REEF ENCOUNTER

The news magazine of the International Coral Reef Society

ICRS International Coral Reef Society

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Reef Encounter is the Magazine Style Newsletter of the International Coral Reef Society. It was first published in 1983. Following a short break in production it was re-launched in electronic (pdf) form. Contributions are welcome, especially from members.

INTERNATIONAL CORAL REEF SOCIETY
The International Coral Reef Society was founded (as the International Society for Reef Studies) in 1980, at a meeting in Cambridge, UK. Its mission is to promote the acquisition and dissemination of scientific knowledge to secure coral reefs for future generations.

CORAL REEFS - THE JOURNAL
The International Coral Reef Society also publishes through Springer its premier scientific journal entitled "*CORAL REEFS*". The Journal publishes high quality scientific papers concerning the broad range of fields relevant to both modern and ancient reefs. For further details, including the list of editors see here.

ABOUT THE COVER | Diver on a reef slope at Tubbataha, Philippines. Photo by Sheree Maris. See the article on page 32 by Alan White.

OFFICERS' REPORTS

SOCIETY ANOUNCEMENTS

UPCOMING CONFERENCES

REEF PERSPECTIVES

Statement by the Society's Officers

The Coral Reef Crisis, Evidence-based Science and Inclusivity

Our commitment to evidence-based science on climate change and the coral reefs crisis

Science should form the foundation of effective policies and decision-making, shaping actions aimed at protecting biodiversity, public health, and the global economy. The integrity of scientific research, through sustained funding, objective communication of findings, transparent inquiry, and support for climate science, underpins our collective capacity to address the environmental challenges of today and the future.

Climate change is the greatest threat to coral reefs today. The impacts of a changing climate, including rising ocean temperatures, ocean acidification, sea level rise, and extreme weather events, are causing significant harm to coral reefs worldwide, as well as to the communities that rely upon them. Without coordinated global action, evidence suggests that up to 90% of the world's coral reefs could disappear by mid-century.

The repercussions of climate change extend beyond the marine environment, affecting coastal communities, food security, and local economies. Coral reefs sustain fisheries that support millions of people, provide coastal protection from storms, and generate substantial revenue through tourism. Globally, coral reefs provide human societies with an estimated economic value of nearly US$10 trillion per year.

These potential ecological and economic losses make it imperative that climate policies prioritize emissions reductions, marine protection, and investments in evidence-based solutions. A future in which climate change is disregarded, and science is marginalized, is a future where coral reefs cannot persist. ICRS is therefore committed to championing science as the basis of effective conservation and policy, ensuring that the best available research informs global efforts to protect coral reefs.

We urge governments worldwide to strengthen their commitments to climate action, recognizing that the future of coral reefs, and the millions of people who depend on them, depends on the actions taken today. ICRS will continue to support our membership in advancing coral reef science, conservation, and policy, ensuring that best available scientific knowledge informs the global response to environmental challenges.

Our commitment to diversity

The International Coral Reef Society (ICRS) is a global organization committed to advancing coral reef science and conservation. In reflecting our international community, ICRS values the diversity of perspectives, backgrounds, and experiences that enrich scientific discovery and strengthen our collective ability to address the urgent challenges facing coral reefs worldwide. Our membership spans reef communities around the globe, and we are dedicated to creating inclusive and accessible spaces where all individuals, especially those from historically underrepresented or resource-limited regions, can contribute meaningfully to coral reef research and conservation.

ICRS welcomes and is strengthened by members of all identities, particularly those from developing, resource-constrained nations. We also remain committed to ensuring our conferences, programs, and professional spaces are inclusive and accessible to all, including LGBTQ+ scientists, all races, genders, and those from underrepresented backgrounds. We encourage the full participation of anyone committed to advancing coral reef research and conservation, regardless of social, cultural, or economic barriers. Increasing representation from underrepresented regions and marginalized communities remains a core value of our Society.

We invite our membership to help us identify additional pathways for the Society to support all coral reef practitioners, enabling wider collaboration and stronger representation across the tropics and beyond.

Opportunities Currently Available within ICRS

- The John Ogden Award reflects our commitment to the global coral reef community, offering vital support to scientists, graduate students, postdoctoral fellows, resource managers, and policymakers from developing or low-income countries.
- To further expand participation, ICRS also provides free memberships to individuals with financial need, either through scholarships or special considerations, with a particular focus on those from low-income countries.
- Additionally, ICRS provides scholarships for graduate students and early-career researchers to support their professional development and participation in the ICRS conference
- Mentorship and Belonging Chapter support our first international mentorship program linking scientists across coral reef regions providing opportunities for career development, networking, and knowledge sharing.

Christian R. Voolstra, President
Tracy Ainsworth, Vice President
C. Mark Eakin, Corresponding Secretary
Mariana Rocha de Souza, Recording Secretary
John A. Burt, Treasurer

OFFICERS' REPORTS

PRESIDENT'S MESSAGE

Christian R Voolstra, President ICRS

Dear Colleagues,

At this critical moment for coral reef science, we find ourselves at the intersection of unprecedented environmental challenges and remarkable scientific advances. Our role as researchers, educators, and advocates has never been more vital.

The recent global bleaching events serve as stark reminders of the urgency to act. While political landscapes shift, science remains our strongest tool for informing policy, guiding conservation, and fostering resilience. We must continue to emphasize that reef health is not just an environmental issue but a societal and economic one, affecting millions who depend on these ecosystems. Strengthening partnerships between scientists, local communities, policymakers, and industry leaders is the path forward.

Amid these challenges, there is hope. Advances in reef conservation and restoration are expanding our capacity to protect and regenerate reefs. Integrating machine learning, genomics, and ocean-based climate solutions will enhance our predictive capabilities and intervention strategies. As a society, we must champion open-access data, interdisciplinary collaboration, and equitable research that includes voices from the Global South.

Looking ahead, our commitment to evidence-based advocacy and innovation will define the future of coral reef science. I encourage all members to engage actively—whether through research, outreach, or policy engagement. Together, we can drive the transformative changes necessary to ensure a future for coral reefs and the communities that depend on them.

Thank you for your dedication and commitment. I look forward to our collective efforts in the year ahead.

Christian R Voolstra
President
International Coral Reef Society (ICRS)

TREASURER'S REPORT (2024)

Anderson B. Mayfield, ICRS past-Treasurer

Reaching the end of my final year as ICRS treasurer (2024), I am proud to summarize several notable achievements, before diving into a shameless plea for your continued support. For one, we sponsored four international events in 2024: the European Coral Reef Society (ECRS) meeting (Italy), the 38th International Coral Reef Initiative (ICRI) general meeting (Saudi Arabia), a regional meeting of the ICRS Mexican Chapter, and Reef Futures (also in Mexico). In the latter, our support ($5,000USD) went towards ensuring several early-career researchers from low-middle-income countries (LMIC) could attend. I had the privilege of meeting some of these individuals at the conference venue and can ensure you that they were grateful and benefited immensely from the opportunity (not to mention the fact that they are all working on the climate change "frontlines" and need our collective support now more than ever). At present ICRS can sponsor three events up to $5,000USD each year, as well as upwards of $10,000 per event as part of our new Sustainability Award (https://coralreefs.org/sustainability-award/).

But what about the hundreds of *other* LMIC researchers and practitioners who would have liked to have attended these meetings (and/or others)? ICRS remains dominated by researchers and conservationists from only a handful of "Global North" countries (**Fig. 1**). For the 2026 ICRS meeting to-be-held in New Zealand, it will be critical to foster a more inclusive and representative group of attendees, and I have worked diligently towards this mission. For one, we are receiving more and more donations from our members (thanks!) and even the odd philanthropist; as an all-volunteer society, these go a long way (~$10,000-20,000 in donations/year).

Furthermore, our "green" investment fund has roughly quadrupled in value over the past 4-5 years, and our plan is to use these earnings (~$150,000USD) to support conference attendance for LMIC researchers.

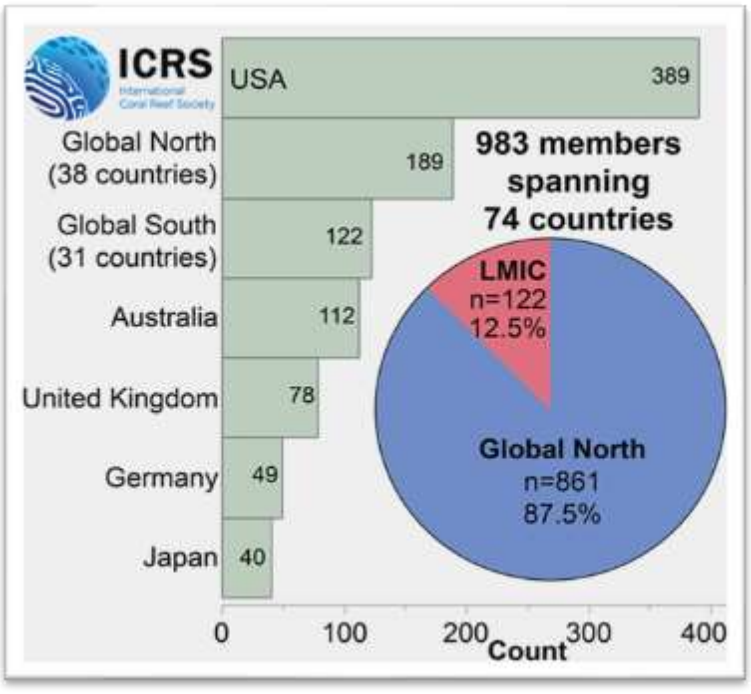

Figure 1. A breakdown of the ICRS membership as of February 2025. Note that the 38 Global North countries exclude those listed elsewhere in the figure (e.g., Australia). LMIC = low-middle-income countries (as defined by the world bank (i.e., "Global South").

While I don't want to belittle this achievement, $150,000USD might result in conference scholarships for only ~50 members, when you consider the costs of attending a week-long international meeting on what may well be the other side of the world (~$3,000USD/person for flights, hotels, food, registration fees, etc.); it's a good start, but it's far from ensuring that the New Zealand meeting in particular will have good representation across all major coral reef regions. Towards this end, even after having ended my four-year term as treasurer, I have been pounding the proverbial pavement with professional fundraisers to try and secure much-needed funds to grow the capacity for successful coral reef research, conservation, and restoration in the Global South. I know the new ICRS treasurer, Dr. John Burt of New York University-Abu Dhabi, is also keen to fundraise for ICRS at a larger scale. If you have ideas on how we can excel at this, please contact Dr. Burt at icrstreasurer@gmail.com or myself at anderson@coralreefdiagnostics.com.

If pulling on your heartstrings by impressing on you the need to make our field more equitable isn't enough, I would like to call your attention like to the pretty reef shown in Fig. 2. Several years ago, we had thought this was one of potentially few reefs on Earth that we needn't worry too much about; not only is it located in the already-warm, salty Red Sea, but it is in the middle of nowhere (halfway between Saudi Arabia and Egypt). But in fact, this reef is now all but dead from repeat bleaching events in 2023 and 2024. We're running out of time, but it's not too late. Your contributions to ICRS, either simply through payment of your membership dues or via donations, are going a long way towards supporting the PEOPLE who are working to halt or even reverse these trends. Moreover we keep our operating costs low by being entirely comprised of volunteers.

Anderson B. Mayfield

Figure 2. My motivation. I used to go diving at this remote reef nearly halfway between Saudi Arabia and Egypt in the Red Sea. Sadly, virtually all corals seen in the left-hand photo (from mid-2024) have now perished on account of coral bleaching events that took place two years in a row.

2024 Society Election Results

Congratulations again to the winners of the ICRS elections whose four-year terms began on 1st January 2025.

The newly elected officers were:

Treasurer - John Burt

Recording Secretary - Mariana Rocha De Souza

The new Council Members are:

Amy Apprill,

Keisha Bahr

Ranjeet Bhagooli

Javier del Campo

Simon Harding

Maggie Johnson

Karen Neely

Alma Paola Rodriguez-Troncoso

We would like to take the opportunity to thank the outgoing Officers and Council members whose terms ended on 31st December 2024. Through their work and dedication, ICRS has made great strides over the past four years:

Treasurer – Anderson Mayfield

Recording Secretary – Anastazia Banaszak

Council Members – Nicole Browne, Luis Eduardo Calderon, Sarah Davies, Ilsa Kuffner, Vikash Munbodhe, Kennedy Osuka, Raquel Peixoto, Nikki Traylor-Knowles

Christian Voolstra, ICRS President

ICRS Signs onto Letter to Support US Science

C. Mark Eakin, Christian R. Voolstra, Tracy Ainsworth, John A. Burt, Mariana Rocha de Souza

I'm sure that all of you are aware of the grave attacks on science in the United States of America and elsewhere that are being executed by the Trump administration. It is a difficult time for science. While such challenges are not unique to the USA, the title to this editorial in Nature rings clear: "Trump 2.0: an assault on science anywhere is an assault on science everywhere"[1].

In February, The International Coral Reef Society was approached by Dr. David Schiffman, whose work on sharks is well-known to many in the coral reef community. Working with the Union of Concerned Scientists, Dr. Shiffman was preparing a letter to call on the US Congress to support science in the United States.

The ICRS officers and councilors voted to sign on in support of the letter[2]. To quote council member James Reimer, "In an ideal world academic societies would be above politics. It is pretty clear we don't live in an ideal world right now."

In addressing the letter (reprinted in part below), the officers and council realized that there is a need to address such issues in other countries as well. In that light, we are discussing a policy to the growing threats to science around the world and how we should approach this as a society. If you have thoughts on the topic, reach out to us at https://coralreefs.org/contact-us/ or icrscoralreefs@gmail.com.

Are you wondering what you can do to help? Lend your voice wherever you can. Contact your government representatives and call to support science. Support science on social media. In many areas there are rallies to show support for science – get out and join them.

> *Dear members of Congress,*
>
> *We, the undersigned professional scientific societies, associations, and organizations, are writing to ask you to take immediate action to protect and restore life-saving and essential scientific research that benefits American families and communities. This scientific research is funded by American taxpayers and authorized by Congress and cannot be unilaterally halted by the executive branch.*
>
> *The nonpartisan organizations signing this letter collectively represent more than 99,000 chemists, geologists, economists, ecologists, engineers, geographers, marine biologists, sociologists, oceanographers, historians of science, and educators. We represent not only*

professional scientists but also technologists, assistants, administrative, service, and custodial staff, without whom scientific research and programs would not be possible. We work in all 50 states, Washington DC, and US territories to lay the foundation for life-saving medical discoveries, clean air and water in our communities, safe and abundant food, healthy ecosystems and wildlife, and thriving local innovation economies.

The actions of this administration have already caused significant harm to American science and are risking the health and safety of our communities. These cuts devastate our ability to conduct important research in the public interest, including finding cures for cancer and ensuring our food and water supplies are safe. Public health experts have been prohibited from sharing important information with the public. Federal scientists have been barred from communicating with international colleagues, preventing critical US input into international conservation and management decisions.

Indiscriminate cuts or pauses to federal science and research agencies are damaging critical research and the nation's economy. Thousands of dedicated public servants have been fired, including early-career scientists who were disproportionately impacted. This jeopardizes the next decade of science and innovation gains, particularly at a time when many senior scientists are retiring. Vital sources of funding have been slashed, including funding that trains the next generation of scientific talent. Because of this, some universities have paused graduate admissions and even rescinded admissions offers. Delays and drastic cuts in federal grant funding will not only negatively impact universities, but also have economic repercussions in the areas surrounding universities. Every dollar invested by the National Science Foundation generates approximately two dollars in economic output in communities surrounding universities, and every dollar invested by the National Institutes of Health generates approximately $2.46.

The suspension of congressionally mandated efforts to broaden participation in science and technology is hampering our ability to produce the next generation of talent essential to our global competitiveness. Essential and cost-effective diversity, equity, inclusion, and accessibility programs provide critical support for training a robust and internationally competitive science workforce, fostering talent that would otherwise be excluded. When the STEM workforce is diverse, so is the knowledge and creativity brought to solving pressing problems. These important efforts have been misconstrued and demonized, and our members from underrepresented minority groups have been unfairly singled out for funding removal and personal harassment.

We ask that Congress take immediate action to:

- *Enforce legislative control over congressionally-approved federal funds*
- *Restore a federal grant expert peer review process that is free from "ideological review," and restore canceled funding streams and grant programs*
- *Allow government scientists to do their important work, including speaking with the public and collaborating with international colleagues*
- *Oppose drastic cuts to workforces at federal scientific research and funding agencies, and oppose drastic cuts to future grants*

- *Protect individual government scientists from being singled out for harassment*
- *Cease attacks on, and restore funding to, diversity, equity, and inclusion efforts in the scientific community*

We are proud of our diverse expertise, disciplines, and perspectives, and we are all united by a common principle: that federally funded scientific research and study is a common public good and should not be politicized, attacked, or frozen. Congress must act now to provide clarity and certainty in this chaotic moment. We stand ready to work with you to provide further information on the importance of scientific research to your state and priorities.

1. Nature Editorial Board, *Trump 2.0: an assault on science anywhere is an assault on science everywhere*, in *Nature*. 2025. p. 7-8.
2. Shiffman, D., *Scientific Societies Call on Congress to Save Science*. 2025.

ICRS Recognized as a UN Ocean Decade Action

Mariana Rocha de Souza
ICRS Recording Secretary
email: mrds@hawaii.edu

The International Coral Reef Society (ICRS) is proud to announce its official endorsement as a UN Ocean Decade Action under the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) - a major global initiative to catalyze transformative ocean science solutions for sustainable development.

What Is the UN Ocean Decade?

The **UN Ocean Decade**, launched by the United Nations in 2021, is a ten-year initiative to mobilize the global scientific community, governments, civil society, and the private sector to **"deliver the science we need for the ocean we want."** Its goal is to reverse the decline in ocean health and ensure that ocean science can fully support sustainable development.

At the heart of the Ocean Decade are **10 interconnected Challenges** that represent the most urgent ocean issues humanity must address. These challenges range from protecting marine ecosystems and reducing pollution, to ensuring sustainable ocean economies and increasing ocean literacy.

What Does It Mean to Be an Endorsed Ocean Decade Action?

Being endorsed as a Decade Action means that ICRS's mission, programs, and impact have been formally recognized as contributing directly to the Ocean Decade's global goals. It signifies that ICRS is part of a select network of institutions and initiatives driving meaningful, science-based change for the future of our ocean.

This endorsement elevates the visibility and credibility of ICRS's work, opening new opportunities for international collaboration, funding, and alignment with other high-impact programs. It also positions ICRS as a leader in the global movement to protect and sustainably manage coral reef ecosystems. This recognition places ICRS among a distinguished network of institutions actively contributing to one or more of the 10 Ocean Decade Challenges. Specifically, ICRS's initiatives directly support:

- **Challenge 2: Protect and restore ecosystems and biodiversity**, through the promotion of coral reef science and conservation.
- **Challenge 4: Develop a sustainable and equitable ocean economy**, by empowering professionals in reef-dependent regions.
- **Challenge 7: Expand the global ocean observing system**, by enabling research in underrepresented reef systems.
- **Challenge 9: Ensure a sustainable ocean observing workforce**, through capacity building for early-career ocean professionals.
- **Challenge 10: Change humanity's relationship with the ocean**, by supporting science communication and community engagement.

ICRS's Contribution to the Ocean Decade

ICRS is uniquely positioned to advance the Ocean Decade's mission by supporting coral reef science, capacity building, and equitable access to resources. ICRS's work focuses particularly on empowering early-career ocean professionals - especially those from developing countries and island nations - through:

The ten Ocean Decade challenges

- Fieldwork and laboratory visit grants to support hands-on coral reef research;
- The Science Communication Fellowship, enhancing researchers' ability to share their work with diverse audiences;
- Student Travel Grants to attend the International Coral Reef Symposia and engage in global knowledge exchange;
- Targeted support for scientists, managers, and policymakers from under-resourced regions, ensuring inclusivity and diverse representation in coral reef decision-making.

These initiatives help cultivate a new generation of coral reef experts equipped to address the complex, interconnected challenges facing reef systems and coastal communities today.

A Shared Commitment to Ocean Sustainability

This recognition marks a major milestone for ICRS and the broader coral reef science community. As an endorsed UN Ocean Decade Action, ICRS reaffirms its commitment to advancing ocean knowledge, supporting underrepresented voices, and driving forward innovative, science-based solutions to ensure thriving coral reefs for generations to come.

We are honored to be part of this global movement and look forward to contributing to a healthier, more sustainable ocean future.

To learn more about the UN Ocean Decade and ICRS's endorsed programs, please visit https://oceandecade.org/actions/international-coral-reef-society-icrs/

XIIIth Mexican and IVth Pan-American Coral Reef Congress

The Autonomous University of Quintana Roo and the Mexican Coral Reef Society (SOMAC) invite you to participate in the 13th Mexican (CMAC) and 4th Pan-American Coral Reef Congress, being held at the University's campus, on the beautiful Caribbean Island of Cozumel, from 13th to 17th October, 2025.

Cozumel Island is located off the east coast of the Yucatán Peninsula and is part of the Mesoamerican reef system. It is a UNESCO Biosphere Reserve that incorporates seven protected areas. Given its scenic beauty and biological diversity, marine tourism has become the main driver of the island's economy and the University's facilities a hub for coral reef research and management.

The Congress will be a platform for sharing integrative solutions to the anthropogenic pressures that coral reefs now face. It will address reef related topics including their conservation, restoration, protection and sustainable use. Student participation is being prioritized and the congress will offer scholarships to assist attendance and prizes for the best student presentations and posters.

Key dates are:

Deadline for submission of abstracts	31st May 2025
Notice of acceptance of submissions	25th July 2025
Early-bird registration rates until	15th August 2025

Registration rates range from 2000 pesos (~ US$ 100) to 5700 Pesos (~US$ 280), being lower for students and for members of SOMAC.

Two airlines run direct flights from Mexico City to Cozumel. Alternatively, there are reliable bus services to the town of Playa del Carmen, from where there are frequent ferries to the island. The recommended agency for securing accommodation as well as for travel is Caribbean Tours Cozumel (Manager Enrique Sauri, cellphone: (52) 987 87 243 18, email esuri007@gmail.com).

For more details please see the conference website at:
https://somac.org.mx/xiii-congreso-mexicano-de-arrecifes-coralinos-y-iv-congreso-panamericano-de-arrecifes-coralinos-2/

International Coral Reef Symposium

19-24 July 2026 • Auckland New Zealand

Working together to ensure a future for coral reefs

Upcoming key dates

www.icrs2026.nz

International Coral Reef Symposium

19-24 July 2026 • Auckland New Zealand

Working together to ensure a future for coral reefs

Call for sessions - *opening April 2025*

Registration - *opening July 2025*

Call for abstracts - *opening August 2025*

Check out the ICRS website for more information

Introducing our Plenary Speakers

Coral reef monitoring and assessment at scale
Dr Greg Asner, ASU Center for Global Discovery and Conservation Science, Hawaii

Traditional knowledge and management
Dr Tamatoa Bambridge, CRIOBE, French Polynesia

Modelling the trajectories of future reefs
Prof Julia Baum, University of Victoria, Canada

Socio-ecological feedbacks:reef value, use, and stewardship
Prof Christina Hicks, University of Lancaster, UK

Indigenous knowledge and science
Dr Dan Hikuroa, University of Auckland, New Zealand

Historical perspectives on coral ecosystems
Prof Paul Kench, National University of Singapore

Coral reef ecology and connectivity
Prof Cynthia Riginos, Australian Institute of Marine Science/University of Queensland, Australia

Innovations in reef conservation and intervention
Prof David Suggett, King Abdullah University of Science & Technology, Saudi Arabia

Cell and molecular biology of coral symbiosis
Prof Virginia Weis, Oregon State University, USA

REEF PERSPECTIVES

The Tipping Point is Behind Us. What do we do now?

Peter Sale

Professor Emeritus
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As I write, COP16, the first global meeting of the Convention on Biological Diversity[1] since 2022, has just ended in disarray (November 1st), while COP29, the 29th UN climate change conference is still moving towards its lackluster finish on November 22nd. In both venues, governments are displaying less than impressive ambition to tackle long evident and growing problems, while being particularly tardy in coming up with mechanisms to generate the financial resources desperately needed if poorer countries are going to be able to cope.

While COP16 agreed on a mechanism to identify ecologically or biologically significant marine areas (EBSAs), the goal of protecting 30% of the planet has stalled and the area of land and water with formal protections for biodiversity has grown only 0.5% since 2020 (New Scientist, 2024). Only 2.8% of the ocean is protected "effectively" (The Guardian, 2024). Never mind the reality of the effectiveness with which such protections are managed. While it is too early to judge the success of COP29 (four days to go), finance is once again a major sticking point, and the news released has confirmed that our emissions of greenhouse gases have yet to plateau and begin to drop. Scientists at the meeting are being blunt about the fact that the 1.5°C goal in the Paris Accord is already beyond reach.

This depressing news will not surprise anyone who has followed global progress on climate or biodiversity, but what should this mean for ICRS or for coral reef scientists and managers around the world? Most trivially it should mean that the statement by IPCC (2018) that "Coral reefs, for example, are projected to decline by a further 70–90% at 1.5°C (*high confidence*) with larger losses (>99%) at 2°C (*very high confidence*)" can now be rewritten as "Coral reefs are projected to decline by a further >99% at 2°C" because 1.5°C is in the rear-view mirror. When one adds the various non-climate pressures on coral reefs, this typically conservative UN estimate surely flips over to virtually certain eradication by the end of this century. The tipping point for coral reefs came some time before nearly all presently active reef scientists and managers began their careers.

[1] On 27 February 2025 COP 16 concluded in Rome with the successful completion of its resumed session. The outcomes of the resumed session completed what the Parties achieved in Cali, Colombia, before COP 16 was suspended on 2 November 2024 for lack of quorum.

The reef science and management community has done a credible job of informing the public and policy makers on the threats to coral reefs worldwide, and the value of the goods and services flourishing coral reefs provide. Coral reefs are highlighted whenever IPCC talks about the ocean, and, more generally, policy makers in the environmental sphere worldwide are now much more aware than they might have been concerning the existential threats faced by coral reefs in the 21st century. Major bleaching events and outbreaks of diseases impacting key reef organisms arguably gain more press coverage than they would without the efforts of our community to alert governments, policy makers and the general public. There is every reason for organizations like ICRS to continue efforts to publicize the plight of coral reefs and the economic, biodiversity and other losses that will emerge as reefs cease to be.

Reefs will continue for some time to provide a rich array of scientific questions to be explored and there is nothing wrong in reef scientists doing what most of us have always done – study reef questions as examples of the wondrousness that is in this universe. There is still room for awe and for novel scientific discoveries in this universe. But, there is also every reason for reef scientists and managers to contribute to society by striving to identify effective ways to sustain or repair coral reefs in a warming world. We need to approach this task with humility, however, knowing that it still is quite likely they cannot be saved, and will degrade to become much simpler, less productive systems.

Reefs will continue for some time to provide a rich array of scientific questions to be explored [...] But, there is also every reason for reef scientists and managers to contribute to society by striving to identify effective ways to **sustain or repair coral reefs in a warming world**.

Believing in our power to engineer our way out of any problem, an unfortunate trait among some of the more technically able amongst us, is likely not helpful in the real world we inhabit, unless it is coupled to a rigorously realistic perspective on the challenges we face. Rather than propagating, cultivating and out-planting of corals likely to succumb to the next episode of bleaching, we would need to truly build a suite of super-coral species that can repopulate the warming benches where reefs used to thrive. And we'd need to do this at scale. When did humanity last create a viable, self-propagating ecosystem of species, and did any of these (I cannot think of one) contain the complexity of relationships that would be needed to replicate the reefs of the past? This will be a very challenging task.

