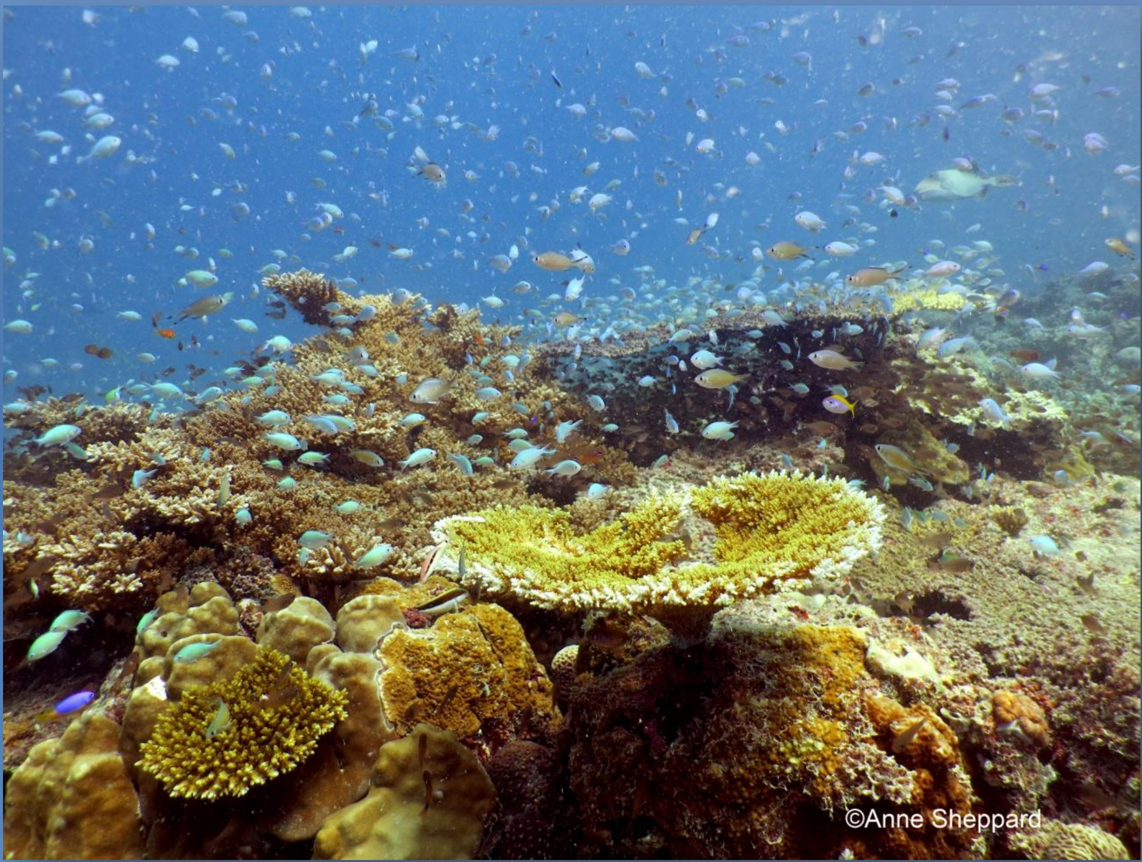
Volume 30, No. 1
March 2015
Number 41

REEF ENCOUNTER



The News Journal of the
International Society for Reef Studies

ISSN 0225-27987

REEF ENCOUNTER

Reef Encounter is the Newsletter and Magazine Style Journal of the International Society for Reef Studies. 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. Please submit items directly to the relevant editor (see the back cover for author's instructions).

INTERNATIONAL SOCIETY FOR REEF STUDIES

The International Society for Reef Studies was founded in 1980 at a meeting in Cambridge, UK. Its aim under the constitution is to promote, for the benefit of the public, the production and dissemination of scientific knowledge and understanding concerning coral reefs, both living and fossil.

CORAL REEFS - THE JOURNAL

The International Society for Reef Studies also publishes through Springer's 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 (see http://www.springer.com/life+sciences/ecology/journal/338).

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COVER PICTURE: **Spawning damselfish (*Chromis* spp.) in the Chagos Archipelago, British Indian Ocean Territory.** See the Reef Perspectives Article by Charles Sheppard (p. 11). Photo: Anne Sheppard.

PRESIDENT'S WELCOME

Dear ISRS Colleagues,

Thank you to those of you who voted in this past election. I am honored by your endorsement and excited to work with our strong leadership team and council for the next four years as ISRS President. I realize that I am taking the helm of an organization in great shape, reflecting the excellent leadership and dedication of Bob Richmond and Caroline Rogers. Bob and Caroline deserve an enormous thank you from us all, and I hope you will join me in acknowledging their service to our community. Our Society has strengthened significantly over the past four years under their stewardship, and we are now financially stable and ready to engage, grow, and flourish.

The mission of ISRS is to promote the production and dissemination of scientific knowledge and understanding of coral reefs. The need for these activities has never been more pressing, and the mechanisms by which we accomplish the mission have never been more varied and dynamic. The diversity of our community and our reach are unprecedented: all strengths that we can build on to further the mission. I hope that you share with me a vision of ISRS as a dynamic hub for activities and services that promote the mission; an inclusive "go to" place where all who work on and care about reefs convene to explore, identify, access and capitalize on mission appropriate resources; and a professional Society where the return on investment and value of membership is so clear that once a member, always a member.

I see my role in achieving this vision as facilitative. I will be reaching out to our membership to assess needs. I will then work collaboratively with the leadership and members to define goals and outcomes. A concerted effort to identify and attract the resources needed to accomplish our goals will include the development of philanthropic relationships and a membership drive. The latter will target sectors of our community that are currently poorly represented in ISRS: We can perhaps better engage the graduate student and early postdoctoral scholars in our community by tailoring resources and activities to their demographic and career stage. I am committed to creating mechanisms to rapidly translate science to the broader audience and making this available to all Society members. I will also actively promote the value of the ISRS as a community of experts who can play a critical role in guiding action and policy aimed at protecting reef resources globally.

In closing, I would like to reach out to members and ask that you share your ideas or vision for the Society with me or other officers and council members; we need and want your input. I look forward to working with you all in the coming four years.
All the best,

Ruth D. Gates
President, International Society for Reef Studies
Research Professor
Hawaii Institute of Marine Biology, University of Hawai'i at Manoa, Hawaii, USA

Vice-PRESIDENT'S WELCOME

Dear ISRS Members,

Being from Palau, an island in the western Pacific, which has for generations depended on coral reefs for sustenance and livelihoods, I am excited and honored to be Vice-President of the International Society for Reef Studies (ISRS), the largest professional organization for coral reef researchers and managers. Our coral reefs are facing many challenges, both locally and globally, now more than ever. To address these challenges, we need sound science to help guide management and conservation efforts, to ensure that we and future generations continue to enjoy the benefits of coral reefs.

Despite the huge challenges that our coral reefs are facing, we cannot give up. Instead, we need to increase our efforts and our membership to tackle these challenges. I would like to work with the leadership and members of ISRS to find ways to continue to increase the Society's membership. We have to maintain current members while exploring ways to attract new members, especially from places that have low membership in the Society. Those new members will further strengthen and expand the Society's role and influence.

I also look forward to working with the ISRS leadership and its members to achieve positive outcomes from the science that we generate. In particular, the next International Coral Reef Symposium provides an excellent opportunity to bring science and management together to produce effective policies to sustain and conserve coral reefs.
Sincerely,

Yimnang Golbuu
Vice President, International Society for Reef Studies
CEO, Palau International Coral Reef Center

EDITORIAL

A brief note to thank all those members who have come forward to contribute articles and other material. Their efforts have again made for a most interesting and informative issue, focussing this time on a range of valuable digital and internet tools. Two types of contribution however are being overlooked. We welcome letters to the editor about both published items (e.g. the "Reef Perspectives" Articles), and on other issues. Do please write! And we would also welcome being sent or notified about more books and other products that we can review - some get drawn to our attention, but not I suspect all. Do please let us know!

Rupert Ormond
Corresponding Secretary ISRS & Editor, Reef Encounter
Honorary Professor, Heriot-Watt University, Edinburgh, UK

TREASURER'S REPORT

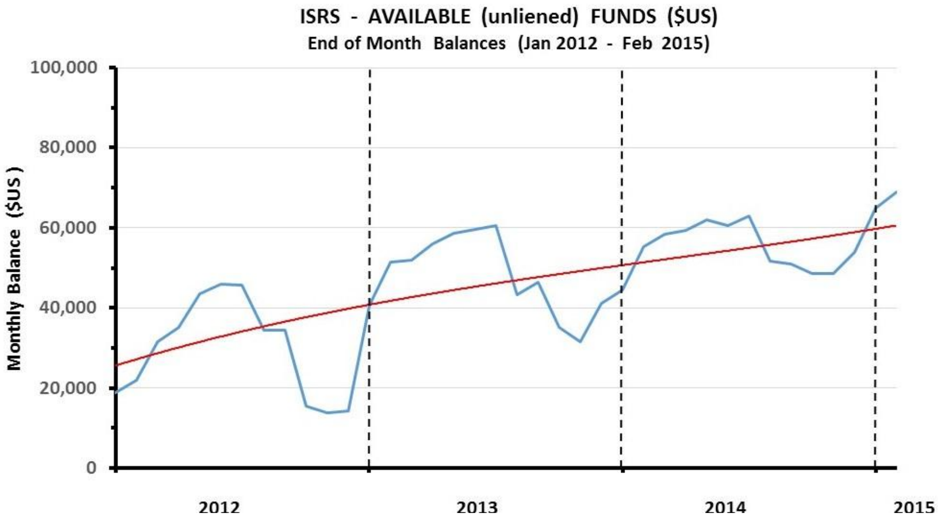

Figure 1. *Monthly totals of uncommitted funds held by ISRS January 2012 to 28th February 2015*

In 2012 the Society contracted with a new provider of support services, The Schneider Group, and renegotiated our agreement with the Springer Publishing Company to provide "Coral Reefs" electronically, rather than in only as hard copies to ISRS members. These decisions reversed a trend of increasing unfavorable expenses for the Society. Since then, finances have improved steadily, with unliened funds available in December 2014 being approximately triple those of three years earlier (Fig. 1). This improvement in our reserves has enabled the Council to re-activate and expand programs providing student grants, and also to offer reduced membership rates for those in developing countries.

Figure 1 also illustrates how our finances have a strong annual cycle. Current income comes entirely from dues, most of which are paid between January and April. The two major expenses, (support services and provision of "Coral Reefs") continue throughout the year, leading to minimum balances in October or November each year. The particularly low balance in late 2012 reflects one-time only costs associated with establishing new arrangements with The Schneider Group that will not recur.

While the current trend is encouraging, the financial strength of ISRS, and hence our potential to provide greater financial support for students, and for research and educational activities, so furthering the goals of ISRS, depends mainly on continuing growth in our Membership. All members are kindly urged to recruit new members among their colleagues and students.

Donald Potts*, ISRS Treasurer*
Professor of Biology, University of California at Santa Cruz, California, USA

RECORDING SECRETARY'S REPORT

The most recent Council Meeting took place on October 7th / 8th 2014, over the internet, with 19 members participating. Items discussed included: Society Elections for 2015-18, the new Awards & Honors system, Graduate Fellowships, the International Coral reef Symposium to be held in Hawaii in 2016, proposals for revision of the Society's Constitution (being prepared by a sub-committee), Society finances, development of an ISRS membership drive, progress with Reef Encounter, expanding the society's new website, and changes to and possible expansion of the editorial board of the society's journal *CORAL REEFS*.

Kiho Kim*, ISRS Recording Secretary & Chair Website Committee*
Associate Professor, American University, Washington DC, USA

SOCIETY ANNOUNCEMENTS

Society Elections

Society elections were held over December 2014 – January 2015 for three society officers, including our President, and half the membership of the Society's Council. As declared by the Recording Secretary (as per the constitution) and announced by (now) past-president Bob Richmond in his email of January 28th, the successful candidates were as follows:

President:
Ruth Gates
Vice-President:
Yimnang Golbuu
Corresponding Secretary:
Rupert Ormond
Council Members (alphabetical order):
David Baker, Stacy Jupiter, Ilsa Kuffner, Kazuo Nadaoka, Serge Planes, Laurie Richardson, Thamasak Yeemin

These members assumed their posts on February 1st and are all due to serve for four years. Their names and email addresses are listed on the inside cover (page 2) of this issue, together with those of continuing officers and council members. The editors wish them all every success in their work on behalf of the society

Recipients of Society Awards & Honors

Since its inception the International Society for Reef Studies (ISRS) has awarded only four established honors or prizes, and these at only relatively low frequency. Last year, however, the Council of the Society agreed to establish an expanded system of awards and recognitions as a means by which the Society can acknowledge exceptional achievement or commitment by a larger number of members ranging from students, through early- and mid-career researchers, to the most senior or eminent scientists. The first recipients of these awards have now been selected and are:

1. **Young Scientist Award** (awarded each year to a scientist under the age of 35) – **Erinn Muller.**
2. **Mid-Career Scientist Award** (awarded each year in recognition of excellence in research by a mid-career scientist) – **Pete Mumby.**
3. **Eminence in Research Award** (awarded each year in recognition of an outstanding body of research over an extended period of time) – **Barbara Brown.**
4. **ISRS Fellows (**awarded to up to 15% of members in recognition of scientific achievement and / or service to reef conservation or management and / or service to ISRS over a significant period of time) – **Andrew Baird, John Pandolfi, Robert van Woesik**.
5. **World Reef Award** (awarded in recognition of scientific or conservation achievement by an individual who is a member of a group under-represented in the field of reef science or management) – no nominations were submitted.

Congratulations to the successful nominees. The next round of nominations will open in November 2015.

Graduate Fellowships

We are pleased to advise members that 24 applications were received for the two Graduate Fellowships, worth up to $2,000 each, the award of which was re-started this year. It had been hoped to complete the selection process in time to include an announcement in this issue of Reef Encounter. However, because of the rather larger number of applicants than anticipated, we now expect to announce the successful candidates by email, and on the Society's website, by the end of March.

13th International Coral Reef Symposium, Hawaii

1st Announcement and Call for Session Proposals

The 13th International Coral Reef Symposium (ICRS) will be held at the Hawaii Convention Center, Honolulu, Hawaii on 19- 24 June 2016. The ICRS, sanctioned by the International Society for Reef Studies (ISRS) and held every four years, is the primary international meeting focused on coral reef science and management. The Symposium will bring together an anticipated 2,500 coral reef scientists, policy makers and managers from 70 different nations in a forum to present the latest research findings, case histories and management activities, and to discuss the application of scientific knowledge to achieving coral reef sustainability.

Hawaii Convention Centre, Honolulu, Hawaii

Theme: "Bridging Science to Policy"

Coral reefs provide essential ecological, economic and cultural services to the people of tropical and subtropical islands and coastal communities worldwide. While scientific knowledge about coral reefs and their structure, functioning and responses to stressors has increased exponentially over the past few decades, the state of reefs globally has declined during this period, at a comparable rate in many places. To address this disconnect, a theme of the 13th ICRS will be "Bridging Science to Policy" with specific goals focusing on:

1) Improving trust and communications among scientists, policy makers, managers and stakeholders.
2) Developing strong partnerships between political leaders and the scientific community.
3) Guiding efforts and strategies for effective allocation of limited financial, human and institutional resources to halt and reverse coral reef decline locally and globally.
4) Developing a framework for quantitatively evaluating the effectiveness of coral reef protection and recovery activities and initiatives by applying the best available science.

Session Proposals:

The scientific planning committee invites proposals for sessions and panels of interest to researchers, resource managers, economists, policy makers, educators and students. Themes will address coral reef science, management, conservation and policy. Multidisciplinary/cross-disciplinary, solution-oriented sessions are particularly encouraged in which a range of participants can interact with a goal of producing concrete outputs leading to positive coral reef outcomes.

Proposal Format:

a) Proposals should include an informative title and a short description (200 words) of the proposed session.
b) Proposals should identify at least two, but no more than four co-organizers and provide their Name(s), Affiliation(s) and Contact Information.
c) One of the co-chairs should be identified as the lead contact for the meeting committee.
d) Proposals should also indicate prospective speakers/participants, but sessions should be open to both invited and contributed presenters.
e) Sessions may consist of oral and poster presentations, panels, moderated discussions or a combination of these. Please indicate the anticipated mix, but note that the final allocation of time slots will be determined by the scientific planning committee after abstract submission closes. Session organizers will assist with the allocation of time within their sessions.

f) Proposals should include the expected audience, both in terms of size and discipline(s).
g) International and cross-disciplinary representation is encouraged, as is a mix of both seasoned and emerging expertise, with an eye towards developing capacity in the Society, the field and the nations in which coral reefs are found. Proposals should indicate whether this objective is being incorporated.

Proposals for sessions will be submitted online via the conference web-link, which will be accessible (hopefully) in early April 2015 through the main ISRS website. The targeted closing date for submissions is by Midnight, Central Time USA, on 30 June 2015. Proposals will be reviewed by the program committee, and organizers will be notified about decisions in August 2015. Once a session is accepted, session organizers may solicit abstract submissions to their session. Scheduling will be performed collaboratively by the planning committee and session organizers.

Projected Fees:
Every effort is being made to make this meeting as accessible and affordable as possible. Based on projected budgets at this point, we anticipate the following *likely* rate schedule:
ISRS members > 2 years – $500 (US)
ISRS members < 2 years – $550 (US)
Non-ISRS members - $750 (US)
ISRS student members - $350 (US)
Non-ISRS member students - $450 (US)
The final rates will depend on the success of external fund raising efforts, which are well underway. Anyone willing to assist in finding donors and sponsors, please contact Bob Richmond as below.

Contacts

For information about the scientific program, including technical or content questions:
Dr. Robert Richmond, Convener, 13th ICRS
Kewalo Marine Laboratory
University of Hawaii at Manoa
41 Ahui Street
Honolulu, HI 96813 USA
email: richmond@hawaii.edu
Phone: (1) 808-539-7330

For practical and logistical information:
Helen Schneider Lemay, Conference Manager, 13th ICRS
SG Meeting and Marketing Services
5400 Bosque Boulevard, Suite 680
Waco, TX 76710 USA
email: helens@sgmeet.com
Phone: (1) 254-776-3550
Fax: (1) 254-776-3767

Honolulu, from Diamond Head

GENERAL ANNOUNCEMENTS

8th Mexican Coral Reef Meeting, Puerto Vallarta, Jalisco, México

May 19th-22, 2015

The 8th Mexican Coral Reef Meeting will be held in Puerto Vallarta, Jalisco, México, organized by the Mexican Coral Reef Society (SOMAC) and the Universidad de Guadalajara, at its Puerto Vallarta campus. This is a biennual meeting at which more than one hundred presentations will be given, mostly by Mexican researchers and students, on organisms and processes occurring on both Pacific and Atlantic (Gulf of Mexico and Caribbean) coral reefs of Mexico. However participants from other countries, including the United States, Cuba, United Kingdom, Costa Rica, Colombia, Chile and Argentina, also frequently attend.

On this occasion keynote speakers will include Dr. Monica Medina (Pennsylvania State University, PA, USA), Dr. Susana Enríquez (Universidad Nacional Autónoma de México, Unidad Académica Puerto Morelos, Quintana Roo, Mexico), Dr. José Domingo Carriquiry (Universidad Autónoma de Baja California, Instituto de Investigaciones Oceanológicas, Ensenada, Baja California, Mexico), and Dr. Héctor Reyes Bonilla (Universidad Autónoma de Baja California Sur, La Paz, Baja California Sur, Mexico). This meeting will include a photography contest, as well as cultural and other events. For more details please have a look at the SOMAC website: http://www.somac.org.mx
We look forward to seeing you in Puerto Vallarta!

Coral Reefs – Secret Cities Of The Seas

A major new exhibition at the Natural History Museum, London

27 March to 13 September 2015

The Natural History Museum, London, in partnership with Catlin Group Limited, is opening a new exhibition on March 27, 2015 called ***Coral Reefs: Secret Cities of the Sea***. The exhibits will include over 250 specimens from the Museum's coral, fish and marine invertebrate collection, a live coral reef tank built by Jamie Craggs from the Horniman Museum in SE London, and an interactive virtual dive based in imagery collected by the Catlin Seaview Survey. Using stunning 360-degree panoramic imagery, the Liquid Galaxy Google Earth experience will guide the visitor along the Great Barrier Reef, Tubbahata Reef (Philippines), Hourglass Reef (Bermuda) and Komodo Island (Indonesia), through a chamber of circular screens.

The principal objective of the exhibition is to increase awareness of coral reefs for general audiences who live far away from coral reefs and do not have direct experience of them. The exhibition provides an introduction to the biogeography, diversity, and ecology of shallow water tropical reefs and associated habitat, and highlights the importance to people worldwide. The exhibition uses the metaphor of coral reefs as "cities of the sea" - inspired by the work of by Robert Ginsberg and colleagues at the University of Miami (*see pages 17-24 ed.*).

For society members highlights will include corals collected at Cocos Keeling Atoll by Charles Darwin during his voyage on HMS Beagle that he used to demonstrate his theory of atoll development. Other specimens include a large colony of *TurbInaria* that was collected by William Saville-Kent in Shark Bay, Western Australia and was on exhibit in the museum in the early 20th century. The exhibition also features many specimens from the British Indian Ocean Territories, presented to the NHM by Charles Sheppard (*see pages 11-16 ed.*) Members should also enjoy the striking images of reefs taken by Eileen Graham in Discovery Bay, Jamaica, in the 1960s, and Anne Sheppard's (University of Warwick) book written to accompany the exhibition.

REEF PERSPECTIVES

Personal comment on reef science, policy and management

THE REEF CONSERVATION CONUNDRUM, IN ONE CORAL ARCHIPELAGO

Charles Sheppard
School of Life Sciences, University of Warwick, UK; email: Charles.Sheppard@warwick.ac.uk

We have probably all heard variants of the granddad who expansively proclaimed: "When I was young, fish were THIS big". Decades ago Cousteau lamented how parts of the Red Sea were deteriorating, and there are many similar stories from around the world. Going back even further, the logs of some sailing ships related how they had been stopped in their tracks because the water was so dense with turtles. We assumed those writers were exaggerating greatly; perhaps this is a kind of *Shifting Baseline Syndrome* that seems to be hard-wired into us. Today, we have measured and quantified the decline of coral reefs, so debate has turned to why we appear unable to arrest the trend. Another assumption that also seems to be hard-wired, probably because we so badly want it to be true, is that we could live in harmony with nature. If we could then we might have less reason to worry, but if we can, why aren't we? Unfortunately, decline is now so extensive that merely arresting the decline is not enough – we need to reverse it too, given the importance of reefs to humans.

In the last issue, Sale (2014) commented on what he felt was needed to try to reverse this, and I agree, but it is helpful to know why this is so difficult to achieve. Some answers come from the story of the Chagos Archipelago, not a typical one in many ways, but one that usefully highlights some of the reasons why it is so difficult to protect reefs in our increasingly resource-hungry world.

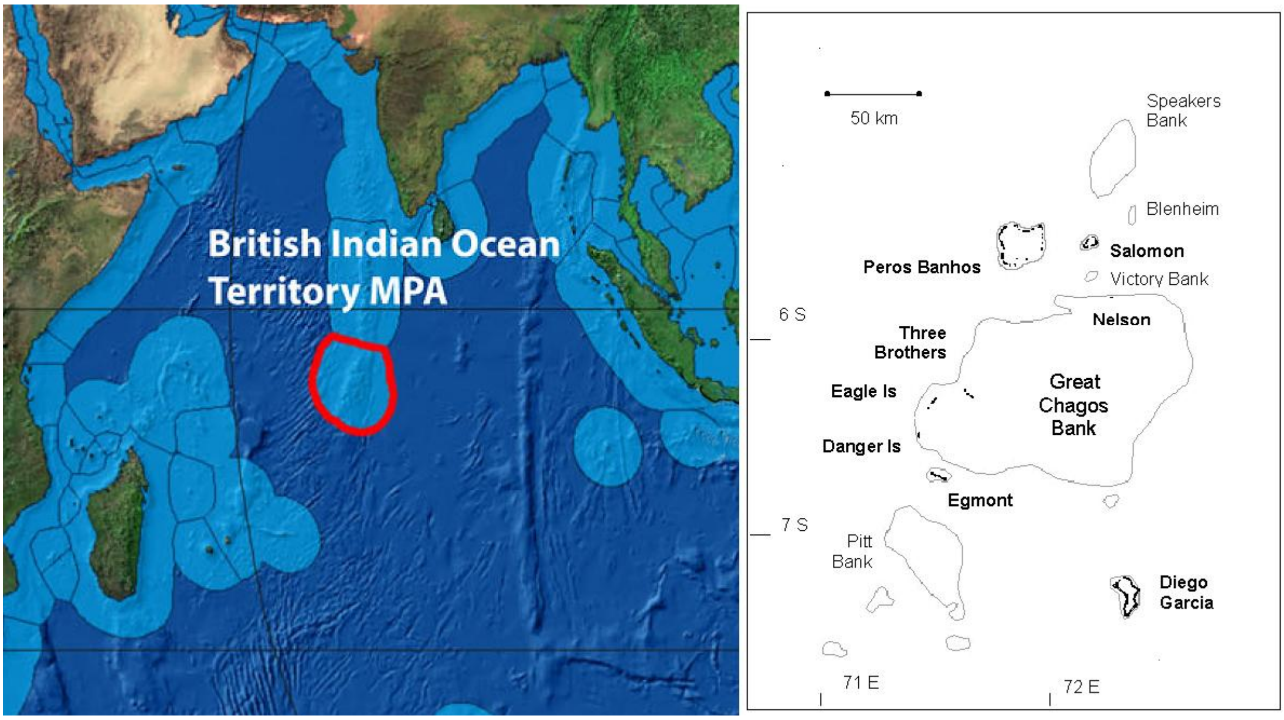

Figure 1. Left: Boundary (in red) of the British Indian Ocean Territory, measuring approximately 650 km across. Right: the Chagos Archipelago, whose atolls, submerged atolls and the scattered islands of the Great Chagos Bank are located in the centre of the Territory. Atolls and islands are in bold font, some larger submerged atolls are named in normal font. These spread over approximately 150 km.

