

# Passive Acoustic Monitoring from gliders

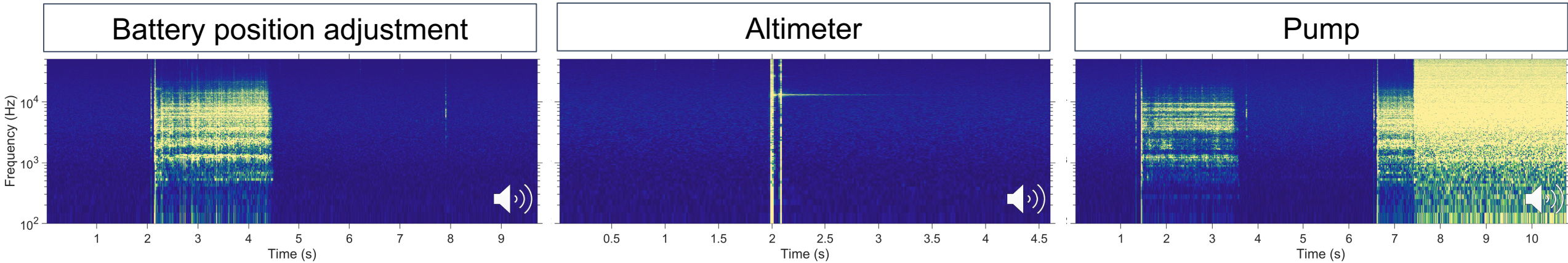
Pierre Cauchy, K. J. Heywood, B. Y. Queste, N. D. Merchant, D. Risch, P. Testor



- ✦ **Silent platform**
- ✦ **Opportunistic deployments**
- ✦ **Extreme weather events**
- ✦ **Marine life**
- ✦ **Anthropogenic noise**

# Gliders for Passive Acoustic Monitoring (PAM)

## ✦ Low noise



Deployment	Duration	Underwater time (~5 m)	Quiet glide time
Mistrals – T02_01	15.9 days	13.8 days	13.5 days
ASICSMED	29.8 days	25.9 days	25.5 days
MOOSE – T00_23	51.0 days	45.2 days	44.1 days
MOOSE – T00_25	33.9 days	28.7 days	27.8 days
REP14 – MED	13.9 days	11.9 days	10.4 days