We might do better using assisted migration to move corals (and at least some of the other key reef species) towards geographic regions becoming more favorable for them, if such exist. We'd need to do this carefully, recognizing the risks that introductions of novel species can bring, although a plague of out-of-control corals might even be viewed a good thing.

Alternatively, we could investigate what it is about reefs that provides the high level of coastal protection, and the fishery yield of thriving coral reefs, and seek ways to replicate such protection and food production on the limestone benches that will be left as real coral reefs disappear. These creations might look nothing like the reefs of the past. They could be partly manufactured rather than replicated through biological growth, although the cost of manufacture may require that such ventures remain a niche solution. (Nations will have other costs as storms intensify and sea level rises that relate more immediately to keeping people safe and housed.) Then again, perhaps the most useful thing that could be attempted will be to work with communities in coastal regions of the global south to find new ways to live in the absence of thriving coral reefs. As well as ecological/environmental expertise, this would require expertise in fields not well represented in ICRS, or in what we typically think of as the reef science community, but it is likely

through cross-disciplinary approaches that real progress can be made. Here again, progress is conditional on recognizing that the past cannot be recovered in a human span of time, but surely there will be ecological systems that develop on tropical coasts and human societies that become adept at living within such future ecosystems.

Apart from research and management efforts, it seems to me that the reef science community must continue to speak out to alert the world to what is happening globally. The degradation of coral reefs provides many stories that can capture the imagination as well as clicks on media. What we must strive to achieve is stories that avoid cheap sugar pills of hope in favor of enticing deeper reflection on what it means to be a powerful sentient creature capable of making decisions that modify the future trajectory of this planet.

By sugar pills, I refer to stories like the discovery of 'the world's biggest coral', the invention of a new way of dispersing coral planulae to settlement sites, or a giant survey to document, in further detail, how reefs are failing and where they might be failing more slowly. These are all stories I have seen in the media recently, promoted by reef scientists and/or managers (although likely hyped by the particular outlet), and presented as signs that all may not be as bad as the headlines report. Yet finding a large coral head, scattering planulae by drone, or mounting another global survey to report on the state of reefs do nothing to halt or reverse reef degradation, but lots to divert attention from the existential problem reefs face.

Reef degradation is a slow process, making it difficult to recognize an endpoint when reef attributes and capacities cease to exist. How long will we pretend that functional reefs are still with us because we cannot face the fact that they have gone? Is one small nubbin of coral in the middle of a limestone bench kilometers in extent still a reef?

Nevertheless, stories reporting that reefs are now essentially doomed because of what humanity has done even though it will take a while for their ghosts to drift from view are stories we are well-equipped to tell. And they provide opportunities to reflect on what we can do to replace them, how we can retain the rich diversity they formerly harboured, and how we can create successful ways of living without them, all while reminding ourselves of the foolish hubris and naked greed that have allowed the world to fail for decades to correct fundamentally unwise behavior despite knowing what it would cost. If the loss of coral reefs can be used to wake people up to the need to live within the limits set by the planet, then that loss will not have been in vain.

References

IPCC (2018) Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty,* Eds: Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, et al., Cambridge University Press, Cambridge, pp. 3-24, doi:10.1017/9781009157940.001.

New Scientist (2024) The world is falling far short of its goal to halt biodiversity loss, article by J Dinneen, 28 October 2024. https://www.newscientist.com/article/2453640-the-world-is-falling-far-short-of-its-goal-to-halt-biodiversity-loss/

The Guardian (2024) Cop16: Colombia prepares to host 'decisive' summit on biodiversity, article by L Taylor, 20 October 2024. https://www.theguardian.com/environment/2024/oct/20/cop16-colombia-prepares-to-host-decisive-summit-on-biodiversity

REEF PERSPECTIVES

The Chagos Archipelago: rights and wrongs

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The future of one of the most important coral reef regions on Earth is in the balance, right now. The Chagos Archipelago (recently also known as the British Indian Ocean Territory) lies in the Indian Ocean, 500 km south of the southern end of the Maldives. It is for now one of the largest protected reef ecosystems, notable for being so remote as to have experienced little to no local human impacts. It includes five coral atolls, over 50 uninhabited islands, seamounts, platform reefs and an area of pelagic open ocean the size of France, and as I experienced myself, during research there in the 1990s, probably the least impacted coral reef communities in the whole Indian Ocean. For the last 15 years it has been managed as one of the largest (640,000 km^2) and most effective no-take marine reserves on the planet: effectively closed to almost all visitors, actively patrolled, Chagos has become a critical laboratory for some the best coral reef scientists on the planet, having a major influence on the way we see coral reefs.

David Stoddart, the founding President of ICRS also laid, in the 1960s, the foundations of research on Chagos. The late Charles Sheppard joined, then led, a highly productive series of Chagos expeditions in the 1970, 90s and early 2000s, following which there has, over the last 10-15 years, been a further surge in science conducted there, spearheaded by the Zoological Society of London. Researchers from around the world have been tagging sharks, seabirds, turtles and mantas, studying mesophotic reefs, fish, corals, oceanography, island ecology, and more. One highlight has been the sea-change in our understanding of island reef connections, with the work of Nick Graham and others revealing the nutrient flows and the connections between seabird nesting islands and coral health and resilience. As a marker of its conservation value, Chagos has over 20 rat-free islands teeming with seabirds - the nearby Maldives with 2000 islands has NONE).

All this may change since now the archipelago is about to handed from the UK to Mauritius. The history is complicated. There were no inhabitants when the islands were first mapped by the Portuguese in the 16th century. People were brought in from the mid-18th century to establish and work coconut plantations. The resulting population, the Chagossians, considered “indigenous” by the United Nations, were mostly of African descent. In the 1960s they were forcibly removed by the British to make way for the construction of a huge US military base on Diego Garcia, the largest and most southern of the atolls, that forms an unparalleled natural harbour. While some of the Chagossians moved to Britain, and others to the Seychelles, many were deported to Mauritius, where they received very limited compensation and lived in slums. At around the same time, Mauritius itself became independent.

A typical Chagos island shore – Middle Brother Island. Photo Anne Sheppard

International law caught up with the UK when it was judged that Chagos had been part of Mauritius before its independence from Britain, that the declaration of the MPA had been illegal, and that Britain should therefore pass the archipelago to Mauritius. This was despite the fact that Mauritius lies in the south-west Indian Ocean, over 2000 km away from Chagos, and despite the fact that the great majority of Mauritians are of Indian rather than African descent. In international law, under United Nations resolutions banning the dismemberment of colonial territories before independence, such a matter is decided by the happenstance of where the previous, originally French (until 1815) and subsequently British, local administrations were most conveniently located. The establishment and future of the most important marine protected area in the Indian Ocean were considered, by some lawyers at least, as no more than a cynical excuse for avoidance and delay. So, negotiations about the transfer began some two years ago, and in October 2024 the new UK government announced that it would indeed hand over Chagos to Mauritius under a new treaty.

Bizarrely, however, the Chagossians themselves appear to have been deliberately excluded from these negotiations – indigenous people it appears have no voice in such state-to-state negotiations. Thousands of Chagossians (including descendants) now have British passports and live in the UK. Apart from occasional visits, they have never been allowed home. But many of them regard Mauritius as just another colonial power, perhaps one as blameworthy as the UK, since it has done little if anything to alleviate the indignity and poverty of the Chagossians living there.

Recent negotiations, it seems, have completely prioritised the US need to retain the military base, which will be leased to the US for a further 99 years. Nice words have been shared about the Chagossians and reassurances given about re-establishing the MPA, but there is no way of ensuring either. Environmental considerations, such as there have been, were largely left to some of the scientists who work in Chagos to deal with, even though one would think that people wanting to carry on their research there after a sovereignty transfer are hardly able to negotiate disinterestedly. Despite their original significance human rights negotiations have had no place at all. Even the UK government could apparently manage no more than a few Zoom calls during which all actual Chagossians were held on mute.

Mauritius has a draft plan for the MPA, and held a somewhat showy conference about the matter early 2024; but nothing has happened since. Mauritius has a somewhat disappointing poor environmental track record, likely because it is not wealthy; thus it is hard to see how it will manage to support conservation in a territory so far away. Much has been made of the fear that it will someday have to rely on China, whose government would doubtless be willing to pay handsomely in order to flatten a few more coral reefs into runways and build their military base on one of the other atolls. Others are worried that the temptations of drilling for oil, or of deep-sea mining will prove too strong. Most likely commercial interests from within or without Mauritius will somehow be enabled to sweep up the diverse and unexploited fish stocks of an area much greater than that which Mauritian fisheries can currently exploit.

The Chagossians, it seems, are just flotsam, utterly ignored. They once lived close to this environment, and many still hold it deeply in their hearts and their memories. Their plight seems particularly poignant given that, in October 2024, the international community gave new recognition of the voice of Indigenous Peoples for biodiversity protection under the Convention on Biological Diversity. Surely their rights should be guaranteed, and both young and old Chagossians actively involved in the sustainable management of their homeland.

In recent years the debate over the rights and wrongs of the situation has become highly contentious, even within the UK marine science community. Such differences need to be put aside. It needs to be remembered that two wrongs do not make a right! Instead, we reef scientists and conservationists must do our utmost to influence and support Mauritius in doing the right thing. We need to help drum up the funds for conservation finance, and to support Mauritian marine scientists willing to work there for the MPA's future. But we will also need to be prepared to raise our voices if things start to go wrong!

Chagos biodiversity. From top left, clockwise: Green turtle; Sooty terns; Native woodland; *Acropora* spp.; Hump-headed wrasse and bohar snapper. Photos courtesy of Mark Spalding (chief scientific advisor to the Chagos) who describes the islands as "*surely the most stand-out coral reef wilderness left on Earth*".





Chagos biodiversity. From top left, clockwise: One-spot snapper and (behind) *Porites* coral that forms the foundation of the reef; Coconut crab; *Porites*; Blue-streak fusiliers on the deeper reef slope; High diversity upper reef slope. Photos courtesy of Anne Sheppard.

REEF PERSPECTIVES

Sir Ronald Fisher's "runaway natural selection" for *Acropora*

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Sir Ronald Fisher, British statistician, evolutionary biologist and geneticist (1890–1962)

Consistently greater numbers of offspring should have a relatively strong control in natural selection, and energy and materials for traits that are less influential might be traded for increased reproduction. As the peahen is especially attracted to peacocks with the largest tails, runaway selection led to peacocks increasing the size and splendor of their tails in competition for reproduction, despite the ultra large tails seeming maladaptive by reducing ability to escape predation (Fisher 1930, Zahavi 1975). The *Acanthaster planci* (CoTS) complex has been around for at least one, and maybe up to three, million years (Nishida and Lucas 1988), yet *Acropora* spp. seem to have remained the favorite prey of CoTS, butterflyfishes, and many other corallivores. When observing the devastation CoTS can do to *Acropora* populations (Fig. 1), one wonders why there has been no effective selection for anti-predator traits after one to three million years. This may be what Ronald Fisher (you probably remember that Ronald Fisher developed ANOVA and the genetical theory of natural selection) envisioned as "runaway natural selection", where the selective advantage of increased reproductive output overwhelms the selection for future defense against predators and tolerance of harsh physical environments. Fast growth may be a trade-off with lower production of heat-shock proteins and other complexities of tolerances, predicting that fast-growing corals may bleach sooner than slow-growing corals (which is a testable hypothesis). Increasing fecundity with rapid growth at the cost of greater vulnerability to predation, disease, and physical environmental stresses may be the "peacock's tail" of fast-growing corals.

Natural selection acts in the present. It sometimes appears to fail in predicting the future. When the abiotic and biotic environments are favorable during many generations for a species, natural selection can sometimes reward diverting resources to prolific production rather than cautiously investing for the unknown future. As with *Acropora*, Coley et al. (1985) pointed out for vegetation that when the environment is favorable and resource availability is high, the rates of herbivory are also high, but the rapidly-growing plants have low production of defensive metabolites. There are at least 128 corallivorous species of fishes (Cole et al. 2008) and 314 species of corallivorous invertebrates (Stella et al. 2011). For fishes, the diets of the majority of corallivores have shown "only a small suite of available prey" (Cole et al. 2008) and the fast-growing *Acropora* and *Pocillopora* are the usually preferred prey for both fishes and invertebrate corallivores. The Neogene, and especially the Pleistocene, were the best times for reef- building corals in geologic history (Kleypas et al. 2001). This predicts that fast-growing corals such as *Acropora* would become especially important while investing little in defenses. Pocilloporids *Stylophora* and *Pocillopora* were predominant in the

Caribbean in the Pliocene and most of the Pleistocene (Budd 2000), but during millions of years of good times, natural selection seems to lose caution for future changes.

Lamont C. Cole (1954) explained how reproducing in abundance early is a powerful trait, determining whether a species will be predominant. Having a larger surface area for a colonial coral could mean more polyps and a greater fecundity. Growing fast means a greater potential fitness with greater fecundity earlier. Selection for the benefits of abundant gamete production may reward some corals that invest much of their resources into fast growth and reproduction at the expense of defense and tolerances of physical factors such as unusually warm or turbid waters. Runaway selection may take traits to the extreme, but not to where fitness is lost, although the cost may lead to handicaps (Zahavi 1975). The harm from runaway selection comes when environmental conditions change the rules of the game and the r-selected corals are caught especially unprepared.

Figure 1. Indo-Pacific acroporids have been preyed upon by *Acanthaster* for 1 – 3 million years, yet there has been no evident selection for defense against CoTS or many other types of predators. Has Fisher's "runaway selection" for rapid and prolific reproductive output been realized by trading off defense against predation and by weakened tolerance of physical stresses?

In contrast, when slower-growing massive corals are under stress, they typically shift energy from reproduction to survival. Perhaps they are selected to survive during hard times and reproduce when things get less risky for recruits. One might classify slow-growing corals as K-selected. With heat stress, *Orbicella* may postpone reproduction for 4 years (Levitan et al. 2014). Kojis and Quinn (1984) suggested variation in coral fecundity could be used to monitor environmental stress on corals. But fast-growing corals like *Acropora* seem to trade investment in survival for fast growth and reproduction. We might classify fast-growing corals, such as *Acropora,* which are dominant during good times for reef-building, as r-selected.

Over the past four decades in American Samoa, the relative abundance of fast-growing branching coral genera (e.g., *Acropora* and *Pocillopora*) generally decreased significantly (though see Fig. 2), while some slower-growing massive or encrusting genera (e.g., *Porites* and *Pavona*) increased significantly. There is a pattern of shifting the predominance of fast-growing to slow-growing scleractinians when environmental conditions become more stressful that has been repeated on three scales: geological time, ecological time, and in laboratory simulation experiments.

There have been three periods in geologic history of strong reef growth by scleractinians, and in these periods, fast-growing genera were prevalent. Kleypas et al. (2001) made a good point that the biological and geological performances of coral reefs are largely independent at the ecological scale. But for now, on the geological scale, we assume that during periods in which reef-growth was strong, the environment was good for corals. The first period was in the later Triassic when the fast-growing

phaceloid (the "branching form" of the Triassic) genus *Retiophyllia* prevailed, with at least 34 species and was found all around the tropical world of the time. The second period was the mid-Jurassic when the fast-growing *Thamnasteria* also prevailed around the tropical world with at least 57 species. The third period is the present Neogene, in which it appears that *Acropora* may be a representative of fast-growing, speciose genera. When these periods of strong reef growth by scleractinians came to an end, the predominant fast-growing genera seemed to become dead genera walking, but many of the slow-growing scleractinian genera became relatively more abundant. I hope that *Acropora* does not do badly while slower-growing species do better if conditions get worse for corals in modern times, but our surveys over the past four decades in American Samoa indicate that this pattern in geologic time may be repeating now in ecological time.

It is interesting that the relatively fast-growing, competitively superior, species in species complexes may also be more likely to go extinct than the slower-growing species in the group. In the Caribbean *Orbicella annularis* complex, the organ-pipe *Orbicella* grew in tall thin columns and seemed to displace the other *Orbicella* into deeper waters. When it went extinct, the other slower-growing *Orbicella* species replaced it in shallower water (Pandolfi et al. 2002).

It is predicted by IPCC and many studies that if tropical sea surface temperatures warm by 1.5 ºC to 2 ºC above those in the early 1800s, coral-reef systems will collapse, greatly reducing diversity, and with net calcification changing to net dissolution. However, a recent set of simulation experiments of what will happen under future climate change (Jury et al. 2024) found that: 1) net calcification rates often declined with decrease in the abundance of corals, but nearly always remained positive. Figure 2 in Kiessling (2009) shows that between periods of strong growth of reefs in the Mesozoic and Paleogene, there were still traces of positive net growth by scleractinians as well as by bivalves, CCA, and cyanobacteria. 2) Corals showed reduced abundance, but were never extirpated. Despite prehistoric mass mortalities, a number of important genera of scleractinians are still here. 3) When corals show reduced abundance, the community composition shifts by reducing prevalence of fast-growing corals. In the experiments, fast-growing pocilloporids showed investment into large numbers of recruits, but had relatively poor survival, as might be expected of r-selected genera.

Competition for space has a major influence on coral community structure and we automatically include competition as a default trait acted upon by natural selection. *Acropora* is often categorized as a fast-growing, r-selected, "competitive" coral because of its predominance. It is true that some relatively slow-growing corals (K-selected) are adapted to competition (Lang 1973), but Fisher's runaway natural selection may favor rapid growth in three dimensions for increased fecundity to the extent that *Acropora* may become a superior competitor as a byproduct. With Occam's razor, we might consider that r-selected *Acropora* is a superior competitor because it grows fast, rather than it grows fast as an adaptation to be a superior competitor. Winning in competition has indirect benefits for fecundity, but we should compare the total fecundity provided by fast growth of living cover with the fecundity made possible by winning living cover in competition.

There are a number of genera of slow-growing corals that have been called "Lazarus corals" because they reoccur after mass mortalities (Rosen 2000). Fast-growing corals are sometimes called "Faustian corals" because runaway selection gives them lives of glory and dominance by increased investing in growth by divesting many defenses and tolerances; but when conditions change for the worse, they become victims of their glorious dominance in the past.

Literature cited
Budd AF (2000) Diversity and extinction in the Cenozoic history of Caribbean reefs. Coral Reefs 19: 25-35
Cole AJ, Pratchett MS, Jones GP (2008) Diversity and functional importance of coral-feeding fishes on tropical coral reefs. Fish and Fisheries 9: 1-22
Cole LC (1954) The population consequences of life history phenomena. The Quarterly Review of Biology 29: 103-137
Coley PD, Bryant JP, Chapin FS III (1985) Resource availability and plant antiherbivore defense. Science 230: 895 – 899
Fisher RA (1930) The Genetical Theory of Natural Selection. Clarendon Press, Oxford
Jury CP, Bahr KD, Cros A, Dobson KL, Freel EB, Graham At et al. (2024) Experimental coral reef communities transform yet persist under mitigated future ocean warming and acidification. PNAS 121 (45): e2407112121
Kleypas JA, Buddemeier RW, Gattuso J-P (2001) The future of coral reefs in an age of global change. International Journal of Earth Sciences (Geol Rundsch) 90: 426 – 437
Kojis Quinn (1984) Seasonal and depth variation in fecundity of *Acropora palifera* at two reefs in Papua New Guinea. Coral Reefs 3: 165 - 172
Kiessling W (2009) Geologic and biologic controls on the evolution of reefs. Annual Reviews of Ecology, Evolution, and Systematics 40: 173 - 192
Lang J (1973) Interspecific aggression by scleractinian corals 2, why the race is not only to the swift. Bulletin of Marine Science 23: 260 – 279
Levitan DR, Boudreau W, Jara J, Knowlton N (2014) Long-term reduced spawning in *Orbicella* species due to temperature stress. Marine Ecology Progress Series 515: 1-10
Nishida M, Lucas JS (1988) Genetic differences between geographic populations of the crown-of-thorns starfish throughout the Pacific region. Marine Biology 98: 359 – 368
Pandolfi JM, Lovelock CE, Budd AF (2002) Character release following extinction in a Caribbean reef coral species complex. Evolution 56: 479-501
Rosen BR (2000) Algal symbiosis, and the collapse and recovery of reef communities: Lazarus corals across the K-T boundary. In: Culver SJ, Rawson PF (eds) Biotic response to global change: the last 145 million years. Cambridge University Press, Cambridge: 164-180
Stella JS, Pratchett MS, Hutchings PA, Jones GP (2011) Coral-associated invertebrates: diversity, ecological importance, and vulnerability to disturbance. Oceanography and Marine Biology: an Annual Review 49: 43-104
Zahavi A (1975) Mate selection – a selection for a handicap. Journal of Theoretical Biology 53: 205-214

Figure 2. Fagatele Bay National Marine Sanctuary has been a conspicuous exception to this generalization. *Acropora* has significantly increased in this small (0.25 mi^2) bay over the past four decades. Photo by Alice Lawrence.

REEF LIVES

An Interview with Charles Sheppard

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In 2021 I approached Charles Sheppard, whose recent passing was reported in the previous edition, to see if he would be willing to be interviewed as part of my PhD project. He generously accepted, and what followed was an interesting and wide-ranging conversation about his experiences with coral reefs and in coral reef science. Below is an edited and abridged version of that conversation, which I thought it would be nice to share with Reef Encounter readers.

What led you into studying corals?
I was born and brought up in Singapore, so as a child I snorkelled on them. That's before they were buried in concrete, a lot of them, as Singapore expanded. I started to go diving for fun in Britain, and was intrigued by what I saw around me.

And what appeals to you about coral science?
It's intriguing. It's like being a detective, and every little thing you solve is great. One of my earliest personal ones was the fact that corals can actually fight each other with their tentacles. And you can see it: either stay up all night, or in an enclosed room you can slowly reverse day and night, so that you don't have to miss your evening in the pub. That was what my postdoc involved, partly. It was showing how a lightning strike, for a coral, might last two weeks... They think slowly. Not like us, not on a human timescale.

Charles Sheppard (right), with wife Anne

Which areas of the world have you worked in?
I did a postdoc for two years in Australia on the Great Barrier Reef. That was wonderful. It was just: "here's the money for two years, do what you want". Then I went to the Middle East. It was a job opportunity which was too good to say no to, Saudi Arabia. The pay was enormous. And the reefs there are absolutely fascinating. The job was to monitor reefs of a new port they were building on the Red Sea, and it was a wonderful year and a half as far as that was concerned.

After I came back - that was a fixed term thing - I didn't have a job. So I sort of did consultancy work for bit. Then I built up my work in the Chagos archipelago, where I began a programme and was able to get, in the end, a lot of people out there.

I still do consultancy work, and I've got one book coming out next week with Oxford University Press. It's a revision of an old one, which takes into account a lot of the new work on the physiology of corals. It has also captured the big mortality episodes that have happened around the world in the last few years. And I have another book with Princeton University Press which has a due date of August I think, which is probably going to be more of a textbook. They said 'we want reefs in 100 double page spreads'. Some aspects of the subjects are very compressed. Some aren't. But they allowed 250 color photos and diagrams, which is great. So I hope it'll go down well; they're certainly making a good big print run of it. It'll either fall flat on its face or it'll do very well, hopefully the latter.

I have been asked back to one or two countries, but won't go back to them because they never listen to your advice. And there are a couple anyway, which I was thrown out of, for giving advice that the powers that be didn't like, because it would have affected their pockets. I wouldn't go back to them anyway, because some of these places are rather dodgy. And if the wrong person found out you were there, then... you know, interlibrary loans probably not so hot in a jail [laughs].

There is another country where I won't be asked back to work. Fishing villages were being abandoned because there was no fish left. And the reason was golf courses were being built over the nursery grounds of the fish. And who owns them? You guessed it, some quite important people. But there are some brave people there. One came up to me and said, 'You know, I'm so glad you found this out', after I had revealed in graphs what was actually going on.

What aspects of reefs have you studied throughout your career?

The ecology of corals. But that's really one aspect of all I've been doing, which is environmental problems. Most of my work has been on disasters around the world, such as fishing villages abandoned because of pollution from industry. And you can give the answers and say, well, it's this factory here, you know, a lead acid factory, on the shores of the estuary here, which has killed so much of it. That's where the problems arise, because a wealthy local person will own it, not the local people who are marginalized, they have no vote, democracy or not. So, the challenge has been to figure out disaster cases, disaster areas, marine pollution, and environmental problems, ecosystems collapsing. That's been my area.

But the Chagos work I've been doing is a contrast to that. It's officially known as the British Indian Ocean Territory. And it's been de facto protected as a military area really since 1970ish. So it's been a privilege to go there as often as I have, because the reefs are – well, were - in very good condition. It's a wonderful contrast to most of the rest of the planet. We see what a reef really should be like, and speaking as an ecologist, how it works. And that can help people in disaster areas too, because if you're the environmental chief in a poor country, you have a limited

budget. Is it this or is it that that's causing the problem? They don't know, there's nothing to go by, they can't always research it because their reefs are already knackered.

Even the Chagos reefs have been very heavily damaged by warming, by heat waves, by marine heat waves. They're currently in a pretty bad condition. But they still have no impacts of a direct human kind... no local human impacts, they only have the global one of climate change, as does everywhere else. So it was always a great contrast and a reference in my mind to be able to go to Chagos and see what all those reefs are like and what they're doing.

It's the same in the North Sea with fishing - you don't have to go to coral reefs. There's a wonderful museum, the German National Oceanographic Institute, and they had a display on the average size of fish, outlines of fish from 1850, and the average size of them now, which by comparison is tiny. People just don't realize how things have shifted.

There was someone from the European Commission, talking about how they're doing wonderful things for fisheries, and they're aiming to restore it to the 1980s sort of condition again... no, no, no. In the 1980s, you had a very low baseline, that would be trying to restore it to something that was already knackered. Try again. These were scientists who were telling him that, including some very famous ones. His reaction: 'how dare you contradict me?'. It wasn't, 'oh gosh, I'd better do a bit better'. No, it was: 'as a commission we're doing brilliantly'. It's authority, I think. We know, for all these problems, what the scientific solutions are, it's not a science problem and hasn't been for 20 years or more. It's a problem of politics, decision makers - so

called - who can't actually make decisions. And it can be frustrating. You win some though.

So how can we tell when a reef is healthy?
They'll be crowded with big fish. And little ones, but a lot of big fish will be there. And it'll have a covering of probably 40 to 75 percent coral, not 100, it's never 100. There are other things that have got to live there - sponges and soft corals – and there as old dead colonies as well. It'll also be quite noisy with clicks, slaps, rustles and things like that. Now, many of the reefs after periods of climate change impact are, well, sort of silent.

I often hear people talking about 'ecosystem services' provided by reefs. Do you think this is a good way to communicate their importance?
I think it probably is a good way even if you don't like it, because, look, the world's run by accountants, isn't it basically? [laughs]. They don't understand about the wonders of a natural system at all, but they understand the numbers. What we know to be important, whether it's the microbial loop on a coral reef or in a kelp bed, would make the accountant go into sort of screensaver mode. Government decisions as well, are based to such a high degree on economics, aren't they? So yes, I think you have to, until people like us rule the world [laughs]. Those who are doing it now, they have to read a spreadsheet, basically.

