

FINAL REPORT PROGRAM LEFE
Two pages to be written in English

Program LEFE/ action(s) CYBER	Project Title DEFINE2 – Diazotroph activity and diversity shaped by fine scale ocean dynamics	Years 2022 – 2023
<p>PI name, email and lab: Mar Benavides, mar.benavides@ird.fr, MIO</p> <p>Participating Laboratories:</p> <ul style="list-style-type: none"> • LEGOS (France) • LOPS (France) • Universidad Las Palmas Gran Canaria (Spain) 	<p>Contribution to:</p> <ul style="list-style-type: none"> • SWOT-the Surface Water and Ocean Topography Adopt-A-Crossover (AdAC) • LEFE (Gourdeau, Cravatte, LEGOS): SWOT-NC- Internal tides and mesoscale structures interactions south of New Caledonia • LEFE (Carracedo, LOPS): CARING-Carbon irrigation to the North-Atlantic by the Gulf stream • Plan Nacional (Javier Arístegui, ULPGC, Spain): eIMPACT- Biogeochemical impact of mesoscale and sub-mesoscale processes along the life history of cyclonic and anticyclonic eddies <p>Other funding sources:</p> <ul style="list-style-type: none"> • ANR-JCJC (Benavides, MIO): FIESTA-FInE scale dynamics of diazoTrophs in the ocean • EuroFleets cruise (Benavides, MIO): FIGURE- Fine scales shaping nitrogen fixation in the Gulf stream 	

Context (2-3 lignes)

Dynamic ‘fine-scale’ structures stir the surface ocean altering biogeochemical gradients, but their role in diazotroph is unknown. Traditional low-resolution methods do not to cover the fine-scale. DEFINE2 implements high-resolution measurements to constrain the role of fine-scales in N₂ fixation inputs in the N Atlantic and S Pacific Oceans.

Objectives / scientific questions (2-3 lignes)

The overarching objective of DEFINE2 is to unveil the effect of fine-scales on diazotrophy and their ultimate impact on nitrogen inputs to the ocean.

Main results

- N₂ fixation rates vary significantly at the fine-scale, showing different magnitude among structures
- Diazotroph species have affinity for fine-scale structures

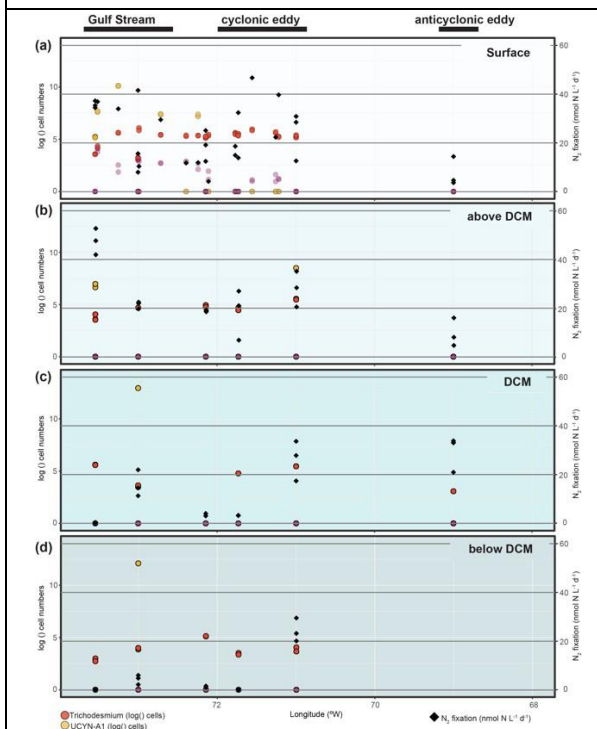


Fig. 1: Bulk N₂ fixation rates and cell abundances of *Trichodesmium*, UCYN-A1 and Gamma-A at (a) surface, (b) above DCM, (c) DCM and (d) below DCM during the FIGURE cruise in the Gulf Stream.

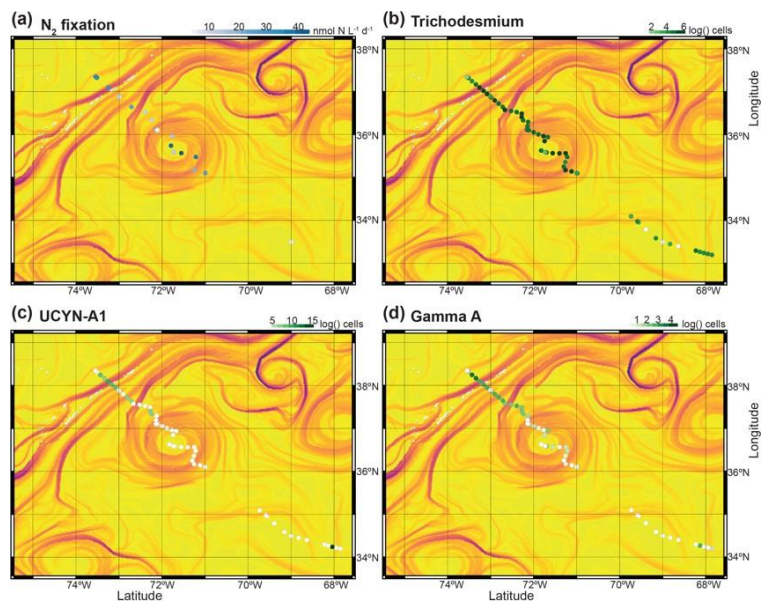


Fig. 2: N₂ fixation (a) and cell abundance of diazotroph species (b-d) quantified by qPCR assays against finite size Lyapunov exponents (FSLE) during the FIGURE cruise in the Gulf Stream.

