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Concursos de Projetos de I&D
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Visão global da candidatura
Application overview

Referência do projeto
Project reference
EXPL/MAT-APL/0262/2021 **(Lacrado a 09-03-2021 às 21:30)**

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1. Identificação do projeto
1. Project description

Área científica principal
Main Area
Matemática - Matemática Aplicada
Mathematics - Applied Mathematics

Área científica Secundária
Secondary area
Agricultura, Silvicultura e Pescas - Pescas
Agriculture, Forestry and Fisheries - Fishery

Painel de Avaliação
Evaluation Panel
Mathematics Evaluation Panel - 2021

Acrónimo do projeto
Project's Acronym
LAPACOM

Título do projeto (em português)
Project title (in portuguese)
Dinâmica da metacomunidade de espécies com ciclo de vida complexos em ecossistemas explorados

Título do projeto (em inglês)
Project title (in english)
Metacommunity dynamics of complex life cycle species in exploited ecosystems

Financiamento solicitado
Requested funding
49.833,51€

Palavra-chave 1
Metacomunidades

Keyword 1
Metacommunities

Palavra-chave 2
Modelos individuais

Keyword 2
individual-based model

Palavra-chave 3
Perturbações antropogénicas

Keyword 3
human-driven perturbations

Palavra-chave 4
Computação Bayesiana Aproximada

Keyword 4
Approximate Bayesian Computation

Data de início do projeto
Starting date
01-12-2021

Duração do projeto em meses
Duration in months
18

Existem questões éticas identificadas neste projeto?
Are there Ethics Issues identified in this project?
Não
No

Objetivos de Desenvolvimento Sustentável das Nações Unidas – Agenda 2030
United Nations Sustainable Development Goals – 2030 Agenda

Objetivo 5 - Alcançar a igualdade de género e empoderar todas as mulheres e raparigas
Goal 5 - Achieve gender equality and empower all women and girls

Objetivo 17 - Reforçar os meios de implementação e revitalizar a Parceria Global para o Desenvolvimento Sustentável
Goal 17 - Strengthen the means of implementation and revitalize the global partnership for sustainable development

Objetivo 13 - Adotar medidas urgentes para combater as alterações climáticas e os seus impactos
Goal 13 - Take urgent action to combat climate change and its impacts

Enquadramento da candidatura nos Objetivos de Desenvolvimento Sustentável
Framework of the application for the United Nations Sustainable Development Goals

In recent years, organizations have accentuated the far-reaching benefits and the importance of gender parity in leadership and decision-making. Still women are continually under-represented in leadership positions. In the present proposal, we incentive gender equality (equal opportunities) and women's empowerment through a full and effective participation in leadership of the Principal Investigator, Dr. ª Joana Vasconcelos (Goal 5. Achieve gender equality and empower all women and girls). In this application, the PI is promoting the cooperation among regional (Universidade da Madeira and Direção Regional do Mar) and international partners (EAWAG - Swiss Federal Institute of Aquatic Science and Technology and Universidad de Las Palmas de Gran Canaria) to enhance knowledge sharing of science, technology and innovation, as well as to promote the development, transfer, dissemination and diffusion of environmentally sound technologies (Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development Technology). The chosen team along with the main idea of the proposal, intends to fill a gap in the prediction of metacommunity dynamics of complex life cycles in exploited ecosystems. This represents a step forward in metacommunity dynamics models by extending them to complex life cycle species, in order to predict future scenarios in exploited and fragmented ecosystems. This information is of utmost importance in current environmental scenarios where human-driven fragmentation is pervasive, being a major threat for biodiversity and a disruption of ecosystem processes (Goal 13. Take urgent action to combat climate change and its impacts).

2. Instituições envolvidas
2. Institutions and their roles

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Instituição Proponente
Principal Contractor

Universidade da Madeira (UMA)
Largo do Município - Colégio dos Jesuítas
9000-081Funchal

Descrição da Instituição
The University of Madeira (UMa) is a State University established in 1988, organized in 4 faculties and 2 schools: Exact Sciences and Engineering, Life Sciences, Social Sciences, Arts and Humanities and Health Higher School and Technologies and Management Higher School. The mission is to be a university of international level, achieving excellence through education, research and service to its regional, national and international communities. Considering that a crucial aspect of the mission of a university is the transmission of knowledge, research is crucial for the quality of teaching/learning process. A university can only ensure the pursuit of knowledge by promoting fundamental and applied scientific and cultural research, enhancing its ability to establish strategic partnerships. Scientific activities have been developed at 2 organization levels: in structured research units and in self assembled groups which in some cases can be seen as embryos of future units. Since 2000, there is a growing activity of scientific research in UMa, spread in various areas of knowledge, such as Arts and Humanities, Education, Life, Earth and Environmental Sciences, Mathematics, Chemistry, Physical and Engineering Sciences. Most of this research received financial support from FCT/ FEDER and the European Community (INTERREG) and has been carried out in partnership with several national and international institutions, with a particular effort to achieve a high degree of internationalization

Instituição Participante
Participating Institution

Eawag: Swiss Federal Institute of Aquatic Science and Technology (Eawag)
Eawag Überlandstrasse 133 P.O. Box 611
8600Dübendorf

Descrição da Instituição
Eawag is a world-leading aquatic research institute both in fundamental and applied research. It covers a wide range of subjects while maintaining close contacts with partners in practice and an international network of collaborators. Eawag offers an excellent environment for gaining a comprehensive understanding of aquatic ecosystems and water resources, identifying emerging problems, and developing broadly solutions for the sustainability of aquatic ecosystems. The natural sciences, engineering and social sciences are all represented at Eawag. This combination enables comprehensive research into water and the water environment, from relatively pristine aquatic ecosystems to fully engineered water and wastewater management systems. The Institute's three key areas of research are: Water for human welfare, Water for ecosystem functioning, and Strategies for making trade-offs and resolving competing demands. Some of its scientists are among the most highly cited researchers in their discipline worldwide. Teaching also plays an important role at Eawag. Students are involved in projects from the outset, and the institute offers an ideal environment for doctoral research, as shown by the awards regularly received for dissertations. Eawag scientists are involved in the work of more than 120 international organisations and committees, as members of scientific associations and advisory boards of renowned research institutes.

Secretaria Regional de Mar e Pescas (SRMar)
Avenida do Mar e Comunidades Madeirenses 23
9000-054Funchal

Descrição da Instituição
The Regional Directorate for the Sea (DRM) is an executive service of Secretariat for Sea and Fisheries (SRMar), whose mission is to develop and evaluate the strategy of the Regional Government of the Autonomous Region of Madeira for the sea, to elaborate, propose and coordinate the regional policy for the RAM sea, namely the valorisation and sustainability of marine resources, aquaculture, artificial reefs, exploration, preservation and research of the sea, management of regional, national and community sea funds, licensing of the sea and its funds and coordination with the National Maritime Authority System, as well as guiding, coordinating and controlling its execution.
DRM is responsible for promote marine scientific research, identifying priorities and favouring innovation in the fields of its mission, in conjunction with other services and entities with competence in the matter and to promote and propose legislative measures, without prejudice to the attributions and competences of other entities in the matter, which aim at establishing rules related to the use and protection of marine resources, the sea and its funds, with a view in particular to the its rational, sustainable exploitation and its ecological and environmental balance.

Universidad de Las Palmas de Gran Canaria (ULPGC)
calle Juan de Quesada, nº 30
35001Las Palmas de Gran Canaria

Descrição da Instituição
The University Institute of Aquaculture and Sustainable Marine Ecosystems (IU-ECOAQUA®) is a research center of excellence at the University of Las Palmas de Gran Canaria (approval published in BOC on February 23, 2016). It was born as a milestone of the European EcoAqua project, in which the EU through the HORIZONT 2020 program focuses on promoting centers of excellence for research and innovation within the European Research Area (ERA). Thus, IU-ECOAQUA is constituted to promote research, innovation and postgraduate training in aquaculture and the conservation and sustainable use of coastal resources. It is a multidisciplinary Institute that brings together experts from different areas of knowledge, such as zoologists, botanists, physiologists, veterinarians, agronomists, pathologists, paleontologists, oceanographers, jurists, economists, etc., with a long history of international cooperation and development.

Unidade de Investigação
Research Unit

Universidade da Madeira (UMA)

Largo do Município - Colégio dos Jesuítas
9000-081Funchal

Unidade de Investigação Adicional
Additional Research Unit

Direção de Serviços de Monitorização, Estudos e Investigação do Mar (DSEIMar)
Estrada da Pontinha
-

University Institute of Aquaculture and Sustainable Marine Ecosystems (IU-ECOAQUA)
Parque Científico Tecnológico Marino de la ULPGC, Carretera de Taliarte S/N
3520 - Telde

3. Componente Científica
3. Scientific Component

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3.1. Sumário
3.1 Abstract

3.1.a (Em português)
3.1.a (In Portuguese)

