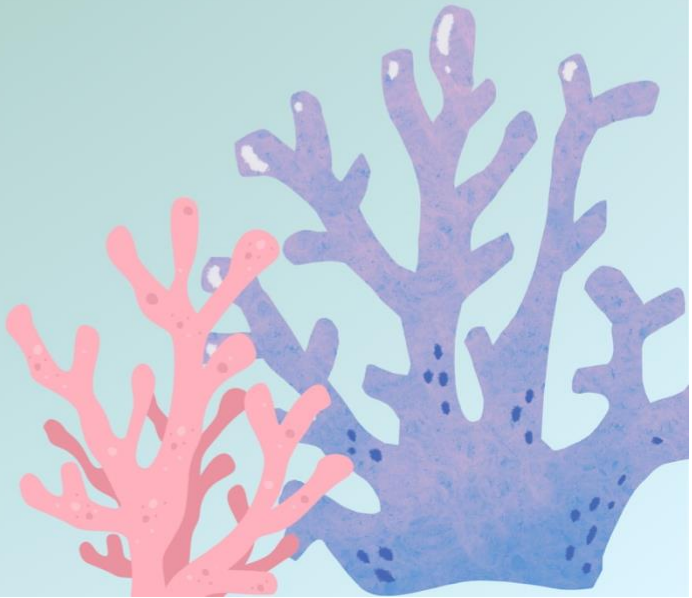
INTERNATIONAL FOSSIL CORAL AND REEF SOCIETY

Fourth Early Career Researcher Symposium

Abstract Booklet

13th November 2025



Contents

Code of conduct

The International Fossil Coral and Reef Society (IFCRS) was created to connect individuals interested in fossil corals, sponges and reef ecosystems in the broadest sense. Researchers and students are the core of our Society, but general enthusiasts are also warmly encouraged to join our growing community. We strive to foster a safe, inclusive, and respectful community that values the diverse perspectives and experiences of all members. Harassment or disrespectful behaviour of any kind is not tolerated. By participating in IFCRS activities, you agree to adhere to the following code of conduct at all times. The IFCRS council will enforce this code as necessary to ensure that all participants feel welcome, and we reserve the right to remove those who are found to be negatively contributing to the society and its activities. The IFCRS is committed to diversity, inclusion, and accessibility for all, and expects members of the society to uphold these values, and treat all equally.

Members of the IFCRS and participants in its activities are expected to treat one another with respect and dignity regardless of gender, gender identity and expression, sexual orientation, marital or parental status, age, immigration status, disability, physical appearance, body size, race, ethnicity, nationality, religion (or lack thereof), socioeconomic background, educational background, career stage, career trajectory, or scientific opinions.

We believe all members of our society and participants in activities have:

- The right to be safe from harassment or discrimination in all its forms
- The right to fully engage in all the activities on offer
- The right to have any complaints or concerns investigated, regardless of career position

We ask everyone to help us maintain an inclusive and safe Society for all by agreeing to the common principles of our code of conduct:

- being courteous, respectful and professional towards others
- valuing the diversity of participants, their views and opinions

If you are being harassed, notice that someone else is being harassed, or have any other concerns, please contact the IFCRS council via fossilcoralreef@gmail.com

Ultimately, please remember why we are here: to network, diversify our knowledge, meet new people, and above all, to enjoy science!

Digital images and social media policy

During the symposium, do not photograph or record a talk without the author's express permission. While the default assumption is to allow open discussion of presentations on social media, attendees are expected to respect any request by an author not to disseminate the contents of their talk.

We request that authors indicate at the start of their talk whether they are happy for the presentation to be shared on social media or not.

Throughout the symposium, we will use the hashtag #IFCRS2025 to share updates about the symposium and presentations. You may also follow and message us on Bluesky (@ifcrs.bsky.social)

Joining the Symposium

The symposium will be conducted fully online. When registering via this link (or https://ifcrs.org/ecrs/), you will receive an email with a link to join the symposium. Please note, this link will be sent to the email address you registered for the symposium. For the symposium, we will make use of the platform Zoom. If you are unfamiliar with Zoom, you may familiarise yourself via the following link: https://zoom.us.

Letter from the IFCRS president

Dear participants of the Fourth IFCRS Early Career Researcher Symposium,

Looking at the headlines of global newspapers reporting that coral reefs have been experiencing a global bleaching event since January 2023, the fourth and most severe on record, with over 80% of reefs in more than 80 countries affected by extreme ocean temperatures, it is hardly an exaggeration to say that soon all coral reefs may become fossil reefs. Given how narrow the boundary between the living and the extinct has become in today's rapidly changing climate, it is also no exaggeration to claim that studying the fossil record of ancient reefs, millions of years old, can reveal why many reef organisms managed to survive past planetary crises. Following the idea that the past of reefs can help us understand their present, and perhaps foresee their future, we gather here for the 4th Early Career Researcher Symposium.

The symposium will feature a mid-day plenary talk by **Dr. Nadia Santodomingo** (Senckenberg Forschungsinstitut und Naturmuseum Frankfurt), highlighting the crucial role of palaeontology in understanding coral reef resilience.

