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BRAIN-be 2.0

BELGIAN RESEARCH ACTION THROUGH INTERDISCIPLINARY NETWORKS - Phase 2

Annual Network Report

To be filled in for the whole network in French, Dutch or English and sent by the coordinator to: BRAIN-be@belspo.be

Contrat nr: B2 / 212/ P1 / OUTFLOW

OUTFLOW

Reporting period: 15/04/23 - 14/04/24

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The *Annual Network Report* (maximum 15 to 20 pages) is drawn up annually by the coordinator for the entire network and sent by the coordinator to the address BRAIN-be@belspo.be on the dates set in article 4 of annex I to the contract. It presents the state of progress and achievements of the research as well as the forecasts for the following year. This information refers explicitly to the tasks and the project schedule defined in articles 2 and 3 of annex I. It also informs of any modification of the data included in the previous reports – except for the possible changes regarding personnel* - and gives the list of publications and missions carried out during the past year.

This template can be completed in French, Dutch or English.

*Modifications compared to previous reports regarding personnel in charge and at the disposal of the project should be completed by the concerned individual partner in the separate form “Annual Report Personnel” to be downloaded from the website. To be completed conform the instructions given in the Initial Report.

NETWORK

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PROJECT WEBSITE, SOCIAL NETWORKS …

We used https://www.researchgate.net/project/OUTFLOW, but ResearchGated discontinued the Projects feature. The project is mentioned on the RBINS-MARECO website. We plan to inform the public about future progress through the social media of the participating insitutes and personal LinkedIn pages.

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY of this report

The main objective of the third OUTFLOW year was to (1) finalise the work related to isotopic tracer development for characterizing the organic matter pool in marine environments; (2) start quantifying possible the carbon accumulation in the vicinity of offshore wind turbines and (3) run an experiment that leads to an understanding of how carbon mineralization processes in offshore wind farms are affected by the organisms colonizing offshore wind turbines.

The final step in the methodological development was to run a test with artificial samples. These are mixes of known quantities of different sources. Extracting the candidate tracers (through compound specific isotope analysis) and using them to mathematically unmix the artificial samples was planned for a final confirmation of the candidate amino acids. Part of these mixes were lost due to a methodological error in the lab, that lead to a delay in the final confirmation of the tracer set. Therefore, additional samples were collected during a field campaign in March 2024. As such, the tests are still possible and the unmixing of the field samples is scheduled for the final year of the projects.

To increase the methodological rigour of the measurements that lead to the quantification of mineralization processes in offshore wind farms, we followed the suggestion of the experts of the follow-up committee to collect additional data in the vicinity of the scour protection layer (SPL) of offshore wind farms. The consortium secured additional ship time and the presence of scientific divers for a detailed sampling campaign in October 2023. The additional data confirm our initial hypothesis of increased carbon mineralization in sediments close to the SPL, and will be integrated with earlier collected data for final modelling during the last year of the project. Integration of these results with results from biological sampling led to a first estimation of the carbon accumulation potential for permeable offshore wind farm sediments. These first estimates confirm a 10 to 13% additional carbon accumulation in sediments at <75 m away from the SPL. Absolute values depend on season, and these first estimates need to be refined based on the model outcomes on the depositional area of faecal pellets produced by the organisms on the turbine. The initial results from the experimental work on the effect of faecal pellet addition suggest functional consequences with respect to response time to the addition of labile organic matter.

2. ACHIEVED WORK

Detailed description of the achieved work and tasks since the previous report ACTIVITIES, RESULTS IN NEXT SECTION

WP 1. Methodological Developments

Task 1.1. Isotopic tracer development

The development for the isotopic tracer methodology, following the protocol delivered in the 2022 Annual report has been finished, and fully implemented. To identify the isotopic tracers with strongest discriminative power, artificial mixtures were prepared and processed following the developed protocol. Using the laboratory result from the artificial mixtures, the unmixing model FingerPro is being implemented to identify the most discriminative amino acids. Unfortunately, the unmixing of some of the prepared artificial mixtures did not result to the correct values. This was due to the use of a wrong reagent in the lab (during the esterification step of the derivatisation isopropanol containing 30 % of water head been used). Artificial mixtures processed with the correct reagent resulted in the correct proportion, unfortunately, most artificial mixtures were processed with the wrong reagent. These artificial mixtures are essential for the valorisation of the methodology. Therefore, new samples have been already collected for phytoplankton with the RV Simon Stevin (11.03.2024). They will be combined with the other contributors of organic matter already stored at the lab to create new artificial samples. They will be prepared and extracted during the week of 25.03.2024.

Task 1.2 Development of SPM trap

This task was fully finalized and reported in the 2022 Annual Report

WP2. Contribution of faecal pellets to the organic matter pool in the offshore wind farms

Task 2.1. Sampling of the OM pool and contributors in an OWF environment

This task was fully finalized and reported in the 2023 Annual Report

Task 2.2 Estimating the contribution of FPs to the total OWF OM pool.

During the past year, artificial laboratory mixtures have been developed. The objective was to verify the effectiveness of the method previous to its application on field samples with faecal pellets and other sources of organic matter. Know proportions of different individual sources of organic matter were mixed in the lab and the amino acids were extracted following the proposed protocol. The technique was also applied on the samples obtained from the sediment traps. These are the samples containing the information of natural contributions of the different organic matter sources in the ecosystem. The extraction of these samples resulted in very clear δ^{15}N-Amino acid data. This data will be processed using the methodology developed in WP1.

WP3. Spatial patterns in OM distribution of FPs

Task 3.1: Physical characterization of FPs

This task was fully finalized and reported in the 2022 Annual Report

Task 3.2: Dispersion at the OWF scale

The dispersion of FP around a single turbine will be modelled. This will be done using the sediment transport of COHERENS V2 (Luyten et al. 2019, http://odnature.naturalsciences.be/coherens). The COHERENS model is a multi-purpose modelling system designed for a wide range of applications in coastal and shelf seas, estuaries, lakes and reservoirs. It follows a modular structure and offers a wide range of physical and numerical schemes.

The development of the numerical sediment transport model has made significant steps over the previous year(s). A two class (sand, mud) including flocculation was implemented and the morphological module has been optimised. The development of the model however took more time and debugging than estimated. The current model however seems stable and will be suitable for application in the current project.

An implementation of a previous version of the COHERENS hydrodynamic model has been executed on a grid of 50 m x 50 m to study the turbulence around wind turbines (Legrand et al. 2018). The new model will be implemented on the same grid to model the dispersion of the FP around wind turbines. Data from Task 3.1 will be used to specify the fall velocity of the FP. Model results will be validated using the data collected by the instruments mounted on the SPM trap and the data derived from the sediment sampling (Task 2.1). The implementation of the model and the running of the different sensitivity scenarios will be performed in the second quarter of 2024.