If reefs were to disappear tomorrow, what would be the biggest impact?
Well, let's rephrase that. What is actually happening right now? It's been estimated that up to half a million people are dying every year from malnutrition, caused by climate change. There are climate change refugees and all the implications there. That isn't something for the future, it is happening now, it's going to get worse and more marked.

The other one is shoreline erosion. It's already happening. Nations in the Pacific have already evacuated some islands. Some countries have bought land in other countries to relocate their populations to. Now, think back to other situations where a population, or an ethnic group, were relocated somewhere else in another country, think of the implications. I think the sociologists are way behind in figuring out what is the best thing to do - nevertheless, countries are, and some countries have, bought up land in other countries, to relocate people to when their own islands are no longer inhabitable, because their reefs are dead and because the sea level is continuing to rise.
It's going to get worse before it gets better, if it ever does get better. And the same applies not only to reefs, but to other environments like, you know, mangroves, sea grasses, fisheries and things like that. It's not only reefs, but reefs are in the forefront. They have captured imaginations because of their beauty. Someone said to me once, why do scientists never bother about the beauty of a place? And I can't really think of an answer. But I guess that's what draws us to coral reefs, rather than choosing to dive on a seagrass bed, whether you are a scientist or a recreational holiday diver.

I guess disciples of any particular discipline in marine science could probably come up with reasons why a mangrove forest or a seagrass bed or a kelp bed are equally or more fascinating or important than a coral reef, and they would probably be right. In my youth, I used to work on kelp beds around Britain and Europe. But these days I think on a more of a macro scale - we're all realizing that there is only one ocean. The different habitats are all components of the one ocean ecosystem. Look at it this way, it's the harm to us which is the difficult bit to get over. I mean, for millions and millions of years, there was life in the ocean, but not on land. There's never been life on land when there's been none in the sea. So we'd better watch out.

Do you still like to dive recreationally, or just for work?
Both. Actually it's kind of hard to split recreation and work sometimes. Even a reef that's on its last legs, or beyond it, can still be interesting to a scientist. "Why has this happened like it has?" That's just the curiosity of a scientist, you can't do anything about it. So, I'll be doing that even if they're only degraded reefs. With luck I'll be diving in my zimmerframe, till it goes rusty.

REEF CURRENTS

Tubbataha Reefs Natural Park, Philippines: corals and fish continue to thrive

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Real reef conservation success stories tend to be few and far between these days. Amidst the general trend of declining corals and reef fish populations, ineffective management, and lack of political will, the Tubbataha Reefs in the Philippines stand out as a beacon of hope for coral reefs and the importance of effective protection.

In May 2024, our "Saving Philippine Reefs" (SPR) expedition team undertook its ninth monitoring trip to Tubbataha Reefs in the Sulu Sea to collect data on the status of the reefs and fish biota. This expedition provided data for the monitoring program that started in 1984 and we now have a 40-year perspective on these reefs, their associated marine life and selected cause and effect events that have influenced them.

Located in the middle of the Sulu Sea some 150 km from land, the Tubbataha Reefs Natural Park consists of the two Tubbataha coral atoll reefs and the submerged Jessie Beasley Reef to the north (Figure 1). The park, which is a no-take area, covers 970 km^2 and is surrounded by a 10 nautical mile wide buffer zone, bringing the total protected area to 3,565 km^2. It includes an estimated 100 km^2 of coral reef, all within the no-take zone, and contains a diverse and abundant array of fish, corals and marine wildlife in clear and pollution free waters. Studies to date have recorded 14 cetaceans, 7 seagrasses, 79 algae, 360 corals, 28 species of sharks, skates and rays, about 800 other fish species, 2 turtle species, 7 resident breeding seabirds (see Fig. 5) and a further 100 or more migrant bird species.

Initially established as a protected area in 1988, and declared a World Heritage Site in 1993, the more recent Tubbataha Reefs Natural Park (TRNP) Act of 2009 lays out the governance arrangements for the park. The Tubbataha Protected Area Management Board is responsible for formulating conservation policies, which are then implemented by the Tubbataha Management Office (TMO). TMO, with its enthusiastic staff based in Puerto Princesa City, Palawan, assumes the day-to-day operations in the park.

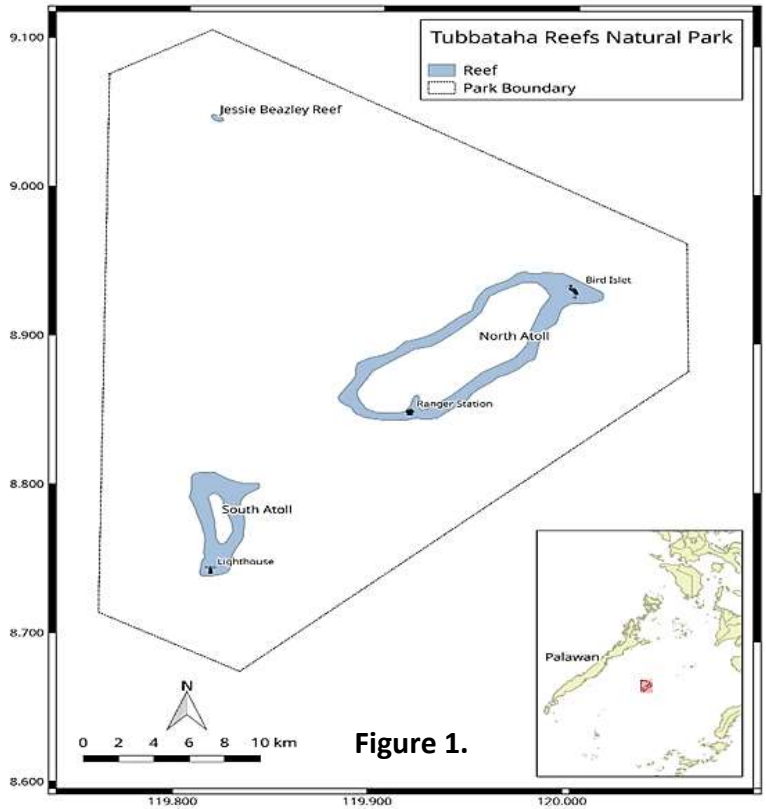

Figure 1.

Enforcement is undertaken by about 9-10 rangers comprising park employees working jointly with Philippine Navy, Coast Guard and Cagayancillo Bantay Dagat (Sea Guardians) personnel. They all stay at the isolated ranger station with rotations every 2 months. A new ranger station complex is being constructed to improve living facilities for the rangers. It will also include a research station that will allow year-round research and accommodate visiting scientists. The park receives significant support from both

local and national government, NGOs, and corporate foundations. The Tubbataha Protected Area Management Board (TPAMB) is co-chaired by the national Department of Environment and Natural Resources and the Palawan Council for Sustainable Development. Its members include representatives from government agencies, scientific institutions and NGOs, academia, and local community organizations.

Only two activities are allowed in the park–research and tourism - and these are currently confined to three months of the year because of the remote location and weather constraints. For the rest of the year, the reefs are impacted mainly by natural events, or potential shipping incidents such as an oil spill or boat grounding and, to a limited degree, by litter or debris drifting in the Sulu Sea. As a premier diving destination in Southeast Asia and rated among the top dive sites in the world, the park receives about 3000 visitors a year. Tourism is the only source of regular income generation through user-fees and operator permits from the live-aboard boats that ply the waters in March-June. Tourism revenues now cover about 60% of the costs of managing the Park. The rest comes from national government (in-kind support), grants and donations.

Tubbataha Reef Natural Park is one of the most well-enforced, large no-take areas in Southeast Asia. Unusually for such remote reefs, we can also be confident that this is an objective result of effective management, thanks to the regular monitoring and enforcement undertaken by the TMO and also by visiting expeditions such as the SPR project of the Philippine NGO, the Coastal Conservation and Education Foundation (CCEF) (www.coast.ph).

Figure 2. Saving Philippine Reefs team of 24 participants in Tubbataha Reefs Natural Park, May 2024 (Photo: CCEF drone shot)

The ninth SPR visit to TBNP in May 2024 included expedition members ranging in age from 22 to 77 years, and diving volunteers from Australia, USA and UK, complemented by the professional Philippine staff of the CCEF (Figure 2).

The methods used are simple and replicable (Uychiaoco et al. 2010; English et al. 1997). The same methods have been applied on all visits, with minor modifications, and many of the volunteers are regulars and have taken part in previous trips, which helps to ensure consistency in data collection that include:

- Percent cover of living coral, and living and non-living substrata (according to broad and standard categories)
- Fish species diversity and abundance (volunteers and staff with expertise on fish species and counting collect these data)

- Abundance of indicator species, such as giant clams, lobsters, crown-of-thorns seastars, butterflyfishes and others
- Presence of large marine life (manta rays, sea turtles, sharks, Humphead wrasses, cetaceans etc.)
- Observations on causes of reef damage, threats and conservation efforts

The 2024 expedition found that the living coral cover is stable and higher than it was prior to the ENSO bleaching event in 1998 and there were few signs of disease or damage (Figure 3a). The biomass of fish

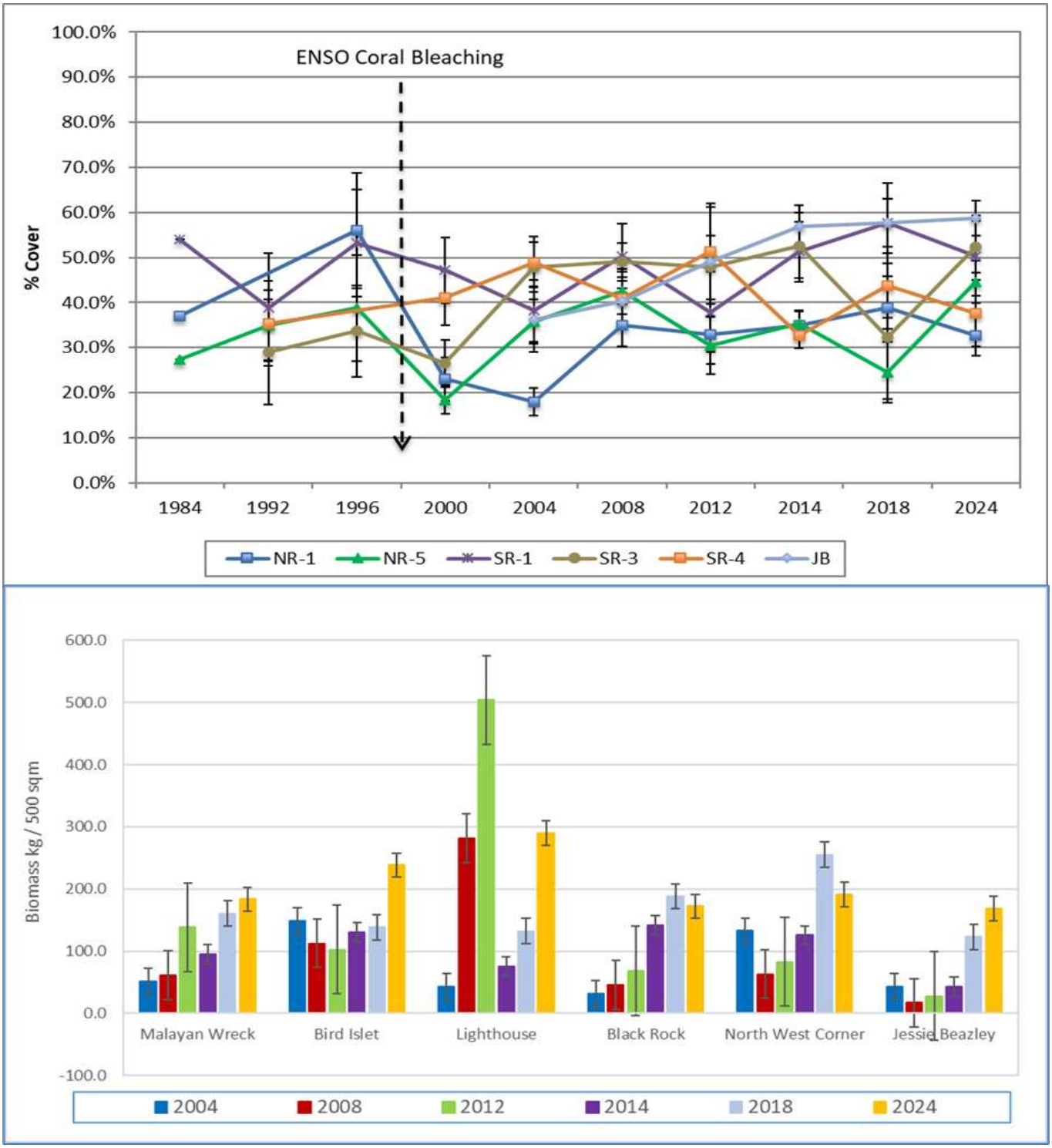

Figure 3. a (above) Percent of living coral cover at 7-9m depth as surveyed in the 7 most frequently monitored sites in the Park. Several sites were not surveyed in each survey year. **b** (below) Fish biomass (Kg/500m^2) has been monitored at 6 locations in Tubbataha since 2004. and was higher in 2024 than in past years at some sites. (Note: The anomaly of very high biomass at Lighthouse in 2008 and 2012 reflects large schools of jacks that are normally present at the site, but not always observed in the fish transect monitoring).

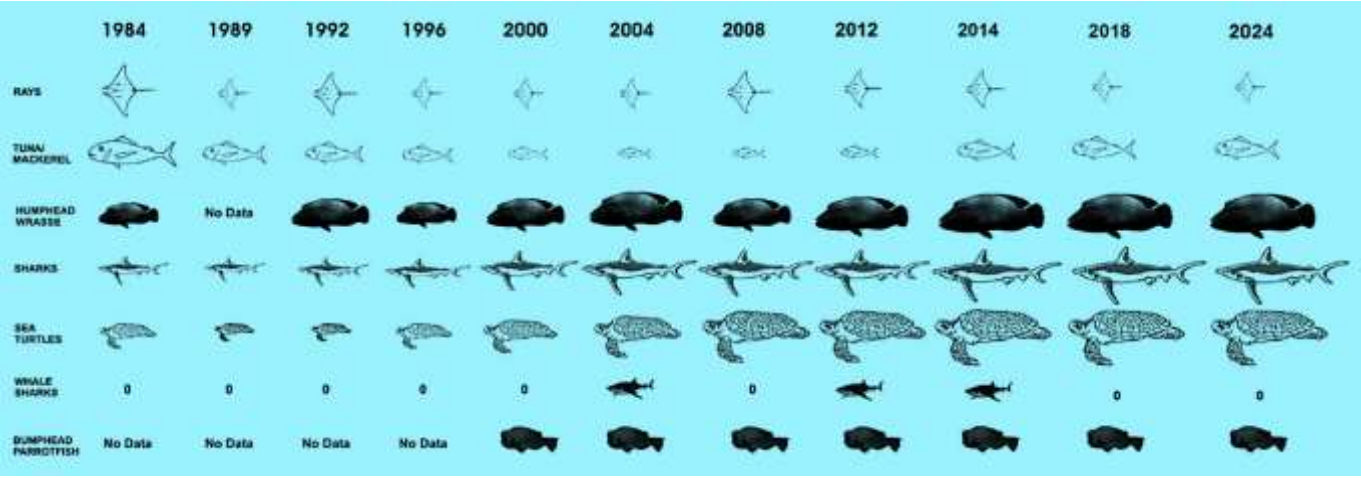

Figure 4. Incident observations of large marine life during SPR survey trips to Tubbataha Reefs from 1984 to 2024. Large reef residents have increased steadily in presence and biomass, but those that migrate in and out of the Park have generally declined (e.g., manta rays and tuna).

recorded increased slightly over previous years (Figure 3b), although the density of smaller fish (number per unit area) appears to be declining, which may reflect the increase of larger predators on the reef. The presence of large marine life monitored through general observations of all divers has increased over the years with a few exceptions (e.g., manta rays are seen less often) (Figure 4). Since the mid-1980s, the presence and biomass of sharks, sea turtles, and humphead wrasse has increased remarkedly.

Overall, the SPR program's results compare well with those obtained through the Park's own monitoring program initiated in recent years using similar, but not identical, methods on the seven transect sites set up for benthic and fish community surveys. Data from the SPR monitoring over the last 30+ years has also shown that live coral cover recovered and is stable after the bleaching of 1998, when coral cover declined by about 22%, on average, throughout Tubbataha Reefs. Coral percent living and dead data have also shown little impact from coral disease, with the most significant declines observed from the bleaching of 1998 and several minor outbreaks of Crown of Thorns seastars. The combined biomass and density of commercially important fish families, such as Acanthuridae, Labridae, Lutjanidae, Scaridae, Siganidae and Serranidae, show an increasing trend from 2004 to 2024, which helps to confirm that fishing activities are absent or relatively minor inside the Park area (Dygico et al. 2013).

To have such positive outcomes for an MPA located in the global center of marine biodiversity, central to the Coral Triangle, is a major achievement. This is not to say that there are no threats. There are concerns about the potential impact of ship groundings and pollution given an increase in international shipping passing through the buffer zone from 2009 to 2024. Nevertheless, the status of this coral reef reflects the consistent planning and implementation of Park management activities conducted by the Tubbataha management team and the joint support of several Philippine government agencies, as well as the private sector tourism operators who work closely with the Park management office staff to ensure the continued protection and careful use of the area.

The prognosis for the future is uncertain, of course, as ocean temperatures rise the likelihood of more frequent and intense bleaching events poses the most serious threat to the Tubbataha Reefs. Storms are also a potential threat, although most storms entering the Philippines pass north and east of the Sulu Sea, so little storm damage has been recorded in Tubbataha Reefs. During our monitoring in May 2024, we were pleasantly surprised to find few bleached corals even though the water temperature was above normal at 30-31°C. Consistent monitoring of water temperature is only recent in the Philippines, but informal records from researchers and divers visiting the reefs beginning in the 1980s indicate a slight average increase during the warmest season from April through June-July. It is also noteworthy that the 1998 bleaching affected corals lying 3 to 5 meters below the surface more than it did the very shallow corals, suggesting that shallow corals had a higher tolerance to the warmer waters than those slightly

deeper. Whether this pattern will be repeated in Tubbataha, remains to be seen. In the meantime, given that most local human induced threats have been removed, so that only regional and global threats, such as longer-term climate related impacts, are likely to impact the reef, there must be hope that some level of adaptation will allow these reefs to survive into the future.

Acknowledgements. The information herein has been provided by too many individuals to mention, but key individuals include: Dalton Dacal and AJ Lozada (CCEF), Sheryll Tesch (volunteer data analyst), Angelique Songco (Director of Tubbataha Management Office), Maria Retchie Alaba (Assistant Protected Area Superintendent/Research Officer, TRNP), all of the Saving Philippines Reefs volunteer participants and CCEF staff who have assisted over the years. A tribute is also due to Philippines President Fidel Ramos (1992-1998) who initiated national government support for Tubbataha Reefs that continues to the present, and Ernesto 'Bebot' Santa Cruz whose foresight in the 1980s led to efforts to protect the reefs.

References and additional reading on Tubbataha Reefs

Alaba MR, Alarcon R, Gedoria G, Songco A (2023). TRNP Ecosystem Research and Monitoring Report 2023. Tubbataha Protected Area Management Board, Palawan, Philippines.

Arquiza, YD, White AT (1999). Tales from Tubbataha, natural history, resource use, and conservation of the Tubbataha Reefs, Palawan, Philippines. Second Edition. Sulu Fund for Marine Conservation Foundation, Inc. The Bookmark, Inc., and Coastal Resource Management Project. Cebu City, Philippines.

Bos AR (2009). Crown-of-Thorns Outbreak at the Tubbataha Reefs UNESCO World Heritage Site. Zoological Studies. National Museum of Natural History Naturalis, the Netherlands. (Field report).

CCEF (Coastal Conservation and Education Foundation) (1992, 1996, 2000, 2004, 2008, 2012, 2014, 2018 and 2024). Summary field reports: "Saving Philippine Reefs" Coral Reef Monitoring Expeditions to Tubbataha Natural Park, Sulu Sea, Philippines. 9 Technical Reports of CCEF, Cebu City, Philippines (http://www.coast.ph/our-work/projects/saving-philippine-reefs).

Dygico M, Songco A, White AT, Green SJ (2013). Achieving MPA effectiveness through application of responsive governance incentives in the Tubbataha reefs. Mar. Policy 41: 87-94. http://dx.doi.org/10.1016/j.marpol.2012.12.031

English, S, Wilkinson C, Baker V (1997). Survey manual for tropical marine resources. 2nd Edition, Australian Institute of Marine Science, Townsville, Australia, 390p.

Jensen, AE (2012). Field Report: Monitoring and inventory of the seabirds and their breeding areas in Tubbataha Reefs Natural Park & World Heritage Site, Cagayancillo, Palawan, Philippines.

Maypa, AP, White AT, Tesch S, Meneses AB, White E (2004). Long-term changes in coral reef benthic composition of Tubbataha Reefs: Response to bleaching in 1998 and protection. Silliman Journal. 45: 2, pp. 60-75.

Uychiaoco, AJ, Green SJ, dela Cruz PA, Gaite HO, Aliño PM, White AT (2010). Coral Reef Monitoring for Management, 2nd Edition. University of the Philippines Marine Science Institute. United Nations Development Programme Global Environment Facility-Small Grants Program, Guiuan Development Foundation, Inc., Voluntary Service Overseas, University of the Philippines Center for Integrative and Development Studies, Coastal Resource Management Project, and Fisheries Resource Management Project. 120p.

Figure 5. Greater Crested Tern (*Thalasseus bergii*) with filefish, near its habitat on North Bird Islet. (Photo by Denise Iling)

REEF CURRENTS

For and By the Community: Bridging Knowledge for Community-Based Management

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Summary

Community-based management (CBM) is recognized worldwide as essential for natural resource management and sustainable development. Implementing it requires a thorough understanding of complex socio-ecological systems involving parties with different backgrounds and interests. A functional bridge between parties is an important determinant of successful outcomes. To better understand and improve the bridging role, and to identify tools to support CBM implementation, information was gathered from 35 case studies and from two half-day workshops on community-driven conservation programs in building coastal resilience at the 5th Asia Pacific Coral Reef Symposium (APCRS) 2023 in Singapore. This involved individuals from 11 countries across 45 organizations, including local community representatives. We identified the bridge as a knowledge translator able to convey a message between the community and policymakers. The community, policymakers, and the bridge can be overlapping. An effective bridge has three types of requirements: those relating to quality (integrity and consistency), those relating to the process (adaptive management, cultural context understanding, key stakeholders' identification, conflict management, empowerment, and pride), and those relating to resources (funding and networking). We also listed 13 valuable tools that can support CBM implementation. The analysis of lessons learned supported CBM mainstream findings from other studies/publications. Furthermore, we identified the importance of viewing different management levels horizontally to convey a stronger sense of equality. We also noted that the involvement of local communities in this process resulted in rich first-hand knowledge sharing, which is fundamental to increasing CBM effectiveness. Further efforts are required to strengthen this type of initiative.

Background

Natural resource managers worldwide recognize **Community-Based Management** (CBM) as an essential tool for natural resource management and sustainable development. Experience with open access and top-down government approaches to managing common-pool resources has demonstrated numerous failures (Cinner et al., 2012-1; Jupiter et al., 2014; Mahajan et al., 2020). Complex social-ecological interactions underpin many environmental problems (Barnes et al., 2019) and are too complicated to be governed by a single agency (Berkes, 2009), especially given the pressures of climate change (Denton, 2015). It is no

surprise that the United Nations puts People and Partnership as two of the five pillars of the United Nations Sustainable Development Goals (SDGs), along with Planet, Prosperity, and Peace (UNSDG,2022). Undoubtedly, effective implementation of the SDGs requires grassroots, community-led actions.

However, implementing CBM is challenging. CBM is understood as an approach that leverages local stakeholder participation for natural resource use, planning, research, development, and policymaking. This is often much easier to contemplate in theory than it is to apply on the ground. Wondolleck and Yaffee (2000) have concluded that the key to CBM is to develop collaborative partnerships (focusing on a common future goal) through a process that builds mutual understanding, trust, and relationships (Marshall et al., 2015). The process requires a thorough understanding of complex socio-ecological systems. All parties must be seen, treated, and respected as equal partners despite their different backgrounds and interests. Yet, even among local stakeholder participants, there are often differing intentions and objectives behind their participation in such collaborations.

The bridging role that is the subject of this paper is essential to bring all the different parties to a common position. Berdej and Armitage (2016) stated that the bridging position is emerging as an important determinant of successful conservation outcomes. Bridging organizations (or individual/s) provide a platform for different forms and sources of knowledge to interact, and for them to engage so that cooperation can begin. It enables trust-building, sense-making, learning, and vertical and horizontal collaboration, as well as conflict resolution (Berkes, 2009).

At the 5th Asia Pacific Coral Reef Symposium (APCRS) 2023 in Singapore, we collected lessons learned in building the resilience of coastal resources from community-driven conservation programs. We specifically went over the gaps and challenges encountered by local community members and other stakeholders in their efforts to carry out these projects. We then analyzed this information together as a group to provide a better understanding of and to improve bridging roles, as well as to identify tools to support CBM. The participants included members of the local communities themselves (translation was provided where necessary), and are thus the co-authors of this paper. We believe that the inclusion of resource users in this process is crucial. First-hand information offers details that are likely to be missed if a story is presented by an NGO, university, or government partner. It also puts communities at the same level of importance as other actors in relation to their natural resources management.

This article discusses the process used to enable these community representatives to come together, share stories, and co-create a system that facilitates CBM. We highlight the importance of bridging as a means of synchronizing disparate knowledge between policymakers and community members, as well as facilitating two-way communication and information exchange.

Methodology

This article synthesizes lessons learned from 35 case studies from 11 countries accepted for presentation at the APCRS 2023, and from two half-day workshops that unpacked how the different community-based programs function in building the resilience of their natural resources. The workshop participants represented 45 organizations/groups, including community groups, non-governmental organizations (NGOs), governments, academia (scientific organizations), and individuals. About 50 percent of the 34 workshop participants had more than five years of experience in community organization, mobilization, or engagement.

Twenty case studies were presented in four sessions under the theme 'Integrated Management and Solution' They were:

- From and by the community: community-driven management strategies for enhancing coastal resilience (17 cases)
- Coral reef ecotourism: towards a carbon neutral destination (1 case)
- Advancing marine area-based conservation in the Coral Triangle: a practitioner forum (1 case)
- From science to management: an integrated approach to science-based management of coastal ecosystems (1 case)

Many of the conclusions shared here emerged from discussions in the half-day workshops. Therefore, all workshop participants are included as authors of this article. The key points that arose included:

1. The main gaps in effectively communicating with communities.
2. The approaches that work in building communication and delivering messages to the community.
3. The communication difficulties faced by communities.
4. The approaches that work for the community in communicating with other stakeholders.
5. The available tools that enable effective communication between different levels of management and policymakers.

These points were also our guidelines in synthesizing other case studies that were not presented (15 cases).

A summary of the participants and the case studies discussed are shown in Table 1. Scenes from the workshop are shown above. Further details are included in an expanded table available on-line at coralreefs.org/society-publications/reef-encounter/ as Appendix 1.

Findings and Discussion

The information derived from the discussion of points 1 to 5 above was analyzed to help us identify the ‘bridge’ (who can be the bridge) and aspects required in meeting the needs of an effective bridge. The result is as follows:

Who can be the 'Bridge'?

