DYNAMO

DYNamic Approaches for assessing Marine biota responses to fluctuating Oceans

Co-Chairs: Marco Fusi and Simone Baldanzi

Title: Dynamic approaches for assessing marine biota responses to fluctuating oceans

Acronym: DYNAMO

a. Summary/Abstract (max. 250 words)

Environmental fluctuations and their predictability play a fundamental role in determining diversity of species, communities, and assemblages in the ocean. Yet, fluctuations of the environment are often labelled as noise or ignored with the risk that effects of environmental change on organisms are mis-estimated. The DYNAMO (DYNamic Approaches for assessing Marine biota responses to fluctuating Ocean) will bring together a diverse community of scientists to advance research in fluctuating environments and provide standards for empirical research which will develop new actions for the effective management of marine ecosystems. Specifically, DYNAMO will quantify to what extent fluctuations of environmental drivers (*i.e.*, temperature, oxygen, pH) and their predictability shape the marine benthic communities (i) physiology and (ii) ecological interactions. DYNAMO will (iii) be able to provide guidelines for appropriate ‘mimicry’ of environmental variability in controlled laboratory experiments and (iv) implement realistic models to account for organismal variation in fluctuating environments. Additionally, DYNAMO will (v) develop a set of new indicators to capture the ecological relevant environmental variability and provide guidance on environmental data retrieval, analysis, and storage. Lastly, DYNAMO will (vi) ensure outreach with society, policymakers and science communicators to produce peer-reviewed and media outputs to disclose the role of environmental fluctuations in shaping marine life and ecosystem services under changing ocean. By providing concrete evidence produced by qualified experts, DYNAMO will accelerate the transition towards problem-oriented and interdisciplinary science needed to build a new narrative for the ocean.

b. Scientific Background and Rationale (max 1250 words)

The need for an ecologically relevant approach in Ocean Sciences

Life on earth and in the oceans evolved in ever-changing conditions of temporal and spatial environmental fluctuations, which influence and are influenced by the biological component of the ecosystems [1]. For example, in marine productive ecosystems, temperature and light availability drive strong fluctuations in water chemistry at diurnal scale, by acting on the rates of photosynthesis and respiration of aquatic primary producers and consumers [2]. *In situ* measurements of environmental variables (*e.g*., pH, dissolved oxygen concentrations, temperature) in a range of coastal marine habitats including estuaries, kelp forests, coral reefs, mangroves and upwelling regions [3–7], reveal considerable natural fluctuations, even over short (diel) timescales (*e.g*., Lemasson et al., 2018; Giomi et al., 2019). Nevertheless, biologists still largely adopt the 'mean conditions paradigm' when it comes to investigate the effect of the 'environmental change' on physiological and ecological processes through both, experimental and theoretical approaches [9,10]. There is abundant evidence that some environmental fluctuations can increase physiological tolerance and promote plasticity of marine biota to novel environmental conditions [2,11]. The type of environmental fluctuation, the spatial and temporal scales and how they interact with relevant physiological and ecological variables to shape local adaptation is, however, unknown. Benthic communities are more sensitive to environmental changes because their low motility will expose them to the condition in the ecosystem they live [12]. Importantly, the magnitude and periodicity of the environmental fluctuations, including the extreme events, could be altered in the near future, with significant implications for marine species survival, biodiversity and ecosystem functions [13]. Studies on how fluctuations affect ecological and evolutionary processes and standardized methods on how to quantify these fluctuations are thus urgently needed to develop biodiversity conservation strategies under global change [14] and this has been highlighted by the working group 2 in the latest IPCC report [15]. A crucial aspect of environmental fluctuations that influences the potential predictability as perceived by organisms, is when environmental variables are temporally or spatially autocorrelated, which creates opportunities for individuals to anticipate and adjust to the near future changes (physiologically bearable conditions; Figure 1) [16].

