Monitoring benthic communities in the OE sector: Seabed integrity and Biofouling

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Ocean Energy

- **Diversity of technologies and structures**
  - Wave
  - Tidal and ocean currents
  - Ocean thermal energy (OTEC)
  - Salinity and temperature gradients
- **Different methods of energy capture**
  - Attenuators, point absorbers, Osc. Wave Surge converters, etc.
- **Different structures according to location**
  - Onshore, nearshore, offshore

Different impacts (and magnitude)

Potential impacts from OE

- **Offshore activities** (eg, mining, pilling, sand extraction)
- **Equipment and structures** (eg, foundations, moorings, anchoring)
- **Moving parts and movement of anchor lines/cables**
  - Hydrodynamics
  - Physical Change
  - Changes in benthic habitats and communities

Seabed integrity

- **Artificial reef effects**
  - Biofouling
  - Enhancement of local biodiversity, sanctuaries for protected/commercial species
  - Propagation of non-native species

Biofouling

- **Noise**
- **Electromagnetic fields**
- **Pollution** (chemical pollution, litter)
- Other impacts

(eg, positive socioeconomic impacts)

Seabed integrity

- **Characteristics** (physical, chemical and biological) **which determine the structure and functioning of habitats and communities in the sea bottom**
- Regarded in different legislative frameworks
  - MSFD, WFD, HD, OSPAR, HELCOM, etc.

- Main challenges to seabed monitoring in the OE
  - Range of human pressures and impacts
  - Need for frequent and long-term monitoring
    - Benthic communities are naturally variable (eg, between seasons)
    - Ascertain changes owed to anthropogenic impacts
  - Different legislation applicable among countries

Seabed monitoring

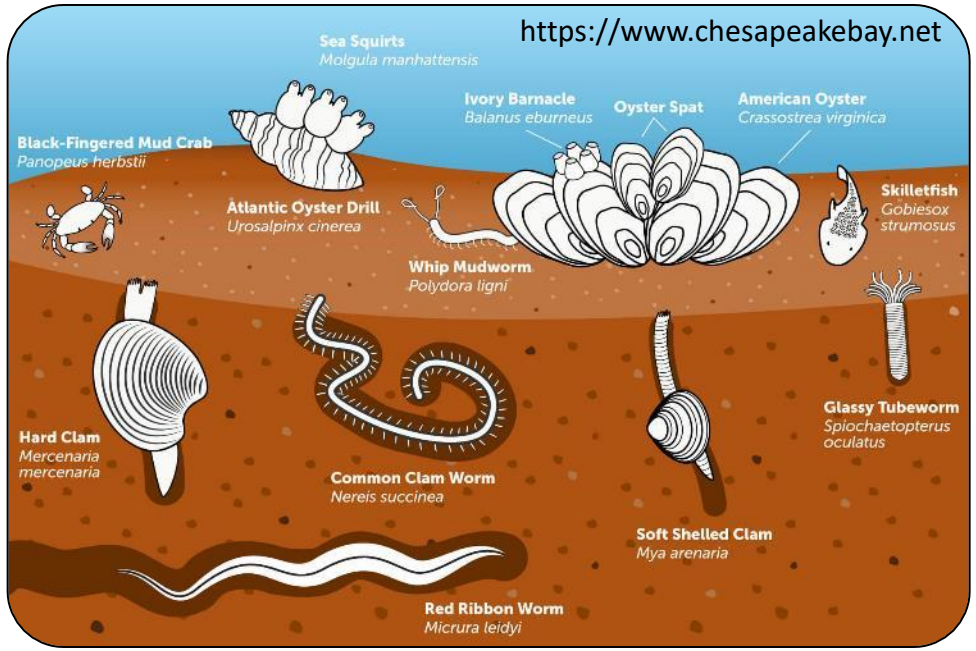
- 1) Desk-based work
  - Marine dynamics, seabed, marine habitats and organisms
  - Allow faster and more objective activities at sea

- 2) Sampling – Pre-construction, Operation, Decommissioning
  - BACI design
  - Inside and outside the projects' area
  - Stratified, Single-spot, Grid and/or Transect sampling in replicates

  - Seabed (including archaeological features) and habitat characterization
    - Active acoustics
      - ADCP, Side-scan SONAR, Multibeam SONAR
    - Divers, ROV, UAV

Seabed characterization

- 2) Sampling – Pre-construction, Operation, Decommissioning
  - Sediment and communities sampling
    - Box-corer, grab sampling and trawling nets (sandy bottom)
    - Scrape sampling (rocky bottom)
    - Divers/ROV
  - Sediment granulometry and contents
  - Community structure, presence of NNS



