At the ARC Centre of Excellence for Coral Reef Studies we acknowledge the Australian Aboriginal and Torres Strait Islander peoples of this nation. We acknowledge the Traditional Owners of the lands and sea where we conduct our business. We pay our respects to ancestors and Elders, past, present and future. The ARC Centre of Excellence for Coral Reef Studies is committed to honouring Australian Aboriginal and Torres Strait Islander peoples’ unique cultural and spiritual relationships to the land, waters and seas and their rich contribution to society.
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<tr>
<th>Time</th>
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<tr>
<td>10.30am</td>
<td>Welcome to Country</td>
<td>Bindal Traditional Elders</td>
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<tr>
<td>10.40am</td>
<td>Opening of Symposium</td>
<td>Graeme Cumming</td>
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<tr>
<td>10.45am</td>
<td>Plenary</td>
<td>David Bellwood</td>
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<td><strong>Reef Futures</strong></td>
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<td>11.05am</td>
<td>Exposure to elevated carbon dioxide affects the cardiac performance of cobia, <em>Rachycentron canadum</em></td>
<td>Kelly Hannan</td>
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<tr>
<td>11.20am</td>
<td>Climate policy implications for coral reef futures on the Great Barrier Reef</td>
<td>Jennifer McWhorter</td>
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<td>Differential susceptibility during latest mass coral bleaching in Australia’s Coral Sea and Great Barrier Reef Marine Parks</td>
<td>Deborah Burn</td>
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<tr>
<td>12.00pm</td>
<td>The response of Red Sea coral communities to recent disturbance events vary along a latitudinal gradient</td>
<td>Nickolas Hammerman</td>
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<td>12.15pm</td>
<td>Epaulette sharks as an indicator species for climate change: Current knowledge and future directions</td>
<td>Carolyn Wheeler</td>
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<tr>
<td>12.30pm</td>
<td>Framing climate risk and crisis in World Heritage governance (and beyond)</td>
<td>Lucy Holmes McHugh</td>
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<td>Plenary</td>
<td>Georgina Gurney</td>
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<td><strong>Ecology and Evolution</strong></td>
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<td>1.50pm</td>
<td>Measuring hydrodynamics and sediment resuspension in coastal canopies</td>
<td>Nery Contti-Neto</td>
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<tr>
<td>2.05pm</td>
<td>Coral Reef Fishes of the Genus <em>Trimma</em>: Distribution, Life History and Diet</td>
<td>Nisha Goldsworthy</td>
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<td>2.20pm</td>
<td>Maternal investment in coral species: the trade-off between egg size and fecundity</td>
<td>Nataly Gutierrez-Isaza</td>
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<tr>
<td>2.45pm</td>
<td>Regeneration in Heliofungia</td>
<td>Beatriz Diaz-Guijarro</td>
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<tr>
<td>3.00pm</td>
<td>From parents to planulae: A review and meta-analysis of trait heritability and additive genetic effects in corals</td>
<td>Kevin Bairos-Novak</td>
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<tr>
<td>3.15pm</td>
<td>Ecological patterns of distribution and cover of sponges and ascidians on coral reefs in Kimbe Bay</td>
<td>Saul Gonzalez-Murcia</td>
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## Wednesday 8th July

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<tr>
<td>10.30am</td>
<td>Welcome</td>
<td>Alana Grech</td>
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<td>10.35am</td>
<td>Plenary</td>
<td>Emily Darling</td>
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<td><strong>Fish and Fisheries</strong></td>
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<td>10.55am</td>
<td>Spatiotemporal determinants of seasonal gleaning in dynamic coastal livelihoods</td>
<td>Ruby Grantham</td>
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<td>11.10am</td>
<td>Sprats are reef fish, not vagrant pelagic fish</td>
<td>Kynan Hartog-Burnett</td>
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<tr>
<td>11.25am</td>
<td>Barramundi, Barramundie, or Barramondi: a century of fisheries narratives of <em>Lates calcarifer</em></td>
<td>Carolina Chong-Montenegro</td>
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<td>Social inequalities in the co-management of coral reefs: the winners and losers</td>
<td>Cristina Ruano-Chamorro</td>
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<td>Carryover effects of boat noise on the escape response of a coral reef fish</td>
<td>Laura Velasquez Jimenez</td>
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<tr>
<td>12.20pm</td>
<td>Importance of solitary and structurally complex sponges as shelter and feeding substratum for coral reef fishes</td>
<td>Amy Coppock</td>
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<td>1.25pm</td>
<td>Plenary</td>
<td>Ove Hoegh-Guldberg</td>
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<td><strong>Global Change</strong></td>
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<td>1.45pm</td>
<td>Geochemistry of large benthic foraminifera <em>Amphisorus hemprichii</em> as a new high-resolution proxy for lead pollution</td>
<td>Netramani Sagar</td>
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<tr>
<td>2.00pm</td>
<td>A ‘lattice of leadership’ and followership were both critical in the transformative success of the Great Barrier Reef rezoning</td>
<td>Jon Day</td>
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<tr>
<td>2.15pm</td>
<td>Investigating impact of individual response on landscape level patterns in dynamic social-ecological systems (SES)</td>
<td>Sivee Chawla</td>
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<td>2.40pm</td>
<td>The neurobiological mechanisms underlying cephalopod behavioural change at elevated CO2 levels</td>
<td>Jodi Thomas</td>
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<td>2.55pm</td>
<td>Understanding microeconomic adaptation feedbacks to enable successful policy design in a climate change context</td>
<td>Henry Bartelet</td>
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<td>3.10pm</td>
<td>Turning rubble to reef: assessing rubble mobilisation and binding dynamics to predict recovery potential of disturbed reefs</td>
<td>Tania Kenyon</td>
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<tr>
<td>3.25pm</td>
<td>Closing Remarks</td>
<td>Graeme Cumming</td>
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Plenary
Speakers
**Professor David Bellwood**

David Bellwood is an ARC Laureate Fellow, Chief Investigator in the ARC Centre of Excellence for Coral Reef Studies and a Distinguished Professor of Marine Biology at James Cook University. He has broad research interests in the evolution and ecology of coral reef fishes, and has published over 300 articles in leading international journals. In 2019, David was awarded James Cook University’s Primary Advisor of the Year, for excellence in supervision of research degree candidates. He is also a recipient of the Indo-Pacific Fish Conference *Bleeker Award*, Australian Marine Sciences Association *Jubilee Award* and is a Fellow of the Australian Academy of Sciences. David pioneered the application of ecosystem function approaches to the study of coral reefs. His current research focuses on the ecosystem impacts of biodiversity loss and climate change, with the goal of developing new approaches to the management of coral reefs.

**Dr. Emily Darling**

Emily Darling is a Conservation Scientist with the Wildlife Conservation Society, where she leads a global coral reef monitoring program to investigate how tropical coral reefs are changing in the face of our climate crisis. Emily is passionate about using collaborative big data to reveal new solutions for coral reef conservation, and she works with partners throughout Melanesia, the Coral Triangle, the Western Indian Ocean and the Caribbean. Trained as a coral reef ecologist, Emily has published over 50 articles in leading scientific journals (e.g. *Science, Nature, Current Biology, Nature Climate Change*) and received numerous awards for research and science communication, including the International Coral Reef Society *Young Scientist Award* in 2017. Previously, Emily was an NSERC Banting Postdoctoral Fellow at the University of Toronto and a David H. Smith Conservation Research Fellow at the University of North Carolina.
Dr. Georgina Gurney

Georgina Gurney is an environmental social scientist and Senior Research Fellow at the ARC Centre of Excellence for Coral Reef Studies. Her research focuses on understanding the socioeconomic conditions that influence opportunities for collaborative management of marine common-pool natural resources, and the multiple socioeconomic and environmental outcomes of such initiatives. Georgina takes a transdisciplinary approach to her research, drawing on theories and methods from a range of disciplines including political science, social psychology, and human geography. She has undertaken most of her research in the Asia-Pacific region, including in Indonesia and Fiji, where she is working closely with resource managers. Georgina has published over 40 articles in leading scientific journals (e.g. Science, PNAS, Nature Sustainability) and is a Queensland Young Tall Poppy award winner, a Fulbright Scholar, and a Virginia Chadwick Award recipient.