Invited talks will expand the temporal and ecological scope across multiple scales. **Emer Cunningham** (University of Queensland) will discuss "ecological novelty" through time, suggesting that coral and zooplankton communities have repeatedly entered new compositional states independent of environmental change — a key insight for predicting future transformations. Focusing on coral skeleton preservation, **Luisa Meiritz** (GEOMAR) will introduce intra-crystalline amino acids as a novel proxy for assessing coral diagenesis and the reliability of geochemical archives. Deep-time roots of reef building will be explored by **Nile Stephenson** (University of Cambridge), who will demonstrate that early metazoans (Avalon Ediacaran communities) already displayed distinct recolonization and dispersal strategies following disturbances. **Jonathan Jung** (Max Planck Institute for Chemistry) will present the first geochemical evidence of photosymbiosis in Mid-Devonian corals. Continuing with evolutionary innovations, **Alison Cribb** (University of Southampton) will trace the long-term evolution of coral ecosystem engineering, identifying biodiversity hotspots throughout the Phanerozoic. Similarly, **Ruaridh Alexander** (University of Edinburgh) will discuss early Cambrian reef diversification. **Patrycja Dworczak** (Polish Geological Institute & GeoZentrum Nordbayern) will examine stromatoporoid growth phases, introducing refined analytical frameworks for interpreting palaeoenvironmental rhythms and interruptions in ancient reef sponges. **Sinjini Sinha** (West Virginia University) will compare Early Jurassic Moroccan reef and level-bottom communities, showing that while reefs collapsed during anoxic events, background faunas remained resilient, suggesting selective stress and potential biotic refugia. A broad evolutionary synthesis will be offered by **Claudia Vaga** (Smithsonian Institution), whose global phylogeny of Scleractinia reveals pervasive morphological convergence, deep evolutionary

roots extending back ca. 460 Ma, and the greater resilience of solitary, heterotrophic corals compared with their shallow-water, symbiotic relatives. **Paola Florez** (MoAm S.A.S.) will reconstruct Miocene coral reef ecosystems in Colombia, revealing vibrant patch and barrier reefs, their faunal composition, extinction patterns, and modern survivors. Finally, bridging modeling and field data, **Claire Williams** (University of Texas at Austin) will show how integrating fossil occurrences into ecological niche models refines predictions of future coral habitats.

Together, these talks will demonstrate how integrating fossil, geochemical, and modelling approaches across geological time reveals the origins, transformations, and resilience mechanisms of reef ecosystems, offering vital insights for their conservation in a rapidly changing world.

A key goal of our Society is to support the scientific development of early career researchers studying corals and reef ecosystems, and to encourage their active participation in our community. We hope the synergy between researchers of fossil and modern reefs will continue to grow and be reflected at the upcoming **15th Symposium of the International Fossil Coral and Reef Society**, to be held in **2027 in Toulouse, France**.

The success of our previous online ECR symposia i.e., Vigo & Vienna (2021), Erlangen (2022), and Chengdu & Nanjing (2024), has established these meetings as vital platforms for intellectual exchange among early career scientists. We are confident that the 4th Early Career Researcher Symposium will be equally inspiring and successful.

We extend our sincere thanks to the organizers - Lewis A. Jones, Danijela Dimitrijević, Alison Cribb, and Amanda Godbold - for their dedication and hard work. We wish all participants an engaging and productive symposium and look forward to seeing many of you continue your research and join us at future Society events.

Jarosław Stolarski (IFCRS President)

Note from the organisers

Dear Delegates,

A warm welcome to the **Fourth IFCRS Early Career Researcher Symposium**! We are delighted to host this event once again and to bring together a vibrant community of early-career scientists who are shaping the future of fossil coral and reef research.

This symposium was first envisioned as a space *by and for* early career researchers – a platform to present exciting new work during the years between the main IFCRS meetings. Since its inception, thanks to the dedication of previous organisers and the enthusiasm of our growing community, the symposium has continued to flourish, drawing in participants from a range of institutions, labs, and research backgrounds.

This year, we are thrilled to feature a diverse programme of talks that span an impressive temporal and thematic range: from ancient to modern reef ecosystems, and from corals and sponges to broader reef-associated environments. We are also honoured to welcome our plenary speaker, Dr Nadia Santodomingo, and research group representatives, who will provide broader perspectives and spark new discussions across career stages.

We encourage you all to take full advantage of this opportunity: ask questions, share ideas, and connect with fellow researchers. Whether you are presenting, listening, or simply curious, your engagement contributes to a supportive and inspiring atmosphere.

Above all, we aim to maintain a respectful, inclusive, and encouraging environment where open dialogue and collaboration can flourish. Please be kind, be inquisitive, and enjoy the day!

Thank you for being a part of this symposium. We are excited to share this experience with you.

With warmest regards,
Lewis A. Jones, Danijela Dimitrijević, Alison Cribb, and Amanda Godbold

Time zone converter

Below, we provide a time zone converter for the day of the meeting for your convenience. If you have any queries about your specific time zone, please do let us know. The following is also a very useful resource:

https://www.worldtimebuddy.com/

Schedule

Thursday 13th November 2025 **(Time zone: UTC)**

See the time chart on the previous page for time zone guidance.