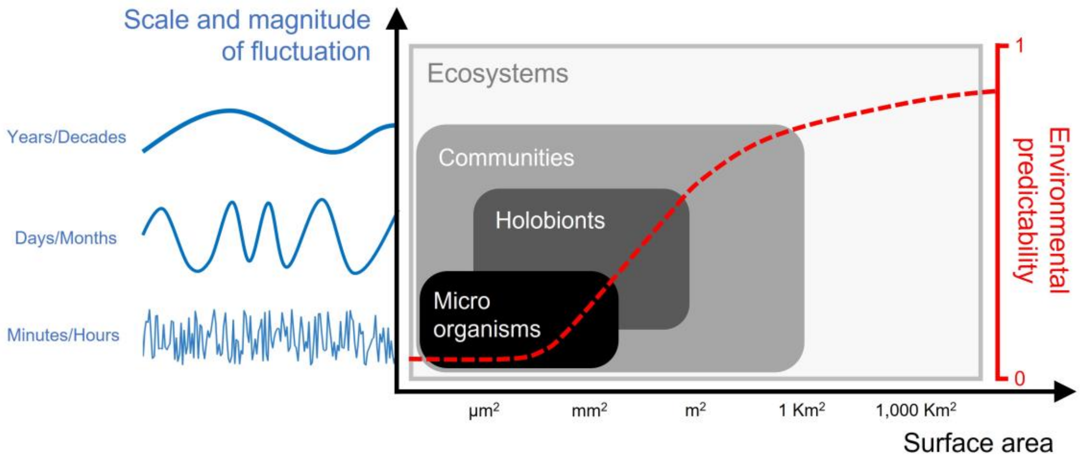

Figure 1. *Different level of biological organisation experiences different scales of spatial and temporal environmental variability (and predictability). Thus, showing the importance of integrating across different environmental scales that connect organisms/communities/ecosystems to climate and anthropogenic changes. At micro/millimetres scales, environmental variables can display random variations across time (rather than a regular, e.g., cyclical, pattern) which make that variability difficult to predict. For example, cyanobacterial biofilms are characterized by a high variability of oxygen and pH fluctuations over time because of different micro-conditions (i.e., irradiance, photosynthetic performance). At larger scales, holobionts and communities experience more predictable patterns of variation. Corals in tropical marine systems live in a predictable pattern of daily temperature variation; likewise, benthic communities in marine productive ecosystems experience regular daily fluctuations of dissolved oxygen driven by photosynthesis and community respiration. At the ecosystem level, the predictability of environmental variables further increases because of the seasonal pattern corresponding to the latitude where the ecosystem is located. Figure from Fusi et al., 2022*.

It is critical, therefore, to define the correlation timescales among ocean drivers affected by climate change, since global warming can make marine environments less predictable [17,18] and therefore disrupt the ecological and evolutionary response of the marine biota [2,19,20]. Few studies have incorporated environmental predictability in marine ecosystems (Fuhrman et al., 2006; Baldanzi et al., 2015; Brodie et al., 2021; Gill et al., 2022), and there is a dearth of knowledge about how and to what extent fluctuations and predictability will be affected in an ever changing and warming ocean [24,25]. Theoretically, in a warmer and more energetic atmosphere, short term extreme events will increase blurring predictable seasonal patterns (Seneviratne et al. 2012). For example, in regions with rapid atmospheric or oceanic fluctuations, such as the Mediterranean Sea and western boundary currents like the Gulf Stream, Marine Heat Waves are unpredictable and intense, disrupting the diel normal fluctuations of those marine ecosystems [26,27]. This process may however be quite complex and it is still not well understood, as trends in temperature predictability over time clearly differ among climatic models and regions. Manipulative experiments have been extensively used to understand how climate change affects marine biota and, recently, the experimental manipulation of environmental drivers and the responses of organisms to multiple climate change-related stressors has received considerable attention [28–31]. The SCOR activity “Changing Ocean Biological Systems” (COBS https://scor-int.org/project/changing-ocean-biological-systems-cobs/) seeks to train scientists worldwide to successfully perform well-designed multi-driver manipulative experiments that are required to tackle the multi-faceted challenges of contemporary climate change. The extent of the magnitude and the predictability of the environmental fluctuation of the drivers is, however, still not considered within COBS. We argue that, although designed in a multifactorial fashion, laboratory experiments based on static conditions (*e.g.*, acclimatization of animals to constant values for a minimum amount of time) still lack realism and are subjected to under- or overestimation of organisms’ responses to stress. This is likely a consequence of a lack of understanding of the modulating role of variability on physiological and evolutionary processes and the lack of best practices both in term of conceptual frameworks and technical aspects. Further, as suggested by recent studies [32–36], exposing animals to field-simulated, fluctuating conditions in the laboratory, increases their capacity to perform well in response to stress and allows scientists to rely on more precise, resolute and realistic results to predict the effects of climate change.

Why a SCOR working group?

