LABORATOIRE DE PLANÉTOLOGIE ET GÉOSCIENCES

Post-doc position

« Challenges for monitoring marine ecosystems using bio indicators based on benthic foraminifera »

Location : University of Angers in France

Laboratory : UMR 6112 CNRS LPG (Laboratory of Planetology and Geosciences) Located on the university science faculties of Nantes, Angers and Le Mans, the "Laboratoire de Planétologie et Géosciences" (LPG) is a multi-site Mixed Research Unit that is supported by the CNRS and the Universities of Nantes, Angers and Le Mans. . Its activities are divided into three research themes: Coastal and Marine Systems, Earth, and Planets and Moons. The post doc will be located at the University of Angers and integrated in the theme « **Coastal and Marine Systems ».**

Duration : 18 months (full time) **Supervisors** : C. Barras and E. Geslin

The scientific project is founded by the French ANR project **BioIndic-IA** dealing with « **Deep learning for automatic image-based biomonitoring of aquatic ecosystems ».** This global project is supervised by M. Laviale (LIEC, Lorraine University) in collaboration with different French (Marseille University CEREGE, Angers University LPG…) and Luxemburg (LIST) institutions. The post-doc grant is co-founded by the ANR and the University of Angers.

Scientific context of BioIndic-IA

Worldwide intensification of land and coastal use and aquatic resources has led to a drastic increase in the intensity and diversity of anthropogenic pressures, simultaneously driving changes in local biotic communities which ultimately impair ecosystem functioning and ecosystem services over multiple spatial and temporal scales. This highlights the **urgent need for developing innovative ecological diagnostic tools supporting robust management responses** to every pressure of human origin impairing the water physical and chemical quality and/or the integrity of habitats. Biomonitoring has been initially based on diversity indices, which rely on taxonomic inventories, and later on biotic indices, which combine the relative abundance of indicator species to their ecological profile, i.e. their sensitivity or tolerance to environmental variables. Within the European Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD), these approaches have already proven their efficiency for assessing the global ecological quality of water bodies using a given biological compartment, such as BENTHIC DIATOMS or BENTHIC FORAMINIFERA, that are both unicellular organisms with shells living on the bottom of aquatic ecosystems.

BENTHIC FORAMINIFERA-based indices are recent and still seldom included in regulatory ecological assessments despite their confirmed potential to track the ecological quality status of coastal ecosystems[1-3]. Besides taxonomy, the assessment of traits should be also now considered[4]. However using foraminiferal based indices and developing new tools based on traits are time consuming studies. This is a lock to include such relevant tools to European and National regulatory ecological assessments.

For any group of organisms, **classical bioindication relies on visual recognition by human experts of indicator species** based on morphological criteria (for foraminifera: chamber and aperture shape, texture of the test…). Some of these morphological traits hold more than just taxonomic information. Indeed, variability in traits can be observed across species (e.g. big vs. small species) but also at the intraspecific level (e.g. porosity for foraminiferal shell) in response to environmental changes[5-7]. However, manual identification of species or routine measurements of traits is too time-consuming, often subject to multiple biases (human expert's experience, imaging system quality) and requires a high level of expertise. Nevertheless, automatic **images acquisition and machine learning for identifying foraminiferal species and measuring morphological traits are promising methods.** State-of-the-art methods from artificial intelligence, such as deep learning based on convolutional neural networks (CNNs) can be used for taxonomic classification[8] and the quantification of morphological traits[9]. However, **the performance of these methods is strongly dependent on the availability and quality of curated image datasets** used for model training, a common bottleneck when implementing machine learning (ML) for ecological image automatic processing[10].

Project of the post-doc researcher

The post doc research is dealing with image acquisition, machine learning for automatic identification of species and traits of living benthic foraminifera. The objectives of the post-doc will be to:

1) **Improve the development of automatic image acquisition of living benthic foraminifera** using two methods: a low cost system based on 3D printer combined with a camera allowing to image the rose Bengal stained specimens AND a higher cost system based on automatic scanner coupled with an epifluorescent light allowing to image living specimens labelled with a fluorescent probe.
2) **Train and validate Machine Learning algorithms** based on an extensive quality-controlled labelled datasets at the species level for different study area of interest
3) **Quantify key morphological traits**
4) **Apply** our automatic approach to several case studies in the context of a regulatory (WFD, MFSD) foraminiferal-based biomonitoring approach.

References

1- **Jorissen et al.** 2018. Developing Foram-AMBI for biomonitoring in the Mediterranean: species assignments to ecological categories Mar Micropal 140: 33 10.1016/j.marmicro.2017.12.006
2- Sousa et al. 2020 Opportunities and challenges in incorporating benthic foraminifera in marine and coastal environmental biomonitoring of soft sediments: from sci. to regulation and practice. J Sediment Environ 5: 257 10.1007/s43217-020-00011-w
3- **Barras et al.** 2014 Live benthic foraminiferal faunas from the French Mediterranean Coast: Towards a new biotic index of environmental quality Ecol Indic 36: 719 10.1016/j.ecolind.2013.09.028
4- **Martini et al.** 2021 Functional trait-based approaches as a common framework for aquatic ecologists. Limnol Oceanogr 66: 965 10.1002/lno.11655
5- **Mondy & Usseglio-Polatera** 2013 Using conditional tree forests and life history traits to assess specific risks of stream degradation under multiple pressure scenario. Sci Tot Environ 461: 750 10.1016/j.scitotenv.2013.05.072
6- **Larras et al**. 2017 Assessing anthropogenic pressures on streams: A random forest approach based on benthic diatom communities. Sci Tot Environ 586: 1101 10.1016/j.scitotenv.2017.02.096

7- Glock et al. 2011 Environmental influences on the pore density of *Bolivina spissa* (Cushman). J Foram Res 41(1):22-32. 10.2113/gsjfr.41.1.22
8- **Marchant et al**. 2020 Automated analysis of foraminifera fossil records by image classification using a convolutional neural network. J Micropaleontol 39: 183 10.5194/jm-39-183-2020
9- **Orenstein et al**. 2022 Machine learning techniques to characterize functional traits of plankton from image data. Limnol Oceanogr 67: 1647-1669 10.1002/lno.12101.
10- Irisson et al. 2022 Machine Learning for the Study of Plankton and Marine Snow from Images. Ann Rev Mar Sci, 14: 277 10.1146/annurev-marine-041921-013023

Skills

Candidate should have a PhD on marine biology/ecology or geology (micropaleontology for example). It is important that the candidate has strong knowledge on taxonomic identification of micro-organisms particularly of benthic foraminifera. Indeed, the algorithms training is essentially based on human knowledge. Additionally, the researcher should be attracted by new technologies based on machine learning. Knowledge of Python language would be an additional value. Finally, to apply our automatic approach to several case studies in the context of biomonitoring, ecological knowledge of foraminifera is needed.

Applications

Application (including a CV, a 1-2 page cover letter and the contact information of two referees familiar with the applicant's research) should be sent as a single pdf file to Dr. C. Barras (E-mail: christine.barras@univ-angers.fr) and Pr. E. Geslin (E-mail : emmanuelle.geslin@univ-angers.fr). The closing date for applications is **20st June 2025**. Potential starting date is 1st September 2025

For additional information please contact Christine Barras (E-mail: christine.barras@univ-angers.fr) or Emmanuelle Geslin (E-mail: emmanuelle.geslin@univ-angers.fr).