Professor Ove Hoegh-Guldberg

Ove Hoegh-Guldberg is Professor of Marine Studies at the University of Queensland and Deputy Director of the ARC Centre of Excellence for Coral Reef Studies. He is deeply-motivated by a desire to communicate science effectively, undertake game-changing research and finding high-impact solutions to address the most pressing and serious challenges facing humanity. Ove holds many high profile international appointments, including Coordinating Lead Author for the ‘Oceans’ chapter for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and the Coordinating Lead Author on the ‘Impacts’ chapter of the IPCC Special Report on 1.5°C. He has authored over 350 peer-reviewed publications (>35 in Science, Nature or PNAS) and has received a Queensland Premier’s Fellowship and an ARC Australian Laureate Fellowship. Ove was elected to the Australian Academy of Science in 2013, received the Prince Albert II Award for Climate Change in 2014, and the International Award from the Banksia Foundation in 2016. Ove is a Highly Cited Researcher and, in 2019, was listed by Apolitical as one of the 100 most influential people in Climate Policy.
Abstracts

Photo: Tania Kenyon

https://www.coralcoe.org.au/
Kevin R. Bairos-Novak

Biography: Kevin is a PhD student in the ARC COE, supervised by Profs. Sean Connolly, Mia Hoogenboom, and Madeleine van Oppen. Kevin’s research aims to understand the evolution of thermotolerance in coral populations using results from micro-evolutionary experiments on coral symbionts combined with mechanistic modelling of coral demography

From parents to planulae: A review and meta-analysis of trait heritability and additive genetic effects in corals

Kevin R. Bairos-Novak¹, Madeleine van Oppen²,³, Sean R. Connolly¹,⁴

¹ ARC Centre of Excellence for Coral Reef Studies & College of Science and Engineering, James Cook University, Townsville, Australia
² Australian Institute of Marine Science, Townsville, Australia
³ University of Melbourne, Melbourne, Australia
⁴ Smithsonian Tropical Research Institute, Panama

Abstract: Anthropogenic climate change constitutes a rapidly intensifying selective pressure shaping the world’s reefs. Already, the genetic composition of reefs has been fundamentally altered, resulting in the evolution of new phenotypes and symbiont associations. With these changes, there is a growing need to understand how reefs are likely to change given future projected bleaching. Trait evolution can be predicted according to the breeder’s equation as a function of natural selection and trait heritability. Whereas the level of selection is often relatively simple to quantify, heritability – the proportion of the variation in a trait due to (additive) genetic effects – is much more elusive but equally important for evolutionary models of coral populations.

Here, we review and meta-analyze more than 50 heritability estimates for various coral species across the Indo-Pacific, Hawaiian, Atlantic, and Red Sea. Most studies report broad-sense heritability estimates using clonal common garden designs that do not separate the effect of additive genetics from other genetic effects (e.g., dominance, epistasis) as opposed to narrow-sense heritability estimates. We identify a number of data gaps including a lack of narrow-sense heritability estimates from studies measuring growth, symbiont photochemistry, and gene expression. Of the studies reporting narrow-sense heritability, most are limited to specific life stages and measured traits, such as larval stages, survival/settlement success, and symbiont assemblages.

Finally, we synthesize available heritability estimates in a meta-analysis. We find differential heritability of traits, such as lower heritabilities associated with measurements of gene expression, while symbiont assemblages and measurements associated with survival/settlement success reporting higher heritability. No effects of temperature on heritability estimates were detected, suggesting heritability is a robust evolutionary quantity in response to environmental change. We also contrast broad- and narrow-sense heritabilities, estimate the relative contribution of additive genetic effects vs. other genetic effects, and compare heritability estimates across different life stages. Our review and analysis finds that heritability in some traits may be higher than those assumed in recent evolutionary models of corals while other traits remain understudied.

https://www.coralcoe.org.au/
Henry Bartelet

Biography: Henry is a PhD candidate at the ARC Centre of Excellence for Coral Reef Studies, where he combines dynamic systems theory with behavioral economics to contribute to the design of effective incentives to facilitate microeconomic adaptation to climate change. He holds a master degree in System Dynamics from the University of Bergen in Norway. After his master degree, Henry worked in Oslo as an energy system modeler in DNV GL’s Energy Transition Program.

Understanding microeconomic adaptation feedbacks to enable successful policy design in a climate change context

Henry A. Bartelet¹, Graeme S. Cumming¹, Michele L. Barnes¹

¹ ARC Centre of Excellence for Coral Reef Studies, James Cook University

Abstract: Global heating will affect ecosystems and the benefits that they provide to people in a wide variety of ways, with profound direct and indirect effects on human society. Microeconomic adaptation to climate change focuses on how households and firms are responding to climate signals by changing their behaviour. However, the effectiveness and the governance of efforts to implement microeconomic adaptation are poorly understood. We review what is known about actual adaptations made by microeconomic actors, and their relationship to private and public sectors, respectively. We find that there are linkages between adaptive capacity and the type of adaptation measures that are implemented. However, there is a lack of focus in current literature on assessing the multidimensional outcomes of adaptation measures. Our paper proposes that these outcomes could have an impact on adaptive capacity, thereby creating a feedback perspective on the adaptation process. Interventions to foster successful adaptation to climate change would benefit from accounting for adaptation cycle dynamics and conflicting interests between adaptation outcomes.
Deborah Burn

Biography: Debs completed her BSc in Marine Biology at Newcastle University (UK) in 2013. She has since worked in various scientific positions in the Maldives and New Zealand before moving to Townsville to work for Prof. Morgan Pratchett. Debs has been involved in a range of research projects sparking a passion for understanding coral reef organism and ecosystem responses to disturbances. Her past research activities have focussed on microbial communities of coral disease, variation in coral growth, ecology and biology of Crown of Thorns Starfish (Acanthaster planci and A. cf. solaris) and butterflyfish (Chaetodon triangulum), and coral recovery following major disturbances. Debs is currently pursuing an MPhil focussing on vulnerability of coral assemblages to disturbance in Australia’s Great Barrier Reef and Coral Sea Marine Parks, supervised by Morgan Pratchett and Andrew Hoey.


Deborah Burn1, Sam Matthews1,2, Andrew Hoey1, Morgan Pratchett1

1 ARC Centre of Excellence for Coral Reef Studies, James Cook University
2 Great Barrier Reef Marine Park Authority, Townsville

Abstract: Coral bleaching can be highly selective in its effects on coral populations and assemblages, but selectivity depends on the severity of the bleaching event. For example, extreme heatwaves lead to high incidence of bleaching across all corals (regardless of size or taxonomy), whereas more moderate bleaching can have much more selective effects. This study examines the differential susceptibility of coral taxa and size classes over a range of severities at 33 reefs within the Great Barrier Reef and Coral Sea Marine Parks during the 2020 bleaching event. As a proxy of bleaching severity, we placed reefs into one of five categories based on the overall proportion of bleached colonies, ranging from ‘low’ (<10% overall bleaching) to ‘extreme’ (80-100% overall bleaching) severity, using in situ data from 45,791 coral colonies in 20 genera at 90 sites during the event. To determine the differential susceptibility among taxa, we compared the proportion of bleached colonies in each size class and taxa within each severity category. All taxa and sizes showed an increased proportion of bleaching with increasing bleaching severity. Whilst reefs with ‘extreme’ bleaching severity left few ‘winners’, some taxa did bleach significantly less than others (i.e. Leptastrea, Lobophyllia and Fungidae). Massive Porites performed well during low intensity bleaching severities compared with the average response of pooled taxa, but was among the most affected when severity became ‘very high’ (60-80% overall bleaching) to ‘extreme’, suggesting a tipping point in susceptibility for this taxon. Other taxa, including Stylophora, Goniastrea and branching acroporids, were consistently more bleached than the average, regardless of severity, reaffirming the case for bleaching ‘winners’ and ‘losers’. For example, whilst 100% of Stylophora colonies were bleached on ‘extreme’ severity reefs, only 29% of fungids surveyed on the same reefs were bleached. There was also an apparent differential bleaching response among coral size classes. Generally, smaller corals appeared less susceptible to bleaching when aggregated across all reefs (<5cm diameter = 36%, 5-40cm diameter = 43%, and >40cm diameter = 48%), but this trend varied among taxa. For example, large Stylophora colonies (>40cm diameter) bleached less often than smaller colonies and juveniles (>40cm = 41%, 5-40cm = 79%, and juveniles < 5cm = 70%). Our study shows clear differential susceptibility among coral taxa, even at the highest severity, suggesting community reconfiguration towards a higher proportion of robust taxa may mask the severity of future bleaching events. Our results infer that taxa previously thought to be more robust (i.e. massive Porites), may become the ‘losers’ of future communities as the severity of bleaching events increases, which allows us to better predict both size structure and composition of future communities under a range of scenarios.

https://www.coralcoe.org.au/
Sivee Chawla

Biography: Sivee Chawla is a PhD student working with Prof. Graeme Cumming and Prof. Tiffany Morrison to understand the scale-mismatch and feedback in peri-urban areas using dynamic simulation models to extend SES Theory. She pursued Computer Science Engineering from Delhi. After working for a year and half with IBM she moved on to pursue her Masters in Geoformation Sciences and Earth Observation, at Twente University (ITC), Netherlands. The topic of the master’s thesis was to “develop sub pixel classification algorithm by exploiting spatial and spectral information in multi-spectral remote sensing images using Markov Random Fields and Possibilistic-C means”. She then worked in India as a GIS modelling engineer and at VITO (Flemish Institute of Technological research) in Belgium for developing fusion models using Remote Sensing for water quality estimation.