Simply speaking, a bridge is built to connect at least two different locations. However, to understand the bridge in the context of CBM, we must first understand who/what are the 'locations', and what needs to be communicated. We identified the 'locations' as community and policymakers, with the bridge as the means of conveying a message (Figure 1).

'Community' comprises local resource users, managers, and owners; those who provide input for policy development and are the leading policy implementors. These stakeholders include local

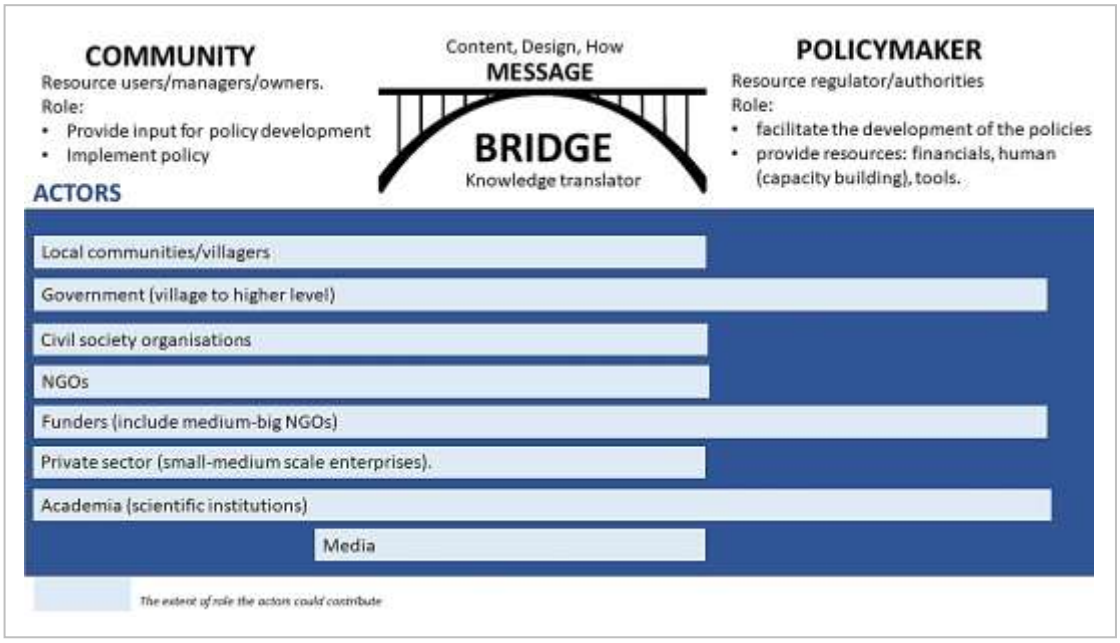

Figure 1. Potential actors able to carry out bridging roles in CBM, their roles, and the likely extent of their roles.

communities/villagers (local people, tribe leaders, religious leaders, etc.), village government, civil society organizations (community groups such as Pokdarwis[2], Pokmaswas[3], MMP[4]; or special interest groups comprising divers, tourists, youths, women, etc.), local NGOs, academia, and the private sector (small and medium enterprises). 'Policymakers' were identified as those who facilitate the development of policies and provide the financial resources, tools, capacity building, and networks required to implement those policies. They could be government (village level or beyond and can also include law enforcement and legislative bodies), academia (universities), and funders (including medium-large NGOs).

The entity that takes on the 'bridging' role is required to be a knowledge translator between the community and policymakers, so as to ensure that the message content, how it is being communicated, and its design (including the tools used) are well understood and received by the target audience. Because communication is a two-way endeavor, the policy and scientific language of the policymakers must be adapted to be readily understood by the community, and vice versa. Many conservation plans and subsequent implementations ignore the fact that communities have a wealth of valuable management information and that local wisdom that can be used in policymaking (Cinner, 2005, 2007; Mazzocchi, 2006).

As a knowledge translator, the bridge is also expected to facilitate/mediate the management of natural resources. This involvement can include, but is not limited to: program development, needs identification, data collection and reporting, capacity building, program documentation and publications, and resource

[2] Pokdarwis (Kelompok Sadar Wisata/Tourism community group is a community group in Indonesia under village government that focusing on developing village tourism).
[3] Pokmaswas (Kelompok Pengawas Masyarakat/Surveilance Community Group is a community group in Indonesia under village government that focusing on surveilance in their village).
[4] MMP (Masyarakat Mitra Polisi Hutan/Community partner of forest ranger) is a community group in Indonesia under the government that support ranger's task.

provision. Our case studies revealed that the role of the bridge has been taken on in different projects by different actors including NGOs (of all sizes), civil society organizations, government (village levels and above), academia, media (from both formal and informal sources, e.g. from journalists to social media influencers), private sector entities, and local communities including villagers.

As shown in Figure 1, there is no hard distinction between actors who can take on the role of community, bridge, or policymaker. The roles can shift or even overlap, depending on the level of the program (at the village, district, provincial, national, or regional level), the availability of funding, and the type (approach) or personality of the actors.

There was a case in which the head of a protected area (appointed by the national level government) in Indonesia became the bridge between national policymakers and the community, i.e., to inform and enforce the national law (Case Study 5, Appendix 1). On the other hand, he also acted on behalf of the community, bridging the local community's voice to the national government by working together with an NGO. In Case Study 24 (Appendix 1), the village governing body developed village regulations. Thus, its role was that of a policymaker. However, the government body could also become the bridge or hold the role of 'community' (representing the community) at higher-level policy discussions. There were also several cases in which an individual or a group, civil society, or community organization/s became the bridge by translating regulations for fellow villagers. In several other examples, a local champion represented the community by identifying what was needed for their community and village. Yet, they could also take a role as a bridge, as they conveyed a message from their community to the policymakers or vice versa (Case Studies 15, 17, 23, and 24, Appendix 1).

Many big NGOs often recruit local staff and provide resources for local champions (thus fulfilling the role of the 'community'); other staff may work as a bridge between the community and policymakers (i.e., working alongside the community to support them in raising their voice to policymakers), and vice versa. To some extent, where the scale of the program is very large, funders and NGOs may play a significant role in policy development, particularly in providing resources. Thus, it is arguable that they also act as policymakers. This finding is consistent with Brown (1991) and White et al. (2022), who mention that NGOs are often best placed to take on these roles because they can bring myriad unrelated actors to a common platform and create partnerships that may not have otherwise existed.

One of the key outcomes of the workshop was the recognition of the value of the 'bridge' in connecting the community and policymakers (Figure 1). Workshop participants pointed to the necessary relationship between the community and policymakers as a straight horizontal line, rather than a vertical line, in order to stress the equal importance of all stakeholders. CBM should no longer be considered the bottom rung of a management ladder.

Meeting the Needs of an Effective 'Bridge'

In total, three key themes were identified as necessary for being an effective bridge (Figure 2). These include needs related to quality (two factors), to the process (five factors), and to resources (funding and networking).

Needs related to quality. Integrity and consistency (including patience) emerged from workshop discussions as two critical qualities of an effective bridge. Integrity, in this case, refers to the need for a CBM project/program to have a clear message and target, including what, when, and how to achieve goals, how to move forward, avoiding engagement fatigue, or how to manage a community that is already experiencing engagement fatigue.

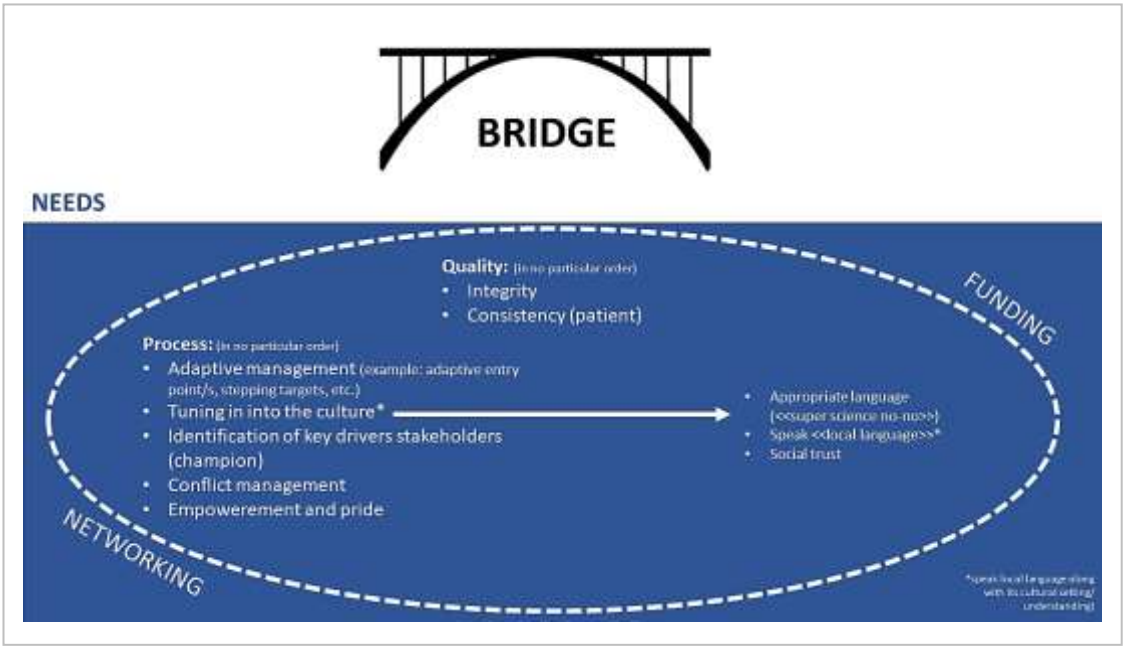

Figure 2. Meeting the needs of an effective bridge

Engagement fatigue is a condition that can arise when (mostly short-term) projects are implemented and repeated without necessarily developing into more significant outcomes or capabilities, or when the community is repeatedly given unfulfilled promises Occasionally, a CBM project may only exist to quickly utilize funds allocated to an organization(such as from a large NGO or from the government), usually near the end of a budget cycle of a program with a very low burn rate. As this kind of CBM project is not planned at the beginning of the budget cycle and is prepared in a rush, messages and targets may remain unclear. Inadequate planning in such projects may lead to engagement fatigue and reluctance to participate actively in conservation programs, or for some actors to purposefully hinder program implementation.

Many CBM communities are located in remote areas, with minimal transportation and communication access. Therefore, the actors who take on the bridge role must also work consistently (and patiently), since a project or program may require a significant amount of time to be fully completed. For example, the LMMA program in East Indonesia, intended to develop natural resource management regulations at the village level, has been running for more than 20 years (Case Study 21, Appendix 1). This led to participants emphasizing the process (the journey) rather than the result.

Needs related to the process. The needs related to the process are (in no particular order) adaptive management, understanding the cultural context, identification of key stakeholders, conflict management, empowerment, and pride. Two important factors we discussed at length in the workshops related to adaptive management were the need for adaptive entry point(s), and the need to develop incremental (intermediate) targets. Workshop participants noted that the entry point(s) identified at the beginning of project implementation may need to be adjusted or amended completely, depending on implementation results and how the situation changes on the ground. The likelihood of situational changes also calls for adaptive management to use incremental targets, since they are easier to modify in response to changing circumstances. Incremental targets are also crucial to ensure that a project or program progresses accordingly. In communication, for example, focussing on the end target with no interim checks could risk the message not being well understood or perceived, which can be potentially counterproductive.

How a message is designed and conveyed is of paramount importance. It should be culturally sensitive and understand and respect local customs and/or restrictions. Scientific terminology, including policy jargon, must be appropriately translated to facilitate clear communication and ease of comprehension. Workshop

participants stated that 'super-science is a no-no' to stress this fact. In addition, speak ing the local language is undoubtedly an asset, but there is still a need to be aware of and take into account how each community talks and listens to each other and to be considerate of local cultural sensitivities. Many participants mentioned the importance of *'nongkrong di bawah pohon*' (Indonesian for 'chilling under the trees'). The term refers to informal daily meetings with the community, drinking tea, coffee or local drinks, and sharing snacks, while chatting about general subjects, typically in a comfortable place, like the shade and cool temperature trees offer in tropical climates (hence the term). This banter is important in building relationships and acquiring local communication skills and knowledge of local customs. These

gatherings are also the gateway to gaining social trust and building rapport, necessary preliminaries for assuming a bridging role and for a project's long-term implementation or survival. The approach mimics expectations by indigenous communities in Australia, where planning meetings happen 'on-'country' as opposed to in meetings and workshops (Hill et al., 2011). Many of the workshop participants pointed out that these kinds of meetings and the need to live with the community prior to program implementation can sometimes take months or even years to complete, consistent with the conclusions of Marshall et al. (2015). It is a lengthy investment often underestimated and undervalued (or even undermined) by policymakers and funders.

Table 1. List of participants and case studies reviewed during the workshop. Annotations: (1) Country is the country where the project presented was implemented. (2) X in column WS = Workshop indicates the project's experience was shared during the workshop. * indicates case study was presented orally at the APCRS. *P indicates case study was presented as a poster at the APCRS. Case studies without an asterisk indicate those cases accepted for consideration, but not presented.

No	Organization	Country[1]	Source of information	
			Case Study	WS [2]
1	World Wildlife Fund (WWF) Hongkong	China	Underwater impact and intention-behavior gap of scuba divers to coral communities in Hong Kong SAR, China*	
2	Reef Check Malaysia	Malaysia	Moving towards Local Participation and Co-management of Tioman Island Marine Park*	X
3	Saga University	Japan	Satoumi Approaches: Community-based Integrated Resource Management in Coral Reef Areas*	X
4	Flora Fauna International (FFI) Indonesia	Indonesia	Community-based monitoring and surveillance contribution to the effectiveness of MPA management in Pisisi Simeuleu Aceh, Indonesia*	X
5			How citizen science contributes to monitor conservation areas in Karimata Islands, Indonesia? *P	
6	Wageningen University and Research/CORDIO	Kenya	Stakeholders' engagement in coral reef restoration– a case study in Shimoni, Kenya*P	X
7	FFI Cambodia	Cambodia	Assessing the influence of community-led compliance on coral reef ecosystems in Cambodia*P	
8	National University of Singapore	Singapore	Intertidal Watch: Harnessing the power of citizen science to protect Singapore's intertidal marine habitats*P	X
9	Kelab Alami (community group)	Malaysia	Local community efforts for sustainable fisheries and the preservation of coastal marine habitats: The story of Kelab Alami in the Western Tebrau Strait*	X

10	WWF Indonesia	Indonesia	Community involvement in the Derawan Islands MPA conservation program: The role of Pokdarwis Sumping Nusa*	X
11			Learning about Participatory Coral Reef Rehabilitation Using the Rockpile Method in Marisa Village, Kangge Island*P	
12	Ay and Rhun community group	Indonesia	Reviving Sasi System for Effective Coral Reefs Management in the Ay and Rhun Islands Marine Protected Area, Indonesia*	X
13	ReefCloud/ Australian Institute of Marine Science (AIMS)	Internatio nal	Bringing together Traditional Ecological Knowledge and innovations in coral reef monitoring to support robust and inclusive decision-making*	X
14	James Cook University	Australia	Emerging Themes in Motivations for and Strategies to Increase Participation in Active Reef Restoration Projects*	X
15	Les Fisherman Community Group	Indonesia	Les Village Reef Community Initiated Coral Reef Rehabilitation Program: From Potassium Cyanide Fishing to Marine Ecotourism and Social Entrepreneurship*	X
16	Missol Baseftin	Indonesia	Strengthen Implementation of Sea Turtle Protection by Grass-root Community to Savu Sea*	
17	Yayasan Konservasi Alam Nusantara (YKAN)	Indonesia	Local wisdom of harvest management in the hand of women that led to protection of coral reef in Raja Ampat, Papua*	X
18	Prince of Songkhla University	Thailand	A Sustainable Approach to Coral Reef Management with Community Participation: A Case Study of Kham Island in the Lower Gulf of Thailand*	X
19	Underwater World Guam (private sector)	Guam (USA)	A Community-Based Crown of Thorns Starfish Control Project in Guam	
20	Reef Check Foundation Indonesia (RCFI)	Indonesia	Flex Tourism*	X
21	Locally Marine Manage Area (LMMA) Indonesia	Indonesia	Village Regulations for Natural Resource Management in Papua and Moluccas*	
22			Sasi Tradition in "guarding coastal and marine resources in Papua and Maluku"	
23	Bondalem Ecodive Community business	Indonesia	Bondalem Ecodive: Community-Based Business to Support Coral Conservation Management	
24	Dive Operator Community Tulamben	Indonesia	Management of Conservation Areas by Local Tourism Communities in Tulamben Bali	
25	University of San Carlos	The Philippines	Transitioning to the New Normal: Stakeholders Engagement in Marine Protected Area	
26	Mindanao State University, Tawi-Tawi	The Philippines	Strengths and weaknesses of marine protected areas (MPAs) management in Tawi-Tawi islands, Southern Philippines	

27	PATH Foundation Philippines	The Philippines	Women-Led Strengthening of Balisungan Marine Protected Area in Coron, Palawan, Philippines	
28			Sustaining the Gains of Siete Pecados Marine Park in Coron, Palawan, Philippines	
29			Women-Managed Area Sustaining Indigenous Food Security and Livelihood Amidst the Pandemic	
30	World Conservation Society (WCS) Indonesia		The role of community-based surveillance group in combatting destructive fishing practices in the Saleh Bay, West Nusa Tenggara, Indonesia	
31			Panglima Laot – A customary legal system meets modern approaches to oversee marine management in Aceh Province, Indonesia	
32	Bukan Sekedar Pasiar Community Group	Indonesia	Bukan Sekedar Pasiar, "Pasiar" - "Leisure with a Purpose”	
33	Aklan State University	The Philippines	Well-being of artisanal fishing communities and children's engagement in fisheries amidst the COVID-19 pandemic: a case in Aklan, Philippines	
34	Kuleana Coral Community Group	USA	Connecting Community and Science through Hawaiian Values	
35	Creative Action Tank	Internatio nal	Framing community consultations to identify climate and anthropogenic impacts to coastal communities and coral reef ecosystems through the years.	
36	University of Malaysia Trengganu	Malaysia		X
37	WWF Malaysia	Malaysia		X
38	Conservancy (Government) Agency of Natural Resources	Indonesia		X
39	University of Diponegoro	Indonesia		X
40	University of Hasanuddin	Indonesia		X
41	National Park Singapore	Singapore		X
42	Lomani Gau Community Group	Fiji		X
43	AOW Thai Marine Ecology Centre	Thailand		X
44	Derawan Community group	Indonesia		X
45	Seacomm Philippines	The Philippines		X
46t o53	Individuals	Various countries		X

Detailed Case Study 1
Benefit of Gaining Social Trust (Case Study 17, Appendix 1)

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In the coastal regions of Indonesia, sasi[1] are historically managed by men - however, the late Betsina Hay, a local woman and wife of a village leader in West Misool, sought to bring more equity to marine resource management and began advocating for a woman-led sasi. She approached Yayasan Konservasi Alam Nusantara (YKAN), an affiliate of The Nature Conservancy in Indonesia, to facilitate the process. YKAN has been working closely with the community there on natural resource management for more than a decade, gaining their social trust. In 2008, the women's group Waifuna was granted a sasi, representing a true first in Papuan history. The women's ownership rights were fully acknowledged by the sub-village government, church, and adat holders. YKAN partnered with Waifuna to provide training around ecological assessments and monitoring to ensure successful management of the sasi. Together, they developed sasi agreements that were to be followed by members of the group in order to ensure a healthy, regenerative ecosystem; these included agreements about issues such as catch limits and size requirements to exclude harvesting of juveniles. Previously within the patriarchal culture, women had often been excluded from leadership roles, and there was little emphasis on administrative or record-keeping tasks. To close this gap, YKAN provided guidance on project management, staffing (e.g., assigning specific group members to free-dive and harvest, overseeing buyers, and managing transactions), and record-keeping in order to generate year-on-year data on the types and total weight of the catch. The profit from each harvest season creates a financial safety net for the entire village, and because the village benefits directly from the women's successful management of the sasi, they are even more supportive of Waifuna's efforts. The village government expanded their sasi area from 32 hectares in 2008, to 215 hectares in 2019. The expanded sasi generates additional financial support, allowing the village to now send their top students to university, transport sick villagers to the hospital, and undertake local projects, such as renovating the village church and celebrating religious events.

[1] A sasi is a temporary closure. Local communities leverage it to prevent the overharvesting of marine

In Papua, building social trust led to the first women's leadership in harvest management (*sasi*) in a village where men have customarily held the role for centuries. The women were comfortable enough to present the idea to their NGO partner and to ask for facilitation in making their vision a reality (Case Study 17, Appendix 1. See Detailed Case Study 1).

Another important factor in the bridging process is the identification of key drivers or stakeholders (loosely defined as 'local champions'). If well selected, a local champion, whether a community, community representative or policymaker, or another actor, is an invaluable asset for successful bridging; conversely, a wrongly appointed 'champion' can potentially obstruct or damage the process. This aligns with the findings of Gutierez et al. (2011) who examined 130 co-managed fisheries and identified strong leadership as the most important attribute to success.

Note that the champion, depending on local cultural and social circumstances, does not always need to be someone who has an official appointment within the local hierarchy. Sometimes, this appointment and the attention garnered from it can lead to a feeling of unfairness, jealousy or offense to those in important or official positions. The 'champion' may also be a group rather than an individual, such as was the case for RCFI (Case Study 20, Appendix 1), who gathered and conveyed valuable information on natural resource management for

several of their project sites. They achieved this by working with women's groups making coconut soap, a lengthy process which, without electricity, provided time to converse, since they needed to sit together for hours to complete the tasks.

It is interesting that in five cases (Case Studies 9, 17, 20, 27, and 29, Appendix 1), women's leadership was highlighted within CBM projects or programs. The importance of women's leadership in natural resource management has been acknowledged in several studies (Agarwal, 2009; Alvarez, 2016). Moreover, three cases (Case Studies 9, 32, and 33, Appendix 1) involved working closely with local youth. Brennan and Barnett (2009) stressed that youth exposure to management leadership and natural resources management is vital to the long-term success of development efforts.

The workshop participants also raised the point that bridging roles must address conflicts. Conflict is an integral part of any process. It could be inherited from any previous project or program or a new issue arising during implementation. Even given the best planning, a project may face challenges on the ground that can lead to conflict (and unavoidable, necessary changes to which it needs to adapt). Therefore, a bridge should be strongly adept at conflict management to enhance the likelihood of success.

Another key factor is empowerment, which can take many forms. Personal or social empowerment (otherwise understood as 'pride') is attained when other parties involved pay heed to or follow instructions for effective program implementation. Political empowerment is demonstrated by an ability to mobilize action (without necessarily getting involved in any local or national political machinery). The bridging process needs to result in a win-win situation that benefits both policymakers and the community; this can then be used to increase personal or social empowerment (or pride and perceived position and status). Case Study 6 (Appendix 1) recognised 'pride' (a sense of recognition and reputation) as an essential driver of engagement. In this case pride was particularly evident, with local youth becoming role models and inspiring their local community to commit to marine conservation. This pride broadens and strengthens a sense of belonging and ownership that eventually enhances trust building and creates keenness and positive receptiveness among key stakeholders. In this particular case, there was community pride in their efforts to establish, grow, and sustain the initiative in spite of limited funds. This demonstrates how the importance of empowerment is magnified when resources are limited.

The Bukan Sekedar Pasiar (BSP) Community from Case Study 32 (Appendix 1) provides another good example. The youths who were the main drivers of community-based tourism (developed as a tool for species and coastal ecosystem conservation in East Nusa Tenggara Province of Indonesia) comprised individuals from different backgrounds, such as academia (students/fresh graduates from local universities), influencers (local celebrities: models, singers, makeup artists), local businesses, religious groups, and local fishermen and farmers, including young people with justice system involvement. They are all very proud of their hometowns / islands, and have worked together for years without significant conflict. Up until the submission of this article, the BSP community was still active as youth ambassadors for conservation efforts in their province, two years after the official project ended.

Needs related to resources. All the needs discussed above require resource support. Funding was an issue raised consistently by many workshop participants. CBM priorities occasionally shift and long-term commitments (such as funding) are very limited. With advances in communication technology, some aspect of support can increasingly be provided remotely, such as through a network. Networking is also about building coordinated efforts for more efficient and cost-effective CBM implementation, especially for large-scale or long-term projects/programs (such as ecosystem-based management, monitoring data networks, etc.), in which multiple bridges may be required within or between organizations. In addition we believe, as argued by Berkes (2009), that joining problem-solving and reflection are essential to

Detailed Case Study 2: Independent CBM

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Kelab Alami (Case Study 9, Appendix 1) is an independent community organization that has been working to empower and enable local fishermen in Mukim Tanjung Kupang, Johor, Malaysia since 2008. Founded by a local community member, Shalan Jum'at, who held the vision and ability to navigate local politics and other issues, Kelab Alami was able to sustain itself with the help of scientific and other advisors who assisted in sourcing funding and access, and provided other support. While this organization began its journey teaching local youths about the importance of their natural habitats and equipping them with citizen science and tour guiding skills, Kelab Alami's goals and methods switched to focus on the fishermen because of escalating development and several other social issues. Today, the organization is recognized for its homegrown efforts to help its community in the face of irreversible change and development. The 'bridge' in this case study was provided by Shalan Jum'at's partner, the co-founder who serves as the organization's English voice, fund-raiser and government liaison. Kelab Alami's success comes from this collaboration between the local champion and his network of external support and facilitation.

Similar cases were identified in Tejakula and Kubu sub district, Bali (Case Studies 15, 23, and 24, respectively, Appendix 1). The Local Marine Protected Areas in the sub-districts were initiated almost 20 years ago as collaborative efforts. The bridges in these cases were mainly local NGOs with limited resources, as well as passionate local champions like Made Merta and Nyoman Sugiarta (Les and Bondalem village, Tejakula sub-district), and Nyoman Suastika (Tulamben village, Kubu sub-district). The communities continue their work today and ensure that the relationship established with the NGO bridges is well maintained.

Self-determination of local champions and effective bridges are key to successful, independent CBMs. However, there remains an issue of how well this kind of CBM will evolve if their local champions are no longer involved.

maturing CBM. We identified several networks and platforms that can hopefully support CBM implementation (see the next sections).

Only two of the case studies presented were of relatively independent community and local champion efforts. They received limited financial support from various stakeholders such as NGOs, government, and private sector donors, including the cost of attending the APCRS. Nevertheless, this support was not deemed part of an organization's long-term umbrella program (Case Studies 9 and 15, Appendix 1). We identified at least three other independent projects whose abstracts were accepted but could not be presented, due to a lack of funding to attend APCRS (Case studies 23, 24, and 32, Appendix 1). Independent CBMs are often overlooked in the CBM analysis; thus, their study has been limited. Nevertheless, their contributions to management are significant despite their resource limitations. Their experiences are crucial to further strengthen our understanding of how to build more efficient CBM, and of best practices in natural resource management.

In summarizing the needs of an effective bridge, we find that the key themes identified by the workshop echo those by Ceptureanu et al. (2018). In that study, the authors analyzed analyzed factors affecting the sustainability of CBM, both from literature reviews and from interviews with 188 individuals from 54 community-based organizations and 134 other non-profit organizations. The top ten

factors contributing to sustainability were mostly related to the process (program champion, community participation, staff involvement and integration, responsivity, community capacity, understanding the community), quality (coordinator competence), and resources (specifically program funding, organization stability).