To tackle the challenge imposed by current climate change on marine systems, the DYNAMO working group (WG) will build from the COBS project (the SCOR activity “Changing Ocean

Biological Systems" - COBS - https://scor-int.org/project/changing-ocean-biological-systems-cobs/) - proposing a multifactorial dynamic approach that will include fluctuations of multiple drivers and the conditions under which these become sufficiently predictable to promote adaptation for different types of physiological and ecological variables. This constitutes a huge theoretical and technical challenges that goes far beyond the already challenging issue of addressing multiple environmental drivers. This justifies the formation of a new SCOR working group with close collaboration with other groups. We believe SCOR is the ideal platform to achieve our activities, which are rarely fundable by standard research grants from national research agencies, providing the ideal basis for developing a consensus across the ocean community. The outputs of DYNAMO WG will both stimulate new type of measurements of environmental variables to better depict the environment at a scale that is relevant to the ecology of marine species and advance our ability to design relevant experimental strategies and to simulate environmental fluctuations in Dynamic Manipulative Experiments (DME, as opposed to manipulative experiment with static conditions). Although the scope of our proposal applies to a large number of marine systems, we will focus on benthic systems as they are particularly threatened by climate change, and they provide a reliable system where to tie environmental fluctuation to population and community levels. These avenues of research represent an innovative area within the field of ecological sciences, which will impact the larger ocean sciences community (included marine policy makers and stakeholders) and train present and future marine molecular and evolutionary ecologists, eco-physiologists, climatic modelers, geographers, and experts in climate change. That is why we are approaching SCOR.

c. Terms of Reference (max. 250 words)

ToR1. Develop guidance for measuring the environmental fluctuations at a global- and relevant temporal scales with the capacity of the working group experts using ecologically relevant *in situ* monitoring techniques to provide novel approaches to measure the magnitude, frequency and predictability of environmental variables experienced by marine organisms, with a focus on benthic systems.

ToR2. Tackle technical challenges and propose new experimental designs for both mechanistic understanding and an appropriate 'mimicry' of environmental fluctuation in DME. Simultaneously, to develop cost-effective methodological standard practices which can be applied in any laboratory, everywhere in the world to measure ecological response under fluctuating conditions and modelling how biological systems (from organisms to communities) filter, integrate, respond to, and predict environmental fluctuations.

ToR3. Create new specific indicators of ecosystem performance, able to capture and quantify environmental fluctuations and predictability by scaling up experimental results with conceptual models to understand the dynamics of benthic physiology and complex ecological interactions in response to environmental fluctuations.

ToR4 Building capacity and disseminate methods on *in situ* environmental logging and DME by transferring and sharing knowledge on (i) environmental data retrieval, analysis, and storage, (ii) novel experimental design able to incorporate the fluctuation component and (iii) train and use the developed indicators as tools to improve marine management decisions.

ToR5. Outreach society, policy-makers and science communicators to produce publications and media to disclose the role of variability and predictability of multiple drivers to integrate the concept of fluctuations in marine management strategies and indicators development.

d. Working plan (logical sequence of steps to fulfil terms of reference, with timeline. Max. 1000 words)

Several activities are planned to fulfil the terms of reference. Specifically, for ToR1 and ToR2 we will challenge the recent technological advances to provide a large portfolio of options for environmental logging. DYNAMO WG will (i) review and propose best practice for capturing environmental variation experienced by marine benthic systems, (ii) build a free accessible website to provide guidance for logging environmental data and hosting open-access reference guides and software tools, (iii) produce guidelines to implement cost-effective DME and measure community responses to environmental fluctuations, (iv) development of packages on an open source environment (*e.g.*, R) that allow anyone to use the approaches generated here, or to create their own models, or to extract the data (need to be in a set format/meet certain standards; *e.g.*, MEDIN, Pangaea) they need for understanding patterns of local variability. For ToR3 we will undertake two extensive systematic reviews and metanalysis in order to conceive and test new marine indicators able to capture effect of the ecologically relevant environmental fluctuations on organismal/community level. One review and metanalysis will focus on the effect of the variability and predictability of multiple drivers associated with climate change on marine benthic ecophysiology (*i.e.*, metabolism, reproduction, and behaviour) and evolutionary ecology (*i.e*., transgenerational plasticity, epigenetics, adaptation). This work will collate historical time series of environmental drivers, identify knowledge gaps and develop a baseline for future studies that consider the 'scales of variation' of the drivers (*i.e.*, from local to global) and the scales of individual responses (*e.g*., physiological responses, molecular mechanisms), grounded on actual patterns of environmental fluctuations. A second review will focus on the types of biological variables that are being used in physiological experiments and their limitations/advantages to improve our understanding of local adaptation, and to extrapolate physiological results of DME to population and community levels. This work will identify knowledge gaps and develop a conceptual framework to include fluctuations of (selected) multiple drivers associated with climate change and their predictability into multi-complex benthic network analysis. Robust environmental data retrieval and marine benthic community responses will serve to implement a set of indicators to assess the level of natural fluctuation and their predictability of environmental marine drivers. In this context, a suite of indicators is being looked upon with the objective of providing standards for monitoring early signs of water quality variations and degradation in such rapidly changing environments that can impact marine organism and populations. Furthermore, the calculation of these indicators can be tested to large global datasets of key environmental variables under different climatic scenarios, by using portal like the Copernicus Marine Service (https://marine.copernicus.eu).