Investigating impact of individual response on landscape level patterns in dynamic social-ecological systems (SES)

Sivee Chawla¹, Tiffany H. Morrison¹, Graeme S. Cumming¹

¹ ARC Centre of Excellence for Coral Reef Studies, James Cook University

Abstract: Rural and natural landscapes along an urban periphery serve as functional spaces for the well-being of urban areas while at the same time supporting rural inhabitants. With rapid urbanization, land in peri-urban areas is being appropriated by urban actors for roads, housing and industries resulting in fragmented peri-urban landscapes. Such fragmented landscapes heavily affect the livelihood of rural inhabitants through reduced availability of land and resources for agriculture or other rural livelihoods. Yet little is known about the influence of decisions made by rural actors in response to urbanization on the outcomes in a large–scale and complex SES such as peri-urban areas. For effective management of resources including land, Ostrom’s design principles for Common Property Regimes stresses the importance of participation of those affected by the rules. Based on the Ostrom’s design principle, we explored the consequences of individual level decisions on landscape level patterns using dynamic simulation models. During urbanization in peri-urban areas, urban actors interact with rural actors for land-use change related decisions. We gradually varied the rural actors’ response from zero resistance to complete resistance to change (on the scale of 0 to 1) and captured the urban-rural interactions using the Game Theory. We then estimated emerging landscape patterns through various composition and configuration landscape metrics (e.g. clumpiness, aggregation, edge density). We observed that the change in the landscape metrics is non-linear in response to the level of resistance. Spatial configuration indices (Clumpy and Aggregation Index) changed rapidly when the level of resistance was low (i.e. below 0.5) as compared to when the level of resistance was high (i.e. above 0.5) among the rural actors. The edge density increased for the group with lower resistance (below 0.5) and decreased gradually for the group with higher resistance (above 0.5). The results indicate that there is a threshold point beyond which the behavior of rural actors strongly influences outcomes in an SES. Such influence is spatially invariant i.e. independent of their spatial location. We extend and operationalize Ostrom’s design principles by identifying that the minimum threshold of number of individuals that should be included in the rule making. Our analysis extends the understanding of influence of local processes on large scale patterns in an SES.
Carolina Chong-Montenegro

**Biography:** Carolina is a marine fisheries ecologist focusing on historical fisheries of rare and threatened fish species. She received her bachelor’s degree in marine biology from ESPO in Ecuador, where she studied the ecology and biology of endemic grouper from the Galápagos Islands. She then received her master’s degree at the University of Bremen, Germany where she studied the biology and fisheries of the Pacific goliath grouper in Colombia. Overall her work focuses on documenting the impact of fishing on vulnerable fish populations and aims to actively integrate local communities into the research process by applying interdisciplinary approaches for developing sustainable fisheries.

**Barramundi, Barramundie, or Barramondi: A century of fisheries narratives of *Lates calcarifer***

Carolina Chong-Montenegro¹,², Ruth H Thurstan², John M Pandolfi¹

¹ ARC Centre of Excellence for Coral Reef Studies and School of Biological Sciences, The University of Queensland, St Lucia, QLD 4072, Australia.

² Centre for Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter, Penryn, UK

**Abstract:** Overfishing generally is characterised by targeting large-bodied marine animals that usually occupy high trophic levels. To prevent the risk of overfishing, conservation managers and fisheries scientists require long-term, species-level monitoring data. However, in most countries, standardised monitoring programs did not commence until the early 1950s, long after exploitation and overfishing of many marine resources had already occurred. In Queensland, Barramundi (*Lates calcarifer*) is a highly valuable fish species for both the commercial and recreational fishing sectors with landings of 800 and 100 tonnes, respectively, in 2017. Despite a long history of fishing, official landings data for this species only extend back to 1987. Using historical records dating from 1865 to 1950, quantitative fisheries data have been extracted from qualitative fisheries narratives, such as newspaper articles, with the goal of reconstructing catch rates (*barramundi fisher h⁻¹*), documenting the effects of technology development on the fishery, and quantifying changes in overall fishing effort over time. Using this approach, we can document the effect of fishing dynamics of the commercial and recreational fishing sectors on barramundi over the past century. Documenting the early commencement of the barramundi fishery in Queensland fills substantial gaps in historical ecological knowledge, and quantifies the earliest effects of fishing on the species. This work provides insight into not only the past fishing trends that led to the current state of the fishery, but also the socio-cultural value of fish species and fishing activities through time.

https://www.coralcoe.org.au/
Nery Contti Neto

Biography: Born and raised in an island in southeast Brazil, Nery has always kept contact with the sea. During his BSc in Oceanography, he was able to complete internships in Hawaii and Trindade e Martin Vaz working with sea turtles. He then moved to Sao Paulo to earn his MSc degree, studying longshore beach currents, at the same time completing a specialised study in tides and sea-level measurements. This gave him the opportunity to get a placement within industry, specially dealing with Meteo-Oceanography data analysis. He is now pursuing his PhD studying the current and wave interaction within seagrass and Coral reefs under the supervision of Dr. Ryan Lowe.

Measuring hydrodynamics and sediment resuspension in coastal canopies

Nery Contti Neto1,2, Andrew Pomeroy1,2,3, Matthew Reidenbach4, Marco Ghisalberti1,2, Mario Conde-Frias1,2, Ryan Lowe1,2

1 Oceans Graduate School, University of Western Australia, Perth, Australia
2 UWA Oceans Institute, University of Western Australia, Perth, Australia
3 The Australian Institute of Marine Science, Perth, Australia
4 Department of Environmental Sciences, University of Virginia, Virginia, USA

Abstract: A number of studies have revealed how the large bottom roughness of coastal benthic ecosystems (collectively referred to as canopies) modify near-bed hydrodynamics. The presence of canopies influence nutrient uptake, sediment resuspension and transport, having a great impact within the community ecology. While a growing number of studies have investigated sediment dynamics within canopies in controlled laboratory experiments, field observations on the turbulence level within natural ecosystems still remain limited. In this study, we investigate how seagrass meadows (Posidonia australis) that are abundant in southwestern Australia modify Suspended Sediment Concentrations (SSC) and fluxes over a wide range of current- and wave-dominated conditions. High frequency current profiles at the millimeter scale from 1 to 50 cm above bed and multi-frequency acoustic sounder measurements were taken from field-adapted instruments generally used in laboratory. Near-bed current values inside the canopy were then used to derive shear stress and understand SSC dynamics over time. Current data measured right above the meadow and higher up in the water column contributed to understand flow attenuation due to the seagrass characteristics. Near-bed (in-canopy) mean current velocities differed up to one order of magnitude from what was measured right above the canopy element. Spectral analysis showed a greater swell attenuation than short period waves. Turbulence was created inside the canopy as a consequence of the roughness elements. Different classes of sediment size distribution were analysed, which provided a general framework to understand the modification of sediment resuspension in terms of both concentration and sediment distribution within seagrass meadows in wave-dominated environments. The results highlight the significant role that canopies play in regulating local rates of sediment resuspension and deposition through flow attenuation at the patch-scale within individual elements.
Amy Coppock

**Biography:** Originally from the UK, Amy completed her BSc(Hons) at Swansea University, UK. She completed her MSc at James Cook University under the supervision of Prof. Geoff Jones and Dr Naomi Gardiner. Here she looked at the ability of newly recruited coral reef fishes to orientate toward their preferred micro-habitat type through the use of chemosensory cues. Amy’s PhD research focuses on fish-sponge associations in Kimbe Bay, Papua New Guinea, specifically how solitary and structurally complex sponge species are important as a source of shelter and/or food for local coral reef fish species. She is supervised by Professors Geoff Jones and Mike Kingsford.

