Job Title	**Modelling multiple stress effects on marine organisms' life-history and population dynamics**
Main Research Field	Life Sciences (LIF)
Sub Research Field	Marine Ecology
Key words	Population dynamics, spatial ecology, multi-stressors, biotic interactions, life cycles, ecophysiology, inter-individual variability, individual-based modelling, Dynamic Energy Budget (DEB) theory
Job Description	**Project context:** Marine populations in coastal ecosystems are subject to multiple physical, chemical (e.g. warming, deoxygenation, acidification, contaminants) and biotic stressors (e.g. competition, predation, allelopathy), which intensity and diversity of origin (e.g. invasive species, emergent contaminant) are reinforced by human activities and climate change. Understanding and anticipating the response of populations is therefore a critical challenge, particularly in coastal ecosystems, which are vital from an ecological, social and economic point of view. An emergent field in population ecology is to develop spatially explicit modelling (SEM) approaches coupled to mechanistic models to study species distribution patterns and population dynamics. At the community level, these new approaches, which will combine biophysical ecology and metabolic theories, are expected to make substantial contributions to the currently developing functional trait-based modelling approaches. Spatial and temporal population dynamics emerge from complex interactions across biological scales, from sub-individual to individual, population and upper levels (community, ecosystem). We are in an urgent need for more mechanistic understanding of how large-scale driving forces (e.g. weather, climate) interact and influence dynamics at these different biological scales. **Objectives:** Our main objective is to combine field work observations, eco-physiological experiments and modelling approaches to better understand and project scenarios on the response of marine organisms and populations to combined multiple stressors. Our works belong in the fields of population ecology, macrophysiology and biogeography and we focus on mechanistic (1) individual energetic modelling and (2) spatially-explicit population modelling approaches. **Relevant approaches include** (1) eco-physiological knowledge of metabolic responses to stressors at sub-individual scale, (2) a metabolic theory (i.e. the Dynamic Energy Budget theory) allowing to simulate the influence of multiple stressors on the different life stages of the organisms, (3) biophysical ecology to account for spatial connectivity, and (4) individual-based population dynamics accounting for biotic interactions (e.g. competition). **The Marie-Curie fellowship aims at** advances in theoretical developments and modelling tools conception to better account for processes acting on population dynamics along spatial and temporal scales. We both need to progress in integrating multiple stressors in individual bioenergetics models and integrating spatial and temporal scales to make realistic projections and envision building realistic scenarios of climate change effects, from local to biogeographical scales.

	Depending on her/his skills and interests the fellow will either work on (1) integrating combination of multiple stressors (e.g. temperature, oxygen, pH, contaminants) in individual Dynamic Energy Budget based bioenergetics models or (2) on spatially explicit individual-based population dynamics modelling developments. She/he will focus on multiple spatial and temporal scale integration. She/he will have to collaborate with scientists from several disciplines such as physical oceanography, geomatics and biology / ecology. **Relevant references** DeAngelis DL, Yurek S (2017) Spatially Explicit Modeling in Ecology: A Review. *Ecosystems* 20:284–300 Helmuth B (2009) From cells to coastlines: how can we use physiology to forecast the impacts of climate change? *Journal of Experimental Biology* 212:753–760 Jusup, M, Sousa T, Domingos T, Labinac V, Marn N, Wang Z, and Klanjšček T (2017) Physics of Metabolic Organization. *Physics of Life Reviews* 20: 1–39. Kearney M, Simpson SJ, Raubenheimer D, Helmuth B (2010) Modelling the ecological niche from functional traits. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365:3469–3483
Supervisor(s)	**The fellow will be supervised by a team of four researchers involved in several projects dealing with each of the previously exposed thematic. This team is leads by Dr. Fred JEAN.** **Dr. Fred JEAN** is a Professor in the University of Brest. His expertise belongs to the fields of marine ecology, biodiversity and pelagos-benthos coupling, ecophysiology of benthic organisms and modelling the effects of multiple stressors on energetics of marine invertebrates at the individual level. He is used to supervise PhD students and to work with post-doctoral fellows and has a strong international scientific international network. https://www.researchgate.net/profile/Fred_Jean Alexandridis N, Dambacher JM, Jean F, Desroy N, Bacher C (2017) Qualitative modelling of functional relationships in marine benthic communities. *Ecological Modelling* 360:300–312 Le Goff C, Lavaud R, Cugier P, Jean F, Flye-Sainte-Marie J, Foucher E, Desroy N, Fifas S, Foveau A (2017) A coupled biophysical model for the distribution of the great scallop *Pecten maximus* in the English Channel. *Journal of Marine Systems* 167:55–67 McFarland K, Soudant P, Jean F, Volety AK (2016) Reproductive strategy of the invasive green mussel may result in increased competition with native fauna in the southeastern United States. *Aquatic Invasions* 11:411–423 **Dr. Yoann THOMAS** is working in the French Institute of Research for Development (IRD, https://en.ird.fr/ird.fr). His expertise belongs to the fields of marine ecology, individual-based modelling, population connectivity, climate change and biogeography. He has extensive histories in working with shellfish ecology, dynamic energy budget models, and the integration of hydrodynamics and

population models.
https://www.researchgate.net/profile/Yoann_Thomas

Thomas Y, Dumas F, Andréfouët S (2016) Larval connectivity of pearl oyster through biophysical modelling; evidence of food limitation and broodstock effect. *Estuarine, Coastal and Shelf Science* 182, Part B:283–293