09:00 – 09:10 **Welcome address**

Session 1

09:10 – 09:30 **Quantifying novel marine ecologies across time scales**
Emer Cunningham
The University of Queensland, Australia

09:30 – 09:50 **Intra-crystalline amino acids as indicator for recrystallisation and preservation of fossil corals**
Luisa Meiritz
GEOMAR, Germany

09:50 – 10:10 **Recolonisation strategies of early animals in the Avalon (Ediacaran 574 – 560 Ma)**
Nile Stephenson
University of Cambridge, United Kingdom

10:10 – 10:15 **Meet the lab:** Lewis Jones
University College London, United Kingdom

10:15 – 10:20 **Meet the lab:** Abid Raza
Hamdard University, Pakistan

10:20 – 10:35 **Coffee break**

Session 2

10:35 – 10:55 **The evolution of coral photosymbiosis**
Jonathan Jung
Max-Planck Institute for Chemistry, Germany

10:55 – 11:15 **Ecosystem engineering in coral reef biodiversity hotspots throughout the Phanerozoic**
Alison Cribb
University of Southampton, United Kingdom

11:15 – 11:35	**Reconstructing redox conditions and assessing its impact on reef metazoan distribution on the Cambrian Siberian Platform** Ruaridh Alexander *University of Edinburgh, United Kingdom*
11:35 – 11:40	**Meet the lab:** Markus Aretz *Université de Toulouse, Géosciences Environnement Toulouse, France*

11:40 – 12:55	**Lunch break**

Plenary talk

12:55 – 13:00	Return and introductions
13:00 – 13:40	**Fossil clues to reef resilience: The critical role of palaeontology in coral reef conservation** Nadia Santodomingo *Department of Marine Zoology, Senckenberg Research Institute and Natural History Museum, Germany*

Session 3

13:40 – 13:45	**Meet the lab:** Nadia Santodomingo *Department of Marine Zoology, Senckenberg Research Institute and Natural History Museum, Germany*
13:45 – 14:05	**Stromatoporoid phases** Patrycja Dworczak *Polish Geological Institute, Poland; GeoZentrum Nordbayern, FAU, Germany*
14:05 – 14:25	**Contrasting response of reefs versus level bottom communities to the Early Jurassic environmental changes [in Morocco]** Sinjini Sinha *West Virginia University, United States*
14:25 – 14:30	**Meet the lab:** Wolfgang Kiessling *Friedrich-Alexander University, Germany*

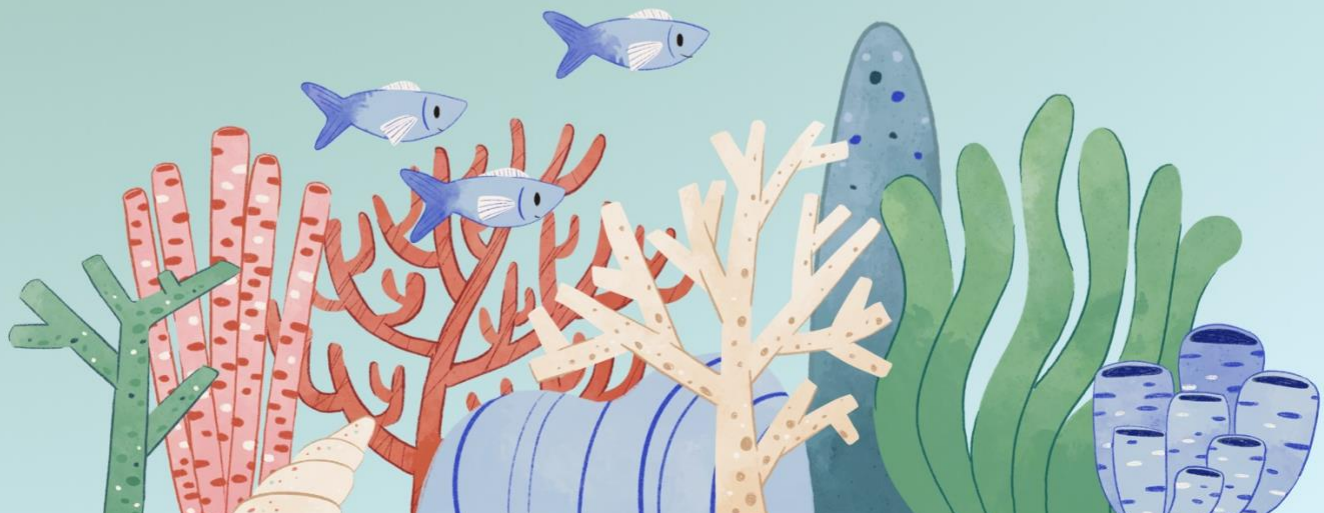
14:30 – 14:45	**Coffee break**

Session 4

14:45 – 15:05	**A global phylogeny reveals the evolutionary history of stony corals: insights on pervasive morphological convergence** Claudia Vaga *Smithsonian Institution, United States*
15:05 – 15:10	**Meet the lab:** Aaron O'Dea *Smithsonian Tropical Research Institute, Panama*
15:10 – 15:30	**Coral reefs from the early Miocene of the La Guajira Peninsula, Colombian Caribbean** Paola Florez *MoAm S.A.S. Colombia, Colombia*
15:30 – 15:50	**Integrating fossil data in paleoecological niche models improves predictions of future habitat for key Caribbean reef corals** Claire Williams *University of Texas at Austin, United States*
15:50 – 15:55	**Meet the lab: Gavin Foster, Jacob Trend** *University of Southampton, United Kingdom*

