Institut de Ciències del Mar

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

JAE SOMMA INTRO 2021 – ICM LIST OF PROJECTS

Title: Plastic-degrading enzymes through the computational microscope.

Advisor: Francesco Colizzi (fcolizzi@icm.csic.es)

Abstract: Plastics have been found widespread in the global ocean, in the soil, and entrained in the air. In response to the planetary diffusion of plastic pollution, microbes are evolving the capacity to utilize such polymers as carbon and energy sources. These plastic-degrading systems offer a starting point for biotechnology applications where enzymes are engineered to improve their catalytic efficiency, toward a circular materials economy. Understanding the molecular details of substrate-enzyme interactions is key to guide the enzyme engineering effort. This project focuses specifically on the enzymatic degradation of polyethylene terephthalate (PET)—the most abundant polyester in the Ocean. Despite extensive research performed, the molecular mechanism of PET enzymatic degradation is still controversial (*Nat Commun* **2019**; 10**,** 5581). In this context, computer simulations could bring about a major productivity leap and will be used in this project to provide information on processes that usually escape experimental detection. Specifically, the dynamics of substrate binding and product release will be investigated for a series of PET-degrading enzymes. The student will become familiar with basic and advanced biomolecular simulations techniques, and will be encouraged to generate experimentally-testable hypothesis built upon the analysis of the simulations. Ultimately, the student will contribute to the long-term goal of the group toward the molecular characterization and optimization of plastic-degrading systems from the deep Ocean and marine sediments.

Advanced molecular simulations are critically impacting the advancement of bio(techno)logical and drug discovery projects. However, it is still rare to see such approaches integrated into a global and interdisciplinary environment focused on marine pollution with tight collaborations

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

among marine microbiologists, physicists, and biogeochemists, such as pursued in our Institute. For this reason, this training may represent a great opportunity to “put your grain of salt” in the field of plastic bioremediation, to discover the beauty of molecules in motions, and at the same time be exposed to a friendly and diverse community of scientists gravitating around marine research.

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

Title: Retrospective analyses of penguin tracking data to protect Southern Ocean ecosystems

Advisor: Francisco Ramírez (ramirez@icm.csic.es)

Abstract: As charismatic and iconic species, penguins can act as ambassadors or flagship species to promote conservation of the valuable marine habitats they inhabit in the Southern Ocean. Unfortunately, there is a clear lack of reliable, comprehensive and systematic efforts aimed at compiling spatial-temporal information on the distribution of penguins. The Institute of Marine Science, in collaboration with international partners from France, Australia and New Zealand, is now launching the "Safe Operating Space for Penguins (SOSPEN)" initiative. Through this initiative, we aim to assemble the most comprehensive tracking dataset for penguins, based on partners' contributions, to be incorporated in a holistic approach to identify key marine areas for the 18 individual penguin species in the world.

We are seeking a highly motivated and qualified TFM student to join our initiative. As her/his main tasks, the student will contribute to compile this unique dataset, and will learn to apply systematic and semi-automatic methodologies and existing curation methods to process and clean tracking data and associated metadata. In addition, the student will learn state-of-the-art GIS methods and cutting-edge species distribution models to identify key marine areas for penguins species and assemblages.

Through this project, the student will acquire a deep knowledge on penguin biology and spatial ecology. From a methodological point of view, the student will also acquire knowledge and skills in the acquisition, management and analysis of tracking and environmental data. The student will interact with other researchers and students involved in the research project, thus developing transversal skills on interpersonal relationships, teamwork and communication skills.

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

Title: Modelización de datos sísmicos y caracterización de propiedades físicas de la zona tsunamigénica de zonas de subducción.

