The 2022 Ramon Margalef Summer Colloquia
"Past, present and future of a living ocean"

The eight edition of the Margalef Summer Colloquia was organized between the 26th of September and the 2nd of October 2022 at the Institute of Marine Sciences (ICM). This year's workshop motto was "***Past, present and future of a living ocean***" and was organized by Dr. Ramiro Logares, Dr. Cèlia Marrasé, Dr. Eva Calvo, Dr. Pedro Cermeño and Dr. Caterina R. Giner.

Central topic:

We have a limited understanding of the long physicochemical and biological evolution of the ocean. In a context of climate change, it is crucial to better understand the paleo-ocean and how it has evolved into the present ocean. That information would allow us to generate better predictions of the future ocean. The main aim of this workshop was to bring together scientists from different disciplines (paleoceanographers, biogeochemists, conservation biologists, microbial ecologists, ecosystem modelers, geologists and physical oceanographers) in order to develop improved perspectives on the future ocean, based on knowledge from the past and present.

The aim of the Ramon Margalef Colloquia is to enhance the exchange of ideas and to promote imaginative thinking by bringing together knowledge from experts on different scientific areas. During the 2022 workshop we made an effort to promote synergies and dialogues between different disciplines as well as networking and knowledge exchange between senior, junior and next-generation researchers from different disciplines. This coming year we brought together a diverse, international group of young scientists studying the ocean. We all learned about new developments in this field, shared ideas, as well as built new collaborations.

A total of 21 students, from 10 different countries, attended the colloquium. Of these, 5 were Spanish, and 8 from the ICM. The other represented countries were Morocco, Ghana, France, Germany, Greece, Poland, United Kingdom, Slovenia, and Switzerland.

A total of 17 speakers were responsible for the sessions. See annex 3 and 4 for more information about the speakers and their talks.

The workshop included 5 days of presentation plus moderated discussions and a two-day retrat. During the workshop the students produced a document summarizing the most important points of each day's discussion. These reports were used during the 2-day retreat to discuss focusing in the past, present and future of the oceans. A report of the conclusions of the retreat was also produced.

The colloquium was supported by the ICM, EuroMarine, the SCOR (*Scientific Committee on Oceanic Research*), Ona Futura and Ona Hotels, the ISME (*International Society for Microbial*

Ecology), Institut Botànic de Barcelona (Museu de Ciències Naturals) and the BSC (*Barcelona Supercomputing Centre*).

The ICM contributed with the plenary room and the technical needs. EuroMarine funded the trip of some speakers and activities of the workshop. SCOR funded the travel and accommodation of two students from developing countries, while Ona Futura, Ona Hotels and ISME funded the trip and/or stay of some speakers. The Institut Botànic de Barcelona contributed hosting the 2-day retreat. The BSC contributed with a guided visit to their facilities.
The sponsors were present in all documentation of the colloquium as well as in the webpage (https://ramonmargalefcolloquia.com/).

Pictures of the colloquia:

Figure. Participants of the Ramon Margalef Colloquia 2022 (top). Attending to one of the plenary talks. (bottom).

Annex #1- Advertisement flyer

Annex #2- Students

Student	**Affiliation**
Nestor Arandia Gorostidi	ICM-CSIC
Odysseus Archontikis	University of Oxford
Mohammad Binsarhan	ICM-CSIC
Sofiya Bondarenko	ICM-CSIC
Georgina Brennan	ICM-CSIC
Lívia Dias Fernandes de Oliveira	University of Strathclyde
Charles Abimbola Faseyi	Africa Centre of Excellence in Coastal Resilience (ACECoR), University of Cape Coast
Sergio González-Motos	ICM-CSIC
Urs Hofmann Elizondo	ETH Zurich
Hajar Idmoussi	National Institute of Fisheries Research
Eloise Littley	Institut de Ciència i Tecnologia Ambientals (UAB)
Xiaoxu Ma	University of Oxford
Alan Maria Mancini	University of Turin
Mathisse Meyneng	Ifremer
Sven Pallacks	Universitat Autònoma de Barcelona
Pierre Ramond	ICM-CSIC
César Nicolás Rodríguez Díaz	ICM-CSIC
Anna Rufas Blanco	University of Oxford
Marta Szczepanek	Institute of Oceanology Polish Academy of Sciences
Judith Traver Azuara	ICM-CSIC
Martin Vodopivec	National Institute of Biology, Slovenia