ToRs 3 and 4, we will create a dedicated session to advance our understanding on how to model the data obtained from the new methodology developed to predict benthic ecosystem responses to climate change. We will produce a series of knowledge exchange opportunities for students, scholars, and technicians, including online events on time-series and fluctuation analysis provided by the DYNAMO WG members and their post-graduate students. We will organise internship in the hosting laboratories of the members aimed to assist early career scientists to set experiment on environmental fluctuation and organize training workshops for members to integrate analysis of time series with ecological network analysis. Findings from the DYNAMO WG will be integrated into existing capacity building programs, e.g. through the SCOR WG149 activities and the large scale capacity building program led by the Ocean Acidification International Coordination Centre (led by Sam Dupont).

To fulfil ToR5, we will outreach to policy makers through to the established networks at regional level (*e.g.,* OSPAR area) and international level. The output produced by the WG will be broadcasted through the established networks that the members have. The WG will outreach society through several platforms (see section *i*) and thanks to direct connection for example to MERI Foundation (https://fundacionmeri.cl/en/fundacion-meri/) and Ocean Leaders (https://oceanleaders.org/).

To achieve the above activities, we propose the following **timeline**:

First year. The kick-off meeting for all WG members will be held in Chile. Non-SCOR funding (e.g. Royal Society International Exchange) will be sought to allow students, postdocs, or scientists from developing countries to attend the meeting. This meeting will focus on: (i) discussing the main goals and activities of the team and the conceptual pathways to push these goals forward, (ii) overall planning of the project calendar and logistics (meetings, reviews, document writing, etc.) and specific deliverables (papers, white papers), (iii) assigning of tasks to subgroups that will be leading the ToRs, coordinated by the chairs. A capacity-building subgroup will be created with the overall aim of transferring knowledge and training of students and early career researchers from developing countries during the 3 years (see section *e* for details). Online meetings will be implemented over the year (at least one per month), to achieve deliverables. Starting from the first year and for the entire duration of the project, the WG will publicise DYNAMO activities to the society, to prepare the ground for the ToR5 achievement. The latter will be accomplished by approaching scientific journalists to publish public articles, sending articles to online journals (see section *e*), as well as by creating and sharing social media profiles/pages of the WG.

Second year. WG Meeting for all WG members to be held in South Africa. During this meeting, the WG will (i) review the activities and progress on ToRs (ii) work on the delivery, (iii) work on the planning of the online courses to be delivered in the second semester, (iv) preparing the road map to impact that will be defined in the workshop for the third year (see below). During the year, online meetings with subgroups will focus on the preparation and submission of scientific publications and we will review and prepare the final version of the best practice guide for field and DME (see section *e*). Online courses should be uploaded to open platforms over the year. During the second semester of the second year, a workshop that will be held at the beginning of the third year (see below) will be advertised through social media and scientific network.

Third Year. A third meeting will be held in UK. The meeting will mainly focus on ToR4 and 5 with the aim to a) raise awareness on the importance of considering environmental fluctuations and their predictability in marine planning and management initiatives, b) maximise the impact of the WG through the existing network while outreaching to governmental and non-governmental institutions, to maximise the implementation of indicators, standardised approached, methods and forecasting models in marine management decision making.

e. **Deliverables (state clearly what products the WG will generate. Should relate to the terms of reference. Max 250 words). A workshop is not a deliverable. Please note that SCOR prefers that publications be in open-access journals.**

(Years 1-2 and ToR 1 and 2). Produce a **guidance document** summarizing best practices/protocols for: (i) capturing environmental fluctuations *in-situ* and their predictability; (ii) controlling variability in laboratory experiment to develop mechanistic experiments as well as reproducing ecologically relevant laboratory DME (*e.g.*, Knights et al., 2020). These protocols will be **deposited in the SCOR collection at the Ocean Best Practices Platform** (https://www.oceanbestpractices.org/) and on the Jove platform.

