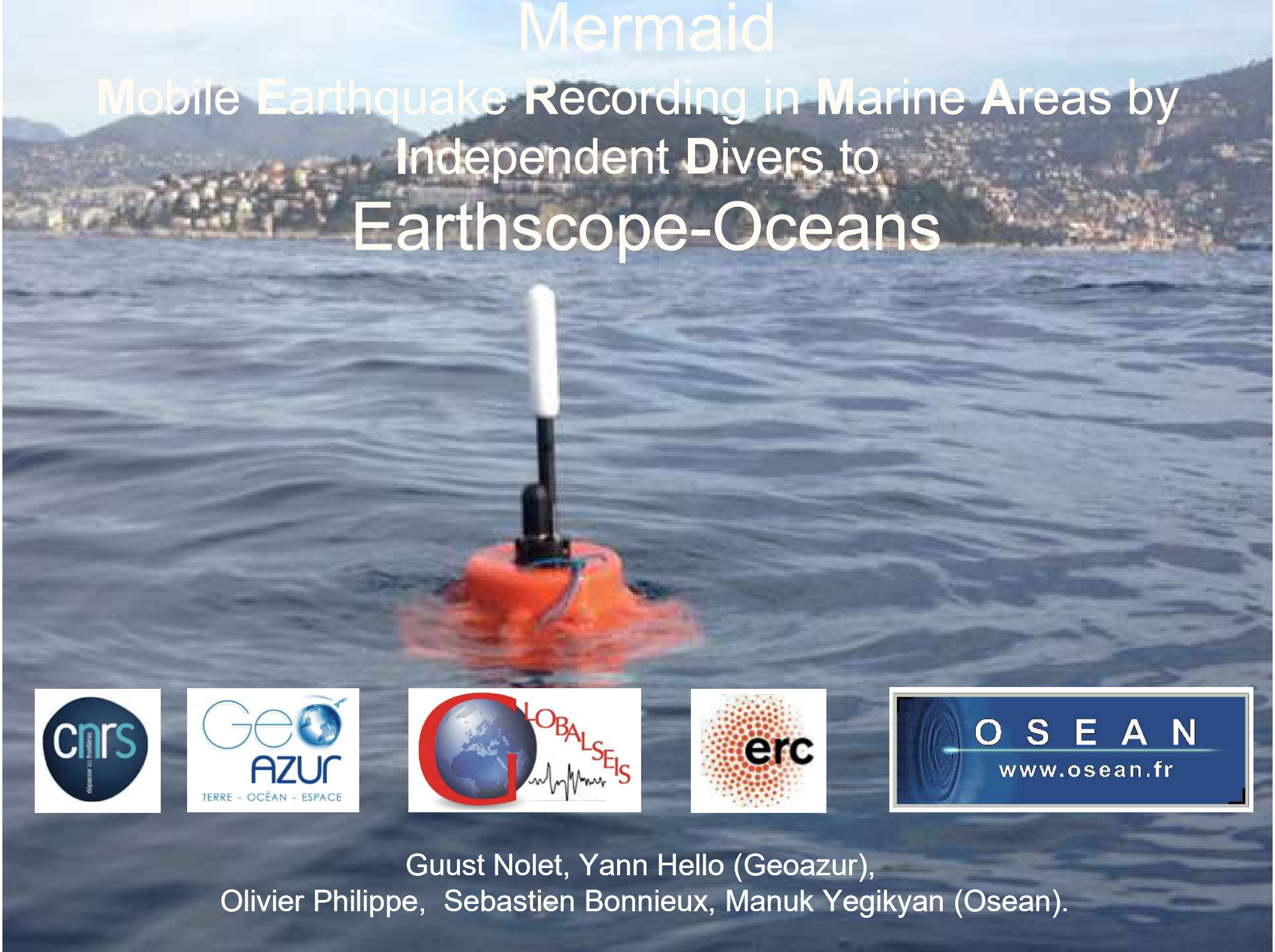
Mermaid

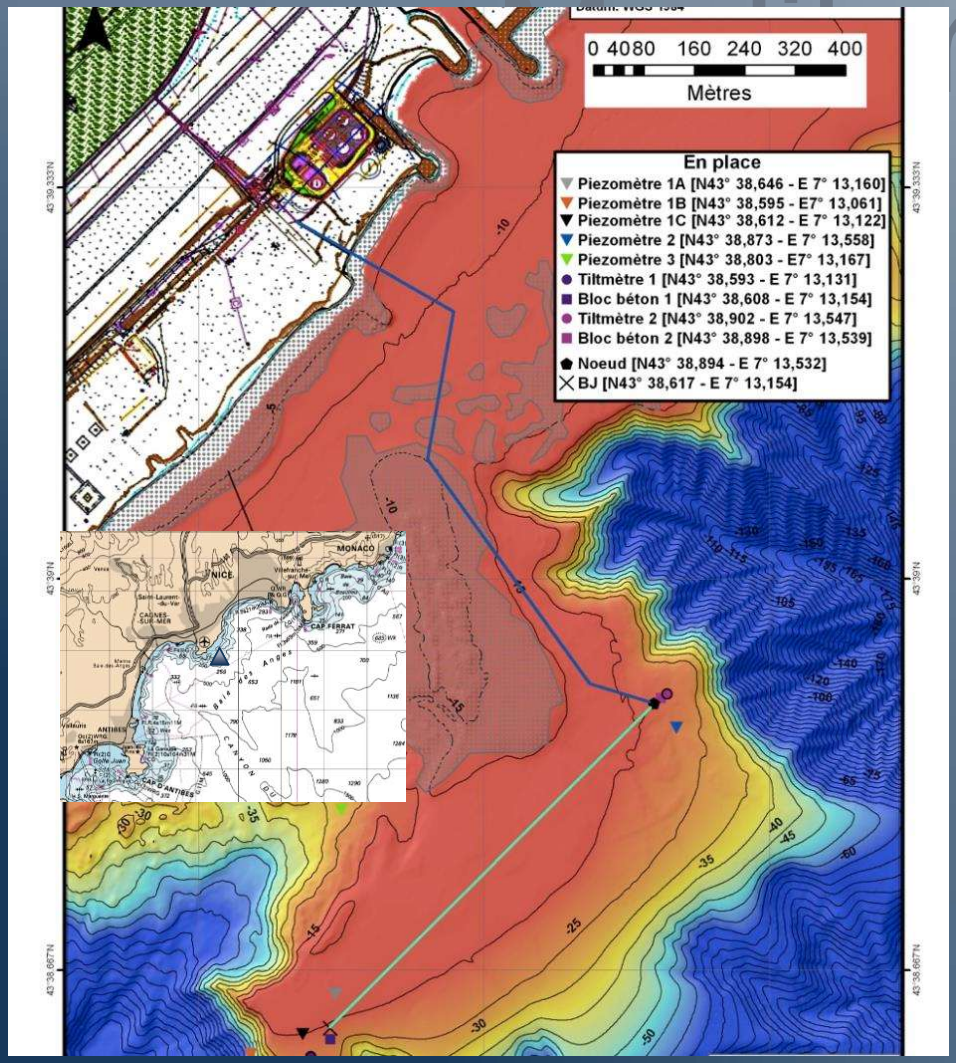
Mobile **E**arthquake **R**ecording in **M**arine **A**reas by **I**ndependent **D**ivers to Earthscope-Oceans

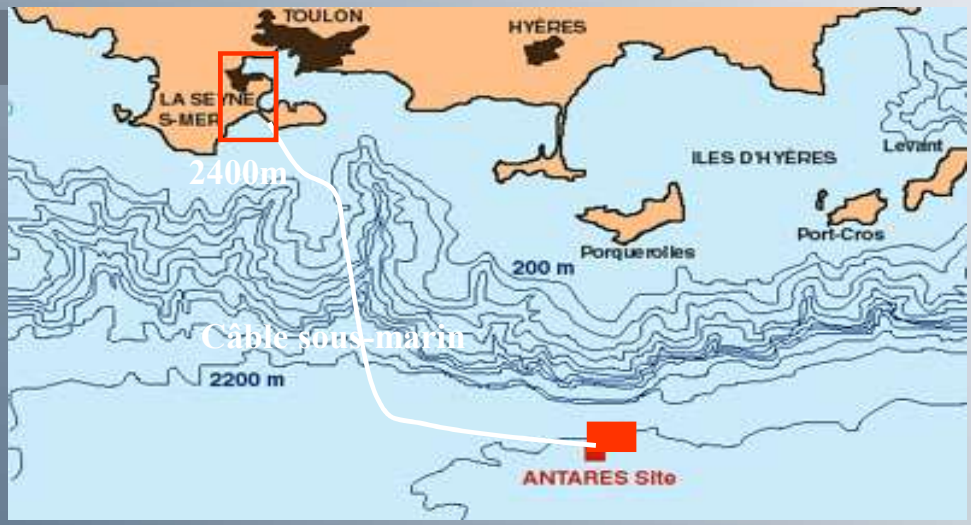


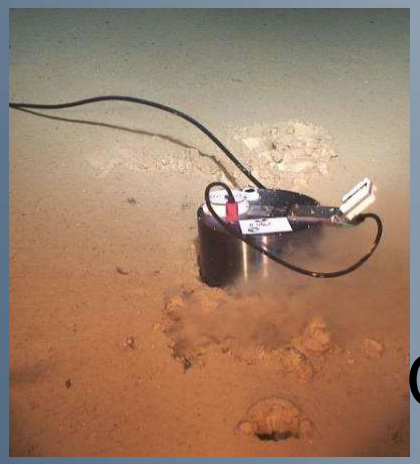
Guust Nolet, Yann Hello (Geoazur),
Olivier Philippe, Sebastien Bonnieux, Manuk Yegikyan (Osean).

Real time cabled OBS are part of larger Observatories (Donet/Neptune), installed on limited sites – Installation is heavy and expensive.

Real Time two Broadband Cabled seimometer in





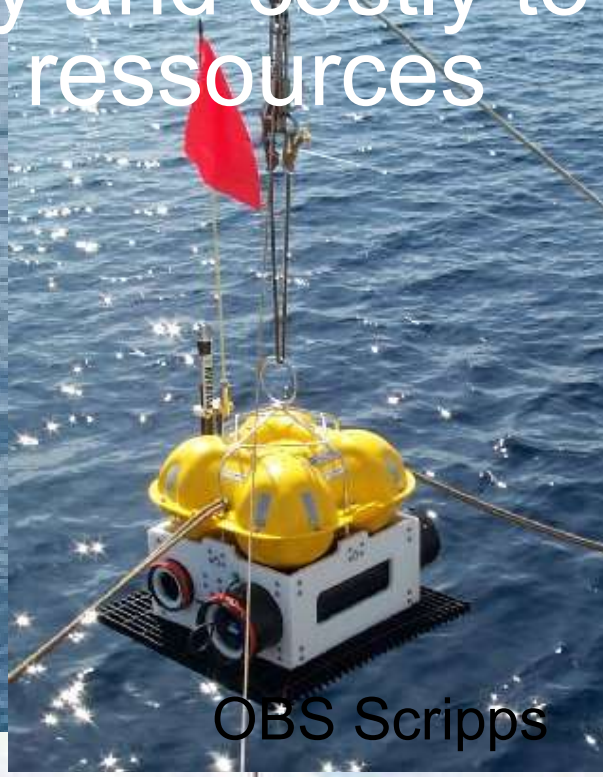


CMG3T/5T Guralp Broad Band

OBS – Short Term Network, few months to a year or two with no control of data quality and costly to operate in shiptime and human's ressources

Hippocampe-Geoazur

MicrOBS Ifremer



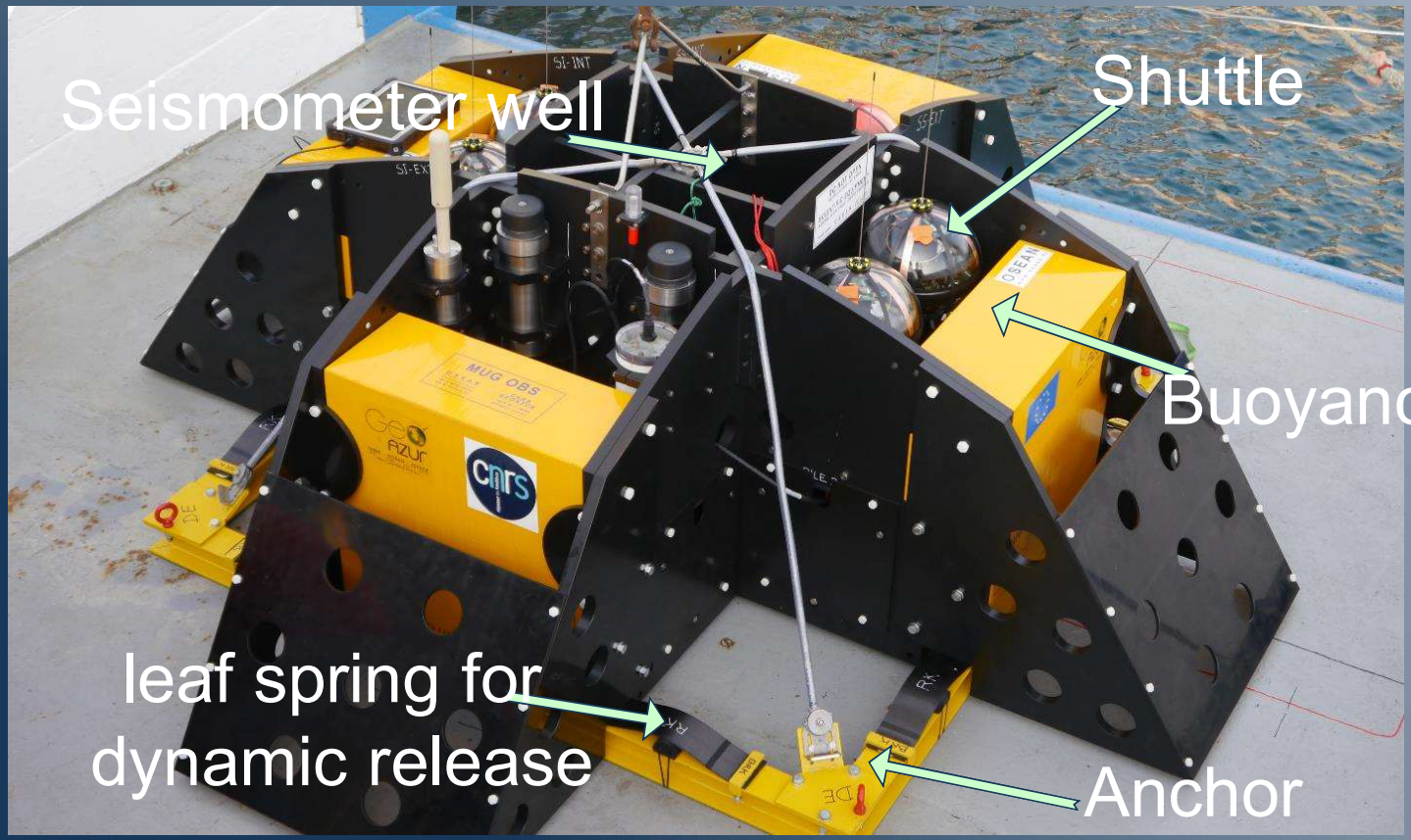
OBS Scripps

OBS GEOMAR

Several attempts to isolate the Broadband sensor from the chassis for a better coupling and response

MUG is an alternative to real time observatory and short time OBS Network.