White et al. (2022) analyzed CBM through the 'NGO's actions in performing its role as a bridge in Raja Ampat, Indonesia. They identified nine categories of bridging tools (in no particular order), including advice, community engagement, co-production of knowledge (producing context-specific knowledge through a dynamic and interactive process), knowledge diversity (integrating different knowledge systems and perspectives), adaptation (facilitating communities and governments in adapting to the unique circumstances or during unexpected changes), exposure (include community exposition), access to resources (funding), as well as link and connection (networking). As with Ceptureanu et al. (2018) and the findings presented here, the first four of these categories were related to process.

Effective Bridging Tools

The workshops revealed (from a discussion of point 5 in the methodology section) 13 valuable tools that supported CBM implementation. They were divided into 1) lessons learned and communication networks, 2) data sharing networks, 3) lessons learned and capacity building networks, and 4) knowledge / information applications.

There were two grassroots networks identified: The LMMA International and Reef Check Indonesia Network (RCIN) learned. LMMA International is a CBM network dedicated to advancing locally-led natural resource management in the Indo-Pacific. Its members are stakeholders who use or plan to use people-centered LMMA approaches. It is governed by a Council made up of representatives from its Country Networks, and membership registration is available on-line through its website (lmmanetwork.org).

The RCIN is an informal network of Reef Check survey[5] practitioners in Indonesia, where members discuss lessons learned and share communication about Reef Check surveys and their applications in CBM through a WhatsApp group and mailing list. As CBM issues are very broad, the network also becomes a source of information on other related knowledge, such as proposal openings, scholarships, potential sponsorships, and training and workshop updates. Membership is open to anybody, including the community, bridges, and policymakers. Requests to join the group can be sent by email to rcindonesia@reefcheck.org.

With the higher frequency, extent, and severity of coral bleaching, RCIN became the backbone of the Coral Bleaching Indonesia Network (CBIN). The CBIN is a network of bleaching observers activated during (potential) bleaching seasons. Membership is open. Anyone may report reef conditions from anywhere in Indonesia, and data can be as simple as whether the reef is bleaching or not, to more detailed information such as percentage dead, species bleached, and other indicators of interest.

Another simple way actors can contribute to data sharing and increase the understanding of coral reefs, bleaching and climate change, is through CoralWatch, a non-profit organization that developed the Coral Health Chart in 2002. The chart standardizes changes in coral colors and provides a simple way for people to quantify coral health and contribute to the CoralWatch global database. The Coral Health Chart can be

[5] Reef Check survey is a global ecological monitoring methodology. It is managed internationally by Reef Check Foundation International based in California, but has chapters and foundations worldwide that support its implementation elsewhere. More info at www.reefcheck.org

used by anybody and has been extensively used throughout the Indo-Pacific since its release. The tools are available at the website coralwatch.org.

For a more detailed and advanced analysis of coral reef data globally, two on-line information and data-sharing tools, ReefCloud and Allen Coral Atlas, were identified as providing platforms for collaborating on and supporting informed management of coral reefs globally. ReefCloud harnesses the power of human collaboration and artificial intelligence, providing an open-access platform for coral reef monitoring where users can fast-track analyses of benthic imagery with the help of machine learning around 700 times faster than humans, saving time and funding. This pipeline helps standardize data collection and analysis, aiding in interpreting, reporting, and communicating coral reef health between communities, NGOs, government, scientists, and citizen scientists locally and globally. With the help of ReefCloud, anyone with an underwater camera and basic photography skills with access to their local coral reef can collect and contribute to understanding the health of their coral reef ecosystem. Users can sign up and start annotating data through the data portal found at reefcloud.ai.

The Allen Coral Atlas maps the world's coral reefs and monitors their threats to provide actionable data and a shared understanding of coastal ecosystems. It utilizes high-resolution satellite imagery and advanced analytics to map and monitor reefs in unprecedented detail. The data is validated by field data collected by scientists and coral practitioners. The results are open access at allencoralatlas.org. The Allen Coral Atlas also has a mailing list for product updates and bleaching alerts. Interested parties can register through the website. Coral reef monitoring

Detailed Case Study 3: Network sustainability

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A network is usually designed to run beyond the cycle of the project which led to its development. Therefore, funding is usually limited or non-existent to sustain its operation. As a result, a lot of strategic networks have stopped operating or become stagnant. Despite this, the RCIN (Case Study 20, Appendix 1) and CBIN networks have continued without a dedicated budget and lasted for several decades. The recipe for their success seems to be that they comprised parties with similar interests: the need to access and gather monitoring data from a vast geographical area. Further to this, cross-subsidies such as those from Reef Check Ecodivers (Reef Check commercial certification by the dive industry), and integration into more stable, long-term systems such as university curricula and co-sharing management with some government entities for CBIN contributed to their longevity. No one organization 'owns' RCIN, and while CBIN is managed officially by the government, both RCIN and CBIN are operating in a friendly manner, so that all members become part of a solid community, as is characteristic of Indonesian culture. The friendships gained through the relationships nurtured in these networks have helped keep them effective and sustainable. They also do not involve a sophisticated bureaucracy and, therefore, can be easily tapped for, or evolve into, another cause and project. For example, RCIN provided the backbone for the development of CBIN, with many of their members overlapping. The Asia Pacific CBM network that developed in the APCRS may also fulfill a similar role.

data quoted officially by the government at a global level is usually available at the Global Coral Reef Monitoring Network (GCRMN). Their regular reports can be accessed freely through their website: gcrmn.net.

Two other networks identified were for lessons learned and for capacity building. The first one concerns coral restoration and reef resilience. The Coral Restoration Consortium (CRC) is a community of practice comprising scientists, managers, coral restoration practitioners, and educators dedicated to enabling coral reef ecosystems to survive through active restoration efforts. Membership is free and open through a mailing list registration, available on their website (www.crc.world). They have five regional groups, including the Australia Regional Group, the Eastern Tropical Pacific Regional Group, the Latin American Regional Group, the Mesoamerican Regional Group, and the Middle East Regional Group.

The Reef Resilience Network is one of the oldest capacity-building networks and connects reef managers and practitioners with peers, experts, and the latest science and strategies. This network provides on-line and hands-on training and implementation support to increase capacity (and their network) to effectively manage, protect, and restore coral reefs and reef fisheries worldwide. Membership is available through a mailing list on their website: reefresilience.org. Training and discussions with experts are available regularly.

With advances in technology, it has become easier to access certain knowledge and scientific information through mobile phone applications or web-based platforms. Two highlighted during the workshop included iNaturalist and Corals of the World. iNaturalist is a social network of naturalists, citizen scientists, and biologists built on the concept of mapping and sharing observations of biodiversity across the globe. The application can be easily downloaded, and information on biodiversity can be shared, discussed, and stored via the website inaturalist.org.

Corals of the World provides an ideal starting point for coral identification. A web version of Veron's legendary coral identification book provides imagery and taxonomic ID resources freely available for anyone to access via coralsoftheworld.org. However, it should be noted that the field of coral taxonomy is extremely dynamic at this point, with DNA species determinations altering many of the previous identifications. Appendix 2 summarizes the tools discussed above. Note that the Asia Pacific CBM network, developed informally in this workshop, is also summarised in Appendix 2. The network focused on bridging communication related to CBM.

Conclusions

The information and lessons learned gathered from these case studies and workshops has reinforced the findings of other studies and publications, even though each case study presented at the conference was unique, as no single solution can fit all (Cinner et al., 2012-2 and Gurney et al., 2016).

While there have been other publications on the value, importance, and key qualities required of a 'bridge' in CBM, this study is distinctive in that it gathers the views and voices of the actual people on the ground, including the community. It was not written and analyzed in a top-down manner by scientists, academic researchers, or the government. Instead, the workshop participants co-created the content based on their experience and case studies. Discussions were multilingual, with translators where necessary, and this ensured that the content generated was true to its source. It also resulted in shared knowledge which is rich in the first-hand content and context that is often missed when collated as data and information by third parties.

One of the important results of this approach was the push from the presenters and participants to view different levels of management horizontally (Figure 1). For decades, we have used the 'bottom 'up' and 'top down' (vertical) approach, implying the community occupies the bottom level when considering management. The horizontal relationship gives a stronger sense of the importance of CBM in natural resources management. We believe that it is vital that the community, the bridge and the policymakers, are held, seen and respected as equal partners in any collaboration in natural resource management. This is particularly true for local communities, whether they are taking a community or a bridging role. Successful natural resource management will only be possible with local community input, involvement, buy-in, and equal partnership, from the very beginning.

The study has also shown that while some CBM and community networks have large sources of funding behind them, there are also cases of independent initiatives that rely on local champions and intermittent funding, yet consistently manage to reach their targets and further their cause. As information on independent CBM is limited, further research and study are required to understand the critical processes that allows for the initiation and the sustainability of such CBMs; such work would help improve CBM practice in general. Moreover, even though independent CBM provides powerful and inspirational examples, it frequently relies on key individuals or champions and, thus, is not necessarily resilient. We should identify means to strengthen independent CMB initiatives and support their long-term success.

This article and the case studies presented demonstrate local communities' great knowledge and experience of CBM. For more effective CBM implementation, further efforts are required to strengthen this type of investigation. In addition, more resources should be made available to local stakeholders, especially from independent CBMs, to enable them to share their stories and lessons learned at APCRS or similar events.

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References

Agarwal B (2009) Gender and forest conservation: The impact of 'women's participation in community forest governance. Ecol Econ 68: 2785-2799. https://doi:16/j.ecolecon.2009.04.025

Alvarez I, Lovera S (2016) New Times for Women and Gender Issues in Biodiversity Conservation and Climate Justice. Development 59: 263–265. https://doi.org/10.1057/s41301-017-0111-z

Brennan MA, Barnett RV (2009) Bridging Community and Youth Development: Exploring Theory, Research, and Application. Community Development 40: 305-310. https://DOI: 10.1080/15575330903279515

Barnes ML, Bodin Ö, McClanahan TR et al. (2019) Social-ecological alignment and ecological conditions in coral reefs. Nat Commun 10: 2039. https://doi.org/10.1038/s41467-019-09994-1

Berdej SM, Armitage DR (2016) Bridging organizations drive effective governance outcomes for conservation of Indonesia's marine systems. PLoS ONE 11: e0147142. https://doi.org/10.1371/journal. pone.0147142

Berkes F (2009) Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. J Environ Manage 90: 1692-1702. https://doi.org/10.1016/j.jenvman.2008.12.001

Brown D (2009). The Effectiveness of Non-Governmental Organizations (NGOs) within Civil Society. International Studies Masters. Paper 75. https://fisherpub.sjf.edu/intlstudies_masters/75

Ceptureanu SI, Ceptureanu EG, Luchian CE, Luchian I (2018) Community-Based Programs Sustainability: a multidimensional analysis of sustainability factors. *Sustainability* 10: 870. https://doi.org/10.3390/su10030870

Cinner JE, Marnane MJ, McClanahan TR (2005). Conservation and community benefits from traditional coral reef management at Ahus Island, Papua New Guinea. Conserv Biol 19: 1714–1723. http://www.jstor.org/stable/3591193

Cinner JE (2007) Designing marine reserves to reflectone local socioeconomic conditions: lessons from long-enduring customary management systems. Coral Reefs 26: 1035–1045. https://doi.org/10.1007/s00338-007-0213-2

Cinner JE, McClanahan TR, MacNeil MA, Graham NAJ, Daw TM, Mukminin A et al. (2012) Co-management of coral reef social-ecological systems. Proc Nat Acad Sci 109: 5219-5222. https://www.pnas.org/doi/abs/10.1073/pnas.1121215109

Cinner JE, Basurto X, Fidelman P, Kuange J, Lahari R, Mukminin A (2012) Institutional designs of customary fisheries management arrangements in Indonesia, Papua New Guinea, and Mexico. Mar Policy 36: 278–285. https://doi:10.1016/j.marpol.2011.06.005

Denton F (2015) Climate Change and Conflict: The tail wagging the dog or new, cascading tensions and inequalities? UN Chronicle 52: 79. https://www.un.org/en/chronicle/article/climate-change-and-conflict-tail-wagging-dog-or-new-cascading-tensions-and-inequalities

Gurney GG, JE Cinner JE, Sartin J, Pressey RL, Ban NC, Marshall ND, Prabuning D (2016). Participation in devolved commons management: Multiscale socioeconomic factors related to individuals' participation in community-based management of marine protected areas in Indonesia. Environ Sci Policy 61: 212-220. https://doi.org/10.1016/j.envsci.2016.04.015

Gutiérrez N, Hilborn R, Defeo O (2011). Leadership, social capital and incentives promote successful fisheries. Nature 470: 386–389. https://doi.org/10.1038/nature09689

Hill R, Walsh F, Davies J, Sandford M (2011) Our Country Our Way: Guidelines for Australian Indigenous Protected Area Management Plans. Cairns: CSIRO Ecosystem Sciences and Australian Government Department of Sustainability, Water, Environment, Population and Communities. https://publications.csiro.au/rpr/download?pid=csiro:EP178808&dsid=DS2

Jupiter SD, Cohen PJ, Weeks R, Tawake A, Govan H (2014). Locally-managed marine areas: multiple objectives and diverse strategies. Pacific Conserv Biol Vol 20: 165–179.

Mahajan SL, Jagadish A, Glew L, et al. (2021). A theory-based framework for understanding the establishment, persistence, and diffusion of community-based conservation. Conserv Sci Practice 3: e299. https://doi.org/10.1111/csp2.299

Marshall PA, Dowd AM, Luder C, Maynard JA, Beeden R (2015) A Reef 'Manager's Guide to Fostering Community Stewardship. IUCN, Gland, Switzerland. https://portals.iucn.org/library/efiles/documents/2016-052.pdf

Mazzocchi F (2006). Western science and traditional knowledge: despite their variations, different forms of knowledge can learn from each other. EMBO Reports 7: 463-6. https://doi:10.1038/sj.embor.7400693. PMID: 16670675; PMCID: PMC1479546

United Nations Sustainable Development Group (UNSDP) (2022) The 5Ps of the SDGs: People, Planet, Prosperity, Peace and Partnership. United Nation. https://unsdg.un.org/latest/videos/5ps-sdgs-people-planet-prosperity-peace-and-partnership

White CM, Mangubhai S, Rumetna L, Brooks CM (2022) The bridging role of non-governmental organizations in the planning, adoption, and management of the marine protected area network in Raja Ampat, Indonesia. Mar Policy 141:105095. https://www.researchgate.net/publication/360686000

Wondolleck JM, Yaffee SL (2000) Making Collaboration Work: Lessons from innovation in natural resources management. Island Press, Washington DC.

Chagos island shore – see article page 21 (photo by Anne Sheppard)

UNFCCC CONFERENCE of the PARTIES 29

ICRS @ COP29

Advancing Coral Conservation Policy at Baku

The International Coral Reef Society (ICRS) was present at the 29th Conference of the Parties (COP29) in Baku, Azerbaijan (November 11–22), bringing critical attention to the state of coral reefs as over 65,000 world leaders, decision-makers, private sector organizations, and civil society members gathered. The ICRS delegation, consisting of Dr. Raquel Peixoto and Dr. Mariana Rocha de Souza, actively participated in multiple high-level discussions, to emphasize the urgency of coral conservation and to highlight successful strategies for reef resilience.

ICRS hosted three key panel discussions, each addressing different aspects of coral conservation. One of these events took place at the Ocean Pavilion, where experts and young ocean advocates shared success stories in ocean and coral conservation. The session titled: **'Ocean Optimism in Action: Success Stories and Strategies for Marine Conservation'** explored impactful initiatives, highlighting essential factors that contributed to their success, from community engagement to technological innovations. With a focus on 'ocean optimism,' the discussion empowered attendees by showcasing effective conservation strategies and the importance of collaboration, scientific advancements, and youth activism in protecting marine ecosystems.

The panel featured Dr. Raquel Peixoto (KAUST & ICRS), Dr. Mariana Rocha de Souza (University of Hawai'i & ICRS), Dr. Kalina Grabb (Woods Hole Oceanographic Institute), Dr. Valeria Pizarro (Perry Institute), and Joe Nagera (Climate Change Youth Advisory Group, New Zealand). The event concluded with final remarks by Ambassador Peter Thomson, the United Nations Secretary-General's Special Envoy for the Ocean, who reinforced the critical role coral reefs play in nature-based solutions for both climate mitigation and for adaptation. He stressed that while coral reefs are often overlooked at COP, they provide invaluable ecosystem services that must be integrated into global climate policies.

Panelists at the event led by ICRS in the Ocean Pavilion at COP29. Left to right: Joe Nagera (Climate Change Youth Advisory Group, New Zealand), Kalina Grabb (WHOI), Mariana Rocha de Souza (ICRS), Ambassador Peter Thomson (the United Nations Secretary-General's Special Envoy for the Ocean), Raquel Peixoto (ICRS), and Valeria Pizarro (Perry Institute).

ICRS also led an event in collaboration with *Care About Climate* at the U.S. Center, titled **'Youth Leadership in Ocean Conservation: Protecting Coral Reefs and Marine Ecosystems.'** This session explored the urgent need to safeguard coral reefs, through the lens of young leadership in ocean policy. Featuring a panel of emerging youth leaders and coral experts, the discussion highlighted the latest scientific findings and the role of youth in policy development.

The event opened with remarks from Dr. Susan El-Gharabawy of IOC-UNESCO, and featured panelists including Lauren Gibson (NOAA Advisor on Youth Engagement), Dr. Mariana Rocha de Souza (University of

Hawai'i & ICRS), Dr. Raquel Peixoto (KAUST & ICRS), and Renee Smith (Environmental Officer, Ministry of Climate Resilience, The Environment & Renewable Energy, Grenada).

ICRS also partnered with the Green Economics Institute (GEI) as the lead applicant for a joint official UN COP side event titled **'Ticking Clock – Climate Change Accelerating: Diverse, Inclusive, Universal Cooperation Together.'** This discussion focused on addressing climate change by harnessing the combined power of biodiversity, human collaboration, and global cooperation. We presented a call to action, co-organized by ICRS together with several other scientific societies, that featured an unprecedented joint publication across 14 scientific journals. This initiative, on the urgent deployment of microbial solutions to mitigate the causes and consequences of climate change, was highlighted as an example of an ambitious, clear, and collaborative framework, aiming at urgent action (more information here). ICRS suggested that similar science-based initiatives should be promoted for other solutions that hold the greatest promise for quickly mitigating the causes of climate change. We emphasised the need for coordinated activities involving different stakeholders to apply and upscale these solutions. We also reinforced the need for local communities to co-develop and deploy local solutions and be active players in protecting coral reefs. The conversation emphasized the urgency of implementing the Paris Agreement and also highlighted strategies for a sustainable future.

Panelists at the event led by ICRS at the US Center at COP29. Left to right: Lauren Gibson (NOAA), Raquel Peixoto (ICRS), Susan El-Gharabawy (IOC-UNESCO), Renee Smith (The Environment & Renewable Energy, Grenada) and Mariana Rocha de Souza (ICRS).

Speakers included Professor Graciela Chichilnisky (USA and Argentina), Professor Ehtisham Abassi (Morocco and India), Dr. Aaron Sternizky (Austria), Miriam Kennet (UK, Director of The Green Economics Institute, remotely via Teams), Professor Raquel Peixoto (President of the International Society for Microbial Ecology (ISME), and ICRS and KAUST, Saudi Arabia), Dr. Mariana Rocha de Souza (ICRS & Hawai'i Institute of Marine Biology), Jean Felix Ebo'o (Cameroon, Association Club Amis de la Planète), Enkhbayar Shagdar (ERINA Renewables Network across Asia, Japan and Mongolia), and Gunel Omahony (Azerbaijan).

ICRS also attended an invitation-only meeting with Dr. Rick Spinrad, who was the head of NOAA before the new US administration appointed his successor. The discussion focused on the uncertainty of the coming years and on efforts to institutionalize mechanisms to ensure that youth and civil society maintain an open channel with NOAA. Dr. Spinrad noted that these efforts have largely been informal and dependent on the administrator's willingness to persue thyem, making them unlikely to continue under the next administration.

Virtual Participation

Attendance at COP in person is often limited by the number of available places (or badges), and this year ICRS was allocated only badge per week. This, coupled with the high costs of travel, meant that in-person attendance was very restricted. However, ICRS expanded its participation by offering virtual badges to several members. These online badges allowed early-career scientists, many of whom had never attended a COP before, the opportunity of engaging with the conference and following key

events and negotiations virtually. These virtual participants included ICRS Student and Early Career Chapter (SECC) Steering Committee members Serena Hackerott (University of Delaware) and Jenna Dilworth (University of Southern California). To further enhance this opportunity, ICRS collaborated with organizations such as Woods Hole, Scripps Institution of Oceanography, and the wider RINGO consortium, to secure additional virtual badges, enabling more participants to attend COP. While the online experience may not replicate in-person engagement, many participants were eager to learn about the COP process, negotiation structures, and related topics. This provided a valuable opportunity for those interested in understanding and engaging with the conference, even if only remotely.

In addition to participating as an ICRS representative virtually, the Secretary of the ICRS SECC Steering Committee, Dr. Serena Hackerott, presented her post-doctoral research in a Global Ocean Forum Virtual Ocean Pavilion event titled 'Oceans of Innovation: Leveraging Technology for Ocean Biodiversity and Community Empowerment.'

COP29 Outcomes and Challenges

The main substantive outcome of COP29 was named the **Baku Climate Unity Pact**, comprising:

- **New global climate finance goal** – The pact calls on "all actors" to raise at least $1.3 trillion per year, with developed countries leading the mobilization of at least $300 billion, by 2035. The decision also references development finance reform, public funding, enhanced access, and reporting mechanisms. A **"Baku-Belem Roadmap to 1.3T"** was launched, in order to scale up finance in 2025.
- **Mitigation work programme** – This decision identified technical options for reducing emissions in cities and encouraging collaboration between governance levels. During 2025 a digital platform will be developed to facilitate information exchange on mitigation actions.
- **Global goal on adaptation** – Countries provided instructions to technical experts working on indicators for measuring progress toward global resilience. The decision builds upon previous UNFCCC adaptation efforts, launching a **Baku Adaptation Roadmap** and establishing a high-level dialogue.

However, it was evident that major challenges remain:

- **Lack of a Clear Commitment to Phasing Out Fossil Fuels** – Despite pressure from Brazil and other nations for stronger language to be used, the final agreement avoided a direct call for phasing out of fossil fuels, using instead vague terms that will allow continued fossil fuel use.
- **Challenges in Climate Finance Implementation** – While the new finance targets are a step forward, enforcement mechanisms and clear pathways for fund distribution both remain unclear, leaving vulnerable nations uncertain about how and when financial support will materialize.

Conclusion

COP29 delivered progress in strengthening ocean representation in climate discussions and advancing climate finance goals. Yet it fell short of securing a firm global commitment to phasing out fossil fuels. The lack of clear implementation pathways for financial commitments remains a major challenge.

ICRS remains committed to ensuring that coral reef conservation remains central to global climate discussions and, most importantly, global climate action. Our society will continue advocating for policies that integrate coral reefs into adaptation and mitigation strategies, strengthening collaborations between scientists, policymakers, and communities. Looking ahead to COP30 in Brazil, ICRS will push for more ambitious commitments, particularly in securing concrete actions that can safeguard coral reefs – since they are one of the planet's most vulnerable yet essential ecosystems.

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Page 57: scenes from COP29


YOUTH LEADERSHIP AND EXPERT PERSPECTIVES
ON THE FUTURE OF CORAL REEFS


COP29 ocean 2024


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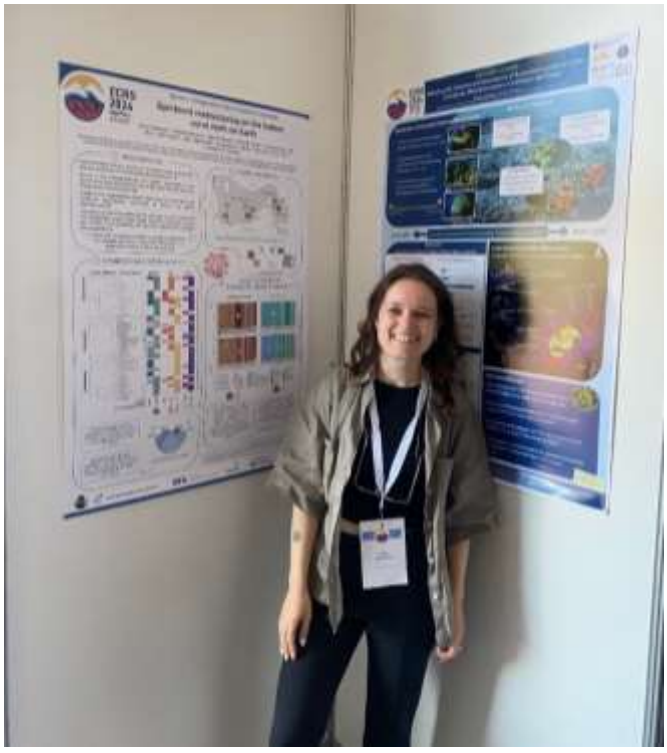
ECRS 2024: Pizza, Pasta and Coral Science

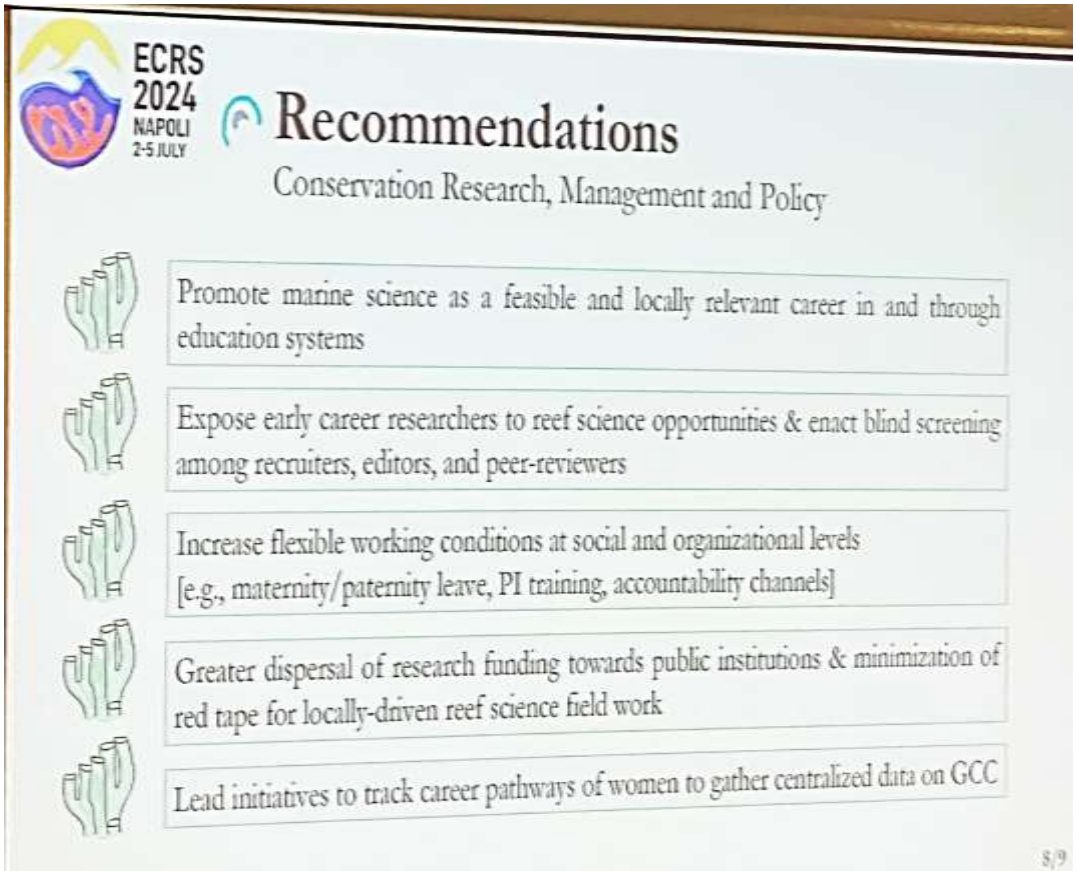
Located in the city of Naples, in the south of Italy, the recent European Coral Reef Symposium (ECRS) was spiked with a Mediterranean flair that is hard to capture into words. Renowned for its pizza and (if you know where to look; thank you, TikTok) cheap Aperol Spritz, Naples is a vibrant city with bustling streets that remain lively even after dark. Nestled in the outskirts of Naples, in the harbor of Bagnoli, lies the *Città della Scienza*, a spacious scientific complex where the gathering of around 700 coral scientists from various geographic locations took place in July 2024. Throughout the city, the imposing silhouette of Mount Vesuvius looms, visible from numerous vantage points, serving as a constant reminder of Naples' geological significance. To enhance the conference experience, organizers implemented a user-friendly app, which proved to be an invaluable tool for navigating the 13 sessions, located in six different rooms, covering anything from coral reef ecology, to past and future perspectives, to coral reefs under a socio-economic perspective.

