# Supporting EOVs and FAIRness with smarter sensors

Eric Delory

Oceanic Platform of the Canary Islands - PLOCAN

# Outline

What does an in-situ observing system do and how?

How much does it cost?

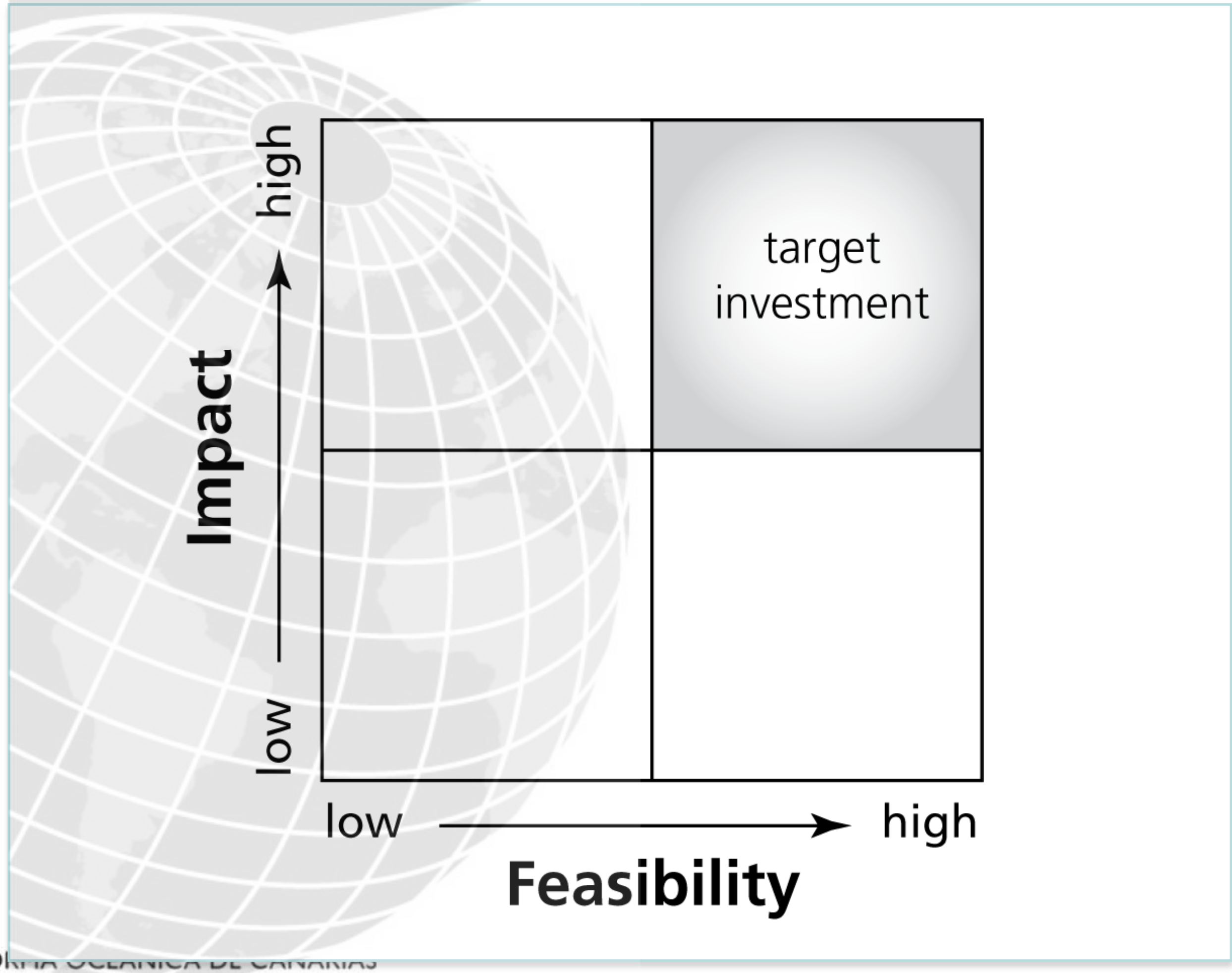
How can sensors help on EOV coverage?

How can we better support FAIRness from sensors?

The role of Research Infrastructures

Driven by requirements, negotiated with feasibility

# Essential Ocean Variables / Core Variables




- We cannot measure everything, nor do we need to
- Driven by requirements
- Rooted in reality
- Measurement must be feasible

| PHYSICS | BIOGEOCHEMISTRY | BIOLOGY AND ECOSYSTEMS |
| --- | --- | --- |
| Sea state | Oxygen | Phytoplankton biomass and diversity |
| Ocean surface stress | Nutrients | Zooplankton biomass and diversity |
| Sea ice | Inorganic carbon | Fish abundance and distribution |
| Sea surface height | Transient tracers | Marine turtles, birds, mammals abundance and distribution |
| Sea surface temperature | Particulate matter | Hard coral cover and composition |
| Subsurface temperature | Nitrous oxide | Seagrass cover and composition |
| Surface currents | Stable carbon isotopes | Macroalgal canopy cover and composition |
| Subsurface currents | Dissolved organic carbon | Mangrove cover and composition |
| Sea surface salinity | | Microbe biomass and diversity (*emerging) |
| Subsurface salinity | | Invertebrate abundance and distribution (*emerging) |
| Ocean surface heat flux | | |
| **CROSS-DISCIPLINARY** | | |
| Ocean colour | Ocean Sound | |