O movimento ocorre durante todo o ciclo de vida ou está limitado a estágios de dispersão, como as sementes em plantas ou os ovos em peixes. A dispersão, definida como o movimento de indivíduos para longe de sua fonte [NaPeCrStCa03], é uma estratégia chave para aumentar o fitness em paisagens dinâmicas movendo-se para ambientes diferentes. Consequentemente, os processos ecológicos e evolutivos que ocorrem num local podem causar mudanças em locais distantes ou noutros ecossistemas por meio do acoplamento ecológico da dispersão de longa distância [GaGaGeHaKi07]. Contudo, em populações altamente fragmentadas os níveis de dispersão podem ser insuficientes, com um aumento subsequente de endogamia que leva à diminuição do fitness em muitas espécies. Pequenas populações com altas taxas de dispersão podem estar sujeitas à extinção em tais situações, enquanto que nas populações marginais com taxas de imigração pode ocorrer um efeito de resgate onde os indivíduos podem persistir [ErElMeMa14]. Infelizmente, a maioria dos modelos que trabalham com taxas de migração baseiam-se numa estratégia de dispersão fixa [LeMuNaCh03], logo entender a ligação entre dispersão, ciclo de vida e dinâmica populacional é fundamental para prever as respostas populacionais à perda de habitat e exploração [BoBe05]. Esta informação é de extrema importância nos atuais cenários ambientais onde a fragmentação antropogénica é generalizada [JoVeFuAlMaNeWa18], sendo uma grande ameaça para a biodiversidade [PiRa00] e uma interrupção dos processos do ecossistema [AcEvStMaGaRiMa02].
Modelos de metapopulação predizem a sobrevivência de populações altamente dispersas, independentemente da depleção local das espécies [LeCh18]. Vários estudos demonstraram que uma diminuição na conectividade entre as populações (contínuas a espaçadamente distribuídas) pode ser acompanhada pela perda de espécies [NiWoSaRaViDaPi15]. Logo, as taxas de dispersão em paisagens alteradas precisam ser altas para manter as populações viáveis [PrBeKeMaSa08]. Por exemplo, os juvenis não são reprodutivamente ativos e até mesmo os adultos de maior porte possuem o maior potencial reprodutivo [HeMu08]. No LAPACOM, iremos contrastar modelos de dinâmica de metacomunidade considerando o ciclo de vida das espécies com padrões empíricos de distribuição e diversidade em ecossistemas explorados. Serão utilizados Modelos Baseados em Individuais (IBM), serão simuladas ações ao nível do indivíduo, e como eles interagem com outros e com a paisagem em que vivem [MaJaNiPrGr13].
Modelos de metacomunidade e metapopulação focaram-se principalmente em ciclos de vida simples, habitats contínuos ou em equilíbrio entre extinções e colonizações [LeCh18]. Apesar dos muitos avanços, muitas incógnitas permanecem para prever a dinâmica da metacomunidade de espécies de ciclos de vida complexos em ecossistemas em desequilíbrio. Em específico, como é que o ciclo de vida altera as probabilidades de extinção em metacomunidades ao longo de gradientes de exploração? Nesse sentido, o LAPACOM visa combinar previsões teóricas com dados empíricos de metacomunidades intertidais como um estudo de caso para prever trajetórias futuras em ecossistemas fragmentados e explorados considerando a estrutura espacial, ciclos de vida complexos, migração e processos demográficos. Isso será alcançado segundo 3 objetivos principais: (1) inferir de que modo os ciclos de vida complexos estão influenciando as trajetórias persistentes ao longo das metacomunidades perturbadas; (2) Interpretar o papel da exploração antropogénica na sincronia espacial e na probabilidade de extinção; e (3) Explorar padrões de diversidade ao nível intra e interespecífico para desvendar o papel da estrutura espacial na previsão da persistência da metacomunidade. A estrutura iniciada neste trabalho servirá de base para prever as respostas às mudanças ambientais por parte de espécies com ciclo de vida complexos, abrindo novas janelas de oportunidades para futuras pesquisas nesta área. Estes atributos tornam o LAPACOM um projeto candidato à produção de resultados de alto impacto: (i) a estrutura desenvolvida aqui refere-se a um modelo de dinâmica de metacomunidade amplamente aplicável a dados de ecossistemas marinhos, de água doce e terrestres (ii) alargamos os modelos de metacomunidade baseados na dinâmica de ocupação de fragmentos estocásticos para espécies de ciclos de vida complexos em populações altamente fragmentadas e exploradas, e (iii) fortalecerá as interações entre cientistas empíricos e teóricos para construir teorias baseadas em dados com aplicação na gestão de áreas costeiras. O LAPACOM é um projeto arriscado, mas sólido, que combina experiências, bases de dados globais e uma nova estrutura de modelação para explorar metacomunidades de espécies com ciclo de vida complexos em paisagens que mudam rapidamente. Os recursos necessários para o desenvolvimento do LAPACOM incluem códigos de fonte aberta e repositórios de acesso livre.

3.1.b (Em inglês)
3.1.b (In English)

Movement occurs during the whole life cycle or is limited to dispersal stages, such as seeds in plants or eggs in fish. Dispersal, defined as the movement of individuals away from their source [NaPeCrStCa03], is a key strategy to increase fitness in dynamic landscapes by moving to different environments. Hence, ecological and evolutionary processes that occur in one location may drive changes at far sites or in other ecosystems through the ecological coupling of long-distance dispersal [GaGaGeHaKi07]. Yet, highly fragmented populations may not experience sufficient levels of dispersal, with a subsequent increase of inbreeding which lead to decreased fitness in many species. Small populations with high dispersal rates may be prone to extinction under such situations whilst marginal populations with immigration rates may experience a rescue effect where individuals may persist [ErElMeMa14]. Unfortunately, most models working with migration rates have used a fixed dispersal strategy [LeMuNaCh03], but understanding the link between dispersal, life cycle and population dynamics is pivotal for predicting population responses to habitat loss and exploitation [BoBe05]. This information is of utmost importance in current environmental scenarios where human-driven fragmentation is pervasive [JoVeFuAlMaNeWa18], being a major threat for biodiversity [PiRa00] and a disruption of ecosystem processes [AcEvStMaGaRiMa02].
Metapopulation models predict the survival of highly-disperse populations regardless of local depletion of species [LeCh18]. Many studies have shown that a decrease in connectivity among assemblages, from continuous to sparsely distributed populations is accompanied by species loss [NiWoSaRaViDaPi15]. Therefore, dispersal rates in disturbed landscapes need to be high to maintain viable populations [PrBeKeMaSa08]. For example, juveniles are not reproductively active and even larger-sized adults harbour the highest reproductive potential [HeMu08]. In LAPACOM, we will contrast metacommunity dynamics models accounting for the life cycle of species with empirical patterns of trait distributions and diversity in exploited ecosystems. Individual Based Models (IBM) will be used, and actions of single individuals will be simulated, and how they interact with others and the landscape they live in [MaJaNiPrGr13].
Metacommunity and metapopulation models have mostly focused on simple life cycles, continuous habitats or in equilibrium between extinctions and colonisations [LeCh18]. Despite many recent advances many unknowns remain to predict metacommunity dynamics of complex life cycles species in disturbed ecosystems. Specifically, how does life cycle alter extinction probabilities in metacommunities along exploitation gradients? In this sense, LAPACOM aims to combine theoretical predictions with empirical data and experiments from intertidal metacommunities as a case study to predict future trajectories in fragmented and exploited ecosystems accounting for spatial structure, complex life cycles, migration and demographic processes. This will be achieved by focusing on three main objectives: (1) Infer how complex life cycles are influencing persistent trajectories along disturbed metacommunities; (2) Interpreting the role of human exploitation on spatial synchrony and extinction probability; and (3) Explore diversity patterns at intra- and inter-specific level to disentangle the role of the spatial structure in predicting metacommunity persistence. The framework initiated with this research will serve as groundwork to predict environmental change responses of complex life cycle species, opening new windows of opportunities for future research in this scope. These features make LAPACOM a candidate to produce high impact results: (i) the framework developed here refers to a broadly applicable metacommunity dynamics model that can be used for data from marine, freshwater and terrestrial ecosystems; (ii) we extend the metacommunity models based on stochastic patch occupancy dynamics to complex life cycles species in highly fragmented and exploited populations, and (iii) it will strengthen the interactions between empirical and theoretical scientists to build data-driven theories with application on coastal management. LAPACOM concerns a risky but solid project that combines experiments, global datasets and novel modelling framework to explore metacommunities of complex life cycle species in rapidly changing landscapes. The resources required for the development of LAPACOM include open-source codes and open access repositories.

3.1.c Resumo para publicação (em português)
3.1.c Abstract for publication(in Portuguese)

Objetivo - O objetivo principal da presente proposta é explorar ciclos de vida complexos em metacomunidades para prever cenários futuros em ecossistemas explorados pelo homem. Antecedentes - A expansão humana ocorreu por todo o globo, afetando a maioria das espécies na Terra. Os ecossistemas estão cada vez mais fragmentados, provocando a perda de habitat e redução do número de espécies por meio de mudanças na estrutura, diversidade, dinâmica, composição de espécies e taxas de recrutamento das comunidades. A

maioria dos estudos em metacomunidades explorou a dinâmica da biodiversidade considerando ciclos de vida simples. No entanto, os efeitos da perda e exploração de habitat em espécies de ciclos de vida complexos em metacomunidades são atualmente desconhecidos. Metodologia - Propomos um projeto que combina trabalho laboratorial, análise de bases de dados e modelação de metacomunidades intertidais como um estudo de caso para explorar trajetórias futuras em ecossistemas fragmentados e explorados tendo em conta a estrutura espacial, ciclos de vida complexos, migração e processos demográficos. Isso será alcançado segundo três objetivos principais: (1) inferir de que modo os ciclos de vida complexos estão influenciando as trajetórias de persistência ao longo das metacomunidades perturbadas; (2) Interpretar o papel da exploração humana na sincronia espacial e na probabilidade de extinção; e (3) Explorar padrões de diversidade ao nível intra e interespecífico para desvendar o papel da estrutura espacial na previsão da persistência da metacomunidade. Impacto e relevância da proposta - Existem algumas características que tornam esta proposta uma grande candidata a produzir resultados de alto impacto: (i) a estrutura desenvolvida nesta proposta refere-se a um modelo de dinâmica de metacomunidade aplicado de forma generalizada e que pode ser utilizado em dados recolhidos de ecossistemas marinhos, de água doce e terrestres; (ii) alargamos os modelos de metacomunidade baseados na dinâmica de ocupação de fragmentos estocásticos para espécies de ciclos de vida complexos ao longo de populações altamente fragmentadas e exploradas e (iii) fortalecerá as interações entre cientistas empíricos e teóricos para construir teorias baseadas em dados com impacto no ecossistema gestão.

3.1.d Resumo para publicação (em inglês)

3.1.d Abstract for publication(in English)

Aim - The main purpose of the present proposal is to explore complex life cycles in metacommunities to predict future scenarios in human-exploited ecosystems. Background - Human sprawl is all over the globe, affecting most species on Earth. Ecosystems are becoming increasingly fragmented, causing habitat loss and species ranges reduction through shifts on the structure, diversity, dynamics, species composition and recruitment rates of communities. Most metacommunity studies have explored biodiversity dynamics considering simple lifecycles. Yet, the effects of habitat loss and exploitation on complex life cycles species in metacommunities are currently unknown. Research plan - We propose a project combining experiments, database analysis and modeling from intertidal metacommunities as a case study to explore future trajectories in fragmented and exploited ecosystems accounting for spatial structure, complex life cycles, migration and demographic processes. This will be achieved by focusing on three main objectives: (1) Infer how complex life cycles are influencing persistence trajectories along disturbed metacommunities; (2) Interpreting the role of human-exploitation on spatial synchrony and extinction probability; and (3) Explore diversity patterns at intra-and inter-specific level to disentangle the role of the spatial structure in predicting metacommunity persistence. Proposal impact and relevance - There are a few features that make this proposal a candidate to produce high impact results: (i) the framework developed in this proposal refers to a generally applicable metacommunity dynamics model that can be used for data collected from marine, freshwater and terrestrial ecosystems; (ii) we extend the metacommunity models based on stochastic patch occupancy dynamics to complex life cycles species along highly fragmented and exploited populations, and (iii) it will strengthen the interactions between empirical and theoretical scientists to build data-driven theories with impact on ecosystem management.

3.2. Descrição Técnica

3.2 Technical Description

3.2.1. Revisão da Literatura

3.2.1. Literature Review

Metacommunity and metapopulation models been widely focused on continuous habitats or in equilibrium between extinctions and colonisations using species with simple life cycles as a model study [LeCh18]. Hence, species with complex life stages have been conventionally neglected. This overlooked info is important in current environmental scenarios where human-driven fragmentation threatens the loss of biodiversity (e.g., [RiVaBaGeSoIn20], Mar. Poll. Bull.; [RiTuBeLoMaPe18], Prog. Oceanog.) and marine conservation (e.g., [SaAlLaRiBe19], Mar. Poll. Bull.; [SoHeVaPiDeRi20], Aq. Conserv.). LAPACOM aims to combine theoretical predictions with empirical data from intertidal metacommunities as a case study by integrating metacommunity dynamics model for highly fragmented populations, fecundity estimation and analysis of datasets.