The talks were organized as either regular talks or speed talks (regular talks were ten minutes + two minutes for questions; speed talks were five minutes + one minute for questions), and there were two poster sessions including drinks. Surprisingly, there were no sessions that went severely over time, as I had anticipated prior to the conference, when learning about the limited length of both regular and speed talks. Unfortunately, the speed talk scheme was not well suited for actual questions. Student talks, or talks on work that isn't yet published, benefited from the short time; but leaving only one minute for questions seemed very ambitious, since thirty seconds of this was necessarily taken up asking the question in the first place. Nonetheless, I was pleasantly surprised by some sessions that really made use of the short amount of time very effectively following both regular and speed talks. One other thing I personally appreciated about the conference was that it only lasted four days in total (3 + 1 workshop day) instead of your regular six days (5 + 1 workshops) - this made concentration much easier and the whole conference more manageable amidst everyone's other deadlines and projects.

Every morning there was a plenary talk, i.e. three in total, which were given by Dr. Marta Ribes, Dr. Sergio Rossi and Dr. Michael Sweet. Marta Ribes and Sergio Rossi both spoke about their research focussing on Mediterranean ecosystems, setting the stage for local communities and research groups. I for one enjoyed these talks and being able to get an insight into research that is often over-shadowed by the "big" topics concerning tropical coral reef ecosystems. Michael Sweet appealed to us and our conscience in his talk, though I found that a community of engaged coral scientists are not necessarily the people whom you need to convince to take action. Further, he used the opportunity to advertise products his lab has invented and sells to he undoubtedly does this out of real concern for the fate of our reefs, he is thereby transforming his knowledge into capital, and finding a niche in the market that in turn profits from coral reef degradation. I could not help but feel that this business model perpetuates the cycle of natural resource exploitation by treating the symptoms of environmental degradation without addressing the underlying, systemic causes. Looking at short-term



The author in front of her poster (left) at the poster session. Picture credit: Marlen Schlotheuber.



The recommendations from the talk by Amal Al Gergawi and Maryam Al Memari, both from NYUAD (New York University Abu Dhabi).

scales, Michael's approach will hopefully contribute to the restoration of degraded reefs. In the long term, however, it will not address the systemic causes of coral reef destruction, which are rooted in the capitalist mode of production. I would argue that real solutions to ecological crises require a fundamental transformation of societal relations to nature that goes beyond market-based approaches and aims for a sustainable, co-operative form of economy.

The first of my highlights from the conference was Andrew Baird's talk, "*Are currently available coral genomes correctly identified? A case study from the genus Acropora*". Genomes are an important resource for studying the genetic underpinnings of many areas of coral research, and through new technologies considerable advances have been made in the recent past. The same goes for taxonomic identification. Andrew managed, while including funny pictures and anecdotes, to give a broad overview of the challenges, and to describe where research is now at, as well as what is crucial for properly identifying corals for which reference genomes have been assembled and made publicly available. The talk was one of the best I have heard, not just because it is my own research area, but because he managed, with the little time he had available, to engage the audience and bring his point across, without the use of overly complicated graphs and figures. The many laughs from the audience made for a nice break from the end-of-all-coral-reef scenarios we were otherwise confronted with throughout the week.

In his talk in the session "*The Ocean Decade: The Science We Need for the Coral Reefs We Want*", Mark Vermeij touched on the Shifting Baseline Syndrome, which explains how, with ongoing environmental degradation at local, regional, and global scales, people's accepted thresholds for environmental conditions are continually being lowered. In the absence of past information or experience of historical conditions, members of each new generation accept the situation in which they were raised as normal. Mark detected this phenomenon in long-term spatial data from Curaçao, where, 40-years ago, the degree of coastal development was a strong predictor of coral reef cover. However, today, the patterns of development do not predict coral cover and newer methods do not account for once important factors. This trend eventually leads to a failure to recognise the most important factors in reef decline globally. This was particularly interesting because it seemed like something a boomer would tell me - a millennial - but actually resonated with me and, as far as I could tell, with a lot of the younger scientists in the room.

As my final highlight, Amal Al Gergawi and Maryam Al Memari from NYUAD emphasised the importance of diverse views and marginalized voices in shaping research efforts, as well as in minimizing parachute science and neocolonialism, in their talk "*The growing role of women in coral*

reef research in the Gulf Cooperation Council". Sadly, this was one of the least attended sessions, though I believe it would have benefitted everyone to hear from these two engaging women (see the recommendations in the adjacent figure).

The Voolstra Reef Genomics lab at the conference dinner. Picture credit: Trent Heydon.

There were of course plenty of social events which, some say, is the heart of a conference, since networking (i.e., meeting old and new friends, supervisors, students, and the like) can be just as important for research as the science itself. There was an icebreaker in the evening of the workshop day, and a so-called conference dinner on the second day of the conference, as well as guided tours of the dinner location and the nearby historical site of Pompeii. I participated in both the icebreaker and the conference dinner, talked to a lot of old and new acquaintances, and made some new connections as a result of which I managed to get to some talks that I would not have otherwise known about. The icebreaker was fun and the location in downtown Naples very nice. The dinner was in a beautiful location, but unfortunately quite expensive, so that sadly not everyone had enough money to be able to attend.

Despite the beautiful location and warm weather, there were some disappointments. The abundance of coffee was much appreciated during the long days, but the food was otherwise disappointing, especially considering Naples' renowned culinary reputation. Understandably, catering for such large events is quite the challenge, but I do think they could have offered more regional delicacies. The above-mentioned conference dinner, priced at a steep 95€ per person, was held in a stunning venue, which is likely where most of the money went, since the amount of food was minimal and even less good than that at the conference itself. Logistical issues plagued the event, workshops were supposedly full, yet then they weren't, which meant some people couldn't attend all events they would have liked to attend. Communication from the conference offices was slow and often non-existent. Perhaps most concerning was the event's environmental impact, with excessive waste generation appearing to contradict the claims of carbon neutrality.

Nevertheless, I am glad I was able to attend and that almost my whole lab was able to attend as well - it made for a nice little group outing. The talks were very interesting, the social events made for good networking, and the location was beautiful. And despite reservations about the organization, in the end it all came together very nicely, with only a few hiccups. The weather was great, and being able to travel to Naples by train from Konstanz (in southern Germany), and spend a few days there to explore the area, before and after the conference, was amazing. I made some very good connections and heard talks that gave me extra insight into my own research and triggered ideas to implement during the final stage of my PhD. In all I am grateful for the experience!

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RCUK 2024: Mince Pies & Coral Conservation

The 27th Reef Conservation U.K. (RCUK) conference was held on 30th November 2024 at the Zoological Society of London, U.K. This annual event was set up with the goal of connecting reef scientists, conservationists, and enthusiasts in the U.K. and offering a networking event for attendees to collaborate on issues relating to coral reef research. The event has grown over the last few decades and now includes shallow water and deep-water coral ecosystems, as well tropical coral reefs. We welcome attendees from all over the world and are proud of the diversity of both presentations and presenters that attend. RCUK has a fantastic, welcoming atmosphere with a tradition of Christmas jumpers and mince pies that is much enjoyed every year.

In 2023 we offered workshops on the Friday afternoon before the conference aimed at students and early career researchers. We continued this feature with over 40 participants enjoying the three workshops offered. Prof. Maria Beger ran an introductory workshop on Marxan and its use in finding conservation solutions. The Coral Conservation in the Overseas Territories (C-COT) working group held a meeting, linking representatives from the Caribbean UKOTs (UK Overseas Territories) with academics and regional collaborators based in the UK. Our third workshop was organised by the Early Career Ocean Professionals (ECOP) programme and focused on science communication and personal branding.

This year we had over 150 attendees who enjoyed 21 oral presentations from representatives of 14 different universities, two NGOs and a consortium of Caribbean coral reef stakeholders. We also had 28 posters and 2 fantastic plenaries given by Prof. Maria Berger of the University of Leeds and Dr. Rucha Karkarey from Lancaster University.

The event began with a tea and coffee mingle allowing friends to reconnect and catch up. After a welcome address from the organising committee, we had our first plenary given by Prof. Maria Berger began. She presented work on tropicalisation that she and her lab have been working on for the last decade. Range-shifting tropical species of coral and fish are moving poleward to high-latitude “refugia” reefs, where they are establishing marginal coral communities; but the expansion of endemic subtropical species could also explain the expansion of coral reefs in these areas. Prof. Berger took us through the benefits of conserving and managing these reefs, recommending dynamic protected areas using the spatial planning software Marxan, using Japan as an example. This keynote reminded the audience that even in the changing world we find ourselves in, we need to consider that every marine ecosystem is biodiverse, beautiful and provides resources and should be a conservation priority. Our first full session was on ‘Reef Ecology and Behaviour’. We had presentations covering the diversity of Caribbean ostracods, the reduction of shark residency on remote coral reefs in the Chagos Archipelago as a result of environmental stress, new software for streamlining BRUV videos, the role of predators in facilitating herbivory in the Lakshadweep Archipelago, and how coral restoration affects fish species composition and abundance in Indonesia.

The first coffee break allowed attendees to peruse the fascinating selection of posters. They covered a wide range of topics from the chemistry of coral reefs (CCA dissolution, sediment fluxes and budgets, and coral calcification), through seagrass meadows, and molecular research (coral heat stress proteomics, studying coral bleaching at the molecular level, and the metabarcoding of microeukaryotes), to coral reef health and disease. Other posters covered emerging technologies being

The RCUK organising committee. Left to right: Michelle Taylor, Louise Anderson, Ines Lange, Coretta Granberry, Ben Williams and Emma Levy.

employed to better understand topics like endolithic sponge bioerosion. As might be expected, several of the poster presentations focused on climate related effects - coral community range shifts, functional reassembly of mollusc communities, and the limited potential for tropical coral range expansion. We also had a number of posters on fish behaviour, the link between seabirds and coral reefs, and coral survivorship and conservation.

The next session was on 'Reef Conservation'. Presentations covered the use of artificial reefs as a fishery management tool as well as the role of herbivory in the success of coral restoration. A case study from Indonesia's Bunaken National Park showed that natural reef recovery is still limited even decades after blast fishing was prevalent. Two presentations looked specifically at marine protected areas - one using spatial planning to identify priority sites, the other focused on the benthic categories currently included in marine protected areas. The final presentation brought in fisher perceptions of shark sanctuaries using the Maldives as a case study.

Our second plenary was given by Dr. Rucha Karkarey who presented work she has been involved with for over a decade, based on the remote Lakshadweep archipelago in the Indian Ocean. Her work there focused on a case study of squaretail grouper spawning aggregations and showed that place-based ecology is as important, if not more so, than global studies. Her original plan to identify universal principles of spawning had changed subtly and profoundly over the last 10 years as she engaged with the islands of Lakshadweep and their people. Place-based ecology recognises the extraordinary, and focuses on the place, not the study site. The audience was enthralled by the concept of primacy of place, and how we need to adjust our approach in order to conserve the unique, un-universal locations we have the privilege of visiting and studying as coral reef scientists.

The third full session of the day was a 'Coral Pick n Mix' and covered topics on everything ranging from the genomics of deep sea octocorals to the use of probiotics for enhanced coral settlement and survivorship to the contributions of sea urchins to reef bioerosion. The session concluded with representatives from the Coral Conservation in the Overseas Territories (C-COT) working group considering how to identify key priority work areas and promote academic partnerships and collaboration, and showcasing the benefits of such work to both U.K. overseas territories (UKOTs) and U.K. research institutions.

The final session was entitled 'Reefs in a Changing World'. The first two presentations focused on the effect of heat stress on cnidarian-dinoflagellate symbiosis and on breeding heat tolerant coral. Then we were given a presentation on the UKOT's first live coral biobank, which is being used to preserve the genetic diversity of corals and create community connections. The final presentation of the day covered how coral abundance is changing across the tropical and temperate reefs of Japan.

Finally, it was time for the Student Prizes. This year the top two awards in each category were agreed unanimously. The best student presentation was awarded to Filippo Varini from Imperial College London, who presented new software used to track sharks and rays to streamline the process and dramatically reduce researcher time. The runner up was Morven Rae-Seaman from the University of Leeds, who presented on using regional spatial planning to identify priority sites for conservation in order to aid in achieving 30% protection by 2030. The best student poster prize was awarded to Orlando Timmerman from the University of Cambridge, who presented an eye-catching poster on the use of data and machine learning to map the future of reefs as a way to scale up coral conservation. The runner up was Sera Maserati from Padjadjaran University in Indonesia, who produced a beautiful poster looking at how butterfly fish behaviour is impacted by coral restoration.

The conference concluded with a drinks reception in the "tiny giants exhibit" within the zoo. As is traditional, with mince pies served the attendees spent a pleasurable two hours discussing the presentations of the day before heading off to the pub! Thanks to all the attendees and committee members who have made this conference such a success over the last 27 years. We look forward to seeing you all next year. If you are interested in being involved in RCUK, please contact us at www.reefconservationuk.org.

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Scenes from the 27th Reef Conservation United Kingdom (RCUK). Clockwise from top left: attendees in the main lecture theatre at London Zoo. Student presentation winners Morven Rae-Seaman (runner up) and Filippo Varini (winner). Best student poster - Orlando Timmerman. Runner up student poster - Sera Maserati.

The 27th Reef Conservation United Kingdom (RCUK) meeting will be in Bangor, North Wales, on 6th December 2025 – see www.reefconservationuk.org.

The New Nyinggulu (Ningaloo) Reef Research Station (Western Australia)

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The Minderoo Exmouth Research Laboratory (MERL), located on the impressive Nyinggulu (Ningaloo) Coast near the North-west Cape of Western Australia, has, since its opening in September 2021, emerged as a major institution pursuing marine research and conservation within the Indian Ocean. Equipped with cutting-edge technology and a dedicated team of researchers, the research station is, despite its remote location, at the forefront of addressing challenges related to ocean health and resilience.

In its first two years of operation, the MERL has achieved significant milestones, contributing to the understanding and preservation of the region's marine ecosystems. In summary it has

a) Established 27 research partnerships across 20 institutions, fostering collaboration and knowledge exchange. This collaborative approach is ensuring a multidisciplinary perspective on marine research, combining expertise from various fields.

b) Been awarded Aus $2 million in research grants and nearly Aus $500,000 in in-kind funding to support innovative research activities. These funds have enabled scientists to explore new frontiers and develop new solutions for addressing challenges in ocean conservation.

The laboratory offers state-of-the-art facilities, including a unique capability to simulate accurate ocean conditions, and has, as a result, achieved high-quality research outcomes. With an advanced capacity for filtering large volumes of seawater and maintaining precise temperature control, the laboratory provides an ideal environment for revealing new information about the effects of climate change and ocean acidification on species health and biodiversity. The multifactor experimental room is equipped with 27 x 50 litre aquaria, housed in temperature-controlled water baths, allowing tank temperatures to be maintained at ± 0.25°C of any required value between 22°C and 36°C, permitting a 3 x 3 x 3 design. Each aquarium is equipped with an in tank wavemaker and also has, situated above it, an Orphek Atlantic V4 light that van be programmed to follow specific light regimes as required.

Work on the selective breeding of corals

There is also an on-site molecular facility that has DNA extraction, quantification and amplification capabilities, being equipped with a PCR thermal cycler, dissecting and compound microscopes, and -80°C storage freezers. In addition to these facilities, the laboratory offers support for fieldwork over most of the northern part of the Nyinggulu (Ningaloo) Reef down to Coral Bay through its two vessels. There is also family friendly accommodation available less than 2km from the laboratory.

With these advantages MERL has supported a diverse range of research projects, ranging from a study of the thermal resilience of sea grass species, through an investigation of the population dynamics of Tiger Sharks in the Exmouth Gulf, to work on coral taxonomy undertaken to discover species new to science. The facility has also enabled the first selective breeding of Nyinggulu (Ningaloo) corals as a pre-emptive response to the impacts of climate change. Principal Researcher, Kate Quigley, at the Minderoo Foundation, led a team of international researchers during the annual mass spawning event. The team successfully employed an assisted gene-flow method in order to crossbreed corals of various environmental tolerances, yielding heat resilient coral larvae to be trialled in the aquaria facility. This project will continue to run at MERL over a series of spawning seasons[1].

In another project sea snake researchers (see picture to left) have been investigating the population connectivity of the Western Australian population of sea snakes within the Exmouth Gulf. In particular the work aims to assess the conservation status of cryptic sea snake species found in the region. The team are using several different methods including activity and passive acoustic telemetry and eDNA to obtain key ecological information about seasonal habitat use, distribution patterns and the impact of the area's prawn trawl fisheries. The findings from this collaborative project will be used to inform the conservation of these species[2].

Cooperative partnerships with the local tourism industry and local environmental management bodies have enabled the laboratory to have a positive impact on the local community. A co-designed project has led to researchers using eDNA techniques to study the occurrence and distribution of Irukandji jellyfish on the Nyinggulu (Ningaloo) Reef. Irukandji jellyfish pose a major threat to swimmers in the region, with Parks and Wildlife receiving annually multiple reports of injuries often resulting in hospitalisation. Findings from this project will be used to inform management of peak periods in the threat of jellyfish stings at tourism hotspots[3].

The establishment of the facility has it made possible to undertake cutting-edge marine research on the remote Northwest coast of Western Australia. MERL is proud to offer its services to scientists worldwide, so as to support biodiversity conservation and ocean resilience. To apply to make use of the facility please find and complete our EOI form at:

Sieving coral spawn

https://www.minderoo.org/minderoo-foundation-exmouth-research-laboratory/.

Follow us on social media. Twitter @ExmouthResearch. Facebook @ExmouthResearchLab.

1 https://www.abc.net.au/news/2023-04-27/ningaloo-reef-coral-crossbred-for-greater-heat-resilience/102261042
2 https://www.abc.net.au/news/science/2023-11-11/unravelling-the-sea-snake-mysteries-of-exmouth-gulf/103069248?sf270218340=1&fbclid=IwAR0ex5YO7UL-1adzi-9MCoock8D_VJOBHE6rX-oisSGKutyd2n4eDn8tFDQ
3 https://www.perthnow.com.au/technology/scientists-scan-ningaloo-water-for-deadly-irukandji-dna-c-10493256

The Coral Conservation Society

Breeding corals on the Caribbean coast of Mexico

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"The teeming life of the beautiful and complex ecosystems that are coral reefs can be saved, *given the will",* these powerful words, written by Professor Charles Sheppard planted the seeds of coral conservation in my heart.

When I first read his book, *Coral Reefs A Very Short Introduction,* in the summer of 2016, I was a volunteer with a small community-led reef restoration program in Akumal, Quintana Roo, on the Caribbean coast of Mexico. The Expedition Akumal project was at that time focused on using coral fragmentation to grow *Acropora cervicornis* in underwater nurseries. Soon however we were introduced to the importance of supporting coral genetic diversity through assisted fertilization, when project lead, Jenny Mallon, trained with Professor Anastazia Banaszak at the National Autonomous University of Mexico. In a 1-month intensive course hosted by the Coralium Lab, in partnership with Secore International, Jenny learned the importance of coral sexual reproduction for restoration and became enthusiastic to apply this new knowledge on Akumal's reefs. I was equally determined to support this mission. I returned to Mexico that summer armed with a microscope, funds (about US$5000 in Pesos and US cash), and a steadfast ambition to help Jenny achieve this new goal.

Among the debris and aftermath of tropical storm Franklin, Jenny and I shopped for mosquito netting and food containers from which to make spawning collection tents, plastic buckets to use as larvae rearing tanks, and many other low-cost and locally sourced supplies that we could use to help Akumal's corals in their summer reproductive season. We worked with local stakeholders and volunteer divers from the Akumal Dive Center, Operation Wallacea and the local community, and in Summer 2017 successfully monitored, collected and fertilized *Acropora palmata* larvae, utilising a room at the Hotel Akumal Caribe as a makeshift coral rearing laboratory.[photo Leona pouring coral spawn water] As far as we know, we were the first to collect *Acropora palmata* gametes from Akumal's coral reefs, and this experience afforded us all a unique sense of contribution towards coral conservation, which in my case motivated me to immerse myself further in the work.

With a vision to secure funds in Canada for raising awareness and for helping organizations around the world conserve coral, my family and I started a small non-profit organization in Canada - the Coral Conservation Society. The society is run by a handful of part-time volunteers, including our science advisor, Dr. Jenny Mallon, and my daughter, Melissa Kustra, an instructional designer who develops educational materials and videos for educational outreach. A large part of our work is completed by myself, drawing upon my background in data analysis and project management.

Leona spreading *Acropora palmata* spawn into multiple tanks

Leona Kustra and Jenny Mallon, in the half-constructed wetlab at Akumal

The following year in Akumal we supported Jenny in building an outdoor wet lab at the Hotel Akumal Caribe for use in future spawning seasons; and a good thing too, as the September 2018 *Acropora palmata* spawning event was much more abundant than expected in Akumal, and the team needed all the space that the lab had to offer. It was wonderful to see scientists from the UNAM and Secore International come to Akumal to collect the coral babies we had produced in our beach-side wet lab.

The physical presence of the lab also allowed us to share our work with the community. That summer, we coordinated outreach activities such as inviting a local children's group to the lab for an education presentation on coral spawning. Jenny gave talks in English and Spanish to students and to tourism sector workers, and we were able to show them some of the hands-on aspects of our work. My daughter painted a spawning coral logo for us with the words *Desove [Spawning in Spanish] 2018,* which we printed on stickers for the children and hotel employees, on t-shirts for the dive shop team who volunteered to monitor for and collect the spawn, and on cell phone waterproof cases for the captains. We designed informational table cards for hotel guests describing coral spawning and our assisted fertilization project. I volunteered in the Akumal coral lab as a research assistant, taking care of some of the less glamourous but equally critical jobs like scrubbing ocean cured tiles for coral larvae settlement and, my personal favorite, cleaning newly fertilized coral larvae of fatty waste through the night.

Since its inception, the Coral Conservation Society has contributed funds and equipment towards research on: coral calcification; deoxygenation on Caribbean coral larval settlement (described in a paper which I was invited to proof read); and low-cost benthic incubation chambers for in-situ community metabolism measurements (for which I fondly recall cutting triangles of heavy plastic that were to become the walls of the chambers). After purchasing dissolved oxygen HOBO loggers for calcification research in the Florida Keys, we watched in grief as the waters reached 38.4ºC that summer as a result of which the planned research had to be abandoned.

While the Society doesn't participate in year-round in water conservation work, we support various coral research by other NGOs via joint projects or by providing supplies if I am travelling near their locations. In years we are unable to do in-water work, we contribute to other coral conservation organizations, as in 2022 when we worked with the Turks and Caicos Reef Fund to have a coral nursery tree installed. We also provide logistical support to NGOs undertaking coral conservation work, and try to visit programs in person to connect with the teams and assess their needs. After visiting different restoration programs, we have been able to supply basic items they need, but may have difficulty purchasing in remote locations, such as spawning collection nets, marine epoxy, diamond saw blades, external hard drives, temperature loggers, and even a Gryphon saw for coral micro-fragmentation work.

Our "*Desove*" T-shirts, with our logo on the back, being – worn by team members

During my daughter's elementary school teaching years we gave presentations to students (Kindergarten to Grade 4) on coral conservation, with my daughter designing fun coral-related activity centres. Her class even wrote letters of

Acropora palmata spawning

encouragement to scientists that work with endangered corals, which were proudly hung on a noticeboard in the Akumal coral lab [photo: encouragement letters on bulletin board].

We created educational outreach materials like our 'How Corals Spawn' infographic and video, and most recently a quick guide for citizen scientists to help identify Caribbean coral, including a one-pager of 20 critically endangered Caribbean coral species designed for dive shops. We hope these resources (available on our web site www.coralconserve.org) help generate public interest in coral conservation. We also use social media tools like Instagram to raise awareness of the beauty of coral reef ecosystems and share important messaging on the urgency of coral conservation efforts.

Recently we were introduced to several citizen science methods that can be used by ecotourists and, thanks to a voyage organized by Dr. Adam Smith of Reef Ecologic, were able to witness the power of citizen science. We watched passengers learn about and become proficient in identifying numerous reef species they were previously unfamiliar with. These new citizen scientists contributed hundreds of research grade iNaturalist observations. iNautralist then feeds research grade observations into GBIF, the Global Biodiversity Information Facility, many of whose records have been provided by citizens that are engaged with and care about the health of our reefs.

We aim to bridge the gap between people who have a conservation heart and the scientists working hard to sound the alarm bells and intervene. We have seen firsthand that citizen science and conversation-oriented ecotourism offer meaningful involvement and hands-on contributions toward coral conservation. I am inspired by Dr. Austin Bowden-Kerby's Reefs of Hope paradigm, and how he has implemented this model at Fiji's Plantation Island Resort to engage the local community in coral rescue while offering visitors ways to be directly involved in conservation initiatives. Their BULA rescue nursery (BULA means 'life' in Fijian) of heat adapted corals is an inspirational call to action and marks a shift from pure restoration to a combination of rescue (local scale translocation) with population rejuvenation. Since time is quickly running out it will take a diverse community of scientists, businesses, NGOs, ecosystem stewards, and tourists - both locally and across borders - to rescue and restore the world's coral reefs.

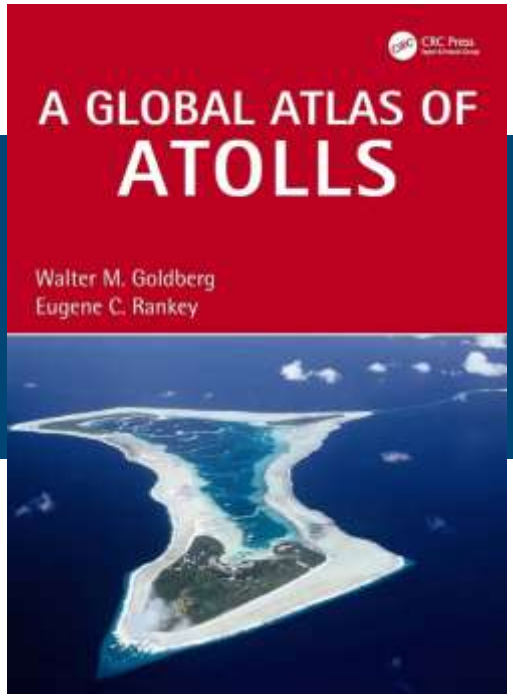
It has been an amazing journey from my initial reading of Professor Sheppard's words to the work I do now. I will continue dedicating time and energy to the Coral Conservation Society to raise public awareness of the pressing need to conserve corals and to support coral conservation NGOs and researchers. It's my dream that future generations will be able to see a healthy coral reef with their own eyes that really motivates our organization's efforts. Coral Conservation Society welcomes any new affiliates and collaborators.