Readiness

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# PLOCAN Observatory


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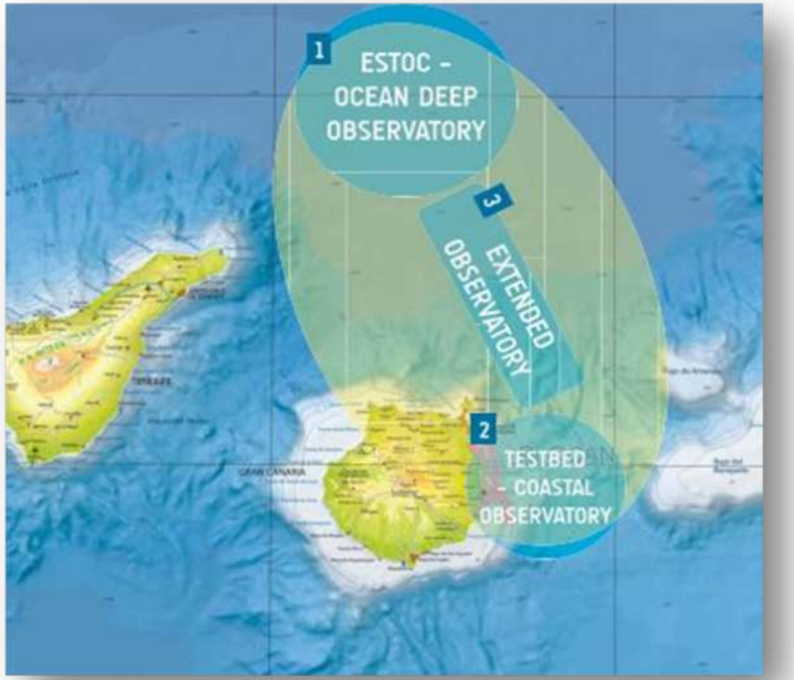
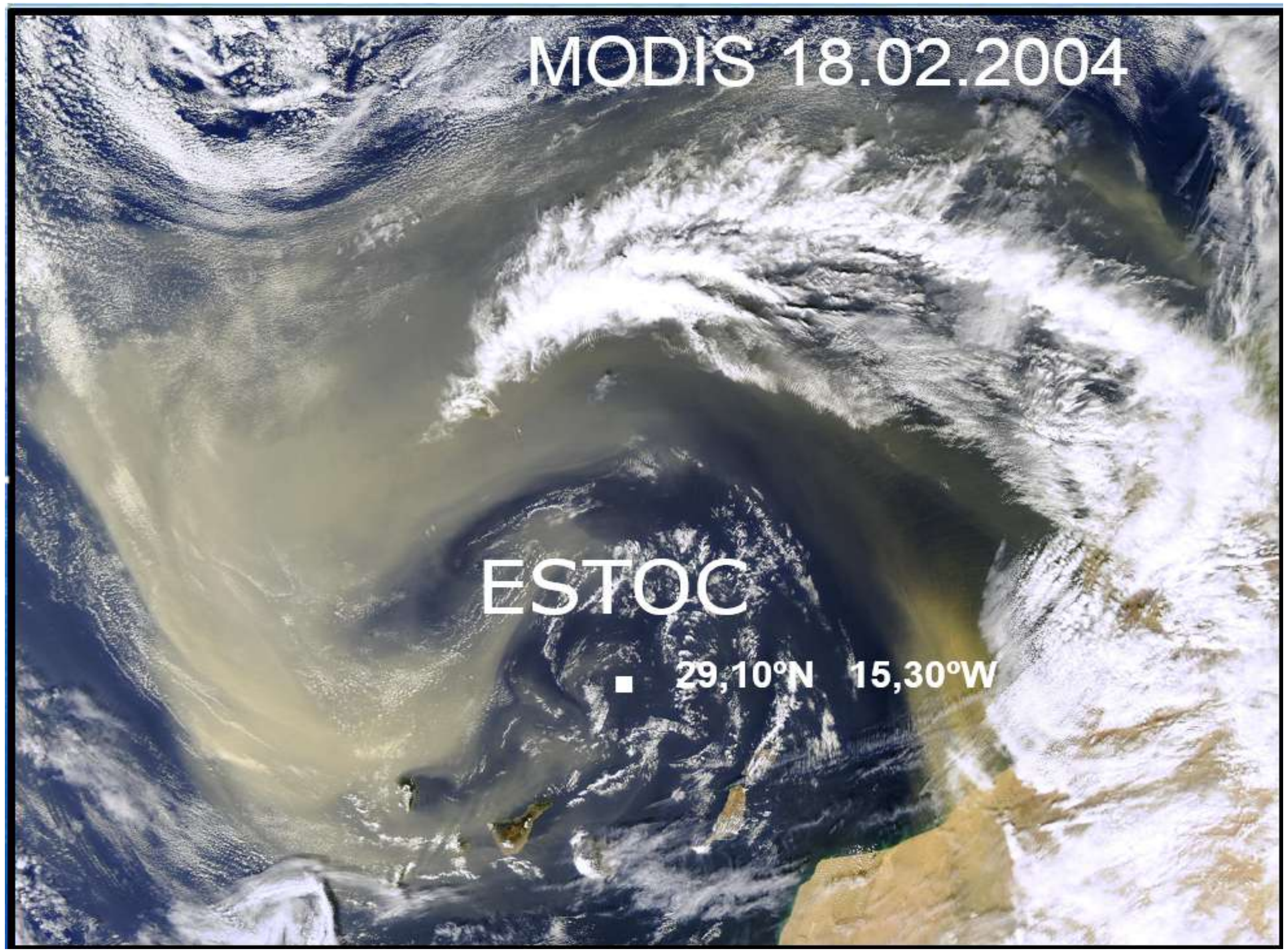
# PLOCAN Observatory

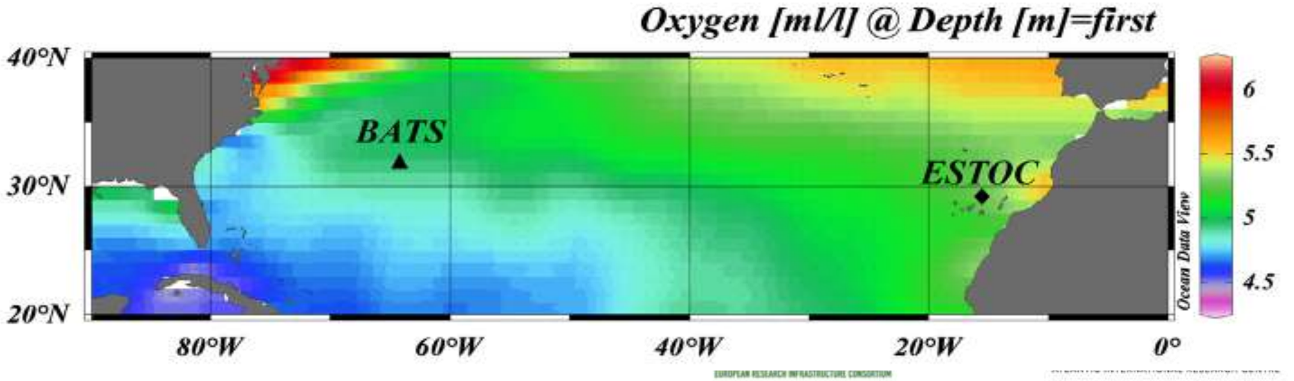



| Observatory component | Start of operations | Depth | Type |
|---|---|---|---|
| 1 – ESTOC – Open Ocean Observatory | 1994 | Down to 3670m | Fixed mooring and surface buoy<br>Near benthic EGIM (2019)<br>Gliders |
| 2 – Testbed & coastal observatory | 2013 | 30m to 600m | RV campaigns, seabed stations |
| 3 – Extended Observatory | 2013 | Down to to 1000m | RV Campaigns, Gliders |

# ESTOC Station

- located 100 km North of Canary Islands in the Canary Current, the weak eastern boundary current of the subtropical North Atlantic gyre.
- 3600m water depth
- exhibits open ocean, oligotrophic gyre characteristics
- Not directly influenced by the coastal upwelling
- Influenced by mineral deposition of atmospheric dust from nearby Sahara
- Close to BATS latitude

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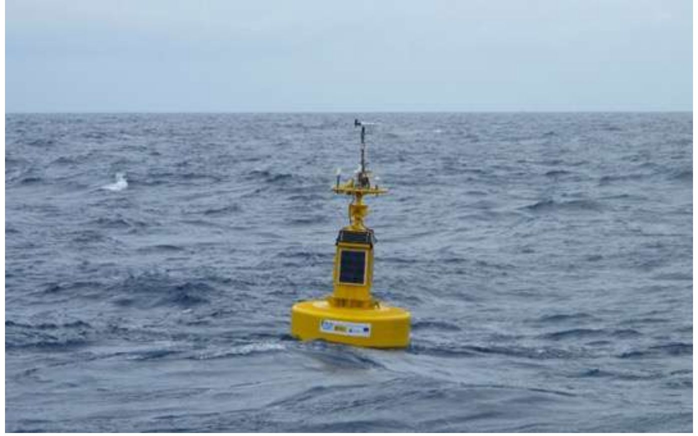

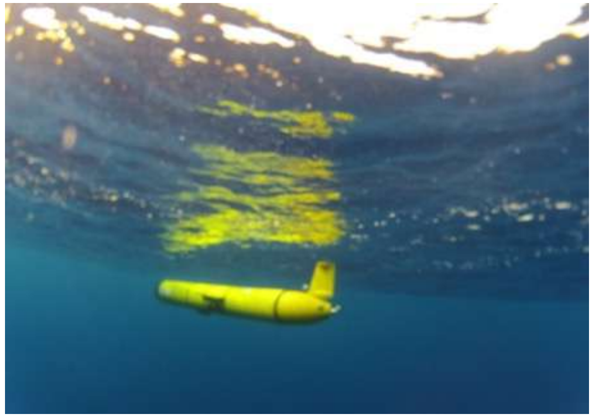

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# Data FAIRness status, good … but best for M2M?