97.6 %

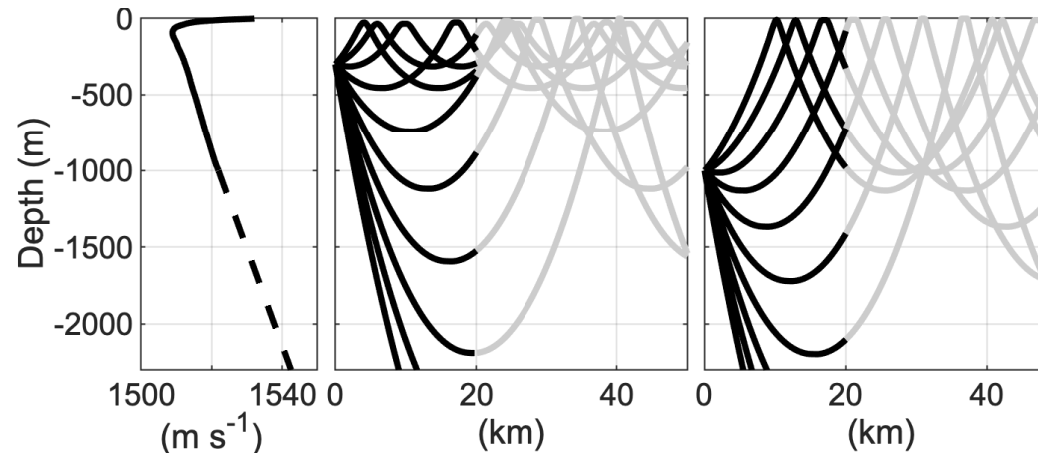
87.4 %

**Piloting matters!**

## ✦ Sound speed profiles

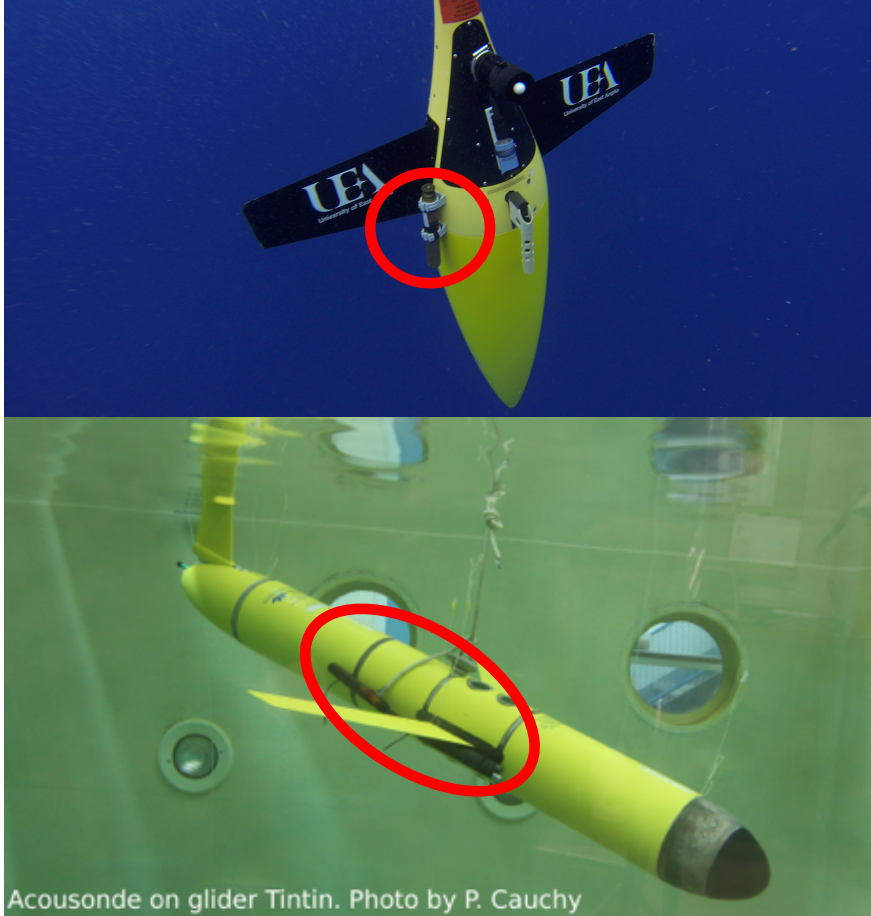
✦ Propagation / attenuation

✦ Ranging



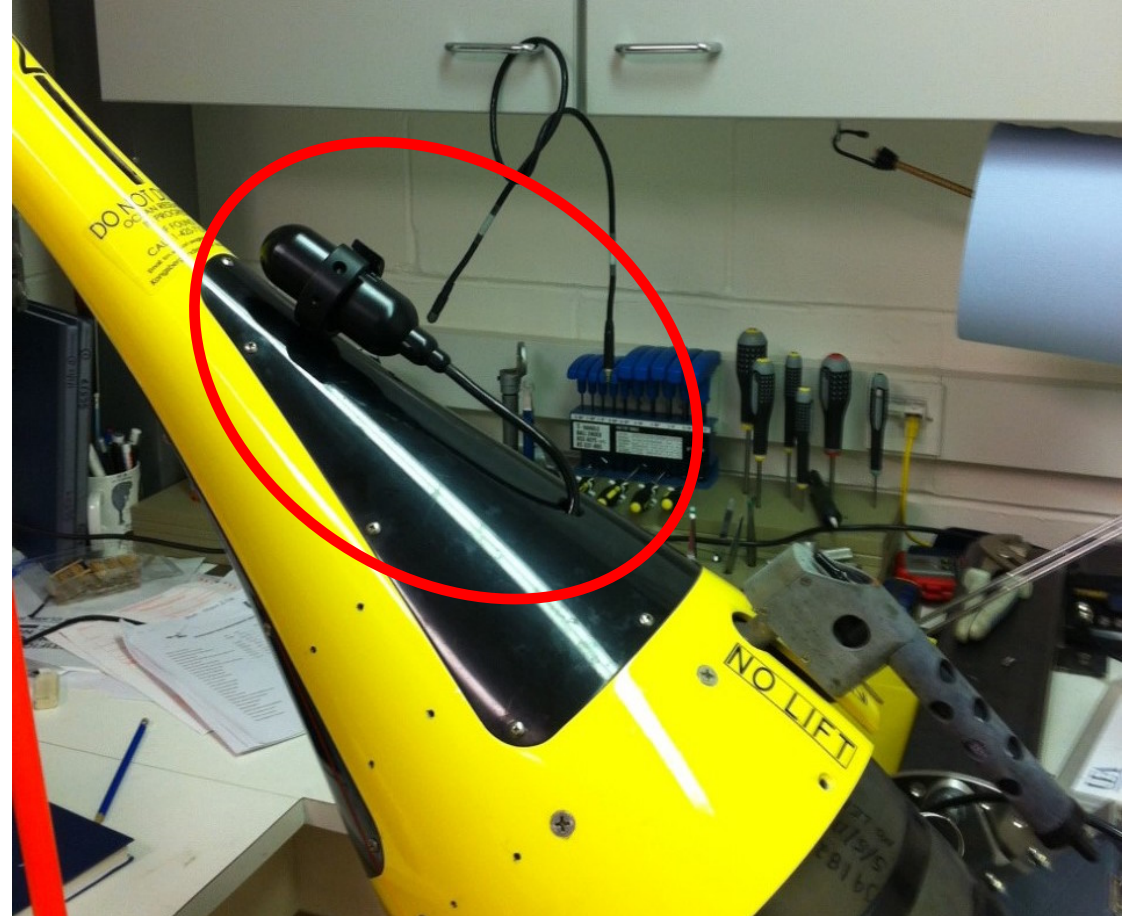


# PAM sensors used



## ✦ Self contained hydrophone

- ✦ 1 kHz – 116 kHz, 16 bits
- ✦ ~3 – 5 days continuous recording
- ✦ Duty cycle



## ✦ Integrated hydrophone

- ✦ 100 Hz – 62 kHz, 24 bits
- ✦ ~30 days continuous recording
- ✦ Piloted from glider

# User feedback

## ✦ Self contained



- ✦ Does not hamper glider mission
- ✦ Easy addition as an extra sensor!