The knowledge of potential fecundity is valuable to determine the timing and magnitude of the arrival of recruits on the shore. Unfortunately, there is a gap on fecundity data of a pivotal group of intertidal molluscs, the Patellid limpets. The team (Dra. J. Vasconcelos (PI) and Dr. R. Sousa (Partner Researcher)) has background on reproductive biology of fish (e.g., [VaFaFrGo17] Fish. Res.; [VaSoHeAmDeRi20], Can. J. Fish. Aquat. Sci.), and molluscs (e.g., [SoVaRiPiDeHe19], Estuar. Coast. Shelf Sci.; [SoHeVaFaRiPiDeHa19], JMBA), where new data was provided on the fecundity type of Trachurus picturatus suggesting an indeterminate fecundity [VaFaFrGo17] and on the occurrence of sequential hermaphroditism in Patella piperata [SoHeVaFaRiPiDeHa19]. These findings are of utmost importance, with direct effect on management and conservation. Migration patterns are also crucial for stock management, especially during the active spawning where they are more vulnerable to fishing as migration involve large concentrations of individuals in small areas during a short period of time. This vulnerability is even higher if species concentrate during spawning season in coastal areas, as occur with scabbardfish (Aphanopus spp.) with mature adults migrating towards areas near the coast of Madeira archipelago followed by an increase of fishing events [VaSoHeAmDeRi20].

Human induced stressors, extensively studied by Dr. R. Riera (Co-PI), go far from influencing just fish and molluscs. They impact the whole food chain (e.g., [RiVaBaGeSoIn20]), functional traits or biodiversity (e.g., [RiTuBeLoMaPe18], Prog. Oceanog.). In response to fishing pressure and coastal surplus of nutrients in the Skagerrak, [RiVaBaGeSoIn20] found a severe shift on epifaunal community, with a decrease of mesograzers, an increase in intermediate invertebrate predators and a decrease in small herbi- and detritivores [RiVaBaGeSoIn20].

The application of technical measures is important, e.g., the usefulness and efficiency of the implementation of management measures in the reproductive potential of Madeiran limpets showed an increase of 14% of reproductive individuals [SoVaRiPiDeHe19]. The implementation of Marine Protected Areas (MPAs) provides multiple conservation benefits (e.g., [SaAlLaRiBe19], Mar. Poll. Bull.; [SoHeVaPiDeRi20], Aq. Conserv.). [SoHeVaPiDeRi20]. The effects of protection from MPAs on limpet populations from Madeira archipelago resulted in a differential increase on size at first maturity, shell size, and capture per unit effort (CPUE). On the other hand, [SaAlLaRiBe19] showed the existence of large differences in MPA efficiency across ecoregions, with contrasting efficiency at protecting multiple roles.

Furthermore, LAPACOM represents a step forward in metacommunity dynamics models by extending them to complex life cycle species, in order to predict future scenarios in exploited and fragmented ecosystems. Understanding biodiversity dynamics in disturbed and fragmented landscapes in metacommunities has been a topic of great interest in our team. Dr. C. Melián (Partner Researcher) has been working with theoretical models and large empirical datasets to study the effect of landscape connectivity on diversification and biodiversity dynamics ([MeSeEgFoDe15], Ecography; [LeDeGaCoPaKuMeSa16], Nat. Commun.). They showed that landscape structure, the strength of assortative mating and the intensity and directionality of gene flow may play a critical role to anticipate the formation of biodiversity spots [MeSeEgFoDe15]. Specifically, scenarios where populations expand from the periphery to the centre of their ranges in a broad set of landscapes, i.e., "the centripetal gene flow model", predicts hot spots with a higher diversification and species richness in the centre of the distribution ranges of diversifying lineages [MeSeEgFoDe15]. More recently, a diversification model was developed taking into account the dynamics of plate tectonics to explore the role of landscape dynamics in predicting hot spot formation and its dynamics in tropical reef fish and coral reefs [LeDeGaCoPaKuMeSa16]. Additionally, he contributed to the fields of Ecological Networks (e.g., [DeMeBiVaDaRoJuVe14], Ecol. Lett.; [MeBaMaViGoDrWi14], Adv. Ecol. Res.) and Eco-evolutionary networks (e.g., [LeDeGaCoPaKuMeSa16], Nat. Commun.; [MeMaAnRoHaFo18], TREE; [CaAnEsMeBeStAp20], Nat. Ecol. Evol). He combined stochastic modelling, empirical datasets, and inference approximations, to quantify the impact of intra- and inter-specific trait variation (i.e., behavior, learning, morphological, trophic or mating traits) on species interactions, divergence and the macroscopic properties of ecological networks.

LAPACOM intends to fill two important gaps: (i) the lack of fecundity data in Patellid limpets, one important group of intertidal molluscs; and (ii) extend the metacommunity models based on stochastic patch occupancy dynamics to complex life cycles species along highly fragmented and exploited populations.

3.2.2. Plano e Métodos

3.2.2. Plan and Methods

Metacommunity models have been extensively used to determine dynamics of species in future environmental scenarios, although species with complex life stages have been mostly neglected. This is particularly relevant for global intertidal ecosystems where most species have complex life cycles, spatial structure, strong effects of biotic interactions and narrow niche structure. The proposed project represents a step forward in metacommunity dynamics models by extending them to complex life cycle species, in order to predict future scenarios in exploited and fragmented ecosystems. In this scope, the specific goals are:

Goal 1: Infer how complex life cycles are influencing persistence trajectories along disturbed metacommunities. We will combine global dataset analysis and modelling to decipher how complex life cycles are influencing persistence trajectories in disturbed metacommunities

Goal 2: Interpreting the role of human exploitation on spatial synchrony and extinction probability. We will combine in situ experiments accounting for exploited and non-exploited habitats (Marine Protected Areas) with modelling scenarios to decipher the role of human exploitation on spatial synchrony and extinction probability.

Goal 3: Explore diversity patterns (i.e., local and regional) at intra- and inter-specific levels to disentangle the role of the spatial structure in predicting metacommunity persistence. We will develop different scenarios accounting for different life cycle traits, and thus allowing us to contrast their importance for diversity patterns.

Furthermore, our project targets another problematic issue that seriously obstructs the progress of the scientific field ecology. Empiricists often collect data that can hardly be used as direct tests of predictions of specific models. On the other hand, Theoretical ecologists build singular models' types but rarely fit them directly to empirical data. Our project targets this problem by combining theory, experimental and field data.

Methodology

Our project will integrate a metacommunity dynamics model for highly fragmented populations, fecundity estimation and analysis of datasets. The following sections contain the available datasets, the fecundity estimations to parametrize the modelling and the modelling framework.

a) Available datasets
We will use intertidal data from the Atlantic archipelagos (Madeira, Canaries, Azores and Cape Verde, 95k-individuals), mainland Portugal (5k-ind.) and from the West Coast of America (100k-ind.) (see Table 1, Task 3). All these datasets contain geographic locations (longitude-latitude), proximity-to-human-settlements (near vs. far) and protective-regime (Full access vs. MPA).

b) Fecundity estimation (for mating scheme in Modelling framework section) (Partners involved: UMa and DRM)
The knowledge of potential fecundity is useful when determining the timing and magnitude of the arrival of recruits on the shore. Unfortunately, there is a lack of fecundity data of one important group of intertidal molluscs, the Patellid limpets. During spawning season, a minimum of 10 females per size class (10 mm) of both Patella aspera and P. candei in the maturity stages 3 to 5 will be collected monthly from the rocky shores of Madeira. Limpet will be sampled, and the ovaries removed and preserved in a Roti-histofix solution before dehydration and inclusion in Technovit 7100 resin, following standard protocols [VaFaFrGo17]. For fecundity-type definition, the four lines of evidence suggested by [MuSa03] and others will be investigated. The methods applied for fecundity estimation will depend on the type of fecundity, indeterminate or determine.

c) Modelling framework (Partners involved: UMa, ULPGC and EAWAG)
We will extend metacommunity models based on stochastic patch occupancy dynamics [LeCh18] to metacommunities accounting for complex life cycles species along exploitation gradients. The following is the structure of the model:
1. MATING scheme: The species in our dataset have external fecundation, with probabilistic encounters between gametes along the water column. Thus, we will include a probabilistic model in this part of the life cycle accounting for different distribution kernels (i.e., lottery model, [DeCh03]. We will also account for an exponential fertilization decay of gametes after their release and the subsequent decrease of fertilized eggs per time.
2. ABIOTIC scheme: We will use the sampling sites distance matrix accounting for ocean currents as the seascape dynamics underlying the dispersal and colonization probabilities (see below the DISPERSAL scheme).
3. BIOTIC scheme: We will take into account human-driven interaction strength as well as predator effects on intertidal communities. Empirical patterns show that exposed sites are less affected by harvesting pressure that sites easily accessible all over the year in the different data containing this information; thus, the general model will account for exposition and extraction as a trade-off part of the dynamics.
4. DISPERSAL scheme: We will consider three empirically estimated dispersal distances to integrate a wide range of dispersal phases in species with complex life stages. Global dispersion will be considered for large distances (> 100 kms), regional dispersion for intermediate distances (1-100 km), and local dispersion for short distances (< 1 km).

Our framework (Fig. 1) assumes that the studied species are constrained to disperse passively by the large-scale and meso-scale environmental conditions, and also by the active dispersion of the larvae. We will consider an empirically sampled intertidal seascape consisting of N sites. At each site, there will be S competing consumer species each with a complex life-cycle population of different initial abundances. To model spatiotemporal changes in population abundances we will combine lottery-type competition models (with trait-based dynamics accounting for complex life cycles, proximity to human settlements, protected areas, spatial heterogeneity and exploitation intensity. The site matrix comprises size, exposition to environment and human pressure.

The following four dispersal scenarios will be explored to contrast model outputs with the empirical data from our intertidal datasets following Goals 1 to 3 and Table 1. This comparison will provide a pivotal benchmark to identify the role of complex life cycles (Goal 1: Infer how complex life cycles are influencing persistence trajectories along disturbed metacommunities), human pressure (Goal 2: Interpreting the role of human-exploitation on spatial synchrony and extinction probability) and ecological interactions (Goal 3: Explore diversity local and regional patterns at intra-and inter-specific level to disentangle the role of the spatial structure in predicting metacommunity persistence) on driving metacommunity dynamics in highly contrasted environments, e.g. the intertidal.
Model 1. Distance- and life stage-dependent dispersal: This first scenario will test the effect of distance-dependent larval dispersal rates under weak competition, with lower rates between highly separated assemblages.
Model 2. Distance- and life stage-dependent dispersal with strong competition: The second scenario will consider that dispersal rates are also distance-dependent, but now competition within sites will be driving mortality rates.
Model 3. Distance- and life stage-dependent dispersal with differential reproductive potential: The third model considers weak competition as Model 1, but now larger individuals have higher reproductive potential estimated from our experimental data. This means time-dependent reproduction probability will be taken into account.
Model 4. Density- and life stage-dependent dispersal with differential reproductive potential and strong competition: The last scenario will consider strong competition and that larger individuals have higher reproductive potential also estimated from our experimental data.