Advisor: Manel de Prada (mprada@icm.csic.es)

Abstract: El plan de trabajo que se propone en esta expresión de interés va orientado a la formación de estudiantes de ciencias de la tierra, en particular, dentro del campo de la geofísica aplicada. El candidato se focalizará en datos sísmicos de reflexión multicanal de la zona de subducción frente a las costas de Nicaragua, una región golpeada por grandes terremotos tsunamigénicos (i.e. 1992 Nicaragua tsunami earthquake). Los datos están ya disponibles. El objetivo metodológico es aprender tareas de procesado y modelización de datos sísmicos con el fin de caracterizar la estructura y propiedades físicas (modelos de velocidad sísmica) del margen. En particular el estudiante se centrará en la parte más cercana a la fosa tectónica, la región más profunda del margen y con mayor probabilidad de generar tsunamis durante la generación de grandes terremotos en la zona de subducción. Por lo tanto, el candidato no solo se formará metodológicamente, sino que además aprenderá sobre los procesos geológicos activos involucrados en la evolución de zonas de subducción, la generación de terremotos y tsunamis. Estos conceptos que se alinean perfectamente con los objetivos demi proyecto Beatriu de Pinós (EXTREME), el cual se centra en estudiar como las propiedades físicas de las zonas de subducción controlan la propagación de grandes terremotos y la generación de tsunamis en estas regiones. La formación metodológica de este plan de trabajo va orientada (aunque no particularmente) a estudiantes del Máster de Geología y Geofísica de Reservorios que imparte la Universidad de Barcelona, y en el que participan investigadores del grupo de investigación al que pertenezco (Barcelona Center for Subsurface Imaging), lo cual facilita la atracción de estudiantes al CSIC. Uno de los principales objetivos de este Máster es la familiarización con la utilización de las técnicas y las herramientas más modernas que actualmente desarrollan y utilizan tanto los equipos de investigación punteros como las principales empresas de exploración de recursos naturales. Por lo que el plan de trabajo presentado aquí ofrece una oportunidad única para que estudiantes de este master puedan realizar el trabajo de fin de master en el CSIC. En este sentido, mi experiencia (~10 años) en el análisis de datos sísmicos y conocimientos en zonas de subducción, además de la

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

experiencia previa en supervisión de trabajos de master, garantiza que la formación del estudiantese lleve a cabo satisfactoriamente.

Title: Using SMOS surface salinity and ocean color optical data to characterize the circulation of freshwater in the Beaufort Gyre.

Advisor: Marta Umbert (mumbert@icm.csic.es)

Abstract: The Arctic is one of the fastest-changing regions on the planet in recent years. It is affected by sea ice shrink, glaciers melting, permafrost thickness decrease and water cycle acceleration, all direct effects of global temperatures increase due to human-generated emissions. As the temperature rises and the ice melts, large amounts of freshwater enter the ocean. The export of liquid freshwater from the Arctic Ocean is important for global thermohaline circulation and climate. The Beaufort Gyre, the largest Arctic Ocean freshwater reservoir, has drastically increased its liquid freshwater content by 40% in the past two decades. If released within a short period, the excess freshwater could potentially impact the large-scale ocean circulation by freshening the upper subpolar North Atlantic (Zhang, et al. 2021). Characterizing these changes with in situ measurement is not easy, as the Arctic has conditions of extreme cold and long periods of darkness in the winter months. Thanks to the use of satellites we can access the polar regions and monitor the state and the changes that are taking place there.

In this work, we will use the new SMOS capability to accurately measure the SSS in the Arctic Ocean to better understand the freshwater flows in the Beaufort Gyre. The main objectives of this master's thesis are: to **characterize the correlation between CDM and SSS at Mackenzie river plume, the surface currents of the Beaufort Gyre and its evolution from 2012 to 2020**. To evaluate the relationship between SSS and CDM in the Mackenzie River plume, we propose to study the relationship between remotely sensed CDM and SSS and derive local regressions between them from 2012 to 2020. We will use SMOS Arctic + Salinity together with standard optical CDM products (the absorption coefficient of dissolved organic materials at 443 nm). The surface currents from Globcurrent products will be evaluated and used to study the influence of river discharge in the local circulation in the Beaufort Gyre.

