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REEF ENCOUNTER



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REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
ISRS Information



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 has been 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).

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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.

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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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CONTENTS

SOCIETY OFFICERS, COUNCIL MEMBERS AND JOURNAL EDITORS	2
CONTENTS	3
EDITORIAL	4
PRESIDENT'S MESSAGE	5
SOCIETY ANNOUNCEMENTS	6
OTHER ANNOUNCEMENTS	6
REEF NEWS	10
REEF PERSPECTIVES	
Addressing the Decline of Coral Reefs. Peter Sale	15
REEF CURRENTS	
Nostalgia of the Nikonos. Walt Jaap	18
Keeping it Visual – visual decision tool for coral identification. Russell Kelley	23
NOAA Coral Reef Watch's Next generation. Gang Liu and others	27
Will 2014-2015 be the Next Big El Nino. Mark Eakin and others	30
Reefs Form Friendship Groups. Christopher Thomas	37
Tubbataha Reef Natural Park. Alan White and Sue Wells	41
REEF EDGE	
Soapfish in Hawaii. John Randall and others	45
Reef Connectivity in the Coral Triangle. Diana Thompson and others	46
BOOK AND PRODUCT REVIEWS	
Biology of Reefs & Reef Organisms. Walter M Goldberg	52
Marine Conservation. Carleton and Jerry Ray	53
Indo-Pacific Coral Finder. Russell Kelley	56
REEF SHELF	
Reef Rehabilitation Manual. Alasdair Edwards	58
Farming and Outplanting Corals. M Omori and K Iwao	59
CONFERENCE REPORTS	
Third Asia-Pacific Coral Reef Symposium	60
PROGRAMME OVERVIEWS	
Green Fins	62
CORRESPONDENCE	64
REEF DEPARTURES	
Ivan Miles Goodbody	65
Richard W Grigg	66
Gerard M Wellington	67
ISRS MEMBERSHIP	70
NOTES FOR CONTRIBUTORS	70

COVER PICTURE: **Two Divers on an Indonesian Reef** using the CoralFinder Coral ID Tool (See article by Russell Kelley in the Reef Currents Section, page 23). Photo by Jurgen Freund.



EDITORIAL

Thanks for the Feedback!

Having somehow found myself in the unlooked for role of editor-in-chief of the re-launched Reef Encounter, it was a big relief to receive, after the last issue was made available, so many messages welcoming the return of the society's newsletter / magazine in its new format, and commenting favourably on the content. Thanks to all those who contacted me. As gratifying has been the interest of members in the new style publication, as evidenced by the increased number of articles and reports that have been submitted for inclusion in this current edition. As a result this is something of a "bumper" issue!



Among other contributions, we have had a good number of news items submitted, and if, as we hope, we receive sufficient contributions to move to publishing three times a year during 2015, then the news will obviously be that much more topical and up-to-date. The task of keeping the news section pertinent will be eased by Sue Wells, long-time previous editor of Reef Encounter, agreeing to oversee this section. Likewise the other section editors have taken on an increasing amount of the editing and reviewing of their respective sections, which has made the task of generating this latest issue, more manageable. I am very grateful to them all.

We have had various suggestions for adding (or removing!) various sections. We are happy to try out new ideas, though obviously a balance needs to be struck between having enough sections that the publication is easy to navigate, and so many that it becomes confusing. In any case our policy is to consider a wide variety of material, so long as it is of potential interest to members. Please don't be put off sending in material just because you are not sure which would be the appropriate section. We are happy to advise and adapt as necessary.

Finally, may I again stress that we hope Reef Encounter will be of value to ALL members, both as a source of information, and as an outlet for their news and views. Contributions from younger researchers and those in less developed countries are as welcome as those from prestigious laboratories in more developed locations.

Rupert Ormond

Corresponding Secretary ISRS & Editor Reef Encounter
Honorary Professor Heriot-Watt University, Edinburgh, UK
Research Professor, King Abdul-Aziz University, Jeddah, Saudi Arabia



PRESIDENT'S MESSAGE

Dear Friends and Colleagues,

This publication of the 2nd “new and improved” online issue of Reef Encounter is another indicator of the Society’s successful efforts to improve communications and streamline our operations to be timely and financially sustainable. A big “thank you” to Rupert Ormond for his continued efforts as editor-in-chief of Reef Encounter and to Kiho Kim for the additional improvements to the ISRS website. I am also delighted to announce that, due to our ongoing reorganization efforts, and Don Potts’ financial acumen, there will be two student fellowships available to applicants this year (see details in this issue and on-line). We plan, with additional support, to add extra scholarships next year. Our relatively new committee structure is also growing, with noticeably solid progress. In particular, a sub-committee under the leadership of Andrea Grottoli, has developed an expanded system of honors and awards. This system has now been approved by the ISRS Council and will, we hope, both recognize and encourage outstanding contributions to coral reef research. Our experience of seeing through these improvements suggests that now would also be a good time to review our constitution and address new efficiencies (such as on-line conference calls) made possible by the internet. Please contact me if you have the time, willingness and expertise to help in this key aspect of the Society’s operations.



Meanwhile planning is well underway for the 13th International Coral Reef Symposium, which will be held in Honolulu, Hawaii, June 19-24th 2016. I will be sending out a call for volunteers to chair key committees in the near future, so please give some thought to your willingness to contribute to this important effort. Based on feedback from the ISRS Officers, Councilors and members, a focus of the ICRS will be on bridging science to policy. While our combined knowledge on the structure and function of coral reefs continues to grow exponentially, these magnificent ecosystems continue to decline globally, indicating a disconnect between science and policy. I recently met with a number of leaders at the Pacific Islands Forum meeting in Palau, and they expressed a great deal of interest in having a leadership summit as part of the Symposium to strengthen partnerships between the scientific and policy making communities. This would seem a logical follow up to the successful Climate Change Consensus effort that took place at the 12th ICERS in Cairns.

Both Vice-President Caroline Rogers and I will complete our terms in office at the end of December, and we still have a list of tasks we hope to accomplish before handing off to the new officers. With that in mind, please carefully consider nominating individuals you feel would be good candidates to lead the Society through the next four years. A formal call for nominations will be sent out at the beginning of October.

With best wishes,

Bob

Robert Richmond
President, International Society for Reef Studies
Professor, University of Hawai'i at Manoa, Hawaii, USA



SOCIETY ANNOUNCEMENTS

Society Elections

Elections are due by the end of the year for three officers' positions and also for half of the membership of the society's Council. The officers completing their term are Robert Richmond (President), Caroline Rogers (Vice President) and Rupert Ormond (Corresponding Secretary). According to the society's constitution the President's post is to be held for one term only, and hence Bob is not eligible for re-election. Nominations are thus sought at this time for the post of President of the Society.

