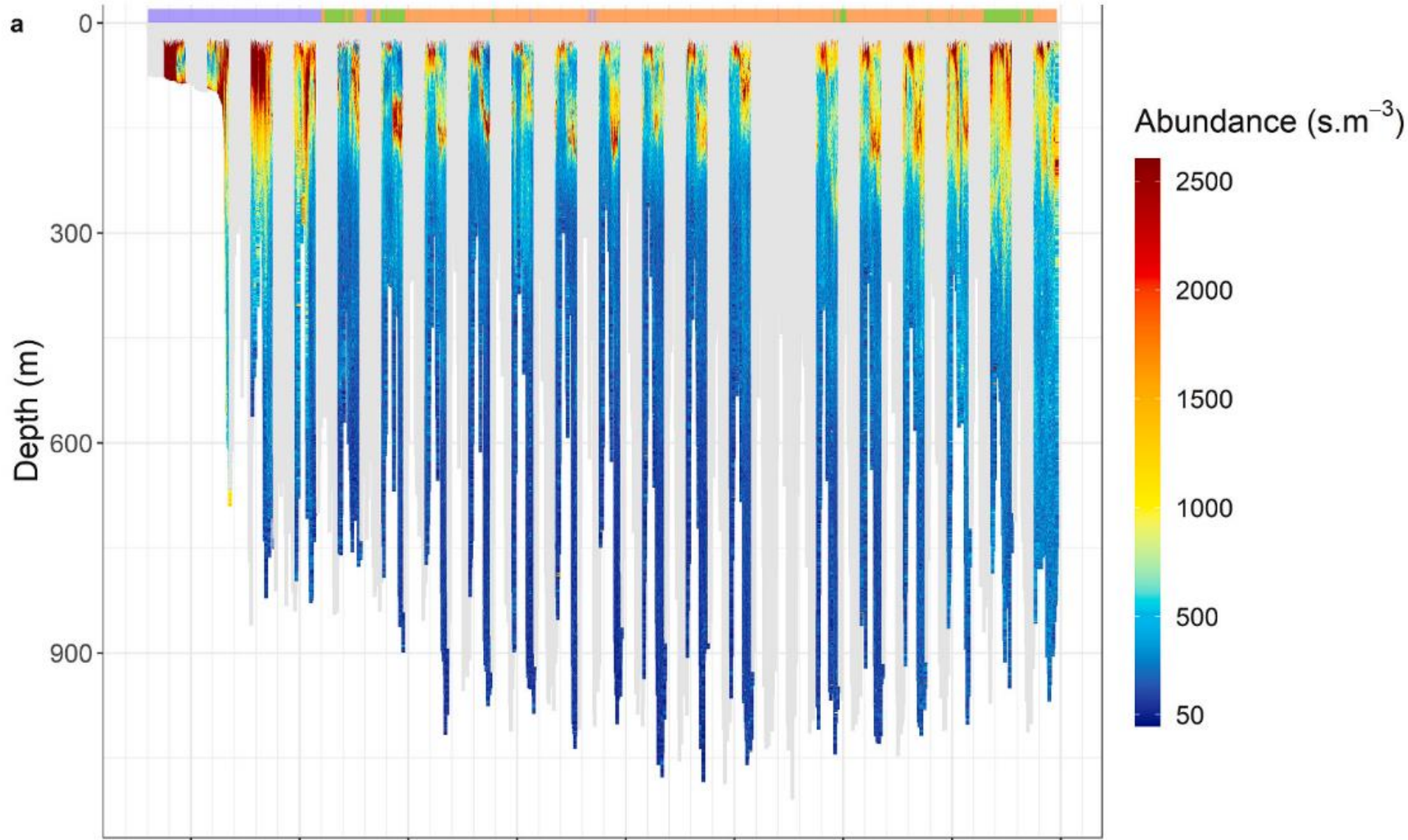


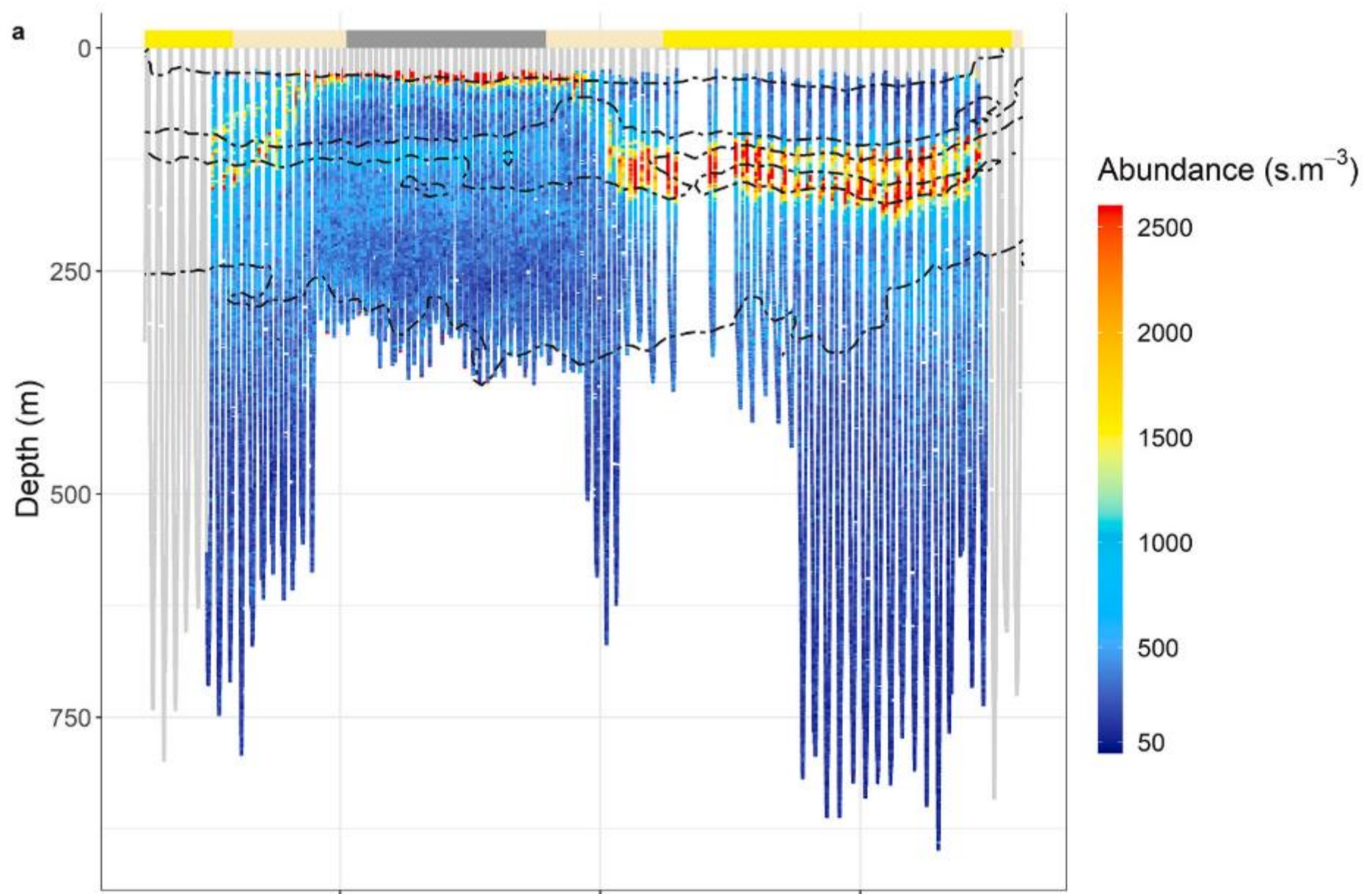
Sampling the biotic environment

Diel vertical migration at Peninsula Valdes

Active vertical migration of living organisms (fish, squids etc)