- ✦ Multi platforms  
(Slocum, Seaglider, mooring, seal...)

## ✦ Integrated

- ✦ High specs
- ✦ Endurance
- ✦ Easy deployment



- ✦ Non re-configurable
- ✦ Additional deployment / set up task

- ✦ Dedicated PAM glider mission only

## Improvements

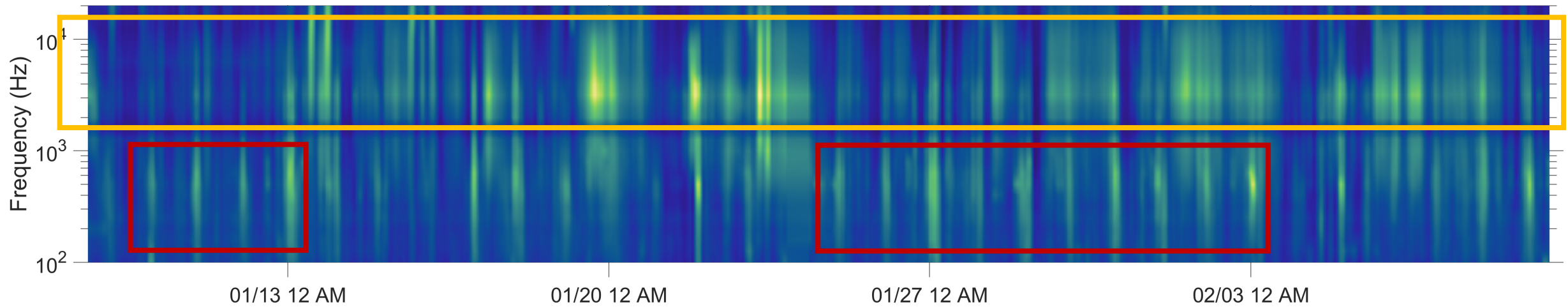


- ✦ Improved specs
- ✦ Increased autonomy

- ✦ Duty cycle (time, depth)
- ✦ On board processing (FFT, detection)
- ✦ Meaningful real time transmission
- ✦ Arrays

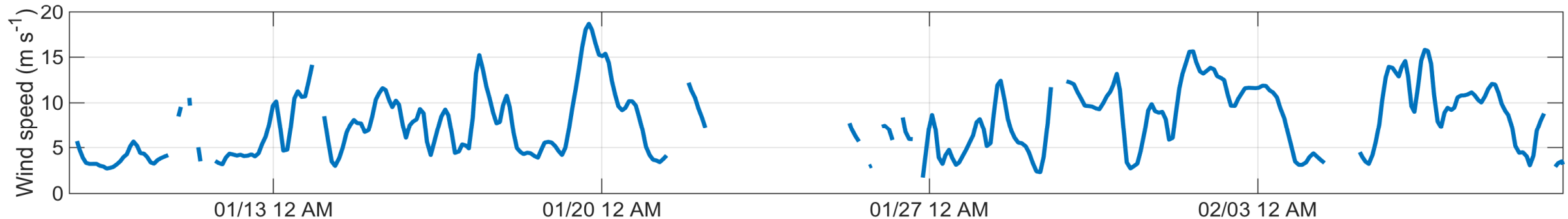
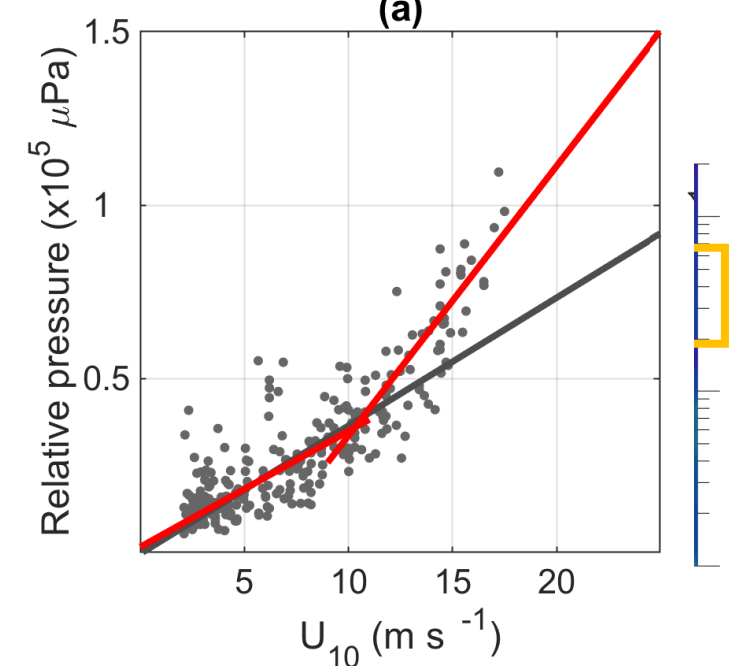
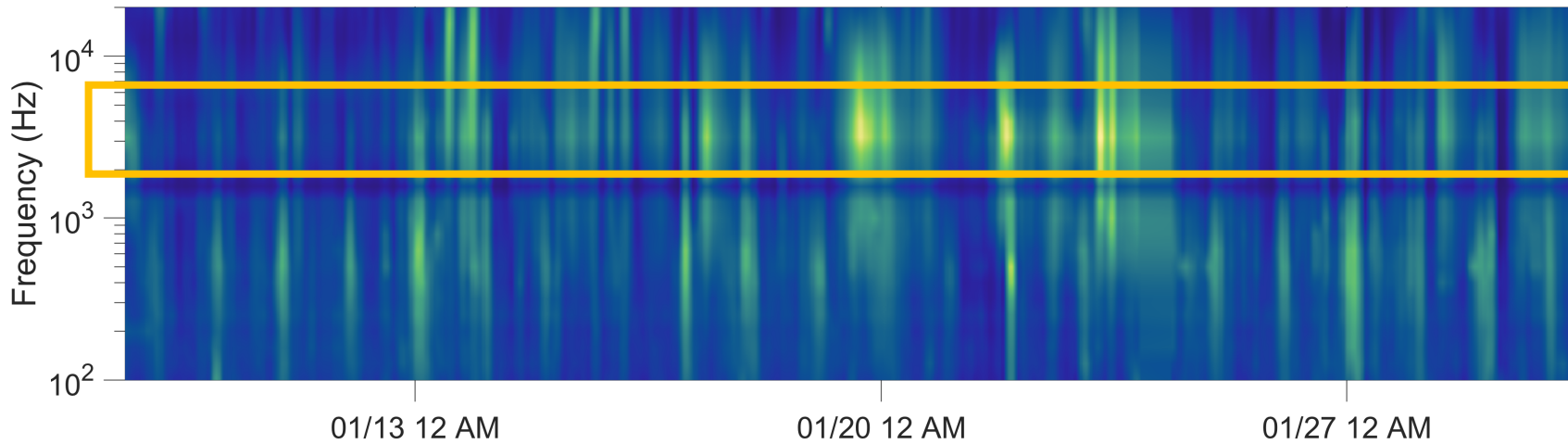