Letters of support for the project (plus office assistant)

REEF SHELF

Four Hundred and Seventy-Six Compleat Reef Encounters (By Satellite): A Global Atlas of Atolls

By Walter M Goldberg & Eugene C Rankey, 2024, CRC Press, Taylor & Francis Group, Abingdon.- viii + 420 pp.
ISBN: 978-1-032-26246-8 (hbk). ISBN: 978-1-032-26247-5 (pbk). ISBN: 978-1-003-28733-8 (ebk)

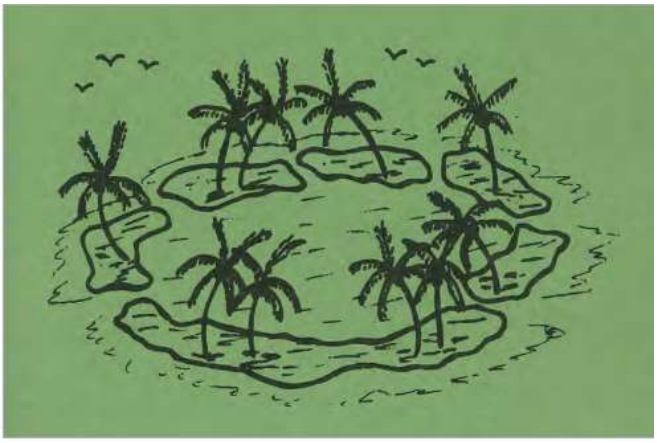


I was on an atoll - or rather I thought I was - when I first opened this book to review it, while staying on Bermuda. I then found that it is not mentioned anywhere in this 428-page long quarto-sized "compendium". It seems little has changed in this regard since Darwin (1842) reluctantly decided to omit Bermuda from his famous global reef map because he couldn't decide which of his three reef categories it belonged to. I have taken the liberty of provisionally deciding this for him (below).

Most of this book (Chapters 3-22) is organized as a gazetteer of 476 individual atolls, which, as people familiar with reefs will know, are tropical shallow-water coral-algal reefs, characterized in a descriptive sense by their annular shape, as seen in plan view at the ocean surface, and whose uppermost profile is like an irregular rimmed plate or saucer. In summary, the book provides relatively short descriptions of each atoll, usually less than a single page, accompanied by a topographic satellite image less than half a page in size. In this respect, the gazetteer approach makes this book essentially a reference work even though the authors have also intercalated much interesting extra information.

Of the authors, Walter M Goldberg is a biologist with the stated special interest on the formation, structure, and biochemistry of coral skeletons, with a broader interest in the biology of reefs and reef organisms. Eugene C Rankey is a geologist whose stated focus has been on the geological, chemical, physical and biological aspects of the oceans. While the book's contents in total reflect their expertise, their Preface emphasises the book's atoll-by-atoll account of physical features, and "reef communities" garnered" “from recently available satellite data."

But why just atolls, which in a reductionist sense are just one special kind of reef? They have unique and enigmatic annular shapes, a colourful contrast of white beaches, rolling surf, blue lagoons, bright sea, green vegetated islands, and beautiful reef life, though the shelter their lagoons offer for ships also masks their ship-wreck dangers. Their beauty and mystique have attracted the attention of travellers, navigators, explorers, naturalists, merchants, artists, and sea-faring people for centuries. Atoll fascination even spurred the founding of the eponymous *Atoll Research Bulletin*



The logo of the *Atoll Research Bulletin*, probably the oldest journal with a focus on reefs.

(https://smithsonian.figshare.com/arb). Also, as knowledge about them increased through the 18th-19th centuries, there was fascination, and even a need, to solve the enigma of what shaped them, why they are almost exclusively restricted to truly oceanic regions, rising abruptly from abyssal depths, and why they are generally located at great distances from each other and from continental mainlands.

Darwin (1842), though not the first to address these questions, did more to tackle them than any previous authors, by famously devoting his entire first book to showing how different kinds of reef could have developed from the same kinds of processes while also subjected to an overriding subsidence regime. In the right circumstances (he argued), this eventually results in the formation of atolls as a kind of end-point. It is a tribute to the enduring nature of Darwin's subsidence model that, over 180 years after he published it, the present authors use it to distinguish their "Darwinian atolls" (the subject of most of their book) from other kinds of "atoll structures" (pp. 8 ff, in Chapter 2). Darwin is always rightly associated in the public's mind, and that of most biologists, with his theory of evolution by natural selection, but his contribution to reef science has similar standing for reef specialists, both biologists and geologists, for which reasons ICRS's premier honour is the Darwin Medal.

Content and organization

The detailed organization of the book presents the reader with some puzzles. The title says it is an "atlas", so it is surprising that there are no maps which show the global distribution of atolls, notwithstanding the precedent set by Darwin himself, with his own famous and innovatively remarkable map (Plate 3 of Darwin 1842; see Stoddart 1995), and the many authors who have since followed suit. There is therefore no quick way of locating particular atolls or atoll regions and their global relation to each other within the book, nor to contexts like plate tectonics, hurricane / cyclone-prone latitudes and major ocean currents. These things have long been regarded as both geologically and biologically relevant to all reefs (not just atolls), especially now that we know more about how their biotas have varied through time, and because studies of present and past global patterns illuminate each other. Understanding these changes is important, not least at the present time when coral reefs are being subjected to, even destroyed by, rapid climatic and oceanographical changes.

In their Preface, the authors say that their use of "recently available satellite data", gives "unprecedented detail" of atolls, much of it, we learn from the introductory Chapters 1 and 2, derived from the *Allen Coral Atlas*. I therefore expected that atoll entries in the present *Atlas* would be accompanied by numerous remote sensing images showing (e.g.) the 18 categories of biotopes and habitats etc., as given in the three images of Vuladdore Atoll on p.3. But in fact, all other atoll images turn out to be satellite views similar to, if not identical to, those in *Google Maps*, so the authors surely meant that satellite imagery informed their text rather than their atoll images. In any case, this leads them to claim that "there is no comparable work". Depending how one interprets "comparable" it seems at least an oversight not to have cited anywhere the two impressive earlier encyclopaedic works covering all reef categories, by UNEP/IUCN (1988) and Spalding *et al.* (2001).

Each atoll has a rather dry minimal description of its basic topography, with vital statistics like size, shape, depths, lagoon area, rim widths, and distances from other places. The descriptions also include a little about habitats and terrestrial natural history and sometimes some history, but the community ecology, which the authors claim to cover (above), is very basic and generalised.

The atolls are in turn grouped by chapter, each dealing with a region, a chain, or an archipelago, for which basic regional information, mainly geographical, climatic and oceanographic conditions, is summarised. Within a chapter, the atolls are treated in a logical order such as their geographical sequence within a particular group.

QUIZ QUESTION
Engraving (after Captain Beechey) reproduced at the beginning of Charles Darwin's coral reef book, and labelled as Whitsunday Island. But where is it? (see the answer at the end of this review)

However, this makes it a slow job to find a specific atoll in the text, unless you know, or can guess, an atoll's region (hence chapter) correctly in the first place, in which case, the chapter maps serve to find where an atoll is covered in the text. It is quicker though to use the index, and fortunately, to judge from some spot-checking, this seems to include all the atolls in the book. In any case, one can also use websites like *Google Maps* and *Google Earth*, whose interactive functions also provide much extra information, which it is not possible to find from the images in this book alone.

Mention of the index leads naturally to the matter of atoll names. Whereas atolls and archipelagos were often given various names by Europeans, Americans and Japanese, as they ventured across the tropical oceans and, in many cases, colonised them, the *Atlas* and its index use only the current official names for them. These are usually their indigenous names (e.g. Kiritimati instead of Christmas) which is fine and proper. But much of the literature on atolls until relatively recently, used older, often colonial, names. For those interested in the rich scientific, social, anthropological and ethnic history of the world of atolls, an appendix, giving some kind of synonymy of atoll names, would have been useful. Realistically though, a thorough synonymy for all 476 atoll names would be a scholarly project in its own right, and probably beyond scope for the present book. But someone should do it! As a case in point, this brings me to my quiz question. Right at the beginning on p.2 of Darwin's coral reef book (above) is an engraving of "Whitsunday Island" (*see figure above here*) after Captain Beechey (not to be confused with the Whitsunday Islands of Queensland). This illustration was evidently copied in other works by later authors, often with considerable artistic licence. But what and where is it? (Answer at the end of the references!)

I have already raised a metaphorical eyebrow about two notably missing references. Of course it is an easy target to pick out missing citations, especially as the reference lists here are scattered through all the different chapters so it is difficult to make quick checks. But the authors do claim to have "summarized and cited the widely scattered relevant literature". Given their emphasis on Darwinian criteria for defining their atolls, it is a pity that, while Darwin's (1842) coral reef book is cited, his detailed account of South Keeling atoll is not mentioned here under that atoll, nor anywhere else. This is despite it being his one opportunity to gather what he felt was the critical evidence, including specimens, he needed to support his theoretical model of atoll subsidence, which in fact he had formulated before he ever saw an atoll (Stoddart 1962, Rosen 1982, Rosen & Darrell 2010). Oddly also, the independent realisation by several authors including this reviewer (Rosen 1982), that plate tectonics provides the underlying reason for Darwinian atoll subsidence (p.4), is not referenced at all.

Themes

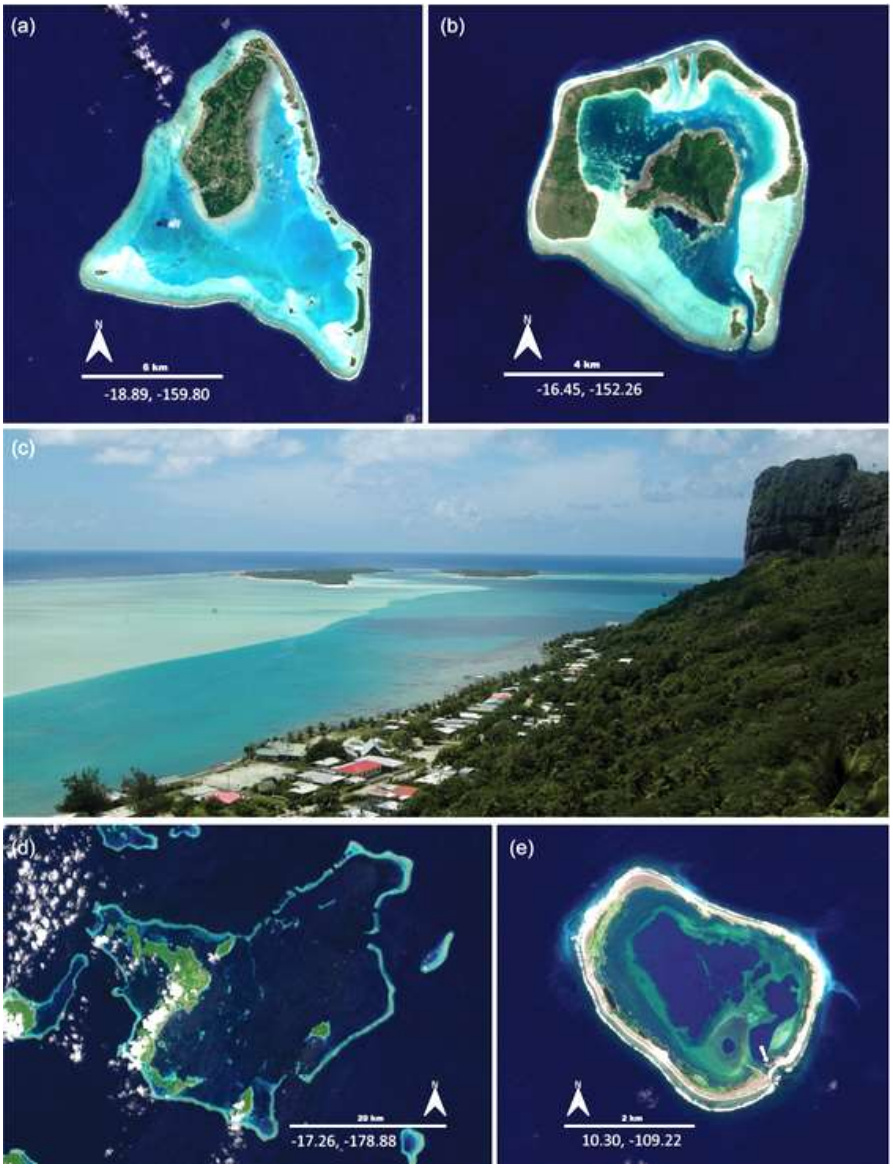
It is admittedly easy to consider what a book does not contain, rather than concentrate on what it does, but it is not unreasonable to have expectations about a book's contents and then compare them with actuality. In fact, the *Atlas* is much more than a descriptive gazetteer, but the only thematic chapters are 1 and 2 and 23. Yet there

is a considerable amount of eclectic, but interesting and readable, incidental text addressing a whole range of subjects. This is scattered throughout the book, however, in the form of rather random, sometimes long asides, wrapped around and amongst the atoll entries. Unfortunately, the index does not help the reader to search for this subject matter, so it is difficult to extract any synthesis of them. I guess the authors preferred to retain their gazetteer format rather than gather up this scattered content into thematic chapters in the manner of a textbook or research memoir. Had they done so, it might even have shortened rather than expanded the book's length.

Diligent readers will still try to extract from the *Atlas* some of the more obvious themes connected with atolls, though they may not find them - the way in which biological and geological processes combine to form atolls; the biogeography of atoll organisms, since atolls are obvious natural laboratories for investigating island biogeography (MacArthur & Wilson 1967); the long-standing debate about the origin of the striking biodiversity patterns of reef organisms (e.g. Bellwood *et al.* 2012); the social and scientific history associated with atolls; and the wide range of ethnic and cultural differences of their populations. Here below I expand on four themes in particular.

Rising sea level

Scientific fascination with atolls can easily be displaced by other, often more pressing human issues. While the Darwinian model of atoll formation poses its own interesting geological questions (below), *Reef Encounter* readers will well know that atolls are currently attracting more immediate, cogent, practical and political attention. Since their only landmass areas consist entirely of small low islands located on their rims, just a few metres above sea-level, global warming is posing the increasingly existential risk to peoples of atoll nations like the Maldives of loss of their lands through drowning by current sea-level rise. This has conservation implications too, as sea level rise also affects atoll habitats, with consequences for their ecology and oceanic biogeography. Taking all these things into account, this book is clearly timely. At least the final ten pages of the *Atlas* in the final and thematic chapter (23) are devoted to these kinds of problems. Perhaps it is not enough, but the



An example of the many illustrative pages included in the volume (Figure 1.5) showing satellite images of a) Aitutaki, Cook Islands, b) Maupiti, French Polynesia, c) also Maupiti (from land), d) Exploring Isles, Fiji, and e) Clipperton Island, Eastern Pacific. Satellite images copyright Planet Labs PBC.

authors plead (p. 407) that, "by necessity, we cannot be exhaustive or comprehensive".

Colonial history

Another obvious theme is the European 'discovery' of atolls which led, amongst other things, to the present scientific interest in them, followed particularly by American and Japanese interests. This is broadly a colonial history, because in fact, most atolls were already inhabited by oceanic people, like the Polynesians and Micronesians, who had discovered and settled them many centuries earlier. The history of reef science (as with many other subjects) needs to be reappraised accordingly. Darwin's intellectual efforts to understand how atolls form have influenced reef specialists ever since, but science historians seem to have only rarely put this into the context of asking what his Captain, Robert FitzRoy, and his famous ship, HMS *Beagle*, were doing in those far-flung waters in the first place? The same question applies to the voyages which took other naturalists into reef waters, like Quoy & Gaimard, James Dwight Dana, and Cook's naturalists, Banks, Solander, and the Forsters.

Some relevant historical complexities can be mentioned briefly. It was not just curiosity about the Earth and what lands still lay 'undiscovered' in the wide blue yonder, which motivated those

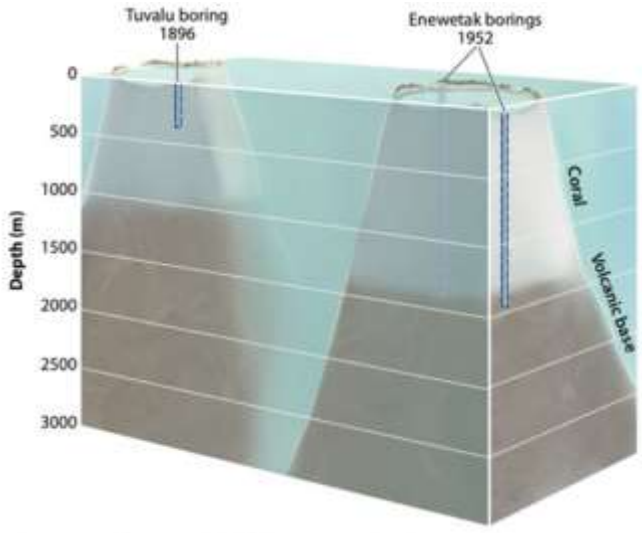


Figure 1.3 from *A Global Atlas of Atolls*, illustrating how, while in 1896 drilling on Funafuti atoll, in Tuvalu, failed to reach any underlying volcanic substrate, in 1952 that was achieved by drilling on Enewetak.

voyages. Interest, though not restricted to atolls, was often motivated by the search for resources and environments to exploit, as with the hapless Captain Bligh's effort (twice) to transplant Pacific bread fruit from Tahiti to the Caribbean for slave food, eventually thwarted by the mutiny of his seamen. The imperative to control whatever useful things were discovered, led to outright colonization, with potential and realized conflict and competition between the colonising nations. Even the seemingly benign tasks of making detailed hydrographic charts of distant places and of understanding how atolls form (both of which were assigned to FitzRoy (above) by the British Admiralty), were driven at least in part by concerns for ensuring the safety of British naval ships (Sponsel 2018), shipwrecks being a regular hazard of reef waters. Another consequence was the impact, often far from benign, of outside interests on native populations - and sometimes the opposite, often for good reason. There is a telling example in the text box (p.251) on "The British colonization of Fiji" in the 19th Century.

Military bases

It does not end there of course. Another more recent (neo-)colonial theme covered here and there in the *Atlas*, but also deserving thematic treatment in its own right, has been the taking over of various atolls for military purposes, and - notwithstanding the significant collateral gains to reef science (below) - the different unfortunate medical and biotic consequences of this, e.g. nuclear weapons testing in the 1950s in the Pacific, as variously applicable to Bikini, Enewetak, Johnston and Mururoa. Not mentioned is the former British nuclear testing at Kiritimati or the joint UK and (mainly) US military base on Diego Garcia, one of the Chagos atolls (see also reef perspectives article on p 21). On Diego Garcia its long-established people were forced to move elsewhere from 1967 onwards when the base was established (https://www.bbc.co.uk/news/articles/ckdg7jjlx2go). The continuing plight of the Chagossians, and of the migrant Tamils who are still on the atoll, as well as the territorial claims on it by Mauritius, and the nervously high-security use of the atoll as a base,

constitute a conflict of interests which came up yet again very recently in the British parliament. More positively, biotically, it is also part of the huge Chagos Marine Protected Area, which is home to the unique endemic brain coral, *Ctenella*, though how far the military are exempt from at least some conservation rules is unclear.

What is an atoll?

So inevitably, we go back to the question which the authors tackle early in their short thematic Chapter 1, what is an atoll? Their 476 "Darwinian" atolls are actually defined on hybrid criteria, i.e. not just descriptively by their annular shape, but also by the largely inferred process of subsidence of their underlying volcanic foundations, as envisaged by Darwin (as a refinement of a Lyell idea). Concrete evidence for subsidence does bestow descriptive status for some atolls, most notably the E1 borehole drilled on Enewetak in 1952, which recovered volcanic rock approx. 34-38 Ma old beneath c.1280 m of younger shallow-water limestones; otherwise inference of subsidence is the majority rule.

Moreover, while Darwin was basically correct in concluding that many atolls lie on subsiding ocean floor, we now know that this is due to subsidence of oceanic sectors of tectonic plates as they move away from mid-ocean ridges. However, he was writing before the realisation of the oceanographical implications of ice-cap fluctuations. He therefore could not have incorporated the effects of the resulting glacio-eustatic sea level changes and the consequent times when emergent reef surfaces were subjected to erosion by karstic dissolution. So via the series of scientific post-Darwin steps, neatly summarised on p.4 of the *Atlas* (see also pp.244-247 in Montaggioni & Braithwaite 2009), we arrive at what might be clumsily termed the glacio-eustatic karstic model of atoll formation, and of their lagoons in particular, of Purdy & Winterer (2001).

While this adds to and complicates, rather than negates, Darwin's subsidence model, it means that the distinctive annular (rimmed) form of atolls is not wholly due to Darwinian subsidence after all. This rather undermines the authors' choice of 'Darwinian' processes to define their subject matter. Might it be simpler to use the descriptive criterion of shape alone to define atolls, without reference to processes? After all, the word 'atoll' has its origin in the Maldivian language, Dhivehi, being an anglicisation of the word "*atholhu*". But the peoples who first used it there were probably unaware of things like volcanic foundations, plate subsidence, and glacio-eustatic events, though they are now certainly very conscious of sea-level rise due to anthropogenic climate change. Ironically this means they might be left without any atoll land of their own, as the rate of rise may be too fast for their atolls' growth to keep up. On the other hand, on descriptive grounds alone, Bermuda (where I started here), whose approx. 30 Ma old volcanic foundation has not noticeably subsided at all (Rowe in https://bermudageology.com/the-bermuda-volcanic-seamount/), could therefore, with qualifications, be classed as an atoll after all.

Conclusion

Overall, this *Atlas* is undoubtedly a valuable source for reef studies and an important contribution to reef literature. The authors rightly claim that their text is readable and accessible to both specialists and non-specialists, though less so in their explanation of their methods in Chapters 1 and 2. Their prose is mostly clear, even pleasingly elegant, entertaining or rhetorical by turns. Their intercalated material is interesting and often important, but would have been more accessible if better indexed, or garnered into several thematic chapters. That aside, the main problem with the book is its colossal price, which rules out most individuals from buying it, including probably, most atoll inhabitants. It is really a reference work for academic libraries, research labs and policy makers charged with addressing the very real threats of climate change to atoll nations.

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References

Bellwood DR, Renema W, Rosen BR (2012) Biodiversity hotspots, evolution and coral reef biogeography: a review. Pp.216-245 *in*: Gower DJ et al., eds. *Biotic evolution and environmental change in Southeast Asia*. Cambridge University Press, Cambridge.

Darwin, Charles (1842) *The Structure and Distribution of Coral Reefs.* Smith Elder and Company, London. xii + 214 pp.

MacArthur RH, Wilson EO (1967) *The theory of island biogeography.* Princeton University Press, Princeton, New Jersey.

Montaggioni LF, Braithwaite CJR (2009) *Quaternary Coral Reef Systems: history, development processes and controlling factors. Developments in Marine Geology* **5**. Elsevier, Amsterdam. xvii + 531 pp.

Purdy EG, Winterer EL (2001) Origin of atoll lagoons. *Geological Society of America Bulletin* **113**: 837-854.

Rosen BR (1982) Darwin, coral reefs and global geology. *BioScience* **32:** 519-525.

Rosen BR, Darrell J[G] (2010) A generalized historical trajectory for Charles Darwin's specimen collections, with a case study of his coral reef specimen list in the Natural History Museum, London. Pp. 133-198 *in*: Stoppa F, Veraldi R (Eds.) *Darwin tra scienza, storia e società. 150° anniversario della publicazione di Origine delle Specie.* Edizioni Universitairie Romane, Roma.

Spalding MD, Ravilious C, Green EP (2001) *World atlas of coral reefs.* Prepared at the UNEP World Conservation Monitoring Centre. University of California Press, Berkeley. 424 pp.

Sponsel A (2018) *Darwin's Evolving Identity; Adventure, ambition, and the sin of speculation.* University of Chicago Press, Chicago. x + 358 pp.

Stoddart DR (1962) Coral Islands [incorporating a transcription of Darwin, C.R., 1835. Unpub. MS. *Coral islands.*] *Atoll Research Bulletin* 88, 1-20.

Stoddart DR (1995) Darwin and the seeing eye: iconography and meaning in the Beagle years. *Earth Sciences History* **14:** 3-22.

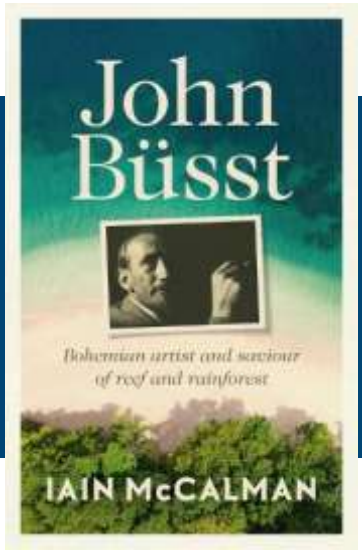
UNEP/IUCN (1988) *Coral Reefs of the World.* UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland, and Cambridge, UNEP, Nairobi. In three volumes.

Answer to quiz question: Pinaki Atoll
https://en.wikipedia.org/wiki/Pinaki_(French_Polynesia)

The Shift in the Zeitgeist

John Büsst: Bohemian artist and saviour of reef and rainforest.

By Iain McCalman
2024, NewSouth Publishing, Sydney, Australia. 264 pp.
ISBN 9781761170096



There was a moment – call it the sixties, although it straddled the late fifties and the early seventies – when the environmental zeitgeist shifted profoundly. It occurred across all ecosystems even if terrestrial ecosystems were in the limelight, and marine ecosystems were johnny-come-latelies.

Before the shift, ecosystems were valued for their utility: forests were for logging, marine ecosystems were, to all intents and purposes, for fishing, and so on. After the shift, ecosystems were valued as entities in their own right, whose existence had a moral dimension with an implied duty of care on society.

And it is the intricacies of the shift that concern Iain McCalman in his biography of John Büsst. McCalman is a narrative historian – some may have read his delightful 2013 book, The Reef: A passionate history[9] – and he writes with brio, but with an historian's authority. He brings to life the contradictions of the post-war world as it struggled with the realisation of a finite planet.

His focus is the Great Barrier Reef and the tropical lowland rainforests of north Queensland, but the story has universal resonance.

Büsst left an artists' colony near Melbourne and came to north Queensland in the 1940s, first building a house on Bedarra Island, a forested continental island, where he painted and fell in love with the rainforest, and later the Reef. Then he shifted to Bingil Bay on the mainland in the

[9] McCalman, I. *The Reef: A passionate history*. 2013, Melbourne: Penguin. 398 pp.

1950s and came under the increasing sway of the Reef. It is fair to say that the conservation of the Reef became his obsession.