WP4. Fate of OM and FPs in OWF sediments

T4.1 Quantification of organic matter mineralization in close vicinity of the turbines

During the follow-up committee meeting in December 2022, it was suggested to take additional measurements to facilitate calibration of the sediment biogeochemical model OMEXDIA. Since ship time with scientific divers was only available in October 2023, this caused delay in data acquisition.

In October 2023, additional sediment cores were collected from 7 and 15 m from the SPL by scientific divers, and with a boxcore at 75 m from the SP. Oxygen profiles were measured with Unisense ox100 sensors at a resolution of 100 µm. Afterwards, porewater was extracted at cm resolution to construct vertical profiles of DIC concentration in the sediment. The remaining sediment was sliced in vertical horizons to quantify pyrite (FeS_2) burial in the sediment. Since pyrite can quickly oxidize, the cores had to be handled in an oxygen-free glove bag (filled with N_2 gas). These additional measurements will aid in calibrating the OMEXDIA sediment biogeochemical model.

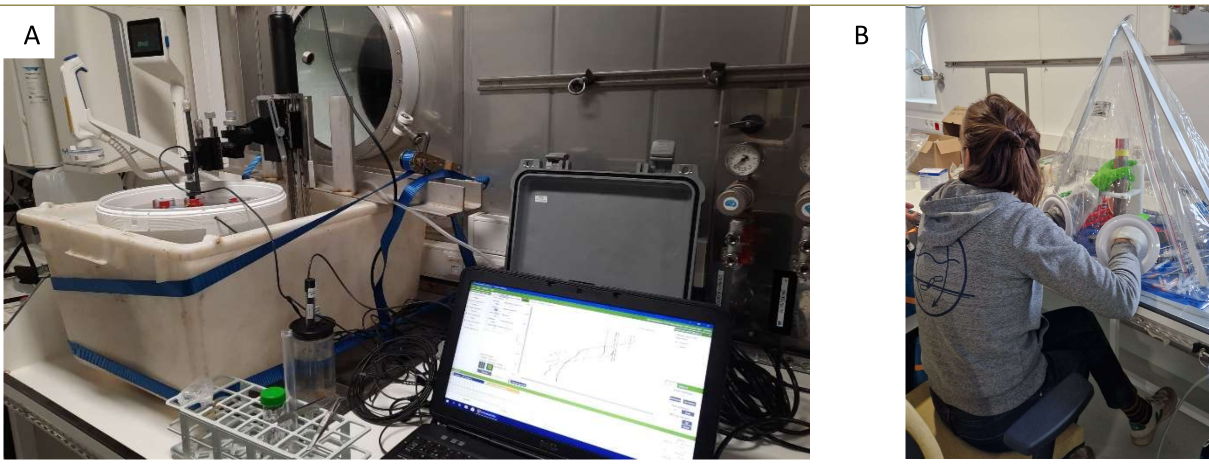

Figure 1: (A) sediment oxygen profiles measured on board RV Belgica with microsensors and (B) extraction of porewater and slicing of sediment cores in an oxygen-free glove bag

Task 4.2: Estimation of blue carbon sequestration potential of OWF sediments

The analysis of the pigments and TOC content and macrobenthos biomass has been finished. Macrobenthic wet weights have been converted to ash free dry weights using established conversion factors from literature (Sistermans et al. 2004 and Gogina et al. 2022), and further converted to C biomass assuming carbon content as 50% of the ash free dry weight (Wijsman et al. 1999).

The organic carbon content (TOC and macrobenthos) during each of the seasons in 2022 has been spatially extrapolated using the surface of concentric circles. The distance to the SPL at which the samples were taken was usedas the radius of the circle. In addition, we assumed that the data from the SW gradient were representative for the entire area. When the shape of the turbine influence has been modelled (Task 3.2; should be ellipses), this spatial extrapolation should be done using concentric ellipses.

Task 4.3: Tracing of faecal pellets in the benthic food web and the total C and N flux at the sediment-water interface

In October 2023, a pulse-chase experiment was carried out on board of the RV Belgica (*Figure 2*). Isotopically ^{13}C enriched mussel faecal pellets were added to mesocosm units containing sediment from C-Power and a reference area outside the OWF on the Goote Bank. The enriched faecal pellets were derived in September 2023 by feeding mussels (*Mytilus* edulis) with ^{13}C enriched algae (*Synechococcus sp.*). These mesocosms were incubated for 7 days. During these 7 days, three closed core incubations were performed. Samples for DIC, DOC, Alkalinity and nutrients were collected at regular intervals. After 5 days the experiment was finished and sediment samples for TOC, bacteria, meiobenthos and macrobenthos were collected. Alkalinity, nutrients and ^{13}C-DIC samples have been processed and analysed, sample preparation of the meiobenthos and macrobenthos has been finalised and are waiting for ^{13}C analysis. Methodology for the ^{13}C-DOC in seawater is still under development. The ensemble of these data will inform us on the fate of the carbon in faecal pellets in the benthic ecosystem (respiration, assimilation in fauna or bacterial biomass, fraction remaining in the sediment in solid and dissolved forms).

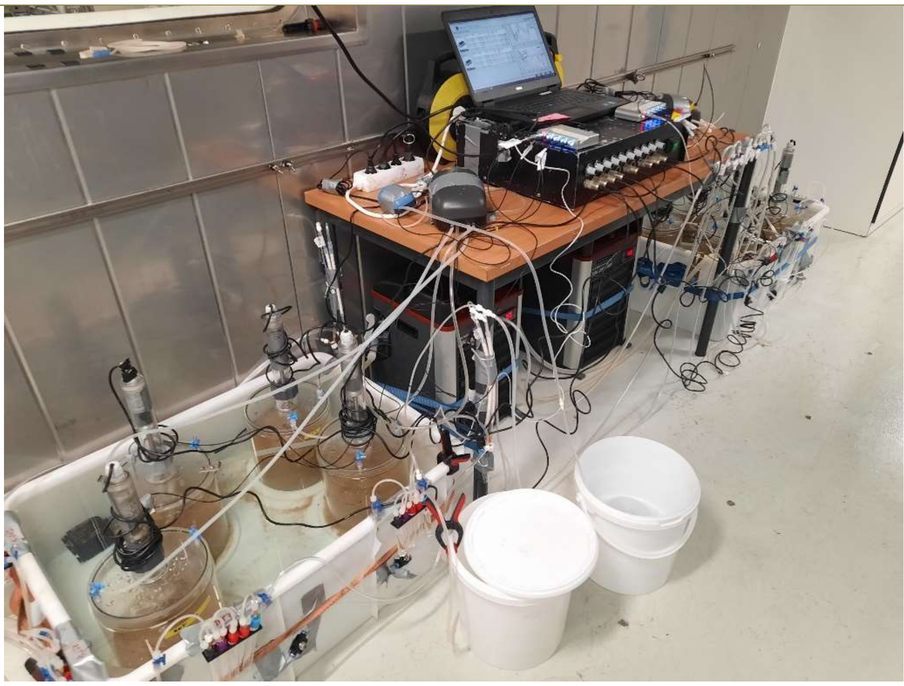

Figure 2 Experimental set-up of pulse-chase experiment conducted on board to the RV Belgica during the 25th and 26th campaign in October 2023.