15:55 – 16:00	**Closing remarks**

MEET THE LABS



Paléo-environnements & Paléo-océanographie

Markus Aretz

markus.aretz@utoulouse.fr

Université de Toulouse, Géosciences Environnement Toulouse, France

Key research topics: All kinds of marine palaeoenvironements of the Phanerozoic including reefs, and some fossil groups as corals, echinoderms and cephalopods.

The PALEO group reconstructs past environments (paleo-environments) and explores their spatial and temporal diversity using a variety of methods, materials, and proxies (fossils, sediments, organic matter, geochemical and isotopic tracers, numerical modeling) applied to different periods in Earth's history.

Lab group homepage: https://www.get.omp.eu/loa/accueil/themes-de-recherche/paleos

thefosterlab

Gavin Foster, Jacob Trend

G.L.Foster@soton.ac.uk; J.J.Trend@soton.ac.uk

University of Southampton, United Kingdom

Key research topics: Geochemistry of Coral Biomineralisation

We use a mix of geochemical and CT image-based approaches to generate a mechanistic understanding of coral skeleton growth and use this better understand the fate of coral reefs in the future

Do you have specific projects to offer at the moment? Yes, several PhD via our NERC DLA Ignite: https://ignite-dla.soton.ac.uk/

Lab group homepage: www.thefosterlab.org

Lab group bluesky: yes please: @thefosterlab.bsky.social

Ancient Oceans Lab (we don't really have one yet!)

Lewis Jones

Lewis.Jones@ucl.ac.uk

University College London, United Kingdom

Key research topics: Biodiversity through time and space, big data in palaeontology, fossil record bias, open-source software

We study how biodiversity has evolved through time and across space, focusing on reconstructing the macroecological and macroevolutionary history of reef-building organisms. Our research integrates a wide range of interdisciplinary tools and data sources — from paleontological fieldwork and museum collections to large-scale data synthesis and Earth System Modelling. We are also committed to advancing Open Science in palaeobiology, developing and contributing to open-source software and resources that enhance transparency and reproducibility in research.

Do you have specific projects to offer at the moment? Yes

Lab group homepage: https://www.lewisajones.com

Lab group bluesky: @lewisajones.bsky.social

Global Change Paleobiology

Wolfgang Kiessling

wolfgang.kiessling@fau.de

FAU, Germany

Key research topics: Reefs through time

The Wolfgang Kiessling Research Group investigates how biodiversity and ecosystems respond to environmental change through deep time, with a particular focus on ancient reef systems. We look at ancient reefs with a data science lens, integrating large-scale paleontological and environmental datasets to uncover the drivers of reef evolution, diversity, and extinction. The group hosts the Erlangen PaleoReefs Database and is one of the most active contributors to the Paleobiology Database. We also developed the Ancient Reef Trait Database, which compiles detailed trait data for fossil reef corals. By combining these resources with cutting-edge analytical approaches, including machine learning, we trace the evolution of reefs and reef builders in unprecedented detail. Our work bridges paleontology, ecology, and data science to understand how past environmental and climatic changes shaped reef ecosystems—and what this means for the future of modern reefs under global change.

Do you have specific projects to offer at the moment? Spatio-temporal reef modeling

Lab group homepage: https://www.gzn.nat.fau.eu/palaeontologie/team/professors/kiessling/

Lab group bluesky: @kiessl.bsky.social

The wigglers

Aaron O'Dea

odeaa@si.edu

Smithsonian Tropical Research Institute, Panama

Key research topics: Tropical paleoecology, evolution and climate

Research in my lab focuses on change in marine ecosystems over time, from millions of years ago to the recent past and the present day. Environmental and ecological transformation of the Caribbean caused by formation of the Isthmus of Panama and global climate changes over the last 10 million years provides a framework to unravel ecological and evolutionary processes in deep time. Human activity has also had a major impact on Caribbean life and this is revealed in young fossil records. By piecing together clues left by fossil coral, sponges, sharks, mollusks and fish, we reconstruct baseline conditions to help guide Caribbean reef conservation and improve our understanding of fundamental biological processes.