# Background noise



- ✦ Individual sources removed
- ✦ Intra-day to inter-annual scales
- ✦ Wind noise, Marine traffic, Marine life choruses...

# Wind speed measurements



✦ Air sea interactions

✦ Can measure during hurricanes!

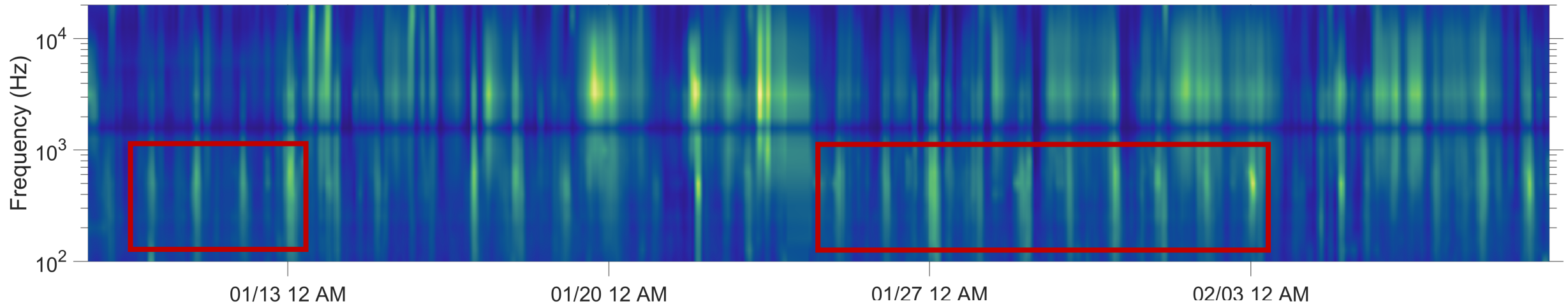
Calibration of satellite measurements

Improvement of climate models

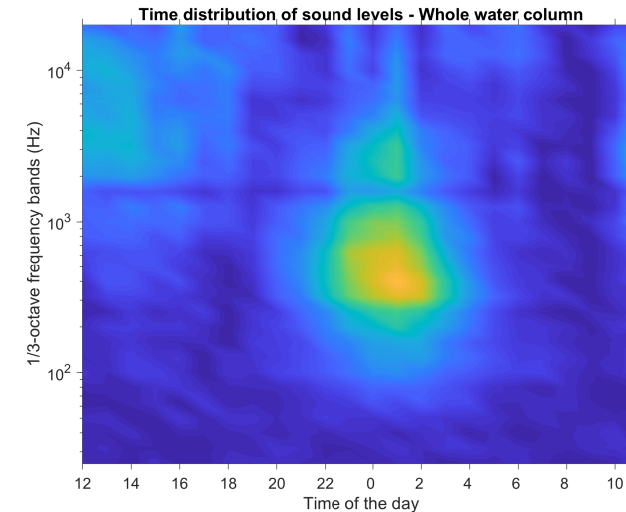
Cauchy et al. **Wind speed measured from underwater gliders using passive acoustics**  
Journal of Atmospheric and Oceanic Technology. Dec 2018.



# Marine life choruses



- ✦ **Population monitoring**
- ✦ Long term – large scale
- ✦ Hidden individuals
- ✦ Non invasive
- ✦ Marine protected areas