WP 5: Spatial upscaling and OWF scenarios
All tasks within this WP are planned for the final year.

WP 6: Coordination, project management and reporting
Task 6.1: Coordination and project management
Coordination included organization of the annual meeting with the follow-up committee (20 December 2023), maintaining regular contacts with the wp leaders to oversee progress and represent the project at national (Blue Cluster) and international (ICES, KNOW Footprint (the Netherlands), UK INSITE) fora.
In addition, OUTFLOW cooperated with the Dutch NWO Footprint to organize a cross-border sampling event, involving simultaneous measurements with RV Belgica, RV Simon Stevin and RV Pelagia. The OUTFLOW coordinator organised the data-analysis workshops following that campaign.

Task 6.2: Reporting
All reports were delivered in time.

WP7. Data Management
Task 7.1: Data management of environmental data
Scientists have provided a first dataset of measurements made on the sediment matrix collected during the project cruises. The provided dataset has been formatted by the data originator following the provided Common Layout. The delivered data has been validated and ingested in the first prototype version of a centralized database tailored to fit the purpose of OUTFLOW project data management. The database in development is now able to host environmental data as well as experimental data. On top of the database (implemented with ORACLE database system), a web application is being developed as well. The web application tailored according OUTFLOW project needs is aiming to offer a dashboard to the project scientists and data managers to import data, procedures and files into the database, to refer to standard vocabularies, to validate taxonomic data and to offer visualization tools such as maps of sampling locations and parameter measurement plots. In addition of the data management work, a training on the principles of the data management (Open research data and data FAIRness) has been provided to the scientists/data originators.

Task 7.2:Data management of experimental data
A first test dataset has been provided by the responsible scientist following the provided Common Layout in order to support the design of the new database structure in accordance to experimental data needs. A first set of the received experimental data has been curated and ingested in the database.

WP 8: Valorisation, dissemination, exploitation of results
Task 8.3 Communication with fellow scientists
OUTFLOW results were mainly communicated at national and international conference. See section 7 for details.

REFERENCES
Gogina, M., Zettler, A., and Zettler, M. L.: Weight-to-weight conversion factors for benthic macrofauna: recent measurements from the Baltic and the North seas, Earth Syst. Sci. Data, 14, 1–4

Sistermans WCH, Hummel H, Engelberts A, Markusse MM (2004) Inventarisatie macrofauna Westerschelde 2004: rapportage in het kader van de evaluatie van de verdieping van de Westerschelde. NI00/CEMO, Yerseke

Wijsman JWM, Herman PMJ, Gomoiu M. Spatial distribution in sediment characteristics and benthic activity on the northwestern Black Sea shelf. Mar Ecol Prog Ser 1999; 181:25–39.

3. INTERMEDIARY RESULTS

Detailed description of the deliverables completed since the previous report

WP 1. Methodological Developments

Task 1.1. Isotopic tracer development

Although an error was discovered during the extraction of the amino acids of the artificially created mix samples, preliminary results on the discriminative power of the amino acids and the implementation of the unmixing model can be reported. Linear discriminating analyses (LDA) were performed with all the end-members (*Figure 3*).

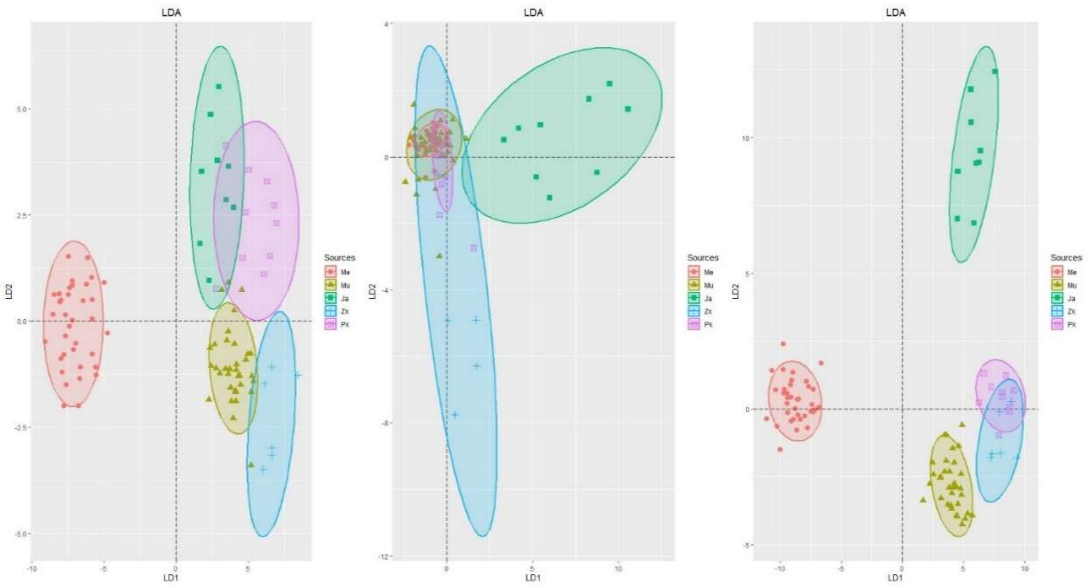

Figure 3 LDA plots for all endmembers subject of study. From left to right: A) LDA of δ^{15}N isotopic ratios of amino acids, B) LDA of the amino acid concentrations added to the mixtures and C) LDA combining of δ^{15}N isotopic ratios of amino acids and concentrations for the three sources of organic matter considered.

In a next step, the results of the artificial mixtures created with different contributors were explored in terms of their δ^{15}N isotopic ratios of amino acids, the concentrations, and their combinations (*Figure 4*). This result represents our approach to the final use of discriminating amino acids. It indicates similar results as the multivariate analysis reported in the 2023 annual report.