Once installed we control the main parameters and data quality and later using a small vessel of opportunities recover data within autonomous shuttles released by acoustic,



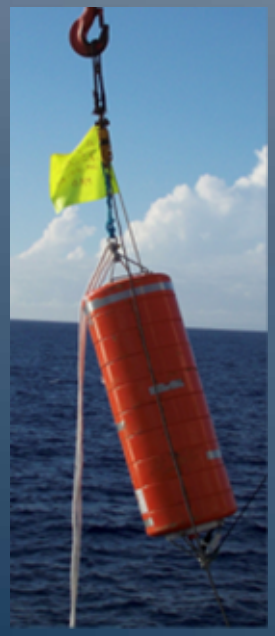
DIMENSIONS
2.9m x 2.9m x 1m.
Shaped to resist a trawling

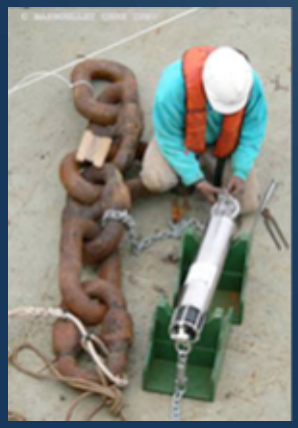
MATERIAL
Non conductive material (Syntactic foam, Polyethylene, glass and Titanium)

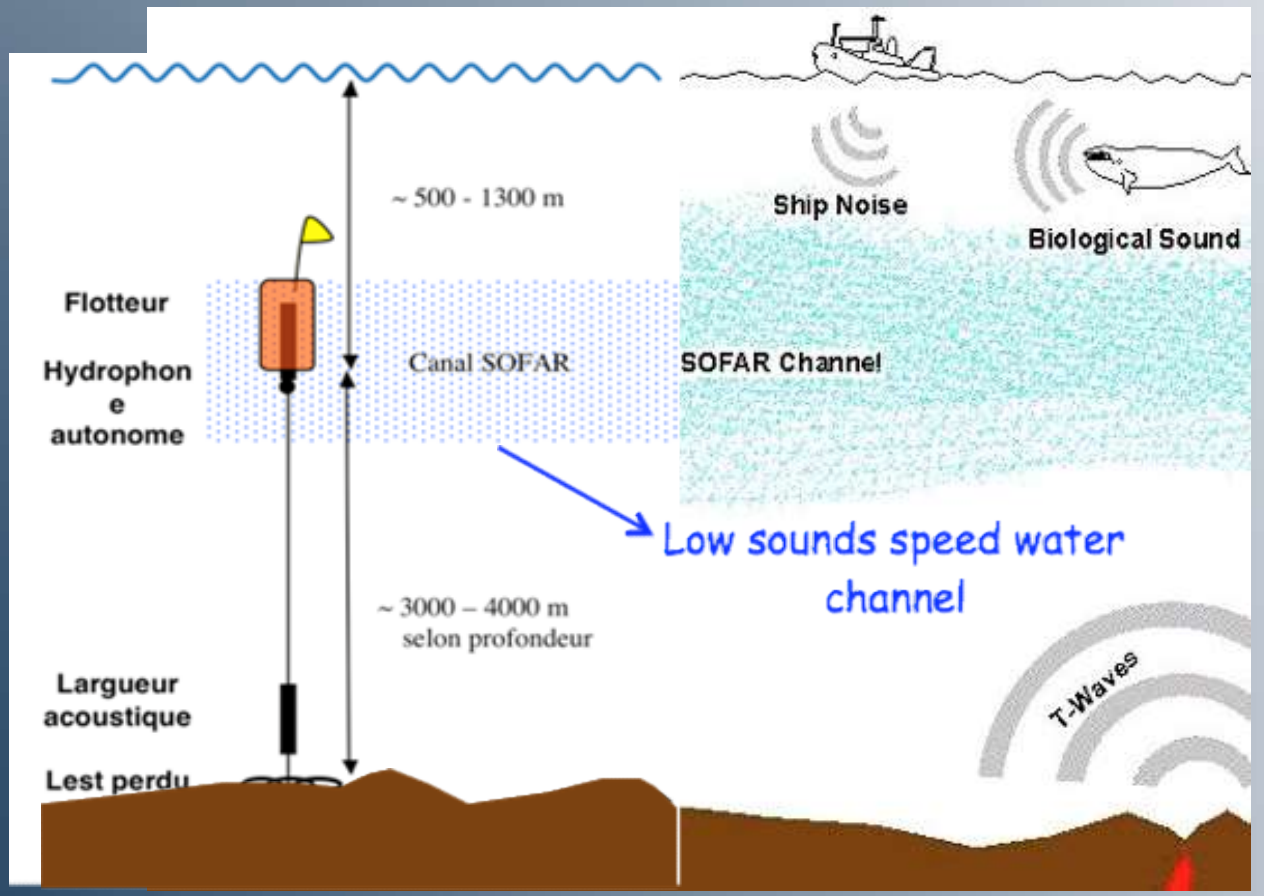
Dead Weight Anchor
Steel with anodes

Weight in Air
1.5t (3307Lb)

recording earthquake at sea using a Hydrophone?



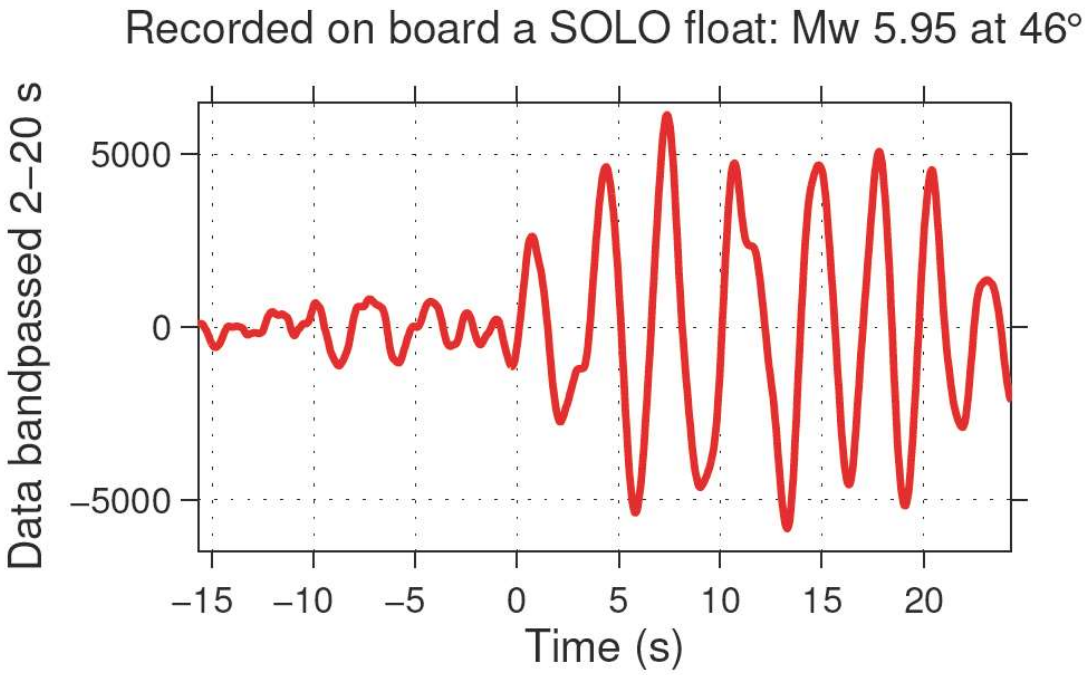




Mermaid - A bit of history

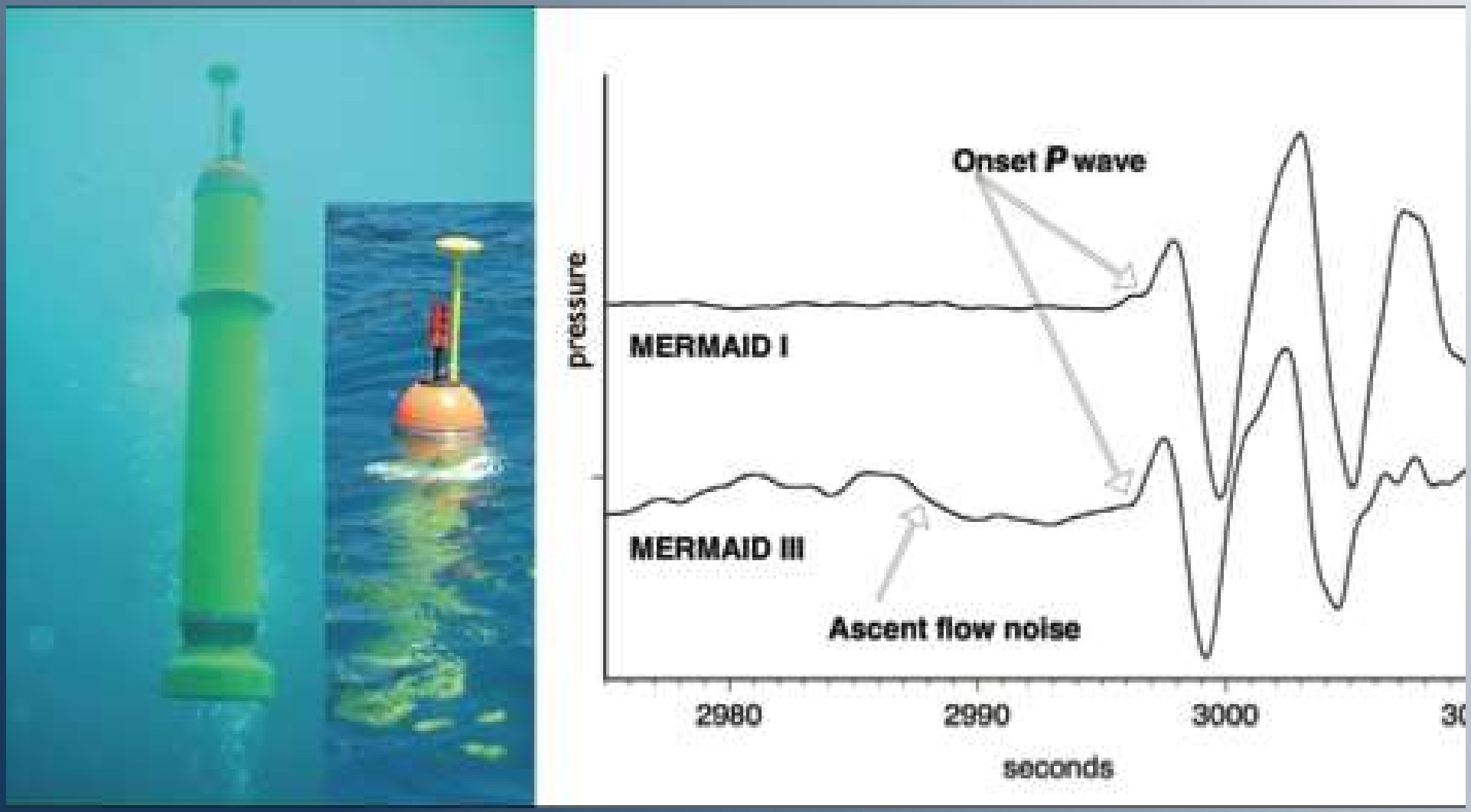
Mobile **E**arthquake **R**ecording in **M**arine **A**reas by **I**ndependent **D**ivers

Nov 5, 2003: Frederik Simons' prototype Mermaid records Mw=5.9 quake at 46º



Simons et al., JGR **114**, B05307, 2009

Geoazur
First recording of a telesismic event June 24, 2011(MW 7.4)



Fox Islands, distance 85°

From an article published in ELSEVIER September 1st 2006 – Frederik J.Simons & al.

Automatic detection and rapid determination of earthquake magnitude by wavelet multiscale analysis of the primary arrival F.