The political name for this large region is British Indian Ocean Territory (BIOT), and it was created in the mid-1960s (Fig. 1). The USA and UK wanted to retain a military base in the Indian Ocean under their own control and, in agreement with Mauritius which was becoming independent, the UK retained sovereignty over the Chagos Archipelago, and the USA developed a military facility in its southernmost atoll Diego Garcia. The islands' coconut plantations had been failing economically, its population was falling (Wenban Smith, in prep), but the Cold War was hot. The workers of that time were removed to Mauritius, and compensation was provided. Subsequently, those workers (Chagossians) became entitled to UK passports by virtue of the Chagos having remained British, and many later came to the UK. Nobody at the time seemed to give much thought to possible future repercussions of the shoddy way (as we now see it) that this evacuation was done, and this has come back to bite the UK Government but, at the time, the UK thought the arrangements were reasonable.

After the creation of BIOT, the atolls apart from Diego Garcia became uninhabited, and remained largely unexploited. Many piecemeal, local environmental laws were enacted over the following years until, in 2010, the developing research programme had produced enough evidence that several leading UK science societies and NGOs, backed by large numbers of the public, encouraged the Government to consolidate it all into a large, no-take marine reserve. In practice, aside from consolidation of laws, the only practical addition in 2010 was the cessation of industrial tuna fishing. BIOT thus became the world's largest no-take marine reserve, encompassing the whole area out to the 200 NM boundary, though Diego Garcia atoll with its base was excised, out to 3 NM.

Global issues writ small

The globe is too much for us to grasp; we understand smaller detail much better. Thus, many issues of the Chagos Archipelago are helpful because they make global issues easier to understand. The reef systems and islands of Chagos are fairly well studied, and five well illustrated chapters in Sheppard (2013) summarise the scores of papers that have been written on it over the last 20 years. More than anything, the archipelago shows us what unexploited reefs can look like when left alone (Figs 2-4; Fig 2 on cover). It is large: its five atolls, numerous submerged coral banks and seagrass

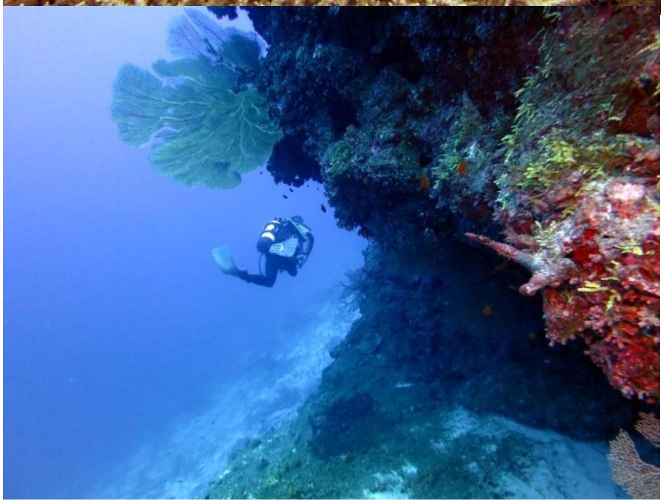

Figure 3 (above). Peros Banhos lagoon, where there are vast expanses of numerous species of corals, especially *Acropora*. (Photo: Anne Sheppard)

Figure 4 (below). Old wave-cut notches and caves are found on many ocean-facing slopes, commonly between 20-45 m depth, suggesting a complicated past history of relative vertical land movements and sea level movements. (Photo: Anne Sheppard)

beds extend over 60,000 km^2 in the middle of the Territory, which altogether is roughly 640,000 km^2 and which includes much soft substrate, abyssal features and about 300 sea mounts.

Because of its history over the past 40 years, the Chagos Archipelago missed what might be called the 'Decades of Destruction', that affected most coral reefs (and other habitats) of the Indian Ocean, when reefs of the world suffered environmental damage as a result of the rapidly rising demands on their living resources. This has led to the present, horribly difficult problem whereby, with the population rising and expectations of standards of living increasing, ever more vigorous exploitation is required to support it, in the manner of the 'Red Queen' who had to run just to stay in the same place. But decades without human occupation meant that Chagos' reefs avoided this so that their condition now starkly contrasts with that of other reef systems.

In contrast, the condition of most of the islands was and remains poor (Fig. 5). Like islands the world over, most had been environmentally trashed decades ago. Of the largest island (Diego Garcia) Stoddart (2001) said that, by the time its military use started, "The atoll was by then simply a coconut plantation. I had to say there was no case in the terrestrial ecology to object to the military plans…" I have seen the resulting saga play out for years, and it has been a fascinating, exasperating, often sad story, rich in lessons for reef science and conservation.

Research since the creation of BIOT

Following the formation of BIOT in 1965, a series of research visits took place, initially few and far between, but now numbering several per year, as the immense ecological value of the place became apparent. By the latter part of the last century the Chagos Archipelago displayed many superlatives. for example in huge reef fish biomass, enormous populations of coconut crabs (Fig. 6), its importance as a stepping stone in the Indian Ocean, its important role as a refuge, the very rapid recovery of coral cover after the 1998 bleaching event, high seabird densities on those few islands that were not razed for coconut plantations, and the lack of marine pollution in sediments or biota. Scientists increasingly wish to see how a 'real reef' works, and therein lies one of its important values today – a reference site against which marine habitats elsewhere in the oceans can be compared. Even most reefs of Diego Garcia look similar. After all, the military development mainly overlaid plantations and, a key point, its population is not dependent on local resources but ships in all its food and energy so that its ecological footprint lies thousands of miles away.

Because of this, Chagos' reefs still teem with life - a reminder of just what the oceans could and should be like (Fig. 7). Protecting the Chagos Archipelago and other rich sites elsewhere is a challenge we face if we are going to live in any sense sustainably with nature in a world with a rising population. This is a salutary point for anyone who feels that, with the world's population as high as it is and rising fast, we can live within a tropical ecosystem without degrading it.

Figure 5 (above). All the larger islands are mostly covered by derelict coconut plantation. The edges of some, like this in Peros Banhos atoll are also being eroded by rising sea levels. (Photo: Anne Sheppard)

Figure 6 (below). Coconut crab. These were almost extirpated, but today their populations average (on Diego Garcia's eastern arm) 300 per ha, with some areas containing 600 per ha. (Photo: Anne Sheppard)

Fishing and reefs

One lesson comes from one of the few examples of resource exploitation that still take place: recreational fishing on Diego Garcia (the other is poaching). Only a few kilograms of fish taken per hectare each year, or along each 100 m of reef, appear to be sufficient to have helped reduce this atoll's reef fish biomass to a quarter of that measured on the uninhabited atolls of this group. Yet, the amount remaining is still as high as in the best protected marine reserves almost everywhere else (Graham et al. 2013)! The point here is that we can likely maintain only an extremely small population through fishing, because reef fishing tends to use up capital (spawning stock) until the fishery collapses in a 'Ponzi'-like effect (Sheppard 2014a; Fenner 2014). Chagos atolls show that only moderate, recreational fishing will substantially reduce fish biomass. It has been known for years that 'sustainability' still needs to be invented as a practical measure with respect to reef fishing (Pauly 2002), and Chagos adds detail to that.

Offshore or blue-water fishing makes another point about why marine conservation is so difficult. There has been no pelagic fishing in the no-take marine reserve (except poaching) since it was created in 2010, thus removing from risk not only the tuna on migratory passage and those whose movement takes place largely within the MPA, but also eliminating the previously substantial by-catch (Koldewey et al. 2012). The no-take measure has attracted strong opposition to the MPA from the tuna industry. I listened to a group of tuna fisheries managers in 2010 who were talking about how they needed to overturn the protection measures within three years – they thought most governments in the region were pretty malleable, after all! Others argue that the no-take rule is pointless so should be revoked, because the tuna will be caught outside the area anyway (if so, why do the no-take rules worry them?!) Earlier, when tuna fishing was permitted, insufficient data were collected by the fishery to be of much use, and this lack of data is now being corrected with new research.

Conservation in a changing political landscape

Another lesson gained from Chagos concerns jurisdiction and politics. Many scientific publications have built up strong support for conservation in Chagos, and a government consultation showed that the public overwhelmingly supported the creation of the MPA. But the issue is political because Mauritius claims the archipelago and the Chagossian issue has not been resolved. The core conservation body for the area, the Chagos Conservation Trust (CCT), remains neutral on political issues as required by its Charter, but CCT can and has highlighted flaws in several resettlement proposals that claim to be cheap and sustainable, whilst ignoring contrary scientific evidence. This has not been well-received by certain parties who therefore accuse CCT, other bodies who collaborate on research there, and individual scientists, of being somehow anti-Chagossians. (In fact CCT and allied organisations have undertaken by far the most outreach work in support of Chagossians). We are also opposed to misinformation that leads people up false paths. It is a well-established tradition to attack scientists if their data are unpalatable, and some of us have received plenty of insults and libellous comments because of this; but pointing out facts is the first step in any responsible science. Vested interests especially seem not to grasp this!

Ownership of the area is therefore an issue with important potential consequences to conservation. The UK Government have stated that they will cede the area to Mauritius when it is no longer required for US-UK defence purposes. Today, Mauritian reefs have very low measured reef fish biomass (Graham et al. 2013) and, as noted, Chagos reefs have the highest. With regional demands increasing even faster than human populations, future reef survival in Chagos cannot be guaranteed if exploited.

Meanwhile, the rising power in the region is China, so it may be that the USA and UK wish to retain the area for a while yet. The important lesson in this is how much global politics determine conservation outcomes: the fact that that the area's political and military importance has had a lot to do with why Chagos remains in such good condition is an irony that generates much angst today.

Deniers

Another general problem that conservation often faces is denial that a problem exists at all. Climate change deniers are one good example, and several of their web sites claim that ocean temperature is not rising, sea level rise is not a problem, that fish have not declined, and may use the simple procrastination approach, namely that no action should be taken yet due to 'uncertainty': more data are needed before doing anything. Scientists' data have been misused several times in such sites. Some deniers may believe their own nonsense, but others have vested interests, or, in the case of BIOT, hate the military or its presence there. I have received numerous emails that reveal, principally, the writer to be in the latter group. Some others simply snipe at work being done, rather than engage with helpful input themselves.

Aside from such opponents, there is a doubtless far larger number of people who simply don't like hearing bad news. Several articles and posts recently have said we are not getting the message across about the importance and magnitude of reef decline, and one reason is a human aversion to uncomfortable facts. Maybe this is hard-wired too.

Costs and values of conservation in Chagos

Through a series of coincidences including East-West political rivalry, a geographically important site with a failing local economy and increasing resource demands almost everywhere else, Chagos reefs remain in strikingly better condition than most places. This created the important opportunity to conserve the largest remaining swathe of coral reefs that could be sustained in good condition, at least as long as global warming and acidification allow – which will likely be a few decades longer than where exploitation makes the reef story one of forlorn disaster. The scientific value of Chagos is rarely questioned now, even by the most energetic commercial interests and critics of the government or the military.

As a consequence, one question here has turned to how to balance conservation with the needs or desires of a community should the area become inhabited in the future. To help resolve this, the feasibility of resettlement of Chagossians is being re-examined (there have been two other studies before this). One key question is how many really want to settle there, and how would they earn a living there? Numbers returning would doubtless depend on what facilities would be offered; but set-up and running costs would be large, even before the costs of countering forecast global reef decline and sea level rise are included. In Diego Garcia, the cost of shoreline strengthening, needed already because of sea level rise, now exceed $10 million per year, for just a few hundred metres of coast. Sea levels are recorded as now rising at nearly 6 mm per year (Sheppard 2014b for brief summary).

Also there is the question of calculating the scientific and economic benefit of retaining intact this large, rich system to the whole ocean and its people. What benefit is there to reef managers who can learn from it what to aim for, and what is its value as a reservoir, sink and source of species? Valuing this is tricky.

Figure 7. Chagos reef survey. A new project is near completion, funded by the Chagos Conservation Trust, which puts all previous data into a GIS-based relational database, to enhance the value of the >250 publications that have been done in recent years. (Photo: Anne Sheppard)

Increasing rarity of reefs is important, and is one reason why the recent revision of reef values by Costanza et al. (2014) has soared since his famous initial work of 1997, partly because the amount of reef remaining has steeply declined and partly because of previously unrecognised 'uses' of reefs. Values proposed have risen over this time from "8,000 to around 352,000 US$/ha/yr due to additional studies of storm protection, erosion protection, and recreation..." Overall, since 1997 "…marine systems show a large loss ($10.9 trillion/yr), due mainly to a decrease in coral reef area and the substantially larger unit value for coral reefs using the 2011 unit values".

So, for all the reasons that many have put forward over the years, Government and society (which part of society?) must judge how to help Chagossians in whichever places they remain impoverished, while at the same time retaining intact this large healthy reef system. Some advocate that we can have settlement supported by local extractive industry and avoid degradation, but evidence suggests that we cannot. There is little evidence to suggest a middle ground. Reef deterioration could be avoided despite re-settlement if the new community were supported from outside in the manner of those employed in the Diego Garcia base; and indeed this, or some carefully planned ship-based planned tourism, was proposed by CCT years ago. But the cost needs to be compared with other ways of achieving a prosperous and sustainable future for the people concerned.

The future

We know that, globally, reef conservation is failing so that reefs are not maintaining their benefits to people. Sale (2014) said: "… most of the causes of decline are due to local human activity … we can anticipate that climate change and ocean acidification are going to become ever more important as causes of reef decline, meaning that … causes of reef decline will be less easily remedied by local actions than they are at present". In the case of Chagos, its resources will become increasingly desired too. If solutions are difficult now they will become increasingly difficult and more expensive if left unaddressed. One solution is to view the oceans as we view the land, that is, to farm it, make someone responsible for it (even own it) and zone it in a not-new procedure called Marine Spatial Planning (Sale et al. 2014). The idea is anathema to many, but the alternative will surely be more of the same, namely remorseless deterioration of all of it. Some areas would need to be intensively farmed (many already are, but usually in *ad hoc* ways), some assigned other uses, planned and zoned, including keeping some as usefully large examples in their unexploited state, for all the oft-repeated reasons. Chagos is the most obvious candidate for remaining an unexploited reserve, and it fits as well as can be the recently enunciated five key criteria for a marine reserve (Edgar et al. 2014). This would be a useful legacy, far preferable to the present overall decline.

We need to remain optimistic! Push through, wherever and however you can the big ideas, such as maintaining intact such giant reservoirs and networks of coral reefs (IUCN in press). Publicise your successes. Challenge deniers and vested interests, resist their pressures and ignore their displeasure. Question procrastinating politicians, who take the path of least resistance, by reminding them that most of the essential knowledge needed to sustain and restore reefs is known, and that their procrastination has become unacceptable. And make the case for conservation outside our own community of researchers.

It is hard to improve societies in a declining environment. You will know, if you manage to help arrest the deterioration of reefs, that this will help the large part of humanity who live far below your own standard of living, as well as maintain the world's most biodiverse ecosystem.

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REEF CURRENTS

General articles and overviews of reef science and management

The Ginsburg Agenda:

a geologist asked questions that no one could answer, leading to a 1993 event that catalysed coral reef science and conservation

Clive Wilkinson[1], Gregor Hodgson[2], Sue Wells[3] and Judy Lang[4]
with contributions from Arthur Paterson, Peter Thomas, Kristian Teleki, Roger Griffis

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By the early 1990s, there were numerous papers and reports about individual reefs that had suffered human impacts. Local pollution and sedimentation were believed to be the main culprits. What was not recognized in the pre-internet age was the geographic extent of human impacts on coral reefs. Were these impacts just local or did they extend regionally or even globally? We wish to recognise the critical role that Robert (Bob) Ginsburg, an experienced geologist, played as a catalyst[1] by asking questions about the ***global*** extent of human impacts on reefs and by stimulating much of the coral reef monitoring and conservation activity that has occurred in the last 21 years. Now retired, Bob continues to enjoy learning about coral reefs and probing visitors with insightful questions and we thought that now would be a good time to provide this tribute and review.

In June 1993, as part of the 50th anniversary of the Rosenstiel School of Marine and Atmospheric Science held at the University of Miami, Bob Ginsburg convened a meeting entitled: 'Forum on Global Aspects of Coral Reefs: Health, Hazards and History' (Ginsburg 1994). He posed 11 questions that no one could effectively answer, but the following five provoked particular discussion:

- are reefs worldwide in decline?
- how will global warming affect reefs?
- how can natural vs. anthropogenic changes be identified?
- can reef reserves protect coral communities? and
- why don't conservation regulations work?

Prior to 1993, there were a few prophetic warnings from the wilderness: Johannes (1975) and Endean (1976) reviewed degradation, pollution and recovery of reef communities with much focus on crown-of-thorns starfish outbreaks on the Great Barrier Reef (GBR). Damage from dredge-and-fill operations on Key Largo, Florida in the early 1970s were monitored by Griffin (1974) with the result that the State of Florida enacted statutes to protect staghorn, elkhorn, and pillar coral (*Acropora cervicornis, A. palmata*, and *Dendrogyra cylindrus*). Even earlier conservation efforts included designating Dry Tortugas as a National Monument in 1935 and the establishment of the Carnegie research laboratory in 1905, as reported in Shinn and Jaap (2005). Early evidence of human impacts on

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[1] A catalyst is a substance that increases the rate of a chemical reaction by reducing the activation energy, but which is left unchanged by the reaction. In non-scientific terms, a catalyst is someone who provides the spark for a much greater level of subsequent activity.

coral reefs in the 1980s was presented by Salvat (1980, 1987), Rogers (1985) and Wells (1988); but the larger focus continued to be on coral reef science.

4th International Coral Reef Symposium (1981)

The first real effort to focus on reef degradation was at the 4th International Coral Reef Symposium in Manila in 1981 entitled by Edgardo Gomez as 'The Reef and Man'; however there were few reports of coral reef degradation from the coral reef science community, outside those from developing countries. It is pertinent to note that the Keynote Speech in 1981 was given by a politician, the Minister of Natural Resources, Jose J. Leido who observed: "…man, being the manipulator of ecosystems, is the strongest ecological force in the world. He has the capability to alter entire habitats, modify climate regimes, and harvest flora and fauna to extinction." At the same meeting David Stoddart (1981) also highlighted the declining status of coral reefs. A few years later, Don Kinsey (1988) summarised the threats to reefs and highlighted that the major anthropogenic stresses were sewage and nutrient pollution, sediment input and tourism, and observed that chronic human-induced stresses often impede recovery from natural stresses like storms.

7th International Coral Reef Symposium (1992)

These early calls to recognise the increasing threats to coral reefs from growing human populations and associated stresses were effectively side lined because most coral reef science was conducted by researchers from developed countries working on 'healthy' coral reefs adjacent to marine research stations. Indeed the 5th and 6th International Coral Reef Symposia in Tahiti (1985) and Townsville (1988) focussed on the science of coral reefs with just passing acknowledgement to reef degradation due to anthropogenic stresses. However this aspect was given unusual focus at the 7th International Coral Reef Symposium in Guam in 1992 by the organisers Chuck Birkeland and Bob Richmond. Both of the opening Plenary Addresses focused on conservation messages relating to increasing reef degradation.

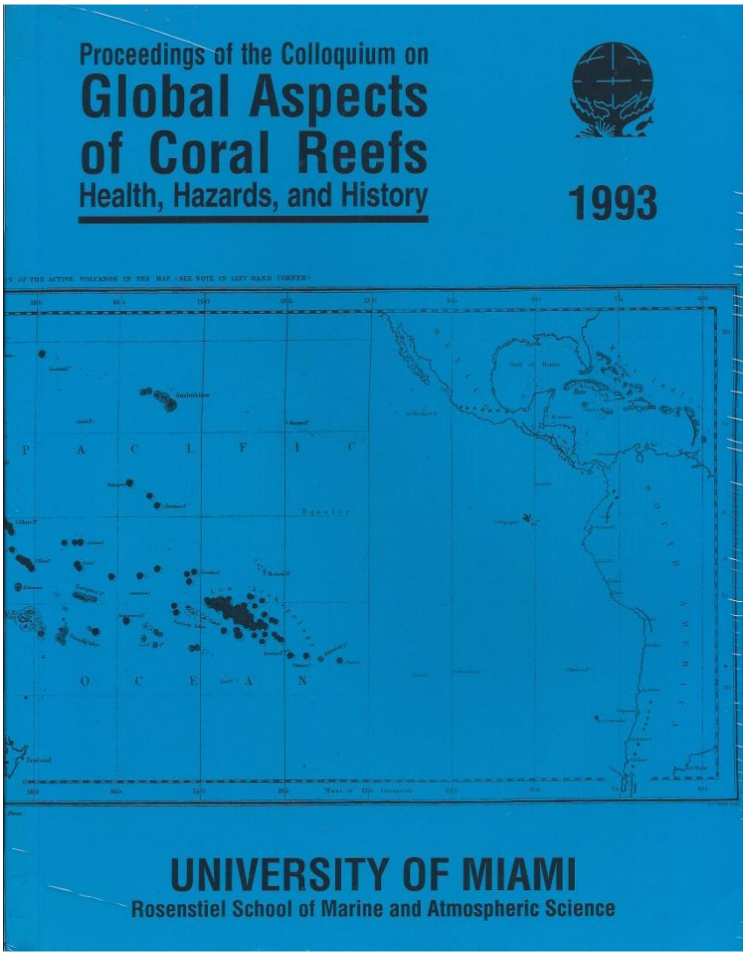
In the first, Robert (Bob) Buddemeier detailed the impending effects of climate change, noting that this would exacerbate the anthropogenic stresses of poor land use, waste disposal into the ocean and over-exploitation, and stressing the threats of increasing ocean acidification (Buddemeier 1993). On climate change he stated that, "I am reasonably confident that in 20 years, retrospective analysis will lead to consensus that greenhouse-induced climate change has occurred …". There is now obvious consensus on this in the scientific world, with the IPCC (2014) report stating that scientists are 95% convinced that current levels of climate change are due to human impacts. However, scientists have to defend this conviction against well-funded lobby groups that deny human causation. Buddemeier expressed doubts that conservation efforts could be implemented rapidly and at sufficiently large scales to arrest the rate of reef degradation.

The second Plenary Address by Clive Wilkinson (Wilkinson 1993) focused on the anthropogenic stresses to reefs highlighted by Buddemeier and included alarming predictions that 10% of the world's reefs were effectively destroyed, 30% of all reefs were approaching that level of degradation, another 30% were under a longer-term threat, while only 30% of reefs were seemingly remote from degradation and in good health. These predictions garnered widespread media coverage but engendered a wide range of responses from the coral reef science community ranging from complete denial to begrudging acceptance, with some scientists saying "I'm glad you said that, we had come to similar conclusions, but did not have sufficient data to make such a statement". Others stressed that these symposia were about coral reef science; management and conservation issues were not welcome additions. Wilkinson's percentage loss calculations were based on the predicted growth in human populations and economies in coral reef countries, relatively extensive monitoring in southeast Asia, scattered reports from around the world, and what could be gleaned from the pioneering three volume series 'Coral Reefs of the World' by Sue Wells and colleagues (1988). These two addresses were probably the catalyst for Bob Ginsburg to launch the Miami meeting, labelled by some notable geologists as a 'Coral Reef Love In', for the 50th anniversary of the Rosenstiel School.

Bob Ginsburg, a geologist with decades of field experience, viewed coral reefs from a perspective of thousands to millions of years, during which reefs had flourished, collapsed due to major climatic change events, and then recovered to vibrant reefs again. Each transition occurred over long (geologic) time scales. He was concerned that the two 7th ICRS Plenary Addresses painted an unnecessarily pessimistic picture of reef futures, using time scales of decades rather than millennia. His original goal was to determine whether these predictions of reef decline in decades were based on anything more than anecdotal reports and how they would compare to 'geological' time scales. He kept saying, "They are not looking in Eastern Indonesia." Thus, he invited nearly 120 reef scientists and managers to present case studies (62 were presented) from all coral reef regions over three days in June 1993 (Ginsburg 1994).

The Miami Meeting 1993

The Miami meeting featured some presentations that foreshadowed what we see today. Bell and Tomascik (1993) presented data showing that reefs in the Caribbean and on the GBR were under stress from land-based runoff. Tomascik et al. (1993) in a scientific presentation that deserved the adjective 'poignant', quoted Umbgrove from 1939 describing Nyamuk Besar and other reefs in Jakarta Bay as stunning coral gardens; these reefs and entire coral islands had disappeared, buried under pollution from land-based sources and mined for coral sand (Umbgrove 1939). One presentation came out a year later as a key paper detailing the anthropogenic links behind the collapse of reefs of north Jamaica (Hughes 1994). Until then, no one considered that a lack of fish was a destabilizing factor; indeed some leading coral reef scientists had stated that fish were of little importance on reefs, because those reefs in Jamaica had great coral cover! Another presentation from Southeast Asia stimulated major discussions, with some participants denying that the damage was as severe as the authors, predominantly from the region, indicated (Wilkinson et al. 1993). The reefs of this region have now been assessed as the most damaged in the world and at greatest risk of imminent collapse (Burke et al. 2011).