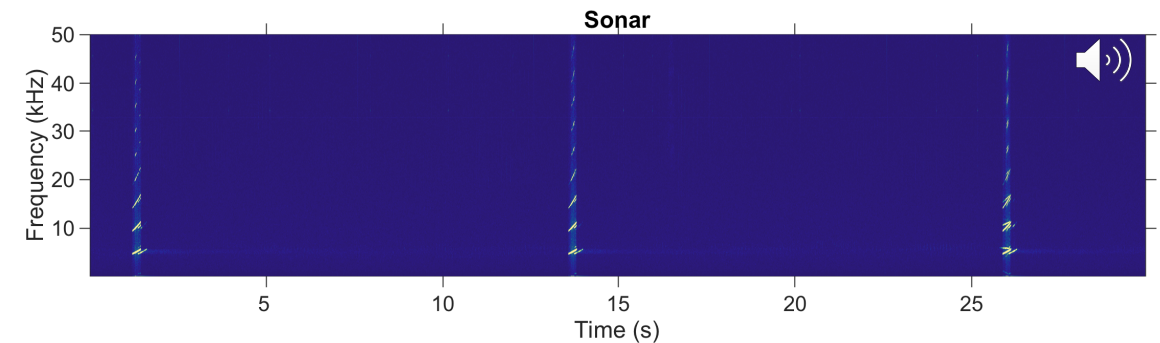
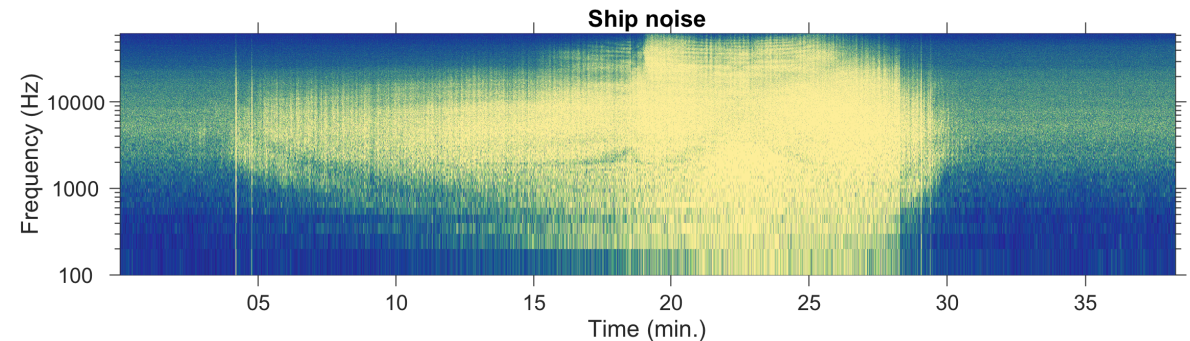
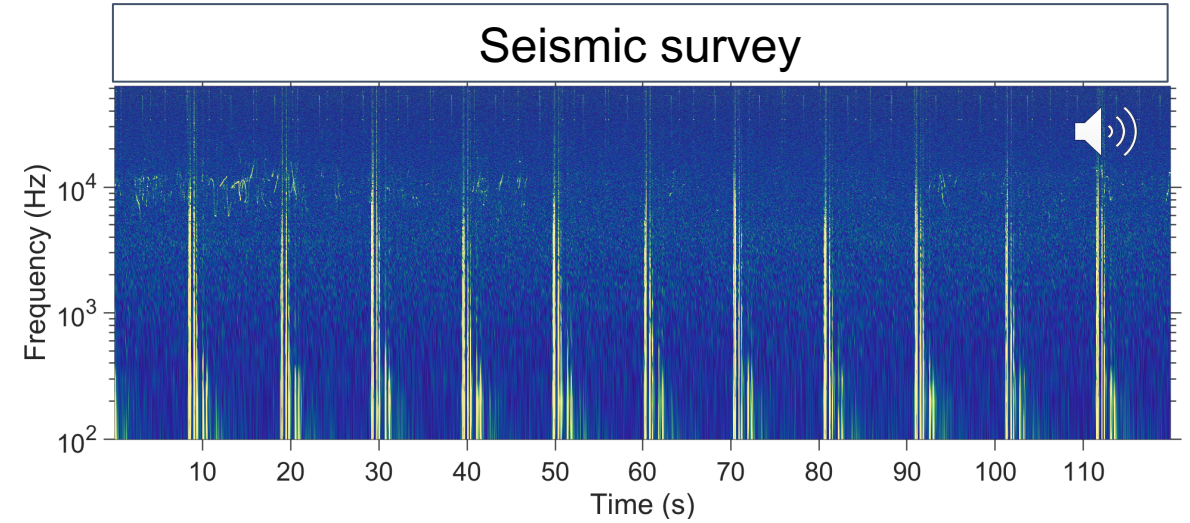
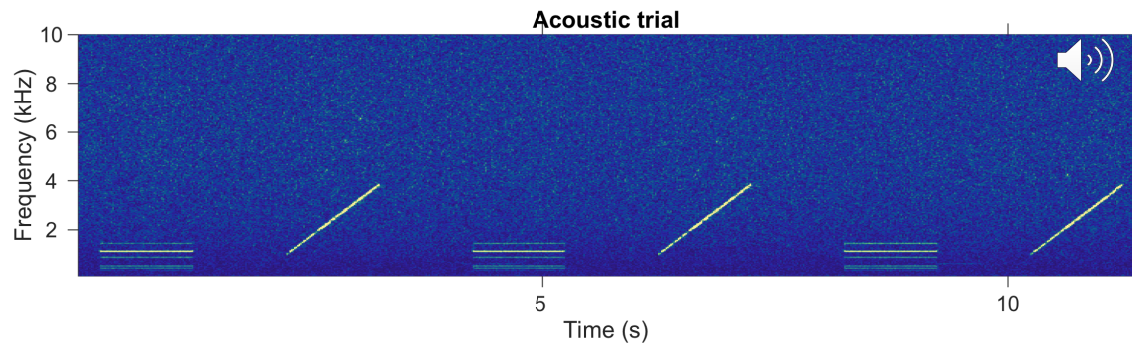


**Potential indicator for ecosystem health**

Di Iorio et al. **'Posidonia meadows calling': a ubiquitous fish sound with monitoring potential.** *Remote Sensing in Ecology and Conservation* (2018).

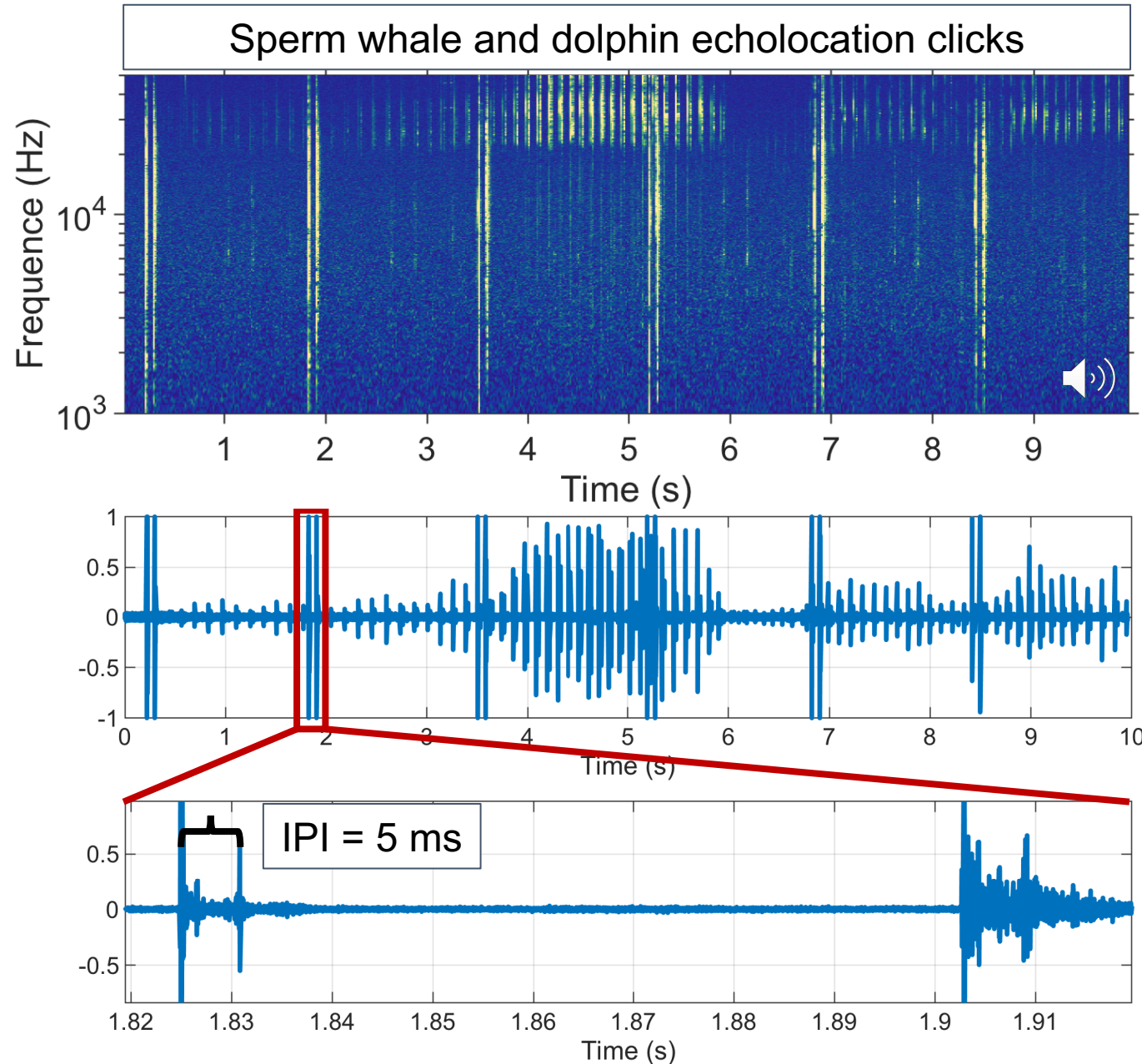
# Individual sources - Anthropogenic

- ✦ Impact of activities
- ✦ Noise pollution
- ✦ Regulations
- ✦ Marine protected areas