**Importance of solitary and structurally complex sponges as shelter and feeding substratum for coral reef fishes**

Amy Coppock¹ Michael Kingsford², Geoffrey Jones³

¹ Marine Biology and Aquaculture, College of Science and Engineering & ARC Centre of Excellence for Coral Reef Studies, James Cook University
² Marine Biology and Aquaculture, College of Science and Engineering & ARC Centre of Excellence for Coral Reef Studies, James Cook University
³ Marine Biology and Aquaculture, College of Science and Engineering & ARC Centre of Excellence for Coral Reef Studies, James Cook University

**Abstract:** Coral reefs are structurally complex ecosystems comprised of a variety of benthic organisms that provide a biotic habitat and essential resources such as food and shelter for other reef-associated organisms. The structural complexity and diversity of corals is known to have a major influence on the biodiversity, distribution and abundance of coral reef fishes. However, interrelationships between fishes and other benthic space-holding organisms, such as sponges have received much less attention, especially in the coral triangle region of the Indo Pacific. Sponges contribute substantially to the composition and complexity in many reef habitats in this region, but little is known of their use as habitat and/or feeding substratum for local coral reef fish species. Here we demonstrate that a number of coral reef fish species positively associate with structurally complex sponges in Kimbe Bay, Papua New Guinea, an area notable for a high biodiversity of sponges with complex growth forms. Fish-sponge associations were quantified on six near-shore reef sites, with data on sponge cover collected a via series of point intercept transects (100 random points per 50m transect), with four replicates at three depths (5, 10, 15m). The habitat usage of two life-stages (adults and new recruits) for 11 common fish species (Blennidae, Chaetodontidae, Gobiidae, Labridae, Pomacentridae and Tetraodontidae) was then estimated. One hundred individuals of each fish species were selected haphazardly, as encountered, and the substrate below them identified. Lastly, four structurally complex sponge species; *Coelocarteria* spp., *Ianthella basta*, *Gelloides* spp. and *Xestospongia testudinaria* were subjected to video-monitoring. In addition to our 11 focal fish species, footage identified a further 20 fish species that associated with our sponge species. Associations included the use of sponges as settlement sites, juvenile and adult shelter, as a source of food or as a surface from which epiphytic or cryptobenthic food could be sourced. This indicates that fish more commonly associate sponges than was originally thought. Coral reefs are currently being subjected to an increasing number of stressors that have resulted in losses to hard coral cover and coral-associated fishes. In many areas, complex sponges make a substantial contribution to the remaining habitat complexity and have the potential to act as an alternative habitat for fishes dependent on a structurally complex substratum.
Jon Day

Biography: Between 1975-2014, Jon was a protected area planner, park ranger and natural resource manager. Jon’s career started in terrestrial national parks (e.g. Grampians, Kakadu) but in 1986, Jon joined GBRMPA to work on the Great Barrier Reef (GBR). For 28 years Jon was involved in many aspects of planning and managing the GBR. In 1998, he was appointed as one of the Directors at GBRMPA, and for the next 16 years was variously responsible for biodiversity conservation, park planning, the GBR rezoning, heritage (particularly World Heritage), Indigenous Partnerships, and commencing the first 5-yearly Outlook Report. Jon retired in 2014 to commence a part-time PhD in the ARC at JCU; being an ‘insider researcher’ was among his many challenges.

A ‘lattice of leadership’ and followership were both critical in the transformative success of the Great Barrier Reef rezoning

Jon C. Day¹

¹ ARC Centre of Excellence for Coral Reef Studies, James Cook University

Abstract: The rezoning outcome in the Great Barrier Reef is well known and widely regarded. Much of the success of the Representative Areas Program (RAP)/rezoning outcome can be attributed to the pivotal role that effective leadership played; it was one of the critical interdependent determinants for the policy reform. Leadership is one of the most studied but least understood topics in any of the social sciences. As part of my PhD, I interviewed a diverse range of politicians, stakeholders, managers, and sectoral luminaries involved in the RAP/rezoning. They were asked to identify who they considered were the key leaders for the three different phases of the planning process and to prioritize the top four leaders for each phase. Forty-seven individual names and 28 groups were initially identified as playing some form of leadership role, but of these, six leaders were repeatedly identified as playing a major role during the RAP/rezoning. From my interviews, Virginia Chadwick, the CEO and Chair of GBRMPA, was highly regarded as an extremely effective and transformational leader. Her inspiring leadership was critical, but complementary leadership was also shown by various others, including technical leadership which provided a fundamental underpinning for the policy reform. Leadership outside GBRMPA was also important, and the political leadership shown by the Minister, David Kemp, was essential to navigate the ‘political minefield’ in Canberra. Many of the relevant sectors similarly had their own influential leaders. Therefore, rather than just a single effective leader, the rezoning success was due to a number of leaders each with their own complementary skills. These various skills were interwoven, with different skills predominating at different times, into a ‘lattice of leadership’. Virginia’s exceptional leadership alone would not have achieved the success of the RAP/rezoning; rather, she was one of a number of effective leaders who, along with a range of others with complementary leadership traits and leadership styles, predominated at various times during the overall planning process. The success of the RAP/rezoning was effectively a team effort, comprising a range of complementary teams, each with its own effective leader, but coordinated by a very effective leadership duo. This ‘lattice of leadership’ also relied upon effective followership within GBRMPA, and it was these combined elements that contributed to the success of RAP/rezoning policy reform.
Beatriz Diaz-Guijarro

**Biography:** Beatriz completed her BSc in marine vertebrate zoology at the University of Bangor, UK, with the goal of working with marine mammals. During summer breaks she volunteered at Seychelles with Global Vision International (GVI) researching the damage a tsunami had caused on coral reefs. She continued her scuba diving education up to reaching dive instructor certification. After her BSc she moved to Townsville, Australia where she completed an MSc in natural resource management, during which she learned she had a passion for molecular genetics. Beatriz went on to intern and work at the Australian Institute of Science (AIMS) where she continued to develop her skills and passion for molecular genetics. She is currently doing a PhD at James Cook University, Townsville.

**Regeneration in Heliofungia**

Beatriz Diaz-Guijarro

1 ARC Centre of Excellence for Coral Reef Studies, James Cook University

**Abstract:** Corals have amazing regenerative abilities, but very little is known about the molecular mechanisms involved in these processes. The molecular bases of development are well understood in the staghorn coral *Acropora* (a member of the *Complexa*), and there is a large developmental dataset for *Heliofungia*, a representative of the other major coral lineage, the *Robusta*. The main aim of this project is to obtain mRNA expression data for regeneration in *Tubastrea* and *Heliofungia* and compare these with developmental data for the same species, in order to better understand how the processes of development and regeneration relate to each other. In order to do this, experiments into regeneration abilities will be conducted on *Heliofungia* corals. This presentation will largely be around the most recent experiments conducted on *Heliofungia* corals and what has been discovered about regeneration in this type of coral.
Biography: Growing up along the Southern coast of New Zealand has driven Nisha to study marine biology and ecology. She completed a Bachelor of Science degree at Victoria University of Wellington, and then ventured to James Cook University in 2019 to pursue a Master of Philosophy under the supervision of Prof. Geoff Jones and Dr Maya Srinivasan.

Nisha’s has always loved all kinds of animals: furry, feathery, slimy or scaly. With the current climate crisis and many ecosystems becoming threatened, she wants to devote her time to helping them in any way she can. Nisha believes that the underappreciated animals that should not be ignored. Her Masters focuses on the ecology of tiny gobies of the genus Trimma. Fishes like these have often been undervalued compared to larger fishes... but they could be more important than originally thought.

Coral Reef Fishes of the Genus Trimma: Distribution, Life History and Diet

Nisha Goldsworthy1, Geoffrey Jones1, Maya Srinivasan1

1 Marine Biology and Aquaculture, College of Science and Engineering & ACR Centre of Excellence for Coral Reef Studies, James Cook University

Abstract: Knowing the ecology of key fish species on coral reefs can further our understanding of how these ecosystems are operating, in order to improve conservation and management methods. Majority of studies focus on the visually prominent fishes in reef systems. However, small cryptobenthic reef fishes that often go unrecognized exhibit extreme diversity, high abundances and are involved in essential ecosystem processes.

Colourful Indo-Pacific pygmy gobies of the genus Trimma fall into this group. The ultra-diverse genus contains 105 species and genetic analysis predicts there could be over 200 species, which would make them the most diverse genus of all coral reef fishes. The most defining characteristic of these fishes is their small size. With a maximum standard length of less than 3cm, they are among the smallest vertebrates on the reef. Novel studies suggest small gobies have short lifespans, rapid growth, high mortality and fast population turnover rates. These are life history traits that lead to high productivity over time. There is also limited evidence to suggest Trimma are planktivores, and thus energy may be brought into the reef by ocean currents in the form of plankton, converted into biomass and then funnelled to higher trophic organisms. Extreme life history traits and feeding habits of Trimma may make them an essential component of coral reef energy flow.