(Years 2-3 and ToRs 3 and 4). The **two scientific publications** will be submitted to open-access peer-reviewed scientific journals. The tentative title of publication#1 will be "*"The effect of environmental fluctuations and predictability of environmental drivers to understand marine benthic community response to climate change*"; the tentative title of publication#2 will be *"The effect of environmental fluctuations and predictability of environmental drivers on organismal physiology and its effect on population community benthic dynamics*". The revisions/metanalyses will led to the production of a set of **new marine indicators** able to capture the magnitude of the environmental fluctuations over a series of marine ecosystems.

(Years 3, ToR 4 and 5). The year 3 will be focused on summarizing and preparing the material to outreach to the stakeholders (governmental and non-governmental). Furthermore, a **special issue of a high impact factor peer-reviewed journal** will be coordinated to welcome all recent scientific contributions that deal with the effects of fluctuating environments and their predictability from micro to macro spatial-temporal scales. An example of a successful special issue dealing with environmental fluctuation and led by three of the full members listed in this proposal can be found here: https://www.frontiersin.org/research-topics/19369/fluctuating-habitats-ecological-relevance-of-environmental-variability-and-predictability-on-species.

f. Capacity Building (How will this WG build long-lasting capacity for practicing and understanding this area of marine science globally. Max 1500 words)

Capacity building will be a core component of the DYNAMO WG. To build capacity and training of students as well as postdocs and research associates from any countries with preferential on developing countries, we will use several approaches. We will create a **web-based portal** using website builders (*e.g.*, https://wordpress.org/) with a shared workspace to **exchange information, papers, and methods, and host interactive tutorials, as well as establish a common framework where students, scientists and technicians can share experiences and ideas.** This platform will echo the activities of each member (courses, scientific contribution, field and laboratory activities) to gain momentum and to reach a wider audience via live feeds on social media (*i.e.*, Twitter). We will **train students and scientists** from any country (with preferential access/waiving of fees for individuals from developing countries), by using **online tools to teach theoretical concepts of the DYNAMO project**, such as those techniques implemented to acquire environmental data for ecologically relevant studies, DME, network analysis, marine data management (*e.g.*, MEDIN, https://medin.org.uk/), modelling and sustainable approaches in coastal management. For example, **open and distance learning methods**, through the implementation of **online courses** can be performed using the MooKit software for **"MOOCs for development"** (https://www.mooc4dev.org/) which offer opportunities in sustainable development. DYNAMO WG include experts that **coordinated PhD and Master courses on species distribution models- SDMs, in biogeography at UNESCO- IODE**; while courses on SDM are currently using static approaches considering average on environmental parameter as predictor for marine species distribution, DYNAMO WG will provide a new set of indicators (i.e. magnitude, frequency and predictability of the environmental driver considered) to use in predicting species distribution in changing oceans. During the COVID-19 pandemic, the chairs of this SCOR proposal, jointly coordinated the **online "course on basic statistics using R"** (free of charge for Chilean students), which was supported by COSTAR-UV (https://costar.uv.cl/news/55-con-exito-se-lleva-a-cabo-curso-de-programacion-en-r). The course will be updated by including statistical analysis on time series to estimate environmental fluctuations and reproposed to a worldwide audience as online course, including for instance students from other developing countries, once a year for the entire duration of the project.

Another area for capacity building will be achieved by distributing an **open access "best-practice" guide**, especially intended to help students and postdocs to design their field and laboratory works during the writing of thesis projects or grant proposals. These guides will be uploaded and shared through the **SCOR collection at the Ocean Best Practices platform.**

In addition to online tools, **one large workshop/training course** will be organised and held upon funding available for non-SCOR support, although participants from developing countries can apply for the SCOR grant to pay for traveling expenses. The workshop will give the opportunity to students and early career scientists to **learn how to improve their understanding of their study environment** and **design and set up dynamic manipulative experiments** which can be successfully applied in **postgraduate thesis, as well as postdoctoral research projects**. This large workshop is intended for **knowledge transfer and capacity building, to promote rapid and wide adoption of field and laboratory methodologies** reviewed and developed in this WG. We will also seek opportunities to **secure additional funding sources to ensure maximum international participation**, particularly from developing countries not yet involved in DYNAMO. To achieve a successful training course, the DYNAMO WG could be cooperate in conjunction with the existing **SCOR activity "Changing Ocean Biological Systems (COBS)"** as well as the **non-SCOR Ocean Acidification International Coordination Centre capacity building program** for the developing of high-level training.