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**http://data.plocan.eu/thredds/catalog/estoc/catalog.html**

**Dataset**

ESTOC

ship-based/

mooring-watercolumn/

buoy-surface/

PLOCAN THREDDS Data Server at PLOCAN see Info

THREDDS Data Server [Version 4.3.23 - 20140826.1617] Documentation

**European marine data and data products brokers and assembly centers:**

Copernicus CMEMS INSTAC

SEADATANET

EMODNET

**European Marine RIs:**

EMSO ERIC, EMBRC ERIC, EuroArgo ERIC

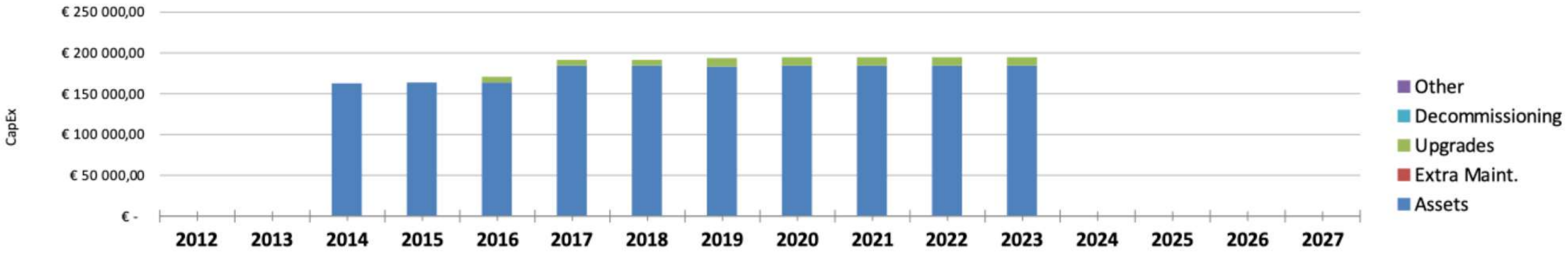
JERICO RI , GROOM

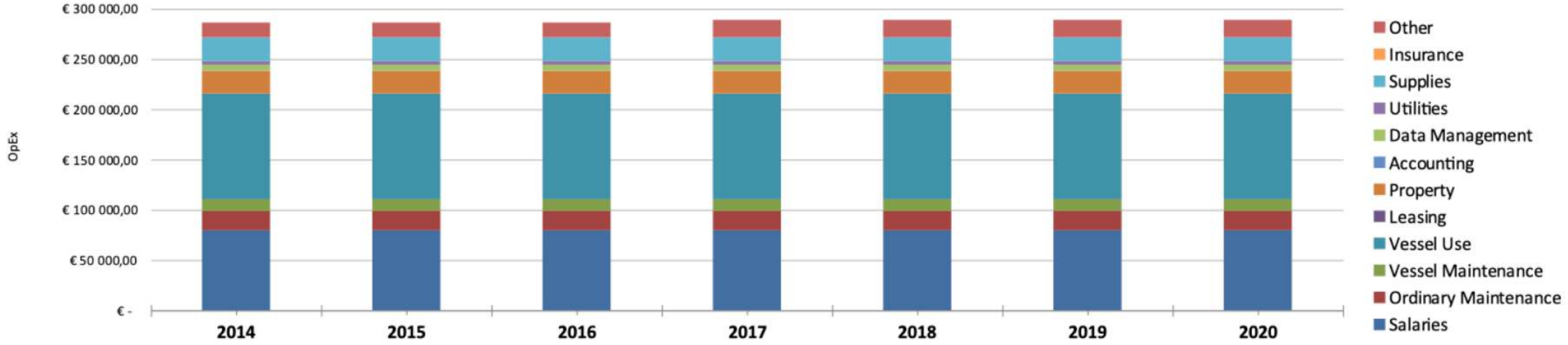
**Common open tools for data retrieval:**

THREDDS

ERRDAP

# EMSO Canarias (ESTOC) open-ocean fixed station costs

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# Some paths for cost-effective EOV coverage and FAIRness

- Mix of mobile and fixed platforms
- Smaller lower-power, and multifunctional sensors
- Greater reliability
- Open-standards and Web Services for FAIRness
- Use the potential of artificial intelligence ?

# Multifunctional ecosystem sensors

- The potential of spectral optics (fluorometry, absorptiometry, …)
- Multifunctionality and multiplatform integration capability (size, power, interoperability)
- Good response time and accuracy, low maintenance, high stability

But …

- Still lack of commercial integration of truly efficient antifouling systems
- The problem of market adoption for smaller platforms, availability of hi-end components (UV LEDs)


Ifremer/ Delauney
Antifouling system



TriOS (Germany) NeXOS
O1-Vis and O2

# Ocean sound, a cross-disciplinary variable

Passive acoustics: hydrophones with embedded acoustic processing
NeXOS, TRL 7 (ocean noise)
Bioacoustics still at low TRL
Other applications:
Geophysics
Meterology

Needs:
artifacts automatic removal, intelligent scene analysis for power/storage optimisation


Test of NeXOS A1 on deep glider


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```xml
▼<sml:PhysicalSystem xmlns:sml="http://www.opengis.net/sensorml/2.0"
 xmlns:swes="http://www.opengis.net/swes/2.0" xmlns:swe="http://www.opengis.net/swe/2.0"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xlink="http://www.w3.org/1999/xlink"
 xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:sos="http://www.opengis.net/sos/2.0"
 xmlns:om="http://www.opengis.net/om/2.0" gml:id="MatrixFlu_UV"
 xsi:schemaLocation="http://www.opengis.net/sensorml/2.0
 http://schemas.opengis.net/sensorML/2.0/sensorML.xsd">
  <gml:identifier codeSpace="uniqueID">MatrixFlu_UV:0001</gml:identifier>
 ▼<sml:identification>
   ▼<sml:IdentifierList>
     ▼<sml:identifier>
       ▼<sml:Term definition="http://vocab.nerc.ac.uk/collection/W07/current/IDEN0006/">
          <sml:label>shortName</sml:label>
          <sml:value>MatrixFlu</sml:value>
        </sml:Term>
      </sml:identifier>
     ▼<sml:identifier>
       ▼<sml:Term definition="http://vocab.nerc.ac.uk/collection/W07/current/IDEN0002/">
          <sml:label>longName</sml:label>
          <sml:value>MatrixFlu Hydrophone</sml:value>
        </sml:Term>
      </sml:identifier>
     ▼<sml:identifier>
```