The Vice President and Corresponding Secretary are eligible to stand for a second term, but other candidates for encouraged and accordingly nominations for these posts are also welcome.

In addition nominations are sought for up to seven members of Council. Under the society's bylaws council members serve for a period of four years. Council members may not be immediately re-elected to the Council, but may stand again after an interval of two years. The Council members completing their term are: Allen Chen, Orla Doherty, Nick Graham, Alastair Harborne, Saki Hari, Nicolas Pascal and John Ware. In addition Alasdair Edwards has asked to stand down early because of other commitments.

Nominations for the posts of President, Vice-President, and Corresponding Secretary should be sent by **Monday 3rd November** by email to the current corresponding secretary (rupert.ormond.mci@gmail.com). Nomination as a candidate may be made either by the candidate themselves or by a separate proposer. In either case the nomination should take the form of a short **Letter of Nomination** that is signed by a) proposer, b) seconder, and c) the candidate him/herself, all of whom must be paid up members of the society. In addition each nomination should be accompanied by a short (approximately half-page) **Personal Statement** in which the candidate summarises their qualifications for the post and outlines any intentions they may have concerning the post, if elected. The letter of nomination may be most conveniently submitted as a scan of the signed letter, the personal statement as a Word or pdf file.

Nominations for ordinary membership of the Council should likewise be submitted to the current corresponding secretary by **Monday 3rd November**, and likewise consist of a **Letter of Nomination** and a **Personal Statement**. Elections (if required) will take place during December, and new officers and council members take up their roles in the new year.

Society Awards and 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:

1. **The Darwin Medal** – the Society's premier honor, awarded only once every 4 years to an eminent, late-career scientist.
2. **Honorary Membership** – awarded for life and held by a maximum of 10 individuals at any one time.
3. **The Best Paper Award** – awarded one per year for the scientific paper considered to be the best published in Coral Reefs during any one year.
4. **A Graduate Fellowships in Reef Conservation** – a small research grant awarded competitively each year to a graduate student.

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Society Announcements



Over April to June this 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 measures include the establishment of ISRS Fellows, and also an award to recognise achievement by under-represented groups. The award system has been designed to be comparable to the recognition systems of other similar scientific societies (e.g. Association for the Sciences of Limnology and Oceanography, American Geological Society, Geochemical Society, British Ecological Society, etc.).

The Society's officers and Council concluded that a system of awards and recognitions is important, not only as a means of acknowledging the work of members within ISRS, but also to provide stepping stones for members towards the achievement of wider recognition at national and international levels. The identification of quality within or by the Society should also enhance the standing of the Society and strengthen its voice. To ensure that the nomination and selection process is transparent and the awardees fully recognised, nomination information and the list of past awardees will be posted on the ISRS website, as well as published in the Society's newsletter / news journal Reef Encounter.

In addition to the four existing honors and prizes, five new awards have been established, available to full members:

1. A **Young Scientist Award** – one awarded each year to a scientist under the age of 35, in recognition of a publication or series of publications.
2. A **Mid-Career Scientist Award** – one awarded each year in recognition of excellence in research during the preceding approximately 10 years by a mid-career scientist.
3. An **Eminence in Research Award** – up to two awarded per year to an established scientist in recognition of an outstanding body of research over an extended period of time. (The award is seen as being second in status to the Darwin award of which only one is awarded every 4 years.)
4. **ISRS Fellow** – the status of ISRS Fellow being awarded to a member in recognition of scientific achievement and / or service to reef conservation or management and / or service to ISRS over a significant period of time. Up to 15% of full members may be recognised as Fellows as a result of a competitive application / nomination process.
5. **The World Reef Award** – one awarded per year 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.

Two further awards, officially recognised and promoted by ISRS, will be available to student members. At each International Coral Reef Symposium, or other Conference sponsored by ISRS, there will be awarded i) A **Best Poster Award**, and ii) A **Best Presentation Award**.

Details of all the above awards, including how to nominate another member (or yourself) for consideration are now available on the relevant pages of the society's website (www.coralreefs.org). Nominations for the 2015 round of the five new awards and honors listed immediately above, and also for the two graduate fellowships, should be submitted to the society's corresponding secretary by December 31st 2014. Successful candidates will be selected and announced in the new year.



GENERAL ANNOUNCEMENTS

2nd International Mesophotic Workshop, Eilat (October 26th-31st, 2014)

The 2nd International Mesophotic workshop will be held in Eilat, Israel, October 26th-31st, 2014, and will be organized by Tel-Aviv University and the Interuniversity Institute for Marine Sciences in Eilat (IUI). We would like to encourage researchers and students which are interested in the mesophotic reefs ecosystems to participate. This workshop has an interdisciplinary focus, welcoming people with backgrounds ranging from ecology, biology, oceanography, molecular studies, social sciences and underwater technology, and will provide excellent opportunities to gain insight into the latest mesophotic research. For more details have a look at the workshop website: <http://www.mceisrael.com>.

We look forward to seeing you in Eilat!

Yossi Loya and Gal Eyal

Field Course in Coral Reef Ecology - Tropical Conservation Consortium (Bocas del Toro, Panama, September 2nd-22nd 2014 and December 16th 2014 - January 3rd 2015)

The Tropical Conservation Consortium (TCC) is offering two field courses this coming September (2nd-22nd) and December/January (Dec 16th-Jan 3rd) in Bocas del Toro, Panama. This intensive 3-week course is designed to build advanced understanding of coral reef ecosystems and offer practical experience in marine ecology field research. Learning outcomes include comprehension of marine ecology; knowledge of Caribbean taxa and their ecology; scientific criticism; development, implementation, analysis, and presentation of an independent research project; beginning scientific diving; and practical field skills. Content presented through lecture is paired with field activities to reinforce concepts and ideas. University credit can be obtained for this course through your home institution. For more information, please visit the course webpage: <http://tropicalcc.org/fieldcourses>, or contact TCC: info@tropicalcc.org

Láís Chaves

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
General Announcements



Reef Conservation UK Meeting, London Zoo, London, 6th December 2014

The annual UK Reef Conservation meeting (RCUK) will be held on 6th December 2014 at the Zoological Society of London (see <http://www.zsl.org/conservation/whats-on/reef-conservation-uk-2014>). This one day meeting will continue to highlight the need for multidisciplinary studies of coral reefs and adjacent environments, as linked to the RCUK themes of conservation, management and education. RCUK meetings provide an excellent opportunity to meet fellow reef workers and enthusiasts to discuss ideas and activities on an informal basis. While the meetings are principally attended by UK reef scientists and conservationists, colleagues from elsewhere are very welcome to attend. Abstracts of proposed talks and posters should be submitted on-line by Friday October 3rd, and registration is required (also on-line) by Friday November 21st. The registration fee is £35 (£30 for students).