Thomas Y, Pouvreau S, Alunno-Bruscia M, Barillé L, Gohin F, Bryère P, Gernez P (2016) Global change and climate-driven invasion of the Pacific oyster (*Crassostrea gigas*) along European coasts: a bioenergetics modelling approach. *Journal of Biogeography* 43:568–579

Sussarellu R, Suquet M, Thomas Y, Lambert C, Fabioux C, Pernet MEJ, Le Goïc N, Quillien V, Mingant C, Epelboin Y, Corporeau C, Guyomarch J, Robbens J, Paul-Pont I, Soudant P, Huvet A (2016) Oyster reproduction is affected by exposure to polystyrene microplastics. *Proceedings of the National Academy of Sciences* 113:2430–2435

Dr. Jonathan FLYE-SAINTE-MARIE is Lecturer in the University of Brest. His expertise belongs to the fields of marine ecology, ecophysiology of benthic organisms and studying the effects of multiple stressors on energetics of marine organisms by coupling field observations, experimental and modelling approaches. He is used to work with PhD students and post-doctoral fellows.
https://orcid.org/0000-0002-6462-0677

Aguirre-Velarde, A., Jean, F., Thouzeau, G., Flye-Sainte-Marie, J. 2018. Feeding behaviour and growth of the Peruvian scallop (A*rgopecten purpuratus*) under daily cyclic hypoxia conditions. Journal of Sea Research. 131. 85-94.

Artigaud, S., Richard, J., Thorne, M.A.S., Lavaud, R., Flye-Sainte-Marie, J., Jean, F., Peck, L. S., Clark, M. S., Pichereau, V. (2015) Deciphering the molecular adaptation of the king scallop (*Pecten maximus*) to heat stress using transcriptomics and proteomics. BMC Genomics, 16 :988. https://doi.org/10.1186/s12864-015-2132-x.

Picoche, C., Le Gendre, R., Flye-Sainte-Marie, J., Françoise, S., Maheux, F., Simon, B., Gangnery, A. (2014) Towards the determination of *Mytilus edulis* food preferences using the dynamic energy budget (DEB) theory. Plos One. https://doi.org/10.1371/journal.pone.0109796.

Dr. Laure PECQUERIE is a researcher at IRD/LEMAR**.** She has a strong expertise in theoretical and quantitative developments in marine ecology within the framework Dynamic Energy Budget theory. Her current research developments and supervision of master, PhD students and post-docs focus on the impact of combined multiple stressors on the life cycle of marine organisms.
https://orcid.org/0000-0002-2973-1056

Johnson LR, Pecquerie L & Nisbet RM (2013) Bayesian inference for bioenergetic models. Ecology 94, 882–984

Pecquerie L, Fablet R, Petitgas P, Alunno-Bruscia M & Kooijman SALM (2012) Reconstructing individual food and growth histories from biogenic carbonates. *Mar. Ecol. Prog. Ser.* **447,** 151–164

Pecquerie L, Nisbet RM, Fablet R, Lorrain A & Kooijman SALM (2010) The impact of metabolism on stable isotope dynamics: a theoretical framework. *Phil. Trans. R. Soc. B* **365,** 3455–3468

Department/Research:	**The Marine Environmental Sciences Laboratory** (LEMAR, https://www-iuem.univ-brest.fr/LEMAR/LemarLab) aims to understanding and modelling marine systems within the biosphere, defining the characteristics of the environment and organisms, and decrypting their interactions. The unit promotes an interdisciplinary policy that is essential to address a complex area such as the interactions between the various components of the marine domain. The fellow will be part of the **DISCOVERY team**. The team skills are: marine ecology, diversity, structure and dynamics of populations and communities. **Infrastructure available**: the fellow will be located at the European Institute for Marine Studies (IUEM / University of Brest https://www-iuem.univ-brest.fr/en/home) and will benefit from all the necessary technical and experimental facilities. This work will be involved into **national and international projects**: Upwelling (effects of upwelling on coastal bays and consequences for benthic species – Peru, Mexico and Senegal); Senilia (Effect of global changes on benthic resources in western Africa); H2020 RISE NOMADS (Novel approaches to evaluating multiscale changes and consequences in north Atlantic dynamic systems)
Suggestion for Interdisciplinary or intersectoral secondments	The project has an interdisciplinary nature and will imply extensive collaborations with oceanographers (to deal with connectivity approaches), geomaticians (for spatially-explicit agent-based modelling), and biologists (for eco-physiological issues and bioenergetics modelling). International collaborations will be encouraged.
Skills Requirements	**Skill Requirements**: Ecological modelling, individual-based modelling, numerical ecology. **Languages**: English, French will be welcome but not essential for work. **Publications**: at least 1 per year since the PhD as1st author. **Other**: Interest and experience of multidisciplinary team studies.