Lab group homepage: www.odealab.com

Lab group bluesky: @odealab.bsky.social

Orion Maritime

Abid Raza

zoicone@gmail.com

Hamdard University, Pakistan

Key research topics: Diving Exploration, Coral Fossil Identification, Fossil Coral, Reef Ecosystems

Our lab is based at Hamdard University, Pakistan, where we conduct diving expeditions and coral reef exploration along the entire coastline of Pakistan. We specialize in the collection and identification of coral fossils from various marine environments and also search for fossil corals across the mountain ranges of Sindh. Our research focuses on understanding coral reef ecosystems and marine biodiversity, with ongoing efforts to explore potential medicinal applications from these resources.

Do you have specific projects to offer at the moment? Yes, currently our lab is working on several projects including the identification and cataloging of coral fossils from different regions of Pakistan, studying the biodiversity of coral reef ecosystems along the coast, and exploring the potential use of coral-derived compounds in medicine. We are also involved in field expeditions to discover new fossil sites in the mountain ranges of Sindh.

Lab group homepage: Currently, we do not have a dedicated homepage for our working group/lab. However, we have an extensive collection of fossil coral samples, with photographic documentation, which we plan to include in our upcoming research papers

REEFrame Lab: Reframing coral reef biodiversity through the lens of deep time

Nadia Santodomingo

nadia.santodomingo@senckenberg.de

Senckenberg Research Institute and Natural History Museum, Germany

Key research topics: Marine biodiversity, Taxonomy, Ecology, Paleobiology, Genetics

Over the summer 2025, I moved from the Natural History Museum in London (UK) to the Senckenberg Research Institute and Natural History Museum in Frankfurt (Germany). I plan to continue doing research that integrates knowledge of living reef ecosystems and their fossil record to understand how they respond to environmental shifts and what that means for the future of reefs. I manage the collections of corals, sponges, tunicates and foraminifera, so it is a great opportunity to integrate these other important frame-building taxa into the equation to understand biodiversity change through time.

Do you have specific projects to offer at the moment? Open to support master students, PhD projects and post-doctoral applications to Humboldt, DFG, MSCA, ERC and other funding agencies.

Lab group homepage: https://www.senckenberg.de/en/institutes/senckenberg-research-institute-natural-history-museum-frankfurt/division-marine-zoology/marine-invertebrates-i-2/marine-invertebrates-i-team-2/

Lab group bluesky: @nsantodomingo

ABSTRACTS

PLENARY TALK

Fossil clues to reef resilience: The critical role of palaeontology in coral reef conservation

Nadia Santodomingo

Department of Marine Zoology, Senckenberg Research Institute and Natural History Museum, Germany

Coral reefs are undergoing unprecedented decline under accelerating climate change, with almost half of reef-building coral species at risk of extinction due to mass bleaching, disease, overfishing, and pollution. Projections are gloomy and suggest that even the most diverse reefs will struggle to keep pace with future warming. In the midst of the crisis, coral reef decline is not uniform, showing high variability at different scales. Some regions, such as the Coral Triangle, have maintained relatively stable coral cover despite shifts in species dominance. Some taxa, such as slow-growing Porites, appear more resistant than fast-growing Acropora and Pocillopora. And along the depth–light gradient, mesophotic coral ecosystems show greater resilience to thermal extremes compared to euphotic shallow reefs. These differences in the spectrum of reef resilience pose pressing questions. Why do some regions collapse while others defeat decline? Which traits allow certain coral lineages to persist through stress while others disappear? Why are mesophotic habitats less affected by thermal stress than their euphotic counterparts? Furthermore, is this observed coral resilience limited to short timescales or does it persist over long, geological timescales? To address these questions, we must look at the fossil record. Over the past 250 million years, coral reefs (those primarily built by scleractinian corals) have endured repeated climate extremes, tectonic shifts, sea-level change, and mass mortality events. Fossil data can reveal which communities and species have persisted, which collapsed, and under what conditions recovery was possible. More importantly, how might those insights from the fossil record be applied to current conservation priorities? In this talk, I will discuss why palaeontology should be in the spotlight to guide the protection of reefs. By bridging palaeontology, neontology, and conservation science—and by empowering the next generation of reef scientists— we can act more effectively to address the urgent challenges of the Anthropocene.

ABSTRACTS

INVITED TALKS

Reconstructing redox conditions and assessing its impact on reef metazoan distribution on the Cambrian Siberian Platform

Ruaridh Alexander

University of Edinburgh, United Kingdom

Whether metazoan diversification during the Cambrian Radiation (ca. 539–515 million years ago) was driven by increased marine oxygenation remains highly debated. Global geochemical proxies have inferred global oceanic oxygenation events, however, the degree and extent of shallow oxygenation and its relationship to diversification remains uncertain. To resolve this, we interrogate an interval from ca. 527–519 Ma, by integrating the spatial and temporal distribution of shallow water, in situ reef metazoans, and the first large calcified motile bilaterians (trilobites), with high-resolution multi-proxy redox data through the highly biodiverse lower Cambrian Siberian Platform. We document primarily dysoxic water column conditions in sections with in-situ metazoans and reef assemblages, suggesting that early Cambrian reef metazoans and motile skeletal benthos did not require near-modern dissolved oxygen levels to evolve. Punctuating background oxygen levels are 1–3 Myr oceanic oxygenation events (OOEs) coincident with positive global carbon isotope excursions that led to modestly elevated oxygen levels. These events correspond to regional increases in biodiversity, rates of origination, and habitat expansion, notably in the reef-building archaeocyath sponges and in the trilobites, shortly after their first appearances. These oxygenation events postdate the first appearance of trilobites and archaeocyaths, however, and are thus decoupled from evolutionary innovation. This regional biotic response to episodes of modestly elevated oxygen levels suggests that elevated oxygen levels enabled habitat expansion, which in turn likely promoted diversification within these groups through a range of other selection pressures. Given the global nature of these oxygenation events, implied by the carbon isotope record, the expansion and contraction of habitable space on biodiverse shallow marine platforms due to dynamic redox conditions offers a potentially globally-applicable model for biodiversification.