# Sperm whale population monitoring



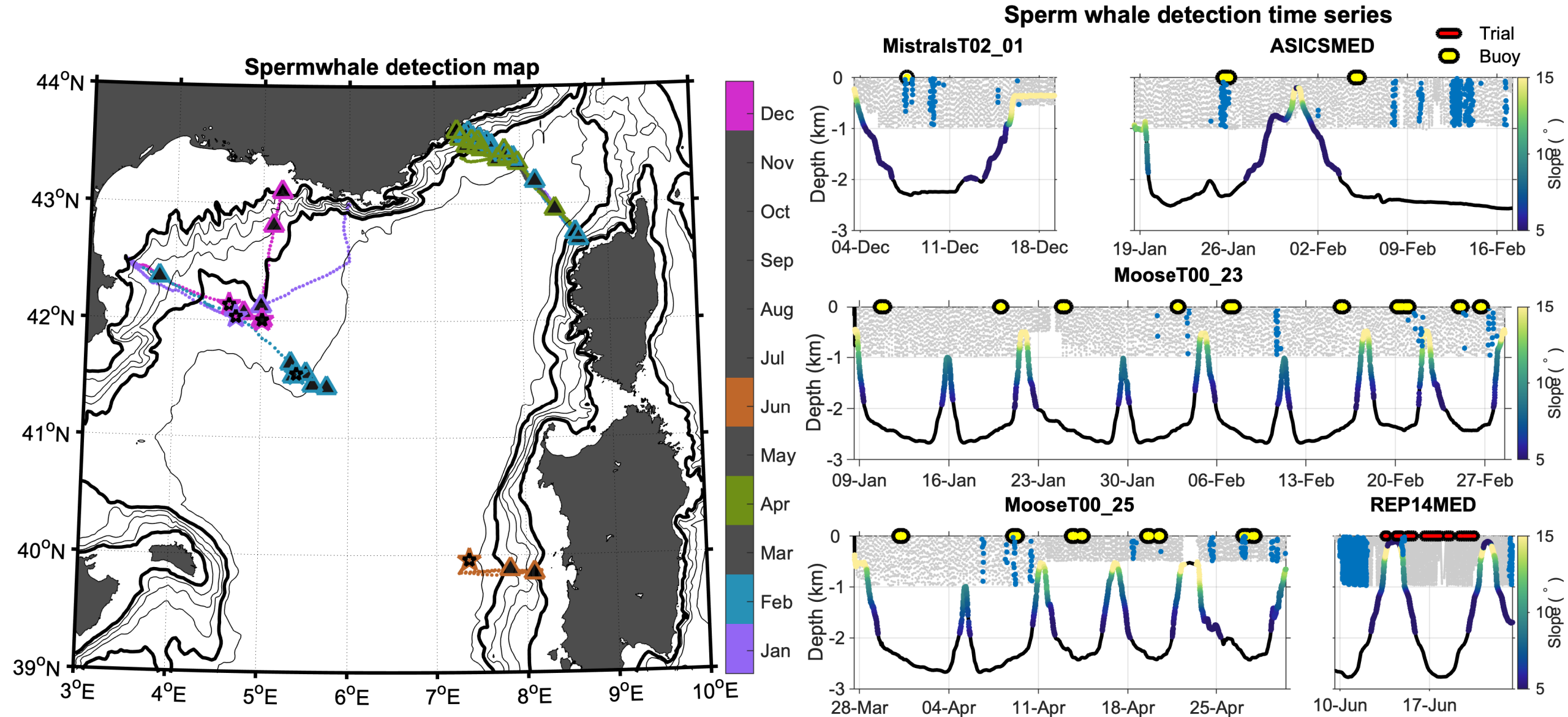
- ✦ **Detection**
- ✦ **Classification**
- ✦ **Characterization**
- ✦ **Size estimation!**

From Growcott et al. (2011):

$$\text{Total length} = 1.258 \times \text{IPI} + 5.736$$

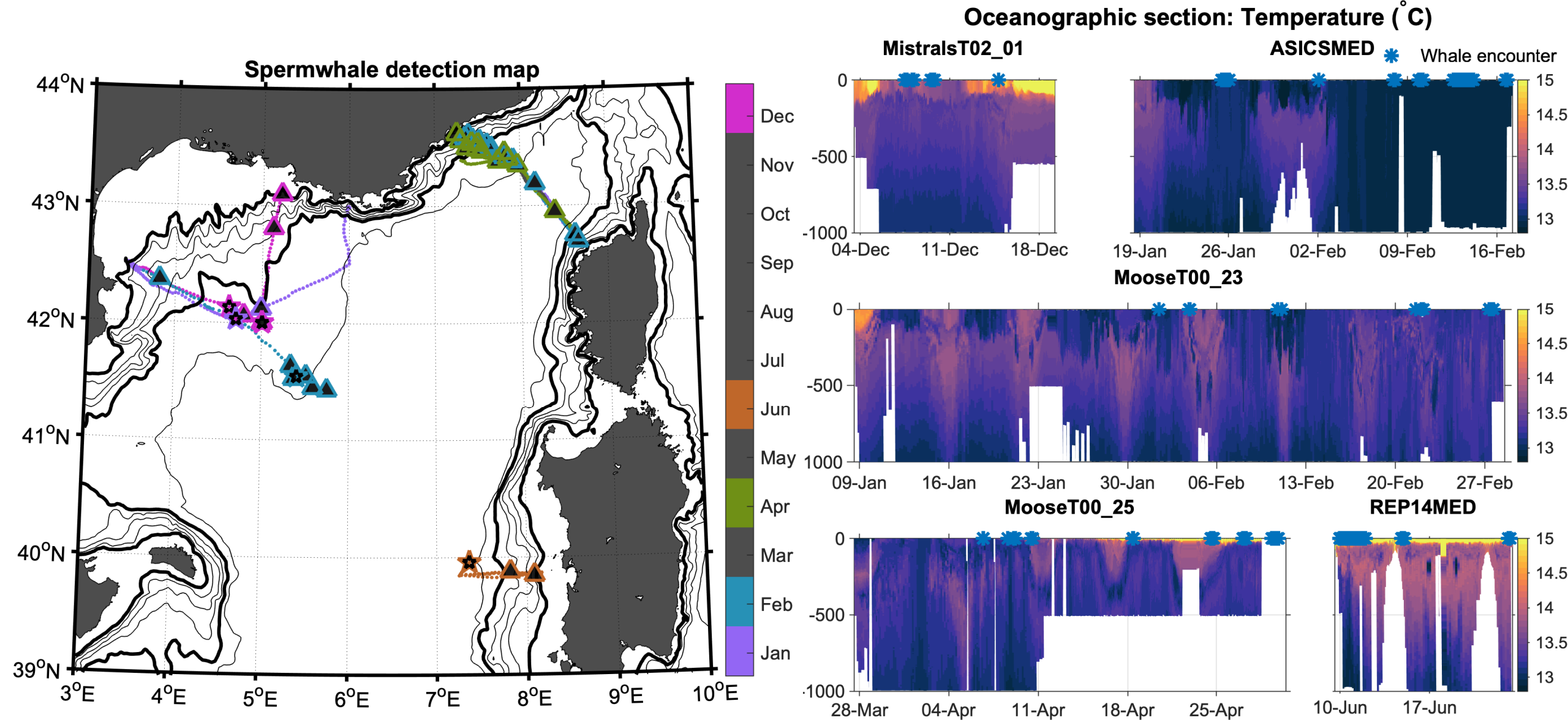
Inter Pulse Interval (IPI) = 5 ms.  
Sperm whale size = 12 m.