Annex #3: Detailed Program

	Sunday 25th	Monday 26th	Tuesday 27th	Wednesday 28th	Thursday 29th	Friday 30th	Saturday 1st	Sunday 2nd
8:30 - 9:00		Welcome*						
9:00 - 10:00		TALK 1 (C. Waelbroeck)	TALK 5 (C. Duarte)	TALK 9 (D. Richter)	TALK 12 (C. Garcia-Comas)	TALK 15 (C. Pedrós)		
10:00 - 11:00		TALK 2 (I. Cacho)	TALK 6 (M. Levy - ONLINE)	TALK 10 (M. Scheffer - ONLINE)	TALK 13 (O. Serrano)	TALK 16 (S. Chaffron)	Introduction	Generate extended report and plans
11:00 - 11:30		Coffe break	Coffe break	Coffe break	Coffe break	Coffe break	Discussion in break-up groups	
11:30 - 12:30		TALK 3 (S. Henson)	TALK 7 (J. Solé)	TALK 11 (R. Siano)	*TALK 14 (S. Rahmstorf)*	TALK 17 (M. Coll)		
12:30 - 14:00		lunch	lunch	lunch	lunch	lunch	lunch	lunch
14:00 - 15:00		TALK 4 (P. Falkowski - ONLINE)	TALK 8 (S. Dutkiewicz - ONLINE)	prepare discussion	prepare discussion	prepare discussion	Prepare presentation	Final remarks & end
15:00 - 16:00		prepare discussion	prepare discussion	Discussion day 3	Discussion day 4	Discussion day 5	Presentations by group	
16:00 - 16:30		Coffee break	Coffee break	Go to BSC			Discussion all students	
16:30 - 17:00		Discussion day 1	Discussion day 2					
17:00 - 17:30	Registration			VISIT BSC + talk R. Bernardello				
17:30 - 18:00	Student's presentations							
18:00 - 19:00	Student's presentations				DINNER (hour to confirm)			

Topics

	Speaker 1	Speaker 2	Speaker 3
TOPIC 1: Physical and biological oceanography across scales	Stefan Rahmstorf	Carlos Duarte	Marina Levy
TOPIC 2: Paleoceanography	Claire Waelbroeck	Isabel Cacho	Raffaele Siano
TOPIC 3: Biogeochemistry	Paul Falkowski	Oscar Serrano	Stephanie Henson
TOPIC 4: Ecology and Evolution	Carles Pedrós-Alió	Sam Chaffron	Carmen García-Comas
TOPIC 5: Big data, AI	Martten Scheffer	Stephanie Dutkiewicz	Daniel Richter
TOPIC 6: Societal challenges	Marta Coll	Jordi Solé	

Annex #4: Detailed Abstracts

MONDAY 26th

What do marine sediments tell us about ocean-climate interactions?

Claire Waelbroeck
CNRS, France

How is current climate change placed in the context of the planet's natural climate variability? Climate archives give us access to past natural variations in climate and ocean circulation. In particular, it is possible to reconstruct past changes in ocean circulation from marine sediments.

Over the last 40 to 50 years, paleoclimate studies have shown that on top of relatively slow climate changes, linked to glacial-interglacial cycles, extremely rapid climate changes have taken place in some regions. For example, surface temperature oscillations have been reconstructed during the last glacial periods in Greenland and the North Atlantic, characterized by abrupt warmings of about 10°C in just 100 years, and associated with profound changes in oceanic and atmospheric circulation.