Ecosystem engineering in coral reef biodiversity hotspots throughout the Phanerozoic

Alison Cribb

University of Southampton, United Kingdom

Ecosystem engineers – organisms whose activities and behaviours change resource availability to impact the overall habitability of their environments – are some of the most important keystone animals in our oceans. As reef-builders, corals are critical ecosystem engineers in our oceans today, engineering the habitats that host some of the Earth's most important biodiversity hotspots. While the ecosystem engineering impacts of corals in biodiversity hotspots are relatively well understood today, their roles in ancient reef ecosystems for creating biodiversity hotspots are less well constrained. Here, we identify occurrences of coral reef biodiversity hotspots throughout the Phanerozoic and quantify the magnitude of reef-building ecosystem engineers' impacts on biodiversity. Using fossil occurrences from the Paleobiology Database, we apply approaches from ecological meta-analyses to identify when coral ecosystem engineers had significantly positive impacts on biodiversity relative to other communities and regions. We also mapped occurrences of all corals, all coral-associated taxa, and those found in formations that preserve biodiversity hotspots through time and space. We find evidence for coral reef biodiversity hotspots in the Ordovician as early as the Tremadocian, becoming a major feature of tropical ecosystems by the Sandbian. However, we also find that coral reef biodiversity hotspots are not a permanent feature of the marine biosphere once they emerge. Some intervals of Earth history see near or total losses of coral reef biodiversity hotspots. We then investigated the controls on coral biodiversity hotspots to identify why some time periods are more characterised by hotspots than others. We find a unique combination of ecology, climate, and biogeography: coral reef biodiversity hotspots, perhaps unsurprisingly, require diverse coral ecosystem engineers, an abundance of tropical coastlines, and moderate climates.

Quantifying novel marine ecologies across time scales

Emer Cunningham

The University of Queensland, Australia

Global change is pushing biodiversity towards unprecedented, "novel" ecological states. There is great potential for the concept of ecological novelty to help uncover patterns and drivers of significant ecosystem change through time, but quantitative studies are currently lacking. In this talk, I introduce a recent framework that uses time series data to empirically detect novel states, and showcase how we have applied this framework across various taxa and time scales. Over the past millennium, we observe novel shifts in coral genus composition along the Australian coast, which occur more frequently and independently than equally significant functional compositional shifts. Over recent decades, zooplankton communities show similar patterns in taxonomic and functional novelty through time, which appear uncorrelated with novel environmental conditions. These empirical studies offer new insights into how global marine ecologies have significantly shifted in the past, which can serve as analogues for a widely predicted future of novel ecosystems.

Stromatoporoid phases

Patrycja G. Dworczak[1,2]

[1]Polish Geological Institute, Poland; [2]GeoZentrum Nordbayern, FAU, Germany

Reef ecosystems dominated sediment production on tropical carbonate platforms throughout the Phanerozoic Eon, both in calcitic and aragonitic seas. Growth rates and carbonate accumulation rates of Palaeozoic reefs are poorly known, because their framework-building organisms (e.g., rudist bivalves, hypercalcified sponges, tabulate and rugose corals), lacking verified evidence of growth rates, are now extinct. However, their fossil remains commonly show well-preserved and easily recognizable growth banding. These increments are characterized by an alternation of dense and less dense skeletal layers, which may reflect annual, monthly or daily rhythms. Among the important Palaeozoic reef-builders in particular, stromatoporoids exhibit exquisite incremental banding (Young & Kershaw, 2005). The aim of this project is to redefine the approach to the study of stromatoporoid skeletal structures by applying the concept of "phases" introduced by Stearn (1989). The research focused on the analysis of variations in growth structures, which may correspond to growth rates. These phases are interpreted as resulting from episodic interruptions in growth. Additionally, well-preserved stromatoporoid material from Gotland allowed for the analysis of complete skeletons, rather than use of small fragments as in earlier studies. Thus, special attention was placed on identification and interpretation of growth interruption layers in stromatoporoid skeletons, which are typically recognized in specimens that have the margins of the skeletons preserved, to allow investigation of the relationship between phases and potential environmental events.