# Habitat use – Topographic features

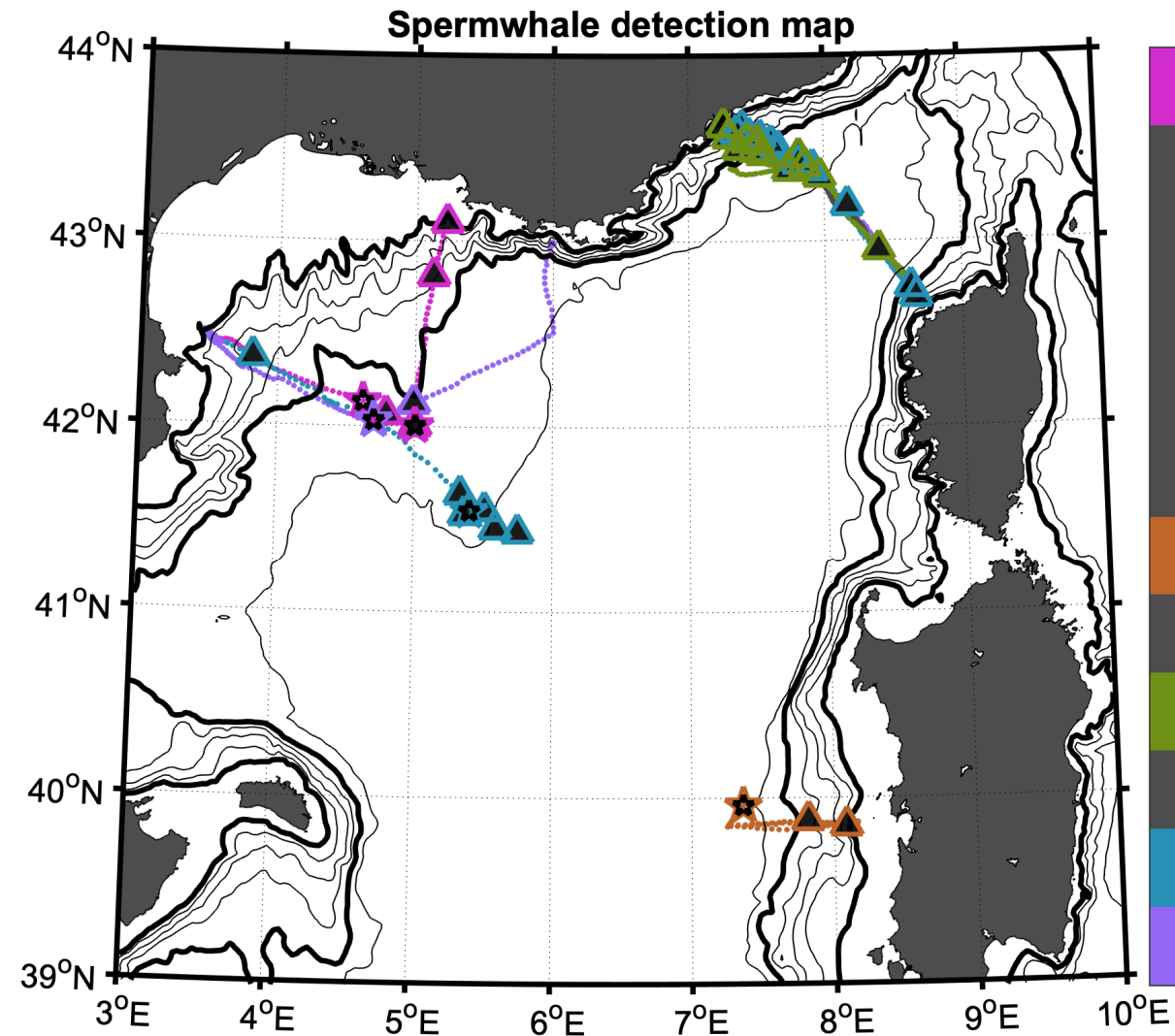




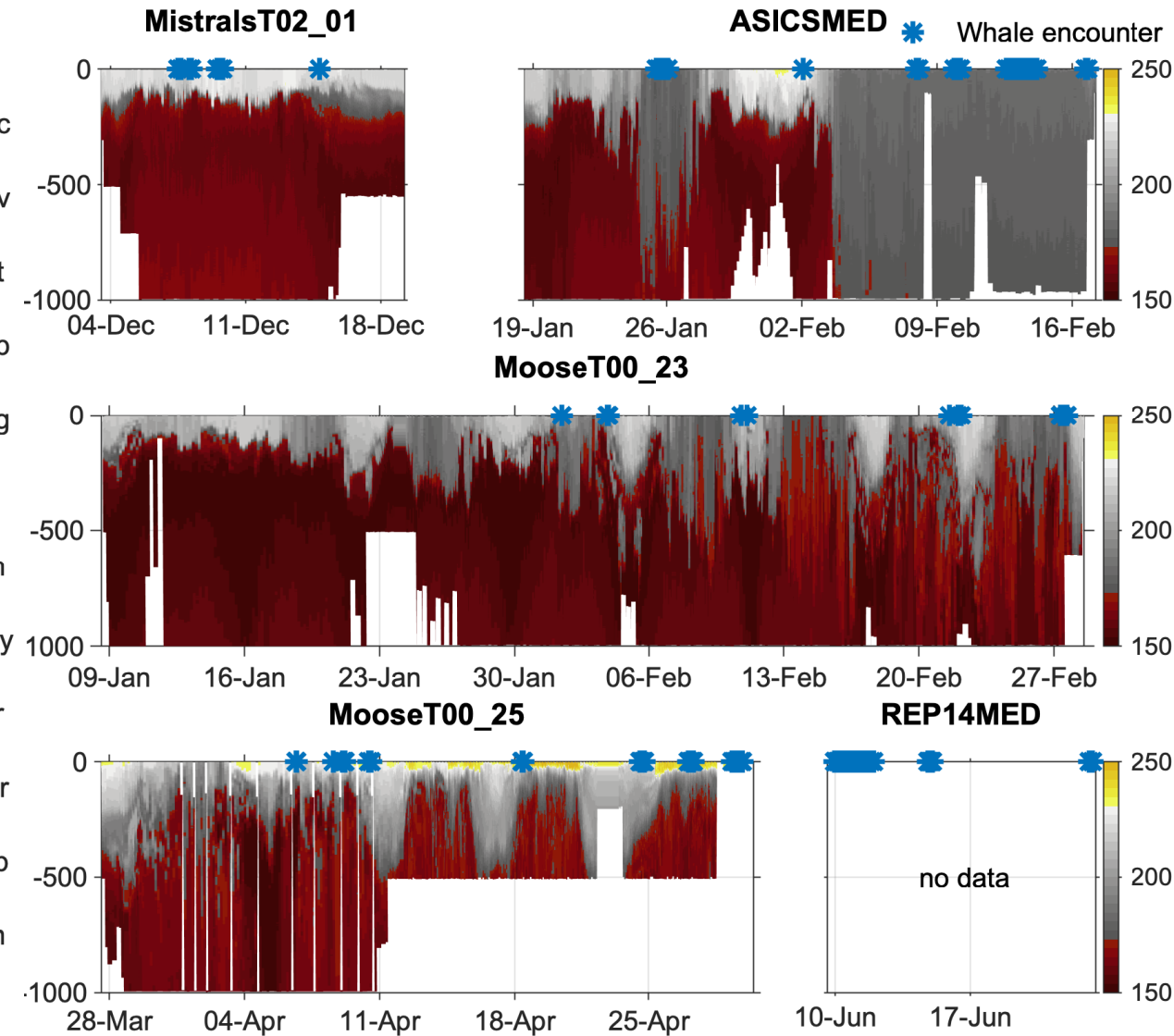
# Habitat use – Oceanographic features



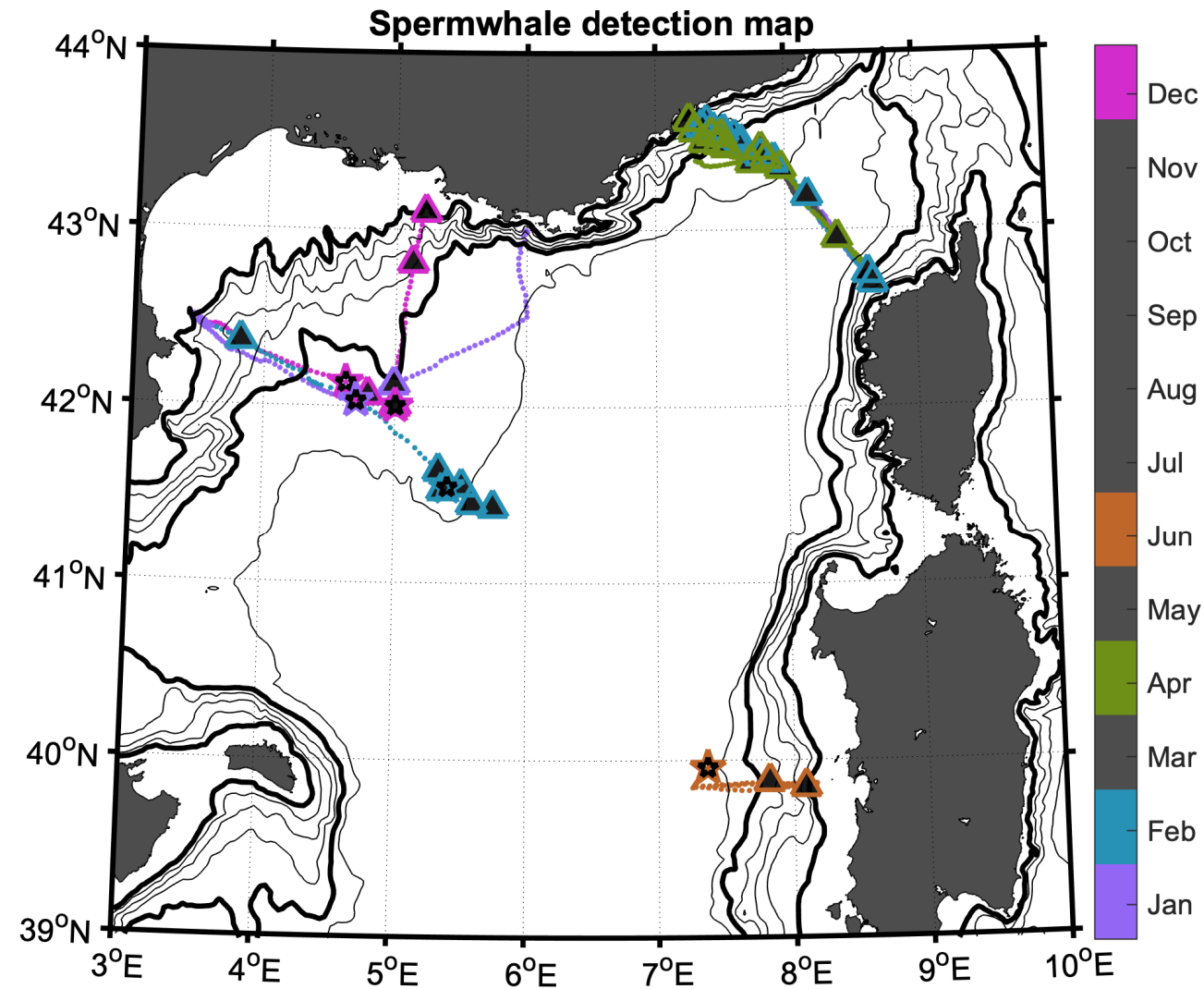
# Habitat use – Oceanographic features



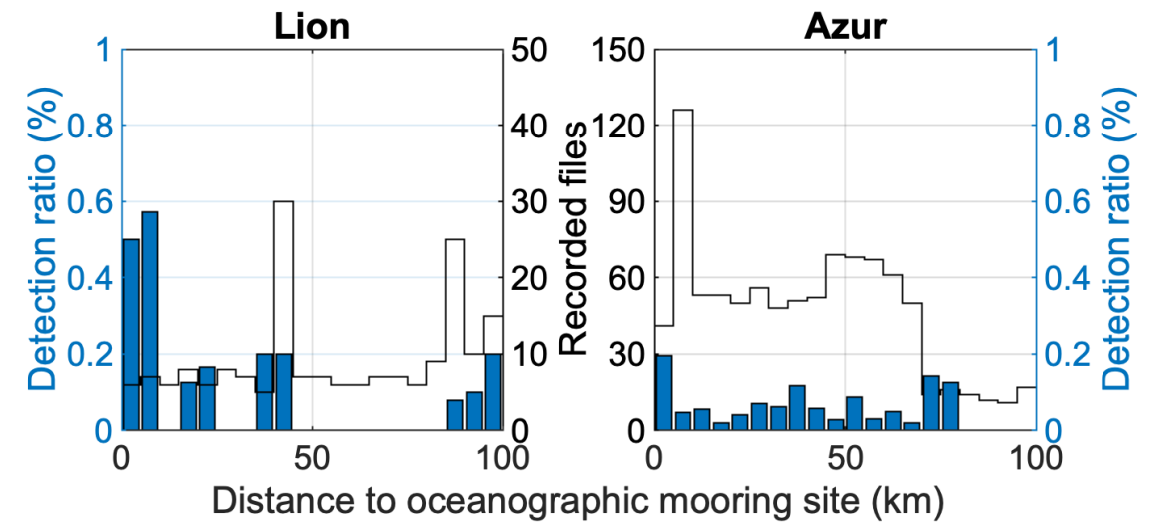
## Oceanographic section: Oxygen concentration



