

## PROPOSITION DE SUJET DE THESE

Formulaire demande de financement : ARED - ISblue – Etablissement(s) - ...

pour dépôt sur le serveur [SML — TEBL \(doctorat-bretagne.oreil.fr\)](http://SML — TEBL (doctorat-bretagne.oreil.fr)) au format PDF

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Acronyme : PrOMi

### Présentation de l'établissement porteur (bénéficiaire de l'aide régionale)

Établissement porteur du projet : UBO  UBS  Institut Agro Rennes

IMTA  ENSTA  ENIB

Ecole Doctorale : EDSML

SPI BZH  SPIN  MATHSTIC Bretagne Océane  pour les projets ISblue

### Identification du projet

Project title	The optic properties of diatom microalgae: use in bioinspired photonics and role in coastal ecophysiology.
Family name	LAVAUD
First name	Johann

### Demande d'ARED

*Se reporter à la notice ARED Région Bretagne et préciser :*

Priorité régionale	/
DIS	D1-Economie maritime pour une croissance bleue
Levier thématique	1-6-Bioressources et biotechnologies marines
DIS secondaire	D1-Economie maritime pour une croissance bleue
Levier thématique secondaire	1-5-Environnement, santé des océans et gestion du littoral
Axe transversal	/

### Organisme de tutelle : encadrement et unité de recherche

#### Porteur du projet HDR

Date obtention de l'HDR	2015
Nom	LAVAUD

Prénom	Johann
Adresse électronique	johann.lavaud@univ-brest.fr
Tel	02 98 49 87 95
Expérience d'encadrement	<p>Currently, I am directing a thesis at LEMAR (Anna Isaia) and I am co-directing a thesis at Laval University at my former assignment (UMI Takuvik CNRS-ULaval) which I left in June 2020 to return to France (at LEMAR laboratory). This thesis in Canada is currently being finalized (defense in February 2023). At the beginning of the academic year 2023, only Anna Isaia's thesis will be in progress (defense in December 2025).</p> <p><b>Direction:</b>  -Anna Isaia: 2022-25, UBO, funding 50% ARED/UBO + 50% EDSML/UBO, subject: 'Effect of the Light spectrum on the photobiology of the Microphytobenthos in the Rade de Brest: implications for coastal primary productivity'.  -Sébastien Guérin: 2018-2023 (defense February 27, 2023), Université Laval-Canada (IRL Takuvik CNRS-ULaval), co-supervision with Marcel Babin, funding: Sentinel North-Apogee Canada-Canadian Research Excellence Fund research program (coord. J. Lavaud), subject: 'Photoregulation in the polar diatom <i>Fragilariopsis cylindrus</i>: photoacclimation, carotenoid synthesis and circadian rhythmicity'.</p> <p><b>Scientific co-supervision:</b>  -Anne Pajot: 2019-2022, Ifremer Nantes, thesis supervisors: Luc Marchal and Elodie Nicolau, funding: Ifremer Nantes and University of Nantes, subject: 'Influence of illumination and N and P bioavailability on the biosynthesis and extraction of metabolites of interest in a tropical microalga', currently: post-doctoral fellow at CEA Cadarache-France.  -Juan Du: 2019-2023, University of Quebec at Montreal-Canada, thesis supervisor: Philippe Juneau, funding: Fisheries and Ocean Canada and NSERC Canada (coord. P. Juneau), subject: 'Contaminants in Arctic waters and ecotoxicology of Arctic phytoplankton', currently a post-doc in China.  Marlène Bonnanfant: 2018-2020, University of Nantes, PhD supervisor: Jean-Luc Mouget, funding: Pays de la Loire region, subject: 'Optimization of microalgae cultures in photobioreactors for the production of high value-added biomass', currently: project leader for algoculture at CEVA-Centre d'Etude et de Valorisation des Algues, France  -Lander Blommaert: 2011-2017, University of Ghent-Belgium, supervisors: Koen Sabbe and Wim Vyverman, funding: University of Ghent, subject: 'Photoprotection in intertidal benthic diatoms', currently: 'educator' at the Botanical Garden Meise-University of Ghent, Belgium.</p>