These four scenarios will consider mollusc species living several years (ca. 3-10) as model system with several development stages (i.e., eggs, trochophore, veliger, juvenile and subadult) each with different dispersal rates. The direction and intensity of connection among populations will be given by larval transport matrices, accounting for the passive transport of larvae by currents and tides. These matrices will be obtained by 3D particle tracking models that incorporate hydrodynamic conditions. The main larval dispersive strategies are (i) passive (=horizontal) transport by oceanic and coastal currents; (ii) flood tidal migration (upward and downward "swimming" by tides). Thus, a wide range of simulations differing in the combination of larval strategy, fecundity and mortality, as well as seasonality (or timing) of eggs release (e.g., winter-spring) are used to support target-setting by analysing the trade-offs resulting from "optimal" environmental scenarios (see Models 1-4).

3.2.3. Tarefas
3.2.3. Tasks

Lista de tarefas (8)
Task list (8)

Designação da tarefa Task denomination	Data de início Start date	Data de fim End date	Duração Duration	Pessoas * mês Person * months
PROJECT MANAGEMENT	01-12-2021	31-05-2023	18	7,2

Descrição da tarefa e Resultados Esperados
Task description and Expected results

The PI (Dra. J. Vasconcelos) and the Co-PI (Dr. R. Riera) will manage the project during all its lifetime to keep track on teamwork, improve communication and collaboration among team members. This management will underpin a high productivity and performance of all the tasks here proposed. The PI will be on the front line of LAPACOM, managing tasks, monitoring and reporting project status, planning meetings and resources, maintain the well-being of the people involved in this proposal, facilitate strategic decisions, to avoid miscommunication, missed deadlines and any other failures. The co-PI will assist the PI due to his expertise in this matter, as evidenced by his contrasted background (see section 5.1. Funded projects list).
We propose 3 face-to-face meetings throughout LAPACOM. A Kick-off meeting will be held in Madeira during the first month of the proposal, and the information needed by the team will be clearly communicated by the PI and supplemented by the Co-PI. The following elements will be outlined in this meeting, (I) Introductions, where all participants (i.e. work and research groups) are presented; (ii) Summary, with a layout of the main parts of the proposal and how they are articulated throughout the project; (iii) Scope and products, that are expected within each of the subprojects; (iv) Roles and responsibilities of each of the participants belonging to work and research groups; (v) Timelines, where schedules of each subproject are detailed; (vi) Outreach actions, where dissemination activities are outlined, with their expected timelines. The second and third meetings are planned prior to the deadline of the first progress report and final report. The second meeting will be held in the EAWAG headquarters in Horw (Lucerne, Switzerland) just before the completion of 1-year project. This meeting will concur with a workshop organized by Dr. C. Melián from EAWAG. All the expenses for this 2nd meeting will be assumed by EAWAG (C. Melián institution). Finally, the closing meeting will be hosted by Dr. R. Riera at the University of Las Palmas de Gran Canaria, with the presentation of results to the research community in the Canaries. Additionally, weekly team meetings are programmed through Zoom or Teams, to keep track on the advances of each task and to avoid deviations from the original plan. In these meetings, problems that occurred during the development of tasks can be exposed and consequently resolved or adjusted accordingly.
Reports will be prepared in Latex, using the online platform Overleaf, and repositories in GitHub. These platforms allow several users to edit the reports/data/code simultaneously. A first scientific progress report will be delivered at the end of the first year of project. This will briefly describe the work performed, the preliminary results and if deviations occurred from the proposed work program or initial budget. A final report of the scientific activity will be delivered at the culmination of the project and will detail the execution of the works carried out during the lifetime of the project, the publications (submitted or in preparation) and other activities and outputs (data, codes, etc.) resulting from the project. The PI, together with the Projects and Cooperation Unit at University of Madeira will ensure that the budget amounts proposed initially are matching real costs. Extensive experience of this unit on research funding will secure a successful budget management of LAPACOM. All eligible costs will be strictly supervised by UMa to be fully in accordance with FCT regulations.

Membros da equipa de investigação nesta tarefa
Members of the research team in this task

Joana Patrícia Reis Vasconcelos; Rodrigo Riera;

Designação da tarefa	Data de início	Data de fim	Duração	Pessoas * mês

Task denomination	Start date	End date	Duration	Person * months
FECUNDITY ESTIMATION	15-12-2021	14-09-2022	9	12

Descrição da tarefa e Resultados Esperados

Task description and Expected results

This task is the responsibility of the PI Dra. J. Vasconcelos and the partner Dr. R. Sousa (SRMP/DRM/DSEIMar), taking into account the knowledge and expertise of the PI in fecundity and in the biology of limpets by Dr. R. Sousa. In order to meet the time allotted for the fulfilment of this task, 2 grants will be open, 1 Research Initiation grant for a Biology Student (3-months period) and 1 Research scholarship for Master student (5-month period). Our main goals will focus on: (i) the definition of the fecundity type (indeterminate or determine) based on the main factors related to oocyte development and recruitment; and (ii) the estimation of fecundity.
Between December and March (minimum of 4 dives, 1/month), a minimum of 10 females per size class (10 mm total shell length, TL) of both Patella aspera and P. candei will be randomly collected throughout the mid-to-lower intertidal zone of the rocky shores of Madeira by an experienced diver (See service procurement and acquisition). Limpets will be measured (TL, 0.1 mm) and weighed (total weight, 0.01 g). Individuals will be removed from their shells, the gonads dissected out and specimens sexed according to gonad pigmentation. Macroscopic examination of the gonads will allow assigning each specimen to a maturation stage, determined by the progression of the gonadal volume in the haemocoel [SoDePiHe17]. Ovaries in maturity stages 3 to 5 will be preserved in Roti-histofix. Subsequent procedures include dehydration (with alcohol at different concentrations: 70, 90 and 95%), inclusion (embedded in Technovit 7100 resin), preparation of blocks and execution of cuts. For confirmation, histological sections (3–5 □m) will be examined to select ovaries containing hydrated oocytes and no signs of POFs [VaFaFrGo17]. For fecundity-type definition, the four lines of evidence suggested by [MuSa03] and others will be investigated: (1) presence of a hiatus between pre-vitellogenic and vitellogenic oocytes; (2) number of standing stocks of advanced vitellogenic oocytes over the spawning season; (3) mean size of standing stock of advanced vitellogenic oocytes over the spawning season; and (4) the incidence of atresia over the spawning season. For the first line of evidence, oocyte diameter measurements will be performed on oocytes with a visible nucleus using the software Leica application suite. For the second and third lines of evidence, the gravimetric method will be applied to the ovaries sampled per month, following [VaFaFrGo17]. After weighting the ovaries, 3 subsamples of ca. 0.02-0.05 g will be extracted from the ovary lobe and placed in a tube on a magnetic stirrer in order to be gently stirred and assist separation of the smaller oocytes. The resulting sub-sample is passed through a sieve, with a diameter equivalent to that of cortical alveoli, to remove the smaller oocytes. The remaining oocytes will be placed in a Petri dish and photographed with the visual image analysis system. The number and the mean size of standing stock of advanced vitellogenic oocytes will be registered and the differences tested with a one-way ANOVA. All statistical analyses will be performed using R software. The incidence of alpha atresia stage in yolked oocytes and the prevalence of atresia are also investigated.
The methods applied for fecundity estimation will depend on the type of fecundity. For example, in species with indeterminate fecundity, the requirements to estimate the annual fecundity are: (i) the number of oocytes spawned per batch, (ii) the % of females spawning per day (spawning fraction) and (iii) the duration of the spawning season [MuSa03]. The information obtained in this task is of utmost importance for the development of the following tasks as it will be incorporated in the modelling framework (Tasks 3-8).

Membros da equipa de investigação nesta tarefa

Members of the research team in this task

(B) Bolsa 1; (B) Bolsa 2; Joana Patrícia Reis Vasconcelos; Ricardo Jorge Silva Sousa;

Designação da tarefa	**Data de início**	**Data de fim**	**Duração**	**Pessoas * mês**
Task denomination	Start date	End date	Duration	Person * months
DATA STANDARDIZATION	01-01-2022	30-09-2022	9	3,6

Descrição da tarefa e Resultados Esperados

Task description and Expected results

Data standardization is a way to ensure that all data set available are consistent (same content and format) and can be compared among them. This action is a key aspect since fitting data to modelling approaches are necessary for later model implementation. In this project we will use intertidal data from the Atlantic archipelagos (Madeira, Canaries, Azores and Cape Verde, 95k-individuals), mainland Portugal (5k-ind.) and from the West Coast of North America (100k-ind.) (Table 1). All these datasets contain geographic locations (longitude-latitude), proximity-to-human-settlements (near vs. far) and protective-regime (Full access vs. MPA). The main goal of Task 3 is to standardize the disparate time series data available converting them into a conventional data format. Typically, datasets created by different researchers/institutions are stored in a certain source system structured in a particular way. The PI, Co-PI and the Master Student will integrate the data through processing workflow of ca. 200k individuals. This will allow data to be analysed and used in a consistent manner for the subsequent tasks. A common structure will be determined to permit the aggregation and comparison of datasets. This task will be divided among the 3 researchers here involved. The information obtained in task 3 will be used on the subsequent Tasks 4 to 8 as these data are the main core for the modelling framework.

Table 1 – Non-exhaustive datasets on intertidal molluscs from the Atlantic archipelagos, mainland Portugal and from the West Coast of America. N spp – number of species; N ind – number of individuals; N sites – number of sampled sites; PHS – Proximity to human settlement; FA – Full access (Table in Attachments section).