# Hot spots

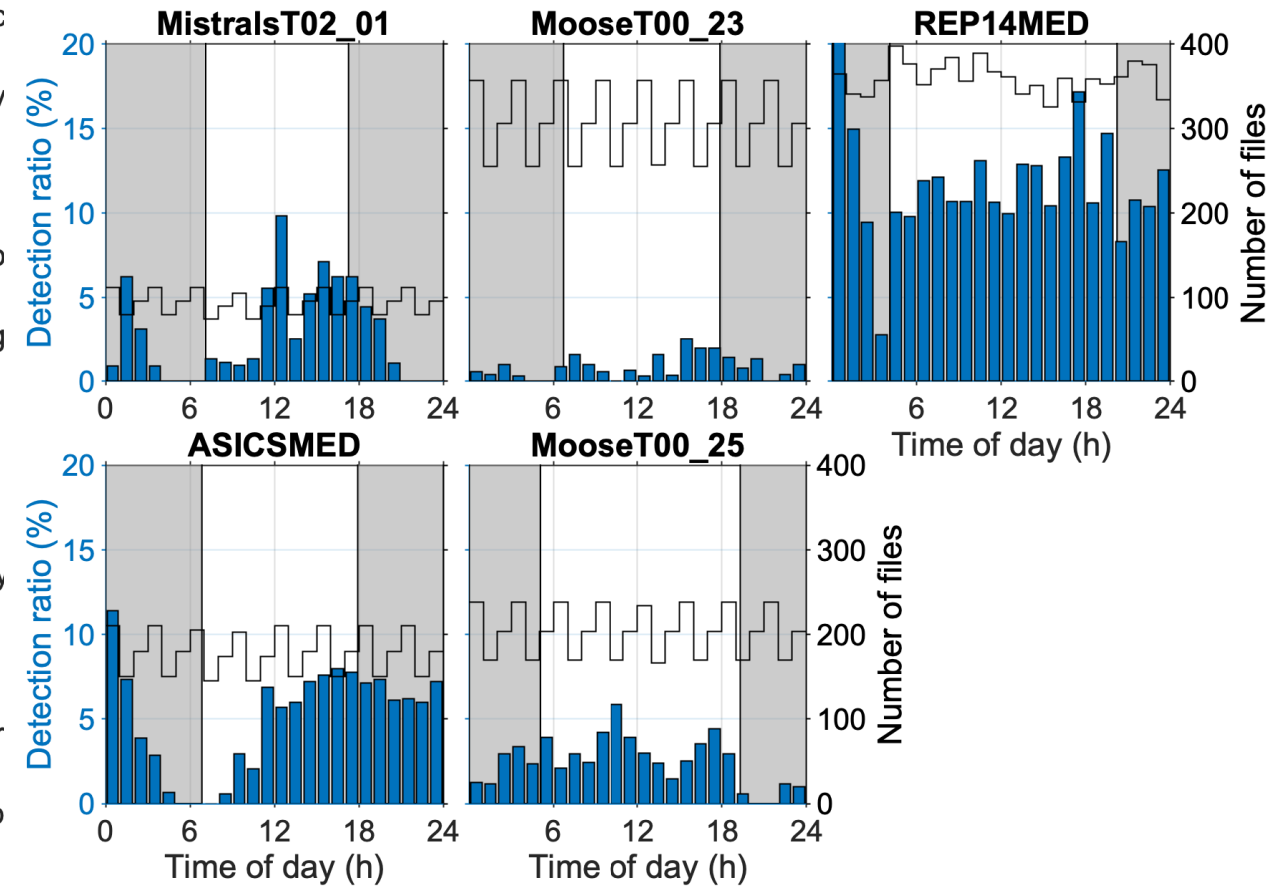
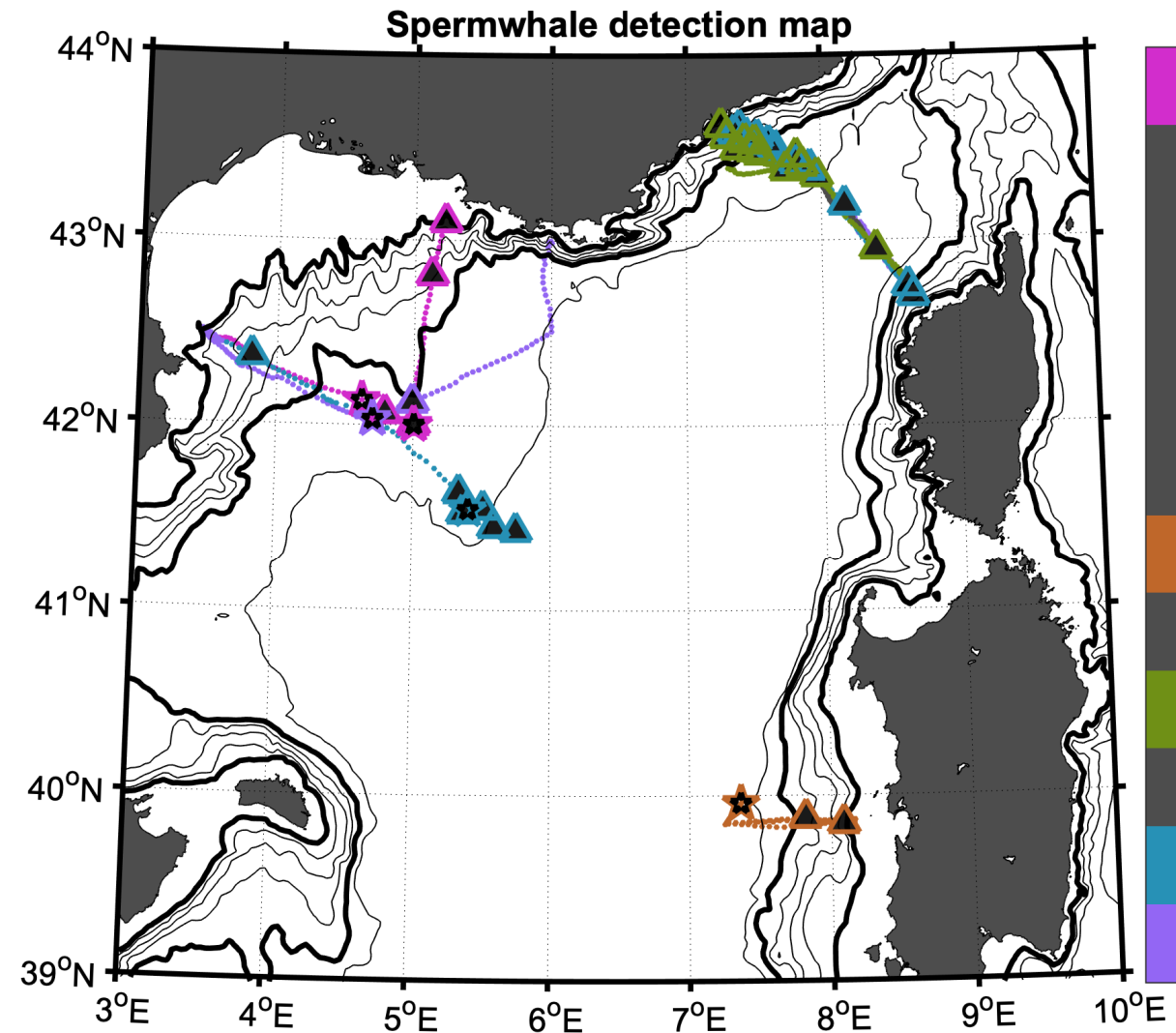


## Mooring lines





# Circadian pattern



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Thanks to the DT INSU and  
UEA glider teams

- ✦ Silent robot and acoustic recorder 👍
- ✦ Existing networks of oceanographic gliders
- ✦ Long term / large scale monitoring
- ✦ Non invasive