One controversial proposal at that meeting was that the coral reef 'world' should adopt a 'triage' approach: Group 1 reefs were in near-pristine condition with few anthropogenic pressures, such as many in the wider Pacific (detailed in Buddemeier 2001); Group 2 reefs required conservation efforts to reduce anthropogenic pressures to ensure they survived; and Group 3 reefs were under major anthropogenic pressures such that they would continue to decline, irrespective of conservation efforts. The suggestion was that all efforts should be allocated to Group 1 and 2 reefs. Immediately it was suggested that the Florida Reef Tract could be classified in Group 3 as coral cover had greatly declined, and anthropogenic pressures were increasing. Bob Ginsburg retorted that there were large areas of 'healthy' reef and so conservation efforts were still required.

The findings from those 62 case studies and in-depth discussion sessions surprised most of those in attendance, and probably most surprised was Bob Ginsburg. The speculation and predictions from the 7th ICRS had probably underestimated the gravity of the situation facing coral reefs around the world (Ginsburg and Glynn 1994). There were four major conclusions from the colloquium (paraphrased here):

1. Reefs have been significantly degraded in many regions, but a global assessment is not possible because many remote areas have not been examined. Reefs near large human populations appear to be the most degraded;
2. There are insufficient data to make reliable statements on the condition of reefs around the world and the causes of observed reef decline;
3. There is an urgent need for science to provide reef management with an understanding of what causes reef decline and the mechanisms that occur in reefs to reverse such declines, such as new recruitment of corals and other organisms; and
4. Most coral reefs are in developing countries with people dependent on reef resources for food and livelihoods, therefore there is a need for increasing awareness to implement co-management of reef resources for long-term sustainability.

Bob Ginsburg was concerned that it was not possible to quantify reliably the status of the world's reefs and so he lobbied for a global monitoring program. He approached Gregor Hodgson specifically to develop a system to systematically survey coral reefs, feeling confident that broad surveys would demonstrate that not all reefs were in decline. The methods (developed as Reef Check) were specifically targeted at volunteer divers who were trained by scientists following urging from Sue Wells. Bob Ginsburg was also a major driver behind the development of the Atlantic and Gulf Rapid Reef Assessment (AGRRA) initiative which debuted in 1997 to fill in spatial data gaps for reef condition, particularly in large, remote areas. AGRRA set the bar for reef assessment and the methods continue to be widely used in the Caribbean today.

Bob Ginsburg – became concerned about the future of reefs (Photo: Peter Swart)

The Miami colloquium recommended that more comprehensive assessments of the status of the world's coral reefs were needed with an emphasis on determining the level of natural versus anthropogenic stresses. Major awareness raising programs were recommended to inform user groups and the public about reefs, their importance and vulnerability. Another critical recommendation was to designate 1996 as the 'Year of the Reef'.

Outcomes from the Miami Meeting

Many significant outcomes can be attributed to the catalytic actions of the questions posed at the Miami meeting organised by Bob Ginsburg, including:

- The International Year of the Reef 1997 (and Pacific Year of the Coral Reef, 1997);
- The International Coral Reef Initiative (ICRI), announced in 1994 and started in 1995;
- The Global Coral Reef Monitoring Network (GCRMN), established in 1996 as an operational network of ICRI and funded by the US Department of State;
- Florida's Coral Reef Evaluation and Monitoring Project (CREMP) which in 1996 extended throughout the Florida Keys and expanded to southeast Florida in 2003 and the Dry Tortugas in 2004 (Porter et al 2002; Sommerfield et al. 2008);
- Reef Check, launched in 1997 with a global reef survey (Hodgson, 1999);
- AGRRA launched in 1997 with a large-scale survey of the Andros, Bahamas reef tract; and

- Executive Order 13089 on 'Coral Reef Protection' issued by President Clinton in 1998 and the formation of the U.S. Coral Reef Task Force.

The conclusions and recommendations from the Miami meeting found a receptive ear in the USA with leadership and staff (Mike Crosby, Bill Millhouser, and Arthur Paterson) in the National Oceanic and Atmospheric Administration (NOAA). NOAA, with the US Department of State (especially Deputy Assistant Secretary for Environment Rafe Pomerance) took up the recommendation to initiate a Year of the Reef for 1996 (later postponed to 1997) and suggested a US Coral Reef Initiative at the 1st Small Islands Developing States Conference in Barbados in October 1994. The latter was taken up by the Australian Ambassador for the Environment, Penny Wensley, who negotiated with France, Jamaica, Japan, the Philippines, Sweden, UK, the Intergovernmental Oceanographic Commission of UNESCO, UN Environment Programme, the World Bank, IUCN and others to join with the USA and Australia in forming the International Coral Reef Initiative (ICRI). The formation of ICRI was endorsed at the First Ordinary Meeting of the Conference of the Parties to the Convention on Biological Diversity in December 1994 in the Bahamas, at a ceremony with Ambassador Wensley and US Under Secretary of State Tim Wirth. Also at that meeting, the Philippine Secretary for the Environment and Natural Resources, Angel Alcala (a particularly active coral reef researcher), along with his co-chair Wensley, invited participants to his home town Dumaguete City in May 1995. Here, ICRI was formally initiated with negotiation of a 'Call to Action' and a 'Framework for Action' (www.ICRIForum.org), that focussed on four main themes: Coastal Management, with calls for integrated coastal management and the designation of marine protected areas; Capacity Building, to improve information flow and exchanges on coral reef issues and management mechanisms; Research and Monitoring, to develop regional networks to enhance reef research and improve reef assessments through the formation of a global coral reef monitoring network; and Review, to periodically assess progress in achieving the objectives of the Call to Action and the Framework for Action. ICRI has developed into the major body providing advice to the UN General Assembly and other UN agencies such as the Convention on Biological Diversity Secretariat and UNEP (United Nations Environment Programme), with the initial core countries accepting the role of coordinating ICRI for two -year periods usually in association with a developing partner country. The full history and outputs are on www.ICRIForum.org.

ICRI has continued as a high level but informal body, advocating management conservation, capacity building, research and monitoring of coral reefs around the world. The first Secretariat was chaired initially by Susan Drake and then Peter Thomas of the US Department of State with the team from NOAA, Barbara Best and Karla Boreri from USAID, and Karen Koltes from the US Geological Survey. The US Department of State made a formal request to Australia to take the Secretariat, with Richard Kenchington of the Great Barrier Reef Marine Park Authority as the next Chair. Since then eight further Secretariats have been coordinated by member countries at approximately 2 year intervals, specifically: France; Sweden and the Philippines; UK and the Seychelles; Japan and Palau; Mexico and USA; France and Samoa; Australia and Belize; and currently Japan and Thailand. One of the first long-term elements that received consistent funding from ICRI partners, especially the US Department of State, was the Global Coral Reef Monitoring Network.

The concept of an International Year of the Reef (IYOR) was greeted enthusiastically by many people. Many NGOs, which were becoming increasingly concerned about the decline of reefs, were pleased that the scientific community was finally behind them. Planning for the IYOR was undertaken by a small Organising Committee, led by Bob Ginsburg, and comprising Sue Wells (then at WWF), Paul Holthus (then at IUCN) and Stephen Colwell (then at the Coral Reef Alliance - CORAL) in close consultation with the ICRI partners (Wells et al. 1997). Numerous reef scientists and conservationists supported the initiative including Gregor Hodgson, Kristian Teleki, Mark Eakin, Jeremy Jackson, John Ogden, Bob Richmond, and US government staff, notably Peter Thomas from the Department of State and Roger Griffis, Arthur Paterson from NOAA and Barbara Best from USAID. The objective was to provide a focus for coral reef issues around the world in order to increase support for conservation of these valuable resources. The initial planned year of 1996 extended to 1997 to ensure that maximal benefits could be obtained. More than 80 countries participated and it is strange to reflect that this was still the early years of the Internet and e-mail (Kristian Teleki helped introduce the reef community to the Internet in a 1995 issue of Reef Encounter, with a list of all websites referring to coral reefs, which was possible in those days!). *Reef Encounter*, the newsletter of the

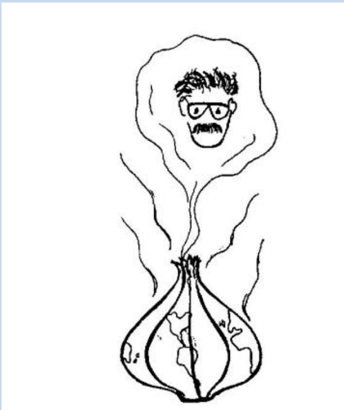
International Society for Reef Studies, was the main means of communication (Reef Encounter (1995-97). The IYOR was made the official publicity arm for ICRI for 1997, and numerous regional issues evolved out of it, such as the Pacific Year of the Coral Reef, organised by SPREP (the Secretariat of the Pacific Regional Environment Programme), which was particularly successful in raising awareness of coral reef issues throughout the Pacific. The success of IYOR helped provide momentum and foundation for the 1998 Year of the Ocean. The IYOR process was repeated in 2008 under the direction of ICRI, with a greater spread of activities throughout even more countries. http://www.icriforum.org/about-icri/iyor. The World Resources Institute entered the process to produce the ground-breaking 'Reefs at Risk' reports, which have since continued to assess the status and trends in coral reefs globally.

Since the Miami meeting in 1993, the GCRMN, Reef Check and AGRRA have produced regional and global estimates of reef 'health'. The first Reef Check global survey in 1997 highlighted an increasing coral reef crisis, due to overfishing, pollution and sedimentation; these were front-page news stories (Hodgson and Liebeler 2002). The significant bleaching and disease-related mortality of Caribbean-area stony corals after the 1998 ENSO event were recorded in early AGRRA surveys (Ginsburg and Lang 2003; Kramer 2003). Similar estimates have come from other large-scale studies (Burke et al. 2002; Burke and Maidens 2004; Bruno and Selig 2007; Bellwood et al. 2004; Obura et al. 2008). In 2008 the GCRMN reported that that live coral cover in the Caribbean had declined following mass bleaching in 2005 (Wilkinson and Souter 2008). Moreover, approximately 19% of the world's coral reefs were severely damaged with no immediate prospects of recovery, and 35% of the remaining coral reefs were under imminent risk of degradation from direct human pressures (Wilkinson 2008). The most recent Reefs at Risk study by Burke et al. (2011) calculated that more than 60% of the world's coral reefs are under immediate threat, a figure rising to 75% if potential global climate change stress is included. GCRMN's monitoring and reporting continues, with its most recent report (Jackson et al. 2014) indicating that live coral cover across the Caribbean has declined by about 50% in the three decades since 1984.

Miami - The Lighter Side

Typical of any event organised by Bob, the **Colloquium and Forum on Global Aspects of Coral Reefs** included many entertaining moments. The meeting was reported on extensively in *Reef Encounter* no 14, from which the following information is culled. In particular "Bob Ginsberg provided a pungent acronym to direct thinking about projects to be undertaken as part of this initiative. Under the **'GARLIC'** criteria, projects should be:

Of **G**lobal concern
Arresting, and take new directions
Relevant to current issues
Show **L**eadership of the field and in determining policy
Innovative
Community oriented



The acronym was illustrated in *Reef Encounter* as shown, with Bob arising in the garlic aroma, the garlic bulb representing the world.
Other good quotes from the meeting included:
"Japan is a very safe place to swim because there is absolutely nothing left in the water which could bite you." (C. Veron)
"For coral reefs, the major problem with climate change is that it is unlikely to be severe enough to eradicate humans." (B. Buddemeier) (*though 22 years on, he might soon be proved wrong on this)*
"We should try to make a statement to the press that we have sworn an oath, signed in blood, that in all our papers for the next three years we include at least one paragraph stating the relevance of the work to reef managers." (A. Bloom)

The momentum that developed after that 1993 meeting in Miami has rippled through governments around the world. Indeed, in the USA President Clinton initiated significant actions to promote coral reef conservation, including the Presidential Executive Order directing federal agencies to help advance coral reef conservation. The US Coral Reef Task Force was established to lead US coral reef conservation efforts and the 2000 Federal Budget Proposal to fund the Coral Reef Conservation Program at NOAA and, subsequently the Coral Reef Watch satellite network and analyses that are used to warn of potential coral bleaching and other threats to reefs (www.coralreefwatch.noaa.gov/satellite/).

Other initiatives followed. The United Nations Foundation funded the International Coral Reef Action Network in 2000 as an operational network of ICRI, to focus on coral reef management and awareness raising; and the World Bank initiated a wide-ranging meeting of coral reef scientists and managers in 1998 (Hatziolos et al. 1998), and later went on to fund the Coral Reef Targeted Research Programme (Hoegh-Guldberg et al. 2007) and other initiatives in recognition of the major contribution that coral reefs play in the livelihoods of coastal communities.

Conclusion

The initial catalytic action by Bob Ginsburg who wanted to answer questions about the global status of coral reefs 'snowballed' into public awareness campaigns such as IYOR and new research programs that led to better communication among scientists, politicians and coral reef managers. This in turn led to increased conservation such as the declaration of thousands of new marine protected areas, including over 200 in the Bahamas and Caribbean (P. Kramer, pers. comm.) and over 40 in the Eastern Pacific (D. Gill, pers. comm.). Much larger areas have also been placed under protection. Examples include expanded protection for the Great Barrier Reef in 2004 (no-take areas increased from 5% to 33% of all reef area), the Papahānaumokuākea Marine National Monument in the Northwest Hawaiian Islands (2007), the Phoenix Islands Protected Area (2008), the Chagos Islands Marine Protected Area (2010) and, in 2014, two more enormous areas: the Natural Park of the Coral Sea (Le Parc Naturel de la Mer de Corail) with an area of 1.3 million km^2 containing 4500 km^2 of the coral reefs of New Caledonia; and the Pacific Remote Islands Marine National Monument with more than 2 million km^2 surrounding seven remote atolls which was announced by President Obama in June 2014.

Numerous local communities are now establishing MPAs to protect and sustainably manage coral reefs; the exploitation of reef species is subject to regulation through international treaties and national legislation; and programmes are underway to increase the resilience of reefs to climate change and other threats. That said, there is still a long way to go to reverse the decline in coral reefs, and we need more champions like Bob Ginsburg. We consider that much of the progress in recent years resulted from that catalytic action in Miami in 1993. Ultimately, the entire scientific community including Bob Ginsburg came to accept that fundamental changes had occurred during the 1980s and 90s leading to global decline in coral reefs. Unlike a chemical catalyst, Bob Ginsburg changed and became a strong advocate for coral reef monitoring, assessment and conservation management.

Vale David Ross Stoddart, 1937 -2014, an outstanding coral reef geographer and scientist.

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The Sponge Guide:

Interactive photographic online guide to the identification of Caribbean sponges

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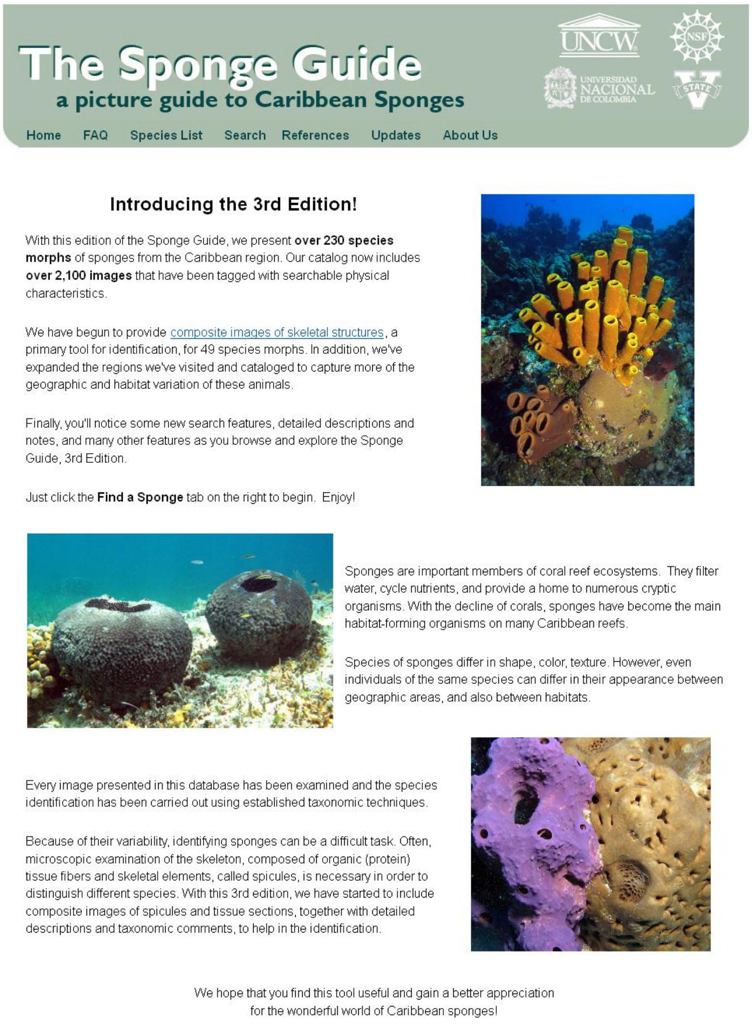
Development

Marine sponges are one of the most important functional components of benthic marine communities throughout the world, but especially in the Caribbean Sea (Wilkinson 1987; Díaz et al. 2001). Sponges are animals living attached to the bottom, feeding by filtering small particles and organic matter from the sea water through a system of internal canals (Bergquist 1978; Simpson 1984). Owing to coral decline and overfishing, sponges are becoming dominant on coral reefs (Pawlik 2011). Unfortunately, taxonomic identification of sponges is usually difficult and undertaken mostly by experts, due to the paucity of characters and their ecological and geographical variability. This fact has hampered their broader inclusion in ecological and other studies, even though only ten or so species usually comprise more than half of their abundance at any given site (Loh and Pawlik 2014). Sponges are identified from their external morphology (shape, color, consistency, surface characteristics), and from the type and three-dimensional arrangement of their microscopic skeletal elements called spicules; the latter are analyzed through digestion of small pieces of tissue in commercial bleach, and through thick, hand-made histological sections. With the advent of SCUBA diving and underwater photography, regional monographs and illustrated printed catalogs (e.g., Wiedenmayer 1977; van Soest 1978, 1980, 1984; Zea 1987, Hajdu *et al*. 2011; Moraes 2011) became important tools for scientists, as well as for interested laymen to become familiar with the most common species. However, printed catalogs are costly to produce and distribute, limiting both their scope and access to the information. With the advent of digital technology, more extensive catalogs can be made available, and these can be updated periodically and made available to all users through the Internet or other sources.

One of the first printed monographs combining detailed descriptions, drawings of skeleton and underwater color photographs was that of Zea (1987). It was written in Spanish and only comprised 89 species (it was intended to be the first of multiple volumes), but it quickly became a useful tool that launched new comprehensive studies in reef sponge ecology (summarized in Pawlik 2011).



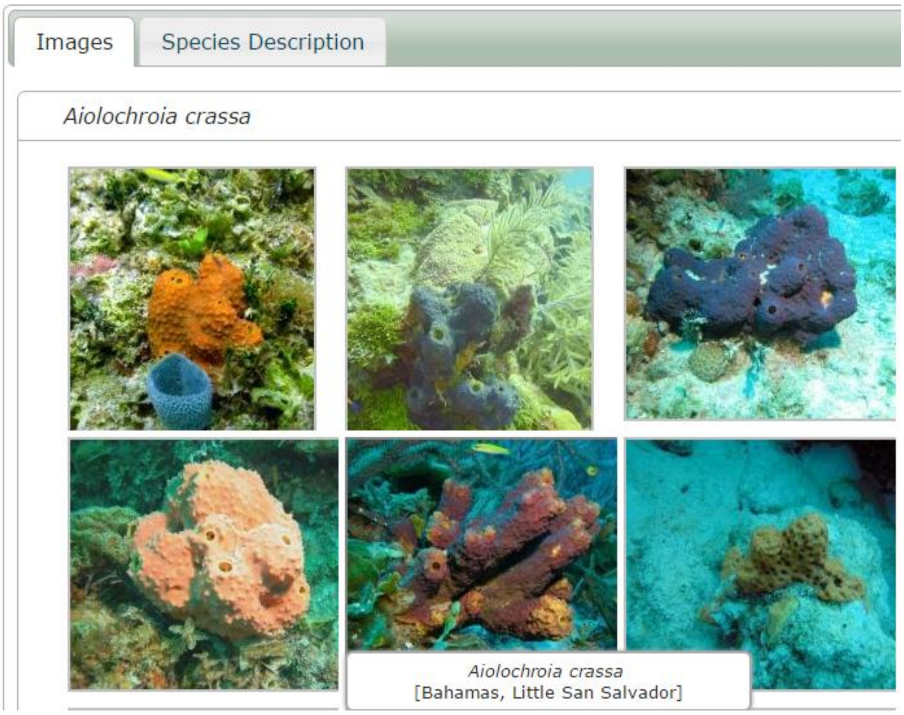
The present guide was initiated in 2000 when Zea served as the sponge taxonomist on a series of research expeditions in the Bahamas led by Pawlik. Over the next 10 years, this collaboration was joined by Henkel, who added knowledge of databases and programming to develop a comprehensive photographic database of reef sponges. While the goal at the time was to develop a tool for researchers on the expedition, in 2009 we put the Sponge Guide (tSG, spongeguide.org) online for everyone to access (Zea et al. 2009). The guide was quickly welcomed by scientists and laymen alike, receiving over 10,000 visits from 125 countries during the first year. It brought interesting discussions among sponge taxonomists and has been highlighted in various venues (Internet lists, specialized workshops and courses, other online guides, e.g. Messing et al. 2009; see also Cardenas et al. 2012; van Soest et al. 2012).

Over the past year and a half, we have worked to resolve many of the tentative identifications first published in tSG, expanding the regions surveyed to the eastern and southern Caribbean, and documenting skeletal information required for more complete identification. This work was made possible by funding from the National Science Foundation, Universidad Nacional de Colombia and a Fulbright Visiting Professor scholarship. From these efforts, in December 2014, the 3rd edition of the guide was launched (Zea et al. 2014), comprising 2,152 images of 231 species, 49 of which now have a full complement of skeletal images, descriptions and taxonomic notes.

GUIDE FEATURES

Cataloging Variability

One of the primary goals of the Sponge Guide is to capture and display morphological variation of individual species alongside their confirmed taxonomic identification. With the 3rd edition, we now have cataloged images of sponges from 10 countries in the Caribbean. In the guide, we have characterized 232 species-morphs, of which almost all have images of at least two different individuals taken *in situ*. We have recorded 5 or more specimens for 75% of the species-morphs in the guide. In each case, taxonomic identification has been verified by the guide's authors.

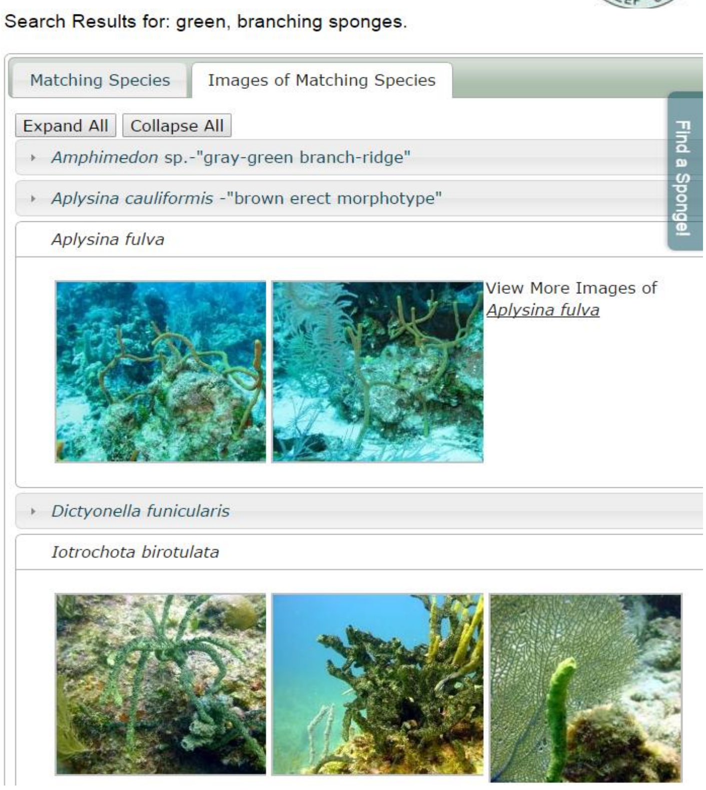


Within tSG, each photograph is tagged with key descriptive characteristics including color, consistency, morphology, and habitat, as well as location (the specific reef and country of origin), photographer and any specific notes of interest for the photograph. By focusing on images taken in the field, the assigned descriptive characteristics are based on the specimen as seen by a diver.