Rebecca Short



REEF NEWS

Update on the Convention on Biological Diversity's work on coral reefs and closely associated ecosystems

In 1998, at its fourth meeting, the Conference of the Parties (COP) of the Convention on Biological Diversity (CBD) drew attention to the severe and widespread coral bleaching episode that took place that year. Subsequently, a specific work plan on coral bleaching was incorporated into the CBD's programme of work on marine and coastal biodiversity. The work plan stressed the need for further actions in relation to: 1. management actions and strategies to support reef resilience, rehabilitation and recovery; 2. information gathering; 3. capacity-building; 4. policy development / implementation; and 5. financing.

In June of this year, the CBD's Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) held its 18th meeting in Montreal and discussed actions needed to improve the resilience of coral reefs and closely associated ecosystems (e.g. mangroves and seagrass beds), based on a review¹ of the latest scientific understanding and management of coral reefs. The review focussed on four main areas:

- (a) Understanding of the vulnerability of corals to multiple stressors;
- (b) Proactive planning for climate risks and associated secondary effects, applying ecosystem-based adaptation measures;
- (c) Management of coral reefs as socio-ecological systems undergoing change due in many cases to climate change, and;
- (d) Formulation of adaptation strategies to enhance the resilience of ecosystems to enable the continued provision of goods and services.

Based on these discussions, the Subsidiary Body recommended that the CBD Conference of the Parties

¹ Background Document on Achieving Aichi Biodiversity Target 10 for Coral Reefs and Closely Associated Ecosystems: <http://www.cbd.int/doc/meetings/sbstta/sbstta-18/information/sbstta-18-inf-07-rev1-en.pdf>.

adopt a series of priority actions² to increase the resilience of tropical and sub-tropical coastal socio-ecological systems to the impacts of climate change and ocean acidification. The priority actions include:

- reducing the impacts of the main local stressors on coral reefs (e.g. unsustainable fishing and pollution),
- improving the adaptive capacity of socio-ecological systems,
- addressing multiple stressors on coral reefs through improved management and coordination, and
- facilitating education, awareness and capacity building, sustainable financing and research and monitoring.

The actions, with further details, are to be included as an addendum to the CBD's work plan on coral bleaching, and will be discussed at the forthcoming 12th meeting of the CBD Conference of the Parties (COP 12) in Pyeongchang, Republic of Korea. If adopted, these priority actions will support the efforts of CBD Parties in taking measures to improve the resilience of corals reefs and closely associated ecosystems.

Simon Harding (simonharding@yahoo.com)

ARC Centre of Excellence for Coral Reef Studies – New Funding

The Australian Research Council (ARC) recently funded the ARC Centre of Excellence for Coral Reef Studies for a further seven years (2014 - 2020). The Centre, led by Terry Hughes, is developing new research programmes which, while building on our traditional strengths in biological science, will increasingly focus on the human dimensions of shifts in coral reef ecosystems. The Centre's three new research programs - 1. People and ecosystems, 2. Ecosystem dynamics, and 3. Responding to a changing world - seek to address this challenge.

² Annex of: <http://www.cbd.int/doc/meetings/sbstta/sbstta-18/in-session/sbstta-18-L-07-en.pdf>.

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef News



Terry Hughes, Centre Director, welcoming delegates to the Centre's 2014 symposium "The Future of Coral Reefs" that launched the re-funded Centre of Excellence (2014-2020) Photo by Mauro Lepore, ARC Centre of Excellence.

The Centre currently supports the research activities of 45 postdoctoral fellows and >200 PhD students, and undertakes fieldwork in 25 countries. We will shortly begin a new round of recruitment of graduate students and research fellows. Applicants can access the positions as they become available over the next 1-2 months under "about us" at www.coralcoe.org.au.

If you are a potential PhD student, then the research interests of many of our researchers are detailed under the sub-heading of chief and partner investigators below personnel on the web site. Further information is obtainable from Jenny Lappin (jennifer.lappin@jcu.edu.au) or David Yellowlees (david.yellowlees@jcu.edu.au).

The Great Barrier Reef, Australia – Approaching the List of World Heritage in Danger

The World Heritage Committee meeting in Doha (Qatar) on 18 June 2014 deferred for 12 months a decision on whether to inscribe Australia's Great Barrier Reef on the List of World Heritage in Danger. The Great Barrier Reef (GBR) was inscribed on the World Heritage List in 1981.

The Committee's concerns over the site relate to planned coastal developments, including development of ports and liquefied natural gas facilities. As part of its decision the committee approved recommendations from UNESCO that "concern" and "regret" be expressed about the federal government's

approval of dredging and dumping of 3 million cubic metres of sludge in the reef's waters as part of the development of new coal ports at Abbot Point, north of Bowen. It has asked Australia to submit an updated report on the state of conservation of the site by 1st February 2015 (<http://whc.unesco.org/en/news-1149>).

As Terry Hughes reported in *Coral-List Digest, Vol 71, Issue 13*, coal mining and coal seam gas extraction in Queensland are expanding rapidly. The Federal government and the State of Queensland earn billions of dollars in royalties from mining and are now fast-tracking new mega-coal mines and the largest coal and gas ports in the world, claiming that the dredging and dredge spoil dumping will cause no significant damage to the environment. A further concern is that on 16th July 2014, Australia became the first country to repeal legislation that curbs CO₂ emissions. However, two studies from James Cook University have shown that dredging is a major threat to marine ecosystems, including coral reefs.



Greenpeace Campaign on the impact of the planned coal port dredging and dumping activities. Photo credit: Dean Miller / Greenpeace / AAP.

Pollock *et al.* (2014) showed that dredging-associated sedimentation and turbidity dramatically increase coral disease levels on nearby reefs. Essentially, corals get sick more often when they are stressed by reduced light levels and sedimentation (see also <https://theconversation.com/dredge-spoil-linked-to-coral-disease-wa-study-shows-29265>). A separate study by Burns (2014) examined the dispersal of fine coal particles, and showed that hydrocarbons from coal have already dispersed across the width of the GBR, and are approaching international benchmarks for toxicity of the polycyclic aromatic hydrocarbons

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef News



(PAHs) in the coal on the benthos. Together these benchmark studies prove that dredging and release of fine coal particles at ports are a major threat to the Great Barrier Reef.