### Unité de recherche

Nom de l'unité	LEMAR-Laboratoire des Sciences de l'Environnement Marin
Acronyme de l'Unité (umr xx, ....)	UMR6539

Nom et prénom du responsable	Géraldine Sarthou
Le cas échéant, nom de l'équipe de recherche	PANORAMA
Le cas échéant, nom du responsable de l'équipe de recherche	Hélène Hégaret, Caroline Fabioux et David Mazurais

**Co-directeur de thèse – si nécessaire**

Nom	HEGGARTY
Prénom	Kevin
Unité de recherche	Département d'Optique
Etablissement de tutelle	IMT Atlantique
Expérience d'encadrement	<p>At the beginning of the academic year 2023, only Florie Ogor's thesis will be in progress (defense in December 2024).</p> <p><b>Direction-In progress:</b></p> <ul style="list-style-type: none"> <li>-Florie Ogor: 2021-24, 'Rapid additive nano-fabrication, by massively parallelized multi-photon polymerization (MPP), of 3D micro- and nano-structures for photonic and bio-medical applications', IMT Future and Ruptures funding.</li> <li>-Thomas Barbottin : 2020-23, 'Study, prototyping and demonstration of the contributions of diffractive optics in automotive applications: structured lighting/signalling, holographic display, LED and laser beam shaping', CIFRE funding.</li> <li>-Soukaina Chakir: 2018-23, 'Design, prototyping and characterization of compact, high view angle, 3D, Head Up Displays (HUD) for automotive applications, CIFRE funding.</li> </ul> <p><b>Direction-Completed:</b></p> <ul style="list-style-type: none"> <li>-Luis Perez Covarrubias: 2018-21, 'Optimization of the photochemical massively parallel writing process and performance of an ultra-fast 3D nano printer', H2020 funding (Phenomenon project), currently in R&amp;D position in Germany.</li> <li>-Qiang Song: 2017-2020, 'Design of synthetic diffractive structures for 3D visualization applications and their fabrication by a novel parallel-write two-photon polymerization process', Carnot and ARED funding, currently in post-doc in China.</li> <li>-Yoran-Eli Pigeon: 2016-2019, 'Massively parallel, multiresolution and multidepth phototracing of diffractive microstructures and nanostructures for antifraud applications', CIFRE funding.</li> <li>-Julien Le Meur: 2015-18, 'Design, assembly, optimization and testing of integrated structured illumination modules based on diffractive optical elements: specific application to facial recognition', ANR funding, current status unknown.</li> <li>Khalil Chikha: 2014-2016, 'Modeling, design, fabrication and large-scale replication of deep diffractive optical elements for anti-fraud applications', CIFRE funding, currently in R&amp;D position in France.</li> </ul>

**Co-encadrant (s) de thèse – si nécessaire**

Nom	LEYNAERT
Prénom	Aude
Unité de recherche	LEMAR, équipe CHIBIDO
Etablissement de tutelle	CNRS
Expérience d'encadrement	<p><b>Direction :</b></p> <p>-<u>Dongdong Zhu</u> : 2019-2023, 'Re-defining the benthic flux of biogenic silica and its role in the global marine silicon cycle', co-direction (30%), en co-tutelle avec l'Ocean University of China, financement: Région Bretagne et ANR.</p> <p>-<u>Natalia Llopis-Monferrer</u> : 2017-2020, 'Rhizaria: an unexpected role in the silica cycle?', direction (100%), financement : LabexMer/Région, actuellement en post doctorat aux USA.</p> <p><b>Scientific co-supervision :</b></p> <p>-<u>Maria Lopez Acosta</u> : 2015-2018, 'Silicon consumption by marine sponges', co-supervision (30%), financement: CSIC-Espagne, actuellement en post doctorat en Espagne.</p>