Power to Search

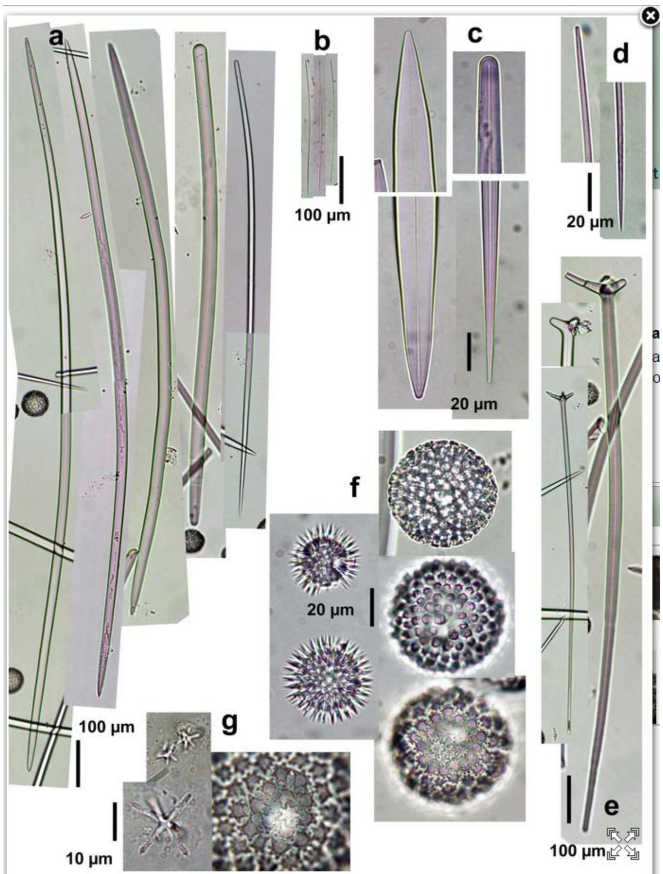
Tagging each specimen with key terms allowed for a searchable interface to be built around these terms. We have designed several methods for finding sponges that are accessible from every page of tSG by clicking on the Find a Sponge (FaS) tab. First, a user can filter the catalog using our predefined characteristics. The search result includes a list of names as well as images that the user can scan through. Links are also provided to view other variations of the species in question.

Another search option leverages a Google Custom Search Engine that has indexed all of the species and individual image pages of tSG. Thus, all of the characteristics, species descriptions, custom notes, and figure captions from tissue and skeletal images are searchable using Google's familiar interface. Within our species descriptions and notes, we include previous taxonomic classifications, so for example, if a user is looking for images of *Pseudoceratina crassa* the guide will point them to the current species page for *Aiolocroia crassa*.



From Macro to Micro Variation and Identification

The largest addition with the launch of the 3rd edition comes from extensive work processing tissue samples and cataloging skeletal structures of 49 different species morphs. Taxonomic confirmation requires analysis of spicules and skeleton, and access to specialized literature with thorough descriptions; thus we decided to bring the guide to a new level, adding composite images of spicules and tissue sections, detailed descriptions and taxonomic remarks.



Spicule Images: a) Oxeas-styloids-styles I; b) oxeas-anysostrongyloxeas II, c) enlarged tips of oxeas-styloids-styles I; d) enlargement of oxeas-anysostrongyloxeas II; e) plagiotriaenes; f) microscleres (sterrasters, developed and developing); g) enlargement of microscleres (rossettes of sterrasters on the right; spined asters in 2 types, oxyasters and and strongyl- or oxyasters). Sample from the Bahamas.

View Source Specimen

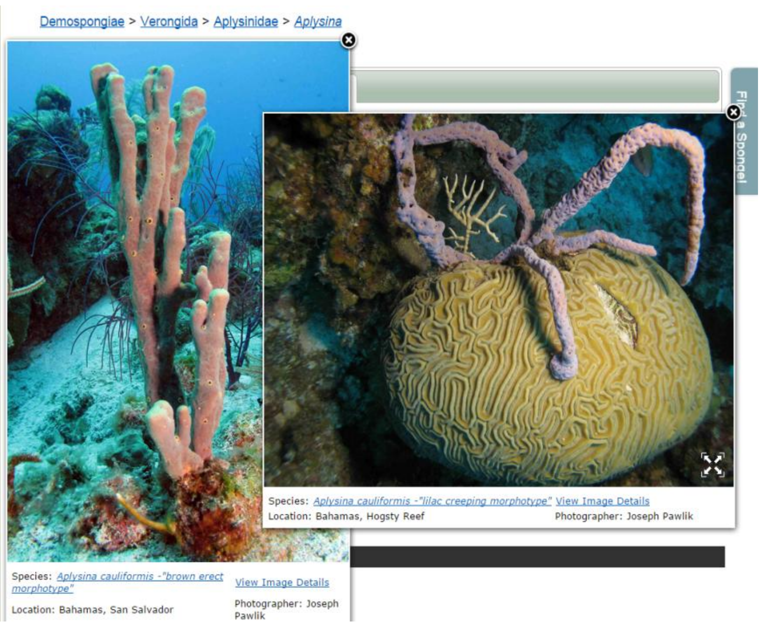
Users can find specimens with skeletal information in two easy ways: Using either the Search page or the Advanced Search box in the FaS tab, results can be filtered to only those with skeletal images by clicking on the "Tissue Samples" label at the top of the search results. Adding the phrase "tissue and spicules" with quotes will also only find specimens with skeletal information. Second, while viewing the Species List page (accessible in the top menu), entering an asterisk (*) will filter names of specimens that have skeletal and tissue information.

Browsing and Comparing

We have also added the ability to browse and compare sponges. Within the species list (or a characteristic search), users can click on any taxonomic level to view all specimens that belong to that group. Users can also view the thumbnails of images that match the criteria. Each thumbnail can be expanded by clicking on it, and moved around the screen. This allows for side by side comparisons of individual sponges.

Fully Referenced and Cross-listed

All of the identifications include a link to the full reference used to assign a specific identification. This allows for comparisons and historical context within the technical literature. Further, tSG is fully cross-listed with the World Porifera Database (www.marinespecies.org/porifera). This provides users easy access to even more information on the identification and distribution of any sponge of interest.



Built for Change and Growth

Finally, the 3rd edition of tSG highlights our desire to have a resource that is able to grow and change based on both new research developments and end-user needs. The online format allows for simple changes to nomenclature based on new studies, as well as presenting the morphological diversity of each group with the large catalog of images. We have begun archiving previous editions of the database online to allow citation and for revisiting previous descriptions. Each species page includes a link to a printable view that presents all of the species information in a simple layout for printing or viewing offline. We are always looking for new ideas and suggestions for formatting and layout to better serve the thousands of sponge enthusiasts that access this resource a year (suggestions@ spongeguide.org).

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Using iNaturalist to learn more about echinoderms

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Context

Echinoderms are among the most conspicuous and abundant marine invertebrates. Several species undergo large demographic fluctuations, with important ecological consequences, for reasons that are not always well understood (e.g. Crown-of-thorns outbreaks, *Diadema antillarum* die-off, starfish-wasting-syndrome, reviewed in Uthicke et al. 2009). In addition, many species are targeted by unregulated fisheries (e.g. Purcell et al. 2014). Despite these factors, echinoderms have received limited taxonomic attention, and many large species remain undescribed or are poorly known.

With recent technological advances, it has become increasingly easier to document species encountered in nature. For instance, smartphones can take a picture and record the exact geographical location and time of the observation. Digital cameras have made underwater photography much more accessible, and many divers now document the species they encounter by sharing their pictures on social media websites. These pictures regularly illustrate species that are undescribed or little-known. Taxonomic studies are increasingly utilizing live appearance of echinoderms, as many taxonomic species are most easily discerned by color pattern or field appearance. Our knowledge of echinoderms could therefore be improved by aggregating user observations of these organisms, while, at the same time, educating the public about the diversity and natural history of these fascinating organisms.

What is iNaturalist?

iNaturalist (http://inaturalist.org) is a website (established in 2008), acquired by the California Academy of Sciences in 2014. iNaturalist allows users to submit observations about any species (on land or underwater), along with images, GPS coordinates and ancillary information about the habitat or natural history (Fig. 1). Once submitted, the observations can be further identified by the community and vetted by "curators"

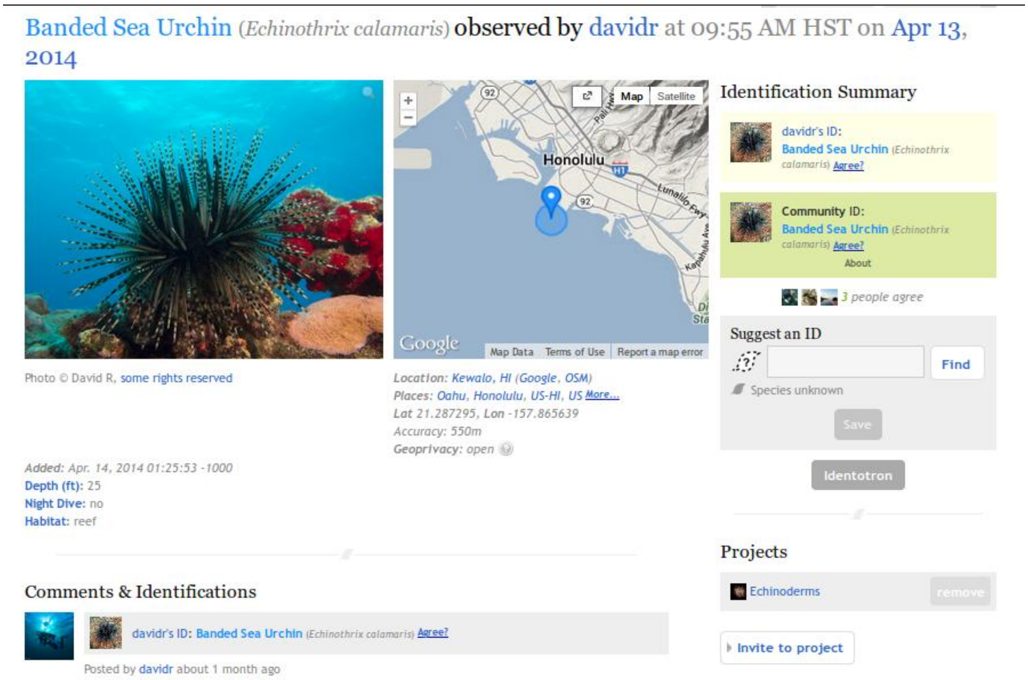

Figure 1. Example of a user-submitted observation.

(users with recognized knowledge of a given taxonomic group whose opinion can be trusted). This mechanism allows users to hone their identification skills, learn about the organisms, and communicate with each other. Observations, in turn, provide a wealth of information about distribution, variation, abundance, and other aspects of natural history. Mobile applications for Android and iOS are available to access and submit observations to iNaturalist.

The Echinoderm project on iNaturalist

We have started a project on Echinoderms using iNaturalist (http://inaturalist.org/projects/echinoderms) to gather observations worldwide, and across taxa. Our goal is to improve our knowledge of species distributions, variation, and biology, and to educate the public about the diversity of echinoderms. This platform provides a great outreach tool facilitating communication between scientists and naturalists. Because iNaturalist is easy to use and has applications for mobile devices, it can also be used during citizen science initiatives (such as Bioblitzes) or class field trips.

Beyond outreach, iNaturalist can be a useful tool for scientists. Echinoderms are among the few mobile invertebrates regularly recorded during coral reef ecosystem monitoring. By submitting species observations on iNaturalist, data will be archived, accessible, and shareable with the community. Additionally, it also provides users with accurate identifications for the species encountered with the help of the community.

The aggregated data are made openly available and can be used by scientists to study demographic and spatial patterns, or infer distributions using ecological niche modelling. For instance, recent taxonomic research on sea cucumbers has shown that species can be told apart based on their color patterns (Kerr 2013; e.g. Kim et al. 2013). However, taxonomic confusion through the years has hindered our knowledge of species distributions, as incorrect identifications in many species complexes are pervasive in the literature. Having photographic evidence associated with geospatial data will allow accurate delineation of the geographical distributions of once confused species, after taxonomic research has clarified species limits. iNaturalist can also help track changes in species abundance (e.g. crown-of-thorns outbreaks) and condition (e.g. starfish-wasting-syndrome).

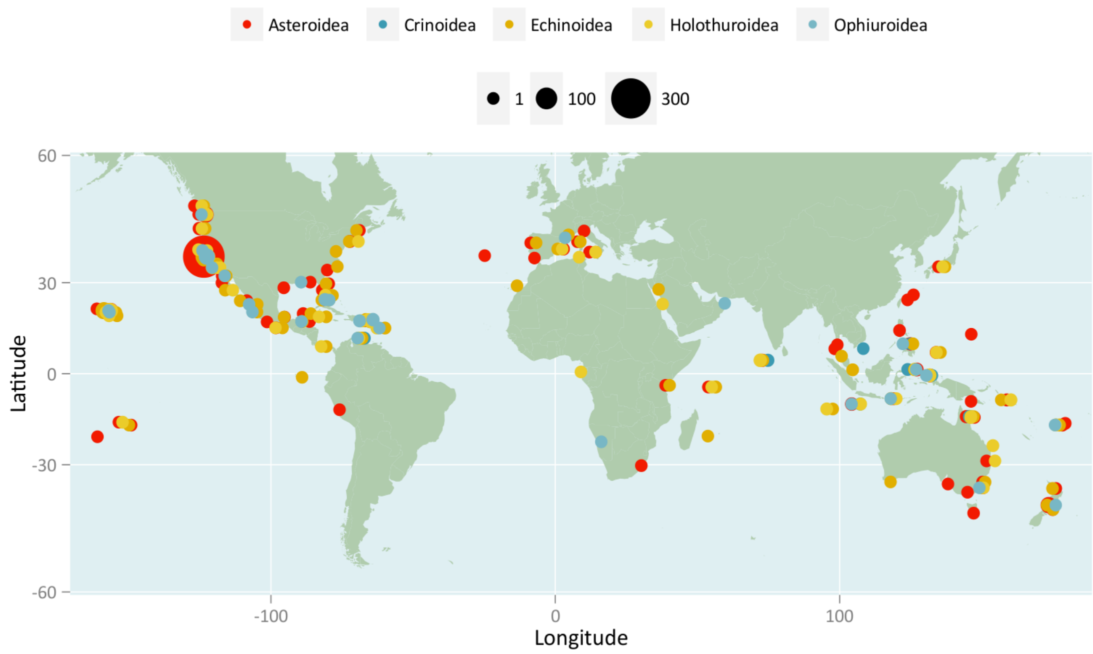

Figure 2. Global distribution, for each class of echinoderm, of observations recorded by iNaturalist users, as of May 29th, 2014.

Present and future observations

Since the beginning of the project in March 2014, over 150 users have contributed 1,300+ observations of 170 species worldwide. Currently, large and abundant species from the intertidal of the Western United States dominate, reflecting the development of iNaturalist in California (Figure 2). However, underwater sightings from the Caribbean and the Indo-West Pacific also represent a large proportion of the observations and indicate the potential of iNaturalist to document marine invertebrate biodiversity associated with coral reefs.

We aim at expanding both taxonomic and geographic coverage. Many of the species associated with coral reefs don't have well characterized geographical distributions. Reef scientists can improve our knowledge of their distribution by reporting the species they see in the field. Additionally, we are in the process of advertising the project to the SCUBA diving community and through citizen science initiatives, in order to increase participation.
We welcome anyone submitting their echinoderm observations, or indeed becoming involved in curating the records submitted to the project. Don't hesitate to join us!

Methods: This article is open-source (Creative Commons Attribution License), fully reproducible, available on GitHub and figshare (doi:10.6084/m9.figshare.1309937). It was made possible using R (R Development Core Team 2014) complemented with the packages ggplot2 (Wickham 2009) to draw the maps, knitr (Xie 2014) to generate the manuscript, taxizesoap (Chamberlain and Szöcs 2013; Chamberlain et al. 2014) to obtain the higher taxonomy of the species observed through WoRMS, and wesanderson (Ram 2014) for the color palette.

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Illustration by KAL

Interactive Electronic Marine Map:
an innovative outreach tool for increasing compliance with Marine Park regulations

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While numerous studies evaluate the effectiveness of Marine Protected Areas (MPAs), an oft-overlooked factor in their effectiveness is the rate of compliance with MPA regulations. Many visitors to MPAs are unaware that activities such as anchoring, pole fishing, spear fishing, use of jet skis, etc… are regulated within MPAs. Or they are unaware of the specific rules for a regulated activity. The goal of a new on-line interactive marine map (Fig. 1) is to disseminate accurate regulatory and policy information to people visiting Virgin Islands National Park (VIIS – the official abbreviation for the **VI**rgin **IS**lands national park).

Located on the island of St. John in the US Virgin Islands this park was established as part of the US National Park Service system in 1956, with 5650 acres of submerged lands (marine habitat) added in 1962. Coral reef research and monitoring conducted over 50+ years have created a significant baseline of reef community status. As with many marine parks and MPAs, VIIS marine boundaries were created based on politics and (submerged) land ownership, rather than ecological processes. Therefore without visitor compliance with protective or restrictive-use regulations, it is unreasonable to expect an ecological difference "inside vs. outside". Unlike their terrestrial counterparts, purely marine parks have no "visitor center", or primary entry point, and in the Virgin Islands visitors to the MPA often boat in and boat out, never coming ashore. Some may not even know they are in a protected area, since signage is virtually impossible. In many cases MPA/marine park boundaries can be found on some electronic GPS devices and chart plotters but these rarely provide information on allowed or prohibited uses within the boundaries. Websites focused on the marine environment provide available resource use and access information, but often regulations/policies regarding anchoring, fishing, and other activities are not easily accessed. Keeping those websites up-to-date with policy changes requires vigilance.

To address the need for getting near real-time regulatory information to visitors while they are actively in (or planning a visit to) the VIIS the National Park Service Resource Managers have created an interactive map displayed in the free program Google Earth. The map provides spatial information to answer many common questions, such as:

a) Where are the best places to snorkel?
b) What do all the buoys mean, why are they different colors and sizes?
c) Where can I anchor?
d) Where can I drive a boat, and
e) Where should I **not** drive a boat?
f) What fees are required? Where do I pay my fees?

The map can be used on a desktop computer or on a smart device (tablet or phone) using the Google Earth App. All marine features (e.g., mooring buoys, floating pay stations) are displayed on the map with realistic picture icons (Fig. 2). Text boxes providing feature information are displayed when the user clicks on a point feature/icon, a colored polygon, or water area within the park. Colored polygons show the locations of the best places to snorkel or dive, designated anchorages, boat exclusion zones, and navigational hazards. Park managers can easily make changes to the map to reflect new rules or modifications to the placement or types of moorings or anchor zones, and a new version will be posted to the website. The revision date will be linked to the downloaded map file so everyone can be sure to have the latest information.

The link for the map can be found on this webpage: http://www.nps.gov/viis/planyourvisit/google-earth-marine-project.htm. Links to download the free Google Earth program are also provided.

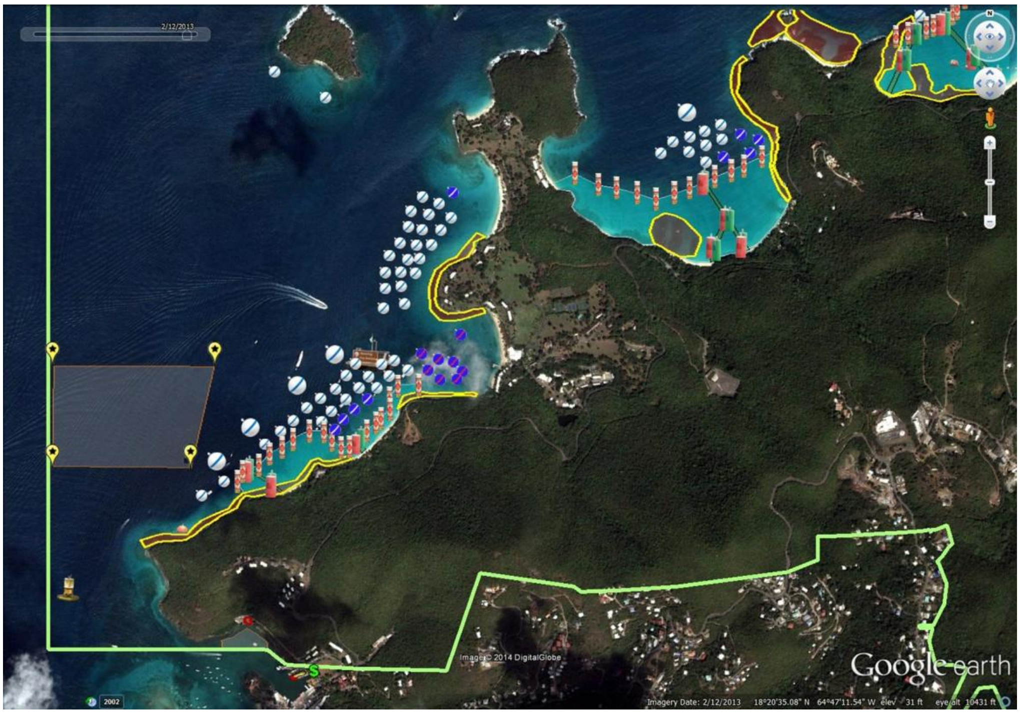

Figure 1. Screen capture of north shore, VIIS with various icons and areas displayed on the Marine Map. Polygons outline anchorages and swim zones/boat exclusion zones, navigational hazards and good snorkel/dive reefs. Point icons pictorially represent real items - mooring buoys, floating fee pay stations, demarcation buoys etc.

The map file is a KMZ file that will be downloaded to your computer or mobile device. That KMZ file, when opened in the Google Earth program (not Google Map), will provide you with a virtual tour of the marine environment of Virgin Islands National Park. Also available on the link is a 2-minute movie file that will show you how to use the file in the Google Earth program. Future plans include incorporating this map and information into a stand-alone App, thereby decreasing the number of steps for the user to get to the information.

With this map, a visitor can have the latest, accurate park regulations and policies while they are on the water. With this knowledge, the visitor has the best chance to comply with the park regulations, and the resources have the best chance to benefit from the regulations designed to protect them.

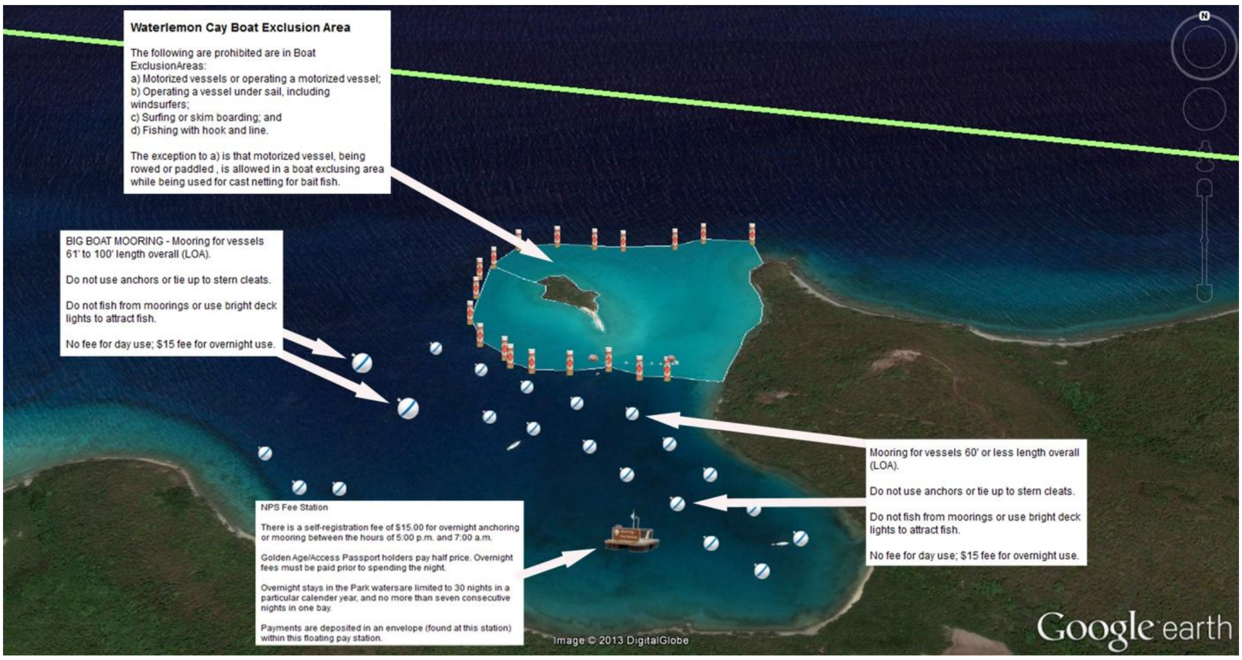

Figure 2. Screen capture of Leinster Bay, St John, displayed on the VIIS Marine Map. Text boxes are displayed when user clicks on a point feature or zone.

Finding the right tool for benthic image analysis:
tips for optimizing analysis and processing of images

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Background

Benthic ecosystems support a wide diversity of marine life and a great variety of habitats, such as kelp forests, rocky intertidal zones, soft sediments, salt marshes and coral reefs (Garrison 2009). Management, conservation and studies of marine ecosystems rely upon understanding how ecological and physical processes affect benthic dynamics. Furthermore, the benthic organisms within these habitats are important indicators of ecosystem health as they are relatively sedentary, have long-life spans and different ranges of sensitivity to stress, and are key components in the cycling of nutrients (Dauvin 2012). In this context the assessment of these communities is of great importance; however assessing community composition can be challenging given that the time that can be spent underwater is considerably limited.

The mapping, visualization and analysis of marine benthic habitats have recently become more accessible due to improvements in technology and decrease in equipment costs (Andrews 2013). One of the most popular tools used to characterize the marine environment are images of the seafloor. Benthic community composition is often quantified from images taken underwater, using several platforms, such as diver-held cameras, Autonomous Underwater Vehicles (AUV), Remotely Operated Vehicles (ROV) and Underwater Towed Video (UTV) systems.