```xml
▼<sml:component name="config">
  ▼<sml:SimpleProcess gml:id="config">
     <gml:identifier codeSpace="uid">MatrixFlu_UV:configurefullData</gml:identifier>
     <sml:typeOf xlink:title="swebridge:modules:instrumentCommand"/>
    ▼<sml:inputs>
      ▼<sml:InputList>
         <!--  ========= Command =========  -->
        ▼<sml:input name="command">
          ▼<sml:DataInterface>
            ▼<sml:data>
              ▼<swe:DataStream>
                ▼<swe:elementType name="dataModel">
                  ▼<swe:DataRecord>
                    ▼<swe:field name="text">
                       <swe:Text/>
                     </swe:field>
                   </swe:DataRecord>
                 </swe:elementType>
                 <!--  Encoding of the command data model  -->
                ▼<swe:encoding>
                   <swe:TextEncoding tokenSeparator="" blockSeparator=" "/>
                 </swe:encoding>
                 <swe:values>START</swe:values>
               </swe:DataStream>
             </sml:data>
           </sml:DataInterface>
         </sml:input>
       </sml:InputList>
     </sml:inputs>
   </sml:SimpleProcess>
 </sml:component>
```


Interoperability at a cost:
- metadata proficiency
- overhead

TriOS LAB

matrixFlu UV

20180713_AB

## Calibration of matrixFlu-UV 182A

**CDOM: Calibration with Quinine-Sulfate-Dihydrate in 0.05 M H2SO4**

| | 254/460 | 320/460 |
|---|---|---|
| Parameter | CDOM 1 (µg/l) | CDOM 3 (µg/l) |
| Offset | 332 | 328 |
| Scaling | 0.01529 | 0.05453 |
| Square | 0 | 0 |

**PAH: Calibration with 6.2 * cPhenanthrene in distilled water**

| | 254/360 |