Nom	PONDAVEN
Prénom	Philippe
Unité de recherche	LEMAR, équipe DISCOVERY
Etablissement de tutelle	UBO
Expérience d'encadrement	<p><b>Current direction :</b></p> <p>-Laura Schweibold: 2021-2024, 'Spatial, seasonal and longer term variations of phytoplankton communities in Brest roadstead in relation to environmental variations', funding: ARED (50%) + BMO (50%).</p> <p>-Léa Bénito : 2022-2025, 'Study of the biological carbon pump in the Southern Ocean and North Atlantic by a multi-tracer approach', funding: ARED (50%) + EDSML/UBO (50%).</p>

**Description du projet : complément****Main location of the project in Brittany :**

The project will take place on two sites in the Brest-Iroise technology park, a few minutes' walk from each other: the LEMAR laboratory of the IUEM-Institut Universitaire Européen de la Mer (European University Institute of the Sea) and the Optics Department of the IMT Atlantique.

**Libellé (attention veiller à respecter le nombre de caractères imposés par le serveur de la Région)****Summary of the project (2 000 characters maximum)**

**Background:** Diatom microalgae provide a number of ecosystem services, especially in coastal environments, and their use in blue biotechnologies is booming<sup>1</sup>. Their trademark is a 3D silica

exoskeleton, the frustule, whose micro- and nano-structures, with unique optical properties, constitute perfect photonic biocrystals which are very close to those used for various advanced industrial applications (e.g. optic telecommunication).

**Objectives: 1)** to study the optical properties of diatoms, in particular those living in the Brest harbor, as an emerging bioresource of bioinspired photonic material, and **2)** to understand how these properties play a role in their productivity, and by extension the coastal primary production.

**Advances: 1)** better understanding of the know-how of diatoms in manipulating their light environment to improve their productivity and growth; **2)** screening of diatom biodiversity to develop a catalog of biomimetic templates for photonic applications; **3)** fabrication of bioinspired microlenses with specific optical properties of interest for industrial applications.

**Approach:** project at the interface Marine Biology-Physical Optics with a very complementary collaborative work between the LEMAR laboratory of IUEM and the Optics Department of ITM Atlantic.

Integrating effect: i) local: interactions between CNRS, ITM and UBO researchers; ii) regional: responses to several expected Briezhcop and DIS of the Brittany Region, links with SOMLIT and CPER Glaz Environnement; iii) national: collaborations with IFREMER and Nantes University; iv) international: collaborations in Portugal and Spain, strong complementarity with two EU Horizon projects.

**The future PhD student:** will work in an interdisciplinary and international framework in order to promote the development of his/her professional project: post-doctorate outside of France in one of the partner laboratories, acquisition of skills in fundamental and applied research in marine biology and photonic optics, in order to eventually consider a career in academic research or in R&D in the industrial field.

#### **Hypotheses, questions asked, sticking points, methodological approach, technique (4 000 characters maximum)**

**Finding and hypothesis:** The optical properties (absorption, reflectance, scattering, focusing, diffraction, transmission, filtration, reflection, iridescence, etc.) of the diatom frustule<sup>2</sup> allow certain wavelengths (e.g., blue light) to be focused within the cell<sup>3-6</sup>. Our current hypothesis is that the optical properties of the frustule would optimize the use of certain wavelengths for, in particular, photosynthetic productivity and growth. However, these optical properties have been very poorly studied, and even less so in an ecophysiological context: there are only two publications on the subject<sup>4,6</sup>, which precludes any reasonable extrapolation of the response of diatoms to the light climate of their natural habitat. The optical properties are due to the frustule structures that function as photonic biocrystals very similar to those used for advanced industrial applications<sup>5</sup>, i.e. quantum technologies. Thus, the optical know-how of diatoms is increasingly attractive for approaches in biomimetic photonics<sup>5</sup>. Given their tremendous diversity (>100,000 species), diatoms compose a bioresource of optical structures of interest that remains largely unexplored.