The decision to choose and permit the most damaging option to the Great Barrier Reef of those available, that is to expand the Abbot coal port, has been widely criticized. Options such as (1) long jetties with no dredging needed or (2) dredging but with the dredge spoil placed behind a containment wall (bund), were rejected in favour of dumping the dredge spoil offshore in the Marine Park. The Great Barrier Reef Marine Park Authority and Federal Government delegates permitted this poor outcome against the best advice of its technical assessment staff. Furthermore this flawed process was only uncovered via freedom of information requests, rather than through any form of transparent decision making regime.

The most recent information suggests that land-based disposal of dredge spoil is now being considered by the developer, but the issue is still far from resolved. The UK national newspaper, *The Guardian*, has been covering the developing issue in some detail (<http://www.theguardian.com/environment/great-barrier-reef>).

Pollock FJ, Lamb JB, Field SN, Heron SF, Schaffelke B, Shedrawi G, Bourne DG, Willis BL (2014) Sediment and turbidity associated with offshore dredging increase coral disease prevalence on nearby reefs. *PLoS ONE* 9(7): e102498. doi:10.1371/journal.pone.0102498 (<http://dx.plos.org/10.1371/journal.pone.0102498>)

Burns KA (2014) PAHs in the Great Barrier Reef Lagoon reach potentially toxic levels from coal port activities. *Estuarine, Coastal and Shelf Science* 144:39-45. <http://dx.doi.org/10.1016/j.ecss.2014.04.001>

This news item was compiled by Sue Wells from information obtained from news sources, with input from Terry Hughes and Jon Brodie.

Centre Scientifique de Monaco moves to the Harbour - 20 tonnes of seawater on a roof!

The Centre Scientifique de Monaco (CSM) has moved from the Oceanographic Museum, where it was based for over 50 years, to large new laboratories which have

been specially designed for the Centre's research. Overlooking Monaco harbour, the new CSM labs are built on the terrace of an existing building that hosts the United Nations IAEA environmental laboratories and also artists' studios. Covering an area of about 2300 m², the labs are home to a broad range of environmental research activities (coral biology, environmental economics and polar biology) as well as a new department of medical biology, dedicated to cancer research and gene therapy.

The CSM also hosts large culture facilities for tropical, deep-sea and temperate corals and gorgonians. Since 1990, CSM has cultured and propagated more than 50 coral species for its experimental needs, including *Stylophora pistillata*, which has become the "coral lab rat" for many research teams. Tropical coral species (mother colonies and nubbins) are maintained in an aquarium room containing five large 10,000 litre aquariums, and temperate and deep-sea coral species are kept in two other rooms supplied with cold water (5000 liters). There are also five experimental rooms containing 78 thirty-litre aquariums, allowing testing of the effects of various environmental parameters on coral biology. All aquariums are equipped with sensors for pH, temperature and oxygen, as well as running seawater (about 10m³/h) obtained from in front of the Oceanographic Museum at 50 meters depth. After circulating through the aquaria, the seawater is UV sterilized and returned to the sea. The sensors are connected to a central alarm, signaling problems in the regulation, and are remotely monitored via the web. In total, the aquariums hold more than 20 tonnes of seawater on the top floor of the building!



The new laboratory (red box) located above the harbor of Monaco, close to the old town of Monaco and the Prince Palace fortification. Pictures from Éric Tambutté © CSM

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef News



French President François Hollande and HSH Prince Albert II with Prof Denis Allemand during a visit of the aquarium facilities of the CSM. Picture by Palais de Monaco ©.

The new laboratories were inaugurated last October by HSH Prince Albert II of Monaco. The French President, François Hollande, visited the labs at the end of 2013 during an official visit to the Principality. For more information, please see: www.centre-scientifique.mc



The new aquarium facilities at the Centre Scientifique de Monaco. Picture from Éric Tambutté © CSM

Update on the *Atoll Research Bulletin*

The *Atoll Research Bulletin (ARB)*, founded in 1951, is a long-standing Smithsonian Institution (SI) publication which has traditionally provided an outlet for information on the biota of tropical islands and reefs, and the physical environments (land and water) that support the biology of these regions worldwide. The *ARB* accepts not only traditional experimental scientific studies, but also treatises on flora and fauna, surveys of land and water quality, and observations on geology and ecology and related processes. The *ARB*, for many years under the Editorship of Dr. Ian Macintyre, is now under the sponsorship of Smithsonian Institution Scholarly Press (SISP) as a no-cost e-publication, with individual articles appearing on an ongoing basis.

In order to promote a stronger link with the ISRS, SI invites members to consider the *ARB* for publication of tropical marine studies covering topics described above. We are also looking for reviewers across all subject areas. The new publication portal is OpenSI (<http://opensi.si.edu/index.php/smithsonian>) which offers links to several series of SI publications, including the *ARB*, for perusal and downloading, paper submission and reviewer tools. New users should register to use the portal to submit and review articles.

The newest issues of the *ARB* are available for download on OpenSI, while archived issues are still available at <http://www.sil.si.edu/digitalcollections/atollresearchbulletin/>. These databases will eventually be combined. Please email ArbEditor@si.edu with any questions. We welcome contributions to this vast and valuable resource, and look forward to expanding the scope of studies made freely available to tropical-island and marine scientists worldwide.

**Marguerite A. Toscano, Associate Editor,
*Atoll Research Bulletin***

The Coral Triangle Initiative on Coral Reefs, Fisheries & Food Security (CTI-CFF)

The World Coral Reef Conference, organised by the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF), was held in Manado, Indonesia in May 2014, five-years after the launch of the CTI-CFF Regional Plan of Action. The aim was to showcase the accomplishments of the CTI-CFF since its

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef News



inception in 2009 and to launch the Coral Triangle MPA System (CTMPAS) Framework and Action plan.

Six countries – Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor-Leste - came together in 2007 to form a multilateral partnership to safeguard the marine and coastal resources of the Coral Triangle region. The landmark initiative is now known as the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF). Under the CTI-CFF, the Coral Triangle countries adopted a Regional Plan of Action with five goals: 1) strengthening management of seascapes; 2) application of ecosystem approach to fisheries management; 3) developing and strengthening the management of marine protected areas (MPAs); 4) implementing climate change adaptation measures; and 5) protecting threatened marine species.

The Coral Triangle MPA System (CTMPAS) Framework and Action plan, endorsed in 2012 by the six CTI countries, is a key achievement under Goal 3. It contains the criteria for MPA management effectiveness as endorsed by the six CTI countries and guides the development of the MPA system. It encourages countries to improve their management effectiveness and contribution to food security through the categorization of MPAs in one of four levels. The World Coral Reef Conference provided an opportunity to officially launch the CTMPAS Framework and Action Plan, to highlight “Flagship” and “Priority Development” MPA sites nominated by each CTI country, and for participants to share information about their respective institutions and home countries.