These studies show that the Earth's climate is not stable and that it can respond to certain perturbations very rapidly. It follows that a better reliability of climate projections for the coming decades requires an understanding of past natural variations of the climate system, and the ability to simulate them numerically.

Past lessons on the sensitivity of the Mediterranean thermohaline circulation to climate variability

Isabel Cacho
University of Barcelona, Spain

Climate conditions over the Mediterranean and surrounding continents determines the formation of specific waters masses that fill the interior of the Mediterranean Sea and ultimately exit into the North Atlantic Ocean, a contribution which has largely been hypothesized could have key implications in the global thermohaline circulation system. This Mediterranean thermohaline circulation (MedTHC) system has already shown to be very sensitive to the currently changing climate conditions, in line with the available model projections that anticipate its overall weakening by the end of this century. Nevertheless, so far, very little is known on the natural ranges of variability of this MedTHC system. In this seminar I will show paleoceanographical evidences from the last glacial period and the current interglacial, documenting the capacity of the MedTHC for rapid reorganizations but with a complex relationship between the different convection cells that fuel the system.

Rapid climate variability of the last glacial period shows a close connection between the MedTHC and the North Atlantic Ocean but with an overall opposite response, more vigorous MedTHC during periods of sluggish Atlantic circulation. On the other hand, the Eastern and Western Mediterranean basins had a complex interconnection during the current Interglacial, major changes in the MedTHC occurred but in some cases had opposite direction between the two basins. These changes had major implications for the oxygen content of the basin and also directly impacted ecological environments such a cold water coral reefs.

Down to the deep - ocean biology's role in the carbon cycle

Stephanie Henson
National Oceanography Centre, United Kingdom

The biological carbon pump is a series of processes that transfers organic carbon from the surface ocean into the deep ocean. Without it, atmospheric CO_2 levels would be ~ 50 % higher than they already are. In this talk, we will discuss: How much organic carbon gets down to the deep ocean? Why is there currently no net anthropogenic CO_2 uptake via the biological carbon pump? Could that change in the future? And what are the remaining big unknowns in how the biological carbon pump functions? I'll finish by presenting some recent progress on using autonomous vehicles to quantify variability in the biological carbon pump, and the implications of our knowledge gaps for robust modelling of the current and future pump.

Why is photosynthetic energy conversion efficiency in the ocean so inefficient?

Paul Falkowski
Rutgers University, USA

In this presentation I will discuss how we close the photosynthetic energy efficiency equation in situ using two, very different in vivo fluorescence measurements - one is based on the quantum yield of photosystem II the other is based on the lifetime of chlorophyll fluorescence.

TUESDAY 27th

Coastal areas in a changing ocean

Carlos M. Duarte
KAUST, Saudi Arabia

Pressures on marine ecosystems, particularly affecting coastal ecosystems, have led to the loss of about half of the abundance of habitats and large marine animals, with a loss of their capacity to support human well being. However, recent policies have led to a change in trajectory to one of decreasing pressures and, eventually, recovery. I summarize here evidence for the capacity of coastal ecosystems to recover upon relaxing human pressures, and put forward the notion that the abundance of coastal ecosystems can be recovered within one human generation. I then focus on coral reefs, arguably the ecosystem most at risk with climate change to assess the risks of losses and the action required to also conserve this important habitats.

Do fine-scale physical processes matter for marine biogeochemistry responses to climate change?

Marina Levy
LOCEAN-IPSL, CNRS, France

In this presentation, I will cover state-of-the art understanding of bio-physical interactions at submesoscale, how we can gain understanding from remote sensing combined with in-situ observations and models, and the limits of each approach. I will then try to provide global quantification of these interactions for the present ocean and their potential role in a changing climate.

