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# Global passive acoustic monitoring of the oceans with MERMAID Argo floats

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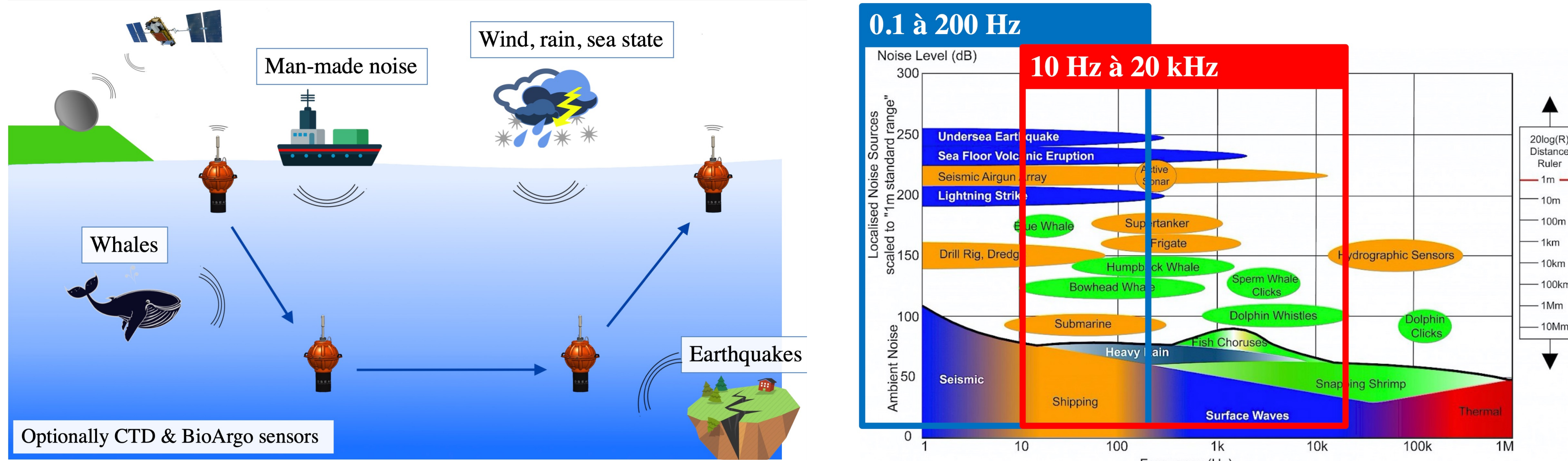
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## MERMAID-MULTI

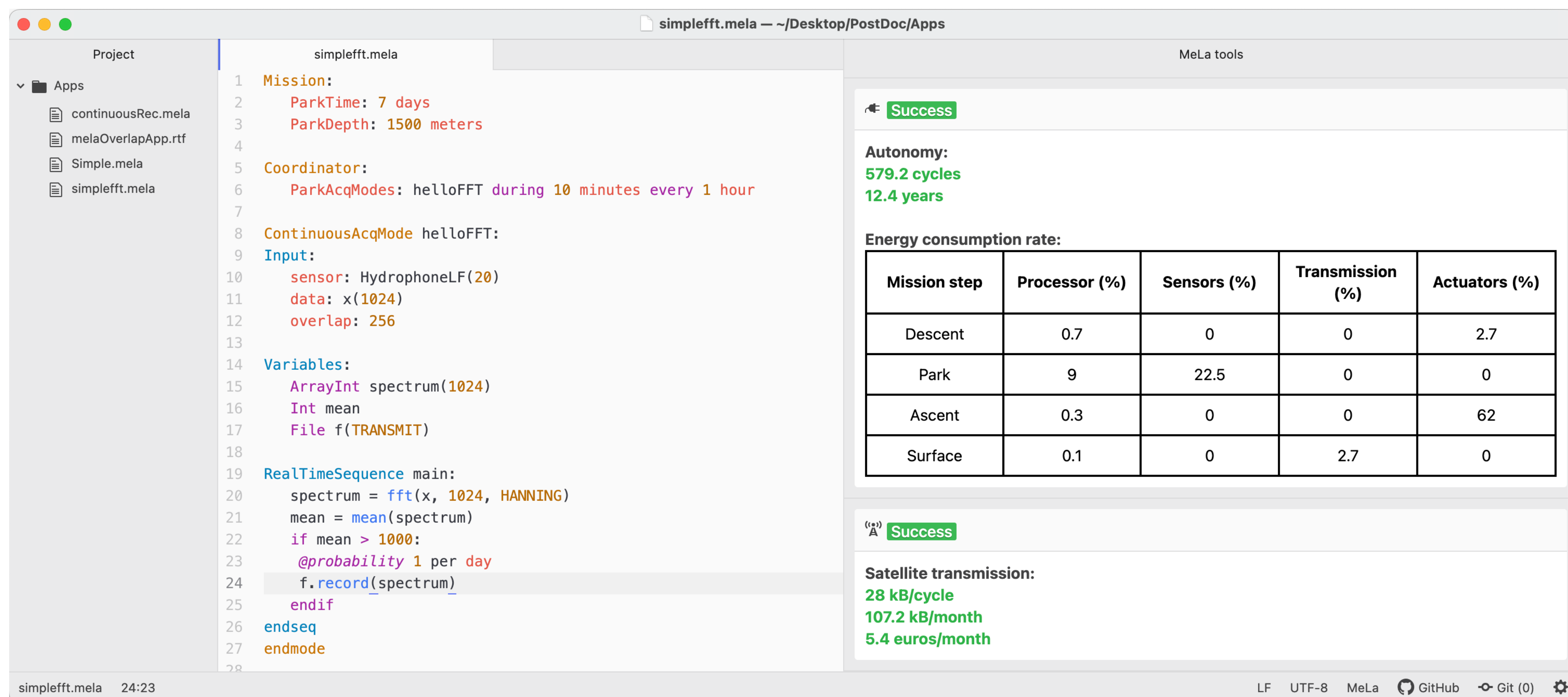
The MERMAID [1] is an autonomous seismometer floating at a depth of 2000 meters in the oceans. It rises to the surface every week to transmit data. We are developing a multidisciplinary version for passive acoustic monitoring from 0.1 Hz to 20 kHz, separated into 2 acquisition channels.