|---|---|
| Parameter | PAH (µg/l) |
| Offset | 462 |
| Scaling | 0.04256 |
| Square | 3.3e-07 |

**BTX: Calibration with Anisol in distilled water**

| | 254/289 |
|---|---|
| Parameter | BTX (µg/l) |
| Offset | 349 |
| Scaling | 0.701105 |
| Square | 3.4e-05 |

**TRP: Calibration with L-Tryptophan in distilled water**

| | 280/360 |
|---|---|
| Parameter | TRP (µg/l) |
| Offset | 484 |
| Scaling | 0.02435 |
| Square | 2.6e-07 |

TriOS Mess- und Datentechnik GmbH
Bürgermeister-Brötje-Str. 25
D - 26180 Rastede - Germany
Tel: 04402 / 69 67 0 - 0

**Calibrated ranges:**

| Emission | | | | |
|---|---|---|---|---|
| Excitation | 289 | 360 | 460 | 540 |
| 254 | 0 – 5000 µg/l BTX | 0 – 1500 µg/l PAH | 0 – 500 µg/l CDOM1 | n. c |
| 280 | - | 0 – 2000 µg/l TRP | n. c. | n. c |
| 320 | - | - | 0 – 500 µg/l CDOM3 | n. c |

n. c = not calibrated





| | | |
|---|---|---|
| Interface | digital | Ethernet (TCP/IP) |
| | | RS-232 oder RS-485 (Modbus RTU, OGC PUCK) |
| | analog | - |

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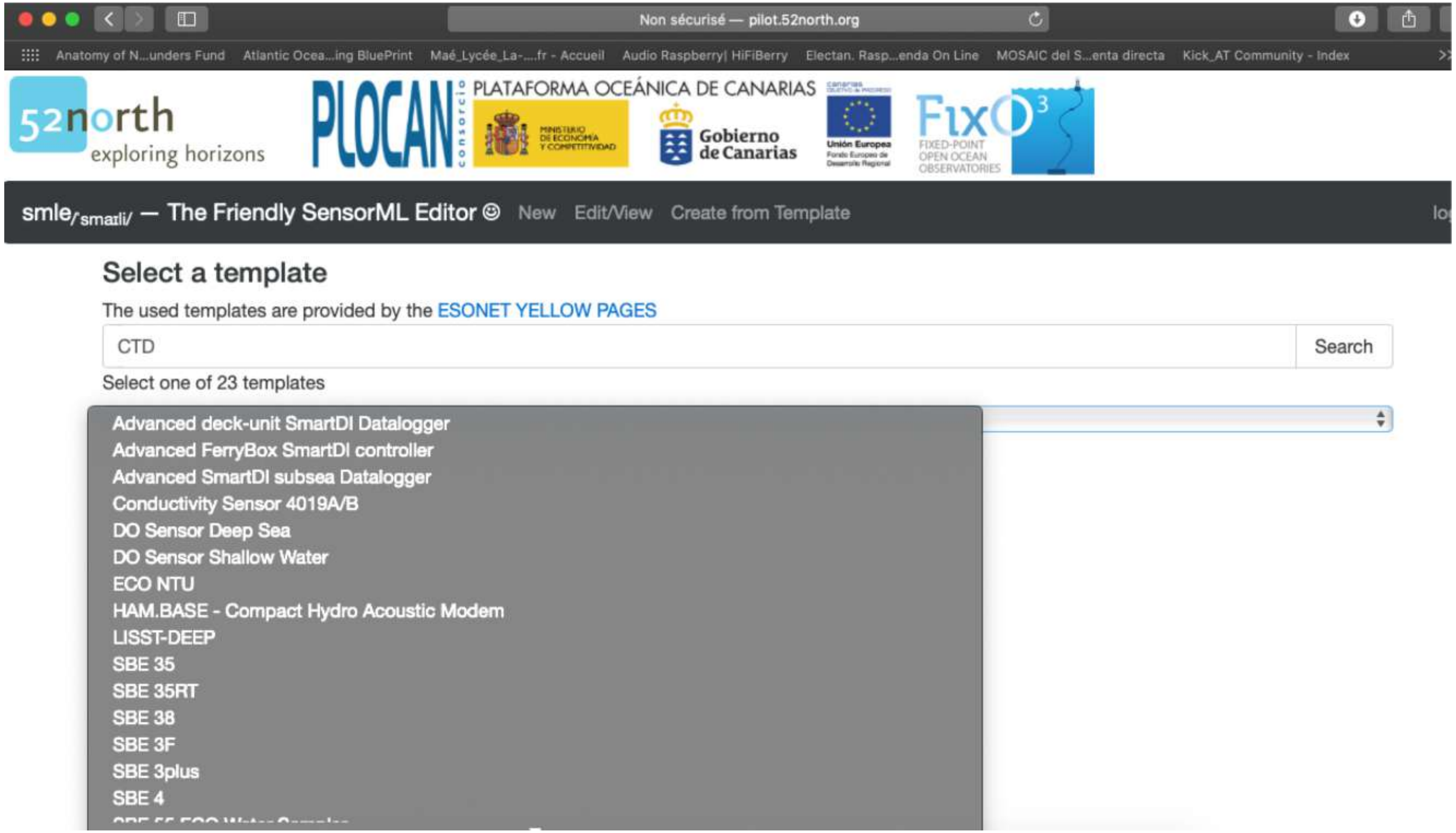
# Friendly sensorML editor for SWE services

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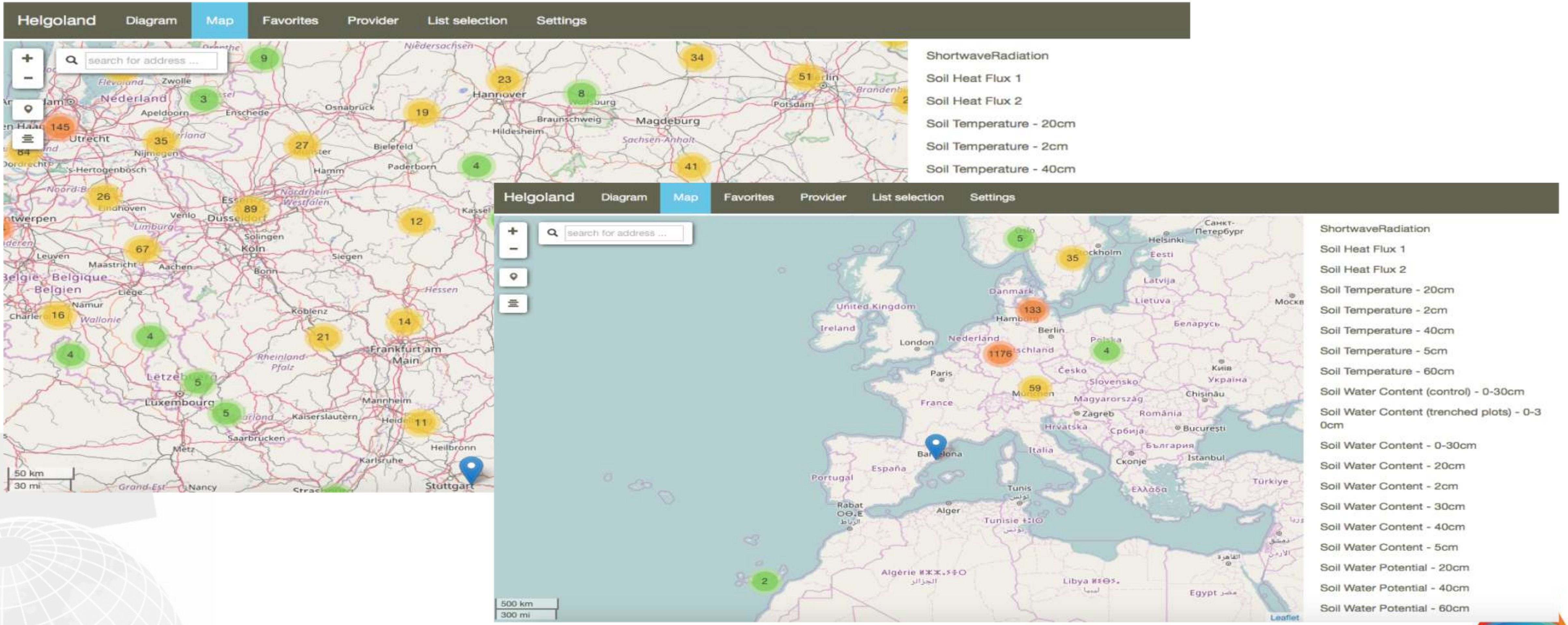
# Scalable, multi-domain, open-source solutions for sensor web discovery (Findability)

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# Adapting commercial sensors and platform to SWE architecture

Sensor Web Architecture components

- Sensor Observation Service
- Sensor Web viewer
- Sm(i)le SensorML editor