Trade-offs between ocean ecosystem limits and social adaptation to global change: challenges and dangers

Jordi Solé
University of Barcelona, Spain

The adaptation and mitigation of climate change implies profound changes in every aspect of the socio-economy and also in the way we relate with environment and nature. Currently, we are dealing with three main crises: climate, ecosystems and energy/materials. EU proposes to rapidly reduce the Greenhouse Gases (GHG) emissions by doing a massive transition to renewable energy sources (RES) and, at the same time, proposes to increase the health and the resilience of the ecosystems by increasing marine protected areas. One big issue that arises from this approach is that large scale RES implementation requires the use of extensive land and marine areas. This can conflict with the increase of protected areas for ecosystem health. On top of that, the main question is if it is enough to replace fossil fuels with RES and keeping the current growth paradigm to deal with the three crisis we have to face.

Using model to help "predict" the future of the ocean ecosystem

Stephanie Dutkiewicz
MIT, USA

Marine ecosystems are, and will continue, to experiences a range of stressors due to climate change. These include warming waters, increased near surface stratification, altered supplies of nutrients, and increased ocean acidity. In this talk we will use numerical models to explore how each stressor affects ocean productivity and planktonic community structure in a different way, making it difficult to predict what the actual world will experience. However, models suggest there will likely be large decreases in productivity in low latitudes and the North Atlantic, and likely increased productivity in some other higher latitude regions. These patterns are set by a balance between increased growth rates due to warmer temperatures and a reduction in nutrient supply. Using an ecosystem model including a diverse set of plankton helps us explore how plankton ecology might change. Reduced nutrients will more adversely impact larger phytoplankton types, and as such the model suggests a shift towards smaller types in a future ocean. Some groups will have increased ranges (e.g. diazotrophs) due to shifts in limiting nutrients. Communities will potentially shift to domination by fewer number of species (reduction of evenness), and turnover (the degree to which a community alters) will occur faster over the course of the century. A range of response to ocean acidification will also lead to significant shifts in community structure, with some groups being outcompeted by those that do better in the lower pH waters. Models suggest potential larger impacts on higher trophic levels (trophic amplification). We still need better understanding of the controlling mechanism of planktonic foodwebs, interactions, and regional distributions, as well as the potential to adapt and evolve to the stressors, before we can adequately "predict" future ocean ecosystems. However, the model does suggest large and detectable changes in planktonic community structure over the course of this century, with likely significant impact on higher trophic levels and the ability of the oceans to sequester carbon.

WEDNESDAY 28th

Metagenomics and metatranscriptomics of microbial eukaryotes in the surface oceans

Daniel J. Richter
Institute of Evolutionary Biology, UPF-CSIC, Spain

Half of global photosynthesis occurs in the surface oceans, where microbial eukaryotes act as primary producers, predators, parasites and prey, forming a critical link in the transfer of energy among trophic levels. We present two complementary approaches to characterize the biology of the most abundant of these microbial eukaryotes, which remains poorly understood. Our analyses are primarily based on publicly available data from the Tara Oceans expedition, which circumnavigated the globe over a multi-year period, collecting samples in the sunlit ocean from over 150 individual stations. For eukaryotic plankton ranging from 0.8 µm-2 mm, three types of sequencing data were produced: metagenomes, metatranscriptomes and metabarcodes of the 18S ribosomal locus. Based on sequence similarity among metagenomes, we partition the oceans into regions inhabited by similar plankton communities. For smaller organisms, these regions are consistent with the provinces of Longhurst based on biogeochemical data, but this relationship breaks down above 20 µm. We find that large-scale transport by ocean currents plays a primary role in shaping plankton communities. Next, to measure the activity of the organisms within these communities, we apply a phylogenetic read placement approach to map metatranscriptomic sequences onto a set of 300 conserved eukaryotic gene trees. Within the pico- and nanoplankton (0.8-5 and 5-20 µm), we find an unexpectedly high relative abundance of dinoflagellates and a substantial representation of transcriptionally active metazoans. Finally, we focus on an example of the relationship between silicon concentration and global transcription of a specific gene, SIT, which transports extracellular silicon into organisms that construct silica-based structures, such as the frustules of diatoms and the loricae of choanoflagellates.