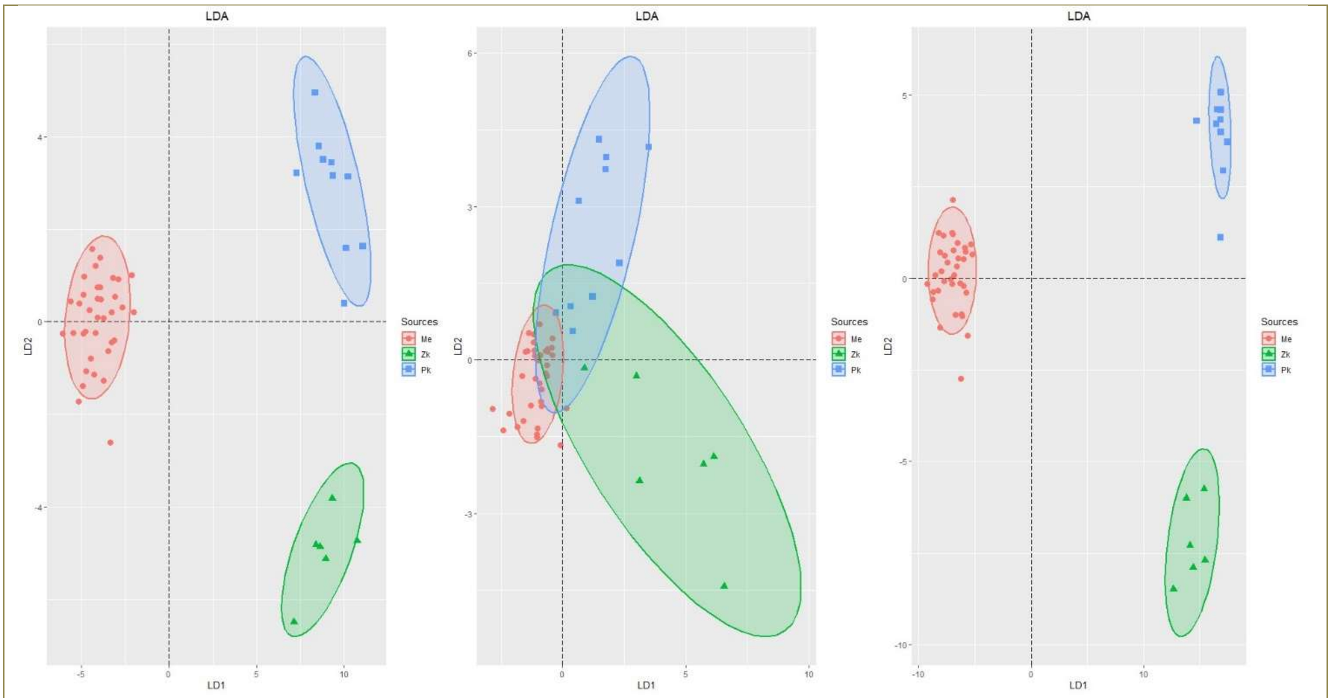

Figure 4 LDA plots for the 3 sources of organic matter used for one artificial mixture: 60% faecal pellets from Metridium senile*, 20% Zooplankton and 20% Phytoplankton. From left to right: A) LDA of $\delta^{15}N$ isotopic ratios of amino acids, B) LDA of the concentrations added to the mixtures and C) LDA combining of $\delta^{15}N$ isotopic ratios of amino acids and concentrations for the three sources of organic matter considered.*

WP2. Contribution of faecal pellets to the organic matter pool in the offshore wind farms

Task 2.2 Estimating the contribution of FPs to the total OWF OM pool

Following the results obtained from the artificial laboratory mixtures, the discriminatory power of each amino acid was explored with ternary pots (*Figure 5*).

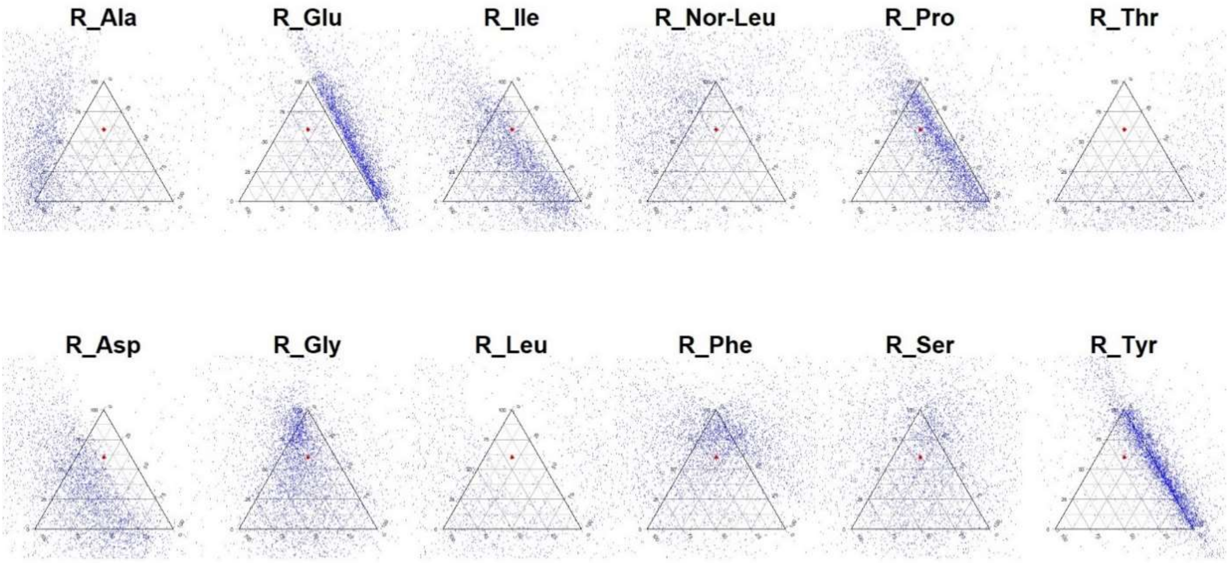

Figure 5 Ternary plots of all possible predictions of each $\delta^{15}N$ isotopic ratio amino acid tracer for an artificial laboratory mixture containing 3 sources of organic matter: 60% faecal pellets from Metridium Senile*, 20% Zooplankton and 20% Phytoplankton. Red dot within the triangles indicates the theoretical solution to the artificial mixtures.*

First, we represented the theoretical result from the mixtures as a red dot within the triangle. This shows the ideal position where the proportions of artificial mixtures that we have created in the laboratory should fall. For example, in Figure 5, the red dot is closer to the top angle because *Metridium Senile* is contributing with 60% to the mixture and the other two end members only with 20%. Considering this information, the amino acid values can be studied. The better the discriminating power of the amino acid the higher the likelihood to cross the theoretical solution (red dot). Therefore, we will add a ranking to each amino acid per artificial sample and organize them on a heat map plot. This classification will allow to narrow down which amino acids work better to discriminate each endmember. Then, the unmixing model FingerPro will be implemented.

After this refinement, and with the validation of the new artificial mixtures, this unmixing procedure will be applied on the natural mixtures collected from the sediment trap samples for which $\delta^{15}N$ amino acid values are already available. The results from the fist unmixing trials offer already a promising path toward the use of this tool to differentiate the organic matter for faecal pellets form other sources of organic matter (*Figure 6*).