A typical MERMAID cycle (left) and monitored acoustic frequency bands (right)

## Applications development

Acoustic data must be processed/compressed on board before being transmitted in near real time by satellite. A dedicated programming language (MeLa) aware of energy and processing power limits is used to develop algorithms without requiring embedded software expertise [2]. Several applications can be programmed over the air even after instrument deployment.

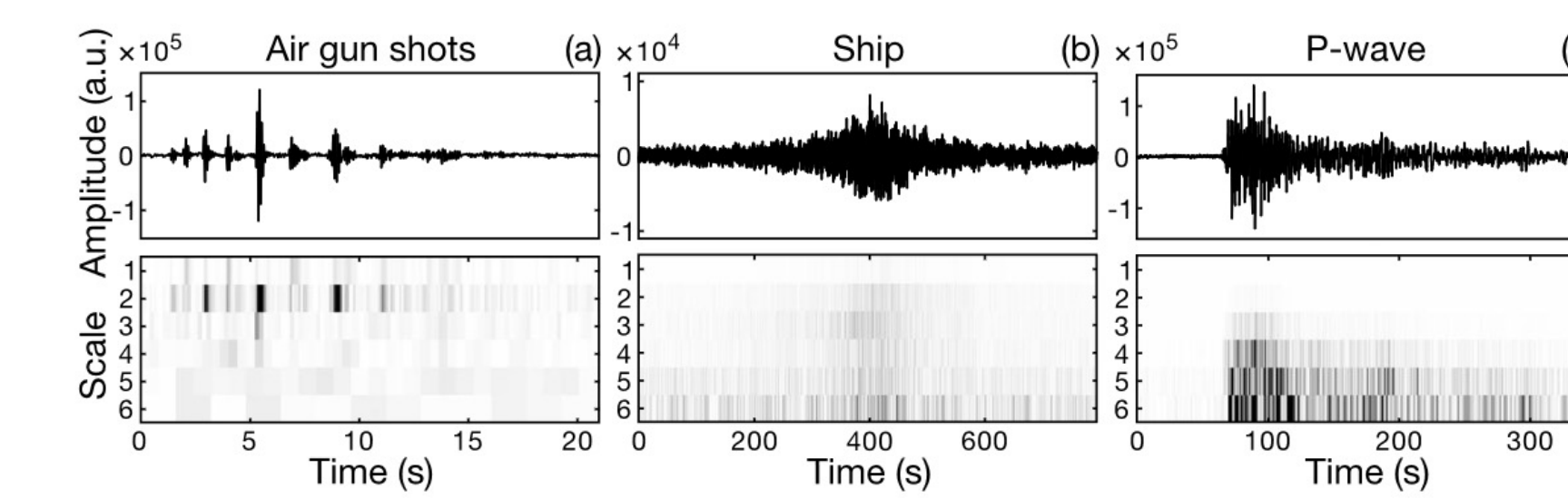


Example of a MeLa application in the Pulsar editor with energy and satellite transmission estimation on the right panel

## Application examples

### App 1:

Detection of seismic waves with the default MERMAID algorithm [3].