Membros da equipa de investigação nesta tarefa

Members of the research team in this task

(B) Bolsa 1; Joana Patrícia Reis Vasconcelos; Rodrigo Riera;

Designação da tarefa	**Data de início**	**Data de fim**	**Duração**	**Pessoas * mês**
Task denomination	Start date	End date	Duration	Person * months
FORMULATION OF THE MODEL STRUCTURE AND IMPLEMENTATION OF THE MODEL IN OPEN SOFTWARE	01-10-2022	30-11-2022	2	1,5

Descrição da tarefa e Resultados Esperados

Task description and Expected results

Our main goals for this task will focus on: (i) General implementation of a metacommunity model accounting for explicit life-cycle stages and human exploitation; (ii) Develop an open-access and public git repo to facilitate reproducibility of the data-modelling methods.
Dr. C. Melián and Dr. A. Vadhati (subcontract) will implement a general five life-cycle stages discrete-patch metacommunity model using the open-source Julia computing language. The general model will contain individual traits and the life stages of two intertidal species described above, namely the limpets Patella aspera and P. candei. The PI Dra. J. Vasconcelos and the Co-PI Dr. R. Riera will supervise the implementation of the general structure of the model that follows the main features of the biology and the ecology of the two species studied. Dr. A. Vadhati and Dr. C. Melián will keep the public open-access repository up to date to facilitate reproducibility of all the steps taken in model development. The metacommunity model, accounting for five life-cycle stages and trait dynamics, will be efficiently implemented in Julia to robustly infer the mechanisms explaining the empirical patterns from each of the different scenarios to be explored. The structure of the model ensures a robust exploration of the life-cycle dependent dispersal potential of Patella candei and P. aspera. as well as the limpet size as a proxy of reproductive potential, i.e., the larger the specimen the higher the number of gametes released by the individual. Because of the different dispersal potential of early stages, i.e., egg, trocophore and veliger larvae, three kinds of dispersal will complement each of the four scenarios described above. Namely, global dispersion for large distances (> 100 kms), belonging to eggs and trocophores, regional dispersion for distances ranging from 1 to 100 km, belonging to trocophores and veligers, and local dispersion for shorter distance (< 1 km), belonging to late-stage veligers. No dispersion will be included in the juveniles and adults' stages, considered sessile organisms with homing.
The general model obtained in this Task is a pre-requisite to have a compact and robust framework able to account for the important biological details of the two species to be explored in the face of human exploitation. The expected result in this Task is to evaluate the properties of the transient dynamics of the general model and its local and global stability properties. Also, the general metacommunity model with explicit discrete-patch and life-stage dynamics will be ready to contrast the consequences of human-driven exploitation in the face of dispersal-limitation (Model 1), density (Model 2), body size (Model 3) and spatial structure (Model 4) (Tasks 5).

Membros da equipa de investigação nesta tarefa

Members of the research team in this task

Carlos Melian; Joana Patrícia Reis Vasconcelos; Rodrigo Riera;

Designação da tarefa	**Data de início**	**Data de fim**	**Duração**	**Pessoas * mês**
Task denomination	Start date	End date	Duration	Person * months
PARAMETRISATION AND SIMULATIONS OF THE DIFFERENT SCENARIOS OF THE MODELLING IN A WORKSTATION	01-11-2022	31-12-2022	2	1

Descrição da tarefa e Resultados Esperados

Task description and Expected results

The main goals for Task 5 are: (i) Implementation of each of the scenarios to explore their response to human exploitation; (ii) Ensure model implementation follows fecundity estimations from the empirical data.
Dr. C. Melián and Dr. A. Vadhati (subcontract) will explore four scenarios with the general model obtained in Task 4. Each scenario will take into account the "Fecundity estimation" obtained in Task 2. PI Dra. J. Vasconcelos and the Co-PI Dr. R. Riera will supervise the work to ensure the empirical estimations of fecundity are well implemented in each of the scenarios. Dr. A. Vadhati will explore how spatial patterns respond to human-driven exploitation in each of the four scenarios: Model 1 explores dispersal kernel is distance-dependent, with lower probability of colonization in highly-separated assemblages. Model 2 includes dispersal rates positively correlated to individual density within each patch. Model 3 explores larger individuals have higher reproductive potential and dispersal capabilities. Finally, model 4 considers a low probability of dispersal to peripheral assemblages relative to the central ones. They will analyse the simulated data generated from each of the scenarios.
Dr. C. Melián and Dr. A. Vadhati will run the simulations for all the scenarios in a workstation. They will implement an explicit-equation modelling alternative to explore the robustness

and the speed of the numerical simulations obtained from the general model. Contrasting the results from the simulations with the ones obtained from the explicit-equation modelling will allow us to explore the speed of the simulations and the number of runs required for each of the scenarios proposed. This Task connects to the feasibility and implementation of the Task 6, Approximate Bayesian Computation (ABC).

Membros da equipa de investigação nesta tarefa
Members of the research team in this task
Carlos Melian; Joana Patrícia Reis Vasconcelos; Rodrigo Riera;

Designação da tarefa Task denomination	Data de início Start date	Data de fim End date	Duração Duration	Pessoas * mês Person * months
MODEL-DATA COMPARISONS USING APPROXIMATE BAYESIAN COMPUTATION (ABC) METHODS	01-12-2022	31-01-2023	2	1

Descrição da tarefa e Resultados Esperados
Task description and Expected results
In Task 6 we intend: (i) To ensure the results obtained from each of the scenarios are robust; (ii) Quantitatively order each of the scenarios given their fitting to the empirical patterns; (iii) Obtain conclusions about the response to human exploitation from each of the scenarios; and (iv) Disentangle the most robust scenario to human exploitation.
Dr. C. Melián and Dr. A. Vadhati (subcontract) will set up the framework combining empirical parametrization and expertise to define the empirical priors for each of the four scenarios from Task 5 (Fecundity estimations to all of them, dispersal kernels, body size distributions, spatial structure, currents, and patch quality). PI Dra. J. Vasconcelos and the Co-PI Dr. R. Riera will team up with the initial distributions of priors to ensure they follow the existing expertise of the biological species. Dr. C. Melián and Dr. A. Vadhati will run the number of replicates and generations per replicate for each scenario following the results obtained in Tasks 4 and 5. Dr. C. Melián and Dr. A. Vadhati will obtain the likelihoods and the Bayes factors from the posteriors along threshold gradients to ensure the robustness of the results.
ABC has advanced greatly in robustness and flexibility during the last decade mostly motivated by novel methods dealing with more complex and realistic modelling scenarios. The scenarios to be explored in this proposal contain a gradient of complexity, from Model 1 that explores dispersal kernels to Model 4 that considers spatial structure. This model complexity gradient can be directly analysed without computing the likelihoods or the analytical derivations. This approach offers a robust method to explore a large number of scenarios and replicates while balancing priors from empirical data and expertise to obtain posteriors that are comparable among the different scenarios. Furthermore, the flexibility of the ABC also allows for comparing non-nested modelling scenarios, as in our proposal. For example, our four scenarios are driven by the expertise in the different data availability and key factors that can predict extinction patterns and not by the constraints of the methods used.
Membros da equipa de investigação nesta tarefa
Members of the research team in this task
Carlos Melian; Joana Patrícia Reis Vasconcelos; Rodrigo Riera;

Designação da tarefa Task denomination	Data de início Start date	Data de fim End date	Duração Duration	Pessoas * mês Person * months
GENERATION OF JUPYTER NOTEBOOK TO FACILITATE REPRODUCIBILITY OF THE WHOLE MODELLING AND MO...	01-01-2023	28-02-2023	2	1,5

Descrição da tarefa e Resultados Esperados
Task description and Expected results
The main goals for Task 7 are: (i) To make the data pre-processing, data processing, data analysis and model-data integration fully reproducible as a Jupyter notebook; (ii) To keep a public git repository UpToDate to allow scientists and the public to access to the data and to the Jupyter notebook to reproduce the results.
Dra. J. Vasconcelos (PI), Dr. R. Riera (Co-PI) and Dr. R. Sousa (research partner) will take care of the data preprocessing and data processing using an open-source language (r, python). Dr. C. Melián will organize the Jupyter notebooks for the different modeling-data stages. We will produce one notebook for each task from Task 4 to 6 (see above). The public git repository will be linked to other databases and research of interest connected to the main scientific and management goals of the project.
Jupyter notebooks using different kernels (i.e., r, python, julia, octave, etc) will be used to secure step by step the commands implemented for the different stages of data pre-processing, data processing, data analysis and model-data integration. The approach will be based on the cell level of Jupyter, where each cell completes a task for a specific open-source programming language. This way the different open-source programming languages used for the different steps will coexist within a given notebook.
The notebooks will be uploaded to the git repository of the project to facilitate the reproducibility of the life-cycle of the analysis, from data pre-processing to plotting results. Jupyter notebook can be opened in the different OS making it suitable for almost any available browser. This will guarantee dissemination and communication of the results to the scientific and developer community. The Jupyter notebooks are the end report from Tasks 4 to 6 communicating compactly the whole life-cycle of the project.
Membros da equipa de investigação nesta tarefa
Members of the research team in this task
Carlos Melian; Joana Patrícia Reis Vasconcelos; Ricardo Jorge Silva Sousa; Rodrigo Riera;

Designação da tarefa Task denomination	Data de início Start date	Data de fim End date	Duração Duration	Pessoas * mês Person * months
OUTREACH AND DISSEMINATION ACTIONS	01-12-2021	31-05-2023	18	7,2

Descrição da tarefa e Resultados Esperados
Task description and Expected results
A series of dissemination activities are planned throughout LAPACOM (months December 2021-May 2023), to scientific and non-scientific audiences, in order to spread the main results of LAPACOM. These activities include (i) Scientific publications in cutting-edge international journals, with special emphasis on Q1/D1 ecology journals such as, American Naturalist, Ecological Monographs or PNAS, among others; (ii) Extensive publications in media (digital newspapers, magazines, webpages of host institutions, etc.); (iii) Updating activities of the project in social media (Twitter, Linkedin, among others).
These activities will be conducted together with community managers and journalists of the PI (UMa, www.uma.pt) and Co-PI (ULPGC, www.ulpgc.es and IU-ECOAQUA, https://ecoaqua.ulpgc.es) host institutions.
Taking advantage of the kick-off meeting at Madeira, a cycle of conferences will be organized at the University of Madeira, for students, researchers and professors of Biology and Mathematics, with interests on the integration of empirical and theoretical ecology. For this event, entities such as the Regional Secretariat for Sea and Fisheries, Marine Biology Station of Funchal, MARE-Madeira, ARDITI and other research institutions that may be interested in, will be invited. The invited speakers will include Co-Pi Dr. R. Riera (ULPGC), Dr. Ali Vahdati (subcontract) and Dr. Carlos Melián (EAWAG). The PI will take advantage of this event to officially announce the project to students (as possible candidates for both scholarships) and to official and governmental entities (as an interested party in the management and conservation of coastal resources in the RMA).
In addition to the conference cycle, a workshop will be held at EAWAG headquarters in Horw (Lucerne, Switzerland) to show preliminary results and work together on the ideas for the model preparation and implementation. This will take place in combination with the mid-term meeting and preparation of the first progress report. Through this event, a high number of interactions and feedback from EAWAG staff is expected. These interactions will be an asset for LAPACOM and also future ideas and collaborations among the research institutions, with special focus between UMa and EAWAG, that may promote a long-term alliance between Portugal and Switzerland.
As a short-term aim, we expect to publish two scientific contributions in top-ranked (Q1, D1) ecological journals (Ecology Letters, Ecological Monographs, PNAS, among others) reporting the results of LAPACOM. We also aim to make the code implement freely available on public repositories (e.g., Dryad, Figshare, Git) following SNSF (Swiss National Science Funding) regulations. Also, the data will be easily reusable by researchers worldwide.
The results of LAPACOM will also be showed in international symposia during the last year, such as, the biennial ESEB European Society for Evolutionary Biology congress, one of the largest conferences in evolutionary biology with about 1500 – 1700 participants).
Membros da equipa de investigação nesta tarefa
Members of the research team in this task
Carlos Melian; Joana Patrícia Reis Vasconcelos; Ricardo Jorge Silva Sousa; Rodrigo Riera;

3.2.4. Calendarização e Gestão do Projeto
3.2.4. Project Timeline and Management

3.2.4.a Descrição da Estrutura de Gestão
3.2.4.a Description of the Management Structure

Project management will be carried out by the PI in line with the Co-PI. The PI has experience on leading tasks from research projects and also become the representative of the previous employer institution (SRMP/DRM/DSEIMar) in international projects. Additionally, the Co-PI will supervise the management of LAPACOM, since he has extensive background in international projects leadership and also is familiar to the particularities of different management procedures regarding funding schemes of international research calls (see project section 5 – other projects).