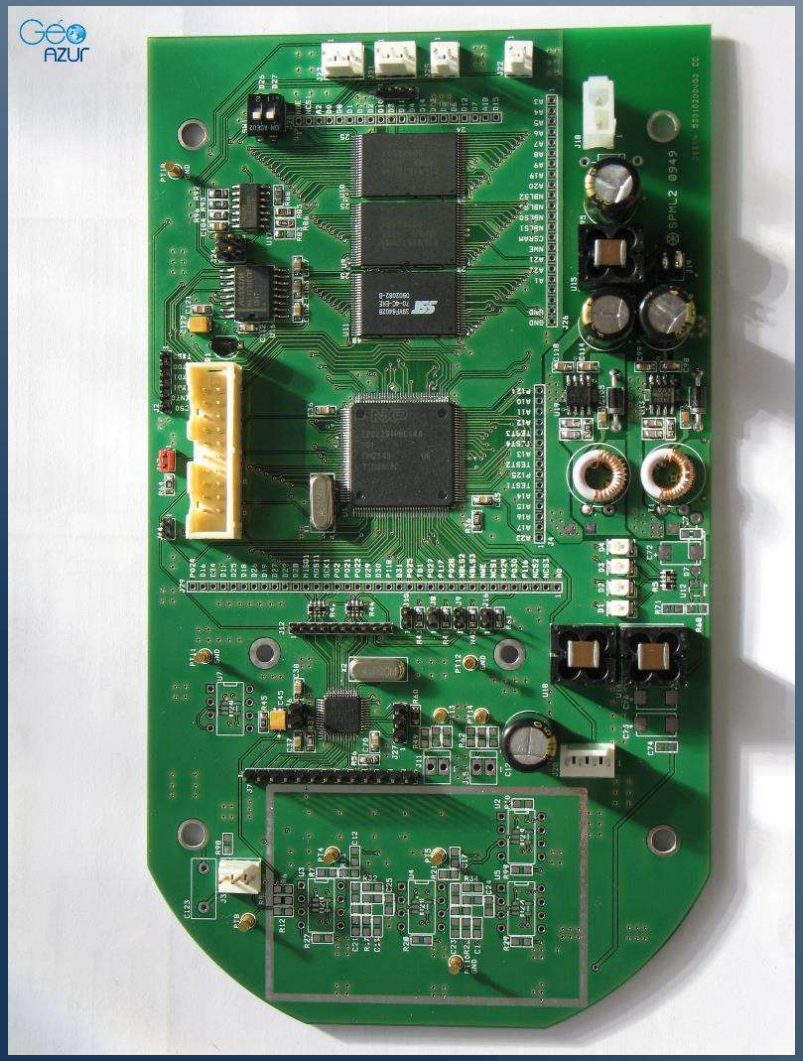
And from a Matlab wavelet transform algorithm :

```
lx = length(x);for j=1:5;for n=2:2:lx−2 x(n)=x(n)−[x(n−1)+x(n+1)]/2; end
for n=5:2:lx−3 x(n) = x(n)−3*[x(n−3)+x(n+3)]/64 +19*[x(n−1)
+x(n+1)]/64; end x = [x(1:2:lx) *
sqrt(2); x(2:2:lx)/sqrt(2); x(lx+1:end)];lx=length(x)/2^j; end
```

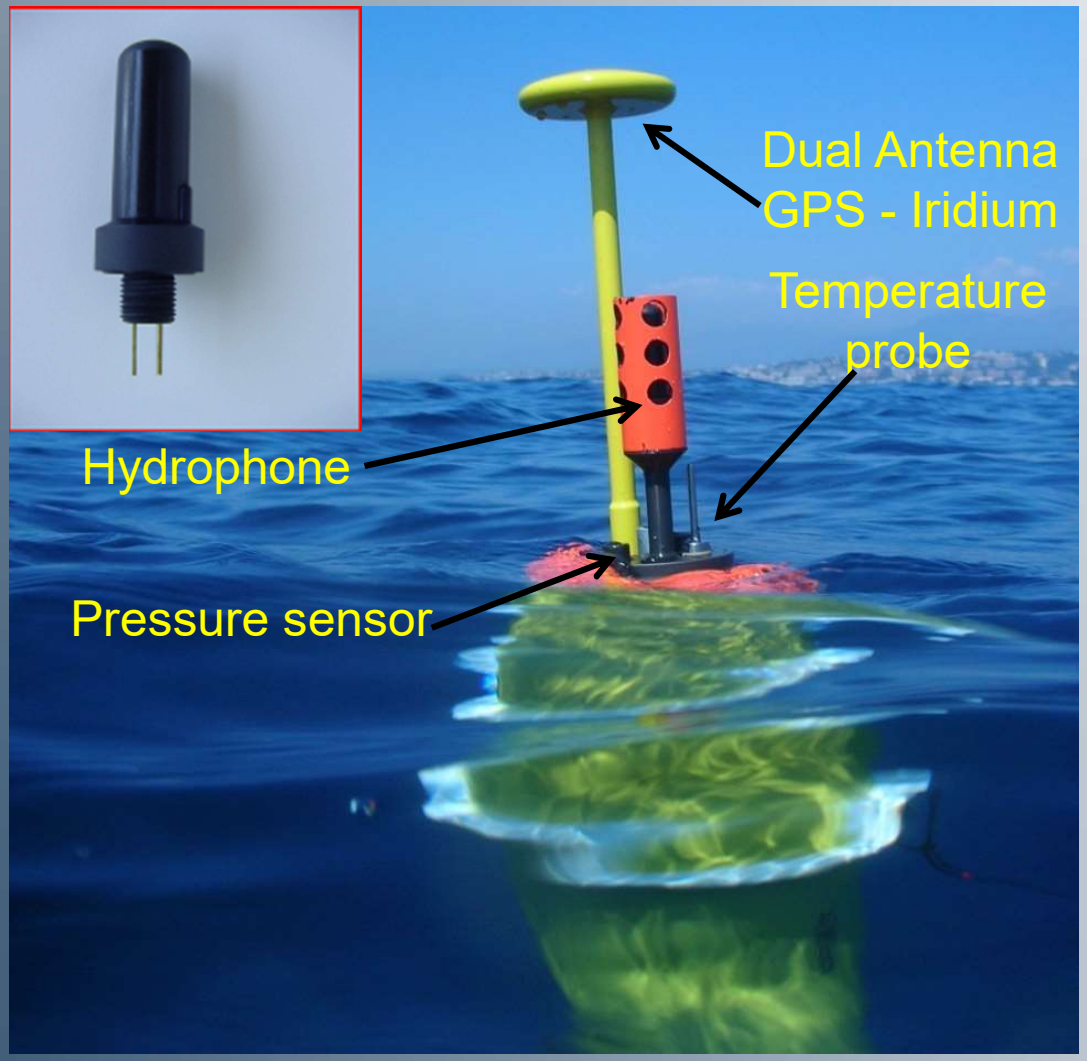
Automatic discrimination of underwater acoustic signals generated by teleseismic P-waves: A probabilistic approach

GRL 2011 – Alexey Sukhovich & al

Sukhovich's algorithm integrated in Mermaid

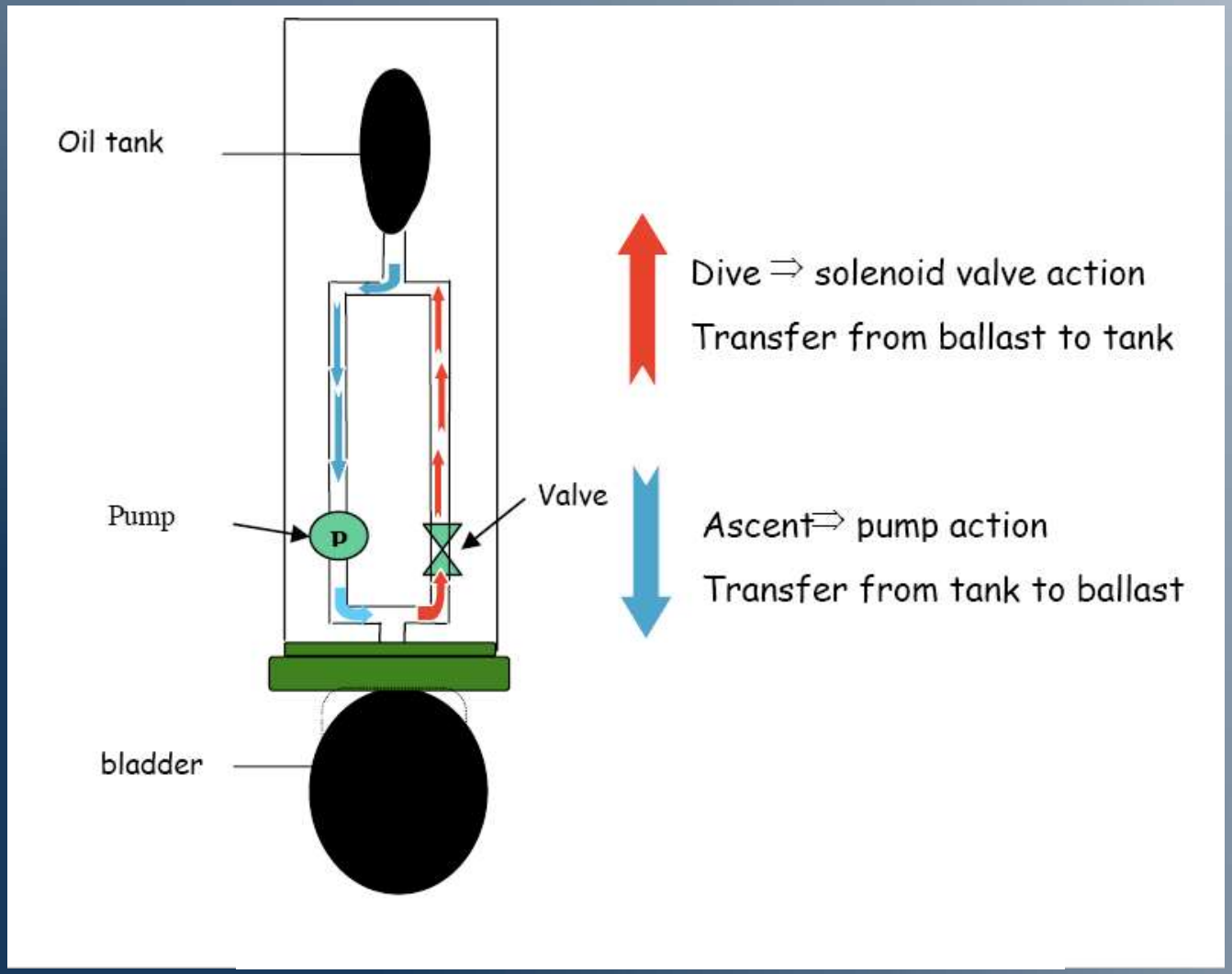


Mermaid board developed by Osean

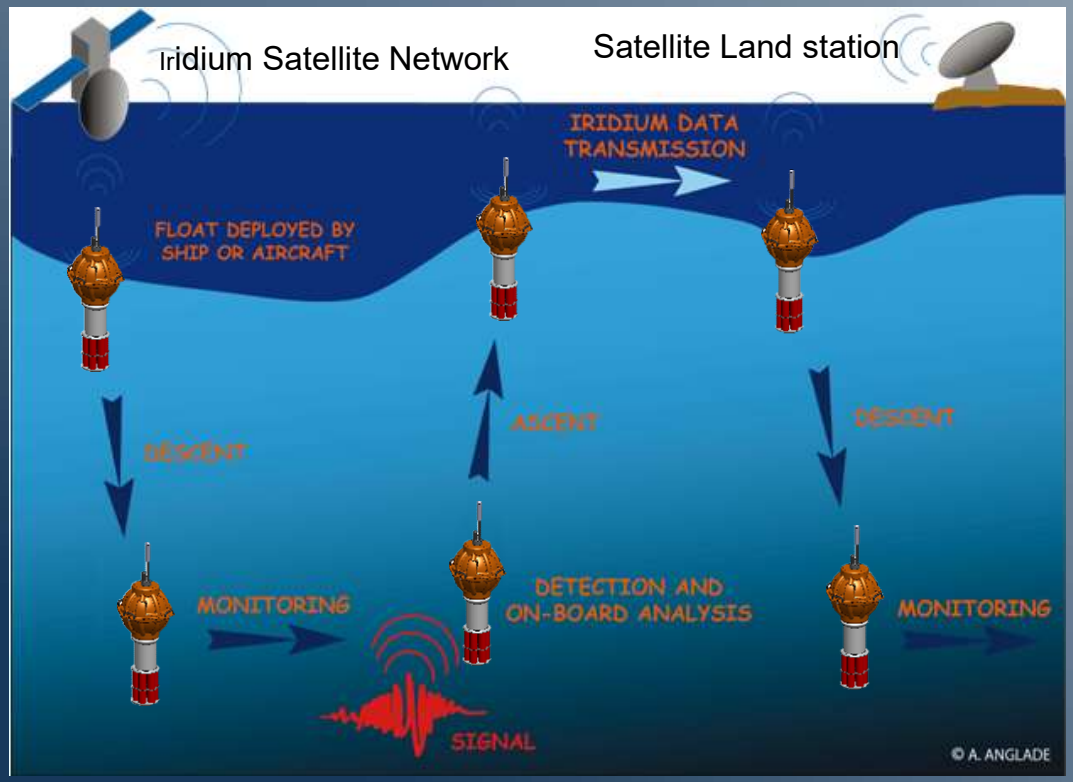


Mermaid in Apex from TWR.

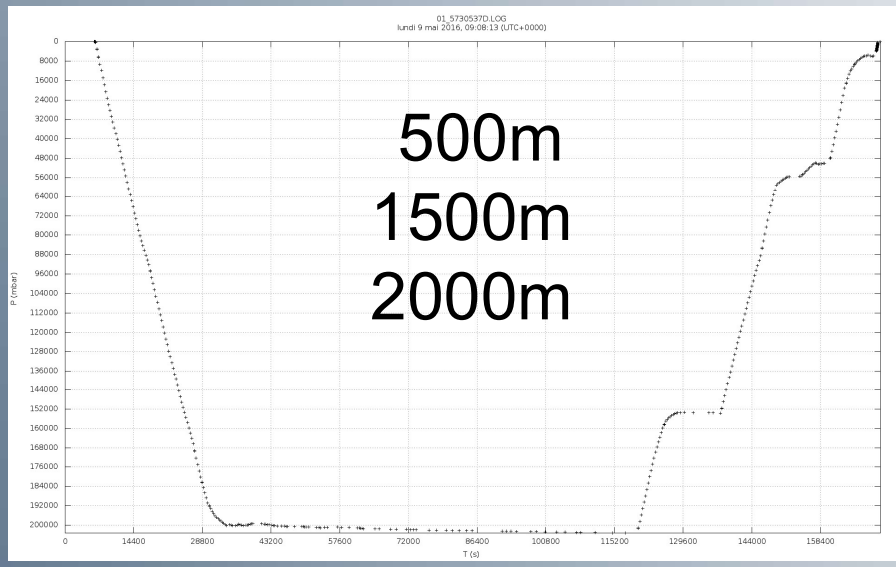
How does works an OSEAN MERMAID Lagrangien float?