Furthermore, we will encourage **a scientist member of DYNAMO WG to serve as a SCOR Visiting Scholar**, through the SCOR Visiting Scholars program, which will give the opportunity to students from developing countries to get trained and mentored for a minimum of two weeks by an experienced scientist. We will encourage the **co-supervision of thesis projects by senior scientists of DYNAMO WG** for students from developing countries to offer unique opportunities to network from an early stage with international experts.

g. Working Group composition (as table). Divide by Full Members (10 people) and Associate Members, taking note of scientific discipline spread, geographical spread, gender balance, and participation by early-career scientists (max. 500 words)

Full Members (no more than 10, please identify chair(s)) *=early career researcher/postdoc

Name	Gender	Place of work	Expertise relevant to proposal
Simone Baldanzi (co-chair)	M	Chile	Marine ecophysiology; environmental epigenetics
Marco Fusi* (co-chair)	M	United Kingdom	Marine ecophysiology; Microbial ecology; Network ecology; Governmental Adviser
Francesca Porri	F	South Africa	Larval ecology; marine connectivity; nature-based solutions; indigenous knowledge-led innovations
Ramona Marasco	F	Saudi Arabia	Microbial Ecology; microbiology, molecular ecology, extreme environments
Eleonora Puccinelli*	F	South Africa	Trophic ecology; food webs
Nicolas Weidberg*	M	Spain	Remote sensing; global change
Gaitan Espitia	M	Hong Kong	Phenotypic plasticity; adaptation; functional genomic
Celia Schunter	F	Hong Kong	Evolutionary and molecular ecology; environmental change
Joanne Ellis	F	New Zealand	Coastal Ecology; multiple stressors
Fernando Lima	M	Portugal	Global network of biodiversity and thermal data collection; dynamic experiments

Associate Member (no more than 10) *=early career researcher/postdoc

Name	Gender	Place of work	Expertise relevant to proposal
David Wethey	M	USA	Global change; sediments; physical environment; modelling
Sergio Navarrete	M	Chile	Marine community ecology; ecological network analysis
Piero Calosi	M	Canada	Evolutionary physiology; Global Change Biology
Yolanda Sanchez	F	United Kingdom	Science Communicator; Educator; Marine conservation; Ocean Leaders
Brezo Martinez	F	Spain	Coastal Marine Ecology, Ecophysiology, Global Change Biology, Distribution Modelling and Biogeography
Alssandro Zaldei	M	Italy	Environmental engineer; modelling
Victoria Cole	F	Australia	Intertidal marine ecology, global change; Shellfish reef restoration
Sam Dupont	M	Sweden	Ocean Acidification; multiple driver experiments; WG149 member
Rosa Poquita	F	Singapore	Coral Biology, Experimental Ecology, Ecological genomics
Hans Dam	M	USA	Transgenerational experiments, adaptation

h. Working Group contributions (max. 500 words)

Simone Baldanzi: is a researcher and professor based at the University of Valparaiso in Chile. His research is focussed on marine invertebrates' responses to environmental changes and local adaptation, including mechanisms of environmental epigenetics. His expertise will connect the study of environmental fluctuation with eco-physiological and molecular responses.

Marco Fusi is a Marine Ecosystem Scientist based at JNCC UK. He is interested in the complex mechanisms of interactions among organisms and environment. His expertise will bridge the study of environmental fluctuation with eco-physiological responses and community assembly of marine organisms.

Francesca Porri is a Senior Scientist based at the South African Institute of Aquatic Biodiversity (SAIAB) in South Africa. Her research is centred on larval ecology and ecophysiology, marine connectivity, and recruitment dynamics. Through her research and focused supervision of postgraduates from rural regions in South Africa, she has the skills and drive for capacity building of individuals from diversified backgrounds.

Ramona Marasco is a Research Scientist based at the King Abdullah University of Science and Technology (KAUST) in Saudi Arabia. She is interested in studying plant-microbe interactions in extreme environments, including coastal-marine areas. Her expertise will provide a solid background in community network analyses.

Eleonora Puccinelli is a Research Associate at the Oceanography Department of the University of Cape Town, South Africa. She aims to understand how natural and anthropogenic processes affect food web dynamics in marine environments. Her research will contribute to the effect of environmental fluctuations on food webs dynamics.