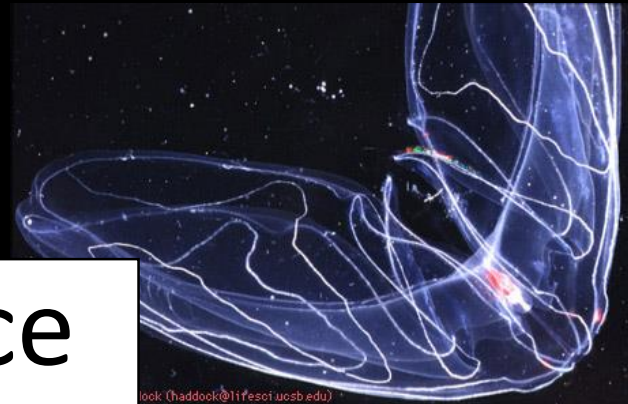
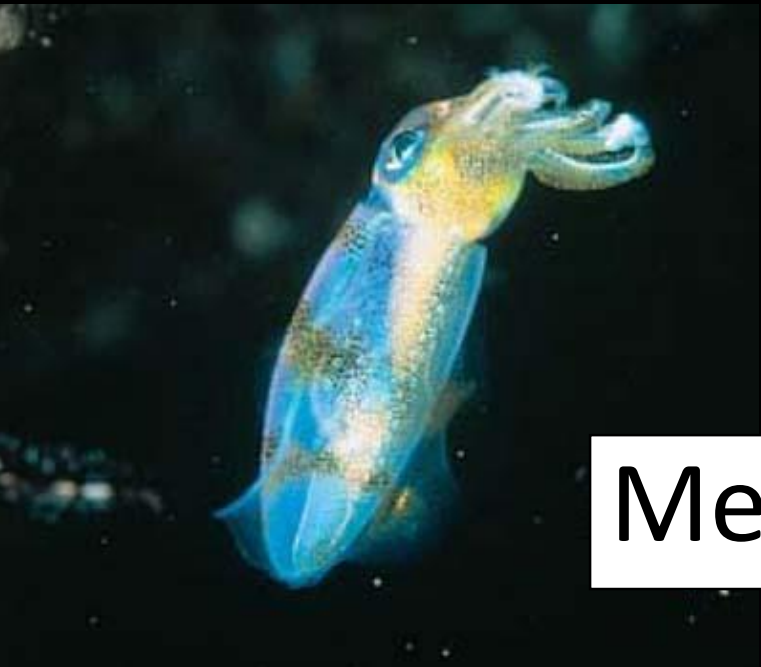
Largest daily migration on Earth





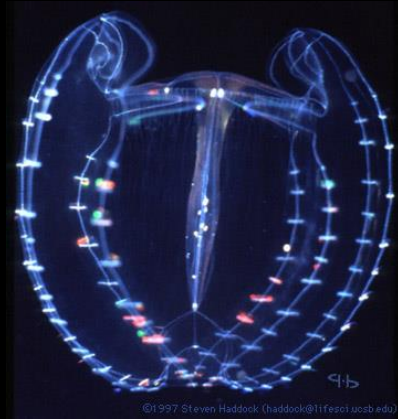


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Measuring bioluminescence



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Clip 3

(Taningia danae)



Developing new biologging techniques to observe and investigate intermediate trophic levels