**Scientific questions:** PrOMi will answer two main interactive questions: **1)** how do diatoms, through their morphology, frustule structuring, and collective structuring (biofilm), manipulate their light environment to improve their productivity, **2)** what is the extent of the diversity of diatom optical know-how at the micro and nano scale, and how can we use it for bioinspired applications?

**Approach:** PrOMi is a project at the interface Biology-Physics with a pooling of expertise and complementary analytical means of LEMAR and ITM.

The work will be divided into two parts, themselves subdivided into two tasks:

V1 : Harvesting of the diatom bioresource in Brest harbor and characterization.

*T1.1 : Harvesting and culture of diatoms (LEMAR).*

*T1.2 : Analysis of cell morphology and micro/nano-structures of frustules (LEMAR+IMT).*

V1 will allow: i) to isolate and cultivate new diatom species; ii) to probe their optical diversity; iii) to analyze the frustule of the selected species by microscopic analysis of micro/nano-structures and 3D static and dynamic modeling.

V2: Analysis of the optical properties of the diatom bioresource and use in photonics.

*T2.1: Measurement of optical properties of living diatoms and their frustules (IMT+LEMAR).*

*T2.2: Fabrication of synthetic optical microstructures inspired by diatoms (ITM).*

Measurements of optical properties will be carried out: i) at two scales of organization: 'single cell' (CESAM Portugal), and population and community (IMEDEA Spain); ii) under different light conditions (several wavelengths, including blue). They will be completed by measurements of photosynthetic productivity (PAM fluorimetry).

Thus, we will be able to better understand, in particular, the modulation of 'collective' optical properties of diatoms, such as biofilms (e.g. iridescence<sup>7</sup>), and which are of interest for some applications (e.g. holography).

Fabrication (3D microprinting) of glass-like resin microlenses will use T1.2 templates. In the short term (FABulous 2023-27 project), 3D printing will move to the nano scale.

#### **Techniques :**

*-Reservoir of the diatom bioresource: the Brest roadstead.*

The diversity of habitats in the bay harbors a biodiversity that will allow us to scan a wide spectrum of morphologies and adaptation to different light spectra (subtidal, intertidal). We already use the sites of Lanvéoc and Daoulas Bay. We will also be able to use the collection of J. Lavaud (@20 species).

*-Analytical methodology:*

LEMAR and ITM have all the necessary logistics, in particular:

-LEMAR: quanta-, spectrophoto- and spectrocolori-meters; culture chambers and systems; fully adjustable LED panels; PAM fluorimeters; benchtop SEM.

-ITM: clean rooms (ISO 6); 3D micro printer; microscopes (including interferometric and SEM); optical bench with 7 different wavelengths.

-CESAM (T2.1-a) : 'single-cell'<sup>4</sup> measurements (Microscopy and Multicolor-PAM).

-IMEDEA (T2.1-b): measurements of 'collective' optical properties <sup>8</sup> (LISST particle analyzer and fluorescence videomicroscopy)<sup>9</sup>.

#### **Scientific environment, positioning in regional/national/international context (2 000 characters maximum)**

PrOMi will be operated by some of the ongoing (EC2CO LuMiÈre, EU Horizon FABulous) and upcoming (under arbitration) projects: EU Horizon REWRITE, ANR PEPR Cabestan, PHC Pessoa (France-Portugal) InterNano.

#### **Local and regional positioning:**

The LEMAR-IMT collaborative work and the feasibility and high potential of this project have been proven during the ISblue Emergence DiatOp 2021-23 project and an IUEM-funded M2 internship (2022). K. Heggarty (ITM) works on the printing of optical microstructures for applications via his industrial collaborations (e.g. Valeo). He has co-invented 6 patents, the last one in 2022. The planned follow-up to PrOMi will be an IMT-LEMAR/Industry Cifre grant.