It is much faster to collect images than collect community composition data *in situ*, but once images are collected it is necessary to analyse them in order to characterize the benthic communities. The process of transforming images taken underwater into quantitative data that can be useful for scientific studies and management decisions requires significant manual efforts. Thus, image annotation methods often quantify a small fraction of organisms present in benthic habitats. In this context, efficient image analysis tools have great potential to benefit marine research. Different tools are available for annotating images, for instance, Coral Point Count with Excel extension (CPCe), the Collaborative and Automated Tools for the Analysis of Marine Imagery and video (CATAMI)[2], ReefMon software, Squidle and CoralNet. The aim of this brief review is to introduce the basic aspects of each of these programs and their main differences, so that marine researchers and managers that need to annotate images can make an informed decision and optimize their efforts.

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[2] CATAMI scheme is a standardized classification scheme of marine biota and substrate regarding the morphology of diverse marine groups developed by ecologists across Australia; for further information: http://catami.org/classification

What is the best way to annotate my images?

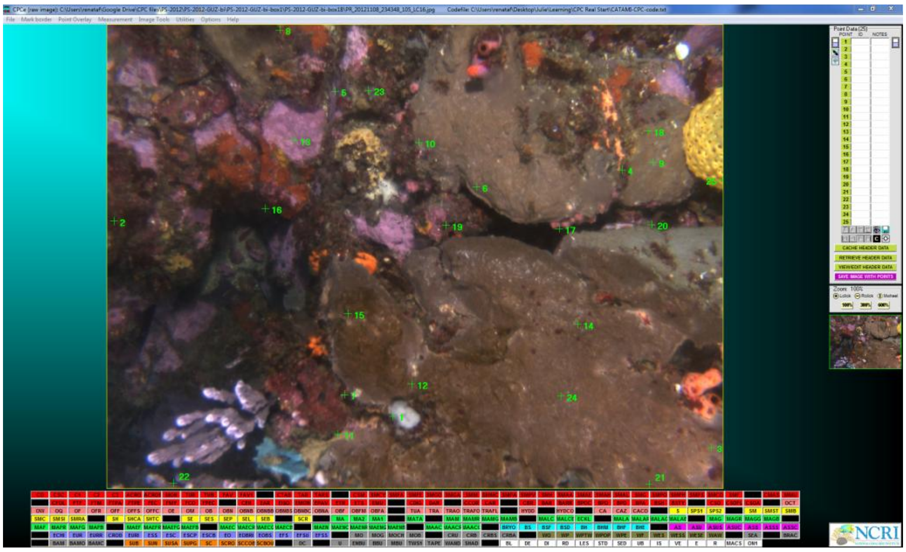
While this is not a comprehensive review of all the tools that are available, here we review some of the programs that are freely available and commonly used. All of them have basic operations with similar purposes, enabling the operator to, for example, specify the number of sample points, zoom in or out, and export the annotation data as a csv. or excel file. But they differ greatly in other aspects, such as their image-editing capabilities, on-line workflow, or the option to use a supervised automatic algorithm to annotate other images. Table 1 summarizes the most common features by program.

			Image selection options			Point selection options			Image		
	System compatib ility	Registrat -ion	Stratif- ied	Rand- om	GRTS **	System -atic grid	Rand- om	GRTS	Edit	Label options	User rating
CATAMI	Online	Required	Yes	Yes	No	Yes	Yes	No	No	CATAMI scheme* based	6
CPCe	Windows	Required	Yes	No	No	Yes	Yes	No	No	User specified	5
CoralNet	Online	Required	Yes	No	No	Yes	Yes	No	No	User specific + label reusing	7
Squidle	Online	Required	Yes	Yes	Yes	Yes	Yes	Yes	Yes	CATAMI scheme* based	9
ReefMon	Windows	Not Required	Unk	Unk	Unk	Yes	Unk	Unk	No	AIMS scheme based	NA

Table 1. Description of basic features among the CATAMI, CPCe, CoralNet, Squidle and ReefMon programs. Unk = unknown.

CPCe

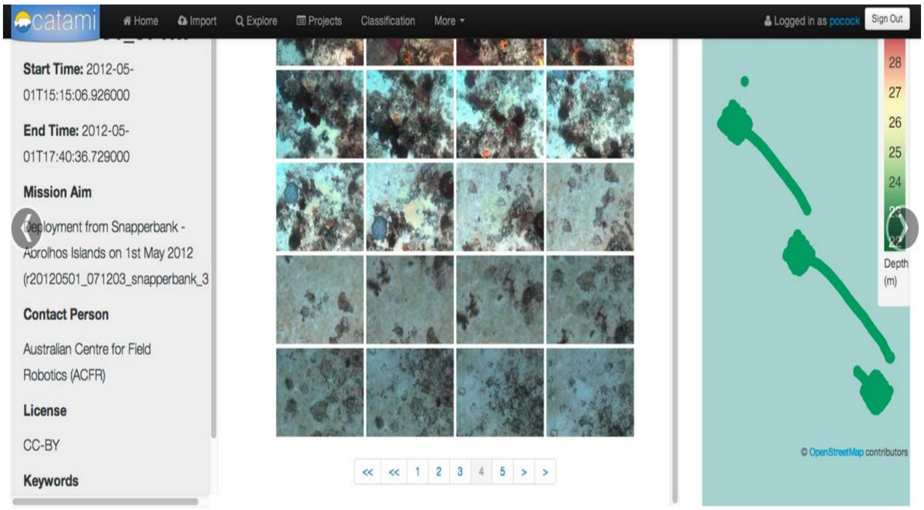
One of the oldest and most commonly used image annotation softwares for marine habitat imagery, CPCe was developed by Kevin E. Kohler and Shaun M. Gill (Kohler et al. 2006) and funded by the National Oceanic and Atmospheric Administration Coastal Ocean Program in 2005. The program is Windows-based (PC use only), but to obtain a copy you need to submit a request that takes ~ 2 days before you are informed of a link from which you can download the software into your computer. CPCe requires the user to keep all files in a specified structure, which often causes problems where the program cannot find existing annotations or images. It takes quite a lot of effort to develop the code-file that is required by the software to make the labels (species names, substrate categories) that you wish to use available, but the newest version has a code file checker that is very useful. CPCe has a good, though quite long, help file. Once you have requested, installed and created your code file, you need to manually select the images you will annotate and load them into CPCe to start annotating them. CPCe only accepts a few

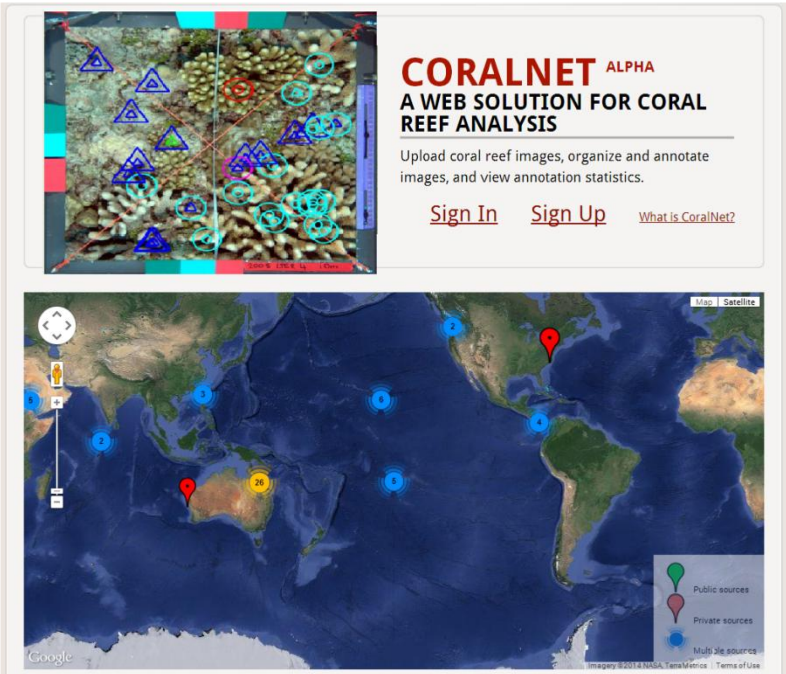


formats, so that you may need to convert your images into the right format, which can be time consuming for many images. It is possible to save annotations of an image half way through annotating and come back to it later. Also, it is possible to zoom in and out of the image but only at specified quantities (100%, 300%, and 600%). CPCe has limited editing capabilities but allows exporting and updating of an already existing file. CPCe exported data has a nice statistical summary and gives the user the option of exporting the raw data or not, however, the format of the exported data requires significant manual editing before it can be used in statistical programs, such as “R”. More information about CPCe can be found at: http://www.nova.edu/ocean/cpce

CATAMI

CATAMI is an e-Research Tool funded in 2013 by National eResearch Collaboration Tools and Resources (NeCTAR), supported by the Australian National Data Service (ANDS). The program uses an online workflow, so there is no need to download and install software, but it is necessary to create a virtual account, and on-line working may not be permitted by some institutions. CATAMI allows the user to analyze images directly on their internet browser and to keep all files virtually stored, with a choice of leaving the data available for public access, or keeping the data private. Once a new dataset of images is uploaded, CATAMI can choose the images using either random or stratified selection across thousands of images within seconds. The user can then choose between three different point-sampling methods (random, fixed 5-point, and uniform grid) to annotate the individual images. The labelling available for the annotation is based on the CATAMI scheme. The program also offers a map view where uploaded images can be visualized provided they are geo-referenced. If the data are made public then a user can click to obtain information on the origin of the imagery, including date and location of deployments, depth range and annotation. Further information about CATAMI can be found at: http://catami.org/





CoralNet

Developed in 2012 by Oscar Beijbom and a team at the University of California, San Diego, and supported by the National Science Fund Project “Computer Vision Coral Ecology”, CoralNet is also an online resource. To use this open-source program, you need to request an account by giving details such as your affiliation, reasons, and project description; then you receive an acceptance or decline within ~2 days. Once accepted you can create an account, select a private or public mode and begin importing images. CoralNet allows manual uploading of files and images, which can be either plain, or already annotated, for example using another system such as CPCe. However, it requires intermediate programming skills to be able to upload CPCe code-files so that they can be read by CoralNet, and creating your own CoralNet source file (a.k.a. code file) can take considerable time. Similar to the previous programs, CoralNet offers three options for overlaying sampling points on to an image: stratified random, simple random, or uniform grid. Unlike previous programs, CoralNET includes the innovation of a machine-annotator that can learn from human-placed labels and then proceed to rapidly process large numbers of new images. In addition, CoralNet offers a nice browse system that presents through a map view all sources available on the platform, either public or private, and a toolbar on which the user can search the data required by year, location, depth, and even by genus. For further information about CoralNet go to: http://coralnet.ucsd.edu/

Squidle

Squidle is a web-based system developed in 2013 by Ariell Friedman and a multidisciplinary team at the Australian Centre for Field Robotics of the University of Sydney. To use it you can instantaneously create an account, and then either import your image dataset or choose from hundreds of thousands of images from the Australian Integrated Marine Observing System Autonomous Underwater Vehicle program, which have been pre-loaded by the ACFR team. Once a dataset is chosen, Squidle facilitates the creation of image subsets through random, systematic (every Nth image), or GRTS (Generalized Random Tessellation Stratified[3]) selection. Alternatively, a subset can be created via the advanced map-based project using filter search tools on depth, altitude, date and/or bounding boxes which can be drawn by the user. Once a subset is created, the user can tell Squidle how to overlay points for annotation on to the image; the options are: random points, GRTS, systematic grid (Nth points across or down), or a spectrometer Field Of View patch (9 points distributed in a grid that optimizes the resolution and field of view of the lens/camera used). Squidle has a preloaded label set, which is based on the CATAMI scheme, but also allows users to suggest their own labels, which are automatically checked to avoid duplication. However, the Squidle team is composed of both computer vision and marine biology experts, who have already specified most labels required, which means that users don't need to spend much time specifying label sets and can get started with annotation right away. The multidisciplinary nature of Squidle translates into a user-friendly interface that has tools to facilitate the work, such as direct image edit (contrast and luminosity), different colors for individual image status of the projects, and the machine-learning feature, which is currently in development. The system also presents an interactive map view browser; this can be used to visualize all images; or to filter them by depth, date, or altitude; or by clicking on the data in the map, to see the spatial distribution of the images used in the different projects. For further information about Squidle go to: http://squidle.acfr.usyd.edu.au/.

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[3] Generalized Random Tessellation Stratified sampling is a system for producing a sampling design that is spatially balanced irrespective of sample size. It is increasingly being used for large-scale long-term environmental surveys. For further information see http://www.epa.gov/nheerl/arm/designing/design_intro.htm.

ReefMon

We did not test ReefMon for this review, however, here is a brief summary of how it works. ReefMon was developed by the Australian Institute of Marine Sciences, mainly to quantify the benthic community from images in their Long Term Monitoring Program. It can be freely downloaded from the internet (http://reefmon.software.informer.com/) and is supported by Windows 8 & 7, as well as Vista & XP. The most popular version is v 6.0. ReefMon which opens images directly from specified folders by following a user-specified directory; it also has the capacity to open a new image if the one being analyzed is blurry or of bad quality, enabling the user to quickly discard a bad image and continue annotating (provided there are extra images in the data set). ReefMon uses 5 fixed points (in four corners and the center of the image), however the number of points can be specified. Because we did not test this software, we are unaware of its common pitfalls or advantages.

Concluding Remarks

Each of the programs described in the above review has its own advantages. Choosing the right one depends principally on the needs of the particular project. Two important considerations are the need for standardization within larger programs or across comparable projects, and any requirement to make the images and data accessible to other users or the public at large. An advantage of those systems that use the CATAMI standardized classification scheme is that this program was produced by collaboration among over 300 Australian marine scientists and standardizes a large range of labels that can be used to classify all marine benthic organisms to a morphological level, to which can be added if desired a taxonomic designation (Althaus et al. 2013). However, if a user has a small manageable data set and desires to annotate all images, then CoralNet and /or Squidle are probably the best options, given that they are the most user friendly, provide robot annotations, work online and have labels that can be shared across other data sets. However, for large-scale institutional monitoring programs we recommend Squidle or CATAMI, given the multiple image selection tools they provide and the thorough classification scheme that supports their labels.

Acknowledgments

We thanks the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Cordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) who supported this work through the Sciences Without Boards award program (Brazil). R Ferrari was supported by the New South Wales Department of Primary Industries and Office of Environment and Heritage, the University of Sydney and New South Wales Education Investment Fund scheme through the Sydney Institute of Marine Sciences (SIMS).

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Computer Models in Biology: Fads, Facts, and Fancies

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Introduction
Perhaps I should begin with just a word or two about my background. I am an engineer who, for the past 40+ years has been the principal designer and software developer for all the automatic systems that control the heading, depth, and pitch on every U.S. nuclear submarine. Along the way, I have developed numerous mathematical and computer models of submarines and associated dynamic systems. It should not be a surprise that the U.S. Navy has voluminous documents which describe how software is written, tested, evaluated, and controlled.

About 20 years ago, I became interested in the idea of developing computer models for ecological processes related to coral reefs. At that time, I encountered many publications that used the word "model" in the title, abstract, or text. In most of these publications however, I would search in vain for any equations. The 'models' were, for the most part, conceptual and verbal descriptions of presumed processes.

In recent years things have changed substantially. There are an increasing number of papers relating to coral reefs and other ecosystems that use computer models (in my admittedly modest database, I have 131). While the advantages of computer modeling seem obvious, permit me to take a closer look based upon my experience. Though I suspect that many or most readers will read what I have written and think "well, of course, I knew that". Good.

Some Advantages of Computer Models
To my way of thinking the greatest advantage associated with development of a computer model is that the process of developing and programming requires a precision of thought that is not required for conceptual models. For example, the Adaptive Bleaching Hypothesis (Buddemeier and Fautin 1993) was a tremendously important conceptual model. However, it was only when it came time to develop a mathematical/computer model of the ABH (Ware et al. 1996) that the detailed list of assumptions on which the concept was based was necessary.

So, the first advantage of computer models over conceptual models is that they require one to focus and clarify ideas that were vague during the conceptual stage and to make explicit assumptions that were initially implicit. (As an aside, few papers that use computer models provide a list of the assumptions on which the model is based.) Further advantages of computer models are that:

- They permit studies at time scales not available to human observation. A hundred years of a process may take only a few seconds to simulate.
- They permit "what if" games that are not possible (or only possible at great cost) in an experimental environment.

A final advantage that I see for computer models is that, despite the fact that nothing comes out that was not put in, some results may not have been anticipated, and may indeed be counter-intuitive. New insights may be gained and/or results are produced that suggest further observation, experimentation, or modeling.

Disadvantages of Computer Models
Well, it can't all be good. Of course there are some disadvantages associated with computer models. For example, the development of the mathematical equations and the subsequent writing of the computer code that solves them require skills that not every biologist possesses. This is why we see mathematicians, physicists, and even engineers making contributions to biology, while we seldom see a biologist abandoning his field to become a physicist.

Let's look at some of the common misconceptions that may be associated with computer models:

- Complexity = accuracy: The more complex the model and the more links there are between different species, functional groups, and processes, the more accurate must be the result.
- Precision = accuracy: Using computer models it is possible, for example, to output that the predicted *Diadema* density on the west coast of Dominica is 7.1513 animals per square meter. All these decimal places do not reflect greater accuracy.
- Computer results are more believable than data from other sources. After all, are not computers always right?

Some Common Computer Modeling Problems

There are also a series of problems commonly associated with the process of formulating a concept, progressing through model development, programming the model, and writing up the results, culminating (hopefully) with publication in a 'learned' journal. Before providing the list, it is useful to provide some definitions that will be useful to those readers who have not built computer programs.

A useful analogy is that a computer program is somewhat like a book. A book is typically divided into chapters, analogous of modules or subroutines in the computer program, that make following along easier. In addition, in the process of writing a book, the author usually follows the common rules associated with the language in which the book is written. Computer programs also have (or should have) rules but, as with a book, some authors do not follow the rules).

The list of these problems is based not only on my observations of the work of other computer program developers, but includes errors I have also made.

- Lack of complete verification. Verification is the process of determining that the program actually does what the designer intended it to do. Here is a simple example. Suppose the concept requires that W = X + Y. Verification involves determining that indeed the program produces the proper result, usually by inputting several values of X and Y and checking that one did not program W= X * Y by mistake. Many scientists and engineers do not perform complete verification of every program step. The tendency is to put everything together, make a few runs, and then, if results match general expectations, bless the program.
- Assuming that verification = validation: The Verification step simply checks that the mathematics are programmed correctly. Validation is the separate process of checking that the chosen equations reflect the actual processes being modeled. For example if the correct equation / model is indeed W = X + Y, and not W = X * Y. Validation requires matching model outputs to real world data.
- Too many eggs in one basket. Most scientists tend to write modules that have several hundred lines of executable code; this makes verification difficult and tempts researchers to take short cuts in the verification process.
- Most commonly when programming is undertaken within a scientific research project, the person who formulated the concept and/or developed the theory is also the one who develops the code. This means that code may violate many rules of good programming practice, simply because the scientist involved doesn't know what the 'rules' are, or even that there are rules.
- Scientists and engineers often do not include sufficient comments in the body of the program to explain what a section of code is supposed to do; this makes updating difficult, especially if the code is really 'clever' and therefore hard to understand.
- Scientists and engineers will also often make modifications to a computer program without documenting the reason for the change and how the change was tested. It doesn't seem logical, but computer programs tend to "senesce". You pick up the program a year or two after the last time you

used it, and it doesn't reproduce the results you have previously reported. Only too often this is because someone altered (improved?) the code and didn't document the change.

- All of the these problems seem more likely to be present in computer models that are intended to match biological processes, mainly because validating such models is usually very difficult, there are few or no software development rules and no one to enforce them.

By contrast, during the process of developing computer code to be used, for example, to control a submarine, there are a large number of rules and a process that must be followed. A rough outline of the standard process would be as follows:

- Develop a requirements document. Each requirement is numbered and must be testable.
- There are strict rules concerning the code itself, e.g. no GO TO statements.
- There is a strict limit on the number of lines of executable code in a module.
- Each module undergoes individual verification testing by a party not involved in either the original concept or the development of the code.
- Subsequently the entire program is also tested against the original requirements and the results verified again by a party not involved in the development of either the concept or the code.
- The computer program is validated by rigorous testing to assure that it can indeed control either a simulated submarine and/or a radio-controlled model. (If the former, then the code representing the simulated submarine is developed under the same rules as the controller code.)
- Once the code is verified and validated, it is then "secured". This means that no change to the code is permitted without following a specified procedure.
- If a problem is found, a Problem Report (PR) is written that describes the problem, its impact, and the proposed solution.
- The PR is evaluated by a formal panel or "Configuration Control Board". Only if the PR is approved, are changes made to the code and the governing documentation.
- The altered code is then tested using the entire process described above, just as if it had never been tested before. No shortcuts are allowed.

The process is expensive and requires many more personnel than only a concept developer and programmer. It may seem unlikely that universities could afford the process. On the other hand, are the consequences of miss-predicting the number of *Diadema* on Dominica less than that of losing depth control of a submarine? Even code that is widely disseminated and has many scientific users is unlikely to have been developed and modified under the stringent procedures described above, simply because of budgetary or temporal limitations. Nevertheless, elements of the above process should, where possible, be put in place.

However, perhaps the greatest problem prevalent in the development of computer models of biological systems is the determination from usually noisy data, the equations and the links between equations of the model and of the values of the (often) many parameters required. Given these difficulties the fundamental question that must be asked and answered whenever a computer simulation is unveiled is: Is the model valid? A computer model is only valid if it accurately represents or predicts the process under study.

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REEF EDGE

Scientific letters or notes describing observations or data

Recent freshwater reef kill event in Kāneʻohe Bay, Hawaiʻi

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Freshwater 'kills' are rare events caused by lowered salinity during severe runoff and storm floods (Coles and Jokiel 1992) that modify the structure of reef communities. Coral reef communities within Kāneʻohe Bay are shallow (>50% of the bay is less than 3.3 m deep) and therefore extremely vulnerable to increased freshwater effluent due to the formation of a persistent freshwater surface layer that causes reduced salinities near these coral reef organisms (Banner 1968; Jokiel et al. 1993). Reduction of salinity to 15 - 20$^{0}/_{00}$ for 24 hours or longer results in extensive mortality in these shallow water communities (Coles and Jokiel 1992; Jokiel et al. 1993). Data on the frequency and intensity of freshwater kills are important in the understanding of long-term trends in coral reef ecology, while long-term monitoring programs need to continue over many decades (e.g. Rodgers et al. 2014) in order to capture their impacts.

Extensive freshwater 'kills' due to flood events with associated low salinity were documented in Kāneʻohe Bay during May 1965 (Banner 1968), January 1988 (Jokiel et al. 1993), and most recently, though less severely, during flash floods in July 2014 – indicating a frequency of re-occurrence of approximately 25 years. During the 1965 flood, the freshwater discharged into the bay in a 24 h period was calculated to be equivalent to a surface layer of 27 cm over the entire bay (Banner 1968). The resulting reduction in salinity in surface waters caused substantial mortality of coral reef organisms, with near total mortality of corals to a depth of 1-2 m in inshore regions. Twenty-three years later, a comparable storm flood resulted in similar destruction of the reef flat corals (Jokiel et al. 1993).

Figure 1. Map of Kāneʻohe Bay, a semi-enclosed estuarine coral reef ecosystem, located on the northeast coast of Oʻahu, Hawaiʻi (21°, 28'N; 157° 48'W). The lower insets show the location of the Bay, and the red box in the main figure the area most heavily impacted.

The event of July 2014 was less severe than previous 'kills' and was localized to the northern leeward patch and fringing reefs in the bay (Fig. 1). Extensive mortality of corals and cryptic reef-dwellers (e.g. eels, crabs, shrimp) was observed following the storm (Fig. 2). A large percentage (50-90%) of the patch and fringing surveyed reefs was negatively affected. The reefs located close to the Waiʻāhole and Waikāne stream mouths were the most adversely affected by the freshwater effluent. Within a 24 h period, 24 cm of rainfall was measured at the Waiʻāhole rain gauge which increased the stream daily mean discharge by an order of a magnitude from 0.74 $m^3 s^{-1}$ to 24 $m^3 s^{-1}$ (USGS 2014). Fortuitously, thermographs and irradiance recorders had been deployed on the reef

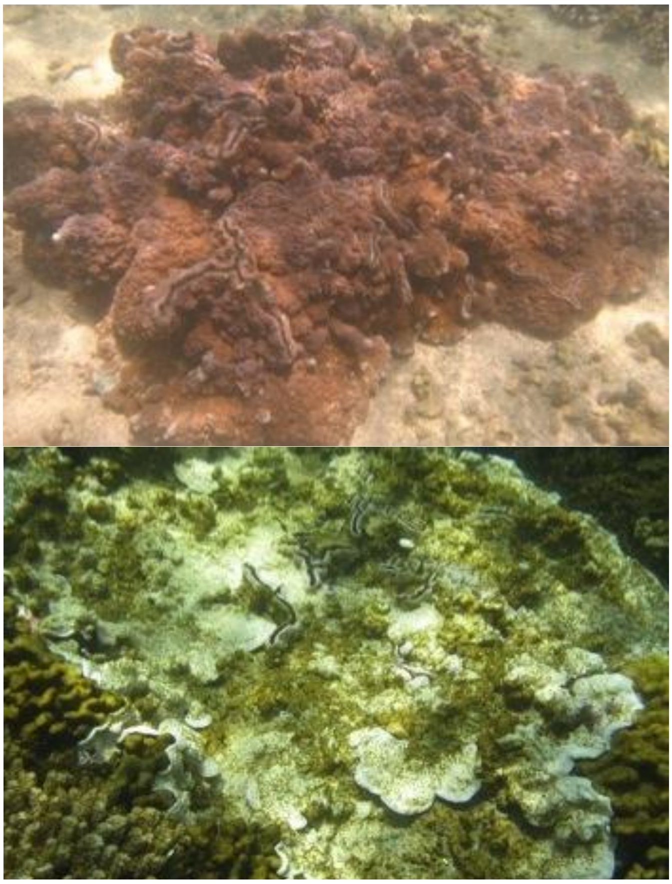

Figure 1. Above, a large bleached colony of the coral *Montipora patula,* with dead tissue sloughing (brownish green), compared to a similar healthy coral (below), located outside of the area of damage during the 19-20 July, 2014 storm event.

before the storm. Temperatures before the storm ranged from 27.4 - 29.2°C on the patch reefs with gauges (Fig. 2: reefs 44, 46, 47). The input of freshwater caused temperatures on the adjacent reef flat to decrease by 1°C and average irradiance levels to decrease by 55%; this compares with reports on the flood of 1988 that caused a temperature drop of 1 - 3°C and reduction of solar irradiance levels by 10-20% (Jokiel et al. 1993).