Coral reefs from the early Miocene of the La Guajira Peninsula, Colombian Caribbean

Paola Florez

MoAm S.A.S. Colombia, Colombia

The Oligocene–Miocene transition was a period of significant change for coral reefs in the Caribbean Basin. However, the fossil reefs in the southern part of the basin have been poorly studied. In the La Guajira Peninsula, located in the northeast of Colombia, rich fossiliferous deposits with corals from the early Miocene outcrop at the foothills of the Cocinas, Jarara, and Macuira ranges. This work provides information on the sedimentology and the spatial distribution of the reef deposits of the Siamaná Formation (Aquitanian–Budigalian), as well as a paleoenvironmental interpretation. Furthermore, a comprehensive inventory of the reef-building species from the Siamaná and Jimol (Burdigalian) Formations is presented. The results indicated that during the early Miocene, a reef system was present on the southeastern margin of the Jarara paleoisland (current Jarara range) in optimal development conditions. The landscape was characterized by two types of reefs: patch reefs, which were distributed in a shallow lagoon area, with reduced inputs of terrestrial material from the Jarara paleoisland, and discontinuous barrier reefs that surrounded the same paleoisland. In both cases, the scleractinian corals were the main bioconstructors. Both types of reefs were dominated by colonies of massive (domestones), erect (pillarstones), and their combinations (mixstones) forms, in clear and shallow water environments. Within bioclastic sediments surrounding the coral colonies (rudstone), rubble of mollusks, coral algae, benthic foraminifera, and echinoderms are the most common. Regarding the identified coral fauna, 32 morphospecies belonging to two orders (Scleractinia and Anthoathecata), 12 families, and 15 genera were found. Most of these species became extinct in two subsequent pulses: at the end of the early Miocene and during the transition from the Pliocene to the Pleistocene. Only three species: Montastraea cavernosa, Siderastrea siderea and Millepora alcicornis, are still present in modern Caribbean reefs.

The evolution of coral photosymbiosis

Jonathan Jung

Max-Planck Institute for Chemistry, Germany

It was long debated whether photosymbiosis first arose in the Triassic, with the emergence of scleractinian corals, or if it was already prevalent amongst older coral groups that have since gone extinct. Using, coral-bound nitrogen isotopes (expressed as CB-$\delta^{15}N$ = [($^{15}N/^{14}N$)sample / ($^{15}N/^{14}N$)air - 1]*1000 in ‰), we found the first conclusive geochemical evidence that Mid-Devonian colonial tabulate and dendroid rugose corals hosted active photosymbionts, while solitary and ceroid rugose corals did not. A remarkable finding of our study on Mid-Devonian reefs was the consistent finding that all colonial tabulate corals analyzed hosted photosymbionts whereas all solitary rugose corals did not. The evolutionary history of this symbiosis might clarify its organismal and environmental roles in the success and demise of Paleozoic corals. Building on these findings, we analyzed colonial tabulate and solitary rugose corals of the Pirgu limestone formation of Estonia and Gotland in Sweden which show the emergence of a CB-$\delta^{15}N$ difference between colonial tabulate and solitary rugose during the late Ordovician while at the same time showing increasing CB-$\delta^{15}N$ values. This suggests a potential emergence of photosymbiosis during the late Ordovician cooling, while increasing δ15N values are consistent with expanded anoxia, potentially caused by intensified phosphorus recycling in the Ordovician ocean.

Intra-crystalline amino acids as indicator for recrystallisation and preservation of fossil corals

Luisa Meiritz

GEOMAR, Germany

Tropical corals are widely used for paleoclimate reconstructions to depict climate and environmental conditions in high resolution. However, the further back in time, the more difficult it is to find well-preserved corals for this type of reconstruction. Most of the measurable element and isotope ratios, which serve as climate proxies, are altered by diagenetic recrystallisation processes over geological timescales and thus become impractical for climatic reconstruction. Nonetheless, a novel methodological approach provides new opportunities for the reconstruction of climate indicators in corals despite of their critical geochemical preservation. This approach incorporates the analysis of organic intra-crystalline material (more specifically: amino acids) in coral skeletons that serves indicator for the state of their preservation. This study will provide a first approach to quantify intra-crystalline amino acid content and the preservation of the inorganic coral skeleton using high resolution HPLC amino acid racemization analysis and X-ray powder diffraction analyses. Additionally, two morphologically different coral species (Porites sp. thin theca walls, and Diploria sp. thick theca walls) from Eocene, Pliocene and Miocene deposits are analyzed to compare their preservation potential over geological timescales.