#### **Regional and national positioning:**

PrOMi is strongly complementary to the EC2CO LuMiÈre 2021-24 project in which the ISOMER laboratory of Nantes University and IFREMER participate. We are working on the primary productivity of coastal sediments of the Atlantic coast which is largely supported by diatoms. The data from the PrOMi project will allow us to optimize our coupled biological-physical modeling of primary production<sup>10,11</sup>. PrOMi will also rely on i) SOMLIT and CPER Glaz Environnement (diversity and productivity data of benthic diatoms) at the Lanvéoc site, ii) Objectif Plancton (Fondation de France, Océanopolis) (diversity data of planktonic diatoms).

#### **European and international positioning :**

K. Heggarty is involved in the EU HORIZON FABulous project (2023-27). Its objective is to improve the fabrication of 3D 'metamaterials' to invent future high efficiency optical objects. It will propel ITM's 3D printing capabilities to the nano scale.

J. Lavaud is participating in the EU HORIZON REWRITE project (on the waiting list). Its objective is to generate new transdisciplinary approaches to provide concrete solutions for the rational management

of intertidal coastal sediments for a better co-benefit between ecological needs and societal expectations.

The PrOMi project fits ideally into this framework, and FABulous and REWRITE will strengthen the international dimension of our approach in the Brest harbor, as well as extend our European network.

### **Scientific collaborations (nature/partnership/country) and envisaged socio-economic partnership.**

Collaborations with :

-the '**Marine primary production**' laboratory, **CESAM-Center for Environmental and Marine Studies, University of Aveiro, Portugal**. Joao Serôdio is one of the international experts (>100 publications) on the photobiology of benthic diatoms<sup>3,4,6</sup>. Johannes Goessling's expertise concerns the optical properties of frustules. Some CESAM equipment complementary to LEMAR will be used during the thesis. The PhD student is expected to spend several weeks at CESAM (Campus France-PHC Pessoa InterNano submitted).

-the '**Physico-biological interactions in the ocean**' laboratory, **IMEDEA-Mediterranean Institute for Advanced Studies, University of the Balearic Islands, Spain**. Juan Salvador Font Munoz, former ISblue post-doc, is a physicist who uses optical methods to study the photobiology of diatoms. He works with Marc Sourisseau (IFREMER, Dyneco-Pelagos). Together, they have published pioneering work on the ability of planktonic pinnate diatoms in the Brest harbor to organize themselves collectively in the water according to their light environment (intensity and spectrum)<sup>8</sup>, which favors their reproduction and growth<sup>12</sup>.

The pooling of our complementary expertise will allow us to consolidate our regional/national approach and to open it up to the international level. J. Lavaud and K. Heggarty already collaborate with CESAM in several projects (ISblue Emergence DiatOp, EC2CO LuMiÈre, FCT Portugal SearchLight coordinated by J. Serôdio).

EU HORIZON FABulous : [https://www.einnews.com/pr\\_news/611581697/european-research-project-fabulous-aims-to-revolutionise-3d-metasurface-fabrication](https://www.einnews.com/pr_news/611581697/european-research-project-fabulous-aims-to-revolutionise-3d-metasurface-fabrication)

ISblue Emergence DiatOp : <https://www-iuem.univ-brest.fr/lemar/projets-scientifiques/diatop/>

EC2CO LuMiÈre : <https://www-iuem.univ-brest.fr/lemar/projets-scientifiques/lumiere/>

FCT Portugal SearchLight : <http://www.cesam.ua.pt/index.php?menu=198&language=eng&tabela=projectosdetail&projectid=1834>

### **Pour les demandes Région Bretagne**

#### **Suitability of the project with the DIS of Rattachement for the applications Region Brittany (3 000 characters maximum)**

The PrOMi project is in line with the Brittany regional strategy for research and innovation in the strategic innovation area 'Maritime economy for blue growth', and in particular the strategic objectives concerning the development of innovative approaches for coastal management and marine biotechnologies and bioresources, as well as the thematic lever 'Environment, ocean health and coastal management'. The PrOMi project is also in line with several of the BreizhCop's expectations: (1) international attractiveness, (2) presence and visibility of Brittany in Europe, (7) focusing research and innovation efforts on biodiversity issues, (8) accelerating the sustainable development of marine biotechnologies, (13) developing and exploiting the potential of solutions inspired by nature (biomimicry), (29) preserving the ecological functionality of natural environments.