To establish an efficient workflow and monitorization of the progress of the team, three face-to-face meetings are programmed:
(i) Kick-off meeting at UMa to go over the project's plan and objectives with the partners and review the proposed time frame. It is also important to clarify roles and responsibilities of each partners in the tasks proposed, as many are pre-requisites for subsequent tasks, e.g., fecundity estimation (task 2) and data standardization (task 3). Team members will be encouraged to point out issues where problems may occur and where improvements could be made.
(ii) Intermediate meeting at EAWAG (Switzerland), in line with a workshop organized for knowledge transfer and to prepare the intermediate report to FCT (all the expenses for this 2nd meeting will be a courtesy of EAWAG).
(iii) Final project meeting at ULPGC (Canary Islands), to evaluate the project performance and prepare the final report to FCT.
The referred meetings are strategically and carefully planned along with the organization of conferences and workshops, that will occur in Madeira and Switzerland as well as, the production of the reports.

In addition to face-to-face meetings, weekly team meetings will be organized (partners and subcontract) through Zoom, Teams or other on-line platforms, so that all can share their progress and make sure that no one deviates from the original plan. If problems emerge, we can all share suggestions or adjustments to be made in order to improve the workflow. The PI, together with the Projects and Cooperation Unit at University of Madeira will ensure that the budget amounts proposed initially are matching real costs. All management procedures will entirely fit within the standards by the University of Madeira, as it has been carried out in previous FCT calls.

In accordance with article nº4 of the Regulation for projects financed exclusively by national funds, the PI will be responsible for the submission of two reports on the FCT portal:
(i) a scientific progress report at the end of the first year of project that will briefly describe the work performed, the results obtained and the deviations from the proposed work program or approved budget if exists; and
(ii) a final report of the scientific activity that will detail the execution of the works carried out during the lifetime of the project, detailing the publications and other results resulting from the project.

3.2.4.b Lista de Milestones

3.2.4.b Milestone List

Data	**Designação da milestone**
Date	Milestone denomination
31-12-2021	Conference organization / Kick-off meeting

Descrição
Description

Conferences cycle for students, researchers and professors with interests on the integration of empirical and theoretical ecology. 1st meeting to introduce/summarize work and research groups, expected scope and products, roles and responsibilities of each participant, timelines and outreach actions.

Data	**Designação da milestone**
Date	Milestone denomination
14-09-2022	Field sampling / Fecundity estimation

Descrição
Description

A wide range of simulations differing in the combination of larval strategy, fecundity and mortality, as well as seasonality or timing of eggs release (e.g., winter-spring) will be used to support target-setting by analysing the trade-offs resulting from optimal environmental scenarios (Models 1-4).

Data	**Designação da milestone**
Date	Milestone denomination
30-09-2022	Data standardization

Descrição
Description

Data standardization to ensure that all data set available are consistent (same content and format) and can be compared among them.

Data	**Designação da milestone**
Date	Milestone denomination
30-11-2022	Workshop at EAWAG / 2nd meeting

Descrição
Description

The second meeting is planned prior to the deadline of the first progress report. It will be held in the EAWAG headquarters in Horw (Lucerne, Switzerland) and will concur with a workshop organized by Dr. C. Melián from EAWAG.

Data	**Designação da milestone**
Date	Milestone denomination
31-12-2022	Model formulation, implementation, parametrisation & simulat

Descrição
Description

Formulation of the model structure and Implementation of the model in open software. Parametrisation and simulations of the different scenarios of the modelling in a workstation.

Data	**Designação da milestone**
Date	Milestone denomination
28-02-2023	Model-data comparisons / Generation of a Jupyter notebook

Descrição
Description

Model-data comparisons using approximate Bayesian computation methods and generation of a Jupyter notebook to facilitate reproducibility of the whole modelling and model-data cycle.

3.2.4.c Cronograma

3.2.4.c Timeline

Ficheiro tipificado como "Cronograma", no 9. Ficheiros Anexos, desta Visão Global (caso exista).
File with "Timeline" type at 9. Attachments (if exists).

3.3. Referências Bibliográficas

3.3. Bibliographic References

Nº de Ordem	**Referência**	**Ano**	**Publicação**
Order No.	Reference	Year	Publication
1	[NaPeCrStCa03]	2003	**Nathan, R., G. Perry, J. T. Cronin, A. E. Strand, and M. L. Cain, 2003. Methods for estimating long-distance dispersal. Oikos 103:261-273.**
2	[GaGaGeHaKi07]	2007	**Gaines, S. D., B. GaylorD, L. R. Gerber, A. Hastings, and B. P. Kinlan, 2007. Connecting places: the ecological consequences of dispersal in the sea. Oceanography 20:90-99.**
3	[ErElMeMa14]	2014	**Eriksson, A., F. Elías-Wolff, B. Mehlig, and A. Manica, 2014. The emergence of the rescue effect from explicit within-and between-patch dynamics in a metapopulation. Proceedings of the Royal Society B: Biological Sciences 281:20133127.**
4	[LeMuNaCh03]	2003	**Levin, S. A., H. C. Muller-Landau, R. Nathan, and J. Chave, 2003. The ecology and evolution of seed dispersal: a theoretical perspective. Annual Review of Ecology, Evolution, and Systematics 34:575-604.**
			Bowler, D. E. and T. G. Benton, 2005. Causes and consequences of animal dispersal

5	[BoBe05]	2005	**strategies: relating individual behaviour to spatial dynamics. Biological Reviews 80:205-225.**
6	[JoVeFuAlMaNeWa18]	2018	**Jones, K. R., O. Venter, R. A. Fuller, J. R. Allan, S. L. Maxwell, P. J. Negret, and J. E. M. Watson, 2018. One-third of global protected land is under intense human pressure. Science 360:788-791.**
7	[PiRa00]	2000	**Pimm, S. L. and P. Raven, 2000. Biodiversity: extinction by numbers. Nature 403:843.**
8	[AcEvStMaGaRiMa02]	2002	**Achard, F., H. D. Eva, H.-J. Stibig, P. Mayaux, J. Gallego, T. Richards, and J.-P. Malingreau, 2002. Determination of deforestation rates of the world's humid tropical forests. Science 297:999-1002.**
9	[LeCh18]	2018	Leibold, M.A. and Chase, J.M., 201). Metacommunity Ecology. Monographs in Population Biology, vol. 59. Princeton University Press.
10	[NiWoSaRaViDaPi15]	2015	**Niebuhr, B. B. S., M. E. Wosniack, M. C. Santos, E. P. Raposo, G. M. Viswanathan, M. G. E. Da Luz, and M. R. Pie, 2015. Survival in patchy landscapes: the interplay between dispersal, habitat loss and fragmentation. Scientific Reports 5:11898.**
11	[PrBeKeMaSa08]	2008	**Provan, J., G. E. Beatty, S. L. Keating, C. A. Maggs, and G. Savidge, 2008. High dispersal potential has maintained long-term population stability in the North Atlantic copepod Calanus finmarchicus. Proceedings of the Royal Society B: Biological Sciences 276:301-307.**
12	[HeMu08]	2008	**Hendriks, A. J. and C. Mulder, 2008. Scaling of offspring number and mass to plant and animal size: model and meta-analysis. Oecologia 155:705-716.**
13	[MaJaNiPrGr13]	2013	**Martin, B. T., T. Jager, R. M. Nisbet, T. G. Preuss, and V. Grimm, 2013. Predicting population dynamics from the properties of individuals: a cross-level test of dynamic energy budget theory. The American Naturalist 181:506-519.**
14	[VaFaFrGo17]	2017	**Vasconcelos, J., Faria, G., Freitas, R. and Gordo, L.S. 2017. Fecundity regulation strategy of the blue jack mackerel, Trachurus picturatus (Bowdich, 1825), off Madeira Island (NE Atlantic). Fisheries Research 190: 150-156.**
15	[VaSoHeAmDeRi20]	2020	**Vasconcelos, J., Sousa, R., Henriques, P., Amorim, A., Delgado, J. and Riera, R. 2020. Two sympatric, not externally discernible, and heavily exploited deepwater species with coastal migration during spawning season: implications for sustainable stocks management of Aphanopus carbo and Aphanopus intermedius around Madeira. Canadian Journal of Fisheries and Aquatic Sciences 77(1): 124-131.**
16	[RiVaBaGeSoIn20]	2020	**Riera, R., Vasconcelos, J., Baden, S., Gerhardt, L., Sousa, R., and Infantes, E. 2020. Severe shifts of Zostera marina epifauna: Comparative study between 1997 and 2018 on the Swedish Skagerrak coast. Marine Pollution Bulletin 158: 111434.**
17	[SoHeVaPiDeRi20]	2020	**Sousa, R., Henriques, P., Vasconcelos, J., Pinto, A. R., Delgado, J., and Riera, R., 2020. The protection effects of marine protected areas on exploited molluscs from an oceanic archipelago. Aquatic Conservation: Marine and Freshwater Ecosystems, 30(4): 717-729.**
18	[SoVaRiPiDeHe19]	2019	**Sousa, R., Vasconcelos, J., Riera, R., Pinto, A.R., Delgado, J., and Henriques, P. 2019. The potential impact of limpet harvesting management on the reproductive parameters of Patella aspera and P. candei. Estuarine, Coastal and Shelf Science 226: 106264.**
19	[RiTuBeLoMaPe18]	2018	**Riera, R., V. Tuset, R. Betancur-R, A. Lombarte, C. Marcos and A. Pérez-Ruzafa, 2018. Modelling alpha-diversities of coastal lagoon fish assemblages from the Mediterranean Sea. Progress in Oceanography 165: 100-109.**
20	[SaAlLaRiBe19]	2019	**Sanabria-Fernandez, J. A., Alday, J. G., Lazzari, N., Riera, R., and Becerro, M. A. 2019. Marine protected areas are more effective but less reliable in protecting fish biomass than fish diversity. Marine pollution bulletin, 143: 24-32.**
21	[DeMeBiVaDaRoJuVe14]	2014	**De Laender*, F., Melián*, C. J., Bindler, R., Van den Brink, P., Daam, M., Roussel, H., Juselius, J., Verschuren, D., and Janssen, C. 2014. The Contribution of intra- and interspecific tolerance variability to biodiversity changes along toxicity gradients. Ecology Letters, 17: 72–81. *First co-authors.**
22	[MeBaMaViGoDrWi14]	2014	**Melián, C. J., Baldó, F., Matthews, B., Vilas, C., González-Ortegón, E., Drake, P., and Williams, R. J. 2014. Individual trait variation and diversity in food webs. Advances in Ecological Research, 50:207-241**
23	[LeDeGaCoPaKuMeSa16]	2016	**Leprieur, F., Descombes, P., Gaboriau, T., Cowman, P. F., Parravicini, V., Kulbicki, M., Melián, C. J., de Santana, C. N. Heine, C., Mouillot, D., Bellwood, D. R., and Pellissier, L. 2016. Plate tectonics drive tropical reef biodiversity dynamics. Nature Comm., 7: 11461.**
24	[MeMaAnRoHaFo18]	2018	**Melián, C. J., Matthews, B., Andreazzi, C. S., Rodríguez, J. P., Harmon, L. J., and Fortuna, M. A. 2018. Deciphering the interdependence between ecological and Evolutionary Networks. Trends in Ecology and Evolution, 33: 504-512.**
25	[CaAnEsMeBeStAp20]	2020	**Calatayud, J., Andivia, E., Escudero, A., Melián, C. J., Bernardo-Madrid, R., Stoffel, M., Aponte, C., Medina, N. G., Molina-Venegas, R., Arnan, X., Rosvall, M., Neuman, M., Noriega, J. A., Alves-Martins, F., Draper, I., Luzuriaga, A., Ballesteros-Canovas, J. A., Morales-Molino, C., Ferrandis, P, Herrero, A, Pataro,L., Juen, L, Cea, A., and Madrigal-Gonzalez, J. 2020. Positive associations among rare species and their persistence in ecological assemblages. Nature Ecology and Evolution, 4: 40-45**
26	[SoDePiHe17]	2017	**Sousa, R., Delgado, J., Pinto, A.R., and Henriques, P. 2017. Growth and reproduction of the north-eastern Atlantic keystone species Patella aspera (Mollusca: Patellogastropoda). Helgol Mar Res 71: 8.**
27	[MuSa03]	2003	**Murua, H. and Saborido-Rey, F. 2003. Female Reproductive Strategies of Marine Fish Species of the North Atlantic. J. Northw. Atl. Fish. Sci. 33: 23–31.**
28	[DeCh03]	2003	**Dewi, S. and P. Chesson, 2003. The age-structured lottery model. Theoret. Pop. Biol. 117: 923-943.**
29	[SoHeVaFaRiPiDeHa19]	2019	**Sousa, R., Henriques, P., Vasconcelos, J., Faria, G., Riera, R., Pinto, A.R., Delgado, J., and Hawkins, S.J. 2019. First observations of hermaphroditism in the patellid limpet Patella piperata Gould, 1846. Journal of the Marine Biological Association of the United Kingdom 99: 1615–1620.**
30	[MeSeEgFoDe15]	2015	**Melián, C. J., Seehausen, O., Eguíluz, V. M., Fortuna, M. A., and Deiner, K. 2015. Diversification and biodiversity dynamics of hot and cold spots. Ecography 38:393–401.**