Resilience good and bad

Marten Scheffer
University of Wageningen, Netherlands

Complex systems ranging from ecosystems to financial markets, the brain and the climate can have tipping points where a sudden shift to a contrasting regime may occur. Predicting such critical points before they are reached is extremely difficult. However, work in different fields of science is now suggesting the existence of generic early warning signals that may indicate for a wide class of systems if a critical threshold is approaching. I will review key findings and highlight opportunities as well as challenges in this rapidly emerging research area. I will also discuss barriers and bridges to move to the practical management of risks and opportunities associated to tipping points.

Back to the past: sedimentary archives revealed protist communities shifts and dinoflagellate species adaptations due to human impact in the Bay of Brest (France)

Raffaele Siano
IFREMER, France

The study of protist remains (viable and fossilised resting stages, sedimentary ancient DNA) across stratified layers of marine sediment cores allows the assessment of centuries-old community and population dynamics. When resting stages can be revived from ancient sediments and monoclonal strains are established and compared to contemporary ones, species physiological and genetic adaptation patterns evolved across time can be inferred. Environmental and experimental observations can be related to other paleo-ecological proxies, such as organic and inorganic pollutants, to determine whether the observed dinoflagellate community and species variations are an effect of human impact. In the Bay of Brest (Brittany, France) paleogenetic studies (V4 and V7- 18srDNA sedimentary ancient DNA metabarcoding) allowed ca. 1400 years of retrospective analyses mostly of protist groups forming resting stages (paleocommunities). Gregarines (Apicomplexa), and specifically the metazoan parasitic genera *Lecudina*, *Lankesteria* and *Seledinium* consistently dominated protist paleocommunties in ancient sediments, when metazoans DNA traces disappeared. Shifts in dinoflagellate and stemenopiles paleocommunities were observed across the time in relation to chemical proxies of anthropogenic impact. In particular, heavy metal pollution traces in sediments ascribed to the World War II period coincided with irreversible dinoflagellate order shifts. After the war and especially from the 1980's to 1990's, dinoflagellate genera shift followed chronic contaminations of agricultural origin and the harmful species *Alexandrium minutum* progressively developed across the 20th century. In order to assess the physiological adaptations of modern populations to the increase in eutrophication and to the progressive phosphorous limitation that occurred in the area across the 20th century, resurrection ecology experiments were carried out on buried cysts of *A. minutum* and, for comparison, on *Scrippsiella acuminata* and *S. donghaienis*. Using a plant seed-inspired priming approach, 150-year old cyst revivification and an increase in the number of revived cells were obtained by stimulating germination using melatonin and gibberellic acid. Metabolomics profiles of *A. minutum* strains of the eutrophication (1980's) and post-eutrophication period (2000's) cultivated in P-depleted conditions were similar, conversely to those of S. donghaienis strains that were significantly different for 27 lipophilic compounds. However, when the alkaline phosphatase (AP) activity was measured at single cell level with an ad-hoc developed microfluidic systems and in P-depleted culture conditions, consistent differences were observed between strains of the pre-eutrophication (1940's) and the beginning of the post-eutrophication period (1990's), both in *A. minutum* and *S. acuminata*. For both species, total AP in the 1990's decade was significantly lower than in the 1940's. Considering that the AP is produced in P limitation, these results suggest that both species would have adapted to the decreasing concentration of phosphorus in the environment. *Alexandrium* *minutum* produced less AP, meaning that this species would perform better in P limitation, likely thriving upon internal phosphorous stocks. This adaption could explain its ecological success in recent time in the Bay of Brest. These results suggest that the evolution of specific biological traits in dinoflagellate species is a key factor to explain multiannual species dynamics and that paleo-ecological approaches can help unveiling and understanding this process. Paleoecological analyses carried out in the Bay of Brest will be contextualised in the frame on new European projects (BioOcean5D, TREC) during which about 20 sediment cores will be collected at human impacted coastal ecosystems. In addition, the specific effect of nickel mining will be assessed using New Caledonia (South Pacific, France) as study site. This inter-ecosystem comparative analysis will allow a general assessment of the effect on human impact during the Anthropocene period, as well as a first characterization of microbial community composition during the pre industrialization period.