Kimbe Bay, Papua New Guinea, is located in the Indo-Pacific Coral Triangle- a region renowned for its marine biodiversity. Many reefs in Kimbe Bay are characterised by steep drop offs that plunge into vast blue, with sheer vertical walls that are crawling with tiny gobies of the genus Trimma. They are highly abundant here and have potential to be an important component of these systems. Yet, no research to date has been conducted on Trimma in Kimbe Bay. Consequently, we know virtually nothing about them in this area- how do multiple species exist in one place? What are their growth rates and how fast do their populations regenerate? What are their trophic roles?

This project will attempt to answer these questions by assessing the following ecological and life history parameters for Trimma benjamini, T. capostriatum and T. yanoi: (1) Distribution, abundance, and habitat partitioning (2) Life history and sex change patterns and (3) Primary dietary source.
**Biography:** Saul was born in the smallest continental country of Latin America, El Salvador. He studied General Biology at the Universidad de El Salvador (University of El Salvador), and conducted his honours research studying zonation patterns in tropical rocky intertidal fishes. After finishing his studies, Saul worked as Research Assistant at the Universidad de El Salvador (University of El Salvador), UDP Ciencias Neotropicales (UDP Neotropical Sciences) and University of California, Merced. In 2013 Saul was awarded with the Australian Awards Scholarship to study his Master’s degree at JCU and returned to El Salvador to work with Fundación Naturaleza El Salvador (Nature of El Salvador Fundation) and the University of California, Merced developing projects of population genetics in insects and intertidal fish. Since 2018 he has been studying regime shifts caused by sponges and ascidians in tropical reefs and their impact on coral reef associated fishes.

**Ecological patterns of distribution and cover of sponges and ascidians on coral reefs in Kimbe Bay**

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**Abstract:** Disturbed coral reef ecosystems can shift toward alternative stable states dominated by algae, cyanobacterial mats, sponges and ascidians. Sponges and ascidians are strong competitors for space and can overgrow corals, due to their rapid growth, fast recovery, and sexual and asexual modes of reproduction. Typically, benthic reef surveys record coral cover alone and neglect the contribution of other taxa. However, given the decline of coral cover on reefs around the world it is crucial to establish baselines for the distribution and cover of other significant taxa that can aid to identify shifts in benthic community composition. In this study, we surveyed benthic communities on 6 inshore reefs in Kimbe Bay, Papua New Guinea, that are exposed to different influxes of sediment. At each reef, we ran four 50m point intercept transects (100 random points for each transect) at depths of 5m, 10m and 15m at the sheltered (landward) and exposed (seaward) side and recorded the cover of hard corals, encrusting sponges, massive sponges, erected sponges, colonial ascidians, solitary ascidians, soft coral, algae, hydroids, anemones, gorgonians, giant clams, dead coral, rubble, rock and sand. Tissue samples of sponges and individual of ascidians were collected to aid in species identification. Corals had the highest percentage cover [31% ±1.20%SE], followed by algae [14% ±1.01%] and sponges [13% ±0.85%]. We have potentially identified a total of 110 species of sponge and 17 species of ascidian. The percentage cover of sponges varied significantly among reefs, reef sides and depths (ANOVA F=2.429, p=0.001). Ascidians had very low benthic cover [0.21% ±0.05%] and a very scattered distribution with no significant differences among depths, sites or reefs. The most abundant species of sponges were *Dysidea cf. granulosa* and *Dysidea cf. fragilis*. The most abundant species of ascidians were *Polycarpa aurata* and a yet unidentified ascidian. Overall, we conclude that sponges represent an important and spatially variable component of the biotic substrata on inshore reefs in Kimbe Bay. Our study represents the first assessment of the biodiversity, abundance and ecology of ascidians and sponges in Kimbe Bay and provides a baseline against which trends in the abundance of benthic taxa and species diversity can be assessed.
Ruby Grantham

Biography: Ruby is a PhD candidate at the ARC CoE Coral Reef Studies, working under the supervision of Graeme Cumming, David Mills and Cristian Rojas. Her PhD research examines intra-annual dynamics of small-scale fisheries, using multi-disciplinary perspectives to explore how and why the role of fishing in coastal livelihoods varies temporally. Prior to joining the centre, Ruby studied at the University of York, UK as an undergraduate in Environmental Economics followed by an MRes in the economics of inland capture fisheries. She then went on to work as a consultant for international NGOs in Myanmar on projects relating to governance and management in inland fisheries and aquaculture. This background underpins her broader research interest in the contributions of small-scale fisheries to human wellbeing and therefore how fisheries management can contribute to improved quality of life, particularly for low income groups and those vulnerable to climate change.

Spatiotemporal determinants of seasonal gleaning in dynamic coastal livelihoods

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Abstract: Dynamic and diversified livelihood strategies enable seasonal adaptation and will be critical for vulnerable coastal communities to navigate climate change. Gleaning is an important coastal livelihood strategy, yet seasonal gleaning dynamics have not been empirically explored. We examined the role of gleaning fisheries as part of livelihood strategies in dynamic coastal-social-ecological systems using household data collected in eight communities and satellite-derived bathymetry for Atauro Island, Timor-Leste. We analysed factors affecting household decisions to glean in each season, the relationship between gleaning and seafood consumption, and seasonal gleaning pressure on intertidal resources. Our findings reveal heterogeneity in the movement in and out of gleaning between fishing seasons. Thus, despite the food security benefits of gleaning during rough sea conditions, many households did not glean in the rough season and some even exited the gleaning fishery. Households that did glean in the rough season, gleaned less regularly and catches were smaller. Multivariate analysis showed that differences in seasonal participation in gleaning were explained mostly by the amount of accessible shallow habitat. Therefore, seasonal community-level gleaning pressures on ecosystems corresponded with coastal morphology. Our research highlights that natural resource dependent livelihoods and associated pressures on ecosystems vary at fine scales through time and space and that structural drivers can be important in mediating interactions. Sustainably managing coastal resources for food security and poverty alleviation in a changing climate will therefore require accounting for drivers and outcomes of livelihood dynamism in context specific diagnosis of livelihood vulnerabilities and adaptation strategies.
Nataly Gutierrez-Isaza

Biography: Nataly Gutiérrez-Isaza is a PhD student under the supervision of Professor John Pandolfi at The University of Queensland. Her PhD focuses on the latitudinal patterns of the reproductive traits of coral offspring and larval performance. She received a bachelor’s degree in Biology from La Universidad de Antioquia in Medellin, Colombia and a Master of Science’s degree in Natural Resources and Rural Development from El Colegio de la Frontera Sur in Chetumal, Mexico. She is interested in reef dynamics, the competition between hard corals and macroalgae, the causes of coral reef degradation, as well as the functional traits involved in coral species adaptation.

Maternal investment in coral species: the trade-off between egg size and fecundity

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Abstract: Corals provide their larvae with energy resources that allow them to survive and settle after being dispersed by ocean currents. This provisioning or maternal investment can be estimated through measurements of traits such as: egg size, which is representative of the energy invested in each egg (propagule or larvae), and fecundity, which is the total number of eggs released per reproductive event. Because there are limited parental resources, a trade-off exists between egg size, where increased energy reserves favor propagule fitness, and fecundity, where a high number of propagules increases chances of settlement. Although investigating this trade-off in colonial organisms is challenging, it has been found in corals that fecundity per polyp is relatively constant within the reproductive tissues, which allows study the trade-off. Evidence for this trade-off exists in a group of diverse coral species with variable reproductive characteristics (gonochoric, brooder, and hermaphroditic). We compiled a comprehensive global dataset of coral egg sizes (123 species) and fecundity (31 species) and complemented this dataset with data we collected from the east coast of Australia. We assessed this dataset to evaluate the maternal investment trade-off, correcting for phylogeny and accounting for inter- and intra-specific variability. We focused on coral species that are hermaphroditic, broadcast spawners, and have horizontal symbiont transmission (21 species). Mean egg size varied from 0.0072 (Leptoria sp.) to 0.213 mm³ (Acropora sp.), while mean fecundity varied from ~99 (Acropora sp.) to 1315 eggs/cm² (Dipsastraea sp.). We found a significant inverse relationship between egg size and fecundity at the intra-specific level (Slope -0.058; 95% CI: -0.081 to -0.035), such that for each 1% increase in fecundity, offspring size decreased by about 0.06%. Although our results support the trade-off between egg size and fecundity for corals at the intra-specific level, they were not significant at the inter-specific level, which might imply that some intrinsic factors that were not included in our analysis are controlling this trade-off among species (e.g. tissue thickness, polyp size). More data is necessary at global scales to obtain estimates of how both intrinsic (e.g. phylogeny, reproductive mode) and extrinsic factors (e.g. temperature, nutrients) influence both coral energy budgets and the balance in maternal investment, and how these vary over biogeographical scales.
Nicholas Hammerman

Biography: Nicholas is a PhD candidate at the UQ within the School of Biological Sciences. His research focuses on paleoecology of reefs within the Saudi Arabian, Red Sea and within Moreton Bay, Southeast Queensland. He employs well-resolved paleoecological techniques such as sediment cores, comparisons of life and death assemblages and highly precise U-series dating to understand reef resilience, possible shifts in dominate coral taxa and ecosystem collapse. By understanding the local history of coral communities following disturbance events, their results provide important clues to identify and predict which regions have the capacity to become climate refugia, remain resilient or are vulnerable to ecosystem collapse in the future. To date, he has developed a wide range of skills during his graduate career and has resulted in nine peer-reviewed journal articles.