Alan White, Senior Scientist and Coral Reef Triangle Programme Manager, The Nature Conservancy

Charlie Veron: 2014 AAUS Scientific Diving Lifetime Achievement Award



Charlie Veron

The 2014 Scientific Diving Lifetime Achievement Award has been bestowed upon J.E.N. ("Charlie") Veron. Charlie is reported to have studied coral reefs during over 7,000 hours on scuba on 67 expeditions to 128 ecoregions. He is described as making it possible for the rest of us to undertake field work on corals through the publication (with his wife Mary Stafford-Smith) of his a 3-volume (1382-page) book *Corals of the World*, that provides colour photos, distribution maps and descriptions of 794 species of reef building corals. The AAUS Newsletter also mentions that he has described over a hundred new species of corals, and is currently preparing a website that will make this taxonomic information more widely available. It is also mentioned how his experience gave him insight into the nature of species among corals, leading to the concept of "reticulate" evolution, as explained in his book "Corals in Time and Space". More details of the award can be found at www.aaus.org/2014_sdla.

Abstracted from the AAUS Newsletter

REEF SIGHTS

“International meetings continue to argue over the evidence for sea-level rise” ?

With apologies to the Cancun Underwater Museum, also known as MUSA, which hosts an underwater collection of statues (visible behind) by the British sculptor Jason deCaires-Taylor. The picture shows a board meeting of MUSA held underwater on site .





REEF PERSPECTIVES

Personal comment on reef science, policy and management

ADDRESSING THE DECLINE OF CORAL REEFS

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Humanity faces a challenge which if not existential certainly threatens our civilization, and, as Pogo found out long ago, the enemy is us. Our varied impacts on the biosphere grow larger as our population and our standards of living grow, and now we are numerous enough and powerful enough to be causing serious damage. Coral reef scientists are generally well aware of the seriousness of our situation – our special parts of the biosphere are among the most, if not *the most*, impacted on the planet and suggestions that coral reefs as we knew them in the mid-20th century could be largely gone by mid-21st century are not far-fetched conjecture but reasoned assessments by scientists who look at the evidence of reef decline. So, what can be done for reefs, and for the wider biosphere and ourselves, and what role should reef scientists and managers play? Here are four steps we need to take to stem the decline of coral reefs.

I suggest we first need to recognize the problem. It is global. It is multifaceted. The facets differ in degree of importance from place to place. And our assessment of the problem involves value judgements – we are inadvertently forcing on the biosphere changes that we do not like, or that we suspect will be harmful to our personal quality of life or our economy. These statements are true even if we restrict attention to coral reef systems: Reefs appear to be in decline almost everywhere, with less abundant and less healthy coral, fewer fish and other reef organisms, less biodiversity, and we suspect, less ecological resilience. But the reasons for this decline vary. Loss of coral cover on the GBR in recent decades has been due primarily to physical damage from tropical storms, outbreaks of Crown-of-Thorns starfish, and bleaching due to climate change (De'ath et al 2012). Loss of coral cover in the Caribbean over the same time period has been due principally to outbreaks of diseases, overfishing, and excessive rates of coastal tourism

(Jackson et al 2014). The diseases in turn, principally of corals and *Diadema* sea urchins, may be cases of human-aided introduction of pathogens from outside the region, may be facilitated by pollution, warming or overfishing, and might even be spread by snorkeling tourists. Within both regions there are places where reef condition has degraded substantially in recent decades and places where it has degraded less. Rates of decline vary through time, and differently among locations. Data for other parts of the world are less comprehensive but the variation in degree and putative cause is also evident in these other places.

Every one of the causes I've mentioned, including Crown-of-Thorns outbreaks (Brodie et al 2005), is directly due to or exacerbated by human activities. And, as a general rule, more remote locations, such as Kingman Reef (Sandin et al 2008), seem generally to be in better overall condition than those close to people, because most of the causes of decline are due to local human activity. Of course, we can anticipate that climate change and ocean acidification are going to become ever more important as causes of reef decline, meaning that in time the overall mix of causes of reef decline will be less easily remedied by local actions than they are at present.

It should be obvious that there is no one action that can be taken to 'repair' all coral reefs, but it may be less obvious that solving one problem at a time at a location may not lead to any improvement in reef condition until most or all problems are addressed. Reef decline is multifaceted and the facets likely interact in complex ways.

If the first step is to recognize the nature of the problem, the second step is to recognize that we do have feasible solutions for many of its facets. This is the good news which may not be getting through to the public. We have known for a long time what is

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Perspectives: Decline of Coral Reefs



needed to correct overfishing, how to avoid delivery of pollutants from on-shore activities and population centers, and how to manage coastal development in ways that do not impact adjacent reefs negatively. We understand what we have to do to control climate change and limit ocean acidification although these solutions are much more difficult to put in place. We understand which facets are capable of being corrected by the creation of marine protected areas, and which facets an MPA cannot affect. Mostly, the fixes needed are not even particularly challenging technically.

Recognizing that we do have solutions leads immediately to the third step -- to acknowledge that, although we have solutions, we have not been applying them effectively. In fact, over many years, we have been woefully ineffective in solving the problems that are leading to reef decline, and it is well past time to replace the wasted efforts under way with more effective action.

Why have attempts to address reef decline been so ineffective, and why do we avoid talking about this? I suggest that the reasons for failure, while diverse, stem from a core feature of environmental management – it is not really management of environment but management of people; living, breathing people with families, societies, cultures, religious beliefs, traditions, stubbornness, dishonesty, corruption, short-term thinking, mortgages, and many things on their minds beyond improving coral reefs. Some live near reefs, feed their families from fish caught there, earn a living in reef tourism, work in NGOs or government agencies; others work at jobs quite unrelated to reef condition. Still others are government officials, international experts, well-meaning philanthropists or dedicated conservationists directly concerned with improving reef management. Making real changes in the lives of any of these people can be very difficult. Many of them ‘know’ that the ocean is limitless, or that God or Nature will always take care of us. Others do not want to see changes that reduce their incomes, influence, or importance. Some, working hard to bring change, fall into the social worker trap – if the problem is finally fixed their jobs risk coming to an end. Over time we have spent far too much time thinking about how to manage reefs, and not enough time thinking, and learning, about how to manage people.