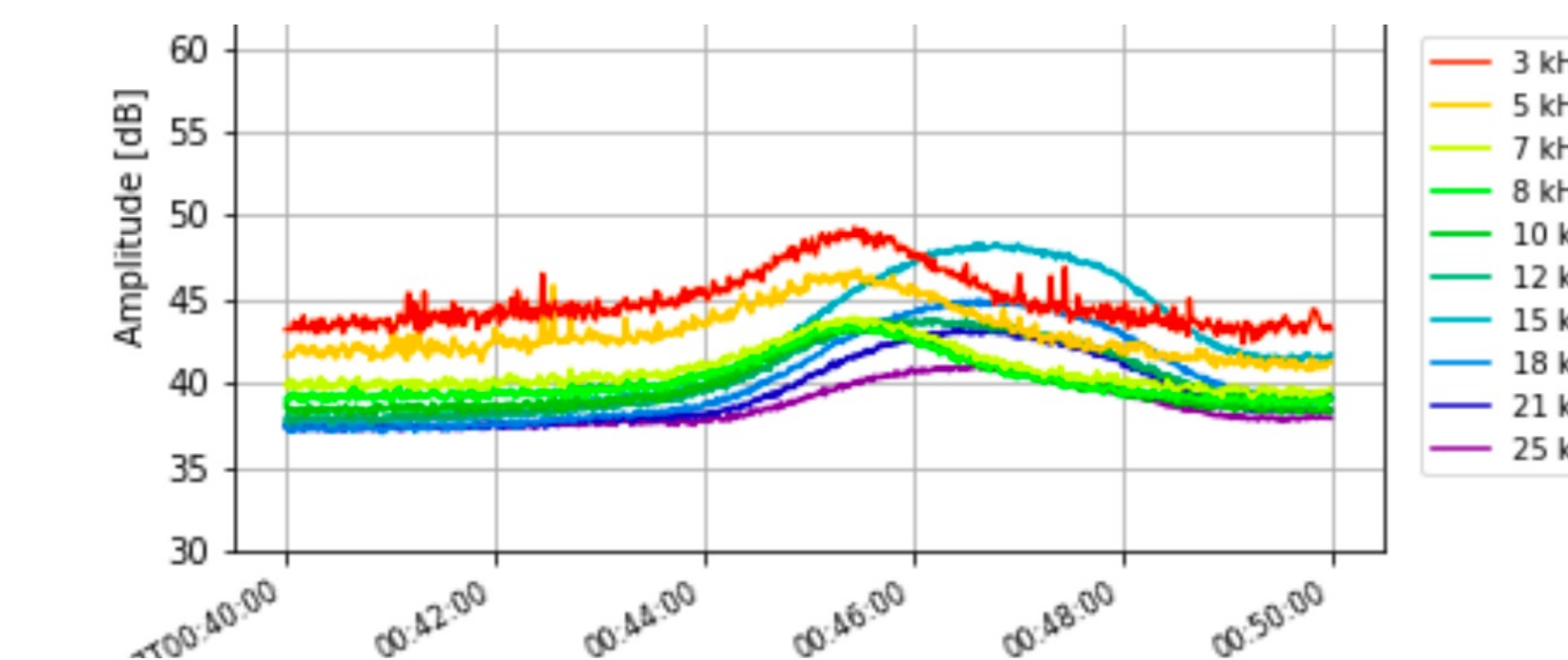
A wavelet transform is used for signal discrimination

### App 3:

Continuous recording at a sampling frequency of 80 Hz to be compatible with apps 1 and 2 operating at 40 and 80 Hz respectively.