#### **Si priorité régionale, préciser (200 caractères maximum)**

/

## Vous sollicitez un financement ISblue,

## Précisez le lien du sujet avec les thèmes ISblue

Thème ISblue	Thème principal	Thème secondaire (si nécessaire)	Autre (si nécessaire)
la régulation du climat par l'océan		X	
les interactions entre la Terre et l'océan			
la durabilité des systèmes côtiers			
l'océan vivant et les services écosystémiques	X		
les systèmes d'observation à long terme			

**Adequacy with theme 4: The living ocean and ecosystem services.**

The PrOMi project is, in particular, a blue economy project that proposes an original and unprecedented valorization of an invisible yet abundant bioresource that is fundamental to the proper functioning of the Brest harbor: diatom microalgae. This project proposes to develop a new approach in photonic optics based on interdisciplinary fundamental research, where marine biology interacts with physical optics, with bioinspired technical solutions based on the know-how of diatoms. One of the expectations of this thesis is the realization of a catalog of morphology and micro/nano-structures versus optical properties couples, based on the tremendous biodiversity of diatoms. They will serve as templates for the fabrication of new optical micro-objects for advanced industrial approaches, some of them with environmental implications, i.e. solar panels for example. Basic research data will help us in parallel, to better understand the ecophysiology of diatoms, essential primary producers, and how their individual and collective responses to their light environment regulate their primary productivity. This aspect of our knowledge is all the more important in coastal and estuarine environments where diatom productivity supports many socio-economic activities with a strong heritage emphasis, i.e. oyster farming for example.

**Expliquez/précisez en quelques lignes dans quelle mesure votre demande correspond à l'un ou plusieurs des critères ISblue ci-dessous :**
**1- Originality, potential impact of the project (4 lines max)**

**Originality:** an interdisciplinary approach at the biology-physics frontier combining fine fundamental analyses and potential applications in innovative blue biotechnologies. **Impacts:** 1) applications in bioinspired photonic optics, 2) a better assessment of marine primary production in the Brest harbor and in estuarine ecosystems.

**2- International positioning of the subject, cotutelle or international co-supervision (4 lines maximum)**

Through the partnership with CESAM-Portugal, IMEDEA-Spain and our EU Horizon projects, this project will position LEMAR, IMT Atlantique, ISblue and the Brittany Region on the European and international scene in coastal marine biology and marine biotechnology, i.e. understanding and using the know-how of bio-structures in the manipulation of light at micro & nano scale.

**3- Integrating effect between research units and / or interdisciplinarity (4 lines max)**

This project confirms our local and international interdisciplinary partnership started in 2021 between LEMAR and the Optics Department of ITM Atlantic, and CESAM-Portugal; collaborations with IFREMER, Nantes University, and IMEDEA-Spain ideally complete it. Interdisciplinarity: ecophysiology of microalgae, bio-optics/photronics, chemical (silica) and physical (light climate) oceanography.

**4- Potential for high-level insertion into the doctor's academic or non-academic community (4 lines max.)**

The PhD student will work in a strong interdisciplinary and international framework (Portugal and Spain)



which will allow him/her 1) to easily consider a post-doctoral stay in one of the partner laboratories outside of France, 2) to acquire skills in fundamental and applied research in order to consider, in the long run, a professional project in academic research or in R&D in the industrial field.

### Financement du projet de thèse

En cas de financement à 50 %, le cofinancement est-il déjà identifié (oui/non) : **OUI**.

Si oui, préciser la nature du cofinancement (ANR, partenaire privé, Ademe, etc.) : ARED ou EDSML ou BMO.

Si le cofinancement n'est pas encore confirmé, date prévue de réponse du cofinancier : février 2023 (EDSML), mai 2023 (ARED), juin 2023 (BMO).