Reasons for failing to talk about the prevalence of failure are more simple. Nobody wants to admit to failure, or to allow the possibility that they do not know how to fix the problem of overfishing, or pollution, or whatever. And we have convinced ourselves that telling the truth about the environmental crisis simply depresses people. Better to talk about the occasional good news stories when things happened to go right. Better still to pretend that the failures are in fact successes – how else to account for the evident pride with which governments, NGOs and other bodies proudly proclaim the number of km² protected in marine protected areas, or display the MPA management plans, legislation and regulations when everybody knows that in the great majority of MPAs no real protection is taking place? When one can snorkel through an MPA, and then through a nearby ‘unprotected’ site and see no evident difference in fish size or abundance (as is a very common experience across the Caribbean, and in other places as well), one knows that ‘no-take’ provisions are not enforced. When one sees mangroves along the Mayan Riviera being cleared right after a hurricane, ostensibly because, stripped of leaves, they are now ‘dead’, or hears of massive plans to dredge new harbors, risking nearby ‘protected’ reefs, because the Australian coal industry absolutely must export its products more quickly, or finds a lobster dinner not on the menu but still readily available out of season, so long as the request is made quietly at a table in a far corner of the Belize City restaurant, one knows that efforts to preserve or repair reefs are not working. Yet still we carry on, developing projects, raising funds, reporting numerous workshops and conferences designed to improve reef management, while consistently failing to create the real, and enduring, changes in human behavior that are essential for improvement to happen.

As a recent example of this tendency to gloss reality with a glitter of false good news, consider the latest report on the state of the Caribbean (Jackson et al 2014). A careful read of this IUCN report provides abundant data, careful analyses, and sad conclusions on what has been happening to Caribbean reefs. The science is well done. The authors do a generally responsible job of assessing competing hypotheses. They state, quite clearly that “the disparate reef histories clearly demonstrate the folly of attempting to understand the causes of coral reef decline for the entire Caribbean as a single ecosystem, an approach

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Perspectives: Decline of Coral Reefs



that ignores the enormous heterogeneity in environments and history of human and natural disturbance among different reef locations.” With a careful read, this is a solid report that assesses the data, points to the seriousness of current trends, and makes clear recommendations for action.

But with a skim of the Executive Summary (the only part also available in Spanish or French), or a look at IUCN’s press release (www.iucn.org/?16056/From-despair-to-repair-Dramatic-decline-of-Caribbean-coral-can-be-reversed), or at various stories in the media from local Caribbean newspapers to Time Magazine, a rather different story emerges. This one is far more about the value of protecting parrotfishes! Whether the authors intended it or not, a detailed, difficult, somewhat depressing tale, with sound recommendations (including the protection of parrotfishes), has been morphed by IUCN and the media into an upbeat story about a serious problem which can be fixed by taking care of parrotfishes. So much for the authors’ warning about the ‘folly’ of expecting a single, simple cause of coral decline across the Caribbean.

The fourth step, once we acknowledge our failures – we have to change our own behavior, reject failure and demand real success. Most current and past projects designed to improve reef management can be characterized as too small, too short-term, too narrowly focused on a single facet of reef decline, with far too little attention to the socio-political components of the problem, and with far too little investment in public education and the building of a broad consensus in support of the new management actions and regulations being introduced. The international development community has talked for years about the need for integrated reef management, a holistic perspective, projects designed at ecologically appropriate spatial and temporal scales, and with the building of community and governmental buy-in that is essential for success, but most projects fail at all of these challenges. One suggestion (Sale et al 2014) for breaking through this log-jam of failure is to recognize that it is now essential that we begin to zone the coastal ocean, much as we do land, in order to systematize and prioritize among competing uses. A greatly expanded use of marine spatial planning (MSP) provides an objective way of making such zoning decisions, but more importantly, if made central to a project, MSP would help jump-start the collaboration, effective cross-agency effort, setting of appropriate

spatial and temporal scales, use of a holistic perspective, building of consensus and demand for real results that are so often lacking.

Success still will not come if real, committed leadership does not exist, but given leadership, success has a much greater chance of appearing than if we continue our current failed approaches. I think we all have a moral obligation to join forces to recognize and articulate reality, admit to our pervasive failures, improve monitoring and experimental evaluation of competing causes of reef decline, and build management to reverse the decline of coral reefs. Reefs could be in much better condition if we acted more effectively than we have been, and better reefs mean better lives for millions of people.

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REEF CURRENTS

General articles and overviews of reef science and management

Nostalgia of the Nikonos™ and Other Fantasies

Walt Jaap

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Those of us with grey or missing hair are awestruck (some of the time) with the progress of digital camera technology. We can grab a camera, submerge, take hundreds of photos or video, surface, review the imagery, transfer it to a computer, crop and edit images, and away we go. This leads to great capabilities in sharing, manuscript preparation, and various analyses with just a few key strokes on the computer or other device. Girls and boys of the savvy generation - your seniors are recalling the good old days! After the dives when we took the film to the local processing lab, we were ecstatic if 50 percent of the photos (slides) were in focus and/or the exposure was not too dark or washed out. These were the thrilling (and frustrating) days of Nikonos 35-mm, underwater photography!

There were other options for a starving-striving coral reef researcher. The Rolleiflex, a twin-lens reflex, 120-mm film camera, was made famous by Hans Hass, who used it for documenting his multiple Red Sea expeditions (Hass 1956) in the late 1940s (one was for sale on E-bay in March 2014 with a housing, listed at US\$6,500).



Rolleiflex camera housing.

Nikonos (originally known as Calypso) was a 1958 invention of Jacques Cousteau and Jean de Wouters. Nikonos models included: I (1962 to 1968), II (1968 to 1975), III (1975 to 1980 - list price was about US\$300), IV-A (1980 to 1984), V (1984 - ceased manufacture in 2001). The V was the last of the classic Nikonos line. However, more recently Nikon offered the Nikonos RS, a big, expensive SLR film camera with auto focus, motor driven film advancement, automatic light metering, a five-pound fish eye lens, and many other features. The RS appeared at the dawn of digital camera technology (it was a short-term market phenomenon) and had significant flooding issues (DeCouet and Green, 1989). Nikonos are available on E bay; model II are listed from \$50.00 up for a camera advertised as working.

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Currents: Nikonos Nostalgia



Nikonos 1, 1963 *



Nikonos II, 1968



Nikonos III, 1975



Nikonos IVa, 1980



Nikonos RS*, 1992



Nikonos V, 1984 *

Nikonos Cameras – the full range

Alternatively Hasselblad (80-mm film) cameras were available with housings and took excellent photos (Faulkner and Chesher, 1979). The alternative was to go with an Ikelite or aluminum housing for a 35-mm SLR camera, a pricy, large package that dedicated the diver-photographer to the camera system. But most of us could not afford these systems, and they required two hands to carry and operate.