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

Project title: Monitoring the contemporary biodiversity crisis in the Mediterranean Sea using digital data from recreational fishing

Advisor: Valerio Sbragaglia (sbragaglia@icm.csic.es)

Abstract: The goal of this *JAE Intro project* is to showcase the potential of digital data from recreational fishing to advance our knowledge on the contemporary biodiversity crisis in the Mediterranean Sea. Many aspects of such crisis remain unsolved because of the lack of the necessary ecological and socio-economic information to guide decision-makers. The student will be introduced to two emerging research approaches (conservation culturomics and iEcology, which use digital data to study human-nature interactions and ecological patters). In this context recreational fishers play a central role for two main reasons. First of all, the impact of recreational fishing on marine ecosystems is not well understood due to constrains in monitoring activity. Therefore, the development of a cost-effective monitoring tool, as planned in this *JAE Intro project*, will increase our understanding of the impact of recreational fishing on Mediterranean ecosystems. Second, recreational fishers constitute a widespread spatio-temporal sampling network that - if properly analysed - can provide an unprecedented body of information, especially for marine environments where sampling is constrained across time and space (e.g., European recreational fishers are estimated to be around 8.7 million). Digital data will be mined from several sources such as webpages, video-sharing platforms and social networks. Data will be filtered using machine learning algorithms and validated against independent datasets (in collaboration with University of Helsinki; Dr. Di Minin is an ERC-Starting grantee and world leader in using digital data in conservation policy-making). Recreational fishing catches will be reconstructed (2010-present) and georeferenced at the Mediterranean level for 3 target species including an invasive species, an emblematic and iconic species, and a threatened species. Three major impacts are expected: (i) publishing 1 high-quality first-author paper in a top journal to showcase the tremendous impact of integrating digital data in the context of marine biodiversity conservation; (ii) an important societal impact by providing a cost-effective monitoring tool and insights on the human dimension of recreational fisheries, which will be shared within the working group of recreational fishing of the FAO-GFCM; (iii) a high career impact for the student that will be put in a competitive position to obtain a PhD scholarship in a very attractive and emerging area of research.

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

Title: STRIKE - Salt tectonics and fluid flow along the plate boundary off SW Iberia: The Lineament South strike-slip fault

Advisor: Sara Martínez (smartinez@icm.csic.es)

Abstract: The Lineament South (LS) strike-slip fault has been interpreted as the present-day plate boundary between Africa and Iberia. Recent works have shown processes of salt tectonics and fluid flow along this large structure. The LS is one of the most dangerous tsunamigenic structures for the SW Iberian coasts. The work will focus on the study of recent tectonic activity along the LS fault through the processing and interpretation of a high- resolution dataset recently acquired in the framework of the INSIGHT-Leg1 cruise. The dataset includes: a) multichannel seismic (MCS) profiles; b) High-resolution (HR) MCS Sparker profiles; c) TOPAS sub-bottom profiles; d) multi-beam bathymetry and HR bathymetry mosaics acquired with an autonomous underwater vehicle. The student will have the opportunity to learn the use of specific software available at the ICM (e.g., Global Claritas, seismic unix, GMT, QGIS or Kingdome Suite) for the processing, treatment, analysis and interpretation of the dataset with which she/he will work. The results are expected to be published in an SCI journal and the student will be part of the list of co-authors.

Students interested in this project can contact the responsible researcher (Dr. Sara Martínez) by email : smartinez@icm.csic.es

MINISTERIO DE CIENCIA E INNOVACIÓN
CSIC Consejo Superior de Investigaciones Científicas
EXCELENCIA SEVERO OCHOA

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

Title: The chicken or the egg: is dysbiosis a cause or a consequence of sponge disease?

Advisor: Dr. Lucía Pita (luciapitagalan@gmail.com)