The response of Red Sea coral communities to recent disturbance events vary along a latitudinal gradient

Nicholas M. Hammerman1*, Alberto Rodriguez-Ramirez1, Timothy L. Staples1, Thomas M. DeCarlo2, Vincent Saderne2, George Roff1,4, Nicole Leonard1, Jian-xin Zhao1, Susann Rossbach2, Michelle N. Havlik2, Carlos M. Duarte2 & John M. Pandolfi1,4

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Abstract: Coral reefs are experiencing a dramatic loss of hard coral abundance and associated habitat structure from a myriad of local and global factors. The relative contribution of local versus global drivers of ecological change on living reefs is often difficult to distinguish; however, comparison of the living and dead coral constituents on a reef can elucidate the timing, extent and, potentially, the causes of past ecological changes in benthic composition. Here, we investigated recent historical mortality events and ecological trajectories from the eastern margin of the Red Sea, utilizing U-Th radiometric age dating and paleoecological comparisons of coral live and death assemblages. We examined four regions along a latitudinal gradient (Yanbu, 24°N; Thuwal, 22°N; Al-Lith, 19°N; Farasan Banks, 18°N) that experienced recent coral mortality and exhibited different ecological trajectories. In all four regions, we obtained U-Th radiometric age-dates of in situ dead Acropora and Pocillopora colonies during the early 21st century, synchronous with previously reported bleaching events in 2010 and 2015 and, at one site (Farasan Banks), an outbreak of crown-of-thorns starfish (COTS) in 2009. The most northern site, Yanbu, represents a resilient and recovering region, with the highest proportion of live coral (42 ± 4%) and the highest relative abundance of Acropora. Thuwal and Al-Lith appear to be transitioning from an Acropora dominant seascape to one with a high abundance of Porites, Pocillopora and Goniastrea. The southernmost survey site, Farasan Banks, underwent a dramatic change in coral benthic structure as a result of previous bleaching events and COTS outbreaks and had the lowest proportion of coral (6 ± 2%), comprised mostly of massive Porites, and no live Acropora or Pocillopora. Regional differences in the ability for reefs to recover from acute disturbances vs experience a change in benthic structure or coral composition are likely driven by both evolutionary adaptations of northern coral populations to cope with thermal stress and the strong latitudinal gradients of temperature, salinity and nutrients within the Red Sea. Whereas reefs in the northern Red Sea may offer corals a refugia from future ocean warming, our results highlight the increased vulnerability of central and, particularly, southern Red Sea coral reefs, with the latter already undergoing apparent ecosystem collapse.

https://www.coralcoe.org.au/
Kelly Hannan

Biography: Currently, Kelly is working on her PhD, supervised by A/Prof. Jodie Rummer and Prof. Munday, examining the effects of ocean acidification on reef fish performance and oxygen transport.

Exposure to elevated carbon dioxide affects the cardiac performance of cobia, *Rachycentron canadum*

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Abstract: Increasing CO₂ due to anthropogenic factors has been decreasing the pH of the oceans at an unprecedented rate. Counterintuitively, teleost fishes typically maintain or even increase aerobic performance under elevated partial pressures of CO₂ (pCO₂). This maintained success has often been attributed to their unique oxygen transport system (Root effect); however, few studies have experimentally investigated alternative mechanisms underpinning maintained performance during exposure to elevated pCO₂. To address this, we simultaneously examine cardiac and swimming performance during chronic exposure to elevated pCO₂ in a pelagic teleost. Cobia (*Rachycentron canadum*) were either exposed to elevated (~1,200 µatm) or ambient pCO₂ for three weeks. After the exposure, cardiac performance, oxygen uptake, and swimming performance were measured simultaneously. From resting to critical swimming speeds, cobia increased cardiac output, via increases in heart rate, by ~20%. However, high pCO₂ exposed cobia regardless of swimming speed had cardiac output ~30% higher than ambient pCO₂ exposed fish, throughout the swimming trial. This suggests that elevated pCO₂ had a greater effect on the cardiac performance of cobia than the swimming challenge, and illustrates a clear cardiac compensatory effort in CO₂-exposed cobia that allows them to maintain swimming performance. This study demonstrates that, though fish are often able to maintain swimming and/or aerobic performance under elevated pCO₂ conditions there may be unmeasured physiological trade-offs associated with this, such as the extra work required by the heart, as found here. From an ecological perspective, important questions arise regarding energy balance/trade-offs that may be required under future climate change scenarios.
Kynan Hartog-Burnett

Biography: Ky completed a Bachelor of Science – Advanced majoring in Marine Biology at JCU in 2014, before joining the Reef and Ocean Ecology laboratory and completing a first class Honours in 2015. His work has focused on tropical clupeiforms over a range of spatial scales. With extensive field experience and a developing molecular tool box, Ky aims to highlight the importance of an understudied but important group of fishes on coral reefs. Ky is a Student Representative on the ASFB Executive Council and is a tenured life member of the JCU Dive Club Committee of Management.

Sprats are reef fish, not vagrant pelagic fish

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Abstract: Marine clupeiformes are a cosmopolitan group that is generally assumed to have pelagic ecologies. These fishes make a major contribution to total fisheries catches of the world. Further, they are predicted to have increasing importance as species higher up food chains are fished out. In this study, we present data that the spatial ecology and seascape genetics of tropical clupeiformes of the Genus Spratelloides equate with other reef fish. In temperate regions clupeiformes form large homogenous stocks that are poorly differentiated and of a pelagic nature. It appears that in tropical regions this understudied group of fishes may not follow the paradigms of these related clupeiforms. Individuals of the species Spratelloides delicatulus found on the Great Barrier Reef are very short-lived compared to related species from other regions. Fish mature at very small sizes (~24mm SL) and rapidly develop with a size maximum of 90mm (SL) and an age maxima of just 160 days. Adults and juveniles have a close association with reefs and facilitated by demersal spawning and high abundance of larvae in shallow back reef lagoons. These patterns of abundance and high reef fidelity appear responsible for seascape genetics more akin to those of site attached reef fishes. Analyses of genetic markers of Spratelloides delicatulus suggests that the geomorphology of reefs, especially large and enclosed lagoons may be sustaining genetic variation. The close reef association appears to be acting as a driver for incipient speciation at the scale of the Great Barrier Reef and indicates that tropical clupeiforms should be managed as a reef fish instead of the homogenous pelagic stocks typical of Northern hemisphere taxa.
Lucy Holmes McHugh

Biography: Lucy is a political scientist from the remote desert town of Alice Springs. She has a Bachelor of Economics and Social Sciences from Sydney University, a Masters in Politics and Public Policy from Macquarie University and a Masters of Development Practice from JCU. Prior to starting her PhD, she lived in Indonesia, working at the Centre for International Forestry Research in science communications. Her PhD draws together her interests in conservation governance, public policy and communications.

Framing climate risk and crisis in World Heritage governance (and beyond)

Lucy Holmes McHugh¹

¹ ARC Centre of Excellence for Coral Reef Studies, James Cook University

Abstract: Climate change and ongoing pressures of resource extraction, infrastructure development, and unsustainable tourism increasingly threaten conservation and biodiversity of marine World Heritage sites, such as the Great Barrier Reef. The cornerstone international organisation for conservation, UNESCO’s World Heritage program, is designed to monitor such threats to World Heritage sites and to mobilise global attention and government action, through the 'In Danger' listing.

Yet, key actors within the World Heritage system often invoke different definitions of risk and crisis to shape what the 'threats' are, and what the solutions should be. These processes affect whether sites are placed on the ‘In Danger’ list, or are able to avoid the contentious listing.