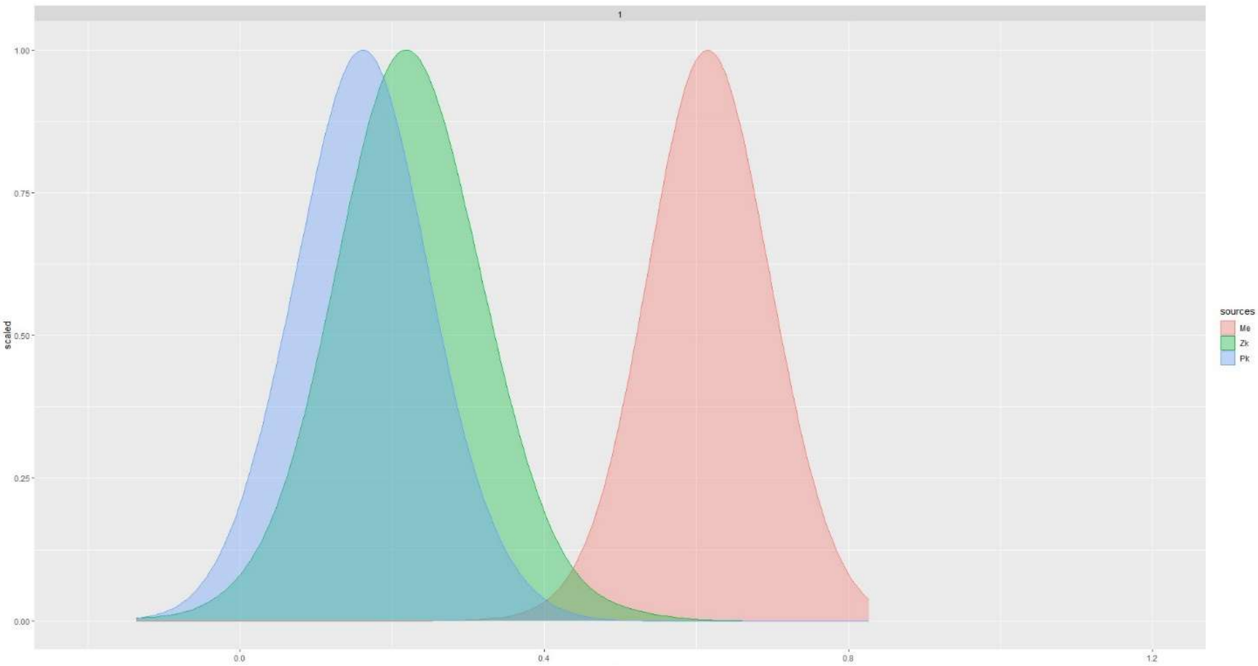

Figure 6 Unmixing results from an artificial laboratory mixture containing 3 sources of organic matter: 60% faecal pellets from Metridium senile*, 20% Zooplankton and 20% Phytoplankton. X- axis from 0 to 1 represents the contribution of each organic matter source.*

WP4. Fate of OM and FPs in OWF sediments

T4.1 Quantification of organic matter mineralization in close vicinity of the turbines

Oxygen profiles (Figure 7) in the sediment showed a clear distinction between samples collected at 7 and 15 m from the EPL and samples collected at 75 m: the profiles at 75 m are typical for permeable, well-oxygenated sediment where oxygen is not depleted in the first centimetre. However, at 7 and 15 m, the sediment was less oxygenated and oxygen was depleted between 4 and 9 mm sediment depth.

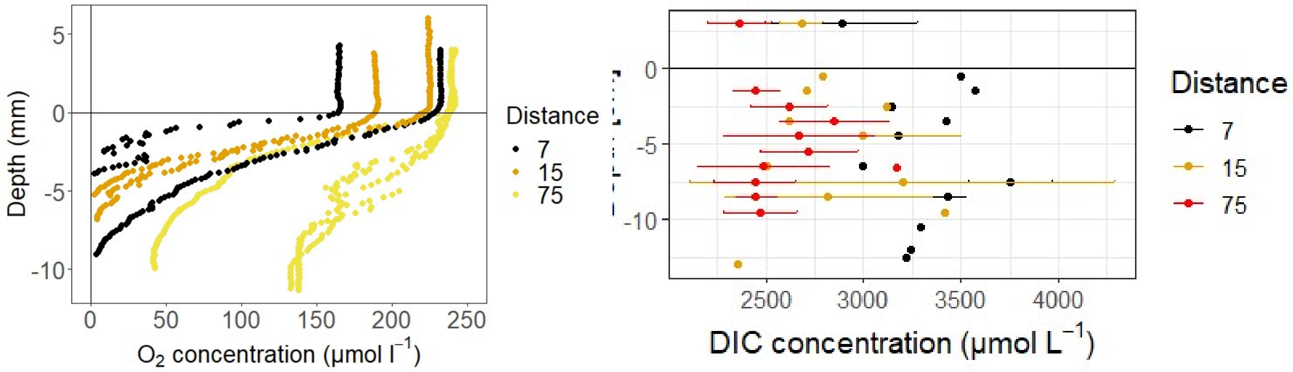

Figure 7: Oxygen sediment profiles (A) and DIC profiles in the sediment porewater (B)

DIC profiles in the porewater showed increasing concentrations with vicinity to the EPL, indicating DIC production resulting from organic matter mineralisation. However, the DIC profiles should, at least in the surface sediment, increase steadily with depth, which is not the case here. This is probably a result from the high permeability of the sediment, and downward porewater displacement during sampling.

Task 4.2: Estimation of blue carbon sequestration potential of OWF sediments

Seasonality in organic carbon content of the OWF sediment

In general, the pigment and TOC content of the sediments SW of turbine D5 in C-Power are very low (Figure 8). A clear seasonal signal is visible in the sediment profiles of pigments and TOC. In spring, higher pigment (fresh organic matter) and TOC (fresh and old organic matter) exhibit higher values in the sediments adjacent to the SPL of the turbine (≤ 25 m) compared to values at 75m from the turbine. At 7m from the SPL, pigment values are highest, also subsurface, but also very variable, indicating patchiness of fresh organic matter deposition.

In summer, the sediment TOC content, but especially the chl a content have drastically decreased, being similar to the values observed at 15 and 25m from the SPL. The degraded pigments ('phaeo') do show a subsurface peak at 7m from the SPL. Also TOC content still shows enriched sediments at 7 and 25m from the SPL.

In autumn, however, both chl a and degraded pigment contents are virtually zero at all sampled locations. Also TOC content has decreased further at all locations.