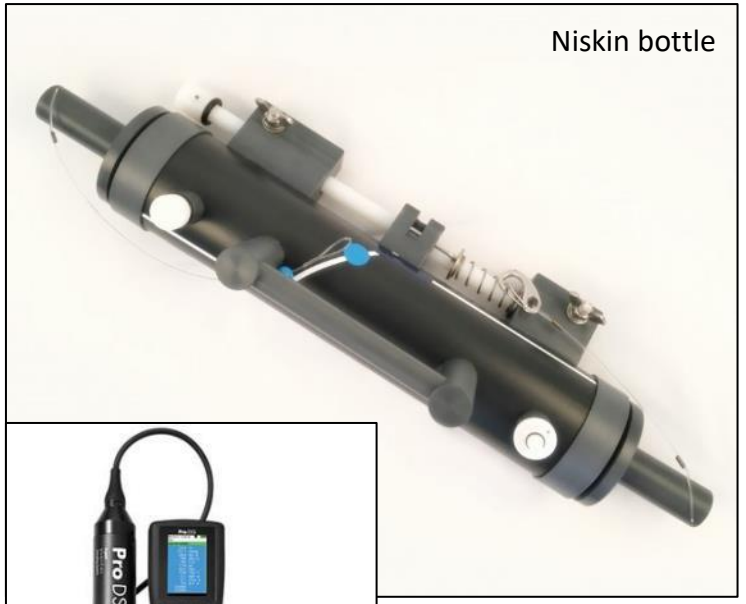
Seabed characterization

- 3) Samples processing
  - Analysis of videos/photos
  - Sediment granulometry analysis
  - Sediment contents analysis
    - Organic matter, chlorophylls, contaminants
  - Benthic communities analysis
    - Sieve through a **1 mm** mesh sieve
    - **Identify, Count** – Density (ind m^{-2}), **Weight** – Biomass (g FW/DW/**AFDW** m^{-2}) and **Measure** (mm, cm) **organisms**
    - Total density and biomass, Species density and biomass, Number of species, Diversity indices (based on density, biomass, or both), Tolerant/Sensitive species (eg AMBI index)

- 4) Data analysis
  - Descriptive and Statistical analysis

Water quality

- **Parameters measurement**
  - Multiparameter probe
    - Salinity/conductivity
    - Temperature
    - Dissolved Oxygen
    - Total Chlorophyll



YSI multiparameter probe

- **Seawater Sampling**
  - Recover water as relevant
    - Enough volume for analysis
    - Adequate depths
    - Keep in dark containers in cold
  - Water analysis
    - Nutrients
    - Chlorophyll a
    - Particulate Organic Matter
    - Turbidity
    - Oils and Greases
    - Polycyclic Aromatic Hydrocarbons (PAHs)
    - Metals

Biofouling

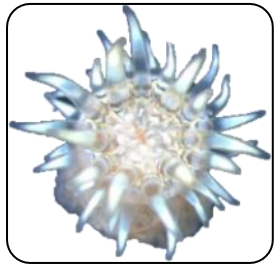
- **Assemblages** of fauna and flora **growing on artificial, man-made, structures**

(e.g., ships' hull, buoys, MRE equipment)

- **> 4000 organisms** accounted as biofouling
- **Microfouling** – e.g., bacteria, fungi, microalgae
- **Macrofouling**

  - **Soft-fouling** – e.g., non-calcareous algae, anemones, hydroids





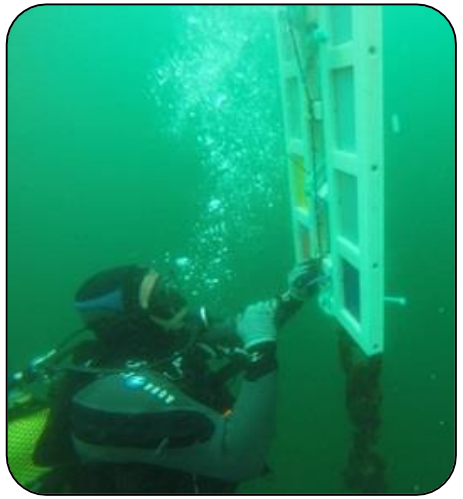
  - **Hard-fouling** – e.g., barnacles, mussels, calcareous tubeworms