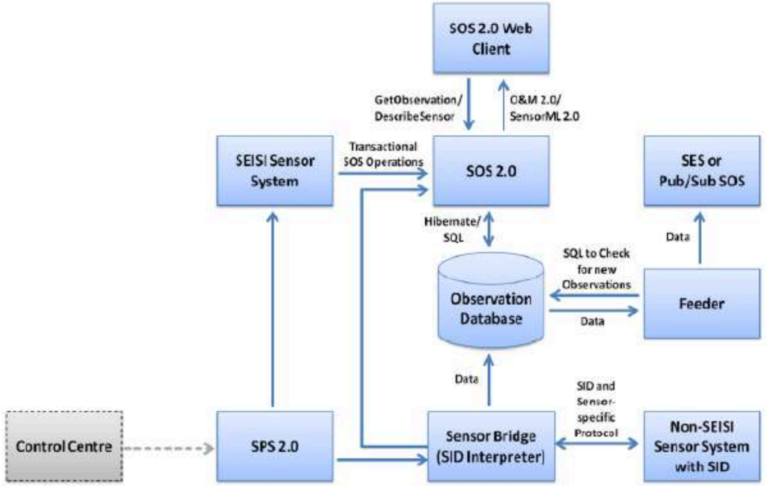


Figure 7. The following tabular overview summarises the proposed mapping:

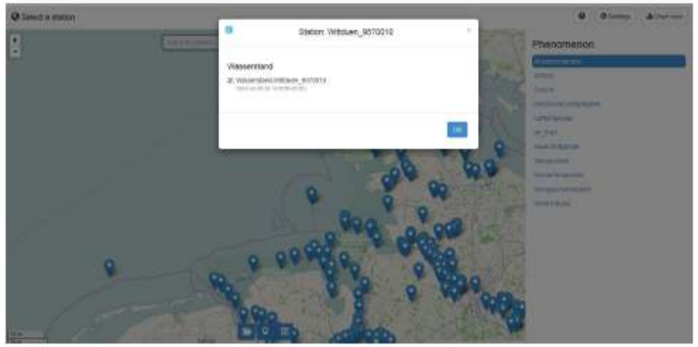

Figure 8 Selection of Time Series to be displayed

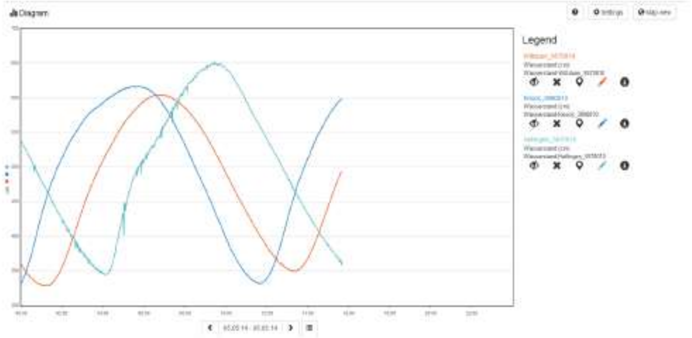


Figure 9 Diagram View of Observation Data

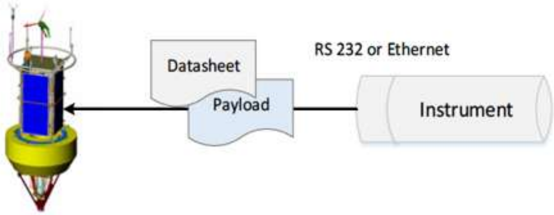


Figure 4 Host issues OGC PUCK commands to retrieve datasheet and payload

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# Integration on vehicles and floats


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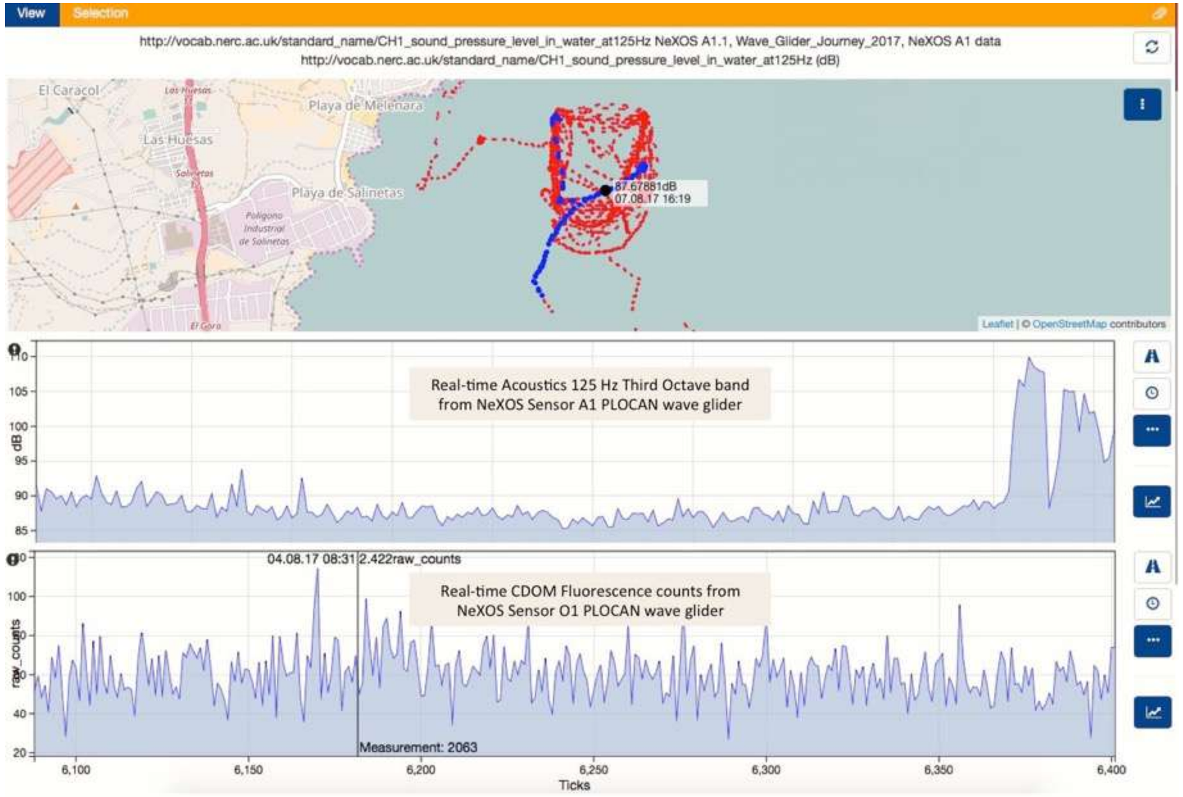


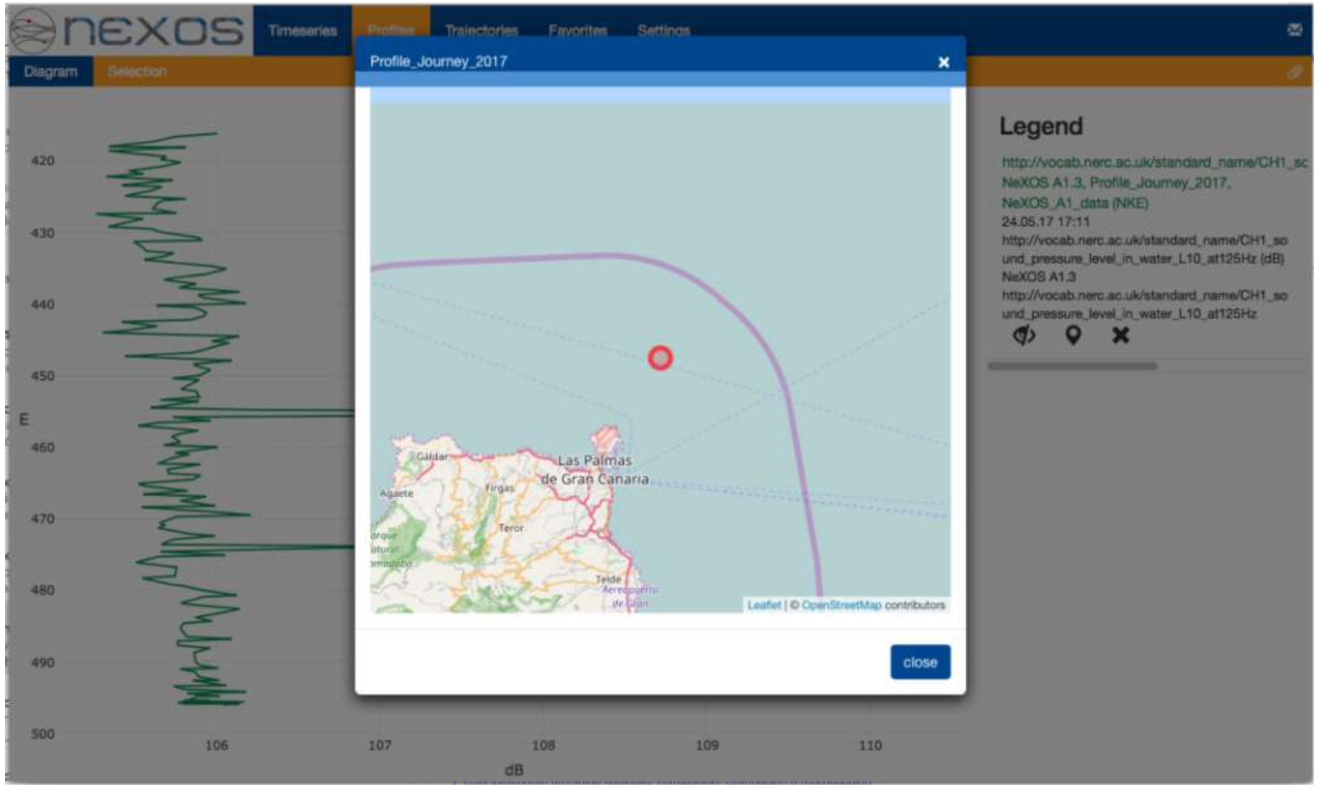
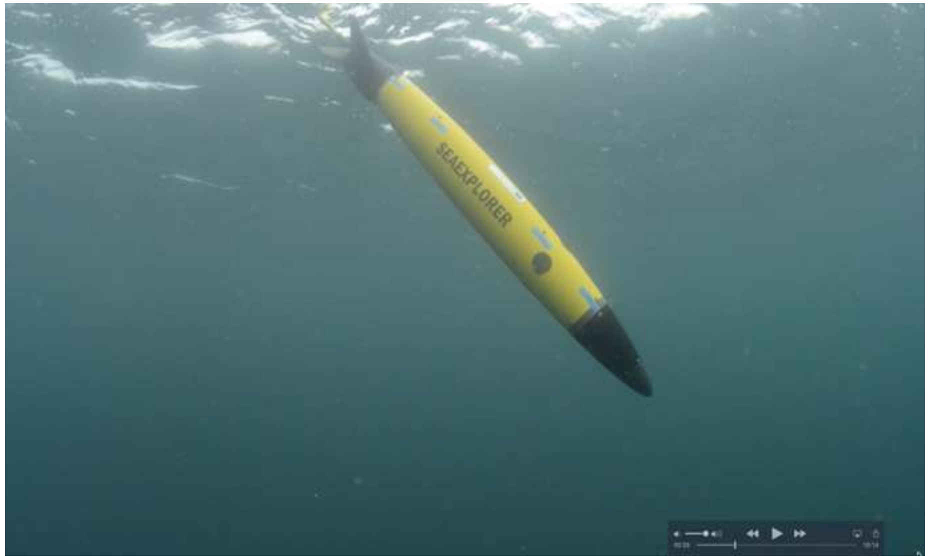
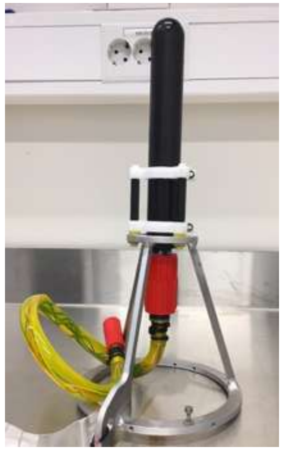




**Figure 19: Demo area, offshore Las Palmas (Spain), Atlantic Ocean.**







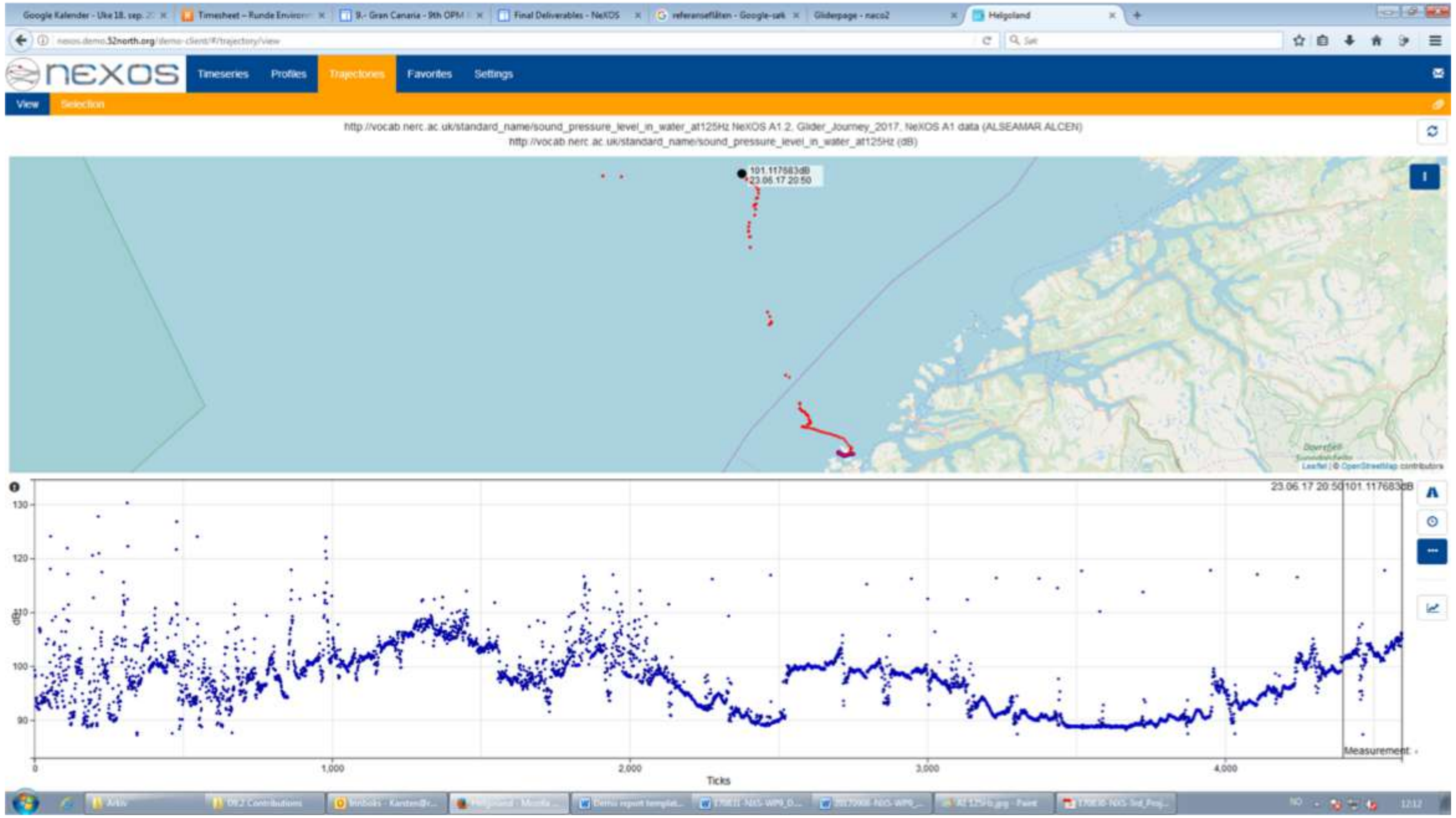
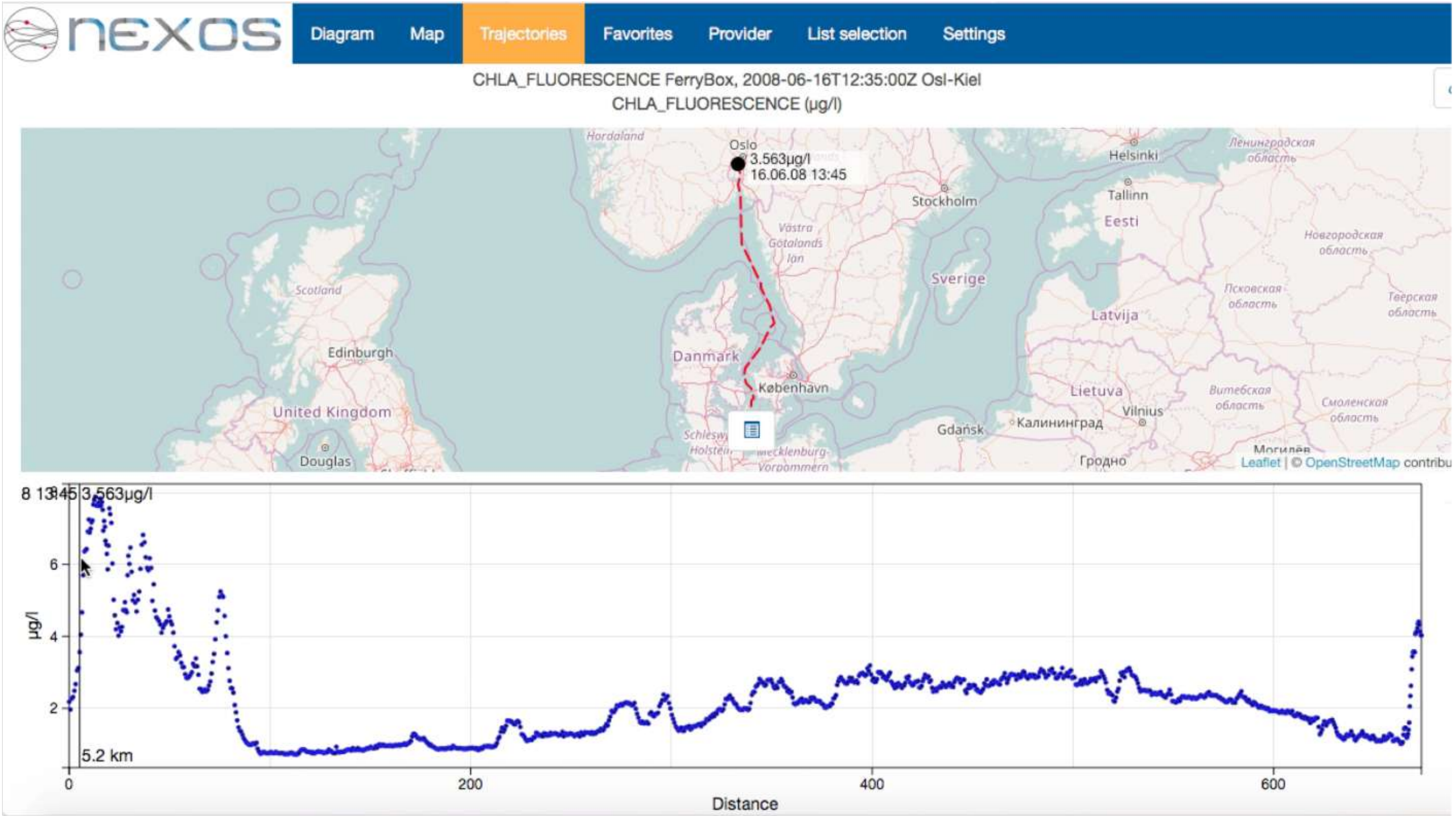



Figure 11: Noise measurements in the 125Hz band for the transect going offshore. The x-axis is data point number. There is definitely a pattern emerging. Spikes on the second half right of the graph are attributed to glider mechanics involved in the control of buoyancy.

# Sensor web technologies
# Cross-domain & multiplatform sensor and data interoperability

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# Reaching out to RIs

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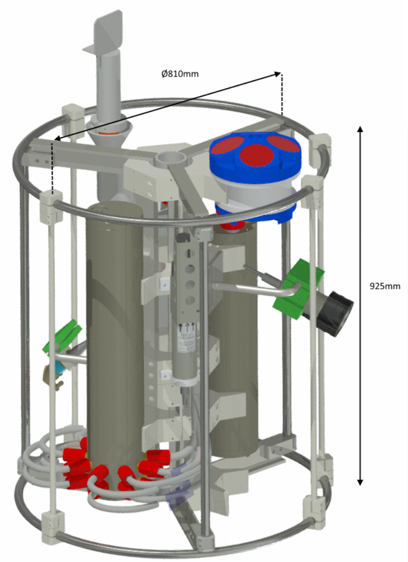
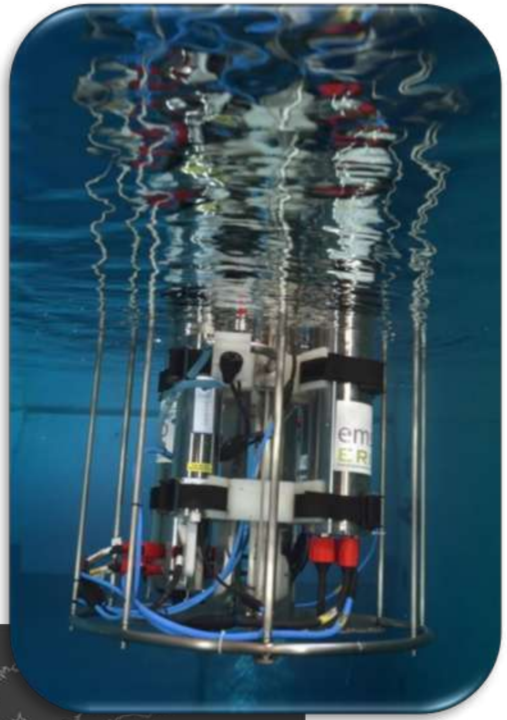
# EMSO EGIM Interoperable multi-sensor packages

- From shallow water to 6000m
- Candidate platform for coastal observatories in JERICO-S3