THURSDAY 29th

Using modelling to understand the emergence of marine biodiversity hotspots and the latitudinal diversity gradient in the last 500 million years

Carmen García-Comas
Institute of Marine Sciences, Spain

Life originated in the sea about 4 billion years ago and, for the first 3.5 billion years, it was exclusively microscopic. Something happened early in the Cambrian period that made multicellular life to thrive, giving rise to the spectacular biodiversity that has been this planet's hallmark over the past 500 million years. This staggering increase in diversity has raised a fundamental question among evolutionary ecologists: are there limits to the diversity of life? Some scientists say that global diversity increases to an equilibrium point or saturation level that is determined by the system’s carrying capacity. Alternatively, others claim that biodiversity is well below the saturation level and thus we can ignore the existence of any limit. These contrasting views have been fueled by interpretations of the fossil record which is severely biased in space and time. To theoretically test these contrasting views, we have developed a regional diversification model. In the model, we let 1 genus to diversify everywhere in the global ocean from 500 million years ago until present according to a model of paleogeography and plate-motion that constrains the diversification time and to a paleo Earth System model that constrains the diversification rate as a function of seawater temperature and food supply. By externally imposing mass extinctions, we explore how the oceans filled with life. The regional model fits surprisingly well global fossil curves and modern biodiversity patterns. According to the model, the ocean is far from saturation except for in the biodiversity hotspots, regions of extraordinarily high levels of diversity, which evolved under prolonged conditions of Earth system stability and maximum continental fragmentation. The model allows us to recreate many things, such as the history of biodiversity hotspots and the evolution of the latitudinal diversity gradient. Ultimately, the model provides a framework to simulate projections of contemporaneous diversity loss and predict its subsequent recovery dynamics.

Blue carbon as a natural climate solution: past, present and future perspectives

Oscar Serrano
CEAB, Spain

Blue carbon ecosystems, including tidal marshes, mangrove forests, seagrass meadows and seaweed, store carbon and provide co-benefits such as coastal protection and biodiversity enhancement. Blue carbon sequestration has therefore been suggested as a natural climate solution. However, these critical coastal areas rank among the most threatened ecosystems on Earth, and thus carbon sequestration and the stability of historic carbon deposits in coastal wetlands are at risk. Globally, blue carbon ecosystems are calculated to store >30,000 Tg C across ~185 million ha, with their conservation potentially avoiding emissions of 304 (141–466) Tg carbon dioxide equivalent (CO2e) per year. Potential blue carbon ecosystem restoration has been estimated in the range of 0.2–3.2 million ha for tidal marshes, 8.3–25.4 million ha for seagrasses and 9–13 million ha for mangroves, which could draw down an additional 841 (621–1,064) Tg CO2e per year by 2030, collectively amounting to ~3% of global emissions. However, there is considerable uncertainty in the historical and current rates of storage due to poorly constrained estimates of the global areal coverage of these ecosystems and great variability in burial rates from system to system. Even greater uncertainty exists for future projections of blue carbon sequestration as a function of climate change, sea-level rise, and land use. How will direct reclamation, sea-level transgression, nutrient enrichment, temperature increases, or sediment supply affect burial rates or release of carbon dioxide? Therefore, understanding past, present and future perspectives of the plethora of ecosystem services linked to blue carbon ecosystems is crucial to support management strategies for climate change mitigation and adaptation. Blue carbon is potentially a cost-effective and scalable natural climate solution, but there are still barriers to overcome before blue carbon project adoption will become widespread.