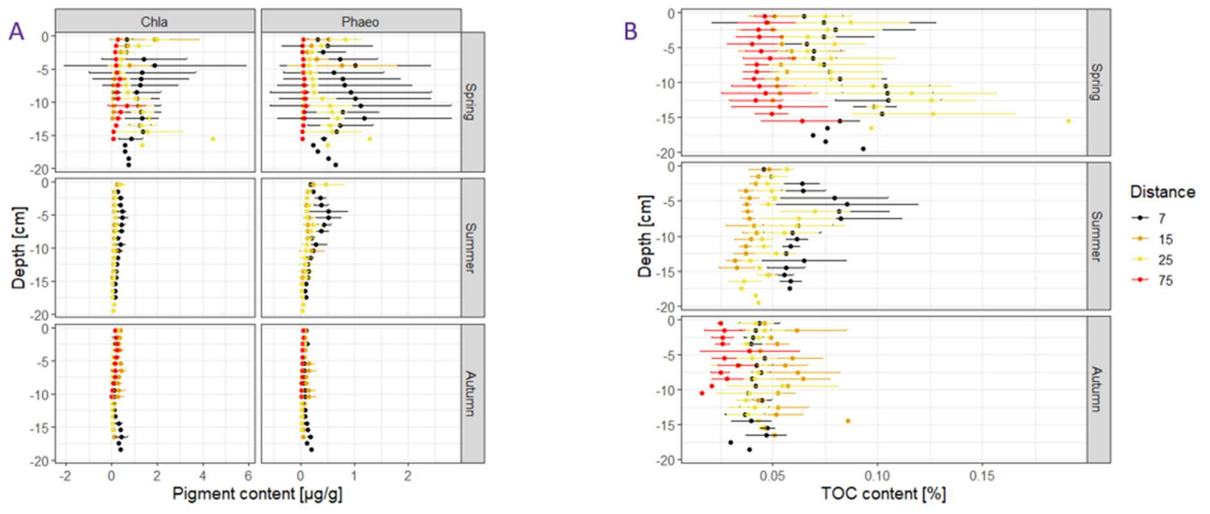

Figure 8: (A) Pigment content (chl a and degradation products 'phaeo') as µg per g dry mass of the sediment; (B) Total Organic Carbon content (%) of the sediment

Macrofauna biomass

Macrofauna was sampled in October 2022. Biomass was highest at 7 and 15m from the EPL (Figure 9 A), largely driven by the presence of the heart urchin *Echinocardium cordatum*. Excluding the heart urchin biomass (Figure 9 B), the highest biomass is still found at 7 m from the EPL.

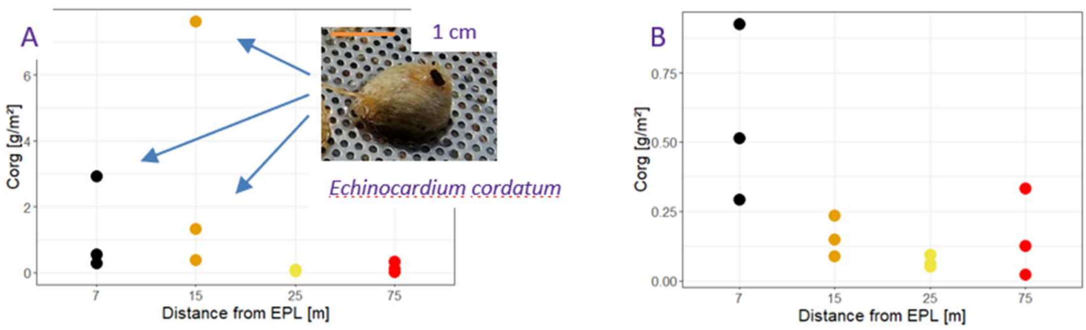

Figure 9: Macrofauna organic carbon biomass in mg m^{-2}, (A) total biomass and (B) total biomass excluding the heart urchin Echinocardium cordatum

Integration and spatial extrapolation of TOC and macrofauna Corg in the sediment

The local enrichment of the sediment in terms of TOC and macrofauna is restricted to the first 25m from the EPL. Macrofauna organic carbon biomass (on average 0.02 – 2.59 g Corg m^{-2}) is two orders of magnitude lower than that of the particulate organic carbon in the sediment (averaged over the three seasons 67 – 119 g Corg m^{-2}). In addition, the enrichment is clearly seasonally driven.

An extrapolation of TOC and macrofauna Corg is made for the high carbon season (spring) and low carbon season (autumn) (Figure 10). In spring (Figure 10 A), 2.65 ton organic carbon is found in the upper 10 cm of the sediment until 75 m from the EPL. Carbon content in the area < 25m is 20-39% higher than in the area > 25m. If we assume a homogenous carbon content across the area with radius 75m, the carbon content would have been 2.38 ton. The dynamics around the turbine and EPL layer as such lead to a 10% increase in TOC stock with respect to the area beyond 75m from the EPL.

In autumn (Figure 10 B), organic carbon content is lower: 1.67 ton TOC in the area within 75m from the EPL. In case no enrichment would have observed, the TOC content would have been 1.46 ton, meaning that the TOC stock is 13% increased with respect to the area beyond 75m from the EPL.

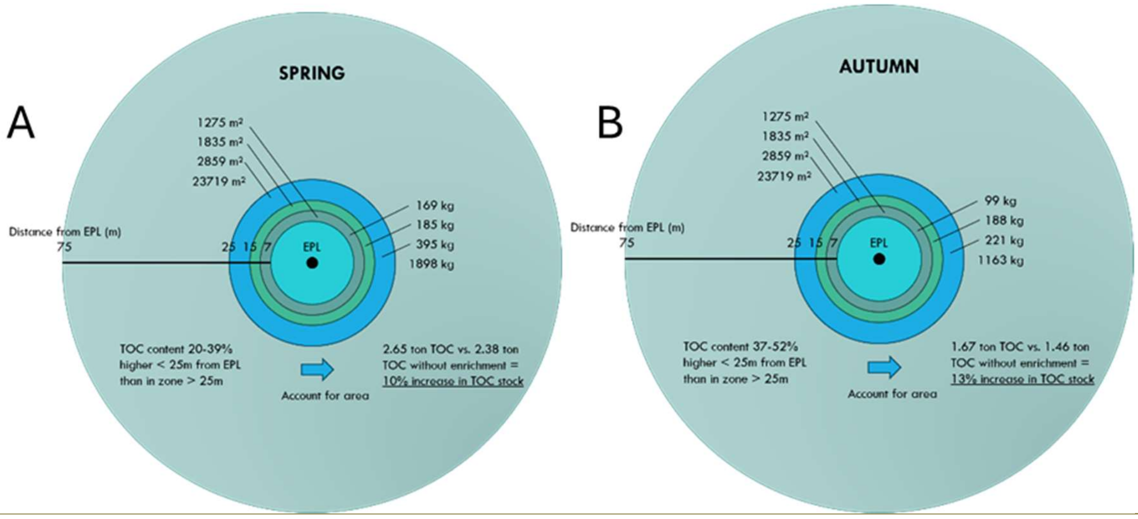

Figure 10: Blue carbon sequestration potential of OWF sediments: (A) in spring and (B) in autumn.

In summary, between spring and autumn, there can be a 10-13% increase in TOC stock (particulate organic carbon and macrobenthos) as opposed to background (> 75m from EPL) values. Note however, that this additional organic carbon is not permanently stored, so it is not carbon sequestration *sensu strictu*. The sediments around the turbines remain permeable, and as such prone to resuspension of stored organic carbon and rapid organic carbon mineralization. In addition, the future decommissioning of the OWF sites will also mean significant removal of the organic carbon that was temporarily stored.