- Low-power antifouling technologies
- SWE capable
- Reliability: tested against  hydrostatic pressure, Solar radiation, Thermal shock during immersion, Vibrations, Mechanical shock
- Validation underway at several sites
- Standalone and cabled
- 12 ports

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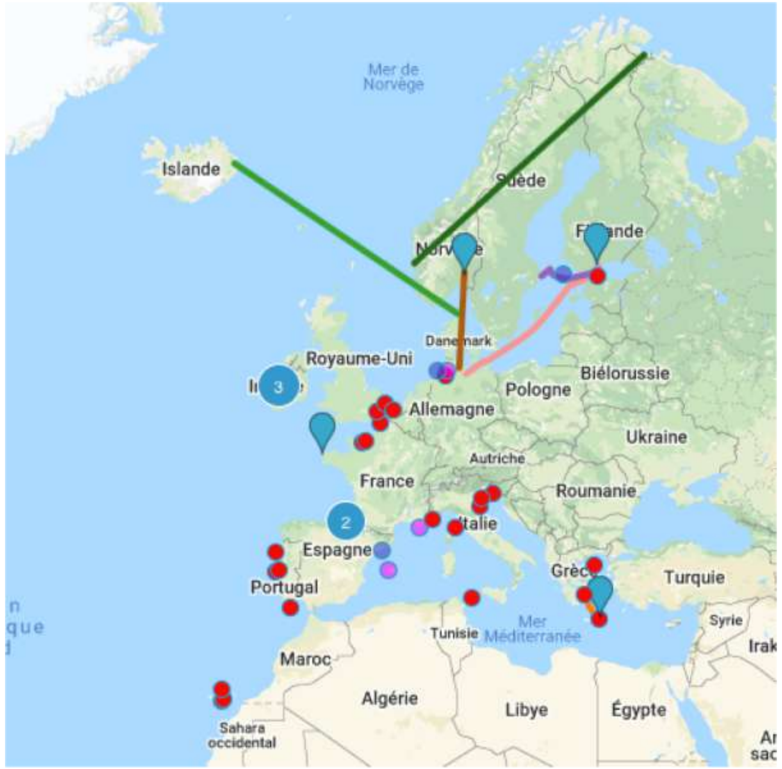
# Smarter sensors for coastal observations

- Innovative sensors and sampler for biogeochemistry,
  contaminants and biology
- Coastal EGIM with embedded AI
- Sensor Web services and easier sensor service registration for FAIRness
- Transnational access
  Call open since 2nd of June

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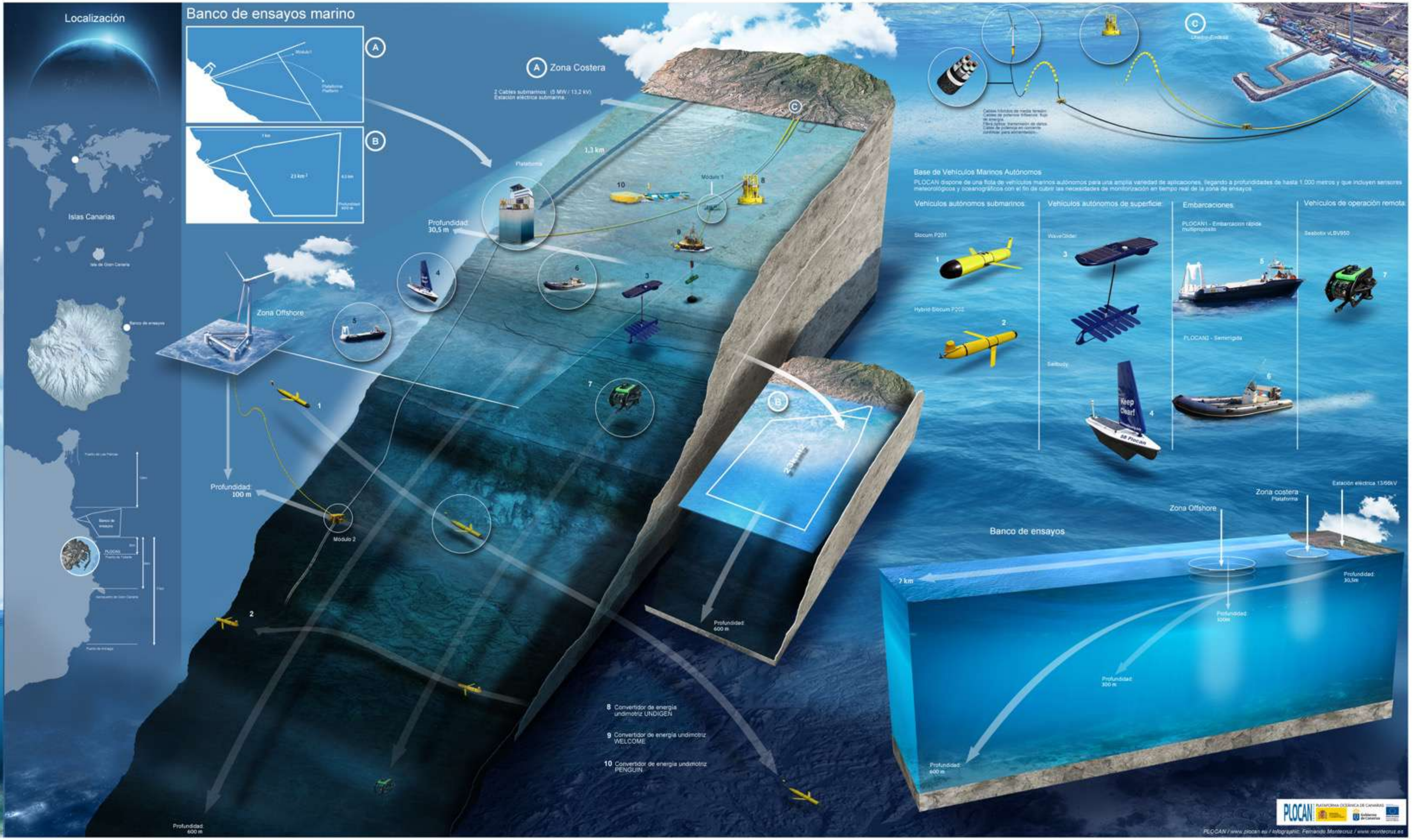
# Banco de Ensayos Marino de PLOCAN

El banco de ensayos de PLOCAN en alta mar presenta un área de 23 km², y está situado a 3 millas náuticas de la sede en tierra de PLOCAN y también bastante cerca del puerto principal de la isla de Gran Canaria (Puerto de Las Palmas). La zona ofrece profundidades progresivas desde la costa hasta 600 m (pudiendo trabajar a profundidades mayores bajo petición) y está dedicado a estudiar el comportamiento y la eficiencia de los diferentes tipos de dispositivos y tecnologías marítimas, contribuyendo así a acelerar el proceso de su introducción en el mercado.

El área marina del banco de ensayos de PLOCAN se estudió exhaustivamente el objetivo de ofrecer un espacio óptimo en términos de logística, infraestructuras compatibles y conexión a la red. Además,la zona cuenta con excelentes condiciones