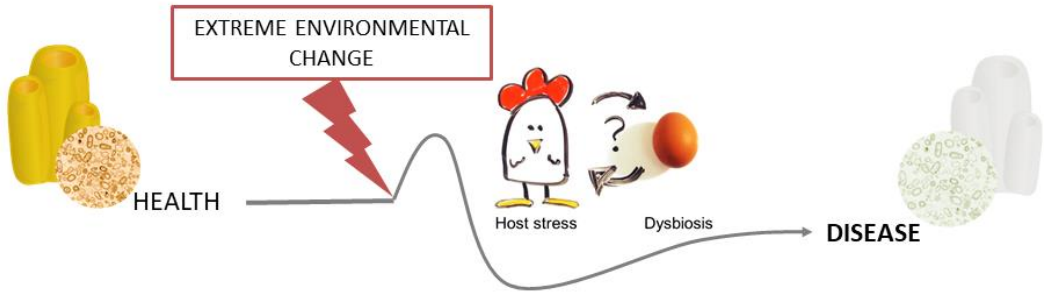
www.luciapita.es

Abstract: The rapid environmental changes resulting from human influence are threatening the delicate balance of host-microbe-interactions in marine organisms. Environmental disturbance and stress will ultimately compromise health. Several studies detected distinct shifts in the microbiome (i.e., dysbiosis) in correlation with disease. This proposed Master's thesis will address the following question: "Is microbial dysbiosis a cause or a consequence of sponge disease?"

To disentangle the role of the host (in particular, immunity) and the microbiome in the response to stress, we combine experimental approaches with molecular analysis.

Candidates should be interested in applying molecular tools to solve ecological questions. The student will engage in experiments, 16S rRNA gene amplicon sequencing analysis, animal RNA seq analysis, and microscopy. This work will contribute to a better understanding on the role of host-microbe interactions in determining health and disease in the ocean.

If you are interested and want to know more, please contact Dr. Lucía Pita and attach your CV.



MINISTERIO DE CIENCIA E INNOVACIÓN
CSIC Consejo Superior de Investigaciones Científicas
EXCELENCIA SEVERO OCHOA

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

Title: Ultra-small microorganisms along the groundwater-marine continuum

Advisor: Clara Ruiz-González (clararg@icm.csic.es)

Abstract: The discharge of groundwater to the ocean is a process that has been poorly studied from a biological point of view, but of great relevance on a global scale, since it contributes large amounts of nutrients, pollutants and other terrestrial elements to the sea. In the Mediterranean Sea, these underground sources of water have been estimated to provide more nutrients than rivers, but the microorganisms that inhabit coastal aquifers, whose activity can transform the chemical composition of the groundwater that reaches the sea, are largely unknown. In particular, groundwaters are known to harbor minuscule bacteria (ultramicrobacteria) that may not be captured by current sampling strategies but that appear to be important in these ecosystems. As very little is known about these minute cells, the objective of the project will be to study the ultramicrobacteria in coastal groundwaters from an aquifer near Barcelona, combining electron microscopy, flow cytometric techniques and molecular analyses to understand the ecology and the role of these minute microbes. The student will also learn to design molecular probes to try to quantify and visualize the ultra-small component of groundwater microbial communities.

The project will be directed by Dr. Clara Ruiz González, from the Department of Marine Biology of the ICM-CSIC, where most of the work will be performed. The student will join a multidisciplinary group with several doctoral students, technicians and post-docs (https://emm.icm.csic.es) in an institute that develops a large number of research projects on various topics, and may participate in some field samplings in collaboration with hydrogeologists from the Universitat Autònoma de Barcelona. The EMM group maintains an important training commitment with its students to guarantee the maximum learning.

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

Title: Spatial trophic dynamics of a large pelagic predator along contrasting oceanic environments

Advisor: Joan Giménez (gimenez.verdugo@gmail.com)

Abstract: Swordfish (*Xiphias gladius*) is a large solitary pelagic predator with a highly commercial importance. In the Atlantic Ocean, two stocks are known: a northern and a southern stock, in addition to the Mediterranean one. Aside from genetic differences, life history parameters, such as growth and sexual maturity differ between the Mediterranean and Atlantic Ocean stocks. Nowadays, this species is considered as a near threatened species in the Mediterranean and European waters by the IUCN Red List, where their populations are decreasing mainly due to overfishing.

This species is an opportunistic predator with a wide trophic spectrum mainly feeding on fin-fish and cephalopods, with spatial and ontogenetic differences in the relative importance of these prey groups. Swordfish typically forages in deep waters during the day and stay in mixed layers at night. Although trophic habits have been identified through its range, a proper spatio-temporal comparison between the Mediterranean and Atlantic basins is lacking. This inter-basin comparison would help to understand the ecological role of swordfish within the pelagic community, as well as to monitor changes of the food web. This information is of special interest for the management of the different stocks of swordfish.