Commentaires sur les illustrations 1 et 2, liées aux résultats principaux

During the FIGURE cruise, we observed highest N₂ fixation rates above the DCM in the Gulf Stream (up to 47-52 nmol N L⁻¹ d⁻¹) where we also detected *Trichodesmium* and UCYN-A1 via qPCR assays (Fig. 1). We detected N₂ fixation most consistently at the edge of the cyclonic eddy across all depth layers which aligns with consistent detection of *Trichodesmium* cells. While rates in an anticyclonic eddy were low at the surface, they increased toward deeper layers (Fig. 1). Considering the diazotroph species distribution (Fig. 2), we contend that N₂ fixation in the Gulf Stream is driven by a diverse diazotrophic community composition of small unicellular diazotrophs (UCYN-A and Gamma-A) and *Trichodesmium*. Further, *Trichodesmium* abundance is likely positively affected by physical advection by eddy activity into the North Atlantic Subtropical gyre. The shared contribution of different diazotroph species to the bulk N₂ fixation rates observed along with timescales of species advection by physical dynamics is currently under investigation with modelling approaches and genomic analyses. The regional contribution of fine-scale structures to nitrogen inputs will be evaluated with geostatistical analyses comparing N₂ fixation fine-scale affected vs non-affected water masses.

Future of the project

Current sampling and data analysis status

Cruise	Sampling	Physics	N ₂ fixation rates	<i>nifH</i> gene sequencing	<i>nifH</i> gene counts
eIMPACT legs 1+2	Done	Done	In preparation	In preparation	In preparation
FIGURE	Done	Done	Done	In preparation	Done
SWOTALIS	April 2023	-	-	-	-

Number of publications, communications and theses

Publications related to the previous LEFE project DEFINE1:

- Benavides, M., Conradt, L., Bonnet, S., Berman-Frank, I., Barrillon, S., Petrenko, A. and Doglioli, A. M. (2021) "Fine scale sampling unveils diazotroph patchiness in the South Pacific Ocean," ISME Communications, pp. 1–6. doi: 10.1038/s43705-021-00006-2.
- Benavides, M. and Robidart, J. (2020) "Bridging the Spatiotemporal Gap in Diazotroph Activity and Diversity With High-Resolution Measurements," *Frontiers in Marine Science*, 7. doi: 10.3389/fmars.2020.568876.

Manuscripts in preparation lead by PostDoc researcher C. Hörstmann associated with the project:

- Hörstmann, C., Barrillon, S., Grosso, O., Carpaneto-Bastos, C., Le Bihan, C., Aguiar-González, B., Pérez-Hernández, M.D., Carracedo, L., Benavides, M. Fine-scale diazotroph connectomics across the Gulf Stream and its eddies.
- Hörstmann, C., Chowdhury, S., Carpaneto-Bastos, C., Cerdan-Garcia, E., Grosso, O., Álvarez-Salgado, X.A., Aristegui, J., Benavides, M. Microbial interactions driving N₂ fixation in aging eddies.

Contributions to conferences:

- Benavides, M. Invited keynote: Fine-scale dynamics of N₂ fixation in ocean. FilaChange workshop, Sorbonne Université, Paris, France.
- Hörstmann, C., Barrillon, S., Grosso, O., Benavides, M. Poster: Diazotrophs' diversity and activity mapped across fine-scale structures of the Gulf Stream and associated eddies. FilaChange workshop, Paris, France.
- Hörstmann, C., Barrillon, S., Grosso, O., Carpaneto-Bastos, C., Le Bihan, C., Aguiar-González, B., Pérez-Hernández, M.D., Carracedo, L., Benavides, M. Oral presentation: Fine-scale diazotroph connectomics across the Gulf Stream and its eddies. ASLO meeting, Mallorca, Spain.

Data availability

FIGURE cruise:

- Cruise information <https://campagnes.flotteoceanographique.fr/campagnes/18002940/>
- N₂ fixation rates are currently under validation in SEANOE
- SADCP data <https://cloud.emodnet-ingestion.eu/index.php/s/lzLDOSTI7SzwMu>
- CTD data are waiting to be validated by LOPS before submission to EMODnet
- *nifH* gene sequence data will be submitted to ENA or NCBI after publication

e-IMPACT cruise:

- N₂ fixation rate and *nifH* gene analyses are currently in progress
- CTD and SADCP data are held by our collaborators at the University of Las Palmas de Gran Canaria