En cas de non-obtention du cofinancement demandé, une autre source de cofinancement est-elle identifiée (oui/non) : **NON**.

Si oui, laquelle:/

Sollicitez-vous un co-financement Is-Blue (oui/non) ? **OUI**.

**Important : Veillez à bien compléter les différents co financements sollicités sur le serveur Thèses en Bretagne Loire lors du dépôt de votre dossier.**

### Projet de thèse en cotutelle internationale

S'agit-il d'un projet de thèse en cotutelle internationale dans le cadre d'une convention (oui/non) : **NON**.

Si oui, préciser l'établissement pressenti (et le pays de rattachement) : /

Ce projet de thèse fera-t-il l'objet d'un cofinancement international (oui/non) : **NON**.

*(Rémunération du doctorant par l'établissement implanté sur le territoire régional (18 mois sur 36 mois), et l'établissement étranger, qui s'engage également à rémunérer le doctorant dans le cadre de son séjour à l'étranger, soit durant 18 mois -a minima-)*

En cas de cofinancement international, préciser -si vous en avez connaissance- l'organisation du calendrier des périodes de séjour : /

Préciser quel est le stade du projet international (joindre une lettre d'engagement du partenaire)

### Vous sollicitez un financement UBO EDSML qui sera porté à la décision du Conseil de l'ED

Indiquez le ici,    oui     non     **et sur le serveur TEBL (indispensable)**

### Le candidat

**Desired candidate profile (major specialty/discipline, scientific and technical skills required):**

Given the positioning of the project at the Biology-Physics interface, the student should have a background in one of the two fields, specifically in marine biology or optics, and will be trained in the other field by one of the two partners, LEMAR or ITM. The student should be prepared to work in the laboratory as well as in the field (sampling in Brest harbour) and in an interdisciplinary and international context (stays in Portugal and Spain), and therefore with a good level of English.

Given the training in fundamental and applied research acquired by the doctoral student during the PrOMi project, he/she will easily be able to envisage, in the long term, a professional project in academic research

or in R&D in the industrial field, such as, for example, a start-up working on algae exploitation. The future of the PhD students (co-)supervised by J. Lavaud and K. Heggarty indeed concerns these two sectors and beyond, here are some recent examples:

- 2023, S. Guérin: post-doctorate at Laval University-Canada in fundamental research on arctic microalgae.
- 2023, A. Pajot: post-doctoral fellow at CEA Cadarache-France in applied research on microalgae (recombinant protein production).
- 2023, A. Barnett: business analyst at Amiltone; 2021-22: ATER Nantes University-France.
- 2022, Luis Adrian Pérez Covarrubias : process engineer at Multiphoton Optics GmbH-Germany.
- 2022, I. Doghri: 'knowledge mobilization adviser', Fonds de recherche du Québec-Canada; 2017-2021: post-doc at UQAM-Canada in microbiology.
- 2022, Khalil Chikha: R&D engineer ARRK Engineering GmbH-Germany; 2019-2021: Bosch Power Tools-Germany.
- 2021, L. Blommaert: educator, botanical garden of Meise-Belgium; 2019-2021: post-doc at NIOZ-Netherlands in applied macroalgal research.
- 2017, M. Pedrosa: professor, Federal University of Parana, Curitiba-Brazil.