Task 4.3: Tracing of faecal pellets in the benthic food web and the total C and N flux at the sediment-water interface.
After the pulse-chase experiment performed in October 2023, all the samples are being analysed and preliminary results can be reported. The sediment community oxygen consumption (SCOC) was calculated from the oxygen consumption recorded during the closed cores incubations performed after 1, 3 and 5 days of faecal pellet addition.

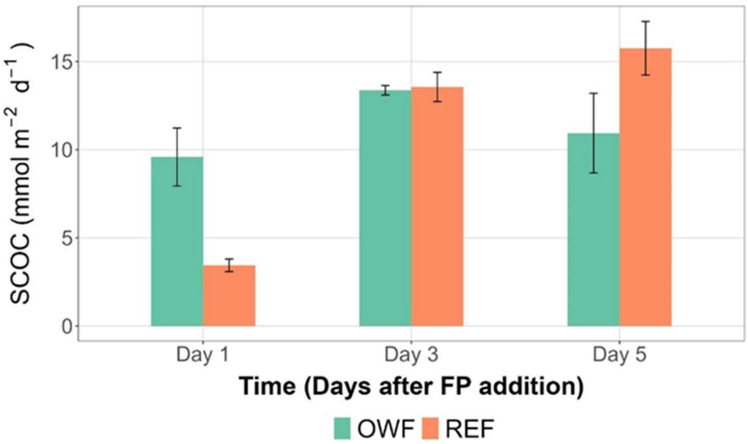

Figure 11. Sediment community oxygen consumption for the 3 times of closed core incubations after the addition of faecal pellets in the microcosms containing sediment from C-Power and a reference zone.

The two sediment types reacted differently to the addition of faecal pellets: while the OWF sediment had an immediate an continuous reaction to the faecal pellet addition, the reference sediment reacted much slower. Initially (day 1), SCOC was more than two times lower than in the OWF sediment, but then increased, being similar to OWF sediment at day 3 and even higher at day 5. (*Figure 11*). The rest of collected samples are being analysed at the moment and their data will be integrated to finally calculate a closed carbon budget taking into account all of the sampled carbon pool within the system.

WP7. Data Management
In order to integrate experimental data together with environmental data, a fit for purpose database is being set-up in the scope of OUTFLOW project. IDOD the current Belgian oceanographic database is therefore not anymore the target database for OUTFLOW data. The data management of the project is being handled through similar workflow than through IDOD i.e. with data transferred via annotated common layouts (data templates) and incorporated into the database. Dissemination thought interoperable repositories (SeaDataNet CDIs service) will happen (where possible) only when the complete datasets will be transferred, validated and ingested into the database. As lab analyses are still being conducted, data curation for preservation and dissemination through the described workflow are pending data delivery.
Following deliverables:

- *Deliverable 7.1.1*. is an annotated database, incorporated in IDOD and distributed through

SeaDataCloud (Month 48).
- *Deliverable* 7.2.1. consists of a publicly available MS Access Database with experimental OUTFLOW data (Month 48)

are therefore updated and rescheduled to the end of the project as the data handling is pending that all samples will be processed in lab, formatted, curated, ingested in the developed database and further disseminate to interoperable repositories and FAIR metadata catalogue.

WP 8: Valorisation, dissemination, exploitation of results

Task 8.3 Communication with fellow scientists

The results of the OUTFLOW project have been communicated at several (inter)national conferences (see section 7.2).

Through these communications, it has become clear that the OUTFLOW participants have a leading role in research on the functionalm effects of offshore wind farms in the marine environment. In addition, the data collected in this (and previous Belspo-funded) projects represent one of the only datasets that can be used for a functional upscaling of the local effects or can be applied in research on emerging renewable energy technologies (i.e floating solar panels). As such, members of the OUTFLOW consortium actively contribute to externally funded projects (NESTORE (funding: France), ECOSTAR (funding: UK), EcoMPV and OWiDEX (funding: Energy Transition Fund). Currently submitted project proposals contributing to the valorisation/exploitation of OUTFLOW data and expertise include Atlantis and SWiM. Finally, OUTFLOW contributes to the FedTWIN projects of OUTFLOW scientists Ulrike Braeckman (FedTWIN METRIC) and Arthur Capet (FedTWIN RECAP).

4. PRELIMINARY CONCLUSIONS AND RECOMMANDATIONS

The main preliminary conclusion so far is the confirmation that the presence of wind turbines leads to an accumulation of carbon in the sediments close by these structures. Absolute values depend on timing of the year, but are always 10-13% higher compared to reference situations. The final OUTFLOW year will confirm whether this is related to the presence of fouling fauna on the turbines, and whether this is relevant at a larger scale.

5. FUTURE PROSPECTS AND PLANNING

Overview of the foreseen activities and planning for the next reporting period, taking into account the current state of the work and the intermediary results

WP 1. Methodological Developments

Task 1.1. Isotopic tracer development

The isotopic tracer development has been completed. The discrimination power of each amin acid as well as the valorisation of the technique is now being tested with the artificial samples and their unmixing analysis. The next step constitutes a crucial moment to narrow the selection and report the combination of amino acids to use to discriminate each source of organic matter as well as its stability per season.

WP2. Contribution of faecal pellets to the organic matter pool in the offshore wind farms

Task 2.2: Estimating the contribution of FPs to the total OWF OM pool

The last steps include the final implementation on the newly created artificial mixtures and application of the unmixing model FingerPro on the natural abundance samples collected from the suspended matter and sediment trap for which δ^{15} N isotopic ratios are already available on the dataset.

WP3. Spatial patterns in OM distribution of FPs

Task 3.2: Dispersion at the OWF scale

The execution of this task has been delayed and will be performed in the second quarter of 2024. The results of this task will be used for the upscaling of the results for the entire North Sea.

WP 4: Fate of OM and FPs in OWF sediments

Task 4.1: Quantification of organic matter mineralization in close vicinity of the turbines

The collected sediment profiles of dissolved inorganic nitrogen (NHx, NOx, O2), TOC and porosity will be used to calibrate the sediment biogeochemical model OMEXDIA in spring 2024. From the model, estimates of nitrification, denitrification and total organic carbon mineralization rate will be derived for the four locations and three seasons on the gradient SW of turbine D5 in C-Power.

Task 4.2: Estimation of blue carbon sequestration potential of OWF sediments

Recalculation of the blue carbon sequestration potential of OWF sediments with the correct area (ellipses instead of circles), based on the information from task 3.1. This estimate will be compared to the organic carbon input derived from the sediment trap.

Task 4.3: Tracing of faecal pellets in the benthic food web and the total C and N flux at the sediment-water interface

The next step to follow is to finalise the analyses of the samples taken during the experiment (task expected to be completed by April 2024). After that, the analysis of the data will lead to an integrated carbon budget of the offshore wind farm compared to the reference sediment, taking into account the addition of the carbon source from the faecal pellets.