MERMAID: detection of long distance seismic event



Diving control accuracy



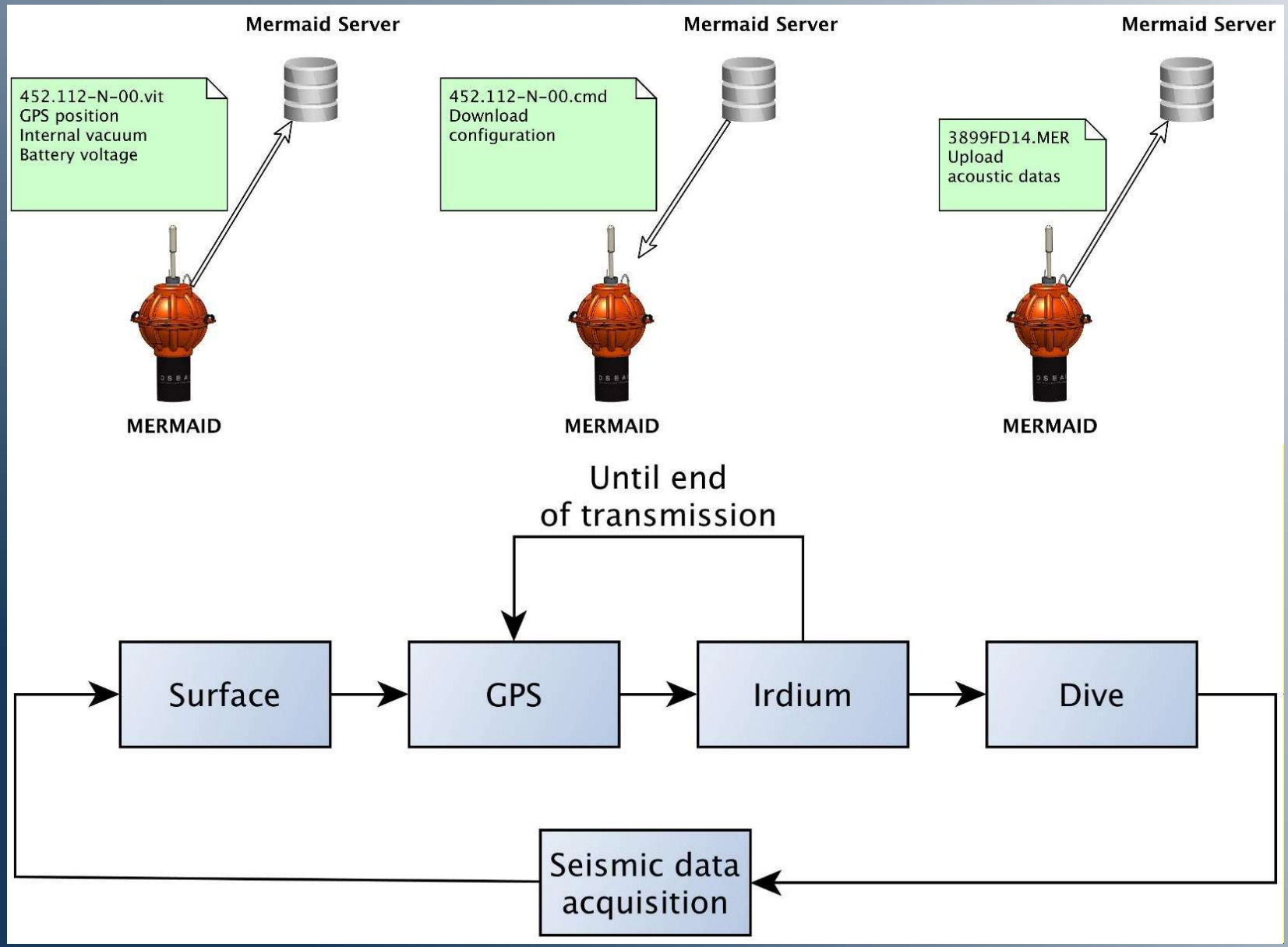
Acoustic wave

3000-10000 km

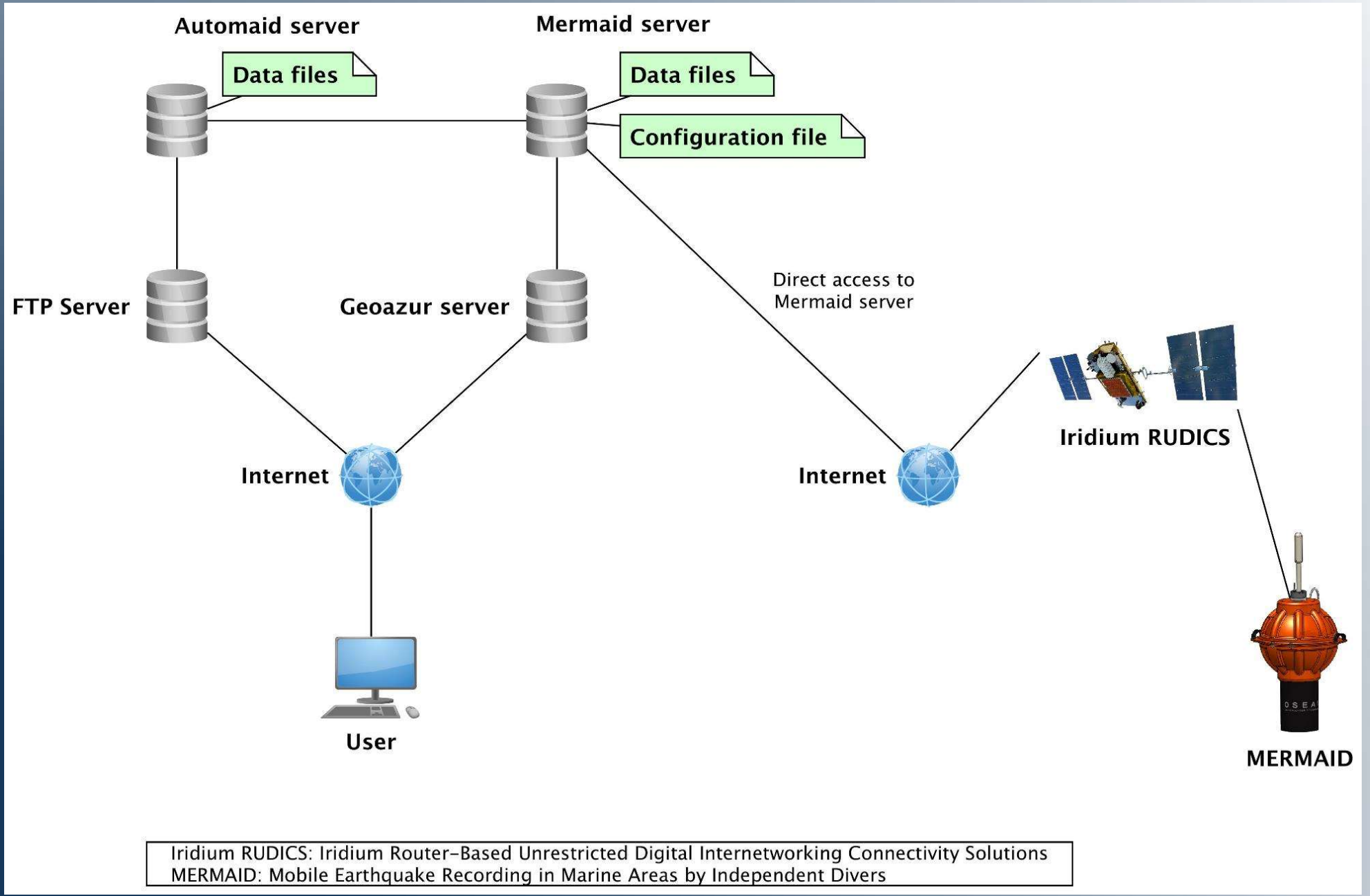
Strong seismic event

seismic wave

Mermaid Cycle

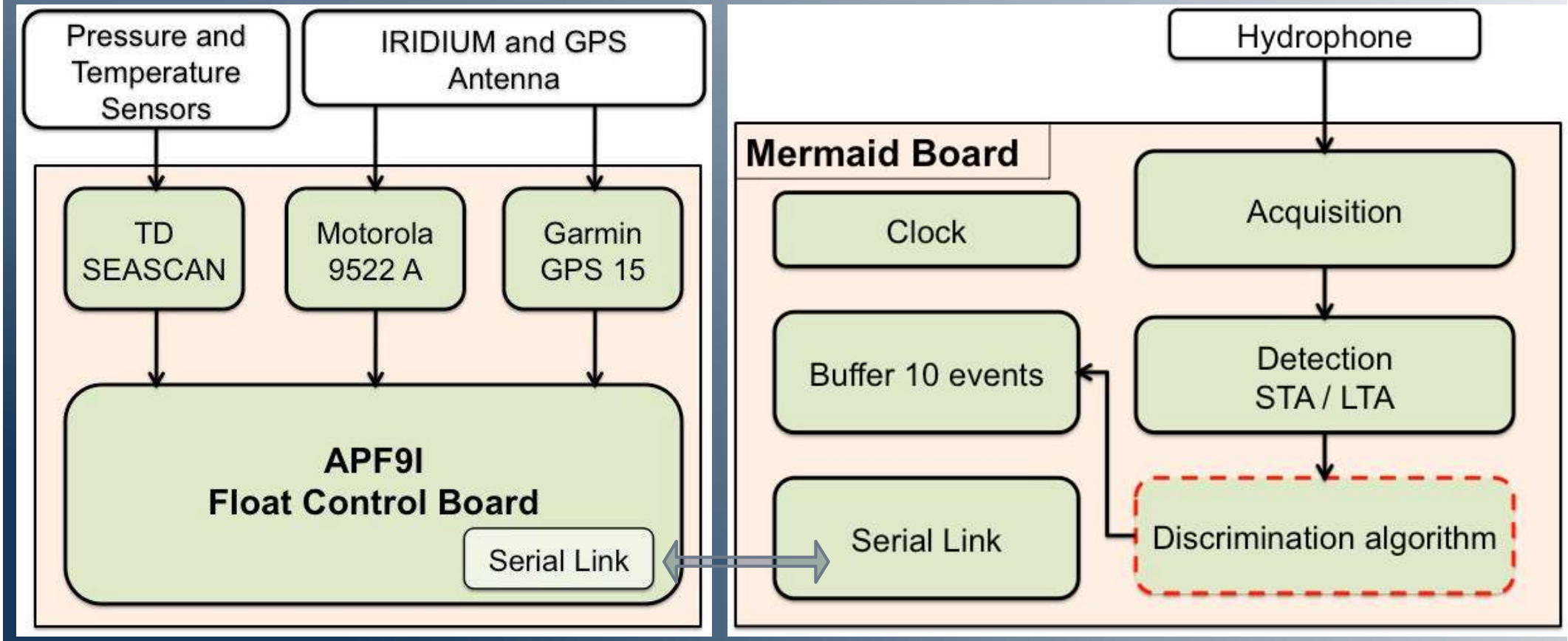


System communication and server access



Iridium RUDICS: Iridium Router-Based Unrestricted Digital Internetworking Connectivity Solutions
MERMAID: Mobile Earthquake Recording in Marine Areas by Independent Divers

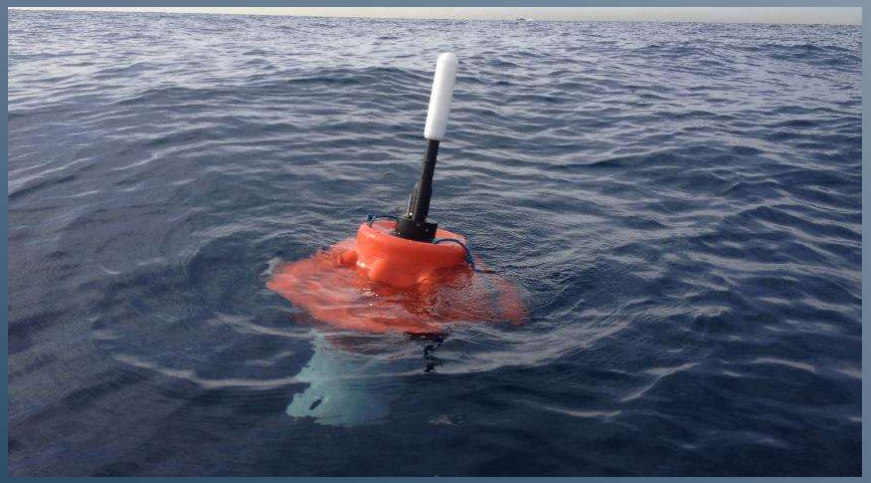
Electronic Synoptics for Mermaid.