ambientales que facilitan al menos 9 meses de ventana operativa y los recursos de energía eólica y undimotriz (energía de las olas) óptimos para las operaciones de ensayo/demostración, que oscilan entre 300-400 W/m² para la densidad de energía eólica y de 4 a 8 Kw/m de energía undimotriz.

## Plataforma

Cubierta técnica (400 m²)
Eslora: 37,9 m
Grúa marina
Grúa de pórtico
Sala de Exposición
Aula de Formación
Almacenes
Estancias de descanso:
6 dobles.
3 individuales.

# References


[1] E. Delory and J. Pearlman, Challenges and Innovations in Ocean In Situ Sensors. Cambridge, USA: Elsevier, 2019, p. 400. doi: 10.1016/C2015-0-06798-3

[2] Z. A. Wang et al., "Advancing Observation of Ocean Biogeochemistry, Biology, and Ecosystems With Cost-Effective in situ Sensing Technologies," Frontiers in Marine Science, Review vol. 6, no. 519, 2019-September-12 2019. doi: 10.3389/fmars.2019.00519

[3] J. J. H. Buck et al., "Ocean Data Product Integration Through Innovation-The Next Level of Data Interoperability," Frontiers in Marine Science, Review vol. 6, no. 32, 2019-February-28 2019. doi: 10.3389/fmars.2019.00032

[4] A. R. Sastri et al., "Perspectives on in situ Sensors for Ocean Acidification Research," Frontiers in Marine Science, Perspective vol. 6, no. 653, 2019-October-29 2019. doi:10.3389/fmars.2019.00653

[5] FP7 Projects: NeXOS, SenseOcean, Schema, CommonSense joint policy brief on innovative ocean is-situ sensors. http://www.nexosproject.eu/sites/default/files/170930-NXS-WP11_D.11.4_NeXOS_PolicyBrief_Final.pdf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