Acknowledgments
We would like to acknowledge the University of Hawai'i Field Problems in Marine Biology students for helping document and obtain data during this storm event.

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Dimming sand halos in Dominica and the expansion of the invasive seagrass *Halophila stipulacea*.

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Coral reefs of Dominica are restricted to the island's narrow shelf. Most of its 31 reefs and reef complexes are clustered in two areas, one in the North and one in the West (Fig. 1). Together they comprise 77 % of the total coral reef area of only 80.5 ha (Steiner 2015) and are exposed to chronic stressors such as storm-induced breakage, sediment resuspension and terrestrial run off due to their proximity to shore (Steiner 2003). Despite Dominica's comparatively modest infrastructural development and a low human population (slowly declining from a peak of close to 74,000 in the 1950s), deforestation, the use of coral lime in construction, and fishing pressure since the 18th century, are among the principal direct anthropogenic forces that have shaped the deterioration of coral reefs throughout the island (Steiner 2015). In addition, the four most recent coral bleaching episodes between 2003 and 2010 led to further substantial loss of live coral cover (Steiner 2015).

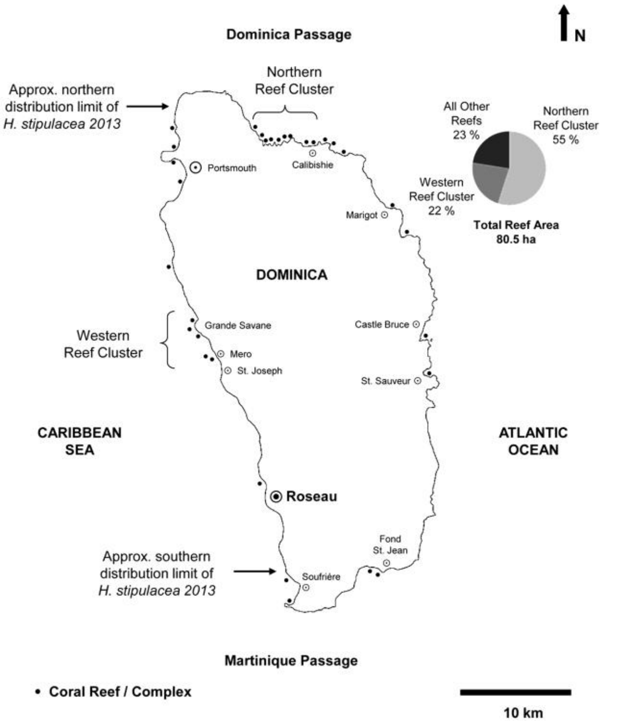
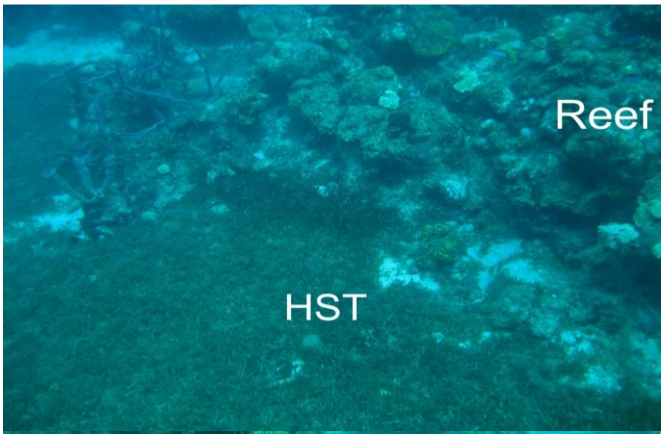


Figure 1. Distribution of coral reefs around Dominica and the distribution limit of *H. stipulacea* on the west coast of the island as of 2013

It has been long known that in many regions where coral reefs and seagrass beds co-occur, the former are commonly surrounded by an unvegetated band of bare sand. This sand "halo" is maintained in part by reef-associated fishes and invertebrates that graze on seagrasses and their epiphytes (Randall 1965; Ogden et al. 1973; Valentine and Heck 2005) or feed on infauna within the sediments (e.g. Mullidae). We have observed that around shallow reefs the erosional effects of current eddies also play a role in maintaining these halos.

In March 2013 we observed the uncharacteristic absence of such sand halos around coral reefs in Dominica, during surveys of the invasive seagrass *Halophila stipulacea*. This native Indian Ocean seagrass was first reported in the Caribbean in 2002 by Ruiz and Ballentine (2004), and has since been identified on at least eighteen islands (Willette et al. 2014). Its second reported observation from the region came from Dominica in 2007 (Willette and Ambrose 2009), since when its distribution has expanded dramatically from isolated patches in 2008 (Steiner et al. 2010) to a 55 km swath along the west coast in 2013 (Steiner and Willette 2015). In this way *H. stipulacea* has profoundly affected the native seagrasses and meadows by replacing many of them. Notably *H. stipulacea* has also, within its current distribution on



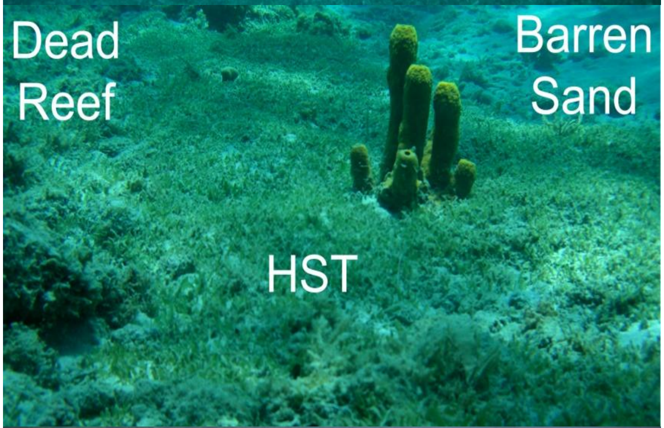


Figure 2 (top). *Halophila stipulacea* meadow (HST) growing up to the moribund Douglas Bay Reef in 2013. **Figure 3** (middle). Margin of dead reef in Scott's Head serving as expansion corridor for *H. stipulacea* (HST). **Figure 4** (bottom). Bioturbated halo separating reef and the invasive *H. stipulacea* (HST) near Mero in 2013.

the island, which is restricted to the western sublittoral, overgrown most sand halos that used to exist around reefs (Figs. 2 and 3). Further, sand and rubble-laden depressions within affected reefs are no longer seagrass-free. In shallow turbulent waters (1-5 m depth), *Halophila stipulacea* has also spread along the semi-consolidated coral rubble that fringes dead reefs (Fig. 3); the rubble thus provided expansion corridors across the highly disturbed sandy surroundings that continue to be unsuitable for seagrasses.

We did find a few locations at depths of 10 to 30 m on particular sections of the largest west coast reefs between Grande Savane and Mero (Fig. 1 and 4) that were exceptions to this pattern. With a live coral cover rarely exceeding 10 % and few living coral frameworks (Steiner 2015) these reefs are nonetheless currently the "healthiest" in Dominica. It remains to be determined whether the native reef-associated fauna or other factors will maintain the last seagrass-free halo fragments vis-à-vis the encroaching *H. stipulacea*. If herbivores are playing a role, it raises the question of whether there are species present at these locations with feeding preferences different to the other native herbivores.

The disappearance of sand halos illustrates one facet of rapidly changing Caribbean coral reef - seagrass seascapes. In the case of Dominica, the invasive seagrass *H. stipulacea* drastically altered native seagrass meadows in four and half years (Steiner and Willette 2015), and colonized sand halos around, and sandy patches within, coral reefs. The paucity of conspicuous reef-dwelling grazers and bioturbators on the island's moribund reefs possibly contributed to expansion of the dense seagrass carpets (Figs. 5 and 6) all the way into reefs. This recent marine angiosperm invasion also shows that future attempts in conserving the remaining coral communities will have to jointly address the conservation of native seagrasses. Unfortunately, the structural and ecological alterations in Dominica's benthic habitats are presently occurring faster than the formation of mitigation initiatives.

Figure 5 (above). Traditional fish pot in typical Dominican *S. filiform*e bed in 2008, with 20 cm tall canopy and open spaces at Bioche. **Figure 6** (below). Traditional fish pot in former *S. filiforme* bed that was replaced by *H. stipulacea*'s dense mat with a 5 cm tall canopy, in 2013 at Mero.

Acknowledgments *Seagrass and reef surveys in 2013 were executed under the Fisheries Research License RP-03/063S-2, Fisheries Division, Government of Dominica. Funding and logistic support was provided by the Institute for Tropical Marine Ecology, J. Esprit, and private research supporters.*

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Presence of the northern star coral (*Astrangia poculata*) as an epibiont on the carapace of a nesting loggerhead turtle (*Caretta caretta*) in the western Gulf of Mexico, USA

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Sessile carapace epibionts provide insights into the movements of sea turtles since the ranges of the turtle and the epibiont must overlap. Therefore, the range of the turtle may be reflective of the carapace community. Casey Key, Florida USA (28.7° N, 82.3°W) annually hosts a large density of nesting loggerhead sea turtles (*Caretta caretta*). At 01:30 on July 22, 2014, a previously untagged (neophyte) female loggerhead was observed during routine nightly patrols. Two anterior flipper tags (left: EEL074, right: EEL075) and a passive integrated transponder (PIT) tag (right posterior flipper; tag #: 982000363075669) were applied. Her minimum straight carapace length (SCL_{min}) measured 78.7 cm, while her minimum curved carapace length (CCL_{min}) measured 89.2 cm, reflecting a slightly smaller than average adult female within this location. Upon close examination, a coral epibiont, *Astrangia poculata*, was observed on the fifth lateral scute of the carapace in addition to *Chelonibia* sp, *Balanus* sp. and *Caulerpa* sp. (Fig 1).

Specimens of *A. poculata* (formerly *A. danae*) have been previously documented on the posterior carapace of loggerheads from Georgia (Frick et al. 2000); however, none of those specimens were directly attached to the carapace, as was observed here. Casey Key loggerheads not only exhibit a strong site fidelity to nesting grounds, but also to foraging grounds, which are located near the northern Gulf of Mexico, the west Florida Shelf of the Gulf of Mexico, regions offshore of the Yucatan Peninsula, the Wider Caribbean or the Florida Keys (Tucker et al. 2014). *A. poculata* is a temperate coral, ranging from the coastline of Florida and up the eastern coast of the United States to Cape Cod, Massachusetts, with additional presence in the northern Gulf of Mexico (Dimond et al. 2013). Given the limited overlap in the range of the turtle and the coral, the foraging grounds of this particular female turtle is likely restricted to the northern Gulf of Mexico or the west Florida Shelf. High reliance on heterotrophic nutrient acquisition does not appear prohibitive given the trophodynamics of neighboring epibiont species (e.g., *Chelonibia* sp. or *Balanus* sp.), though the symbiotic state of the observed coral colony suggests that autotrophy via *Symbiodinium* also occurs (Fig. 1). Because *A. poculata* experiences diverse environmental conditions across its geographical range, it is capable of an epibiotic lifestyle on a mobile host.

Figure 1. *Astrangia poculata*, *Chelonibia* sp., *Balanus* sp. and *Caulerpa* sp. on the fifth lateral scute of a nesting loggerhead sea turtle. Anterior is at the bottom of the photograph. Inset: a similarly-sized *A. poculata* colony collected from the benthos.

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BOOK & PRODUCT REVIEWS

Reviews of books, software, hardware and other products

Here Come the Heroes: use of new generation small digital underwater cameras for reef research.

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The explosion in availability of small digital cameras has led to rapid and radical advances in the underwater imaging available to photographers and scientists alike. Cameras and housings are getting smaller, technologies are getting smarter, and there is now in most instances no need to use large, bulky and leaky housings, with SLR's squeezed inside, in order to collect good, clear scientific data. Similarly a camera's ability to operate in a wider number of settings, be that wide, macro, low light, video or still has been distilled into one handy package. No longer must we surface to change lenses or charge up bulky strobes; the compact camera is the future and at its current price point is beginning to render its larger cousins obsolete.

This is part one of a two part review of the value of the latest generation of small digital cameras for underwater research and conservation, intended as therapy for those who were carried away by Walt Jaap's article "Nostalgia of the Nikonos" in the last issue of Reef Encounter. This first part will focus on small video cameras, with an intended sequel on underwater digital still cameras. My qualifications for writing come not only from experience as a marine researcher assessing coral reef health, but also from work in the photographic section of a busy up-market dive store, and occasional work as a professional photographer. While gathering feedback from the general dive community, I more recently invited comment via Coral List, incorporating the results into what follows. However, before continuing, I would caution that, for the scientist, the choice of underwater camera, as for much else, ultimately comes down to the research question(s) being addressed, and the budget available.

So, the first obvious decision to be made is "still camera or video". Let us look firstly at what is available for video. For most scientific purposes, there now seems to be one outright winner and that is the GoPro. Forget their beautifully edited commercials and brilliant marketing; they have that market cut and dried. Other manufacturers are trying to compete, usually with a cheaper similar product, but for the price difference the quality margin is nearly always greater. The new GoPro Hero4 Black is a video powerhouse: with 4K "Ultra High Definition" video the output has over 8 million pixels and therefore has around four times the resolution of standard 1080p video. There are a number of other cameras offering 4K definition such as the RED and Canon DSLRs, as well as cinematic video equipment, but when you compare a RED Scarlet X, at roughly $16,700.00 for the body alone and up to $40k for a cinematic lens, then the $499.99 for a GoPro Hero4 Black is "a drop in the ocean". That is not to say that the GoPro is as good as a RED camera, far from it; they are worlds apart, but most scientists don't need cinematic resolution; we need portability, durability, battery life, and ease of use. The greater the resolution, the more precise the picture; but when we view stuff primarily on conventional monitors or portable laptops we simply don't need cinematic resolution.

For those few who have not yet encountered the GoPro, it is a small (roughly 5x6x3cm) lightweight

(approx. 150g) action camera that comes (when purchasing the right package) with a housing that waterproofs it to 40m (131ft). The cameras have a 14mm equivalent wide angle setting and a 28mm "narrow" setting, meaning you can get up close and personal with your subject, while its periphery remains within shot. This is important when detail and colour are key, since they can be lost as a function of distance from the subject (due to lack of light transmission through water and turbidity). Water sucks colour from light, especially towards the red end of the spectrum, so for your images to have clarity, contrast and bright colours, you need to be "right on top of your subject".

The newest GoPro, the Hero4 Black, records video in any of 720p, 1080p, 2.7K, and 4K formats. These are the pixel densities meaning for instance for 1080p that there are 1920 pixels in width and 1080 pixels in height in any given frame. 4K is effectively cinematic resolution, but you will need to downscale it to play smoothly on standard monitors. There is also a slightly cheaper GoPro Hero4 Silver edition which also shoots in 4K, but don't expect to get top quality 4K video from it as it only shoots at 15fps (frame per second). The more frames per second you can shoot the smoother will be the result. Further, a lower frame rate could lead to the video missing key detail especially in fast moving species. However, both new GoPros have 1080p video at 60+ fps (Silver 60fps, Black 120fps), more than enough for getting great detail at superb resolution.

Readers should however be warned that while GoPro has been very clever with the construction of their cameras, they have been equally clever with their accessories business, so that to achieve more than basic functionality requires the purchase of one or several "add-ons". Thus to mount the camera on a pole for BRUVS (Baited Remote Underwater Video Surveillance) work you need to buy the correct mount (pole mount $ 19.99 RRP), or to get an LCD screen so you can see what you are actually framing, you need to purchase the LCD Touch BacPac ($79.99 RRP).

Battery life is one of the few but consistent complaints received from Coral-Listers. Running time can be extended with a Battery BacPac ($49.99 RRP). Thus Brian Reckenbeil of the Florida Fish and Wildlife Service uses GoPros frequently and with the battery extension module gets about 4 hours battery life taking 1 photo per minute on the time lapse function. However, it doesn't look like things will improve further, given the power-hungry Hero4. If you're shooting 4K 30fps video on it, you'll only get 1 hour 5 minutes before you need to change batteries.

A detail worth noting here is that the battery life quoted by manufacturers rarely measures up to real world application, since varying the fps, depth, and temperature will change the current drawn from the battery. If able to change batteries (e.g. between dives) the cost of spare batteries is also important. Don't be afraid of non-OEM batteries as long as they carry a similar (if not better) current rating (mAh); they are typically better value for money. At the same time however it should be noted that the Hero4 cameras are not compatible with any older GoPro batteries you might have lying around, so you'll have to buy new spares. On the other hand, if longer dives or run times are critical to you, then you need to compare cameras looking at their mAh, and offsetting cost against quality.

Another potential drawback is that GoPros are so small; a number of respondents pointed out the need to mount the Gopro on a handle or dive slate just to keep hold of it. However various pistol grip and pole mounts are available for as little as $12, and a mount that can be used to attach the camera to a dive slate or helmet should come in the package. Alternatively there is also a head-band mount ($19.99 RRP) which some divers find useful and one company (Mudder) has even produced a dive mask with a GoPro mount incorporated. Rupert Ormond (Heriot-Watt University, Edinburgh, UK) commented: *"I now wear a GoPro on my head whenever undertaking standard reef surveys e.g. UVC for reef fish. It won't see everything that is recorded by the observer, but it's excellent for giving general qualitative habitat information and in many cases for enabling confirmation of species identifications. However you MUST play with the angle of the camera on your forehead so that it doesn't only look down below you or look up at the blue, and learn to consciously turn your head to look at views and objects you want to record, rather than just looking from side to side with eyes only in the normal way ."*

This range of attachment options is also, however, one of GoPro's strong points. The cameras can be mounted to dive tanks, clipped to dive slates, bolted to Baited Remote Underwater Video Stations (BRUVS), mounted to neuston nets and wherever they are placed left to run with very little user interaction, allowing either for unsupervised survey or for a diver to get on with other work. Other benefits of the new Hero4 cameras include a new user interface, the ability to mark key moments of a recording so you can locate them quicker later with a HiLight Tag button, and improved camera controls with a new dedicated button that allows you to quickly access and adjust camera settings.

Another point to note if you have or are thinking of purchasing an older model GoPro for use underwater is that it is highly desirable to replace the standard dome port for a flat port, since otherwise, when used underwater, the distortion and backscatter in the housing can make the footage rather unsatisfactory. Both Isaac Westfield (Northeastern University, Boston) and Amilcar Magaña (University of Guadalajara, Mexico) emphasised this point and recommended buying a later model or switching the dome for a flat port. There are a range of flat ports and port replacement kits now available on the market. However the Hero4 has replaced the dome port with a flat one, which essentially fixes the issue.

A separate issue is colour. Colour may with corals for example be a poor species identifier, but it is something people like to see and that their brains remember. There is only a limited custom white balance capability on GoPro cameras, so it useful to correct GoPro colours using clip on filters. The recommended tool of choice seems to be the Backscatter Flip 3.1 which comprises shallow, dive, and deep filters, as well as additional an green water filter and a yellow filter (for fluorescence night diving). The set will "set you back" around £100.

Another consideration is that although the GoPro housing was designed to go to 40m, which is probably deep enough for most of us, it should be remembered that these cameras were not specifically designed for high intensity scientific work and so need careful maintenance. Thus Kate Philpott (University of Exeter, UK) reports, after using GoPros on BRUVS, "*The housing was a bit temperamental and you had to be utterly scrupulous with up-keep. I know this might seem fairly obvious but I have my own Canon underwater camera that I use just for fun; I'm quite rough with it, rarely re-grease the "O" ring and I have never had a problem. The GoPros however will leak if even the tiniest hair or piece of dust is in the way. So*

Effect of Flip 3.1 dive filter at 34 ft.

providing they can be assembled in a dry, clean area by someone with good eyesight then they are brilliant for BRUVS studies; the camera worked really well, was easy to use and the picture quality was great. We were able to see sharks and rays well enough to sex them!"

A number of users have also reported issues with the new design of waterproof seal around the back rim of the GoPro 4. These seals are looser than on previous models (apparently to make them easier to change). But it also means that unless the user is careful they now get trapped under the edge of the back port as it is closed.

A further important consideration is the minimum focus distance that can be used for macro imaging; after much searching I have found a 12" consensus on www.dpreview.com, although GoPro does not seem not provide any figure. The LCD BacPac may be useful for checking if something is in focus, although whether you can tell on a screen that small through a housing is debateable!

Many Coral List responders also highlighted that GoPros don't do well in low light. They have a fixed f2.8 lens which is quite wide, but the sensor is small and struggles in low light conditions to resolve shadowy areas. The new Hero4 has the largest sensor, so should perform better and has more manual controls allowing one to either adjust for bright light conditions or push the camera a little further in low light. But due to the GoPro's one button design, menu operation underwater can be tricky, so it is usually necessary to set the camera up for its intended purpose before entering the water.

A comparison of still pictures taken using a GoPro (left) and Canon S110 (right) at similar distances; the Canon's ability to resolve detail and colour due to its manual white balance feature is notable (Photos: left Beth Taylor, right Adam Porter)

Grabbing stills from video also doesn't seem to produce good enough results for benthic substrate analysis. Shooting stills in the GoPros still or time lapse mode is reportedly sufficient, but if your main purpose is to shoot photo-quadrats for subsequent analysis, then a stills camera is still likely to be preferable, given its higher resolution.

A GoPro shoots at 72dpi (the number of dots per inch), whereas even a small digital camera shoots at 180 dpi giving 2.5 times more detail in a photo – potentially critical when looking at the fine detail of coral calices for identification purposes. As Elayne Looker (5 Oceans Environmental Services, Muscat, Oman) commented: *"For video transects we now use GoPros mounted onto a dive slate (easier to hold whilst gliding along transect lines), and we've used them for BRUVS work too. However, if stills are made from these videos the quality is too poor for decent benthic analysis linked e.g. to CPCe; at best you can identify a coral to genus, but rarely species level. So we now combine both techniques for survey work: one diver films the transect followed by a diver with a stills camera.*

I have exhausted several pages on the GoPro and for good reason; it's the best all round action cam out there…but there are others. The Sony Action Cam was recommended by Ian Butler (University of Queensland, Brisbane, Australia), who, after suffering numerous setbacks with GoPros, switched to the Sony. *"I really like my Sony for its reliability, which is what bothered me so much about the GoPro at the time. It is also half the price, and takes great high res stills; but it all works off one button while in a housing, so (as with the GoPro) you have to pre-set everything before going underwater."*

The Sony "spec" does measure up pretty well to that of the GoPro, save for that of the waterproof housing - critical for use beneath the waves. The current model is only waterproof to 10m; older models were waterproof to 60m/197ft, meaning that Sony seem to be pushing itself out of the underwater market, rather than in to it. In all other ways it's a serious contender, and perhaps for the price an older model deserves consideration. By contrast, a second serious contender, the Veho Muvi K2, claims to be waterproof to 100m (330ft). I have not been able to find any feedback on its use by research scientists, but at the price of £200 and with a battery life considerably better than that of the GoPro (4 hours compared to the GoPro 1hr30) users with specialist requirements might want to investigate further. Readers still uncertain may like to know that 90% of Coral-list responders were using a GoPro, 5% a Sony Action Cam, and 5% an Intova Action Cam. For yet more guidance try http://www.gizmag.com/compare-best-action-cameras-2014/34974/ for a pretty decent roundup on the salient features of an even wider range of models.

Many thanks to Rupert Ormond, Beth Taylor, Chelsea Bennice, Benoit Tchepidjian, Nicole Crane, Sean Clement, Chad Scott, Elayne Looker, Ian Butler, Steve Piontek, John Ogden, Ben Prueitt, Ryan Nash, Brian Reckenbeil, Isaac Westfield, Phanor Montoya-Maya, Erik Meesters, Jill Harris, Kaho Tisthammer, Chris Perry, Renata Goodridge, Kate Philpot, Deborah Gochfeld, José Speroni, Bill Allison, Parth Tailor, Anne Theo, Barbara Kojis, Katie Peterson, Russell Kelley, Ken Nedimyer, Ray Buckley, Amilcar Magaña, James Engman, Craig Osenberg, Dennis Hubbard, and Ocean Leisure Cameras for their comments and feeback.

The Sponge Guide: an interactive photographic online guide to the identification of Caribbean sponges

(Sven Zea, Timothy P. Henkel and Joseph R. Pawlik)

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Caribbean sponges constitute one of the most diverse and abundant faunal components of shallow and deep-sea benthic communities. Their diverse size, shape and color, and their ecological and biomedical relevance, have attracted great interest from a wide audience.