Trial & Test

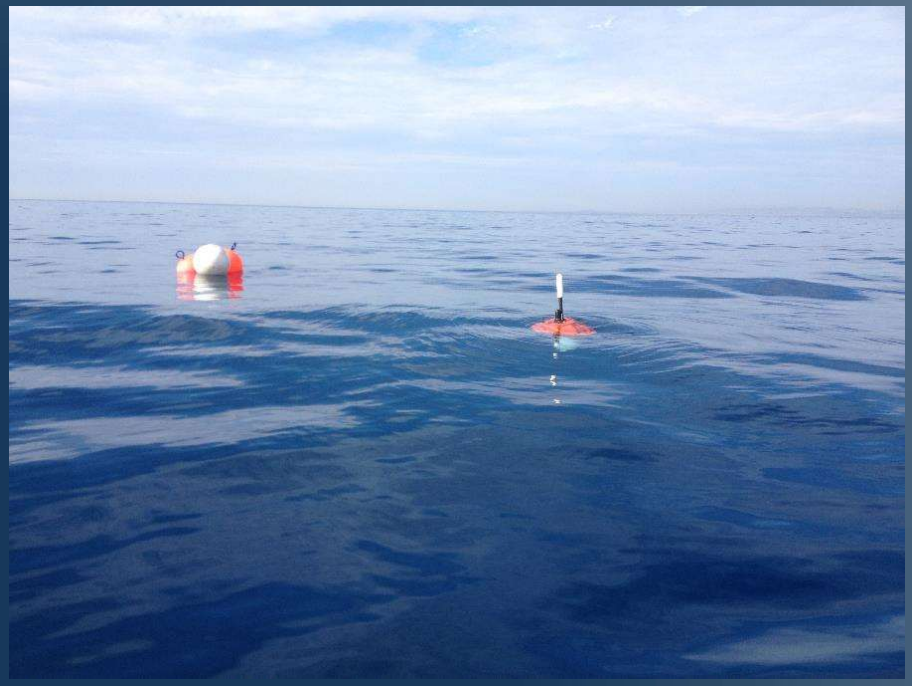
at Villefranche sur mer

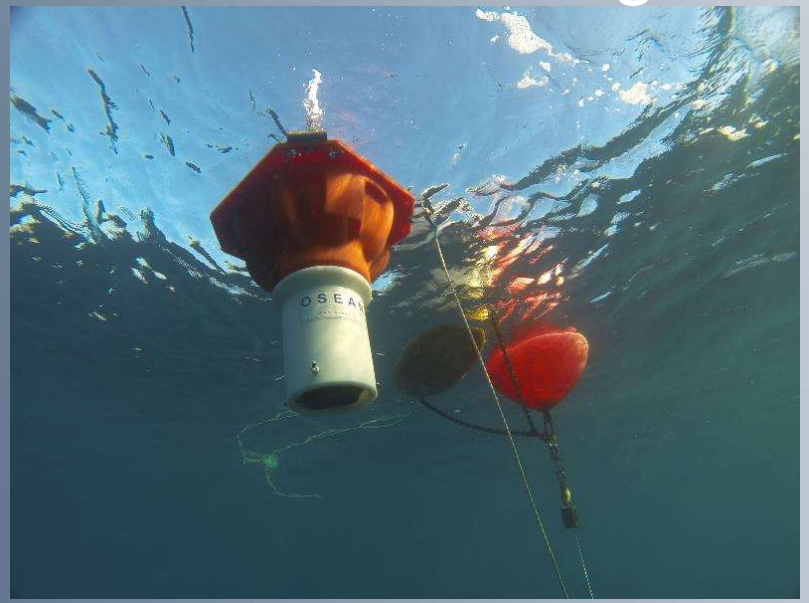
2014 - 2016



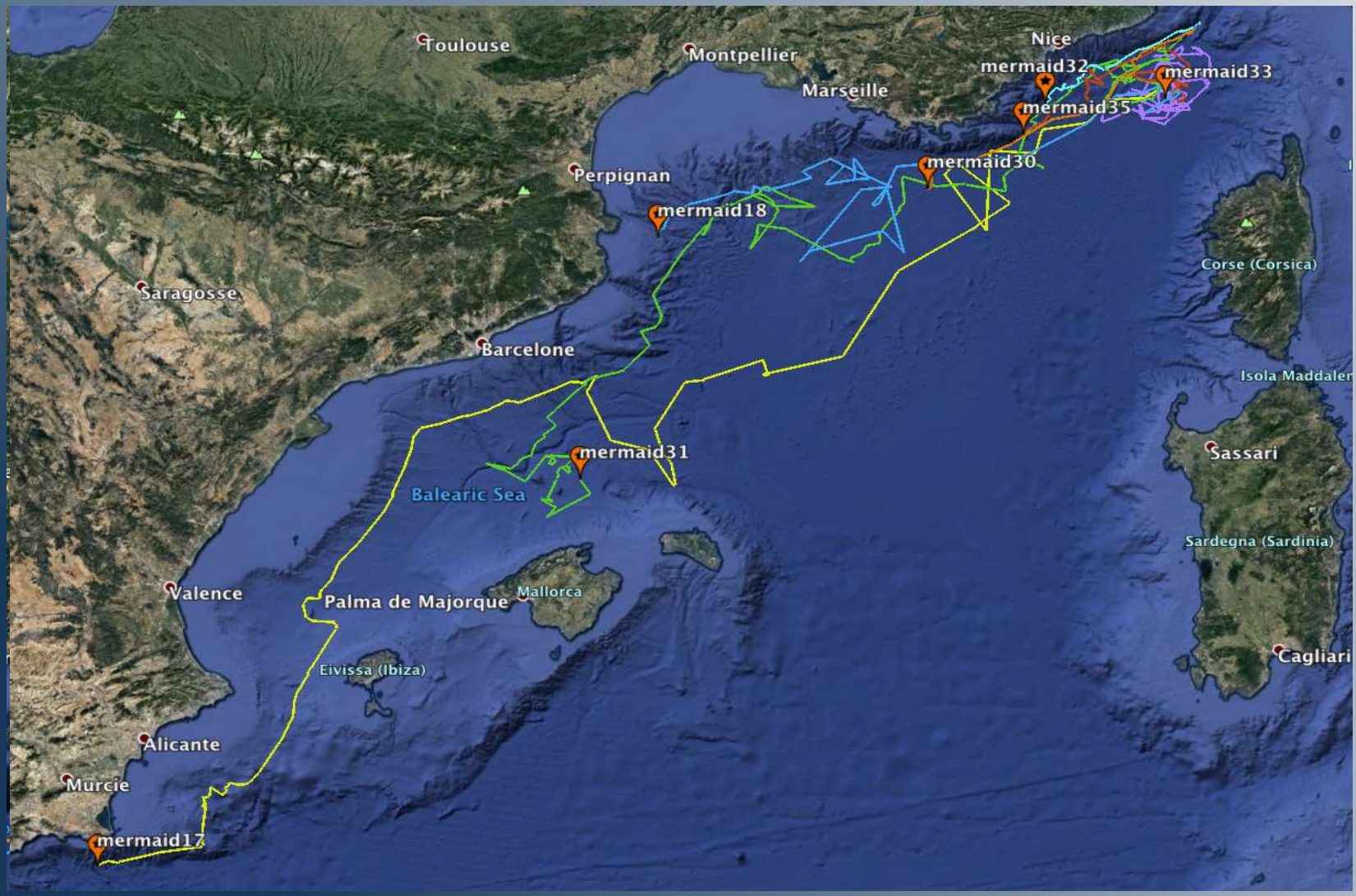
At sea from 60 to 1000m

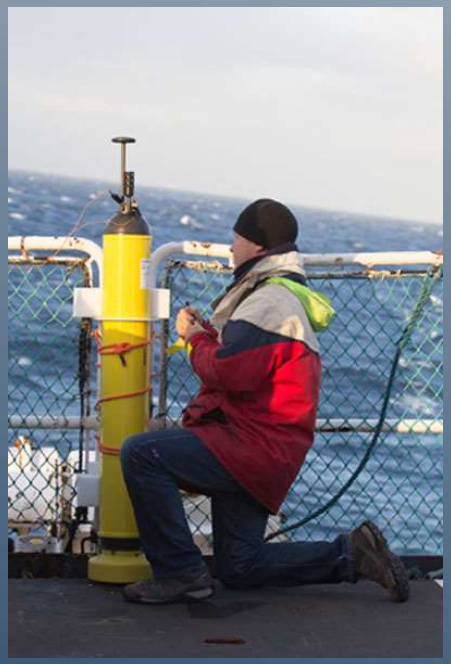
On a 250m mooring line





Tests and development in the Mediterranean

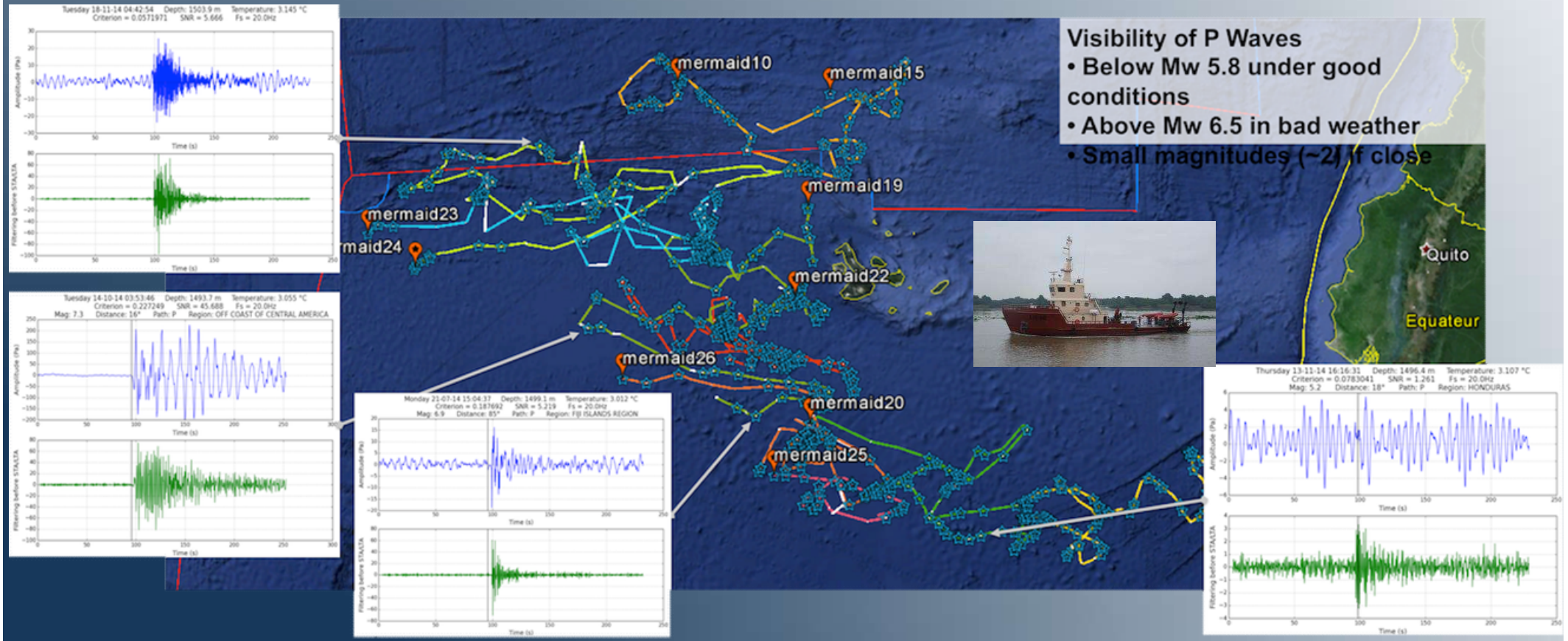




Mermaid Deployments

2012 - Mediterranean – (3 +2) Floats 2013 -
Indian Ocean – (3 +2) Floats
2014 - Galapagos – 10 Floats

Mermaid Network coverage in the Galapagos after 18 months.



Visibility of P Waves

- Below Mw 5.8 under good conditions
- Above Mw 6.5 in bad weather
- Small magnitudes (~2) if close

Mermaid, a multidisciplinary float resulting from a fruitful collaboration between an experienced company in Marine development “Osean” and “Geoazur” a scientific laboratory specialized in Marine Geophysics

OSEAN
www.osean.fr

GeoAzur
TERRE - OCÉAN - ESPACE

Mermaid, a multidisciplinary float resulting from an ERC Proof-of-concept and collaboration with local industry Osean

Large Autonomy

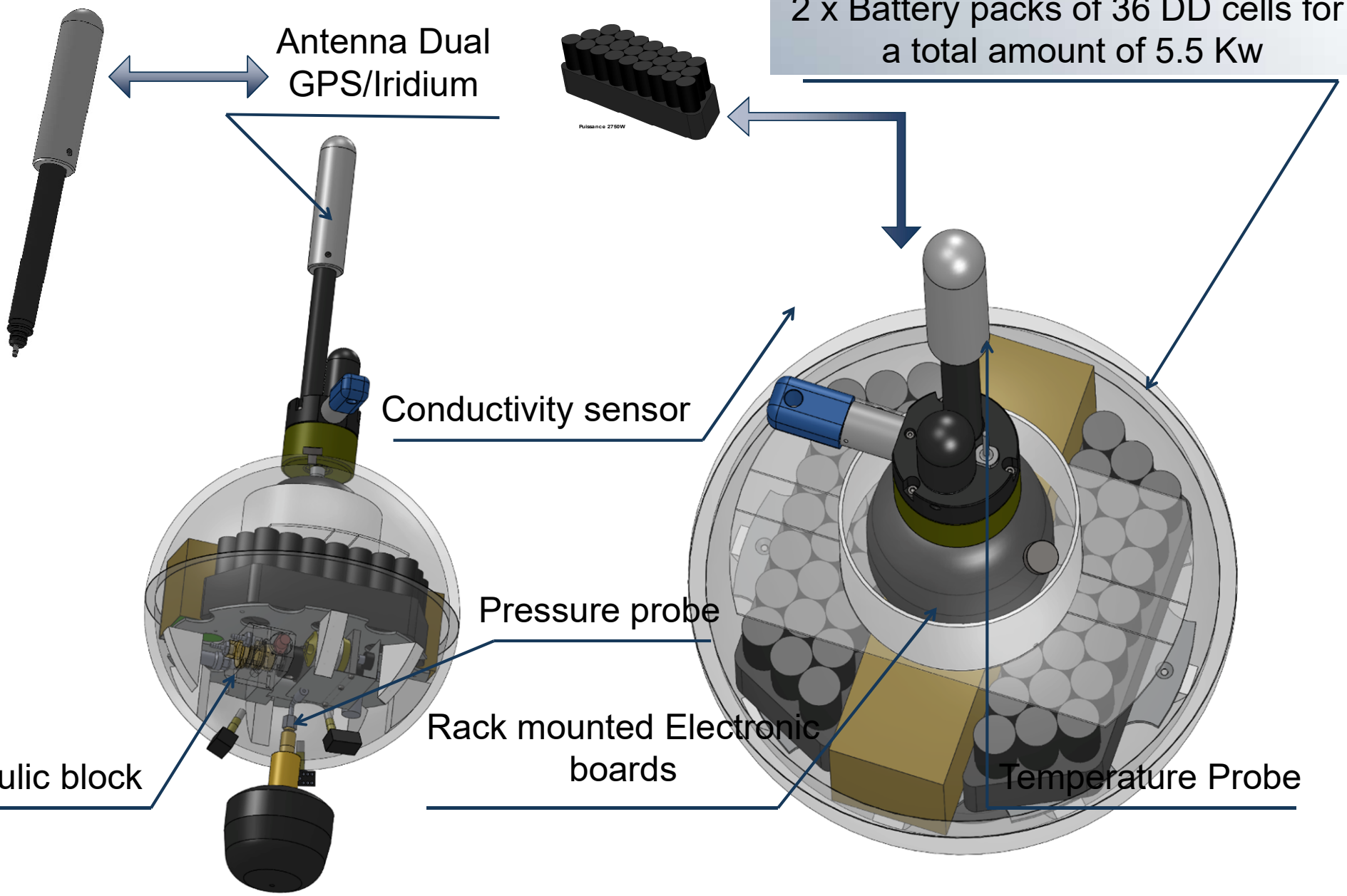
- Based on OBS sphere (17”)
- More batteries (5.5 KW