In the present project, we will examine the feeding ecology of swordfish along a latitudinal gradient (Mediterranean Sea and Atlantic Ocean) between 2017 and 2020 using a combined approach of stomach contents and stable isotopes analyses in muscle tissues. This study will provide interesting new insights into the ecological role of this species at risk. The Severo Ochoa JAE Intro grantee will acquire identification skills of stomach content analysis, analytical skills regarding stable isotope analysis, as well as statistical skills to analyse the data. The applicant will be integrated in the *Functioning and Vulnerability of Marine Ecosystems* group and will interact with several researchers devoted to numerous topics regarding marine conservation and ecosystem functioning.

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

Title: Microscopic and genomic exploration of unusual cyanobacteria-algae symbiotic interactions involved in the marine nitrogen cycle

Advisor: Fran Cornejo (frcornej@ucsc.edu)

Abstract: A widespread symbiosis was recently discovered in the ocean between a unicellular cyanobacterium (UCYN-A) and a single-celled eukaryotic alga. UCYN-A lacks typical cyanobacterial features such as the capacity to perform oxygenic photosynthesis, CO_2 fixation or the tricarboxylic acid cycle, and must thus rely on the supply of organic matter from the algal host. In turn, UCYN-A shows a dramatic genome reduction with a high specialization in nitrogen fixation, providing fixed nitrogen to the alga. The UCYN-A symbiosis has been shown to be key for the marine nitrogen cycle and, although multiple UCYN-A sublineages have been detected based on genetic analysis of functional marker genes, a deep genomic and microscopic characterization of the UCYN-A diversity is still missing. The objective of the project will be to mine global metagenomic datasets for the biogeographic characterization of new UCYN-A associations as well as the development of new molecular probes for their detection and visualization by means of epifluorescence microscopic approaches.

This project will be directed by Dr. Francisco M Cornejo Castillo at the Department of Marine Biology of the Institute of Marine Sciences (ICM)-CSIC. Besides the training needed for accomplishing the tasks of the project, the student will be integrated in a multidisciplinary team of master students, PhD candidates, post-docs and senior scientists, which will provide a great opportunity to acquire multiple research skills and knowledge on marine microbial ecology and oceanography.

Pg. Marítim de la Barceloneta, 37-49
08003 Barcelona
+34 932 309 500
www.icm.csic.es

Title: Unraveling the ecological roles of deep ocean viruses

Advisor: Felipe Coutinho (fhernandes@icm.csic.es)

Abstract: The deep oceans are the most under explored habitats in our planet. Life in these ecosystems is sustained by microorganisms, whose metabolisms contribute to ecological processes of global relevance. These include nutrient and energy cycles which are still poorly characterized. The Malaspina expedition sought to fill this knowledge gap by sampling deep ocean regions throughout the globe. Among the many discoveries derived from this project are included the elucidation of the species composition of the microbiomes from the deep oceans[1], as well as the roles played by them in the Carbon, Sulfur and Nitrogen cycles[2]. Yet, one important component of these microbiomes has not been investigated in detail: the viruses. Viruses, especially those that infect microbes, are the most abundant and diverse biological entities in the oceans. They influence these ecosystems through three major mechanisms: selective killing of their hosts, expression of metabolic genes during infection, and by acting as agents of genetic exchange. The expression of metabolic genes are of special relevance as it alters the host metabolism and re-directs it towards pathways that benefit viral replication[3,4]. Considering the enormous amounts of viral infections taking place in the deep ocean daily[5], the expression of viral encoded metabolic genes is likely to have a major influence on the aforementioned elemental cycles. The goal of this project is to elucidate the diversity of viral encoded metabolic genes in the deep oceans. The student will analyze a collection of metagenomes generated by the Malaspina expedition in search of viral genomic sequences in this dataset. Next, these genomes will be queried in search of metabolic genes of ecological relevance, such as those involved in carbohydrate, energy, and amino acid metabolisms. Using state-of-the-art bioinformatics tools the viral genomes will be linked to their putative hosts to estimate the potential contributions of these viruses to biogeochemical cycles of global relevance.

The student will receive training to perform all the necessary analysis, thus developing skills in programming, comparative (meta)genomics, and microbial ecology.