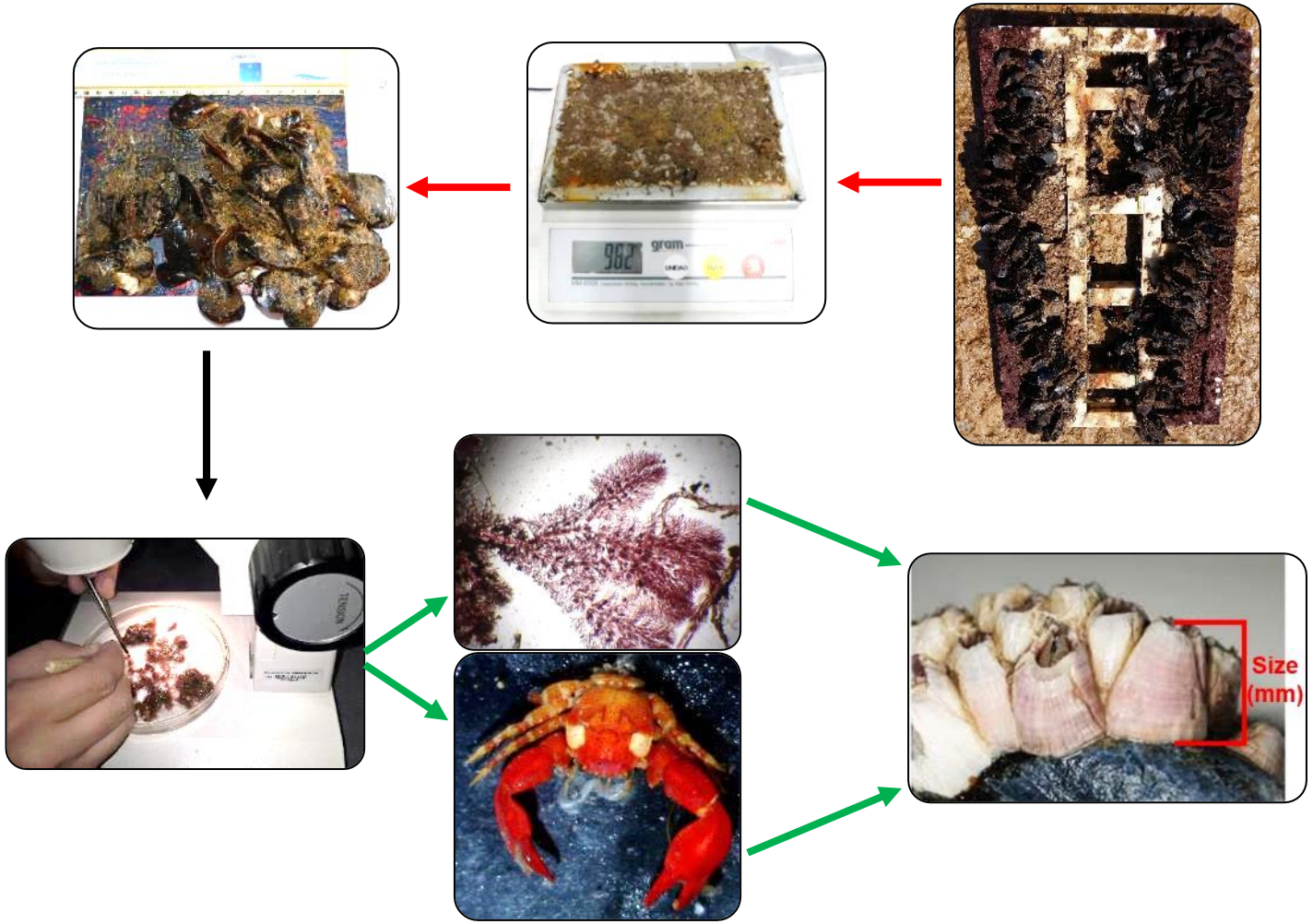
Stepwise assessment

1. Activities at sea → **2. Samples processing**

- **Biofouling sampling**
  - Scrapings/Removable samples
  - Video (and photographic monitoring)



Stepwise biofouling assessment



2. Samples processing

- **Samples**
  - Biofouling **weight** (eg, fresh weight: g FW m^{-2})
  - Biofouling **thickness** (mm)
  - Biofouling **coverage** (%)

- **Biofouling communities**
  - Characterization
    - **Composition, Number of species**
    - **Abundance**
      - Density (ind m^{-2})
      - Biomass (g FW m^{-2})
      - Coverage (%) of species/groups
  - **Hard-fouling**
    - **Size** (height/length; mm) **+ the above parameters**