3.4. Publicações Anteriores

3.4. Past Publications

Nº de Ordem	Referência	Ano	Publicação

Order No.	Reference	Year	Publication
1	MeMaDeRoHaFo18	2018	**Melián, C. J., Matthews, B., De Andreazzi, C. S., Rodríguez, J. P., Harmon, L. J., & Fortuna, M. A. (2018). Deciphering the interdependence between ecological and evolutionary networks. Trends in ecology & evolution, 33(7), 504-512. DOI: 10.1016/j.tree.2018.04.009**
2	deGuMe18	2018	**de Andreazzi, C. S., Guimaraes Jr, P. R., & Melián, C. J. (2018). Eco-evolutionary feedbacks promote fluctuating selection and long-term stability of antagonistic networks. Proceedings of the Royal Society B: Biological Sciences, 285(1874), 20172596. DOI: 10.1098/rspb.2017.2596**
3	RoRiDe17	2017	**Rodríguez, R.A., Riera, R., Delgado, J.D. (2017) Ecology: Science or philately? An interdisciplinary analysis of sustainability by exploring if it is possible to get more and more information by reducing collateral environmental damages. Science of the Total Environment, 596-597: 43-52. DOI: 10.1016/j.scitotenv.2017.04.053.**
4	VaFaFrGo17	2017	**Vasconcelos, J., Faria, G., Freitas, R., Gordo, L.S. 2017. Fecundity regulation strategy of the blue jack mackerel, Trachurus picturatus (Bowdich, 1825), off Madeira Island (NE Atlantic). Fisheries Research 190, 150-156. DOI: 10.1016/j.fishres.2017.02.009.**
5	SoVaRiPiDeHe19	2019	**Sousa, R., Vasconcelos, J., Riera, R., Pinto, A.R., Delgado, J., Henriques, P. 2019. The potential impact of limpet harvesting management on the reproductive parameters of Patella aspera and P. candei. Estuarine, Coastal and Shelf Science 226: 106264. DOI: 10.1016/j.ecss.2019.106264**

4. Equipa de investigação
4. Research team

4.1 Lista de membros
4.1. Members list

Nome Name	Função Role	Grau Degree	Custos (€) Costs (€)	% de dedicação % of commitment	CV nuclear Core CV	CV
Joana Vasconcelos	Inv. Responsável	-	0,00	50	✓	CIÊNCIAVITAE
Rodrigo Riera	Co-investigador Responsável	-	0,00	50	✓	CIÊNCIAVITAE
Carlos Melian	Investigador	-	0,00	15	✓	CIÊNCIAVITAE
Ricardo Sousa	Investigador	-	0,00	33	✓	CIÊNCIAVITAE

(O curriculum vitae de cada membro da equipa está disponível clicando no nome correspondente)
(Curriculum vitae for each research team member is available by clicking on the corresponding name)

Total: 4

4.2. Lista de membros a contratar durante a execução do projeto
4.2. Members list to hire during project"s execution

Membro da equipa Team member	Função Role	Duração Duration	%tempo %time
(B) Bolsa 1	Bolseiro	5	100
(B) Bolsa 2	Bolseiro	3	100

Total: 2

5. Outros projetos
5. Other projects

5.1. Projetos financiados
5.1. Funded projects

Referência Reference	Título Title	Estado Status
BMBF180034		Em curso
KVA2018		Concluído
KVA2020		Em curso
NPRP7-1129-1-201		Concluído
PGC2018-099166-B-I00		Em curso
SFRH/BSAB/143056/2018		Concluído
UREP22-145-1-022		Concluído

(Os detalhes de cada projetos estão disponíveis clicando na referência correspondente)
(Details for each project are available by clicking on the corresponding reference)

Total: 7

5.2. Candidaturas similares
5.2. Similar applications

(Sem Candidaturas Similares)
(No Similar applications)

6. Indicadores previstos
6. Expected indicators

Indicadores de realização previstos para o projeto
Expected output indicators

Descrição Description	2021	2022	2023	2024	2025	Total
A - Publicações Publications						
Livros Books	0	0	0	0	0	**0**
Artigos em revistas internacionais Papers in international journals	0	0	2	0	0	**2**

Artigos em revistas nacionais Papers in national journals	0	0	0	0	0	**0**
B - Comunicações Communications						
Comunicações em encontros científicos internacionais Communications in international meetings	0	0	2	0	0	**2**
Comunicações em encontros científicos nacionais Communications in national meetings	0	0	0	0	0	**0**
C - Relatórios Reports	0	1	1	0	0	**2**
D - Organização de seminários e conferências Organization of seminars and conferences	1	1	0	0	0	**2**
E - Formação avançada Advanced training						
Teses de Doutoramento PhD theses	0	0	0	0	0	**0**
Teses de Mestrado Master theses	0	1	0	0	0	**1**
Outras Others	0	1	0	0	0	**1**
F - Modelos Models	0	0	1	0	0	**1**
G - Aplicações computacionais Software	0	0	1	0	0	**1**
H - Instalações piloto Pilot plants	0	0	0	0	0	**0**
I - Protótipos laboratoriais Prototypes	0	0	0	0	0	**0**
J - Patentes Patents	0	0	0	0	0	**0**
L - Outros Other						
Hypermedia videos (HMV)	0	1	1	0	0	**2**
	0	0	0	0	0	**0**
	0	0	0	0	0	**0**

Acções de divulgação da actividade científica
Scientific activity spreading actions

A series of scientific outreach activities are planned throughout the proposal, to the general public in order to spread the main activities and results of LAPACOM. For this purpose, local magazines and newspapers will be involved through the publication of press notes regarding the tasks and results obtained throughout LAPACOM. The infrastructure of social media of the host institutions (UMa, ULPGC, DSEIMar and EAWAG) will be considered as a vehicle to promote LAPACOM and its activities. Social media (e.g., Facebook, Twitter, Instagram) will serve as a platform to update activities of the project, as well as, as a communication framework to interact with the general public. Additionally, two Hypermedia videos (HMV) will be prepared, one for launching LAPACOM and one with the final results obtained in LAPACOM. These videos will consist in different types of content (video, image, info graphics, maps, websites, and other) that are connected together so that the user can access and interact with all of them simultaneously on a single screen. We will also participate in the Macaronesia Researcher's Night (https://macaronight.eu/macaronight/gran-canaria/) organized by 3 countries (Spain, Portugal and Cape Verde) and 6 partners including UMa and ULPGC.

For scientific public (students, researchers and professors), collaborators or non- academic with interests on the integration of empirical and theoretical ecology and in learning more details about this project, a cycle of conferences will be organized at the University of Madeira. For this event, official and governmental entities (as an interested party in the management and conservation of coastal resources in Madeira) and research institutions will be invited. In addition to the conference cycle, a workshop will be held at EAWAG headquarters in Horw (Lucerne, Switzerland) to show preliminary results and work together on the ideas for the model preparation and implementation. Through this event, a high number of interactions and feedback from EAWAG staff is expected. These interactions will be an asset for LAPACOM and also future ideas and collaborations among the research institutions, with special focus between UMa and EAWAG.

Regarding the knowledge transfer dissemination plan, as a short-term aim, we expect to publish two scientific contributions in top-ranked (Q1, D1) ecological journals (Ecology Letters, Ecological Monographs, PNAS, among others) for reporting the results of LAPACOM. We also aim to make the code implement freely available on public repositories (e.g., Dryad, Figshare, Git) following SNSF (Swiss National Science Funding) regulations. Also, the data will be easily reusable by researchers worldwide. The results of LAPACOM will also be showed in international symposia during the last year.