### App 4:

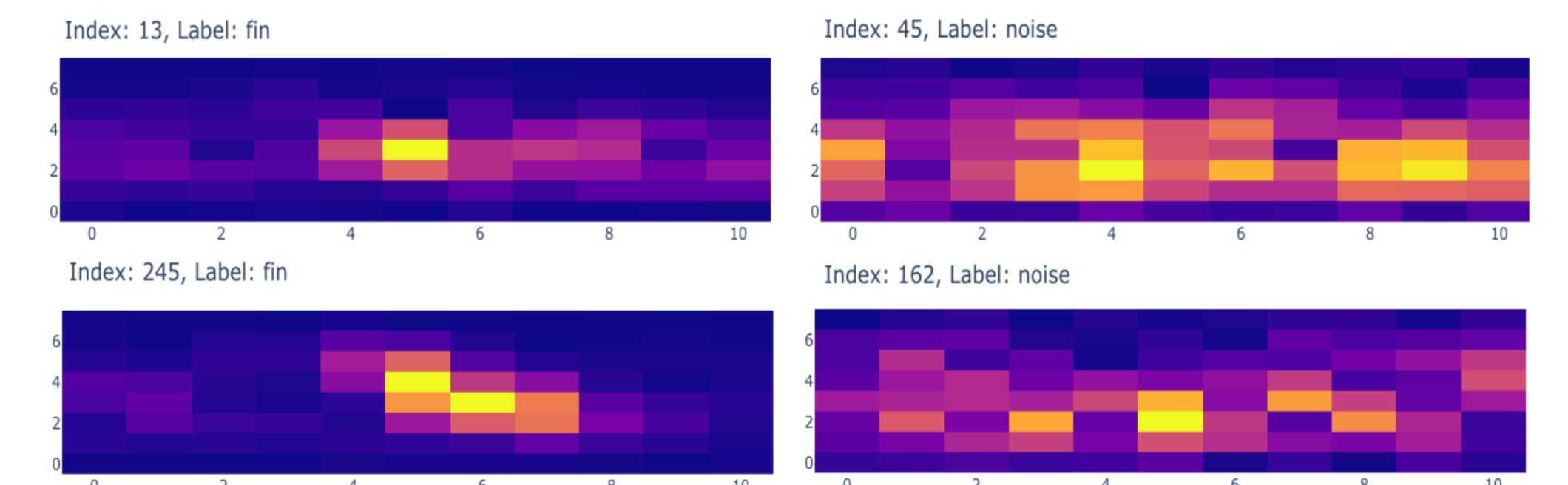
Sound pressure level is recorded at several frequency bands to monitor rain and anthropogenic noise pollution [4].



Example of a short rain - drizzle event recorded by the MBARI MARS hydrophone

### App 2:

Detection of fin whales calls using a Dense Neural Network (DNN) trained on the Watkins Marine Mammal Sound Database.



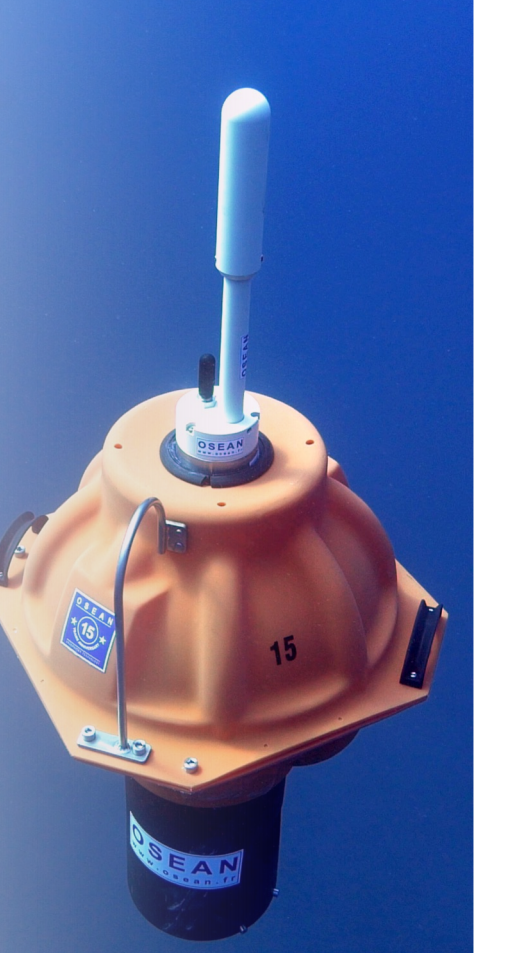
The DNN is made of two layers of 10 and 5 neurons and trained with TensorFlow Lite.

Precision is 99 % i.e., 1 detection over 100 is not a fin whale call  
Recall is 96 % i.e., 4 fin whales calls over 100 are not detected

### Resource usage:

The MeLa language estimates the autonomy at 6 years, with an average processor utilization rate of 3 %, and 600 kB of data transmitted by satellite each month.