Stepwise biofouling assessment

$$1 - \Sigma\,(pi \log_2 pi)$$

$$\frac{S-1}{\ln N}$$

$$1 - \Sigma \frac{[Ai(Ai-1)]}{[A(A-1)]}$$

3. Data analysis

i) Descriptive analysis

- **Seawater parameters** and how they **affect biofouling**
- **Which groups** (eg, crustaceans, bivalves, gastropods, annelids)
- **Number of species** (eg, total, within group)
- **Dominant and rare species** (abundance, weight, size, coverage)
- **Non-native species**

ii) Statistical analysis

- **Differences** among sites, depths, seasons, substrates (eg, PERMANOVA)
- **Species most contributing** to the differences (e.g., SIMPER)
- **Seawater parameters associated to the differences** (eg, PCO)

iii) Ecological indices

- **Diversity/Equitability**
  - Margalef
  - Shannon-Wiener
  - Simpson

Impact of biofouling

- Artificial structures = **Artificial reefs**
  - ✓ Promoters of ecosystem diversity and function
  - ✓ Sactuaries for commercial and/or protected species

- Contribute to the **propagation of non-native species (NNS)**
  - ✗ Impacts biodiversity, habitats and/or ecological processes
  - ✗ Economic threats (eg, species of commercial interest)

- **Biofouling**
  - ✗ Issues related with use of **antifouling (toxic) solutions**

- **Alter hydrodynamic properties of equipment**
  - Add substantial weight and thickness/roughness
    - Increased drag, loss of performance/functionality

- **Cause damage and induce/accelerate corrosion**
  - Direct damage (eg, from boring organisms)
  - Damage by waves/currents (eg, pulling kelp or bryozoans)
  - Damage during maintenance activities (eg, when removing barnacles)
  - Expose surfaces to seawater –> Corrosion
  - Facilitate MIC (Microbiologically Influenced Corrosion)

- **Increase maintenance frequency**
- **Increased costs, downtime periods and loss in revenue**

European Biofouling Database (Vinagre et al., 2020; *in preparation*)

- Knowledge on biofouling not sufficiently transferred across the MRE sector (Loxton et al., 2017)
- Biofouling data is dispersed, and many times not standardized
  - Improper design of devices/components
  - Improper O & M plans
  - Hence, **increased costs**

- Allow the MRE sector (and others) a more **informed and quick decision**
  - Provide overview of biofouling in a specific area
  - Support site selection, frequency and type of maintenance operations
  - Support development of biosecurity risk management plans

European Biofouling Database (Vinagre et al., 2020)

i. **Realm, Province and Ecoregion** (Spalding et al. 2007): Overview of countries encompassed in the mapping (e.g., 'cold' versus 'warm' regions)
   - ✓ 9 Ecoregions

ii. **Country and Site**: Country (e.g., Portugal, Netherlands) where biofouling samples were taken
   - ✓ 24 Countries

iii. **Distance to shore:** Distance (km) between the sampled site and the closest land
   - ✓ 0.1 – 195 Km

iv. **Type of equipment/structure: MRE**; Oil & Gas, deliberate artificial reefs, test panels

v. **Period of immersion:** Period (months, years) during which the biofouling could grow (i.e., from the equipment deployment until data was gathered)
   - ✓ 1 month – 39 years

European Biofouling Database (Vinagre et al., 2020)

vi. **Depth:** Depth (m) at which data was retrieved

- ✓ Surface – 90 m

vii. **Temperature and wave height:** Temperature and wave height data in the area sampled