By contrast the Nikonos was light, compact, and relatively inexpensive, which made it popular with diving scientists. (So compact in fact that Rupert Ormond describes how in the Red Sea he usually carried his in his armpit, to protect it from knocks and free up hands for other gear.) Nikonos cameras were typically supplied with a 35-mm lens, but Nikon provided alternative Nikkor lenses ranging from 15 to 80 mm. There were also many screw-on and clip-on magnifying lenses, framers, and extension tubes, that were are useful for macro photography with the Nikonos.

Preparation was tedious but diligence would be rewarded; first install a roll of 35-mm film, clean and lubricate the O-rings, then, seal the camera. The I, II, and III models came in two pieces (three if you include the lens) and were jam-fit together. Lenses were bayonet style, twisted 180 degrees to seal them into the body. They had to be inserted after the other two parts were fitted together. (Disaster could ensue if a beginner forgot to remove the lens first, before trying to lever the camera apart to recover their film. The camera could easily be destroyed this way.) Thankfully the Nikonos IV-A and V no longer came in two parts but had hinged back doors to seal them.

The Nikonos IV-A and V also included auto exposure, whereas in the previous models speed, aperture and distance had to be set manually. Experience taught that setting the speed at 1/60 or 1/125 of a second, and the aperture at f/8 or f/11, would bring into focus a fish or coral that was less than 1.5 m from the camera. In case you were having a nostalgia moment there: the f-number = f/D , where f is the focal length and D is the aperture diameter. The larger the f number the smaller the aperture opening and the greater the depth of field in the photo (Lens physics 101). Judy Lang reports the strategy that she and her colleagues adopted at Discovery Bay Laboratory, Jamaica,

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Currents: Nikonos Nostalgia



before UW light meters were available: “since we were approximating f-stops and shutter speeds as a function of the ASA value of the film, how far the developer being employed could push its ASA beyond its posted value and the vagaries of ambient light penetration, we bracketed most shots by an f-stop above and below the presumed ideal. That gave us images of about 12 different subjects per roll and, each having one UW camera, we were pretty ecstatic if we got one good photo per dive.” She also described that at Discovery Bay they also bought black and white Tri X (ASA 400) in bulk and rolled their own cassettes. They then practiced alchemy in their dark room, by pushing the developing chemical formulas by as much as 1200 to 1600 times the recommended concentrations and times. (If you are unfamiliar with darkroom chemistry, how long the film is in the chemicals and the temperature is very critical to quality of the photos.)

Before underwater strobes were developed, we had the intense joy of using a flash gun and bulbs for artificial illumination. Flash bulbs were a true pain-in-the-you-know-what. We devised ways to take them underwater so they would not float away- since, containing air, they were lighter than water. Not only did such flashbulb-launch occur when you least expected it, but as they drifted upwards they were elusive to find and recover. Judy Lang tells how, on occasion, in Jamaica, escaped bulbs were devoured by hovering barracuda. If we put bulbs in a mesh bag, then we had to extract a bulb, twist it into the socket of the flash gun, figure out the lens f/stop setting based on guide numbers for the flash bulb and film speed, set the distance, find our photo target, hold the camera in one hand and flash gun in the other, pray that the flash bulb would work (many bulbs flooded when they went under the waves), and finally push the shutter lever. All this camera preparation quickly consumed air and bottom time. Flash bulbs were one-dive wonders; unused bulbs were discarded because once we surfaced, they corroded like crazy. On terra firma, strobes eventually replaced flashbulbs which then became like *T. rex*, found only in museums.

Crucial to the flash function, was a connector-socket on the bottom left of the Nikonos. If after each dive operation we did not unthread the flash connector, clean and dry it, and lubricate the threads, then electrolysis would fuse the connector to the camera body. If this happened, the chance of salvaging it was very poor.

Initially underwater strobes were terrestrial strobes installed in plastic housings as a result of which their low power output was unsatisfactory. Dedicated underwater strobes with improved wattage became available in the late 1970s. I recall paying a king’s ransom for a huge black thing that was heavy, bulky, and did not work most of the time. This particular brand was made in SE Florida; I took it to them after it blew up underwater (a big puff of smoke belched from the O-ring seal, and water rushed in). What a mess. The business was unimpressed with my problem. In their workshop, I could see flooded black strobes from floor to ceiling. The firm went bankrupt; they did not fix my strobe.

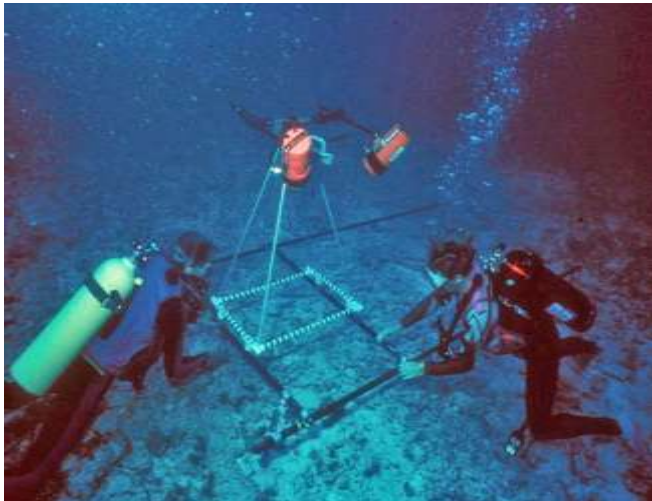
Nikon did offer a light meter (the Sekonic L-86 Auto-Lumi). We calibrated the meter based on film speed, sealed it in its housing (it had O-rings), and gained yet another widget to fuss over and worry that it would not flood. Find the fish, crab, urchin, or coral, aim the light meter at it, read the meter, set the f/stop and the distance, and press the shutter lever – lots of multi-tasking for the photographer.

Flash bulbs were one step ahead of William Longley’s technology used at Dry Tortugas. In 1917, Longley built a camera housing, donned a Miller helmet, and started to photograph fish. To get better colors for his photos he used a magnesium flare on a barge above the area where he was diving. They devised a signal to ignite the flare and press the shutter. Some of Longley’s photos appeared in National Geographic Magazine. The flare was a high-risk deal; Longley was burned in an accidental firing; so, if you try this trick, check your insurance first.

“If we used a very slow film (for example Kodacolor, ASA 25), you could forget taking photos using ambient light at any depth greater than a few meters!”

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Currents: Nikonos Nostalgia



A Nikonos camera stand for photogrammetry (Jaap et al. 1990). Many of us fabricated camera stands of stainless steel, aluminum and PVC for photogrammetric analysis (photo-quadrats).