3 times more than current floats)

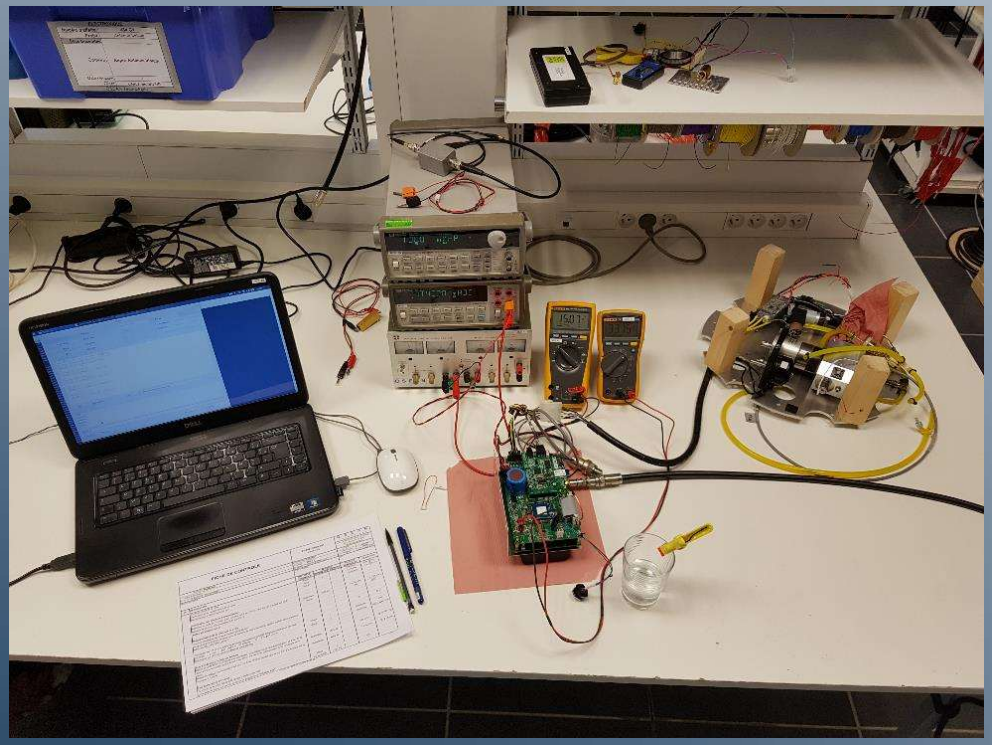
- Larger life time (5-6 yr)
- Remotely programmable
- *Multidisciplinary*:

- Temperature,
- Conductivity,
- High frequency acoustics
- Low frequency acoustics
- Green Energy

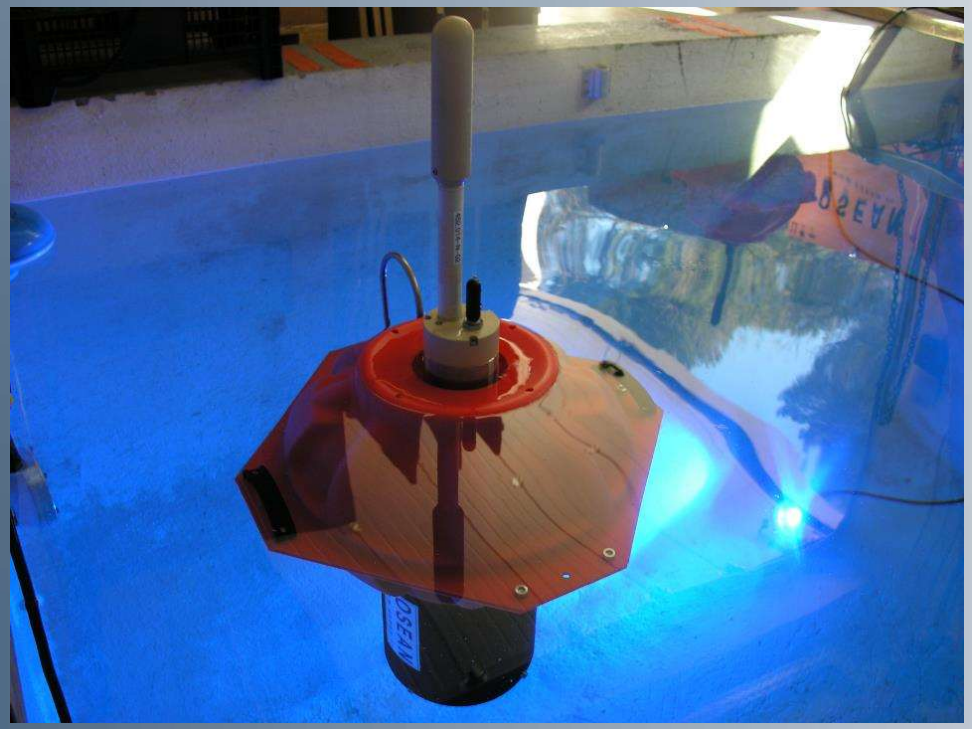
Thermal Recharging Battery



Details of the constituent components of Mermaid

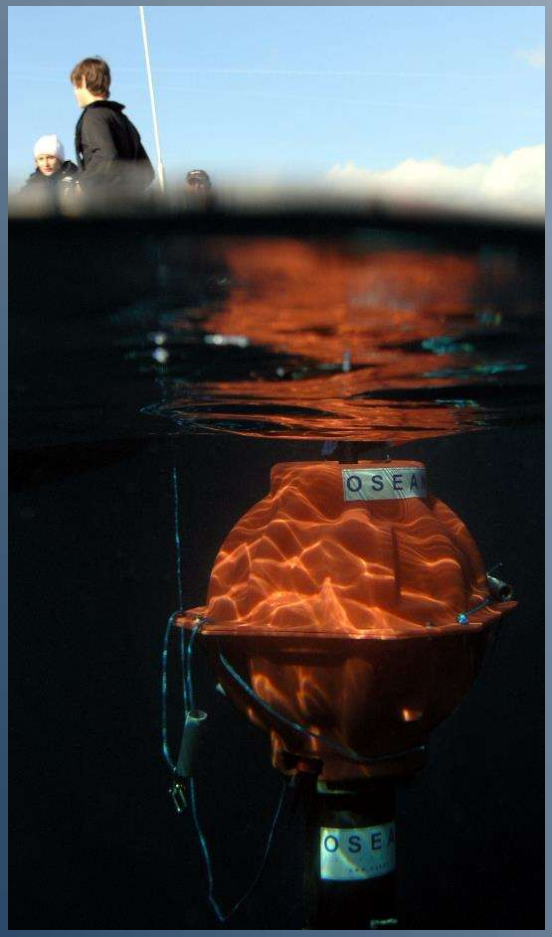


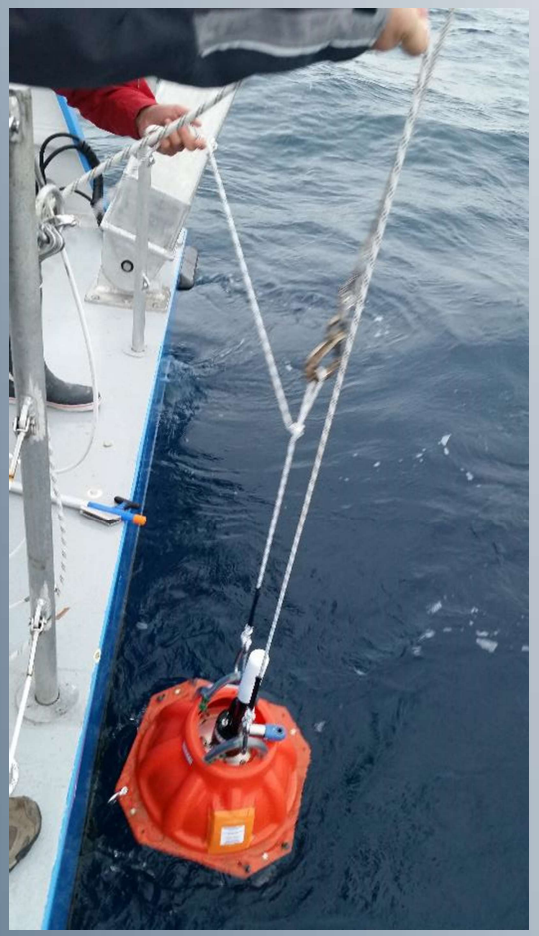
Tests in lab, in pool and at sea



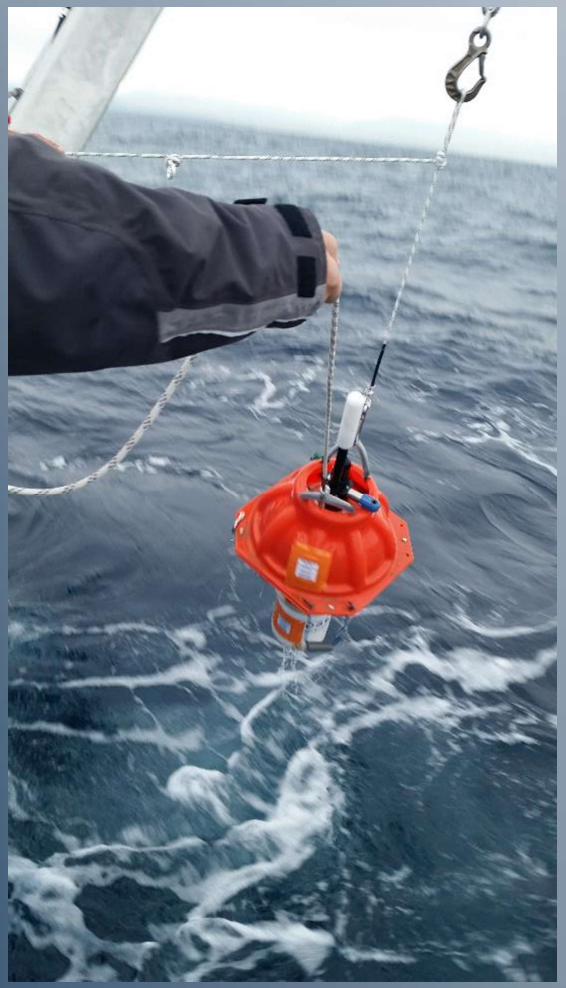
Mermaid easy launching

RV Sagitta III – 12m





Mermaid easy recovering



Mermaid equipped with a CTD will give a great value to ARGO

OEM - SeaBird
SBE-41
for 2000m
CTD Profile
mounted on
the
Mermaid Frame.

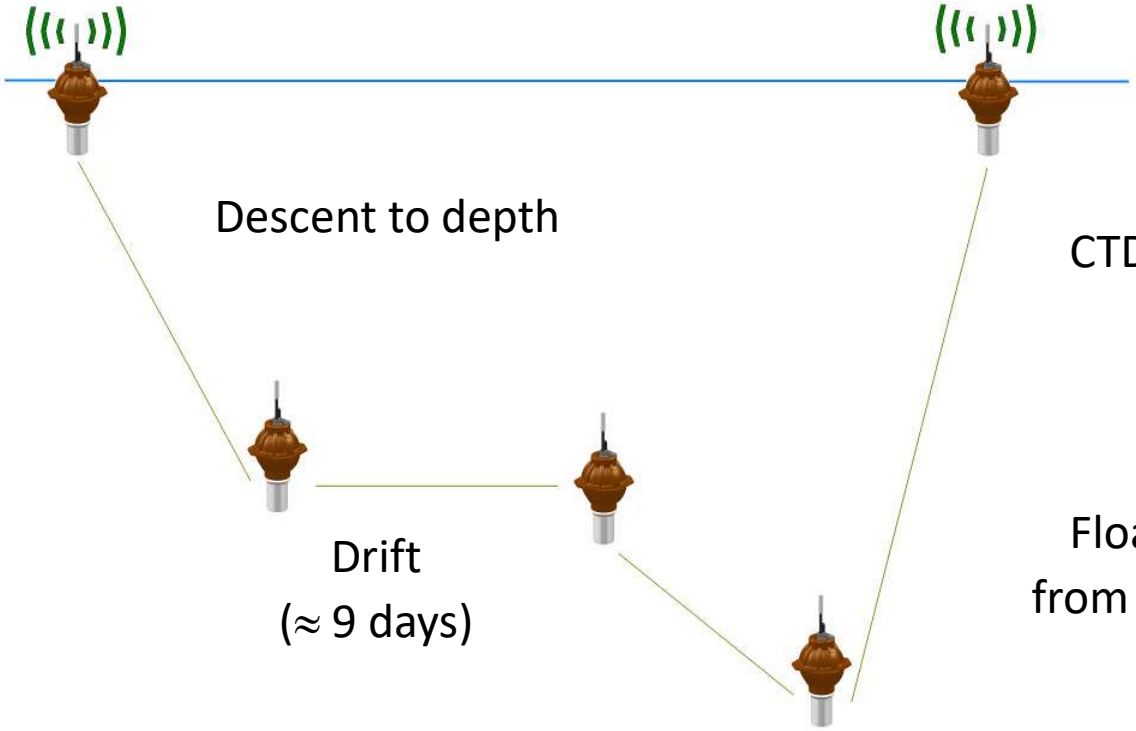
We are collaborating with
SEABIRD
to integrate a CTD
On Mermaid