Nicolas Weidberg is a postdoctoral researcher based at the Coastal Ecology Group of the University of Vigo, Spain, and University of South Carolina, USA. He is interested in zooplankton distributions, remote sensing and environmental variability. His expertise is unique to develop the best methods to measure environmental variability at relevant scales.

Fernando Lima is a researcher based at Research Centre in Biodiversity and Genetic Resources (CIBIO) in Portugal. He is a specialist in intertidal biogeography, studying the mechanisms driving species distributions. His experience based on a multidisciplinary approach will be fundamental to develop our initiative

Celia Schunter is an assistant professor based at the Swire Institute of Marine Science in Hong Kong. She uses functional genomics to understand the effects of environmental change within and across generations. In particular she continues to explore the impacts of climate change on behaviour and population dynamics of marine organisms.

Joanne Ellis is a senior lecturer based at the University of Waikato in New Zealand. Her research focuses on understanding how human drivers of environmental change, including coastal intensification and climate change. Her expertise will contribute to method development linking fluctuations and extremes in the environmental data with ecological responses and the development of indicators.

Juan Diego Gaitan Espitia is an evolutionary ecologist working as assistant professor at the University of Hong Kong. His works aims to develop better understanding of the mechanisms that influence geographic patterns of phenotypic/genetic diversity in nature, phenotypic plasticity, and micro-evolutionary processes driving local adaptation. He is a contributing author for the IPCC AR6.

i. **Relationship to other international programs and SCOR Working groups (max. 500 words)**

DYNAMO WG will have a **strict relationship with the SCOR WG 149 "CHANGING OCEAN BIOLOGICAL SYSTEMS (COBS)"** because it will advance the framework of investigation on how climate change will shape the future of marine biota by focusing on the role of the environmental fluctuation. DYNAMO WG associate member Dr Sam Dupont will ensure the integration of the two working group subjects to produce novel outputs. Furthermore, Dr Dupont will facilitate **integration of DYNAMO information into future trainings organized through the Ocean Acidification International Coordination Centre capacity building program** (https://www.iaea.org/services/oa-icc/building-capacity).

Links could be made between the DYNAMO WG and the **Marine Alliance for Science and Technology for Scotland (MASTS) thanks to Dr Marco Fusi who is part of the Steering Committee of the Marine Climate Change Forum.** MASTS consists of a consortium of organizations engaged in Marine Science in Scotland and the Marine Climate Change Forum provides a focal point for climate change related research within the MASTS community. Likewise, the initiative will be advertised in the **Mangrove Microbiome Initiative (MMI)** that aim to gather and disseminate novel procedures for environmental monitoring in mangrove ecosystems. Dr Marco Fusi will also increase the visibility thanks to the **existing networks in governmental and non – governmental program and initiatives in UK and worldwide**.

Dr Fernando Lima through the **Electric Blue technology transfer start-up coop** (https://electricblue.eu/), and Dr Alessandro Zaldei from the National Council of Research in Italy (https://www.ibe.cnr.it/) will share their state-of-the-art technology and methodology in environmental logging with the research team leading DYNAMO WG, facilitating their employment in the field and in the data collection, storage and use. In particular Alessandro Zaldei developed a real time system of data collection that can serve as repository for long term time series collection: see https://airqino.magentalab.it/.

Dr Simone Baldanzi through the **Coastal Observation Center for Marine environmental Risks of the Valparaiso University** (COSTAR-UV; https://costar.uv.cl/) and **Laboratorio de**

Ecofisiologia y Ecología Evolutiva Marinas (*e*°CO_2lab) from the Faculty of Marine Sciences and Natural Resources of the Valparaiso University will provide support to the Project, hosting the first meeting and offering field assistance for sensor deployment and logistical support. Yolanda Sanchez with her network from the Ocean Leaders can disseminate the output of the working group and liaise with international young research member for example of YCIMARE to promote among future leader the new perspective developed by the DYNAMO working group.

j. Key References (max. 500 words)

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Appendix

For each Full Member, indicate 5 key publications related to the proposal.