Contrasting response of reefs versus level bottom communities to the Early Jurassic environmental changes [in Morocco]

Sinjini Sinha

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The Pliensbachian/Toarcian boundary event (~183.1 million years ago) and Toarcian Oceanic Anoxic Event or Jenkyns Event (~182.7 million years ago) represent two of the most severe environmental perturbations of the Early Jurassic Epoch, leading to global marine ecosystem disruption and biotic crises. Previous work on these crises has implicated warming-induced anoxia as the primary driver for the extinctions. Recent studies, however, show elevated extinction rates in well-oxygenated basins, such as the Lusitanian Basin in Portugal, and the Iberian Basin in Spain. Here, we report and compare the differential responses of level bottom (non-reefal) versus reef communities to the environmental stressors from multiple sites in the Central High Atlas Mountains of Morocco. The studied Moroccan sites preserve expanded records of Lower Jurassic strata along an onshore-offshore depth transect, capturing both the Pliensbachian/Toarcian boundary and the Jenkyns Event. We use basin-wide sequence stratigraphy to correlate the occurrence, abundance, and diversity of the level-bottom communities (e.g., bivalves, brachiopods) across multiple sections in the Central High Atlas Basin of Morocco. There was no significant loss of taxonomic diversity or functional groups across the two events, instead there was a diversification amongst the macrofaunal communities after the Toarcian event. The resilience of level bottom communities is in stark contrast to the multi-phased collapse of reefs and extinction of corals and foraminifera, which indicate that environmental stressors were not uniformly detrimental to the fauna of the Central High Atlas basin. Despite the extinctions, coral reef communities recovered relatively rapidly in Morocco. The quicker recovery of reef organisms combined with no significant diversity loss amongst level bottom communities, indicates that Morocco was likely a low latitude refuge for Early Jurassic communities. These new stratigraphic paleobiological data are critical to understanding organism survival during the Early Jurassic environmental perturbation and serve as important analogues for modern ocean ecosystems.

Recolonisation strategies of early animals in the Avalon (Ediacaran 574 – 560 Ma)

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The first geographically widespread metazoans are found in the Avalon assemblage (Ediacaran; 574 – 560 Ma). These early animals were regularly disturbed by sedimentation events such as ash flows and turbidites, leading to an apparent "resetting" of communities. However, it is not clear how biological legacies – remains or survivors of disturbance events – influenced community ecology in the Avalon. Here, we use spatial point process analysis on 19 Avalon palaeocommunities to test whether two forms of biological legacy (fragmentary remains of Fractofusus and surviving frondomorphs) impacted the recolonisation dynamics of Avalon palaeocommunities. We found that densities of Fractofusus were increased around the Fractofusus fragments, suggesting that they helped to recolonise the post-disturbance substrate, potentially contributing to the Fractofusus dominance found in 8 of the 19 palaeocommunities. However, we found no such effects for survivor fronds. Our results suggest that the evolution of height was for long-distance dispersal rather than local recolonisation. In modern deep-sea environments, there is a trade-off between local and long-distance dispersal, and our work demonstrates that this differentiation of reproductive strategies had already developed in the early animals of the Avalon.

A global phylogeny reveals the evolutionary history of stony corals: insights on pervasive morphological convergence

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Global climate change is impacting coral reefs worldwide. Understanding how stony corals, the primary architects of both shallow and deep reef ecosystems, responded to past environmental challenges is key to predicting their future. However, reliable phylogenetic reconstructions and resolution of longstanding evolutionary questions of the order Scleractinia have been hampered by a substantial underrepresentation of azooxanthellate and deep-sea species and a paucity of available molecular markers. Our comprehensive, time-calibrated molecular phylogenetic analysis, which includes hundreds of newly sequenced coral taxa, sheds new light on the deep-time evolution of scleractinian corals. We found that the most recent common ancestor of Scleractinia is dated to occur ~460 million years ago and was likely solitary, heterotrophic, and free-living, thriving in both shallow and deep waters. Symbiosis with photosynthetic dinoflagellates, established ~300 million years ago and spurred coral diversification. However, only a few photosymbiotic lineages survived major environmental disruptions in the Mesozoic era. In contrast, solitary, heterotrophic corals with flexible depth and substrate preferences probably thrived in the deep sea following environmental disturbance events. Our analyses reveal greater vulnerability and reduced resilience in shallow-water symbiotic corals compared to their deep-water, solitary counterparts. Moreover, in our phylogenomic reconstruction several genera and families were recovered as polyphyletic assemblages highlighting pervasive macro and micromorphological convergence in the order, thus underscoring major challenges in reliably placing fossil taxa in Scleractinia clade stems.

Integrating fossil data in paleoecological niche models improves predictions of future habitat for key Caribbean reef corals

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Ecological niche models (ENMs) help assess the abiotic preferences of species by linking their occurrences to the environmental conditions in which they live. This study applies ENMs to assess four critical reef-building Caribbean coral species. We first examine whether their ecological niches have remained consistent (niche stability) from the Holocene to the Present, and whether incorporating data from past warm climate periods better estimates the corals' fundamental niche. Given a finding of niche stability, we used the ENM-reconstructed niche characteristics to predict area and location of suitable habitat for future climate scenarios in the years 2050 and 2100. Our findings show that including Holocene fossil data broadens the niche hypervolume, resulting in a greater projection of suitable habitats than models based solely on modern data. Although our models show that suitable habitats exist for these corals in 2100, suitable habitat declines dramatically (45-100% decrease in area from Present), there is a significant restriction of lower latitude habitat suitability, and marine protected areas do not overlap the majority of future suitable habitat. These results support that preventing significant degradation of these vital ecosystems requires action towards reducing emissions and expanding protected areas in the northern Caribbean.

Thank you!

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