## Références bibliographiques

### En gras les co-encadrants de la thèse et les collaborateurs au projet :

- [1] B. Lebreton, A. Rivaud, L. Picot, B. Prévost, L. Barillé, T. Sauzeau, J. Beseres Pollack, **J. Lavaud**, From ecological relevance of the ecosystem services concept to its sociopolitical use. The case study of intertidal bare mudflats in the Marennes-Oléron Bay, France, *Ocean Coast Manage*, 172 (2019) 41-54. <https://doi.org/10.1016/j.ocecoaman.2019.01.024>
- [2] **A. Leynaert**, C. Fardel, B. Beker, C. Soler, **G. Delebecq**, A. Lemerrier, **P. Pondaven**, P.E. Durand, **K. Heggarty**, Diatom frustules nanostructure in pelagic and benthic environments, *Silicon*, 10 (2018) 2701-2709. <https://hal.archives-ouvertes.fr/hal-02093104>
- [3] **J.W. Goessling**, Y. Yanyan Su, P. Cartaxana, C. Maibohm, L.F. Rickelt, E.C.L. Trampe, S.L. Walby, D. Wangpraseurt, X. Wu, M. Ellegaard, M. Kühn, Structure-based optics of centric diatom frustules: modulation of the *in vivo* light field for efficient diatom photosynthesis, *New Phytol.*, 219 (2018) 122-134. <https://doi.org/10.1111/nph.15149>
- [4] **J.W. Goessling**, S. Frankenbach, L. Ribeiro, **J. Serôdio**, M. Kühn, Modulation of the light field related to valve optical properties of raphid diatoms: implications for niche differentiation in the microphytobenthos, *Mar. Ecol. Progr. Ser.*, 588 (2018) 29-42. <https://doi.org/10.3354/meps12456>
- [5] **J.W. Goessling**, W.P. Wardley, M. Lopez-Garcia, Highly reproducible, bio-based slab photonic crystals grown by diatoms, *Adv. Sci.*, 7 (2020) 1903726. <https://doi.org/10.1002/advs.201903726>
- [6] E. De Tommasi, I. Ilaria Rea, M.A. Ferrara, L. De Stefano, M. De Stefano, A.Y. Al-Handal, M. Stamenković, A. Wulff, Underwater Light Manipulation by the Benthic Diatom *Ctenophora pulchella*: From PAR Efficient Collection to UVR Screening, *Nanomaterials*, 11 (2021) 2855.
- [7] B. Kientz, S. Luke, P. Vukusic, R. Péteri, C. Beaudry, T. Renault, D. Simon, T. Mignot, E. Rosenfeld, A unique self-organization of bacterial sub-communities creates iridescence in *Cellulophaga lytica* colony biofilms, *Sci. Rep.*, 6 (2016).
- [8] **J.S. Font-Muñoz**, M. Sourisseau, A. Cohen-Sánchez, I. Tuval, G. Basterretxea, Pelagic diatoms communicate through synchronized beacon natural fluorescence signaling, *Sci. Adv.*, 7 (2021). DOI: [10.1126/sciadv.abj5230](https://doi.org/10.1126/sciadv.abj5230)
- [9] **J.S. Font-Muñoz**, R. Jeanneret, I. Tuval, G. Basterretxea, Method for the determination of preferential orientation of marine particles from laser diffraction measurements, *Opt. Express*, 28 (2020). <https://doi.org/10.1364/OE.390388>
- [10] **V. Méléder**, R. Savelli, A. Barnett, P. Polseneare, P. Gernez, P. Cugier, A. Lerouxel, A. Le Bris, C. Dupuy, V. Le Fouest, **J. Lavaud**, Mapping the intertidal microphytobenthos Gross Primary Production. Part I: coupling multispectral remote sensing and physical modeling, *Frontiers Mar. Sci.*, 7 (2020) 520. <https://doi.org/10.3389/fmars.2020.00520>
- [11] R. Savelli, **V. Méléder**, P. Cugier, P. Polseneare, C. Dupuy, **J. Lavaud**, A. Barnett, V. Le Fouest, Mapping the intertidal microphytobenthos Gross Primary Production. Part II: merging remote sensing and physical-biological coupled modelling, *Frontiers Mar. Sci.*, 7 (2020). <https://doi.org/10.3389/fmars.2020.00521>

[12] **J.S. Font-Muñoz**, R. Jeanneret, J. Arrieta, S. Anglès, A. Jordi, I. Tuval, G. Basterretxea, Collective sinking promotes selective cell pairing in planktonic pennate diatoms, Proceedings of the National Academy of Sciences of the United States of America, 116 (2019) 15997–16002. <https://doi.org/10.1073/pnas.1904837116>

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