a. data recovered from the cited work

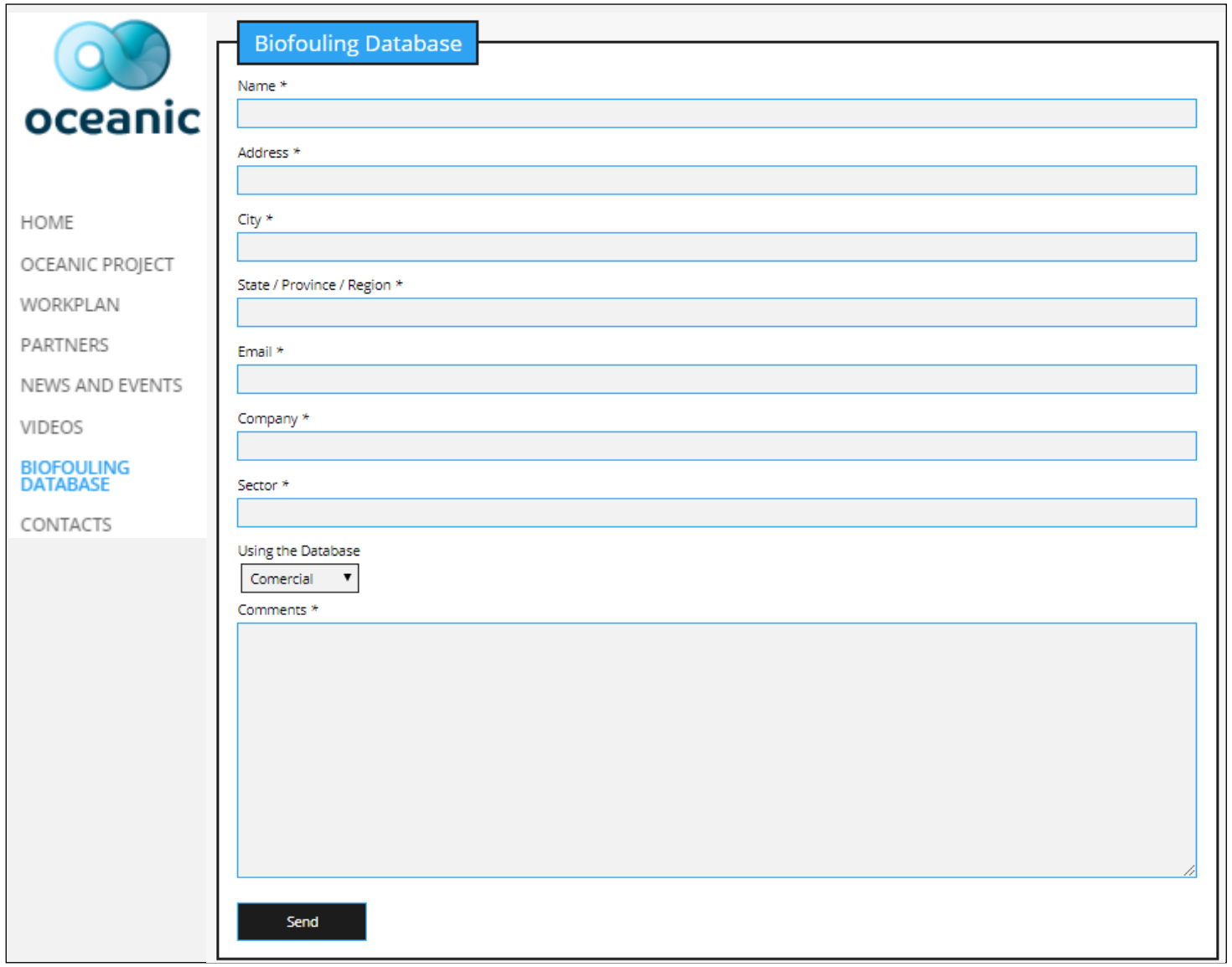
b. data not presented by the authors –> data retrieved from WindGuru (www.windguru.cz) for that site (or the closest area available) and fouling period (mean ± standard deviation)

c. no fouling period is mentioned by the authors, or if WindGuru data does not cover the fouling period –> last two years of available data retrieved from WindGuru (mean ± standard deviation)

viii. **Biofouling data:** Qualitative and quantitative information on samples and on biofoulers including NNS

- Samples thickness (mm) and weight (g FW/DW/AFDW m^{-2})
- Biofoulers size (length or height; mm) and weight (g FW/DW/AFDW m^{-2})

vii. **Reference:** Authors who reported the data



- Updated frequently
  - Data from published papers, reports and projects
- Next step
  - Funding to make it an **Interactive Map**

- Download from

www.oceanic-project.eu/biofouling-database

- Soon moved to WavEC website

https://www.wavec.org

…to Summarize

- **Many and diverse OE technologies and structures**
  - Knowledge gaps in the interaction between OE and Environment

- **Seabed monitoring**
  - Very challenging, and time and cost demanding
    - Long-term monitoring (years) (at the devices and in reference areas) to understand the interactions
    - Monitoring may require temporary shutdown of devices
  - Requires specific logistics, and monitoring techniques and parameters
    - Depends on which parameters intended and the aim (EIA, ecological studies, …)
    - Depends on legislation applicable (variable between countries)
  - **Develop standardized approaches applicable globally**
    - **Allow data comparability**
    - **Increase understanding of OE effects on the environment**

…to Summarize

- **Biofouling**
  - Monitoring needed
    - Standardize methods and parameters
    - More precise modelling
  - Weight and thickness/size are preferable
    - Provide more realistic information about the assemblages
    - More realist understanding of impacts (eg, loading, drag, damage)

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