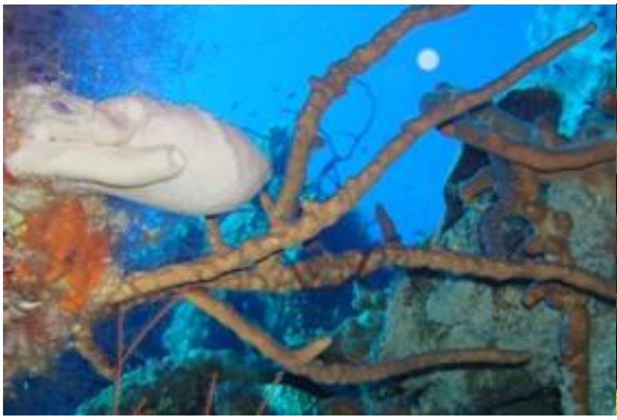
Despite their conspicuous presence and importance in the world oceans, basic aspects, such as their taxonomic diversity, names and relationships and their ecological role, have remained inaccessible to recreational divers, students, marine researchers and environmental managers. Sponge species are described in scientific monographs in which specialized language, understood by only a few specialists, is used to characterize them. The difficulty in distinguishing sponge species is aggravated by the plasticity of characters such as their color and shape, and by the simplicity of their external morphology. As a consequence, sponges have remained one of the most difficult marine taxa to identify. Ever since the first scientific descriptions of marine sponges from the Caribbean by the German zoologist and botanist, Peter Simon Pallas, in 1766 (e.g. *Aplysina fistularis* and *A. fulva*), only 100 or so specialists have contributed to the description of the approximately 800 sponge species currently recognized in the Caribbean. Further, at present, there are fewer than a dozen scientists with expertise in the classification and identification of Caribbean marine sponges.

To address this situation, in 2009, Sven Zea (Universidad Nacional de Colombia), Timothy Henkel (Valdosta State University, GA) and Joseph Pawlik (University of North Carolina, Wilmington, NC) embarked on the construction of a first pictorial database, together with a computer-based search platform for Caribbean sponge species. Their recently web-published "The Sponge Guide, 3rd edition" offers a renewed, improved version of this database, in the form of an interactive photographic on-line guide to the identification of Caribbean sponges. Two hundred and thirty one morphospecies are depicted by more than 2000 photographs. The taxonomic breadth of the species represented in the Sponge Guide includes 220 species from the class Demospongiae, 7 from the class Homoscleromorpha, and 4 from the class Calcarea. Most species represented in the guide inhabit open reef habitats (within scuba-diving range), and approximately ten percent seagrass or mangrove environments.

Within the guide, each species is characterized by reference to three features of their external appearance (shape, external color, and consistency), with approximately 4-10 states being distinguished for each. A species can be searched for by selecting single states for one to three of the characters. Species can also be searched for by their occurrence in one of the three habitats distinguished by the authors (deep reef, mangrove/coastal lagoon, or rocky shore/shallow reef). The guide also allows searching for a particular taxon by its scientific name. For example, if a marine park manager hears about a disease spread among a particular sponge species (e.g. *Callyspongia plicifera*), he/she can use the database to get an idea of the natural, healthy appearance of the species, and could conduct a survey in a particular locality of interest. Alternatively, a researcher might have found on seagrass flats a black, tough sponge harboring a particularly interesting species of polychaete. The researcher can select: black, massive, and tough, and coastal lagoons, and choose among 9 potential species candidates that the database will suggest. A new feature in the 3rd edition is the inclusion of microscopic characters, so far for only a minority of the sponges. The guide also includes taxonomic notes for some of the species depicted, and offers a direct link with Dr. Sven Zea for taxonomic inquires.

The Sponge Guide appears to me to be a project of great practical value, that ideally should have been started much earlier, in support of major reef studies, such as AGRRA and CARICOMP. How can we know the status of a reef if we ignore its most diverse benthic component, which at the same time can bioerode, overgrow, and/or feed on the other major component of coral reefs?

[4] This is an independent review of the online guide details of of which are described by the authors on pp 25-28



Examples of the diverse, unexplored sponge fauna found in caverns and cryptic habitats on Caribbean coral reefs. Left: a cavern on Little Cayman, showing the white, calcareous sponge *Leucetta floridana* (Haeckel) and the branching *Agelas cervicornis* (Schmidt) (at 20 m). Right: *Aplysina sciophila*, (Rützler, Piantoni, van Soest & Díaz, 2014) under a small ledge in Belize (23 m).

However, as a "quarter century sponge expert", with a keen interest in the understanding, popularization and preservation of sponges, I must raise a series of reflective questions. Considering the need for and difficulty of spreading knowledge of Caribbean marine sponges, we must ask: is the Sponge Guide the best ever illustrated guide to Caribbean marine sponges? What are its greatest assets, and what are its pitfalls? To avoid providing only a self-centered opinion, I sent a short set of questions to a handful of colleagues that included sponge systematists, reef ecologists and natural product chemists. Generally, all would recommend the Sponge Guide to non-experts, and all agreed that the best features of the guide were the large photographs of the species described. All also appreciated the inclusion in the guide, for 20% of the species, images of the microscopic skeleton elements. All were keen to see this feature extended to cover all species. However, when asked what percentage of Caribbean sponge species that they estimated were covered by the database, the answers ranged from 5-70 %, demonstrating the problem of getting to grips with Caribbean marine sponge biodiversity.

In fact the Sponge Guide, in its 3rd edition, depicts 230 morphospecies of the approximately 800 species currently recognized for the Caribbean (as determined from the Caribbean list at https://www.portol.org/resources/). Its major asset is the inclusion of a large portion of sponge species from open habitats in Caribbean reefs and seagrass flats. But the Guide would benefit tremendously from by making use of one or two additional morphologic characters: notably internal coloration and surface appearance. The latter could easily be shown using close-up photographs, and is a most useful feature for distinguishing among similar appearing species. On the other hand, a significant improvement to the guide has been the introduction of a link to the World Porifera Database (https://www.marinespecies.org/porifera/), which is a platform for information on the classification, distribution and bibliographies of all currently described species. Users could benefit if it offered links to other "sponge guides," such as the interactive sponge guide to shallow South Florida marine sponges (www.portol.org/guide/), which distinguishes 100 sponges using 12 morphological characters (5-10 character states each).

Despite this and other efforts, a large portion of Caribbean sponges species and/or varieties still await discovery. Cryptic coral reef, mangrove, and mesophotic reef habitats and sandy continental platforms are among the least studied environments, besides which considerable endemism is apparent among sponge communities across the Caribbean.

Thanks to the authors of the Caribbean Sponge Guide for their unique and fruitful effort; also to Klaus Ruetzler (Smithsonian Institution, USA), Rob van Soest (Naturalis, Netherlands), Phil Crews (UCSC, USA), John Reed (HBOI-FAU, USA), Deborah Gochfeld (UM, USA), Chris Freeman (Smithsonian Institution, USA) and Larry Manes for their contributions to this review.

CONFERENCE REPORTS

Informative overviews of recent conferences and meetings

Annual Meeting of the Japanese Coral Reef Society (JCRS)

(27th November - 1st December 2014)

The 17th Annual Meeting of the Japanese Coral Reef Society (JCRS17) was hosted jointly by the Kuroshio Biological Research Foundation and Kochi University, in Kochi prefecture. Over 185 people attended the meeting, which included 39 oral presentations and 81 posters.

A workshop on precious coral and deep-sea coral was held as part of the meeting, as precious corals have been harvested from Kochi prefecture for over 100 years. The aim of this workshop was to review the basic biology and ecology of these corals and their conservation in Japan. On the 4th day of meeting, a symposium on “Hermatypic corals of the temperate zone” was held, aimed at disc-ussing the wise use of these coral communities for research, educat-ion and tourism.

To encourage young researchers, poster awards were presented to young students/scientists (under 35 years old) as follows: 1st Sena Uyama, Sophia University; 2nd Masaru Mizuyama, University of the Ryukyus; and 3rd Asuka Sentoku, Kyoto University. The prestigious Kawaguchi prize for young scientists was given to Dr. Akira Iguchi (Okinawa National College of Technology). The JCRS award for coral reef conservation activities was given to “Diving Team Snack Snufkin” for their work recording the coral reef biodiversity of Oura Bay (to the north of Cape Henoko, Okinawa Island), and for the exhibitions of photos, videos and specimen collections that they had organized to disseminate this information. The photograph below shows marine organisms recently discovered in Oura Bay, some of which are yet to be described.

A post-symposium diving field excursion took place to Otsuki, in southwestern Kochi prefecture, where reef-building corals are most abundant due to the influence of the Kuroshio Current; they form a patchy community (see below) that grows directly on the upper part of rock substrata. 16 participants from JCRS took part in the diving tour and enjoyed the beauty of the corals and coral communities found adjacent to the Kuroshio Biological Research Foundation research station.

The next JCRS meeting will be held in Tokyo, Japan in autumn 2015. For more information about JCRS, please visit the website: http://www.jcrs.jp/?page_id=1598

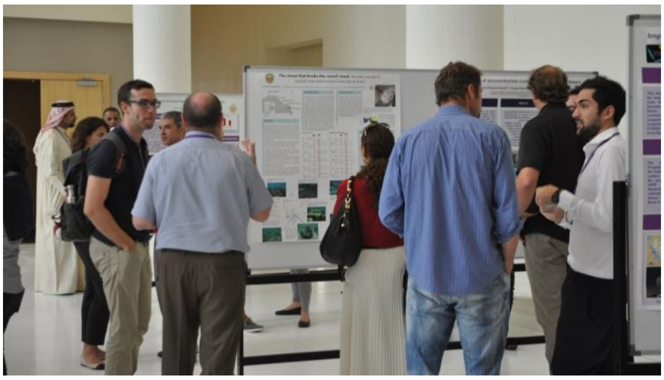
Takuma Mezaki,
Chair, JCRS17 Organising Committee, Kuroshio Biological Research Foundation,
Kochi, Japan

Participants on the field excursion to Otsuki, Kochi Province

Coral Reefs of Arabia, Abu Dhabi

(15th-17th February, 2015)

The Middle East contains some 6% of the world's coral reefs by area, as well as a number of unique biogeographic provinces including those characterized by extreme environmental conditions (e.g. Persian Gulf), high biodiversity and endemism (e.g. Red Sea and Gulf of Aden), and highly productive coastal upwelling zones (e.g. Arabian Sea and Gulf of Oman). Despite the interesting and unique nature of these systems, the region has - up until recently - remained relatively understudied. In recent years there has been rapid growth in interest in the region, with research expanding rapidly in locations that have previously been under-represented in the reef literature.



In February 2015 the "Coral Reefs of Arabia" conference was held at the New York University Abu Dhabi (NYUAD) campus in the United Arab Emirates, bringing together researchers from around the region to discuss results of recent research and to enhance collaboration across the region. John Burt, an Associate Professor of Biology at NYUAD and organizer of the conference, said that the one of the major goals of the conference was to enhance regional dialogue. "While a good deal of research is available from localized areas such as in the Gulf of Aqaba or the southern Persian Gulf, there remain considerable gaps in our knowledge of reef ecology for the region as a whole. We have started to see considerable growth in our knowledge of reef systems around the wider Middle-eastern region in recent years and one of the goals of this conference was to bring together people from across the various regional seas to develop a more integrated picture of the status of reef research".

The conference included sessions on a variety of topics including adaptation to extremes, holobiont ecology, coral communities, patterns and processes in coral reef fishes, coral reproduction, biophysical processes, evolution and biogeography, and conservation and management. Each day of the conference included keynote addresses from leading coral reef ecologists working on regional reefs including Bernhard Riegl, of Nova Southeastern University, Florida, US ('What Arabian coral reefs can teach us about the past, the future, and the management of the world's coral reefs'), Andrew Hoey, of James Cook University, Townsville, Queensland, Australia ('Where are all the herbivores? A case study from the southern Arabian Gulf'), and Charles Sheppard, of Warwick University, Warwick, UK ('Gulf coral reefs are mostly dead: can we do anything about it?').

The conference was attended by researchers from 18 countries, including regionally-based and international reef scientists. Prizes were awarded by ISRS for the best student oral presentation, to Anna Roik, of the King Abdullah University for Science & Technology (KAUST), Thuwal, Saudi Arabia, and for the best student poster to Remy Gatins (also of KAUST).

Above: Coral Reefs of Arabia session, opened by organizer John Burt (NYU Institute, Abu Dhabi). Below: the ISRS prize for the best student oral presentation being awarded to Anna Roik of KAUST, by John Burt.

People who may have missed the conference but have an interest in reefs of the region are welcome to join the recently established Mideast Coral Reef Society (www.MideastCRS.org), which, it is anticipated, will be affiliated with ISRS.

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17th Annual Reef Conservation UK (RCUK) Meeting

(5th December 2014)

Reef Conservation UK (RCUK) returned for another successful meeting on Saturday 5th December at the Zoological Society of London. This was the 17th annual meeting which brought together over 130 reef scientists, conservationists and volunteers. RCUK was founded to facilitate discussion and collaboration among all engaged in applied biological, ecological, socio-economic, educational, and policy-based aspects of reef conservation, not only within the UK, but from neighbouring and associated countries. The meeting broadly followed four themes: reef fish ecology, reef resilience, molecular tools in reef science and coral reef conservation.

It was good to see such a strong conservation session, spanning topics from the effectiveness of reef rehabilitation by culturing coral larvae to social sciences and the value of reefs for human wellbeing. For UK based researchers there was an update from Lesley King (LTS International) on Darwin Initiative funding, highlighting poverty alleviation as a key tenant of future coral reef conservation. The reef fish ecology and reef resilience sessions both focused on processes structuring reef communities. Fish science presentations covered topics ranging from small scale environmental effects (such as wave exposure, depth and algal quality) through to regional biogeographic patterns. The reef resilience session included discussion on the role of cyclones and sediment in structuring coral communities prompted by several talks on the Great Barrier Reef. Henry Duffy (Imperial College, London) caused much laughter with his account of being abandoned by his supervisors on Pitcairn Island (*vide* “Mutiny on the Bounty”) for several months, with only goats for company, as part of a project to monitor changes in fish biomass.

Prior to the final session Alisdair Edwards (University of Newcastle) lead a short tribute to Professor David Stoddart, highlighting his considerable contribution to reef science, including serving as the first president of ISRS, and securing the protection of Aldabra Atoll (in the Seychelles), the largest raised atoll in the Indian Ocean. For many younger reef scientists it was a revelation to learn of his influence in shaping their field.

The day finished with a somewhat unusual but “very cool” talk by Jon Chamberlain (University of Essex), demonstrating a new web based tool - Purple Octopus (www.purpleoctopus.org). This allows the user to search for images of any chosen marine species that anyone may have uploaded and identified on Facebook or any other online forum. This “crowd sourcing” of species identification, while not always totally reliable, seems nevertheless potentially very useful, as a means of checking for other images of a particular species. New technology in the form of Twitter also facilitated real-time comment on talks and posters and allowed those unable to attend to glean a selection of key issues (see #RCUK2014 and @ReefConsUK).

The meeting was, as in previous years, notable for its mix of experienced reef researchers, early career scientists, research students and undergraduates, a feature the RCUK organising committee is proud to encourage. However, the year saw a large change in membership of the RCUK organising committee; the new committee thanks all retiring members and invites all concerned for the future of reefs to join them at RCUK 18, to be held again at London Zoo, on 28th November 2015.

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Red Sea and Western Indian Ocean Biogeography Workshop

(23rd-27th February, 2014)

The first Red Sea and Western Indian Ocean Biogeography Workshop was held at the King Abdullah University of Science and Technology (KAUST) from February 23 to 27, 2014. The workshop hosted international scientists from institutions as far and wide as Australia (James Cook University, Curtin University), United States of America (Hawai'i Institute of Marine Biology, California Academy of Sciences, Florida Museum of Natural History, University of California Santa Cruz, Field Museum in Chicago), Africa (CORDIO: Coastal Oceans Research and Development in the Indian Ocean, South Africa Institute for Aquatic Biodiversity, University of Johannesburg, Stellenbosch University) and Europe (IFREMER: Institut Français de Recherche pour l'Exploitation de la Mer, Natural History Museum of London, Vrije Universiteit Brussel). Also, six promising undergraduate students studying in the United States of America, South Africa, Scotland and Australia were sponsored by KAUST to not only attend the workshop but also present posters outlining their honors projects.

The workshop focused on questions related to genetic connectivity, phylogeography and demography, as well to the diversity and distribution of coral, most other marine invertebrates, and reef fish from the Indian Ocean into the Red Sea. Topics regarding data coordination and sharing within the existing Indo-Pacific genetic/metadata network initiated by NESCent (National Evolutionary Synthesis Center at Duke University) were also discussed. During the workshop, researchers tried to identify key knowledge gaps in these regions and working groups were established to address and/or resolve these gaps. As a result of the workshop, a special issue in the Journal of Biogeography (JBI) will be published in spring 2015.

Diego F. Lozano-Cortés,
Red Sea Research Center - Coral Reef Ecology Laboratory,
King Abdullah University of Science and Technology, Thuwal,
Kingdom of Saudi Arabia

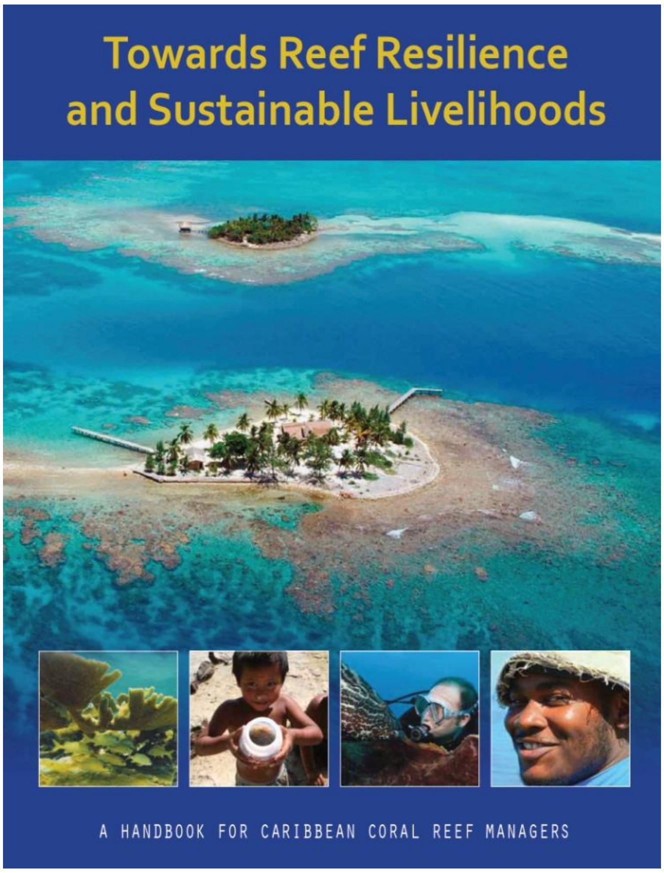
The workshop's closing event at the Al Marsa Yacht Club.

REEF SHELF

Details of new publications – manuals, reports and books

Towards Reef Resilience and Sustainable Livelihoods: A handbook for Caribbean coral reef managers

Peter J Mumby, Jason Flower, Iliana Chollett, Stephen J Box, Yves-Marie Bozec, Clare Fitzsimmons, Johanna Forster, David Gill, Rosanna Griffith-Mumby, Hazel A Oxenford, Angelie M Peterson, Selina M Stead, Rachel A Turner, Philip Townsley, Pieter J H van Beukering, Francesca Booker, Hannah J Brocke, Nancy Cabañillas-Terán, Steven W J Canty, Juan P Carricart-Ganivet, John Charlery, Charlie Dryden, Fleur C van Duyl, Susana Enríquez, Joost den Haan, Roberto Iglesias-Prieto, Emma V Kennedy, Robin Mahon, Benjamin Mueller, Steven P Newman, Maggy M Nugues, Jorge Cortés Núñez, Leonard Nurse, Ronald Osinga, Claire B Paris, Dirk Petersen, Nicholas V C Polunin, Cristina Sánchez, Stijn Schep, Jamie R Stevens, Henri Vallès, Mark J A Vermeij, Petra M Visser, Emma Whittingham, Stacey M Williams (2014) University of Exeter, Exeter. 172 pp.



The sizeable authorship of *Towards Reef Resilience and Sustainable Livelihoods: A handbook for Caribbean coral reef managers* reflects the scale of the Future of Reefs in a Changing Environment (FORCE) project from which this publication has arisen. The European Union funded FORCE project was a collaboration of institutions in the Caribbean, the UK, Australia and the United States. The multi-disciplinary team brought together expertise across the natural and social sciences, with the research aimed at providing reef managers with tools and solutions that achieve better outcomes for people and reefs. Although the project finished in 2014, the ongoing legacy of the collaborations will last for many years with more than 50 papers already published.

The reef managers' handbook is not solely focused on results of the FORCE project and aims to provide a fairly comprehensive guide to issues facing Caribbean reef managers. It is broken down into eight broad sections, such as reef resilience, livelihoods, governance, climate change and reef fisheries, all focused on Caribbean reefs. Each section starts with an up-to-date review of the topic, and is followed by a series of stand-alone 'briefs'. These briefs provide concise information on a particular issue, using the latest research to inform management actions. The topics covered by the 29 stand-alone briefs include parrotfish management, bleaching vulnerability in MPA planning and social network analysis in reef governance. The last section of the handbook provides practical advice on reef monitoring methods and a guide for interpreting reef monitoring data.

The handbook is designed to be graphically appealing and easy to read, with extensive use of photos and informative diagrams throughout. Though written with reef managers in mind, the accessible format makes it a useful resource for students, researchers and policy makers. The handbook is available for free download in both Spanish and English from the FORCE project website, where other publications and tools are also available (see http://www.force-project.eu/node/252).

Jason Flower
University of Exeter, Exeter, UK

Field Guide to the Hard Corals of South Yemen – Arabic Language Edition

Ameer Abdullah, Francesca Benzoni, Claude-Henri Chaineau, Eric Dutrieux and Michel Pichon
(256 pp. *ISBN*: 978-2-8317-1691-6)

The Arabic language version of the “Field Guide to the Hard Corals of South Yemen” first published in English in 2010 by Biotope Editions and the Museum National d’Histoire Naturelle, Paris, has just been released. Its production is the result of the combination of funding provided by the Yemen LNG Company as part of the regional capacity building drive inscribed in the company’s policy, and the publishing expertise offered by IUCN (Global Marine and Polar Programme). The Arabic version retains the contents and presentation of the English edition, to which the name of the translator has been added. The volume is available free of charge to worthy bona fide recipients and can be obtained from Yemen LNG (Sana’a), IUCN Headquarters (Gland, Switzerland), IUCN Jordan (Amman), the Arab Regional Centre for World Heritage (Bahrain) or TOTAL (Paris).

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Coralpedia: a million page views

Several years ago, a project funded by parts of the UK government, as a UK Overseas Territories (OTEP) project, supported by other work funded by the governments of Mexico and other Caribbean States, led to the creation of a photo-guide to corals, soft corals and sponges of Caribbean reefs.

Diploria labyrinthiformis (Photo: Charles Sheppard)

At the time, there were numerous projects underway or just starting up. In several it was obvious that many species, even sometimes common ones, were being misnamed. To make things worse, many projects named their species ‘Species A’, or ‘Sponge 1’, ‘Sponge 2’ and so on, and naturally a ‘Coral 4’ in one place was different from the ‘Coral 4’ described by another group in another place.

As a side-line to other reef projects, I had compiled a few hundred photos, and I compiled these into a cd featuring the commonest couple of hundred corals, soft corals and sponges of the Caribbean, and called it *Coralpedia*. I had generous advice, from several leading taxonomists (all acknowledged of course in an accompanying doc). And, because much of the Caribbean is Spanish speaking, I enlisted the help of my then PhD student, Dr Rodolfo Rioja-Nieto, of Mexico to translate all text into a Spanish version. A toggle simply flips between English and Spanish.

Aplysina fistularis (Photo: Charles Sheppard)

Another toggle flips between a taxonomic listing and a listing by shape of the colony. After creating and mailing a few hundred CDs, I called a halt and funded a programmer to turn it into an online version. Embedded into it is Google Analytics which records statistics about use.

This first version was used well. Three years ago I decided to, firstly, update the taxonomy in several areas, and also improve the software. The UK's Darwin Fund supported this. The software revision was done by another PhD student, Dr Elizabeth Widman, who carried over the Google Analytics too. Today, the software tells me the site has now exceeded a million page views, and that there are dozens more each day. Of course a lot are accidental glances, but fully one third of the page views are repeat or part of prolonged use – which is the purpose of the guide in the first place. About one quarter come from Spanish speaking countries, so the decision to add that language was clearly useful too.

The point of all this of course was to improve consistency of all the various Caribbean reef conservation projects, and the ease of doing them. We hope it has helped. The guide can be found at http://coralpedia.bio.warwick.ac.uk. All feedback on names is welcome – this has always been intended as an interactive project. Names change, and so should the guide.

Charles Sheppard
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REEFLECTIONS
(unusual locations and species)

Bermuda's Winter Lionfish Derby

Introduced through the aquarium trade, Indo-Pacific lionfish (*Pterois volitans* and *P.miles*) have recently invaded the northwestern Atlantic. As voracious predators with broad diets, they could pose a threat to ecologically important fish species, and hence to reef health. Although Bermuda's first sighting came in 2000, four years before lionfish arrived in the Bahamas, their population has grown slower than elsewhere. However, in mid-December 2014, a lionfish was spotted in St. George's Harbour, the farthest inshore any had yet been observed. Soon after that, local dive shops and permitted lionfish hunters began reporting increased numbers. In response, it was decided to hold a "Lionfish Derby", with cash prizes as an incentive to encourage culling during winter, when diving opportunities are limited by cold water and frequent gales.