But it needs to be remembered – and it is hard to walk in the shoes of scientists of more than 60 years ago – that the Reef was then seen as a resource to be exploited, and its bounty assumed to be vast. It was not for nothing that Saville-Kent's 1893 opus, The Great Barrier Reef of Australia[10], had, as its subtitle, Its products and potentialities. There had been, since Europeans first ventured on the waters of the Reef in the 19th century, a series of boom-and-bust episodes – pearls and pearl shell, trepang, turtles and dugong. And, of course, fishing. There was also a nascent tourism industry. But all these activities, tourism included, were utilitarian uses of reef resources.

Indeed, as late as 1967, the Great Barrier Reef Committee – the world's oldest coral reef society – recommended the 'controlled exploitation' of the Reef. We may think of this as the institutional view – the view of senior scientists and the institutions they ran. And it was pervasive at that time. Consider that the First International Coral Reef Symposium in 1969 had zero papers on reef conservation or environmental management, the Second in 1973 had a conservation section of 3 papers, the Third in 1977 had an environment management section of 8 papers, while the Fourth in 1981 had a major section on Reef and Man, 14 papers on fisheries, 22 papers on environmental stress, 22 papers on resource management and marine parks.

The zeitgeist had shifted, not through the efforts of senior scientists, but, as McCalman argues, through the efforts of 'outsiders' – bohemians like Büsst who had an emotional and aesthetic view of the Reef, and young marine science students who didn't yet have a foot on the institutional ladder. Theirs was an unlikely alliance, the students bringing their scientific nous to the collaboration, and Büsst, a well-to-do and well-connected (he was on first name terms with five prime ministers) artist, bringing the know-how on traversing the halls of power.

The crisis came in 1967. A lease to dredge limestone had been granted over Ellison Reef, a mid-shelf reef off the Queensland coast from Innisfail, on the basis that it was a 'dead reef'. Büsst appealed to the Mining Warden's Court. He organised and paid for the young students who ran the Queensland Littoral Society to undertake an underwater survey of the reef. QLS, the forerunner of the Australian Marine Conservation Society, was then a rag-tag collective running on the smell of an oily rag (full disclosure: your reviewer was the sometime editor of its newsletter and magazine). The team included Eddie Hegerl, the young president of the QLS, and Ross Robertson, then still a doctoral student (and who went on to a stellar career at the Smithsonian Tropical Research Institute). They found – surprise, surprise – that the reef was in no sense dead, but had a flourishing fish fauna and good coral coverage.

While the young scientists produced their reports, Büsst campaigned in the media. He famously said that mining the Reef was like bulldozing the Taj Mahal for road gravel. A perfect one-liner, utterly emotional, but worth a hundred sober-sided scientific reports for the cause.

The appeal was granted and the mining lease revoked. But everyone knew that Ellison Reef was merely a stalking horse for the oil industry. A Royal Commission on Oil Drilling quickly followed and disallowed oil drilling; this was followed by the declaration of the Great Barrier Reef Marine Park in 1975.

Büsst (who died in 1971), the artists, like the poet Judith Wright (with whom he collaborated), and his gaggle of young scientists from the QLS, had won!

Roger Bradbury[11]
Australian National University, Canberra

[10] Saville-Kent, W. *The Great Barrier Reef of Australia: Its products and potentialities*. 1893, London: W H Allen. 387pp.

[11] With great sadness we report Roger's death on March 27th this year. His perceptive insights will be greatly missed. We will publish a memorial article in our next issue.

REEF DEPARTURES

Tributes to recently departed members and reef scientists

Rolf P. M. Bak 1942-2024

Final farewell to the cornerstone of Dutch coral reef science

Photo: Jeffrey Sybesma (2017)

On the 20th September 2024, our longtime friend, colleague and mentor, Professor Dr. Rolf P. M. Bak, passed away on the Dutch island of Texel, lovingly surrounded by his wife Birthe, son Lennart and daughter Kamilla. In his passing, we lost one of the foremost pioneers of coral reef science.
Rolf Pieter Martin Bak was born on October 30th of 1942, in Den Helder, The Netherlands, into a loving Dutch Reformed protestant family. He was the eldest of the two sons of Gerrit Bak, a schoolteacher, and Anna de Boer. As a child, he took a great interest in the marine life that he found on the dikes of Den Helder and especially enjoyed family vacations in the Netherlands, when he could go out in the early morning to spot wildlife with his father and brother. This early interest in nature would result in a lifelong commitment to marine science and conservation.

Rolf attended high school at the Den Helder Lyceum where he met Koos den Hartog, who became a lifelong friend and professional colleague, specializing in cnidarians and joining Rolf in the Snellius II expedition to Indonesia years later. After high school, Rolf joined the master's program in biology at the Free University of Amsterdam in 1961. Here, he took part in numerous projects, including research on spiders, with Professor Lambertus (Bert) Vlijm, and seabirds with Professor Karel Hendrik Voous. While Rolf remained fascinated by seabirds, the seminal work by Odum and Odum (1955) on the trophic structure and productivity of coral reefs around Enewetak Atoll inspired him to pursue a career in coral reef ecology.

In 1961, he met the love of his life, Birthe Gade, during a biking holiday to Denmark: they married in 1965. After finishing his master's degree in 1970, Rolf was quickly offered a PhD position at the Free University of Amsterdam, and he moved to Curaçao, thus starting his coral reef career at the Caribbean Marine Biological Institute (Carmabi) at a time when coral reef ecology was a very young discipline. Here, Rolf and Birthe's son Lennart was born in 1971, followed by daughter Kamilla in 1974. The whole family has fond memories of living on the rural west side of the island with a panoramic view over the Caribbean Sea and the silhouette of Bonaire on the horizon. Rolf's first peer-reviewed paper was published in 1973 and described an innovative method to weigh corals (and determine their growth) underwater. With great foresight, that same year, he started following changes in coral communities using photo-monitoring of permanent coral quadrats, which grew into the still-ongoing inventory of changes on Caribbean reefs - the longest continuous coral reef monitoring project in the world. In 1976 he received his PhD from the Free University of Amsterdam, and then continued working at Carmabi, leading a new Coral Reef

Rolf with lifelong friends and colleagues leading an expedition in the Derawan archipelago, East Kalimantan, Indonesia (Bak family photo collection)

Project, and serving as deputy director from 1978 to 1984.

Rolf considered research on Curaçao's coral reefs as "working in paradise". The small number of coral reef ecologists globally at that time, meant that they frequently met. Through these "meetings of minds" he became close friends with other coral reef pioneers such as John Ogden, Bob Ginsburg, Betsy Gladfelter, Barbara Brown, John Bythell, Judith Lang and Terry Done, who all helped lay the foundations for what we understand as coral reef ecology today. What set him apart from others was his focus on quantitative and experimental reef research, rather than traditional taxonomy and description. Ultimately, this new approach resulted in lasting changes to Dutch marine science programs and curricula. Rolf authored and co-authored a total of 141 impactful scientific papers on coral reef ecology.

Rolf's research covered numerous topics, including the ecology of reef building corals, their recruitment, regeneration, survival processes, and factors causing mortality. He made forays into the effects of herbivory and bio-eroding organisms, such as Diadema, on coral growth, the importance of excavating sponges and ascidians as coral competitors, and the impact of various forms of pollution on coral survival. Carmabi soon became known as a major center for reef research. Today, over 50 years after he started there, many of Rolf's former students still build on his pioneering work, and some 300 coral reef scientists are hosted by the institute each year.

In 1984, Rolf and his family moved back to the Netherlands, where he became a senior scientist at the Netherlands Institute for Sea Research (NIOZ). At the time, NIOZ showed little interest in coral reef research and Rolf was asked to focus on North Sea microbes and their role in marine food webs. He complied but always found opportunities to remain active in coral reef research. Between 1984 and 1989 he organized several research projects on Indonesia's coral reefs, including the Snellius II expedition (1984-1985), while also working with a team on microbial ecological processes in the North Sea.

In 1987, a delegation of NIOZ, the University of Amsterdam and the Royal Netherlands Academy of Science (KNAW), led by the influential NIOZ director Professor J. J. Zijlstra decided that coral research was too important for NIOZ to abandon, and Rolf was allowed to continue his coral reef work. He then began innovatively applying his microbial expertise, developed in the North Sea studies, to the microbial mechanisms operating on coral reefs, such as the role of microbial food webs and bacterial communities in coral survival. In 1989, he was awarded a special professorship at the

Rolf during a research dive on his favourite reefs off Curaçao (Bak family photo collection).

Under the old Acacia tree: Rolf with students and colleagues (Erik Meesters to the right of Rolf) during coffee break at Carmabi, early 1990s (Carmabi photo collection).

University of Amsterdam and received the Colá Debrot prize from the Island Government of Curaçao for his contributions to Caribbean science. Even though his scientific work eventually covered the globe, from the North Sea south to the Weddell Sea of Antarctica and from French Polynesia in the Pacific to the Caribbean Sea in the Western Atlantic, Curaçao and Bonaire remained his "scientific home base" to which he always returned. Sadly, Rolf witnessed the decline of reefs in Curaçao and Bonaire and elsewhere, which worried him greatly and was a focus of his research.

Rolf was a very active Council member of the International Society for Reef Studies (ISRS) (as it was then called), in the 1980s just after it was founded. He was Treasurer during a period when the Society was facing considerable financial difficulty and had only just over 200 members. In the Society history, published in Reef Encounter in 2021, he recalled that David Stoddart had informed him at the Marburg meeting that he was to become the next Treasurer, and that he had no idea of what he was letting himself in for. "As I found out soon, ISRS was going bankrupt. … Council members started to recruit new members to help but, alas this only increased my worries. Individual membership fees were well below the cost that Springer [the publisher producing the journal] was charging the Society each time a new member was recruited." Sue Wells recently found some 1989 hand-written correspondence with him, pleading for additional funding for the costs of publishing Reef Encounter, with apologies from him for appearing 'stingy' and subsequent agreement of a budget of £500 (US$640) for the printing and overseas postage of the next issue (there was talk of funding for a 'typist' but fortunately technology was moving fast and this request was dropped!). Rolf worked incredibly hard, and with great good humour, to keep the Society solvent. By 1990, when he handed over the Treasurer role to Pat Hatchings, his efforts had drummed up membership to the extent that we then had a problem funding the newsletter postage.

Subsequently, he was Editor-in-Chief of the journal Coral Reefs from 2008-2013. Betsy Gladfelter, a close friend and colleague since the mid-1970s, remembers this time: "We went over each manuscript a number of times as they developed from first submission to subsequent submissions, often improved through addressing subject editors and reviewers' comments. We probably met an average of 2-3 times per week via skype [over those years]", an intensity of voluntary work typical of Rolf. In 2018, he received the Society's award of Eminence in Research in recognition of the outstanding body of research he had undertaken over his career.

His memberships of professional societies also included the Netherlands Zoological Society, and the Association of Island Marine Laboratories of the Caribbean. He was a member of the International Advisory Board of the Center for Tropical Ecology in Bremen, the boards of Biological and Geological Research in the Tropics, and the Foundation for Scientific Research in Surinam and the Netherlands Antilles. He served as Editor for the journal Marine Ecology Progress Series for over 20 years and, as guest scientist at the Universities of New Castle and Marseille, undertook field work in Moorea and the Tuamotus (French Polynesia). In early 2024, he was awarded the Dutch royal distinction of Officer in the Order of Orange-Nassau for his life of service to society.

In 2000, he survived a bout of maxillary sinus cancer, which forced him to abandon his habitual "evening cigar", but he quickly returned to diving as if nothing had happened. He retired in 2007 but kept an office at NIOZ, on Texel, where he continued supporting and collaborating with his many former PhD students, post-docs and assistants and good friend Gerard Nieuwland. During this period, he authored and co-authored 21 scientific papers.

Rolf with his wife Birthe in August 2019 (photo: Viktor Rietveld).

Rolf taught, inspired, coached, trained and collaborated widely and extensively with scientists from around the world and with his own (former) master's, doctoral and postdoctoral students, associates and colleagues. He helped create and inspire several generations of researchers and reef enthusiasts who now hold important positions in academia and conservation. His closest scientific colleagues throughout the years were Gerard Nieuwland, Mark Vermeij, Fleur van Duyl and Erik Meesters with whom he published most. His lasting impact on experimental marine ecology in the Netherlands and coral reef science worldwide is monumental and his work continues to be intensively cited. His contributions to the field of coral reef research will remain important for generations of coral reef scientists.

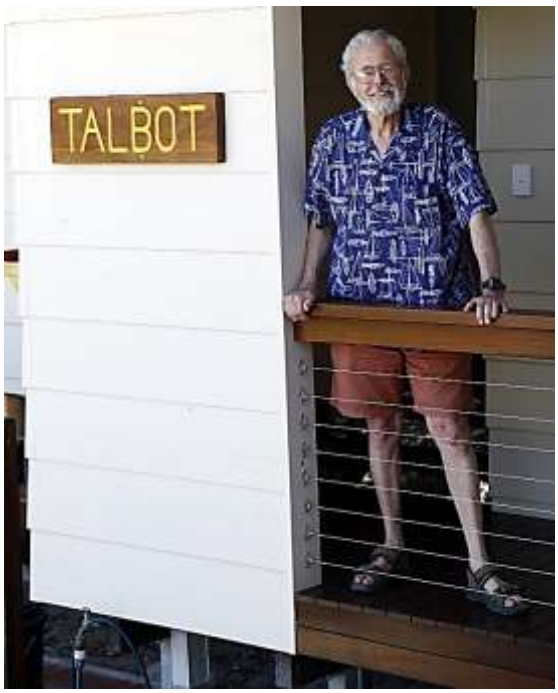
We have lost not only a brilliant scientist but most of all a kind, inspiring and compassionate friend.

Adolphe O. (Dolfi/Al) Debrot (Wageningen Marine Research/previously deputy director and director of the Carmabi Foundation), Mark J. A. Vermeij (scientific director, Carmabi Foundation/ University of Amsterdam), Erik H. W. G. Meesters (senior scientist, Wageningen Marine Research). With additional input from Betsy Gladfelter, Barbara Brown and Sue Wells.

Frank Talbot 1930-2024

Professor Frank Hamilton Talbot, renowned marine biologist, environmentalist and museum director, passed away peacefully on 15th October 2024, surrounded by family, at the age of 94. He had lived an extraordinarily productive life. Like many of us reef scientists, this included studying coral reef fish biology and ecology, contributing to conservation and management of marine biodiversity, and developing and running the facilities that supported this work. What made his expertise unique was his power of integration and a vision that could be understood by a broad range of decision makers and potential benefactors.

Frank was born in South Africa and developed an early interest in coral reef fishes. Professor George Branch, now at the University of Cape Town, provided this account of one of Frank's early inspirations:



"When I was a youngster at school I came down to Cape Town on holiday. Being bitten by the biological bug from an early age, I fossicked around in tide pools and collected various species. I took them to the South African Museum (now Iziko Museum) where Frank was then based, and asked if he could ID them for me. Initially bored by a rather routine task, Frank was suddenly electrified by one animal, which he eulogised about as being the first record of the species in South Africa. Little did he

know that his excitement would lead me to marine science! I later recounted this to him, as it really was a pivotal moment for me. He, in turn, told me of his own youthful encounter with the ichthyologist JLB Smith. Frank's passion for fish emerged early in his life, and his father, wishing to encourage him, packed him off on a three-day bus and train journey to meet and gain inspiration from JLB. After arrival and a lengthy wait, Frank was admitted to JLB's lab and explained his desire to become an ichthyologist. JLB could be a crusty old bugger, and responded with 'My boy, there is only room for one ichthyologist in this country, and that's me!' And that was the end of the interview! What a good job Frank remained undeterred in his quest!"

Frank in his laboratory in Zanzibar (mid to late 1950's, photographer unknown).

After completing his BSc at Witwatersrand University in Johannesburg in 1949, and an MSc at the University of Cape Town in 1951, he was appointed as demonstrator at King's College, University of Durham UK. In the UK, he married Sue, a fellow South African and marine biologist. In 1954, he moved to Zanzibar, where he worked as a fisheries scientist with the British Colonial Service, obtaining his PhD from the University of Cape Town in 1959 for his thesis on the lutjanid fishes of the East African Coast. He then worked as Assistant Director of the South African Museum in Cape Town, continuing his taxonomic work on fishes. In 1965, Frank moved to Australia to become Fish Curator at the Australian Museum (AM). His daughter Helen recalls the family arriving by ship in Sydney Harbour and sailing under the harbour

Frank sorting fish, Zanzibar (mid to late 1950's, photographer unknown).

bridge, where Dr Don McMichael, the Mollusc Curator, met them on a water taxi, a memorable moment for an 8 year-old. In 1966, he became the Director, and began to transform the AM into a modern scientific institution, recruiting marine researchers, fish, marine and invertebrate curators, an archaeologist, and an ecologist to establish a Department of Environmental Studies. Most were from overseas with PhDs, leading to a substantial increase in the AM's research output and documentation of Australian marine fauna.

Recognising the importance of fieldwork, Frank organised his first expedition to One Tree Island (OTI) in the Capricorn Bunker Group of the Great Barrier Reef (GBR) in 1965 and then annually until 1974. In 1969, the AM formally leased OTI and its reef. Building of the Research Station started in 1971, and this quickly became central to some of Australia's first diving-based research studies. Frank, with his research assistants—Dr Barry Goldman, Dr Barry Russell, and Gordon Anderson—conducted pioneering investigations into the biodiversity and community structure of coral reef fishes, as well as seasonality and recruitment studies using small experimental artificial reefs constructed from concrete blocks, that were monitored for juvenile fish recruitment. OTI was also a significant site for collecting by the AM diving taxonomists, such as Dr Pat Hutchings, Dr Doug Hoese, and Dr Helen Larson, as well as visiting scientists from international museums. Research focused on reef fish assemblages and

GBR Fish monitoring workshop at Heron Island 1977. From the left; Gordon Anderson, Greg Stroud, unknown lady, Dave Pollard, Frank Talbot, Pete Sanger, Barry Goldman, unidentified backside (possibly Soames Summerhayes), Hugh Sweatman, Peter Doherty, unidentified back, Barry Russell, Dave Williams. (Photographer unknown)

demographic processes, using artificial reef systems for experiments.

Needing funding to expand OTI, Frank invited Henry Loomis, a wealthy American benefactor, and his wife to visit the island in 1972, accompanied by Frank and Pat Hutchings. Henry had developed a fascination with coral reefs after leasing a Florida island for holidays with his brother. When the island was made a national park, Henry started looking for a holiday home on the GBR that could also function as a research centre. Despite the high-quality wine provided by Frank, the tiny wind-blown coral cay with its cacophony of breeding birds did not make an impression, and they left the following day.

Henry and Paula Loomis with Frank Talbot at One Tree Island, January 1972. Courtesy of the Australian Archives, photographer Howard Hughes

Undeterred by the OTI episode, Frank visited Henry in the USA, having decided that he wanted to compare the fish diversity of reefs in the north and south, from a base in the far Northern GBR. He persuaded the Loomis couple to explore the islands up to Lizard Island, with him, on the understanding that, if a suitable site was found, Henry would assist with funding. Only Lizard Island offered year-round safe anchorages and a lagoon, with a private airstrip and plans for an exclusive resort, ensuring regular commercial flights. In June 1973, during the 2nd International Coral Reef Symposium, Frank took several international scientists to look at a reef on the eastern end of Lizard Island, well separated from the planned resort. This site received enthusiastic approval, and Frank secured a substantial donation from Henry. The required matching funding was provided by Mrs. Topsy Waters through her Taiping Foundation; Frank had met her during the Tektite II underwater habitat program in 1970.

After resolving permit issues with Queensland National Parks, the building of Lizard Island Research Station (LIRS) started. Initially, it had a house for the Directors, a workshop, and a dive facility, with visitors making do with tents set up for cooking and sleeping. Frank participated in studies of reef fish at both OTI and Lizard Island, addressing a wide range of ecological topics, from the behaviour of individual species to the processes influencing the structure and diversity of reef fish communities with his postgraduate students.

Today, LIRS[12] is a world-class coral reef research station, a facility of the AM, and has just celebrated its 50th Anniversary. Supported by the Lizard Island Research Foundation, the station has grown significantly, raising funds and awarding numerous research grants. In late 1974, Sydney University took over the lease for OTI and now operates the station. So Frank was responsible for two research stations on the GBR of international repute.

Having secured funding from the National Geographic Society and the AM Trustees, Frank led a month-long expedition to Lord Howe Island, the world's southernmost coral reef, in 1973 with ichthyologists from the AM and Bishop Museum in Hawaii. They collected over 6,000 fish specimens

[12] https: www.lizardisland.com.au

from 77 families and 295 species, resulting in reference collections still used by scientists today. Frank was a key figure in promoting coral reef research globally and a prominent figure at the International Coral Reef Symposiums, attending the first in India (1969) where, with Dr David Stoddart, he suggested hosting the next symposium in Australia. The Australian Great Barrier Reef Committee (GBRC) agreed, and in June 1973, the 2nd Coral Reef Symposium was held aboard the cruise liner "Marco Polo". A total of 264 researchers

Frank – in his office at Australian Museum (Courtesy of the Australian Archives, series 391, M642-13.)

presented 120 papers while sailing from Brisbane to Lizard Island, combining snorkelling, diving, and scientific presentations. Frank, his wife Sue, and several AM researchers participated actively. Frank was an active member of Working Group 35 of the UNESCO Scientific Committee on Ocean Research (SCOR), chaired by David Stoddart, which was instrumental in advancing study of quantitative ecology of coral reefs and developing and standardising methodologies for description of abundance, composition and distribution of invertebrate and fish communities on reefs. This work resulted in a significant monograph - Coral reefs: research methods, which included a co-authored paper on collection and sampling of reef fishes. In 1970, Frank joined the US Government's TEKTITE II underwater habitat program in the US Virgin Islands, living and working underwater for 14 days with US ichthyologists Bruce B. Collette, C. Lavett Smith, James C. Tyler, and Jeffrey Wayne Marsten. This resulted in publication of pioneering scientific diving observations on coral reef fish activity patterns.

In 1975, Frank resigned from the AM to become the Foundation Professor of Environmental Studies at Macquarie University in Sydney. Here, he supervised several PhD students conducting fish studies at Lizard Island and other locations while continuing to advocate for coral reef conservation. He was Chair of the Coral Reef Committee, International Association of Biological Oceanographers. In 1982, he left Macquarie to become the Director of the California Academy of Sciences in San Francisco, and then, in 1989, Director of the National Museum of Natural History at the Smithsonian Institution in Washington, D.C (the first and, so far, the only Australian to hold this position). On completing his term in 1994, he was named Emeritus Director of the Museum and returned to Sydney to enjoy his retirement.

Frank was not someone to retire quietly, however. From 1996-2004 he was a Trustee for the World Wildlife Fund (Australia). He was also instrumental in setting up the Sydney Institute of Marine Science (SIMS) in 2006 by obtaining funding, and again this continues, used by a consortium of Universities in Sydney. In 2012 he was awarded the Member of the Order of Australia (AM) Medal for service to environmental protection, to coral reef research, to museum development and management, and to international scientific organisations. In 2016 he received the Lifetime Achievement Award from the AM Research Institute.

30th Anniversary of LIRS 2004 on the beach at Lizard with Sandy Shuetrim, Lyle Vail, Des Griffin, Marianne Pearce. Photographer Charlie Shuetrim.

Frank holding a model of Lutjanus bohar in 2013. (Courtesy of the Australian Museum, photographer Stuart Humphries.)

Frank made a unique contribution to marine science, and had a major influence on the research and conservation of the GBR. His vision of the maintenance of the ecological health of the GBR grew out of his early fascination with the ecological complexity of reef ecosystems and how to use this for effective conservation. He had drafted a letter to the Australian Prime Minister and the leader of the Opposition, expressing dissatisfaction with current policy on reef conservation a few days before he died, this has now been signed by numerous scientists and has been sent.

Frank was beholden to no government or industrial enterprise despite actively seeking both for funding for reef research and conservation. His view was that, if global warming is going to have catastrophic consequences, as scientists we need to understand the underlying mechanisms and the rates at which projected changes will occur. He had a sound understanding of the flow of policies that guide governments with respect to environmental legislation. His actions however went beyond strategic understanding: he was also a tactician in that he established the necessary hardware, field stations, labs, museum departments when and where they were required.

Those of us who worked with him also benefited in ways that are only now becoming apparent. There was nothing self-serving in his support and friendship; we were colleagues on the same journey. We are unlikely to see another Frank in the near future.

Howard Choat, Professor Emeritus, James Cook University, Townsville.
Pat Hutchings, Senior Fellow, Australian Museum, Sydney.
Barry Russell, Curator Emeritus of Fishes, Museum & Art Gallery of the Northern Territory, Darwin.
George Branch, University of Cape Town.

ICRS MEMBERSHIP

ICRS membership is open to anyone interested in any aspect of the science of coral reefs. While the society's membership consists principally of researchers, managers and students with interests in coral reefs and associated ecosystems, other people with a genuine interest in or concern for reefs, of any type, are welcome. The benefits of membership include:

- Receipt of the Society's scientific journal *Coral Reefs* (either on-line or hard copy)
- Receipt of the Society's newsletter/magazine *Reef Encounter* (by email or on-line)
- Access to the Society's on-line membership services, including the on-line Membership Directory
- Reduced registration fees for the International Coral Reef Symposium and other meetings sponsored by the Society.

Full / Individual Member
Membership includes all the benefits listed above, but rates vary depending on whether a hard-copy subscription or on-line access to the Society's academic journal Coral Reefs is preferred, and according to the mean income level of the member's country.

Student Membership
The benefits are the same as for a Full / Individual Member, and include hard copy or on-line access to Coral Reefs, all at a much reduced rate.

Family Membership
Family memberships are available for partners who live at the same address. Each receives the same benefits as Full Individual Members, but only one hard copy of any journal, if any, is supplied.

Sustaining Membership
Sustaining Membership is for those Members who would like to contribute extra to support the work of the Society. They receive additional minor benefits, and their support is acknowledged.

Honorary Membership
Honorary Membership has been conferred on a small number of members who have rendered special service to the society or otherwise distinguished themselves in the field of reef science.

The membership subscription varies considerably depending on the type of membership selected and the primary country of residence of the member. Very generous membership rates are available for students and residents of developing countries. For low to low-middle income countries, full membership costs only $40 (US) per year, and student membership only $20 (US) per year.

For details of current rates and to complete the on-line membership form or download a hard copy please go to the society's membership portal at: https://icrs.memberclicks.net/

NOTES FOR CONTRIBUTORS

Reef Encounter welcomes in particular:

(1) general overview or review articles (3-5 pages) on particular reef science topics
(2) short communications / scientific letters (1-2 pages) reporting recent observations
(3) general interest articles describing personal views and experiences
(4) news of ongoing or new projects or programmes

It also carries Announcements, Conference Reports, Book and Product Reviews, and Obituaries. Authors are encouraged to include colour pictures or other illustrations (normally 2-4 per article).

There are no specifications regarding the format of articles for submission to the editors, but **we particularly ask that references should be cited and listed using the style of the ICRS academic journal *CORAL REEFS***, see: http://www.springer.com/life+sciences/ecology/journal/338. Articles from non-ICRS members are welcome, but the those from members are generally given priority. Items should be submitted by email to the senior editor (rupert.ormond.mci@gmail.com) or another relevant member of the editorial panel (see page 2).

About the back cover: an aerial view of part of Diego Garcia, the largest atoll in the Chagos Islands – see article page 21 (photo by Mark Spalding)