MERMAID: Deep CTD profile

IRIDIUM Satellite

At surface to transmit data to satellites

IRIDIUM Satellite Land Station



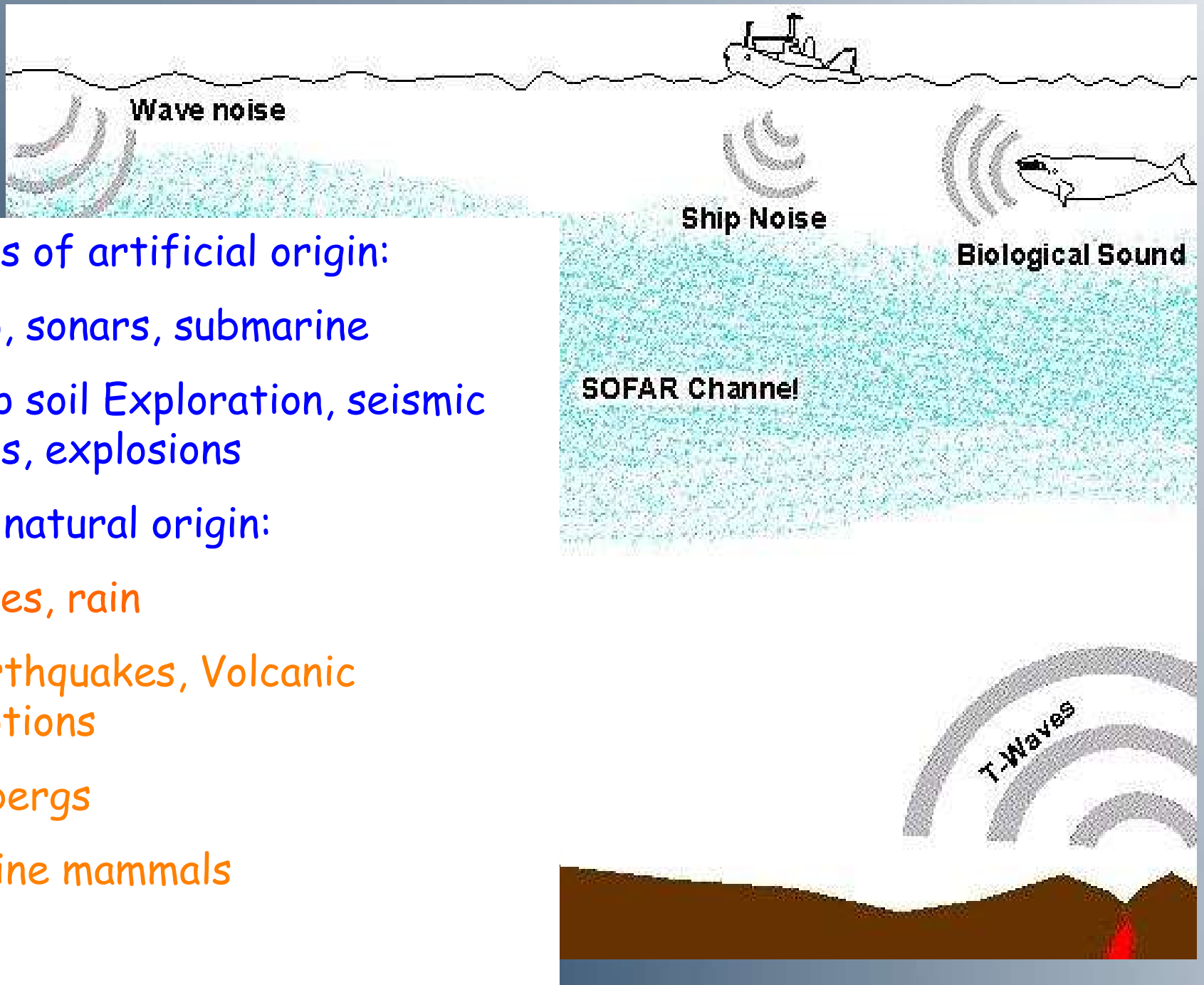
Descent to depth

CTD measures during ascent
(up to 12 hours)

Drift
(≈ 9 days)

Float descends to begin profile
from greater depth (up to 3000 m)

Ocean: a "silent world" but also noisy !



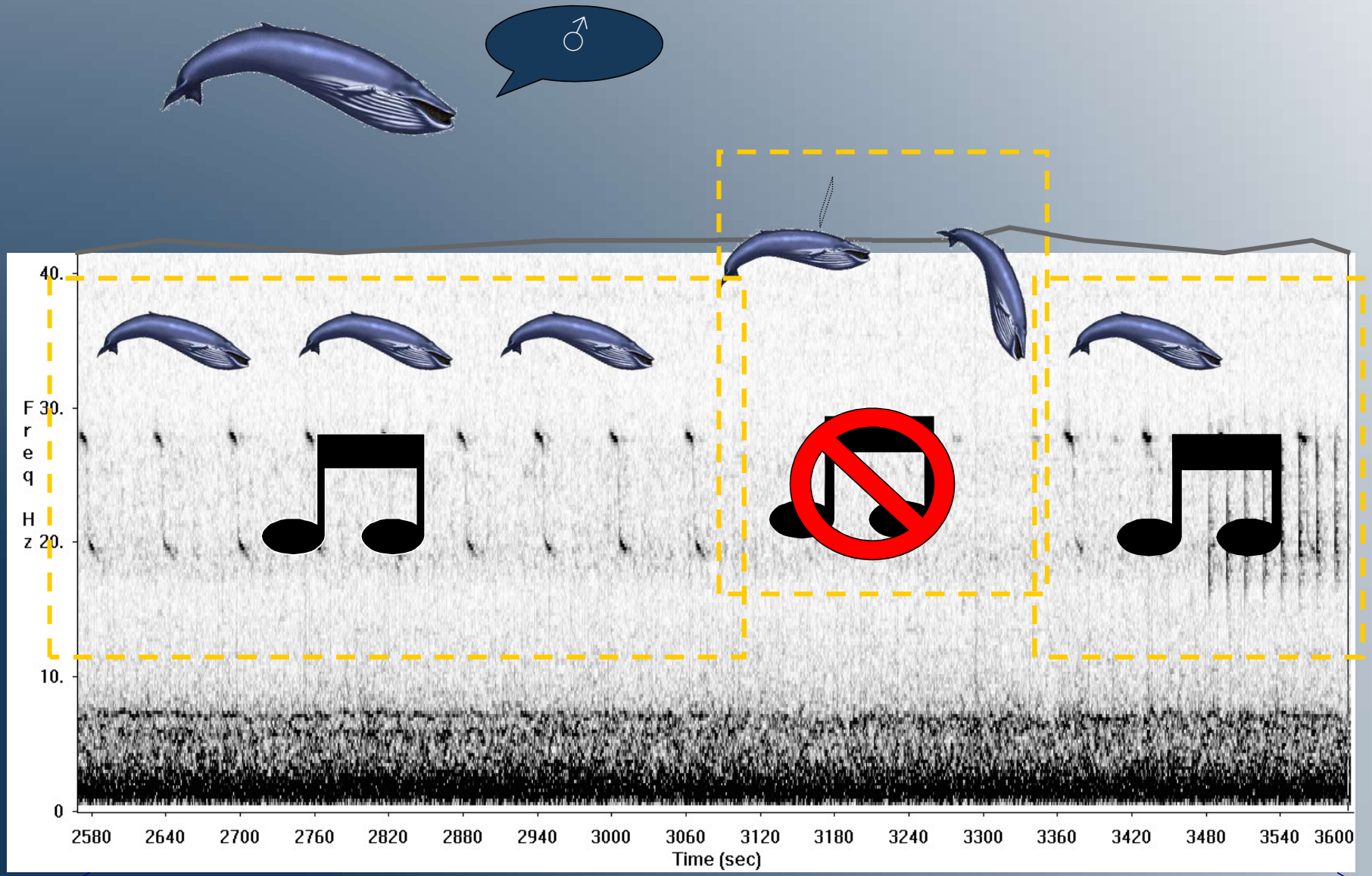
Sounds of artificial origin:

- Ship, sonars, submarine
- Deep soil Exploration, seismic shots, explosions

Or of natural origin:

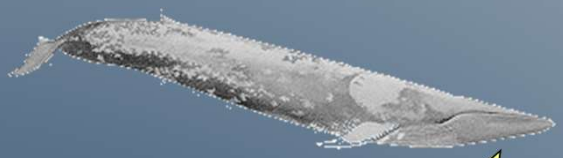
- Waves, rain
- hearthquakes, Volcanic eruptions
- Icebergs
- Marine mammals

Sounds for blue whales

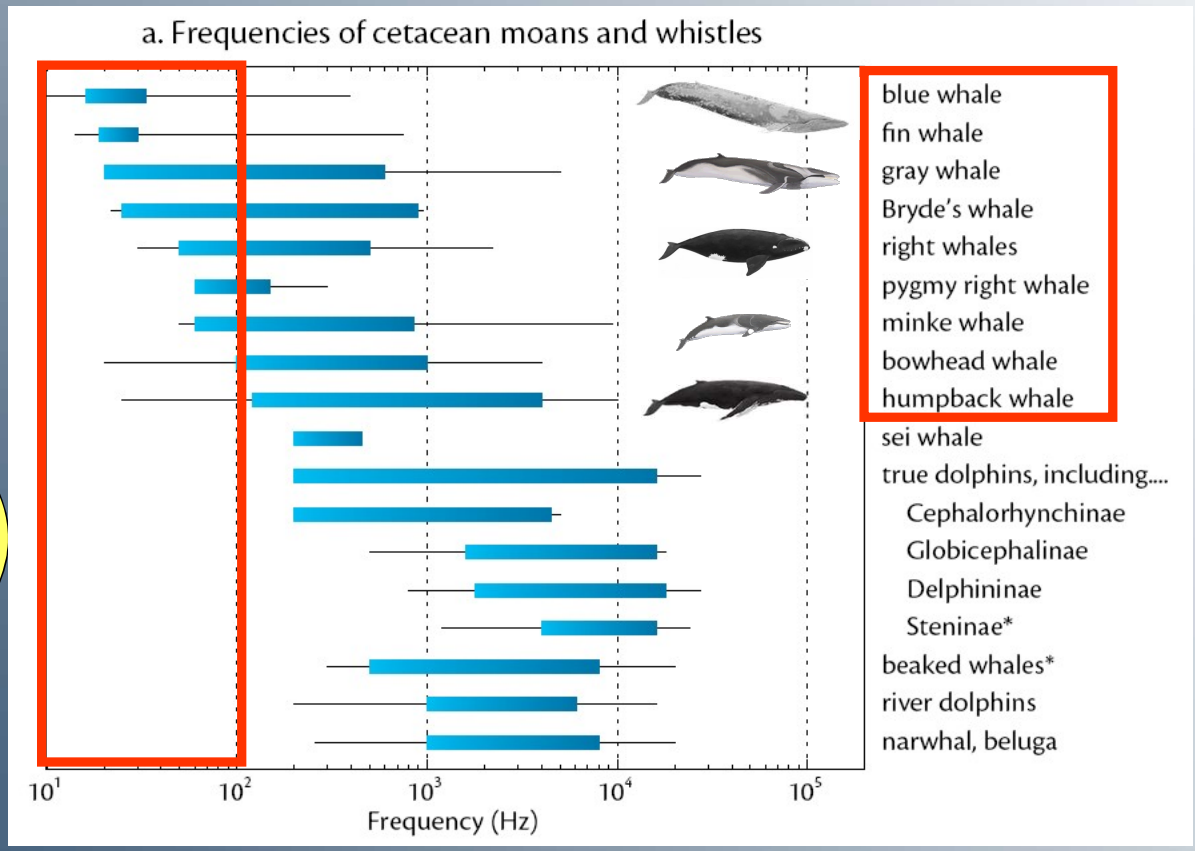


Samaran, 2010

Identifying Mamals



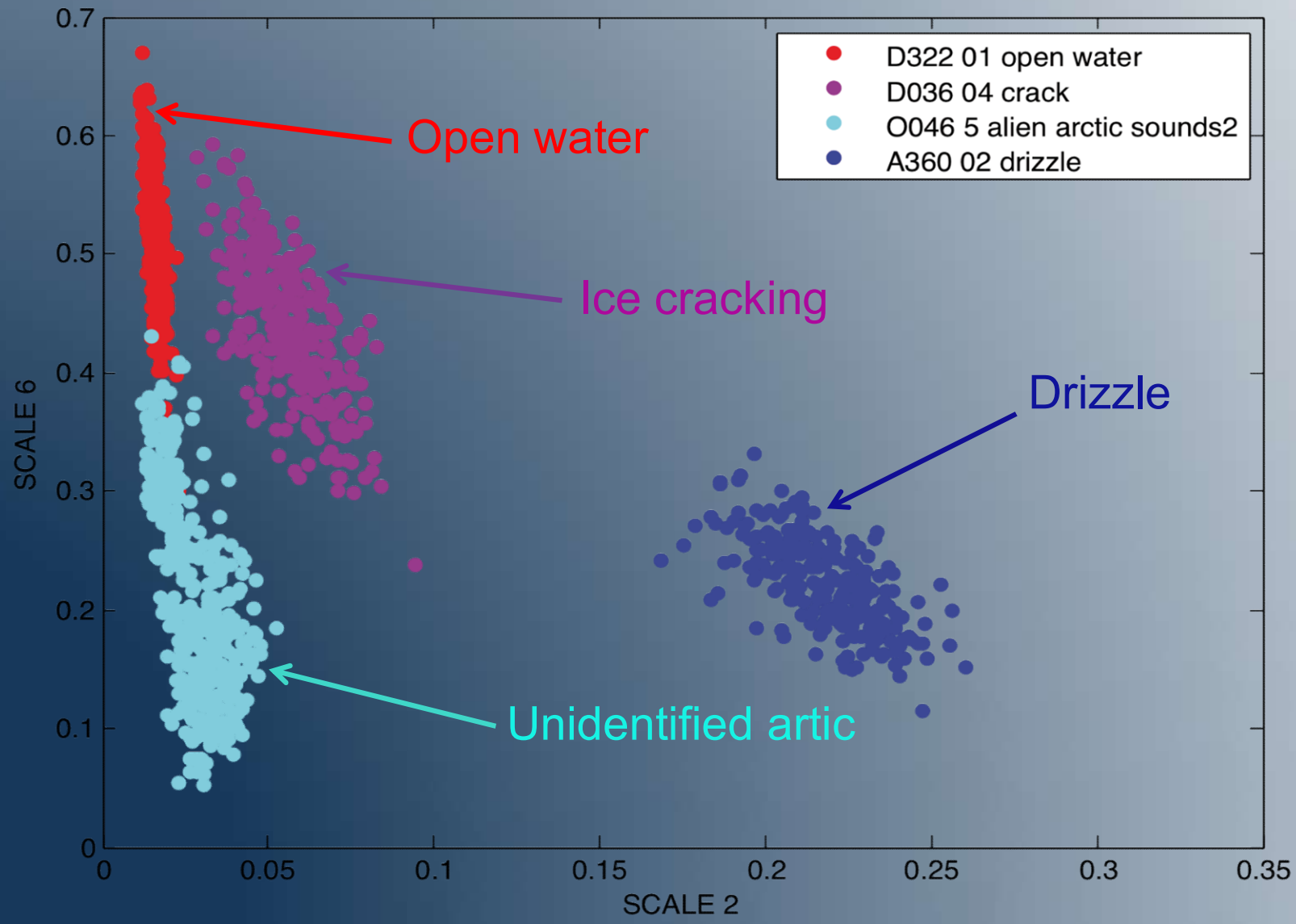
Stereotypical sounds
Low frequencies
Strong intensity
regular interval