Differing notions of risk and crisis can be scientifically problematic and call into question the integrity, legitimacy, and conservation impact of the World Heritage system. Definitions of risk and crisis tend to reflect different political and institutional constraints for the actors concerned. On the ground, ecosystem management authorities frame conservation risks and crises within their own political context, organisational mandate, and resource concerns. At the global level, powerful countries and dominant alliances can work to redefine risks and crises, in ways that potentially weaken conservation outcomes.

Focusing specifically on the issue of climate change, I draw key lessons from risk and crisis literature to understand how climate change framing may impact policy and governance. I contend the ‘climate emergency’ represents a new phase in climate change framing that has sparked much debate about how it will affect climate action. As yet, we know little about the impacts such an emergency framing could have for conservation. I discuss what opportunities and challenges this new framing may bring.

Finally, a risk and crisis research agenda is critical to uncovering how we can strengthen institutions and reporting in World Heritage and other multiscale conservation regimes. A more systematic understanding of conservation risk and crisis can also help us better navigate the critical intersection of climate change, sustainable development, and coral reef conservation.
Tania Kenyon

Biography: Tania Kenyon began her PhD at the University of Queensland in 2016, after several years of experience working in environmental impact assessment. She was also an ambassador coordinator and community educator for Reef Check Australia from 2015, continuing in this role until 2019. Tania’s PhD focuses on the recovery of rubble beds on coral reefs following disturbances including storms, trampling and dynamite fishing. She has collected experimental and observational data, from the field in the Maldives, and using a wave flume. Using this data, Tania seeks to describe the rates at which rubble beds can become consolidated by encrusting and binding organisms; how frequently rubble is mobilised on coral reefs; and how coral recruitment is affected by rubble mobilisation.

Turning rubble to reef: Assessing rubble mobilisation and binding dynamics to predict recovery potential of disturbed reefs

Tania M. Kenyon¹, Dr Christopher Doropoulos², Assoc Prof Sophie Dove³, Dr Daniel Harris⁴, Prof Gregory E. Webb⁵, Dr Steven P. Newman⁶, Prof Tom Baldock⁷, Dr David Callaghan⁸ and Prof Peter J. Mumby⁹.

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Abstract: Production of rubble on coral reefs is increasing due to more frequent and severe disturbance events including mass coral bleaching, cyclones, ship groundings and blast fishing. The recovery of rubble fields is constrained by physical and biological processes, particularly those associated with rubble mobilisation and binding, of which we have a limited understanding. Rubble that has been consolidated by rubble-binding organisms – including sponges, ascidians and coralline algae – has the potential to provide a solid substrate for coral recruitment. Conversely, the hydrodynamic mobilisation of unstable rubble can inhibit binding and increase the mortality of new coral recruits, potentially limiting recovery and shifting the reef to a rubble-dominated system.

We identified the hydrodynamic thresholds for rubble mobilisation based on rubble characteristics in-situ, on highly degraded reefs in the Maldives, and under controlled hydrodynamic conditions in a wave flume. The threshold velocity at which 50% of rubble pieces moved at least 1 cm, was higher in the field (0.32 m/s) compared to the flume (0.25 m/s). Mobilisation was exacerbated as rubble length and complexity decreased, while rubble interlocking inhibited mobilisation up to 0.42 m/s. Experimental manipulations were used to test the effects of smothering and abrasion, as proxies for rubble mobilisation frequency, on coral fragments. Smothering caused 100% mortality on sand and 0-11% mortality on rubble, depending on species. When rubble was abraded every 2-3 days, even robust coral species such as Porites rus suffered reduced growth and increased partial mortality (30%). Rubble binding experiments indicated that 87% of stabilised rubble pieces were strongly bound, primarily by sponges and colonial ascidians, 6 months after deployment. Binding rates were generally higher at shallow than deep depths, but were reduced in exposed sites.

As reefs are exposed to increasing rates of coral rubble production, management agencies and policy makers require the most up-to-date information on the ecological processes driving coral recovery in degraded, rubble-dominated reefs. Using this information, at-risk reefs can be identified and prioritised for management strategies including the implementation of active measures (e.g., rubble stabilisation) if necessary.
Jennifer McWhorter

Biography: Jennifer McWhorter’s joint PhD between the Universities of Queensland and Exeter (QUEX) explores a unique methodology for improving climate projections on coral reef environments. She began her PhD following 8 years of experience in marine spatial planning, ocean observations, and marine policy, most recently from the Scripps Institution of Oceanography, University of California, San Diego. Commonly seen in the literature, downscaling General Circulation Models over coral reef environments tend to lack important coastal complexities for climate projections. Jennifer has been developing a unique method using a vertical 1-D physical-biogeochemical model to drive various 21st century climate change projections over the Great Barrier Reef (GBR). By calculating many 1-D individual profiles, the model accounts for key drivers of vertical mixing using local bathymetry, tides, and atmospheric inputs then outputting various water column properties such as surface and bottom temperature, and photosynthetically active radiation (PAR). These projections provide a more detailed analysis of the frequency and severity of warming events into the future while using relatively simple computing.

Climate policy implications for coral reef futures on the Great Barrier Reef

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Abstract: As the climate continues to warm, more frequent marine heatwaves threaten coral reef ecosystems. Climate models have been used to generate projections of marine heatwaves under various CO2 emission scenarios, however, previous downscaling methods of climate models over coral reefs often lack details in coastal areas. Applying a new downscaling method to the Great Barrier Reef, our results indicate in the ‘business as usual’ climate scenario, the average frequency of coral mortality events diverges exponentially from the low end scenario around 2040, rapidly increasing in magnitude and severity to approximately seven events per decade by 2050. In the best case climate scenario of 1.9 W/m², the frequency of events leading to coral mortality is estimated to slightly rise but, remain similar to current warming trends of approximately three events per decade. In addition to these temporal trends, certain regional patterns indicate noticeably cooler areas acting as a potential refuge. Our downscaling approach transfers atmospheric inputs using tides and local bathymetry into a 1-D vertical heat transport model over any coastal environment globally at any given resolution. This model was used to downscale three climate emission scenarios from five models using the most recent phase (phase 6) of the Climate Model Intercomparison Project (CMIP6), including the new global target limiting warming to 1.9 W/m². Our projections provide scientific indications of when climate emission policies need to occur in the perspective of coral reef vitality.
Cristina Ruano-Chamorro

Biography: Cristina was trained in biology, marine resource management, and conservation studies. Her research interests cover marine conservation, environmental management, small-scale fisheries, and environmental justice, and she draws on disciplines from natural and social sciences to conduct her research. Most of her work has been focused on coastal marine systems and small-scale fisheries management in Chile, where she did her master thesis and worked as a research assistant at the Pontificia Universidad Catolica de Chile. Currently, she is a Ph.D. candidate at the ARC Centre of Excellence for Coral Reef Studies. Her project focuses on understanding what fishers’ perceptions of equality and equity are, what the drivers of these perceptions are, and how these perceptions influence management and conservation outcomes.

Social inequalities in the co-management of coral reefs: the winners and losers.

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Abstract: Co-management is considered one of the most successful management strategies in fostering the sustainability of fisheries in terms of biological, social, and economic benefits. Co-management refers to collaborative management arrangements involving direct users, governments, and other actors. Yet, co-management can exacerbate existing social inequalities if these benefits are unevenly distributed, resulting in detrimental effects on people’s wellbeing and co-management effectiveness. Here, we surveyed 790 resource users in 43 coral reef co-management arrangements across five countries to examine the livelihood benefits that resource users report from co-management, identifying inequalities as departures (either losses or gains) from those of the wider community. We then evaluate how social and institutional factors contribute to aspects of subjective and objective inequality in the distribution of co-management benefits. We find that inequality is driven by both contextual conditions (e.g., distance to market, population, and wealth) and institutional design (involvement in decision-making, graduated sanctions, clear boundaries, and the rules in use). This study contributes to improving our understanding of what are the conditions that create social inequality in coral reef co-management systems, which may have potential implications for environmental justice, human wellbeing, and ecological success.
Netramani Sagar

Biography: Netra joined the Coral Reef group at the University of Western Australia (UWA) as a PhD candidate in 2017. His research aims to reconstruct anthropogenic signals on the Indian Ocean margins, using geochemistry of scleractinian corals and larger foraminifera. His principal supervisors are Prof. Malcolm McCulloch, Dr. Aleksey Sadekov, and Associate Prof. Matt Kilburn. Netra has completed his Master’s degree in Applied Geology from the Indian Institute of Technology Roorkee, India. Before joining UWA, Netra was working as a Scientist in the Geochronology and Isotope studies division with the Council of Scientific and Industrial Research-National Geophysical Research Institute (CSIR-NGRI), Hyderabad, India.