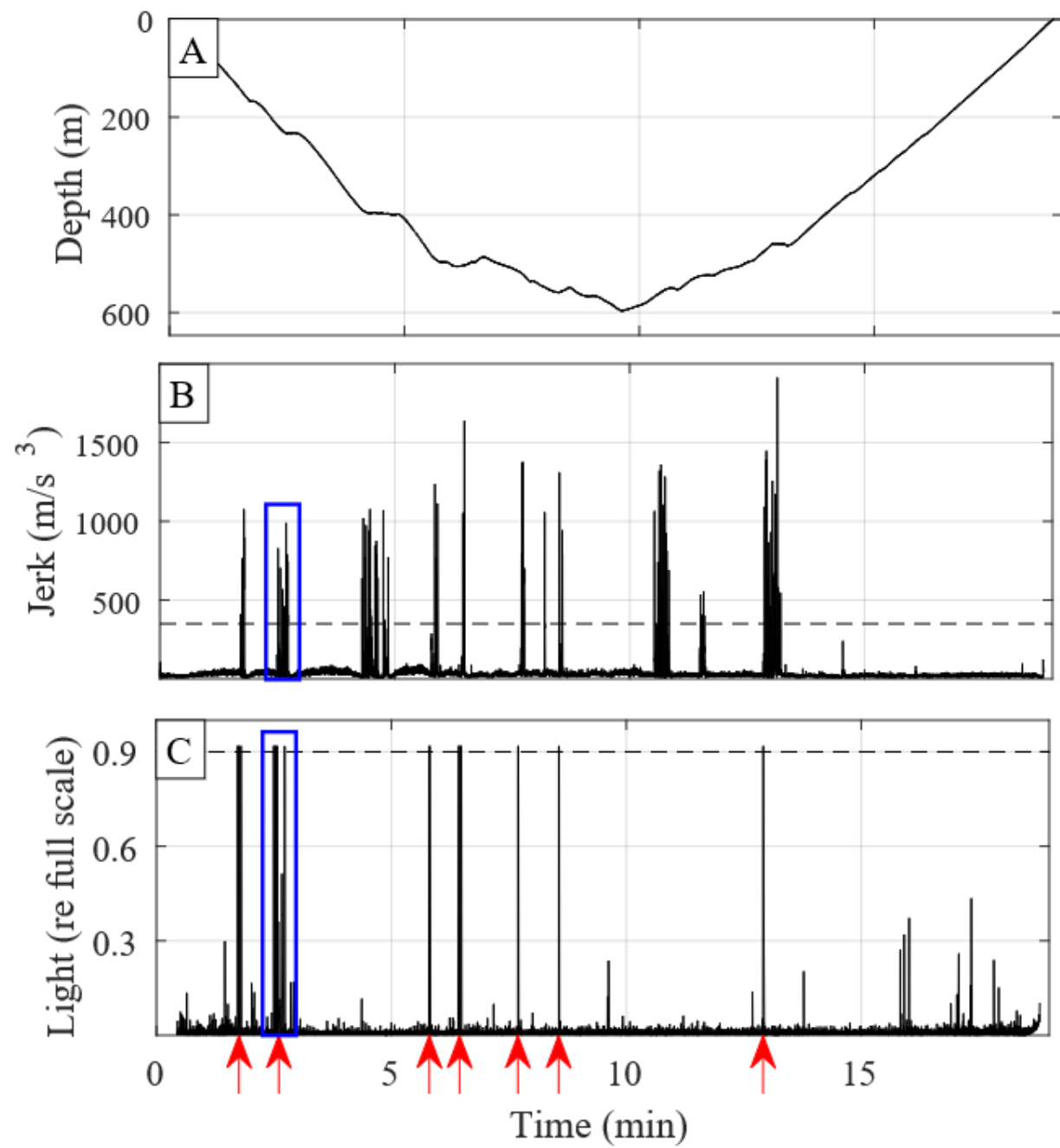


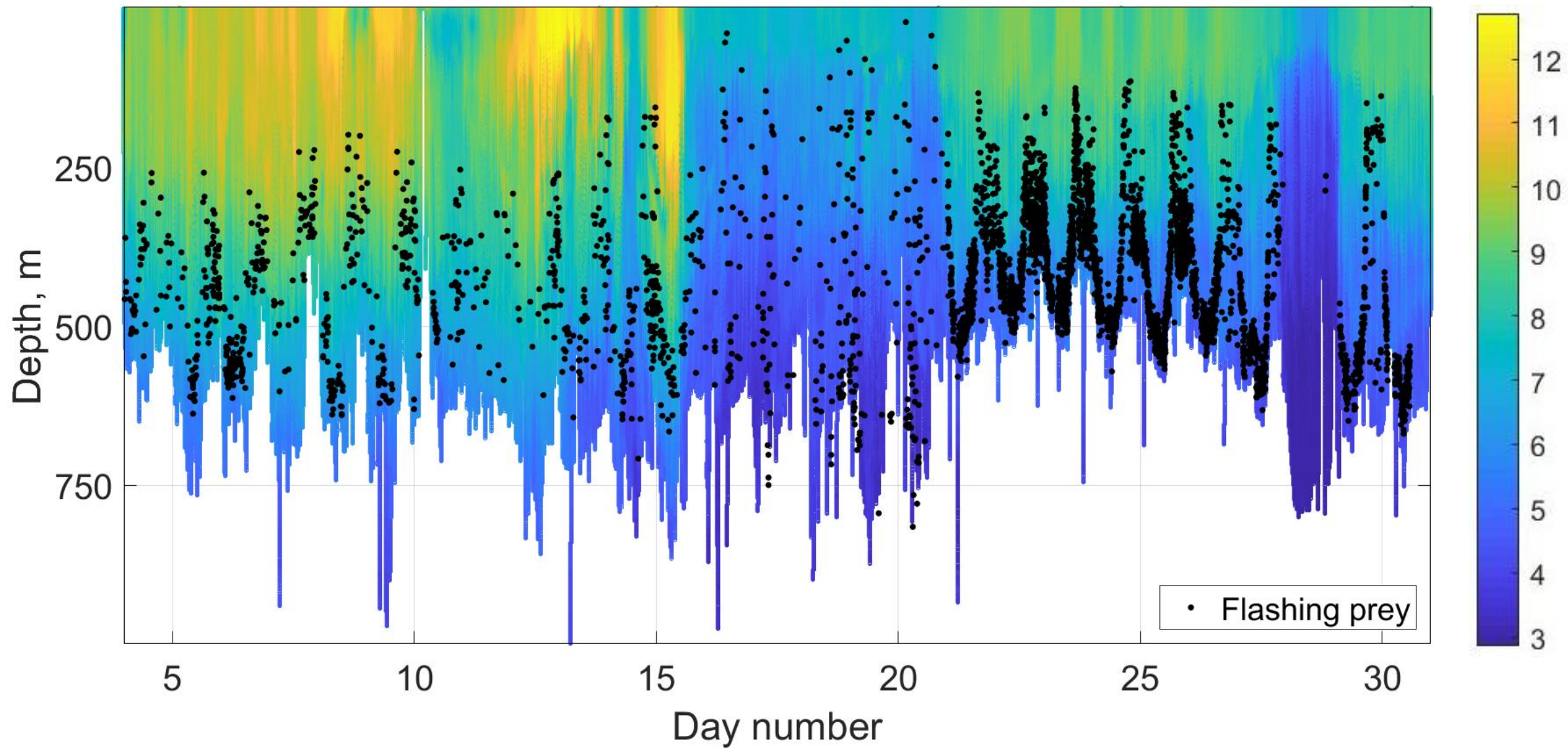
High frequency position (GPS) and movement sensors (acc, mag, P)