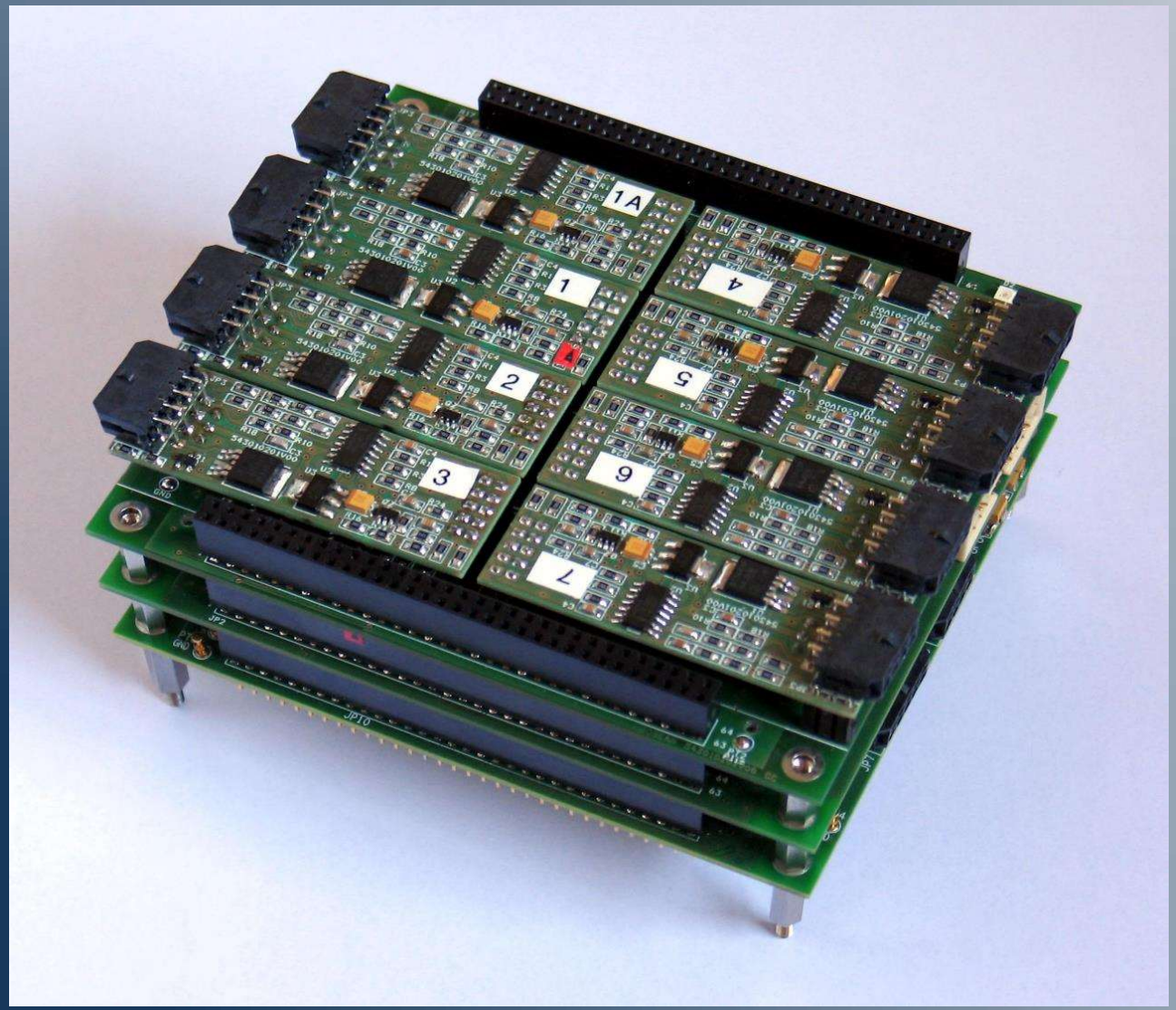
Distribution on long distances
(Hundreds of miles)

Mellinger et al. 2007

the Sukhovich discriminator applied to meteorological data



Multi-sensors Interface



Multi-mermaid float can carry up to 8 extra sensors.

Ed-Lu sensor (7 λ 400-665 nm)

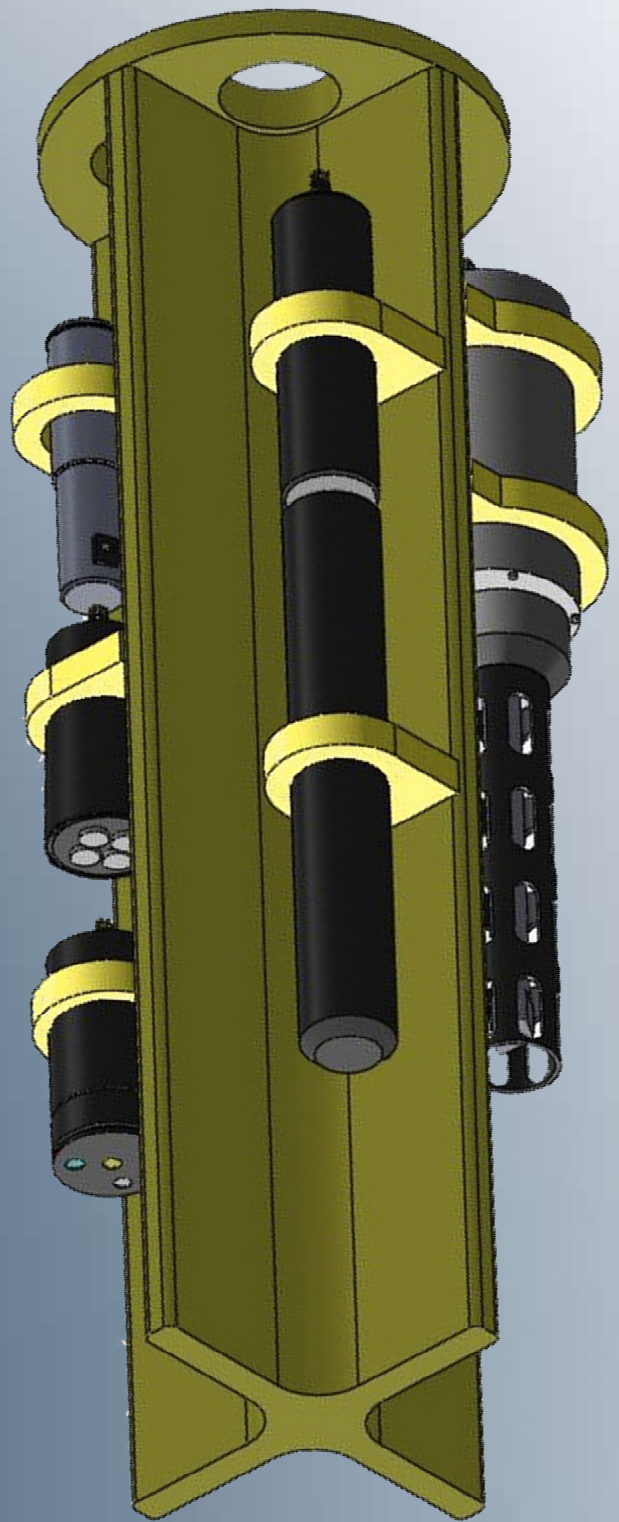
Chlorophyll-a sensor

CTD sensors

SBE O2 sensor

Optode sensor

Nutrients sensor



Green Renewable Energy

PROFILE COST REDUCTION

- Multi-disciplinary Floats
- Extra sensors: Bio Argo's….

But Extra Payload & Energy

Our GREEN SOLUTION

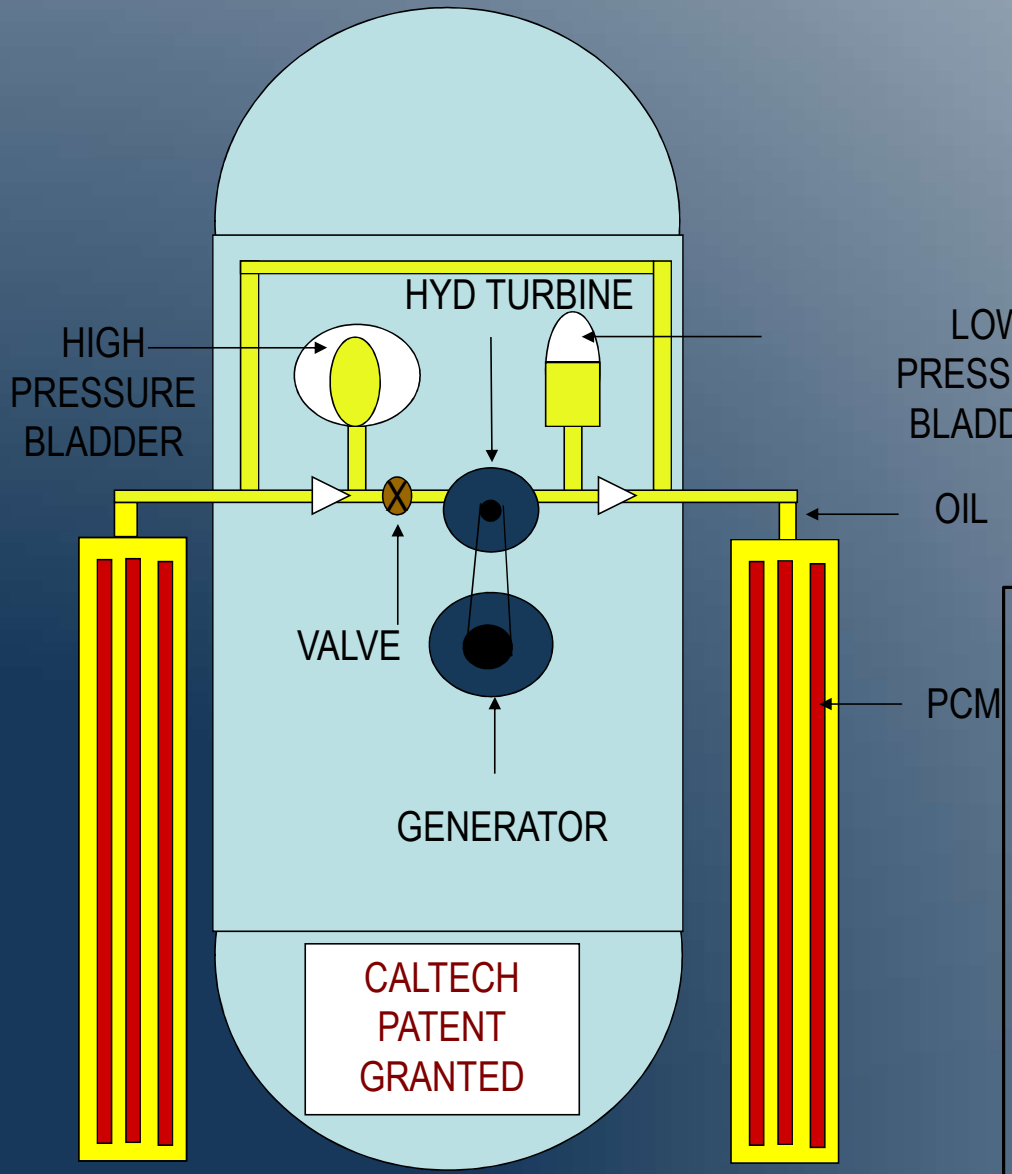
Supplying new green/renewable energy source for underwater applications with Partner SEATREC

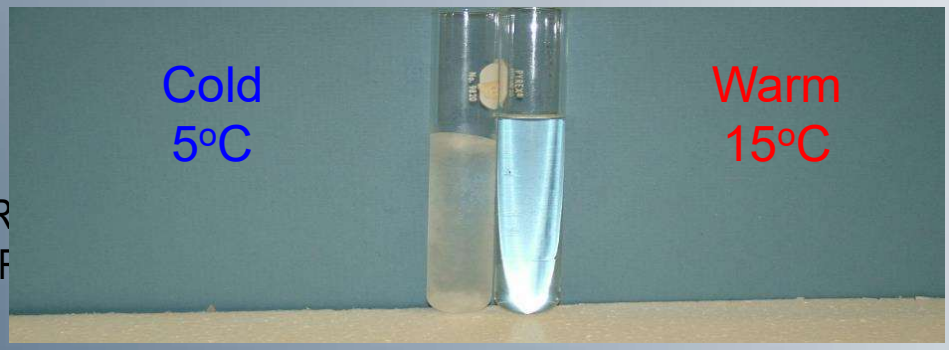
SEATREC

Technology Innovation

Temperature Difference → Volume Change → Pressure Difference

Battery Recharging





Phase Change Material (PCM)

PCMs expand/contract as they encounter warm/cold waters at surface/depth, and create a pressure differential, which will drive a hydraulic motor to generate electricity and charge battery.

EarthScope-Oceans

- P delays can be observed under water
- Robots are affordable
- A network of about 300/1000 Mermaids would fill the ‘ocean gap’ for seismic tomography
- Efforts can be shared between three continents. China can lead EarthScope in Pacific an Indian Ocean.
- Financing can be divided over at least three disciplines (meteorology, biology, solid earth

Thank you