The Oceans in a Changing Climate

Stephan Rahmstorf
Postdam University, Germany

The Earth is undergoing a major rapid warming, unprecedented in its speed for millions of years. How is this affecting the physics of the oceans, and thereby us? The lecture will cover ocean warming and its consequences: 1. Arctic summer sea ice cover has shrunk by half in extent and also in thickness, so that only about a quarter of the ice mass that was normal until the 1970s is left now. 2. Thermal expansion and loss of land ice is causing global sea-level to rise, by around 20 cm thus far, and accelerating. The latest IPCC report concluded that 2 meters by the year 2100 cannot be ruled out. 3. Tropical cyclones draw their energy from the heat stored in the upper ocean and are consequently already getting more violent with global warming, and also extending their range to higher latitudes. 4. The Atlantic meridional overturning circulation (AMOC) has been weakening since the mid-twentieth Century and is now weaker than any time in the last 1,000 years. This is of great concern as it is already having an impact on European weather, and the AMOC has a tipping point where it will grind to a halt altogether.

FRIDAY 30th

The ocean microbiome through space and time

Carles Pedrós-Alió
Department of Systems Biology, Centro Nacional de Biotecnología, CSIC, Spain

The ocean is the largest ecosystem in the Planet. But due to its size and depth, our understanding of the microbiome is still rudimentary. We can count how many microorganisms live in it and we can measure some of their activities. But we only have crude estimates of how many species do they belong to. The microbiome includes a few abundant taxa that carry out most ecosystem functions and a very long list of rare taxa that provide a formidable richness of genes and potential. Microbes can easily disperse globally and, intriguingly, they can also travel in time. Even though we have an emerging picture, the possibility of engineering the ocean microbiome is still very remote.

Community network models to reveal marine plankton systems ecology

Samuel Chaffron
University of Nantes, France

Marine plankton form complex communities of interacting organisms at the base of the food web, which sustain oceanic biogeochemical cycles and help regulate climate. Understanding the mechanisms controlling their assembly and sustaining their activities is a major challenge in microbial ecology. Though global surveys are starting to reveal ecological drivers underlying planktonic community structure and predicted climate change responses, it is unclear how community-scale species interactions are constrained, and how they will be affected by climate change. By leveraging Tara Oceans meta-omics data, plankton community network models can be integrated with niche modelling to reveal biome-specific plankton community responses to environmental change, and forecast most affected lineages within each community. To go beyond statistical models, genome-resolved community networks enable to model and predict metabolic cross-feedings within prokaryotic assemblages. These mechanistic models allow to predict potential interactions within predicted communities and pinpoint specific metabolic cross-feedings shaping plankton microbial communities. Integrating ecological and metabolic models provide a useful framework to assess community structure and organismal interactions, to reveal important mechanisms shaping natural microbial communities in our changing ocean.

Global ecological modelling to simulate future trajectories of change in marine ecosystems

Marta Coll
Institute of Marine Science, Spain
Ecopath International Initiative, EII, Spain

There has been considerable effort to predict the impact of climate change and anthropogenic activities on the biophysical environment, biodiversity, and marine resources at regional and global scales. To further our understanding of how changes in the environment and marine resources will affect marine ecosystems, there is a need for advancing global integrated assessments. I will introduce the recent efforts to model the global ocean using marine ecosystem models (MEMs) and, specifically, I will present a spatial-temporal ecosystem model of the global ocean (EcoOcean), spanning food web dynamics from primary producers to top predators, and including worldwide fisheries. EcoOcean reproduces spatial-temporal ecosystem dynamics by linking species productivity and distribution to main environmental conditions in flux under climate change (e.g. primary production, sea temperature, salinity), accounting for varying species compositions of functional groups over time. The modelling platform is used to simulate past and future scenarios of climate change and fisheries, considering the uncertainty of internal ecological hypotheses and alternative input drivers using standardized outputs from Earth-System Models (ESMs) and contrasting emission scenarios (RCPs) for historical and future periods. Standardized ecological indicators are used to compare changes in marine structure and functioning among scenarios. These efforts set a baseline to further develop global ocean analyses and contribute to the quantification of cumulative effects assessment of multiple stressors and plausible ocean-based solutions to global change, considering species, biodiversity and food-web spatial-temporal dynamics.