WP 5 Spatial upscaling and OWF scenarios

As this WP will provide the integration of the different data streams, it will start early in year 4 of the project, with an internal workshop on data needs (generated both within the project and data to be collected from external sources). This will then determine the modeling needs (modules of COHERENS). Members of the follow-up committee will be asked for input for defining relevant scenarios for model application.

WP7 Data Management

Task 7.1: Data management of environmental data

The second part of the sediment dataset will be formatted and provided by the data originator as soon as the lab processing will be done. Transferred data will be curated and ingested in the database by the responsible data manager. The database in development will be further normalized and enriched with standard vocabularies to ensure database consistency and consolidation. The web application will be further developed to a minima allows handy upload of the dataset through the dashboard. The dataset will be described with their metadata following a metadata template and will be openly published with the data on the RBINS metadata portal for dissemination and for achieving FAIRness of the dataset. Standardized data will be further disseminate to interoperable repository (SeaDataNet CDI service) where possible (i.e. for data types and parameters accepted by the repository).

Task 7.2: Data management of experimental data
Formatted experimental data performed on biota and biological communities will be further provided by the responsible scientist when lab analyses will be completed. Transferred data will be curated and ingested in the developed database. The database and web application developments will be further tailored according the data type constraints. The dataset metadata will be provided as well to be published on the RBINS metadata portal in accordance with the open research and FAIR principles similarly to the environmental data.

6. FOLLOW-UP COMMITTEE

Date(s) of the meeting(s) and overview of the concrete contributions of the follow-up committee

Date meeting: 20 December 2023, hosted by the ISOFYS lab.
Main input of the follow-up committee was on the workpackage on carbon accumulation:

- suggestions to use sediment trap data to estimate carbon sediment rate. Calculate mass deposition rate and use porosity to estimate sediment deposition rates.
- OMEXDIA a modeling tool for sediment processes is difficult in permeable sediment, but can be applied when irrigation terms are adjusted (sediment depth and irrigation rate). Sediment depth can be derived from nutrient profiles
- Make comparisons with other habitats (including terrestrial habitat) after upscaling to provide context for the estimates

7. VALORISATION ACTIVITIES

7.1. PUBLICATIONS

NA

7.2. PARTICIPATION/ORGANISATION OF SEMINARS (NATIONAL/INTERNATIONAL)

Oral presentations, posters… and/or organisation of workshops, conferences, etc.

2023

BASIS symposium (Gent, Belgium; 20.04.2023)

- Esther Cepeda Gammella et al. Use of compound-specific stable isotope analysis of amino acids to estimate the contribution of fouling fauna to the marine organic matter pool in offshore wind farms.

(20.04.2023). Ort

-

ASLO Aquatic Science Meeting (Palma de Mallorca, Spain, 04-09.06.2023

- Esther Cepeda Gamella et al. Stable isotope fingerprinting through amino acid content in faecal pellets of fouling fauna from offshore wind farms. Oral presentation
- Vanaverbeke J, Voet H, Vlaminck E, Van Colen C, Moens T, Braeckman U. Climate change can modify the effect of offshore wind farm fouling fauna on the marine ecosystem. Poster presentation

-

SIME: (Glasgow, UK, 28.06.2023)

- Esther Cepeda Gamella et al. Towards assessing fouling fauna contribution to the organic matter pool of an offshore wind farm by their faecal pellet production. Oral presentation
- Esther Cepeda Gamella et al. First steps to assess faecal pellet contribution from fouling fauna to the organic matter pool of an offshore wind farm. Poster presentation

-

ICES Annual Science Conference 2023 (Bilbao, Spain, 11-14.09.2023)

- Ester Cepeda Gamella et al A fingerprinting approach to unravel the contributions to the organic matter pool at an offshore wind farm. Presenter: Esther Cepeda Gamella et al (13.09.2023)
- Jan Vanaverbeke et al. The scour protection layer as 'easy' tool for incorporating the nature inclusive design principle in offshore wind farm construction.
- Jan Vanaverbeke: Ecosystem science needed to support a new era of offshore marine renewable energy. Session co-chair

Conference on Wildlife and Wind 2023 (Sibenik, Croatie, 18-22.09.2023)

- Van Duren et al (with Jan Vanaverbeke) : Ecosystem effects of large-scale implementation of offshore wind in the North Sea. (poster presentation)

Noordzeedagen 2023 (Texel, The Netherlands, 28-29.09.2023)

- Hendriks et al. (with Jan Vanaverbeke). . The impact of offshore wind turbines on local hydrodynamics and stratification in the North Sea.

2024

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INSITE meeting (Aberdeen, UK, 25.01.2024)

- Esther Cepeda Gamella et al. INSITE-OUTFLOW: Quantifying the contribution of fouling fauna to the local carbon budget of an offshore wind farm. Oral presentation

VLIZ Marine Science Day (Oostende, Belgium, 06.03.2024)

- Poster presentation at VLIZ Marine Science Day (Oostende, Belgium). Tracking labelled Faecal Pellets and their effect on carbon dynamics in Offshore Wind Farms sediments. (06.03.2024)

De Blauwe Cluster – Blue Session Ecosysteembenadering (Oostende, 01.02.2024)

- Jan Vanaverbeke – panelist discussion ecosystem approach in blue economy developments

7.3. SUPPORT TO DECISION MAKING (IF APPLICABLE)

OUTFLOW scientist and data are supporting the development of the Roadmap on Offshore Renewable Energy by the International Council for the Exploration of the Sea (ICES).

7.4. OTHER

OUTFLOW scientists (Ulrike Braeckman, Esther Cepeda Gamella, Jan Vanaverbeke) supported the production of a television documentary produced for ARTE.

8. ENCOUNTERED PROBLEMS AND SOLUTIONS

Encountered problems/obstacles, implemented and/or considered solutions, if any.

1. An encountered problem this year was the use of isopropanol containing 30 % of water during the amino acid extraction of the artificial mixtures. This led to loss of amino acids during the procedure as the presence of water prevents amino acid derivatization. Double effort and time are necessary to produce new artificial mixtures. Additional samples were collected for this purpose in March 2024 and prepared for lab analysis. These additional data will serve the initial goal of identifying suitable amino acids as fingerprinting tool.

2. During the follow-up committee meeting in December 2022, it was suggested to take additional measurements to facilitate calibration of the sediment biogeochemical model OMEXDIA (Task 4.1). Since we only had shiptime with scientific divers in October 2023, this caused a delay in data acquisition. OMEXDIA calibration is now scheduled for April-May 2024,

3. The plans of the Belgian government to move forward with the building of the energy island came with a significant additional workload for some of the OUTFLOW participants. This lead to a delay in Task 3.2. As this task informs WP4 and 5, the coordinator will organize regular meetings with all scientists involved. The first meetings will be planned very early in the last year of the project. Progress will be closely monitored to make efficient use of the remaining time.

9. POSSIBLE MODIFICATIONS COMPARED TO THE PREVIOUS REPORT

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10. REMARKS and SUGGESTIONS

Concerning for example: the coordination, the use or valorisation of the results, personnel change …

NA