Geochemistry of large benthic foraminifera *Amphisorous hemprichii* as a new high-resolution proxy for lead pollution in coastal environments

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Abstract: Anthropogenic lead (Pb) contamination resulting from the rapid growth of industrialisation in coastal environments poses significant challenges. In this study, we report a novel approach of utilising the large benthic foraminifera *Amphisorous hemprichii* as a biogeochemical archive for monitoring Pb pollution in tropical to warm temperate coastal waters. Live juvenile specimens of *A. hemprichii* were cultured in the laboratory for 16 weeks with a range of seawater Pb concentrations. Lead uptake in both newly grown and pre-existing chambers of individual specimens was characterised using the microanalytical technique, Laser ablation-ICP mass spectrometry. We found that Pb concentration in foraminiferal shells cultured in the laboratory is proportional to seawater [Pb] with the lead partition coefficient ($K_{DPb}$) of 2.61±0.2. This calibration together with a new biomineralisation model now enables *A. hemprichii* to be utilised as a naturally occurring archive to quantitatively monitor current and reconstruct past anthropogenic Pb pollution in coastal waters.
Biography: Jodi is a PhD candidate at James Cook University, Australia, supervised by Prof. Philip Munday and Dr. Sue-Ann Watson. She is investigating the neurobiological mechanisms through which elevated CO₂ affects marine invertebrate behaviours, focusing on squid. Jodi completed her Bachelor of Science (Honours) in Neuroscience at the University of Otago, New Zealand. Her honours project, and following work as a research assistant, focused on the neuroendocrine regulatory and molecular mechanisms underlying female-to-male sex change in sequentially hermaphroditic fish. Jodi is interested in the intersection of neuroscience and zoology, and the role of the brain in behaviour and phenotypic plasticity.

The neurobiological mechanisms underlying cephalopod behavioural change at elevated CO₂ levels

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Abstract: Carbon dioxide (CO₂) levels predicted to occur in the ocean by the end of this century can alter marine animal behaviour. In marine invertebrates, a mechanistic understanding of these behavioural changes is lacking. The prominent mechanistic hypothesis, the GABA hypothesis, was proposed in fish and suggests altered functioning of the gamma-aminobutyric acid type A receptor (GABA₂R) is responsible for altered behaviour at high CO₂. We pharmacologically assessed the GABA hypothesis in a cephalopod, the two-toned pygmy squid [Idiosepius pygmaeus](https://www.coralcoe.org.au/). Adult squid were exposed for 7 days to current-day and predicted end-of-century CO₂ conditions. Their behaviour was then tested after treatment with one of the GABA₂ receptor antagonists, gabazine or picrotoxin, or a sham treatment. If altered GABA₂R functioning is responsible for behavioural changes at elevated CO₂, GABA₂R antagonist administration is expected to reverse elevated CO₂-induced behavioural alterations. Elevated CO₂ was found to alter aggressive and exploratory behaviours, and activity levels of the squid. Gabazine and picrotoxin had an overall significant effect on some measures of squid behaviour, suggesting the concentration administered was adequate to antagonise GABA₂Rs. Both drugs partially reversed the effect of elevated CO₂ on some exploratory behavioural measures. However, neither drug reversed the effects of elevated CO₂ on aggressive behaviours or activity levels. Thus, altered GABA₂R functioning is likely involved in some but not other behavioural alterations observed at elevated CO₂ in this species. A mechanistic understanding of behavioural change at high CO₂ will help us to predict which marine invertebrates are likely to be the most vulnerable to rising CO₂ levels.
Laura Velasquez Jimenez

**Biography:** Laura was born in Bogota, Colombia where she completed her undergraduate degree in ecology in 2013. In 2016, Laura moved to Australia to do a Master of Marine Biology and Ecology at JCU. For her minor project, under the supervision of Mark McCormick and Maria del Mar Palacios, Laura evaluated the effect of mesopredator release on the behaviour of *Pseudochromis fuscus*.

Laura is currently completing a PhD under the supervision of Geoffrey Jones (JCU), Jennifer Donelson (JCU), Sophie Nedelec (University of Exeter) and Mark McCormick. The aim of her research is to examine the effect of anthropogenic noise on the behaviour and physiology of coral reef fish and evaluate their potential for habituation.

**Carryover effects of boat noise on the escape response of a coral reef fish**

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**Abstract:** Anthropogenic noise is increasing in marine environments as a result of human activities. The recent recognition of this stressor as a pollutant highlights the necessity of conducting research in order to provide governmental institutions with information for its management and regulation. Noise from recreational boats has been found to affect the anti-predator behaviour of fish, potentially increasing their vulnerability to predators. However, it is unknown whether these effects remain after the noise source moves away or is removed, or whether exposure of parents to noise affects their offspring. The aim of the present study was to investigate the carryover effects of boat noise on the escape response of a juvenile reef fish. We exposed breeding pairs of spiny damselfish, *Acanthochromis polyacanthus*, to ambient reef sound or boat noise playback. Clutches from these breeding pairs were divided into tanks and maintained in ambient reef sound or boat noise playbacks and reared for a further 41 days. Posteriorly, individuals were tested for their escape response in the absence of noise. Our results showed that there was an effect of parental exposure to boat noise on the escape response of a juvenile reef fish. We exposed breeding pairs of spiny damselfish, *Acanthochromis polyacanthus*, to ambient reef sound or boat noise playback. Clutches from these breeding pairs were divided into tanks and maintained in ambient reef sound or boat noise playbacks and reared for a further 41 days. Posteriorly, individuals were tested for their escape response in the absence of noise. Our results showed that there was an effect of parental exposure to boat noise on offspring, however this was only manifested when the juveniles were also exposed to boat noise. Juveniles in the boat * boat (parent-juvenile) treatment were less likely to respond and when respondent were more likely to turn towards the simulated predator strike. Individuals in the boat * ambient and the ambient * boat noise treatments did not show lasting effects of boat noise exposure, suggesting that carryover effects were the cumulative result of parental or embryological effects and long-term exposure after hatching. Our results show that long-term effects of boat noise exist when exposure is consistent, but if either the juveniles or the parents experience a break from boat noise the negative effects are lost.
Biography: Carolyn is a co-tutelle PhD student between the School for the Environment at the University of Massachusetts Boston and the ARC Centre of Excellence for Coral Reef Studies at James Cook University. Carolyn spent the first half of her PhD working with the Anderson Cabot Center for Ocean Life at the New England Aquarium in Boston studying the effects of temperature on development and physiological performance of epaulette shark embryos and hatchlings. She then received a graduate fellowship through the American Australian Association to continue her research at JCU assessing the impacts of thermal stress on reproduction in adult epaulette sharks.

Epaulette sharks as an indicator species for climate change: Current knowledge and future directions

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Abstract: Elasmobranchs (sharks, rays, and skates) play a key role in structuring marine ecosystems and indirectly protect habitat and food security for humans. For most of these species, we do not know if and through which mechanisms they can survive impending climate change stressors like ocean warming and acidification. Furthermore, roughly 40% of all elasmobranchs are oviparous, meaning that embryos undergo part of their development within an egg case on the ocean floor where they are restricted to and potentially vulnerable to the surrounding environmental conditions. The epaulette shark (Hemiscyllium ocellatum), a small oviparous shark endemic to the Great Barrier Reef, has been the focus of many climate change related laboratory studies by our research group because this species thrives in captivity and is considered of least concern by the International Union for the Conservation of Nature (IUCN). Additionally, this shark species is considered resilient to abiotic conditions, such as elevated carbon dioxide (CO2) and hypoxia (low oxygen, O2), and we propose this shark could serve as a conservative indicator species for elasmobranchs that are more sensitive to environmental change or logistically difficult to study. In other words, if epaulette sharks cannot cope with future climate change conditions, how will less-tolerant elasmobranch species fare? Here, we synthesize six years of findings to outline our current knowledge base and discuss key studies that are in progress. Broadly, ocean acidification conditions – alone – do not dramatically impact growth and development in embryos or neonates or physiological performance and foraging behaviours in adults. This species is also noted as the most hypoxia-tolerant elasmobranch studied to date. However, ocean warming scenarios (i.e., temperatures in the tropics at or exceeding 31°C) heavily impact growth, development, and physiological performance in this species. Today, our research aims to the effects of chronic thermal stress on the reproductive biology and endocrinology of adult epaulette sharks. Overall, we recommend epaulette sharks as a physiological indicator species for the ~400 species of oviparous elasmobranchs, particularly those native to tropical regions. Outcomes will prove important toward conservation and management efforts, where the degree of sensitivity to climate change is key for vulnerability assessments.