High sensitivity-High frequency 50 hZ sampling Light sensor

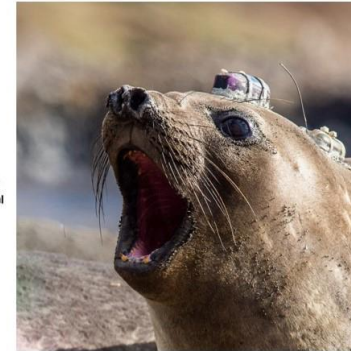
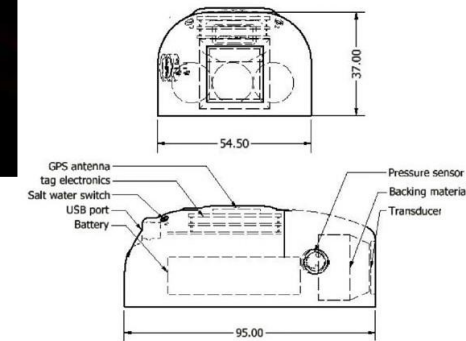
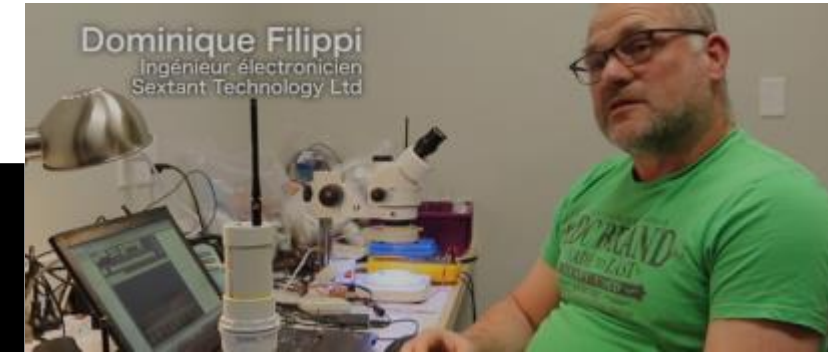
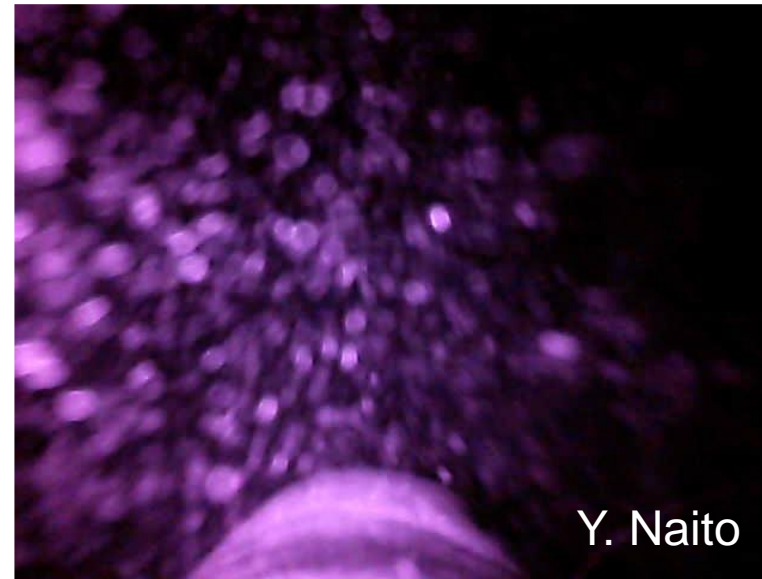
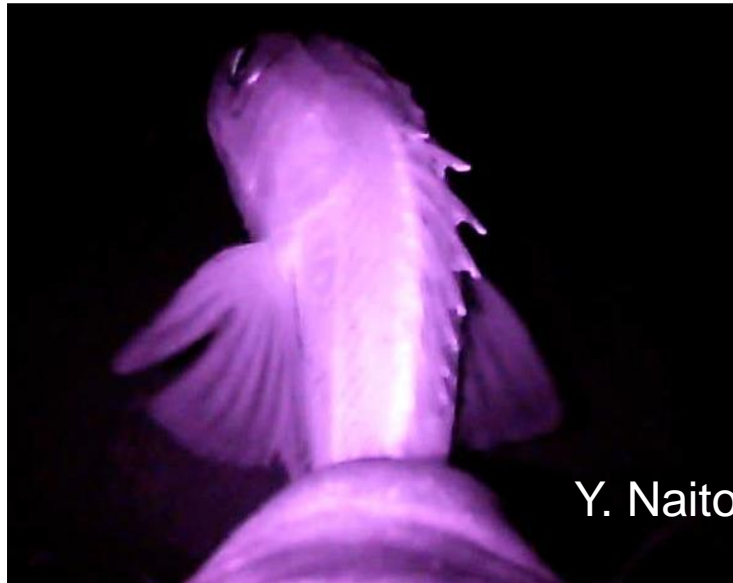


To study brief **anti-predatory** emissions from bioluminescent organisms, e.g. myctophid fish, squids...





Under development: a micro-camera-sonar tag



Naito : video camera (not sharp enough to identify small organisms (zooplankton taxonomic groups))



Merci de votre attention