First trials at sea in 2024 !  
Add your own app n°5 !



## Toward a global network

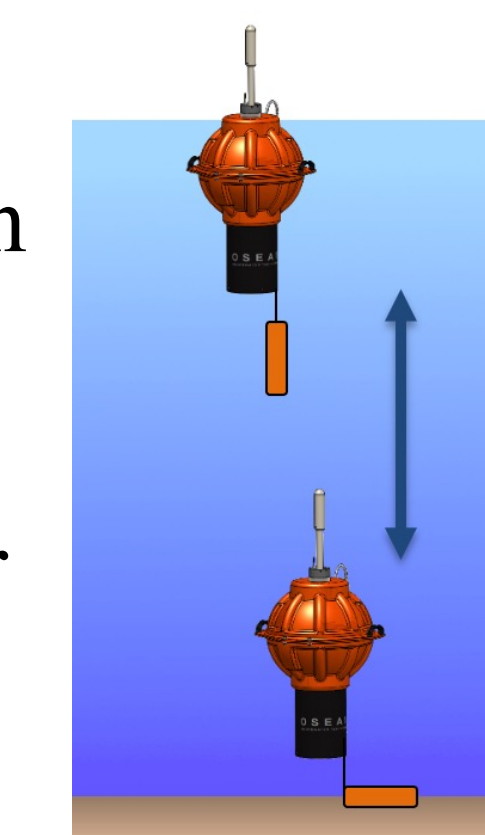
Records of seismic waves traveling through the earth's mantle are used to compute the earth tomographic image. More than 50 floats have been deployed by the Earthscope-Oceans organization since 2016 [5].



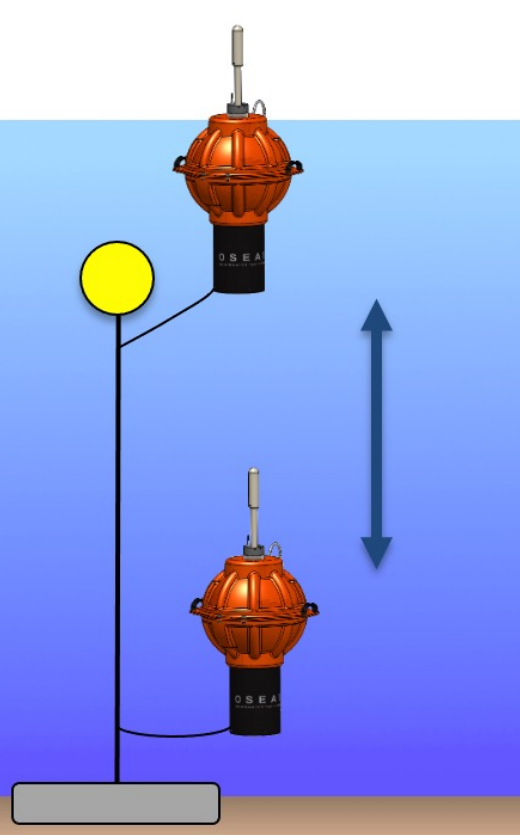
Maps of the last known position of Earthscope-Oceans floats

## Lander and moored versions

The float can be configured to settle down to the ocean floor with a small anchor, preventing drifting on the ocean floor. This operating mode has been thought for local seismic crisis monitoring.



The float can be fixed on a subsurface mooring to avoid any drift. This is useful for coastal operation, but deployment requires more resources.



### Contacts:

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**References:**  
[1] Hello Y, Nolet G (2020) Floating Seismographs (MERMAIDS). Encyclopedia of Solid Earth Geophysics. Springer.  
[2] Bonnioux S, Cazau D, Mosser S, Blay-Fornarino M, Hello Y, Nolet G (2020). MeLa: A Programming Language for a New Multidisciplinary Oceanographic Float. *Sensors*.  
[3] Sukhovich A, Irissou J-O, Simons F J, Ogé A, Hello Y, Deschamps A, Nolet G (2011). Automatic discrimination of underwater acoustic signals generated by teleseismic P-waves: A probabilistic approach. *Geophysical Research Letters*.  
[4] Reinicke I (2023) An acoustic detection and classification algorithm for rainfall measured on the oceans by autonomous underwater floats. University of Duisburg-Essen master thesis  
[5] EarthScope-Oceans website: <http://earthscopeoceans.org>