Spencer Wood with a lionfish caught in only one metre of water.

The Derby ran from January 9th to February 1st, during which time 133 lionfish were captured and 79 were submitted to the contest, a much higher number than any previous winter. Surprisingly, a majority of the fish were captured by freedivers in 10 meters (30 feet) of water or less. The Derby winner caught 53 lionfish in nine dives. The largest lionfish was 43cm (17 inches) and the smallest 25cm (10 inches). Not only was the Derby successful in promoting a cull, it also provided data on the distribution, reproductive activity and feeding behavior of lionfish in the winter, a key contribution to our ongoing research programme.

Corey Eddy
University of Massachusetts Dartmouth, North Dartmouth, USA
email: coreyeddy1@gmail.com

PROGRAMMES & PROJECTS

Update on the International Coral Reef Initiative (ICRI)

2015 is an important milestone in terms of the Convention on Biological Diversity's Aichi Targets. Target 10 specifically concerns coral reefs and requires that:

"By 2015, the multiple anthropogenic pressures on coral reefs and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning."

As the sole global partnership dedicated to coral reefs, the International Coral Reef Initiative (ICRI) is committed to accelerating momentum towards Aichi Target 10 and beyond, and we look to members of ISRS for guidance and collaboration.

ICRI is a partnership of governments, international organizations, and non-governmental organizations which aims to conserve coral reefs and their related ecosystems. It was initiated by eight governments at the First Conference of the Parties to the Convention on Biological Diversity in 1994, and now counts over 60 members with its membership steadily growing.

The ICRI Secretariat is hosted by two member states on a voluntary basis and rotates every two to three years. Since April 2014, Japan and Thailand have been serving as co-hosts, and this joint secretariat has set three themes for the Plan of Action during its tenure:

1) engaging other sectors;
2) promoting marine spatial planning;
3) revisiting ICRI's place among multilateral environmental agreements, other international bodies and initiatives.

In October 2014 ICRI members convened in Okinawa, Japan, for the 29th General Meeting. This included a technical workshop on the theme "Engaging other sectors – community-based coral reef management" at which case studies from the Dominican Republic, Mexico, Vietnam and Japan were presented.

As an outcome, ICRI adopted a resolution on "promoting an integrated approach to community-based coral reef conservation and management emphasizing land-sea connectivity," in which the need was recognized to look not only at the immediate coastal communities and sectors but also beyond to the inland areas, both of which can equally affect the health of coral reefs.

As a result of this resolution, this year the ICRI Secretariat is compiling case studies about communities that have implemented conservation and management practices with land-sea connectivity in mind, and will report on such cases at the 30th General Meeting to be held in Thailand. We also plan on organizing a technical workshop on marine spatial planning at the General Meeting, as well as a side event on coral reefs at the upcoming Ramsar Convention COP12. We sincerely hope that there will be many opportunities for exchanging knowledge and experience between ICRI and ISRS.

For more information about ICRI, visit www.icriforum.org. For information on the 29th General Meeting and Resolution, go to http://www.icriforum.org/ICRIGM29

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REEF DEPARTURES

Memories of recently departed members and reef scientists

David Ross Stoddart (1937–2014)

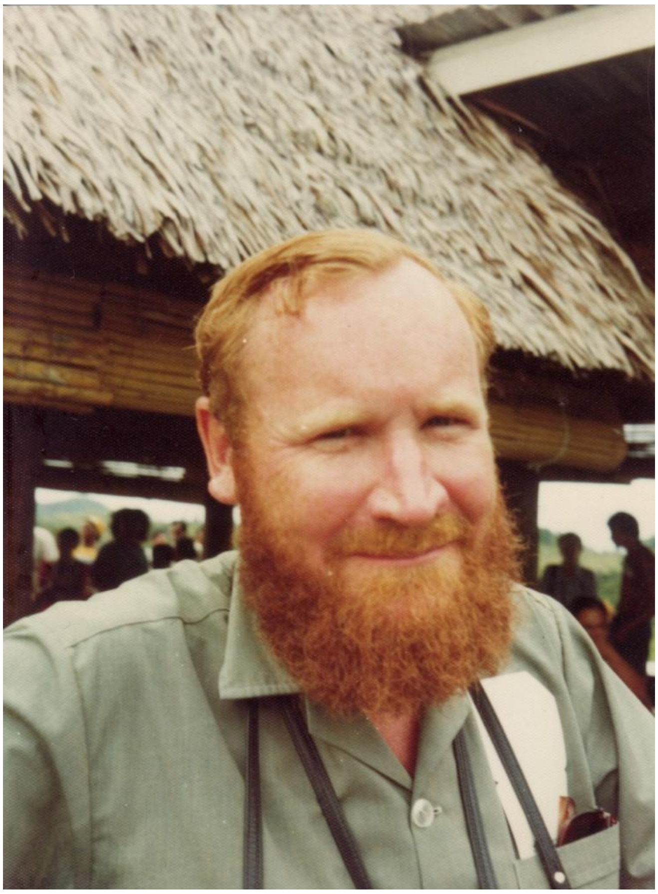
Grandeur in his view of life: expanding the frontiers of knowledge in the reef seas

David Stoddart, the first President of the International Society for Reef Studies, the first Co-ordinating Editor of *Coral Reefs* and the driving force behind the setting up of the quadrennial International Coral Reef Symposia, died in Berkeley, California on 23rd November, 2014, at the age of 77. It is difficult to summarize in a few words the life-force of such an extraordinary person but fortunately the man himself did it for us[1]. Having effectively defined the coral reef research agenda at the end of the 1960s[2], he then spent the next half century pursuing it: personally, through his students and also by energising and encouraging the community of coral reef researchers all around the world.

David Ross Stoddart was born in November 1937 in Stockton-on-Tees in NE England; even at school he was reading W.M. Davis' *The Coral Reef Problem*. He entered St. John's College, Cambridge as an Exhibitioner in 1956, progressed through the Geographical Tripos with distinction, and then proceeded to graduate studies on the Belize Barrier Reef under the direction of Professor Alfred Steers, completing his Ph.D. degree in 1964. He was a Demonstrator in the Department of Geography at Cambridge from 1962 to 1967 and University Lecturer from 1967 to 1988, before being enticed away to a Professorship (and Chair of Department) at the University of California at Berkeley.

The impact of Hurricane Hattie on the Belize reefs in 1961 gave David the remarkable opportunity to compare pre- and post-storm impacts on the barrier and set the tone for his subsequent extensive, detailed mapping of coral islands throughout the reef seas. Short but powerfully built, with a shock of sandy hair, piercing blue eyes and an impressive beard, David was in his element in the field. Whilst still an undergraduate, he travelled overland to India, took ship passage to West Africa and trekked through the jungles of South America. Once in the security of a University post, he went everywhere that he could in the reef seas; by his own estimate, he averaged at least three field trips a year to the Tropics, a pace he kept up for more than three decades.

When he wasn't on the 'big jets' as he called them, he was always on the telephone, at the typewriter, by the fax machine or involved in research, expeditionary logistics and advocacy at the great London learned institutions, in that triangle between Carlton House Terrace, Regent's Park and Exhibition Road. His breadth of on-the-ground experience, and his encyclopaedic knowledge of the geological, biogeographical, zoological and botanical literature on reefs, gave him huge advantages when it came to



David Stoddart in Fiji in the mid 1970s (by kind permission of June Stoddart)

David Stoddart surveying reef formations on Mauke, 1986

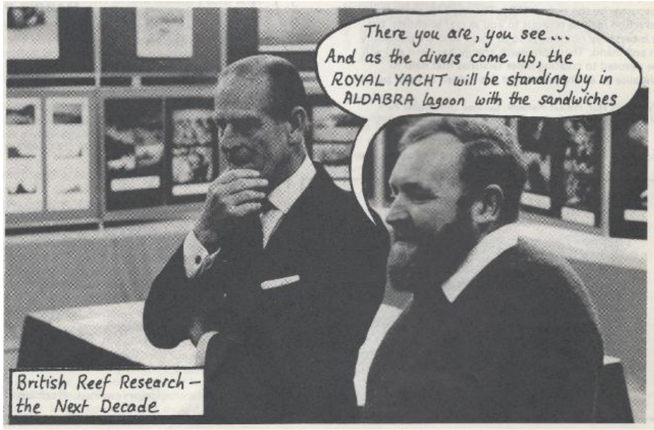
'reading' and making sense of newly-encountered coral reef and reef island landscapes. The subsequent reports, often in the Smithsonian's *Atoll Research Bulletin*, were enhanced by a deep knowledge of the reports of early explorers and travellers. In a pre-internet era, his wheeled card index of references on all aspects of the study of landforms – geomorphology - and his 'island files' in some 14 filing cabinets, were legendary.

Strong and sustained support for this work came via the Royal Society of London, from opportunistic visits with small teams (where participants were referred to by nickname: 'black dog', 'tuddy', 'scruffy', 'the vicar'…) to large, multi-disciplinary ventures – such as the marine programme of the Solomon Islands Expedition (1965; led by the botanist E.J.H. Corner) and the Northern Great Barrier Reef Expedition (1973; led by David himself while he was still in his thirties) – ranging widely, lasting for many months and leading to impressive synthesis volumes in the Society's *Philosophical Transactions*. To David it was entirely appropriate that 'the Royal' should be involved in this way as from its beginnings, the Society had wished to expand knowledge of the world's oceans, issuing 'Directions to seamen bound for far voyages' in the first volume of the *Transactions*. He thus traced his own scientific lineage back to the great voyaging naturalists: Joseph Banks, Johan Reinhold Forster and, of course, Charles Darwin, whose original notes on the structure and distribution of coral reefs he unearthed in the Cambridge University Library. 'Four handshakes from Darwin' as he memorably told delegates at the ISRS European Meeting in 2002. Not surprisingly, he was deeply proud of being the first recipient of the ISRS Darwin Medal.

The most significant outcome of this Cambridge – London collaboration, which involved advocacy at the highest levels of government, both in the UK and USA, was the saving of the near-pristine, now World Heritage Site-listed island of Aldabra Atoll, S.W. Indian Ocean, from development as a military staging post. David was responsible not only for the initial rapid reconnaissance, which established its ecological significance, and the authoritative briefings that followed, but also for pushing through the construction of a field station and overseeing a decade-long, 50 person-year research effort on the atoll's geology, geomorphology, climate and ecology. His legacy is probably one of the best understood oceanic coral islands in the world. He continued to support scientific research on the atoll after management was transferred to the Seychelles Island Foundation, returning there for one last time in 2007 to celebrate 25 years of in-country support.

David was a gifted and natural speaker, with a stentorian voice and a natural sense of comic timing. As early as the 4th International Coral Reef Symposium in 1981 in Manila his plenary entitled 'Coral reefs - the coming crisis'[3] outlined the fragility of reefs in the face of man's actions and the need for improved international co-operation both at the level of governments and reef scientists. This was a very timely wake-up call given that only two years later reefs were to suffer from the first global-wide bleaching event as a result of elevated sea surface temperatures.

David was a heavy drinker, often starting the Departmental day with a 100 ml lab. beaker of sherry and pressing the Chinese spirit 'Maotai' on dinner guests. He had no time for petty University bureaucrats and could be ruthlessly aggressive towards such people. In later years, the un-pc postcards from the South Seas were replaced by lurid photocopies of his latest afflictions, as the years of hard living and relentless hatless mapping under the tropical sun resulted in diabetes, erupting skin cancers and foot problems. As he became increasingly housebound, he built a remarkable library full of rare



Stoddart and the Duke: cartoon produced at the time based on a photo of David Stoddart showing HRH The Duke of Edinburgh around an exhibition featuring Aldabra Atoll, Seychelles.

books and old maps of the world's oceans and islands. He leaves behind memories of an intense camaraderie, much laughter and many schoolboyish pranks (or 'tee hees' as he called them) but also a certain sadness for a world of broad knowledge and deep scholarship which has almost completely vanished.

His awards included: Officer of the Order of the British Empire (1979); Fellow, American Association for the Advancement of Science (2000); Ness Award (1965) and Founder's Gold Medal (1979), Royal Geographical Society; Livingstone Gold Medal (1981), Royal Scottish Geographical Society; Davidson Medal (2000), American Geographical Society; Darwin Medal (1988), International Society for Reef Studies; Herbert E. Gregory Medal (1986), Pacific Science Association; and Prix Manley-Bendall (1972), Institut Oceanographique de Monaco / Société Oceanographique de Paris.

He is survived by his wife June, a constant stabilising and supportive presence in his life since his early years in Cambridge, a daughter (Aldabra), son (Michael) and granddaughter (Kathy).

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[1]Stoddart, D.R. (1969) Ecology and morphology of Recent coral reefs. Biol Rev 44: 433-498
[2]Stoddart, D.R. (2001) Be of good cheer, my weary readers, for I have espied land. Atoll Research Bulletin 494: 234-272.
[3]Stoddart, D.R. (1981) Coral reefs: the coming crisis. Proc 4th Int Coral Reef Symp 1: 33-36.

Gerry Bakus (1934-2014)

One of the last of the natural historians

Gerry passed away last August, with Grace, his wife of 60 years, and their two children Melanie and Paul by his side. We have lost a gentle man of unique talents and impressive grasp.

Gerry was born in Wisconsin, did his PhD at the University of Washington with Dixie Lee Ray, was then hired by the University of Southern California (USC) in 1962, and never left.

His field skills and the extent of his intellectual grasp showed themselves from the beginning. He went on the first Fanning Island Expedition in 1963, planning to work on the birds but, when he arrived, there were no birds. So he looked around and saw lots of ocean, and lots of holothurians, and started observing, wading about, and looking at things. He found that, when he turned over rocks in shallow water, the undersides were covered with benthic invertebrates which were promptly eaten by grazing fish. That is, except the brightly-coloured ones. He also noted that some of the organisms were adversely affected by sedimentation.

Gerry Bakus

And so, all of a sudden, based on a few days' field observations, some of the earliest papers on the importance of grazing on coral reefs, the impacts of sediments, and the importance of chemical defences were generated. This was seminal, foundation work in some of the most important fields in modern coral reef ecology.

Some men would have been content with that, but not Gerry. He published widely, and wrote books on subjects as diverse as quantitative ecology, natural history, and the Spanish guitar. He was a friendly and engaging man, and not one to put on airs. His many field trips (for example to Catalina Island, Mexico) were legendary for the amount learned during the days and the amount imbibed during the evenings.

Modern science has a schizophrenic approach to previous work: we know we stand on the shoulders of others, but as soon as those others recede from view, the more important seems our own work. It seems that much of the recent research on grazing and allelopathy has served simply to prove that he was right all along - he should have been cited more.

Gerry was the quintessential natural historian, hiking and diving new places, observing and connecting. One of his "colleagues" at USC, a whizzbang cellular physiologist whose name has long since vanished into obscurity, once accused Gerry of doing "Stone Age Science"- because he counted "critters". Now that he is gone, we realise how much we needed him, and how much we need more like him. Someone has to count the critters.

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Robert F. Dill (1927-2004)

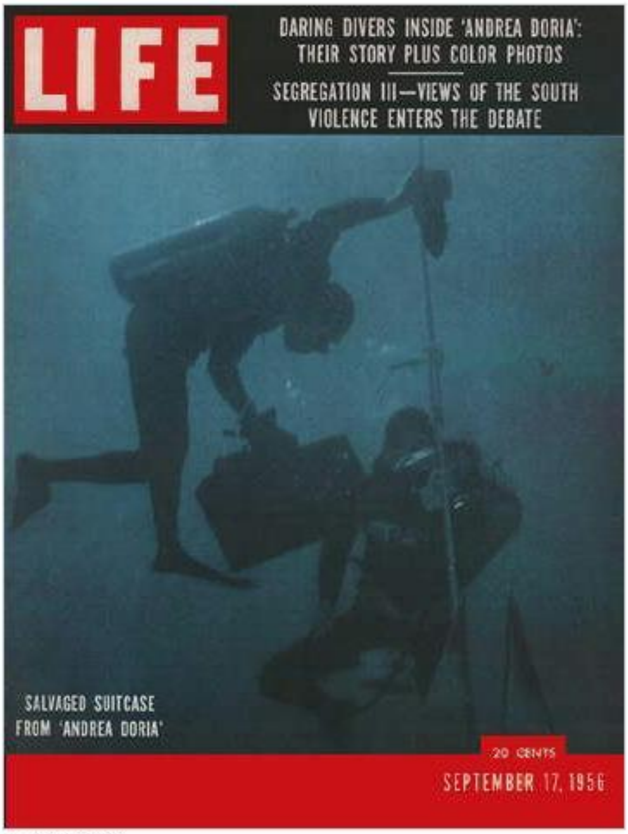
An Appreciation

It seems like yesterday, but 11-years ago the coral reef and diving community lost a most unusual and often controversial colleague. He was one of the first divers to reach the *Andrea Doria* that sank in more than 200 ft. of frigid waters off New York in 1956. A photograph of him making that dive was featured on the cover of *Life Magazine*. Anyone remember *Life*? *Life* went the way of the *Saturday Evening Post* and other American magazines during the rise of TV news. If you remember these magazines, you probably remember Robert F. Dill.

Bob Dill was truly a most unusual scientist / geologist. We first met on a Florida Keys field trip. Bob was wearing a fake bloodshot eye, and his booming voice made us all laugh with his hilarious stories. We became instant friends, and Bob stayed over a couple of days so I could take him to some of my favorite reefs.

The first thing he did on every dive was dig holes in the sand. At one of my favorite places, his excavation revealed a caliche crust. For the non-geologists, caliche forms only in air, never under water. That crust was later sampled, and carbon-14 analysis showed it was roughly 12,000 years old. That date and digging holes formed a turning point in Keys coral reef geology. Before long, we were finding and dating that caliche layer in many places. Because of Bob's digging, we learned that Florida Keys reefs were less than 6,000 years old. Before that, the reef areas had been dry land. Extensive coring by Ronald Perkins and others soon revealed the Keys had been dry land many times during what is commonly called the Ice Ages. In fact, sea level had been about 400 ft. below present just 16,000 years ago. It all started because Bob dug that shallow hole in the sand with his hands.

Earlier in his career, Bob and some very notable people mapped a strip of sea bed off the California coast that extended from the northern to southern Mexican border. His team of graduate school students (they called themselves General Oceanographics) consisted of Harris B. Stewart, Bob Dietz, Bill Menard, and a professor named Edwin Hamilton. Stewart later became Director of the NOAA Atlantic Oceanographic Meteorological Laboratory on Virginia Key, Florida. Dietz championed seafloor spreading before deep-sea drilling provided proof. Menard served as Director of the U.S. Geological Survey. Bob's professor and long-time friend was world renowned Francis Shepard. The dive-team members had little money and shared parts of a new invention while diving in the cold California waters. They could afford only one wet suit. One would wear the top and another would wear the bottom. A young geologist from an oil company sponsor named Tom Barrow would accompany the team on their dives and retrieve the notes they took under water. They used a self-invented underwater meter to measure dip angles. Many years later, Tom Barrow would become president of EXXON. Other associates included Douglas Privitt who constructed the first *Nekton* two-person submarines, and Richard Slater who piloted them all, including the *Delta*, Privitt's most recent design.



Sep 17, 1956
Divers in Doria
Photo: Peter Gimbel, Robert Dill, Earl Murray and Ramsey Parks

At Scripps Institute of Oceanography, where Bob worked, he met a young Frenchman named Jacques Cousteau and gave advice on setting up a surplus Navy mine sweeper for divers. The boat was later named *Calypso*. And there was also Bob Nevin, officer in charge of the *Trieste*, the Navy's, and the world's, deepest diving bathysphere. The list goes on and on.

Dill eventually joined NOAA's MUST (Man Under the Sea Technology), which later became NURP (National Undersea Research Program), and finally he became head of the Fairleigh Dickinson University West Indies Laboratory on St. Croix, where he began coral reef research.

But his discoveries were not over. His digging around on the bottom uncovered modern stromatolites in the channel adjacent to the Lee Stocking Island Caribbean Marine Research Laboratory, which at the time was headed by his long-time friend Bob Wicklund. The only other known stromatolites outside of the Bahamas were in Shark Bay, Australia. Stromatolites were the first life forms on Earth. Textbooks said they had died at the beginning of the Cambrian. These 2m high structures were a major discovery and became a *Nature* cover story.

There are many stories that can be told about Bob Dill, but the one I remember best was a rum-inspired midnight march around Lee Stocking Island singing Belafonte's refrain "*Midnight come and I want to go home*" into the various water cisterns. We were searching for the best echo chamber to get that Belafonte sound. We called ourselves the "Cistern Chapel Choir." Ah, what great memories. What more discoveries would he have made if Bob were still with us.

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ISRS MEMBERSHIP

ISRS membership is open to all persons 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 genuine interests 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 opposite, but rates vary depending on whether a hard-copy subscription or on-line access to the Society's 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 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 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 in Society publications.

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.

Membership services are now operated by Schneider Group which provides such services to academic societies. They may be contacted at:

ISRS Member Services
5400 Bosque Blvd, Suite 680
Waco, Texas 76710-4446 USA
Phone: 254-399-9636
Fax: 254-776-3767
email: isrs@sgmeet.com

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 services page at: https://www.sgmeet.com/isrs/membership/memberlogin.asp

NOTES FOR CONTRIBUTORS

Reef Encounter welcomes the submission of Scientific Articles, News Items, Announcements, Conference Reports and Book and Product Reviews, relevant to the coral reef researchers and managers. We especially welcome contributions by young researchers with a fresh perspective and seasoned reef scientists able to integrate a lifetime of experience.

Colour pictures or other illustrations (normally 1 -3 according to article length) are welcome to accompany an item. Cartoons and stand alone pictures of special note may also be submitted.
Different types of item should be sent directly (preferably by email) to the relevant section editors (see inside front cover - page 2 – for details).

Types of Article

Reef Encounter accepts three distinct type of "Scientific Article". Note that, for any of these types of article, priority will normally be given to authors who are members of ISRS.

The **REEF PERSPECTIVES** section takes 2-4 page articles which express a fact-based opinion about a scientific or management issue. Our goal is to encourage thoughtful and stimulating discussion within and across disciplines and generations. Authors thinking of offering an opinion-type item are encouraged to consult the editor. Readers are encouraged to respond by writing to letters to the **CORRESPONDENCE** section, but such responses should be well reasoned and respectful (in contrast to the faster-paced open discussion characteristic of coral-list).

REEF CURRENTS takes 1-5 page articles which overview a topic or a programme with which the author is familiar or has become acquainted. Priority will be given to articles focusing on subjects which are relative new or poorly known or often misunderstood.

REEF EDGE takes short scientific notes or papers (scientific letters) of three-quarters of a page to two and a half pages in length. The intention is to provide a forum for recording observations of scientific or management value that may be too limited in scope to form the basis of a full scientific paper in a quality journal (such as Coral Reefs). It is especially intended that this section provide a useful vehicle for young scientists or those whose first language is not English. Nevertheless submissions must be based on adequate data and appropriate analysis.

For any of the above type of article no standardised division into sections is required; rather authors can propose section headings as best suited to their material. Similarly abstracts will not be used. However articles should be properly referenced, with typically 3 -12 publications cited in a reference section at the end. All types of article will be subject to refereeing by one or more suitably experienced referees.

Style and Format

Contributions should be clearly written and divided into paragraphs in a logical manner. They should normally be in English, but editorial policy is to accept one article per issue written in French or Spanish, but with an abstract in English.

Pages are set with margins as follows: Top 1 cm; Bottom 1.5 cm; Sides 1.3 cm
Reef Currents articles are set as a single column across the page. Reef Perspectives and Reef Edge (and also Reef News) items are set as double columns with the gap between columns = 1 cm
The standard font is: Calibri size 11, with section headings in Calibri 11 Bold. Sub-headings are also in Calibri 11 bold, but set into the beginning of the paragraph.
References are in Calibri font size 10, and footnotes in Calibri font size 8.

Paragraph settings are: line spacing = single with a 10 pt line space after a return or at the end of a paragraph, but no additional line spacing before. There is no indentation on either side, except when lists or bullet points are inserted.

Figures & Pictures should have a resolution of at least 350 dpi and be of a size suitable to the format. Each should have an explanatory caption either below or alongside it. Captions should be reasonably full, but not too long. Leave a single line between a figure and a caption below it. Use "Fig." (i.e. abbreviated) in the text, but "Figure" (e.g. Figure 1) to start a caption

Tables may be single column or page width, but large tables are not normally being suitable for publication in Reef Encounter. Each should have an explanatory caption either below or alongside it. Leave a single line between a table and a caption below it.

References

The style of References follows that used by Coral Reefs with no points or stops after initials or abbreviations, but with parentheses / brackets around dates, e.g. for journal papers and books:

Matsuura H, Sugimoto T, Nakai M, Tsuji S (1997) Oceanographic conditions near the spawning ground of southern bluefin tuna; northeastern Indian Ocean. J Oceanogr 53: 421-433

Klimley AP, Anderson SD (1996) Residency patterns of white sharks at the South Farallon Islands, California. In: Klimley AP & Ainley DG (eds) Great white sharks: ecology and behaviour. Academic Press, San Diego, pp. 365–374

Each reference should have a hanging first line with subsequent lines indented by 0.5 cm. A full list of abbreviations can be found and downloaded from the Springer website at http://www.springer.com/life+sciences/ecology/journal/338