7. Orçamento
7. Budget

Instituição Proponente
Principal Contractor

Universidade da Madeira

Descrição Description	**2021**	**2022**	**2023**	**2024**	**2025**	**Total**
Recursos Humanos Human resources	0,00	6.417,38	0,00	0,00	0,00	**6.417,38**
Missões Missions	2.890,00	0,00	3.450,00	0,00	0,00	**6.340,00**
Subcontratos						

Subcontract	0,00	11.025,00	0,00	0,00	0,00	**11.025,00**
Registo de patentes Patent registration	0,00	0,00	0,00	0,00	0,00	**0,00**
Demonstração, Promoção e Divulgação Demonstration, Promotion and Publication	0,00	1.600,00	13.060,00	0,00	0,00	**14.660,00**
Adaptação de edifícios e instalações Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	**0,00**
Aquisição de Bens e Serviços Service procurement and acquisitions	1.250,00	150,00	0,00	0,00	0,00	**1.400,00**
Gastos gerais Overheads	1.592,36	2.041,85	4.127,50	0,00	0,00	**7.761,71**
TOTAL DESPESAS CORRENTES TOTAL CURRENT EXPENSES	**5.732,36**	**21.234,23**	**20.637,50**	**0,00**	**0,00**	**47.604,09**
Instrumentos e equipamento científico e técnico Instruments and scientific and technical equipment	2.229,42	0,00	0,00	0,00	0,00	**2.229,42**
Total	**7.961,78**	**21.234,23**	**20.637,50**	**0,00**	**0,00**	**49.833,51**

Orçamento Global
Global budget

Descrição Description	**2021**	**2022**	**2023**	**2024**	**2025**	**Total**
Recursos Humanos Human resources	0,00	6.417,38	0,00	0,00	0,00	**6.417,38**
Missões Missions	2.890,00	0,00	3.450,00	0,00	0,00	**6.340,00**
Subcontratos Subcontract	0,00	11.025,00	0,00	0,00	0,00	**11.025,00**
Registo de patentes Patent registration	0,00	0,00	0,00	0,00	0,00	**0,00**
Demonstração, Promoção e Divulgação Demonstration, Promotion and Publication	0,00	1.600,00	13.060,00	0,00	0,00	**14.660,00**
Adaptação de edifícios e instalações Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	**0,00**
Aquisição de Bens e Serviços Service procurement and acquisitions	1.250,00	150,00	0,00	0,00	0,00	**1.400,00**
Gastos gerais Overheads	1.592,36	2.041,85	4.127,50	0,00	0,00	**7.761,71**
TOTAL DESPESAS CORRENTES TOTAL CURRENT EXPENSES	**5.732,36**	**21.234,23**	**20.637,50**	**0,00**	**0,00**	**47.604,09**
Instrumentos e equipamento científico e técnico Instruments and scientific and technical equipment	2.229,42	0,00	0,00	0,00	0,00	**2.229,42**
Total	**7.961,78**	**21.234,23**	**20.637,50**	**0,00**	**0,00**	**49.833,51**

Plano de financiamento
Finance plan

Descrição Description	**2021**	**2022**	**2023**	**2024**	**2025**	**Total**
Financiamento solicitado à FCT Requested funding	7.961,78	21.234,23	20.637,50	0,00	0,00	**49.833,51**
Financiamento próprio Own funding	0,00	0,00	0,00	0,00	0,00	**0,00**
Outro financiamento público Other public-sector funding	0,00	0,00	0,00	0,00	0,00	**0,00**
Outro financiamento privado Other private funding	0,00	0,00	0,00	0,00	0,00	**0,00**
Total do Projecto Total of the project	**7.961,78**	**21.234,23**	**20.637,50**	**0,00**	**0,00**	**49.833,51**

8. Justificação do orçamento
8. Budget rationale

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8.1. Justificação dos recursos humanos
8.1. Human resources rationale

Tipo
Type
(B) Bolsa

Nº de pessoas
No. of persons
1

Duração (em meses)
Duration (in months)
5

Custo envolvido (€) ***(calculado)***
Total cost (€) *(estimated)*
4.029,90

Outros custos (€)
Other costs (€)
711,95

Justificação do financiamento solicitado
Rationale for requested funding

Task 2 is time consuming and involves both limpets species sampling, gonad collection and preparation for the subsequent histological procedure, oocytes measure and counts, fecundity type determination and estimation. In order to meet the time allotted for the fulfilment of this task, a Research scholarship for a Master student will be available (5 months period). The student will also assist the PI and Co-PI in managing the intertidal data (task 3) to standardized and fit the requirements needed for subsequent tasks. The Master student will be included in the publication of LAPACOM results.

Tipo
Type
(B) Bolsa

Nº de pessoas
No. of persons
1

Duração (em meses) Duration (in months)	Custo envolvido (€) *(calculado)* Total cost (€) *(estimated)*	Outros custos (€) Other costs (€)
3	1.248,36	427,17

Justificação do financiamento solicitado
Rationale for requested funding

Task 2 is time consuming and involves both limpets species sampling, gonad collection and preparation for the subsequent histological procedure, oocytes measure and counts, fecundity type determination and estimation. In order to meet the time allotted for the fulfilment of this task, a Research Initiation grant for a Biology Student will be available (3 months period). The student will have the opportunity to work on a project with an international scope, to learn the sampling scheme and histological technique and even be part of the scientific publications of these preliminary results.

8.2. Justificação de missões
8.2. Missions rationale

Designação Designation	Custo envolvido (€) Cost (€)
Kick-off meeting at University of Madeira	2.890,00

Justificação do financiamento solicitado
Rationale for requested funding

Travel expenses for a 5-day period, including flights, accommodation (4 nights in a 3* hotel) and allowances (per night) for the team members Dr. R. Riera (ULPGC), Dr. C. Melián (EAWAG) and Dr. A. Vahdati (subcontract) to participate in the kick-off meeting at UMa. In this 1st LAPACOM meeting it will be outlined the main parts of the proposal and how they are articulated throughout the project, scope and products that are expected within each of the subprojects, schedules and timelines of each subproject and outreach actions to disseminate the activities.

Designação Designation	Custo envolvido (€) Cost (€)
Final meeting at Universidad de Las Palmas de Gran Canaria	3.450,00

Justificação do financiamento solicitado
Rationale for requested funding

Travel expenses for a 5-day period, including flights, accommodation (4 nights) and allowances for the team members Dra. Vasconcelos (UMa), Dr. Sousa (DRM), Dr. Melián (EAWAG) and Dr. Vahdati. In this meeting it will be outlined the final report, where the main results are shown, and also the data are uploaded to open repositories, together with codes used to develop the modelling approaches. These results will be also adapted to be published in top journals for the scientific community, and outreach publications for general public to make accessible and understandable the results of LAPACOM.

8.3. Justificação de aquisição de bens e serviços
8.3. Service procurement and acquisitions

Tipo Type	Custo (€) Cost (€)
Fecundity estimation	1.200,00

Justificação do financiamento solicitado
Rationale for requested funding

For fecundity estimation, an important feature for the mating scheme in the modelling framework section of LAPACOM, some disposable laboratory material/consumable are needed for the development of histological technique, e.g., bottles for gonad fixation, plastic bags, Technovit 7100 kit (The Sliceable), fixative Roti-histofix eco plus, alcohol, Hematoxylin and Eosin dyes, among others. Also, for the sampling of limpets it will be necessary to acquire laboratory material (e.g., callipers, tweezers, scissors, scalpels, and others).

Tipo Type	Custo (€) Cost (€)
Acquisition of Biological samples	200,00

Justificação do financiamento solicitado
Rationale for requested funding

To obtain a minimum of 10 females per size class of both Patella aspera and P. candei, we will need an experienced professional diver with a harvesting license to perform a minimum of 4 dives (1/month) throughout the mid-to-lower intertidal zone of the rocky shores of Madeira, between December and March (reproductive season of these limpet species in Madeira). This subtask (task 2) is of utmost importance as it will define the quality of the samples for fecundity estimation, e.g., having a wide range of length classes in both species.

8.4. Justificação do Equipamento
8.4. Equipment rationale

8.4.1. Equipamento já disponível para a execução do projecto
8.4.1 Available equipment

(Vazio)
(Void)

8.4.2. Discriminação do equipamento a adquirir
8.4.2. New equipment requested

Tipo de equipamento Equipment type	Custo (€) Cost (€)
Desktop DELL OptiPlex 7780 All-in-One	2.229,42

Justificação do financiamento solicitado
Rationale for requested funding

Task 2 includes capturing high-contrast digital images using a digital camera coupled to a stereomicroscope and a computer with a software of image analysis. These images are used for oocyte characterization and measure. For best results, we need a high-resolution, large-sized screen for image manipulation. The DELL OptiPlex 7780 is a premium, intelligent 27” All-in-One that delivers best-in-class performance, audio and video (equipped with 10th Gen Intel processors). Tasks 4 to 7 will also gain with this acquisition, permitting the subcontracted Dr. Vahdati to work in the modelling phase.

8.5. Justificação de registo de patentes
8.5. Patent registration

(Vazio)

8.6. Justificação de adaptação de edifícios e instalações
8.6. Adaptation of buildings and facilities

(Vazio)

8.7. Justificação Subcontratos
8.7. Subcontract

Designação	Custo (€)
Subcontratação Dr. Vahdati	11.025,00

Justificação do financiamento solicitado

To accomplish tasks 4 to 7, we count on hiring Dr. Vahdati that has an extensive background on a wide range of methods such as agent-based model, network science, analysing genome wide data to study fundamental evolutionary questions, and combining modelling biological dynamics with machine learning. Dr. Vahdati wrote the first agent-based modelling framework in the Julia language which is a mature framework by now with several people contributing to its development every month. He has been teaching machine learning to biology students at the University of Zurich and has supervised students.

8.8. Justificação Demonstração, Promoção e Divulgação

Tipo	Custo (€)
International workshop/Symposium participation	4.760,00

Justificação do financiamento solicitado

Travel expenses (flights/accommodation/allowances/symposium registration fees) for the 4 team members to participate in major public events and present the scientific achievements in conferences and workshops in the Europe space, an important part of the adopted dissemination strategy at an International level. This will allow the contact with other researchers working in this field and get some feedback, e.g., on the preliminary/advanced/final results. Therefore, all partners involved in the present project will be responsible for publishing the results in third party events.

Tipo	Custo (€)
Publication fees	6.500,00

Justificação do financiamento solicitado

Two publication fees to publish two scientific contributions in top-ranked ecological journals (e.g., PNAS, BioScience, among others) reporting the results of the present proposal. Open access permits the authors to have their article immediately freely available to everyone, including those who do not subscribe. Thus, the results will spread out through the whole scientific community.

Tipo	Custo (€)
Roll-up panel and promotional material	400,00

Justificação do financiamento solicitado

Expenses associated with poster printing for conference presentation and publicity roll-ups of the LAPACOM project.

Tipo	Custo (€)
Hypermedia videos (HMV)	3.000,00

Justificação do financiamento solicitado

Expenses associated with outreach actions, namely the creation of 2 short videos, one initial promotional video of the project/partners involved and one final video representing the main results obtained at LAPACOM. An animation of the model will be created in order to reach a wider audience.

9. Ficheiros Anexos

Nome	Tipo	Tamanho
Figure_1_CONCEPTUAL_MAP.pdf	Outros	516KB
LetterSupportCarlosMelian.pdf	Outros	60KB
Table_1.pdf	Outros	37KB
timeline.pdf	Cronograma	142KB

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