Simone Baldanzi

1. **Baldanzi S**, Storch D, Fusi M, Weidberg N, Tissot A, Navarrete SA, Fernández M (2020) Combined effects of temperature and hypoxia shape female brooding behaviors and the early ontogeny of the Chilean kelp crab *Taliepus dentatus*. Marine Ecology Progres Series 646: 93-107.
2. Fusi M., Marasco R., Ramond J.-B., Barausse A., **Baldanzi S.** (2022). Fluctuating Habitats: Ecological Relevance of Environmental Variability and Predictability on Species, Communities, and Ecosystems. *Frontiers in Ecology and Evolution,* 10.3389/fevo.2022.907622.
3. **Baldanzi S.** Watson R, McQuaid C, Gowus G, Porri F. (2017) Epigenetic variation among natural populations of the South African sandhopper *Talorchestia capensis. Evolutionary Ecology 31:77–91*
4. **Baldanzi S**, Fusi M, Weidberg N, McQuaid CD, Cannicci S, Porri F (2015) Contrasting environments shape thermal physiology across the spatial range of the sandhopper *Talorchestia capensis.* Oecologia. DOI 10.1007/s00442-015-3404-5.
5. **Baldanzi S,** McQuaid CD, Cannicci S, Porri F (2013) Environmental Domains and Range-Limiting Mechanisms: Testing the Abundant Centre Hypothesis Using Southern African Sandhoppers. *PLoS ONE 8(1): e54598. doi:10.1371/journal.pone.0054598.*

Marco Fusi

1. Giomi, F., Barausse, A., Duarte, C.M., Booth, J., Agusti, S., Saderne, V., Anton, A., Daffonchio, D. and **Fusi, M.,** 2019. Oxygen supersaturation protects coastal marine fauna from ocean warming. *Science advances*, *5*(9), p.eaax1814.
2. Booth, J.M., **Fusi, M.**, Giomi, F., Chapman, E.C.N., Diele, K. and McQuaid, C.D., 2021. Diel oxygen fluctuation drives the thermal response and metabolic performance of coastal marine ectotherms. Proceedings of the Royal Society B, 288(1953), p.20211141.
3. **Fusi M**, Daffonchio D, Booth J and Giomi F (2021) Dissolved Oxygen in Heterogeneous Environments Dictates the Metabolic Rate and Thermal Sensitivity of a Tropical Aquatic Crab. Front. Mar. Sci. 8:767471. doi: 10.3389/fmars.2021.767471
4. Baldanzi, S., Weidberg, N.F., **Fusi, M.,** Cannicci, S., McQuaid, C.D. and Porri, F., 2015. Contrasting environments shape thermal physiology across the spatial range of the sandhopper Talorchestia capensis. Oecologia, 179(4), pp.1067-1078.
5. **Fusi M**., Giomi F., Babbini S., Daffonchio D., McQuaid C.D., Porri F. and Cannicci S.(2015). Thermal vulnerability of African mangrove crabs at large geographical scales: global warming and the challenge of predicting population persistence. Oikos 124:784-795

Francesca Porri

1. Vorsatz L, Pattrick P, **Porri F** (2021) Ecological scaling in mangroves: the role of microhabitats for the distribution of larval assemblages. In press in Estuar Coast Shelf Sci
2. **Porri F,** Puccinelli E, Weidberg N, Pattrick P (2021) Lack of match between nutrient-enriched marine seafoam and intertidal abundance of long-lived invertebrate larvae. J Sea Res 170 doi.org/10.1016/j.seares.2021.102009
3. Vorsatz L, Pattrick P, **Porri F** (2021) Quantifying the in situ 3-dimensional structural complexity of mangrove tree root systems: Biotic and abiotic implications at the microhabitat scale. Ecol Indic, 121, p.107154.
4. Strain EM, Steinberg PD, Vozzo M, Johnston EL, Abbiati M, Aguilera MA, Airoldi L, Aguirre JD, Ashton G, Bernardi M, **Porri F** et al (2021) A global analysis of complexity–biodiversity relationships on marine artificial structures. Glob Ecol Biogeogr, 30(1), pp.140-153

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Ramona Marasco

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2. **Puccinelli E**., Sardenne F., Pecquerie L., Fawcett S., Machu E., Soudant P. 2021. Omega-3 pathways in upwelling systems: The link to nitrogen supply. Frontiers in Marine Science - Global Change and the Future Ocean. 8. doi: 10.3389/fmars.2021.664601
3. **Puccinelli E**.; Smart M.S.; Fawcett E.S. 2020. Temporal variability in the trophic composition of benthic invertebrates in the Indian Sub-Antarctic Ocean. Deep-Sea Research I. 163: 103340. doi.org/10.1016/j.dsr.2020.103340.
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2. **Weidberg, N.**; Wethey, D.; Woodin, S.. Global Intercomparison of Hyper-Resolution ECOSTRESS Coastal Sea Surface Temperature Measurements from the Space Station with VIIRS-N20. Remote Sensing. 13 -24, 2021.
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Joanne Elliss

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