The maximum number of photos for a camera on a dive was 36- more like 34. So, we either had several cameras or changed out film between dives. The ultimate Nikonos gizmo might be a system developed by Terry Done: two Nikonos cameras and strobes were mounted on an “L” frame. Cameras were aligned so that, when slides were displayed, side by side, they produced three-dimensional photogrammetric measurements of corals and other biota. –It was an impressive photographic contraption and the lab analytic gear also was awesome (Done, 1981). This system was an important tool for several of Terry’s and colleagues’ work on changes in Great Barrier Reef coral community structure (Done et al. 2007; Wakeford et al. 2008).



Two pictures of Terry Done’s twin Nikonos photogrammetric camera apparatus, circa 2005; Mary Wakeford, camera operator.

Nikonos I and II models were notorious for weak rewind mechanisms. Shafts and gears did not work very well; especially with a roll of 36-exposure film (the alternative was 24 exposure film). I recall taking a Nikonos with a broken rewind mechanism into the dark room, putting the camera in a black bag, opening it, removing the film, and fumbling around with a screw driver to rewind the film into the canister.

We were always fussing with O-rings to be sure the camera did not flood. If it did, the operation went to chaos mode. The I and II models’ good news was that if we dumped out the film and sea water, then flushed with fresh water, disassemble the major components, dried them with a hair dryer, and then reassembled, with luck it was back to work we went. The I, II, III models were all mechanical and not too difficult to fix. Model III had more delicate plastic parts and so, when it flooded, was a harder to fix in the field. But a flooded model IV-A or V was

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Currents: Nikonos Nostalgia



usually a total loss, though perhaps one could salvage the lens and replace the body. I recall that a firm in Texas sold flooded cameras as a conversation piece for your bar or coffee table.

It was a time that brings back many memories of fiddling with a Nikonos on a boat in a remote location, hoping it might be possible to get the thing to advance the film, rewind, not leak at the flash connector, and that I might just possibly get some decent photos of coral spawning. In my time with Nikonos, I flooded a few, but also claim some reasonable photos. Today, with a ten-megapixel digital camera and a large memory card, we can capture a huge number of photos. The other deal we like a lot is that we can dial-in auto-focus, auto-exposure settings and not have a care about aperture, exposure time, and distance; we had to pay close attention to these settings with the Nikonos. Digital photography is a spectacular tool for documenting the underwater world. These cameras are reliable and versatile, save us time and money, and greatly improve the quality and quantity of images that we can acquire in a single dive. Maintenance is simple –flush with water, dry, and stay vigilant with O-rings, but it is not a task that requires special skills. We love ‘em! I still have a Nikonos II, but it is just keepsake.

One of the benefits of using the Nikonos was that we learned the relationships of exposure speed (no, I don’t mean removing your swim suit in five seconds or less) and aperture settings = depth of field. But my epiphany-conversion to digital came during an expedition to the Florida Middle Grounds in 2003. I had a Nikonos RS with several lenses and was excited about getting some exceptional photos in this remote area. A colleague had a COOLPIX digital. After a few dives, it became evident that the digital was knocking the socks off the film camera: the number of images, the quality of the photos, and, they were viewable immediately. When crafting manuscripts, it is so easy to insert an image. In a recent project we captured 1,220 images with a digital camera. Using a Nikonos, that would have required 34 film changes and servicings of O- rings, not a joy to contemplate. Case closed.

For a ride down the memory lane, pick up a vintage underwater-photography manual (DeCouet and Green, 1989) and thumb through it to look at the cameras and gadgets that were cutting-edge technology a few decades past. You can even go to E bay and purchase these items to gather dust on your museum shelf.

Ah, Nostalgia!

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Keeping it Visual: Developing a Visual Decision Tool for Underwater Identification of Corals.

Russell Kelley³

Coral Hub & BYO Guides; email russellkelley@mac.com

*Writes the sea, the secret of her yearning in vast caves
Where yours will fall, the first of human feet.*

Robert Browning: Paracelsus, 1835

Problem! What Problem?

For years I have wanted to use this quote from Browning because, for me, it captures a sense of the “*emotion of the ocean*” - the force that draws so many people to explore the underwater realm. It also hints at something missing from our “dive culture” in general. Most divers, though highly trained in various skills, lack the tools they need to explore the ocean realm in an ecological meaningful way. Indeed many divers eventually get bored and drop out of the sport. In a report on the lifestyle and demographics of active divers in the U.S., Daniels and Roberts (2006) estimated a diver's half-life to be only 5 years. i.e. 50% of newly certified divers will stop diving by the end of the fifth year. Talk to any dive business owner and you will discover that “diver drop out” is a major concern for the dive industry.

Compared to the topside world, our “ocean literacy” is low. For example when I say “pine, palm, dog or frog” powerful mental images leap into the mind - everyday human experience preloads a taxonomy of the topside world to our “soft disk”. But when I say “feather star, whip, sea slug or moss animal,” for most people only a limited array of mental images come to mind. Despite this, the identification tools we apply to the marine realm are designed for an audience with a high level of assumed knowledge. Moreover, most of those tools can't be taken underwater where they are needed. During almost 10 years of working to train others in coral identification, I have found visually driven underwater tools allow a much broader audience to discover marine life and build the skills they need to understand the ocean realm. This is important because being able to assign each variety of marine life a name is for most people a key first step in understanding and appreciating coral reefs.

The Eyes Have It!

Coral identification has a reputation for being hard. Corals are shape shifters - they change their form between environments (Fig. 1). So to be competent at coral identification you need to be able to recognise coral species in



Figure 1. Shape shifters: Just some of the variation in form found within a single species, *Isopora palifera*

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Reef Currents: Developing Coral Finder



all their growth forms. With over 500 Indo-Pacific shallow water species to choose between the variation is more than anyone (or a very few!) can keep in their head. Added to this, the truth is that for most folk a lot of interesting science lies forever hidden behind misanthropic taxonomic keys. For most divers, dense text, especially technical latin-laced text, combined with a dichotomous key, is the natural predator of self-directed learning.

As a communication designer, I decided to tackle these roadblocks to coral identification by developing a tool with a visual navigation system that anyone could use. This led to the publication of the *Indo Pacific Coral Finder* (2009) (see www.byoguides.com) - a novel underwater tool that anyone with a good eye for detail can use to quickly identify corals at least to genus (see cover picture & Fig. 2). The Coral Finder is a tough plasticized underwater book designed to make learning the basics of coral taxonomy much easier. I used a largely visual navigation and decision making system that cross-references to Charlie Veron's epic 3 volume treatise *Corals of the World*.

How It Works.

You can follow how the guide works by reference to Figure 2. The user, swimming up to a coral, is asked to place it in a "Key Group". Key Groups refer to visually obvious morphological, textural or ecological cues. For example: Is it branching? Does it have meandering texture?? Does it have tentacles expanded during the day? The user is then required to answer a question about the corallite wall structure and to measure (using a scale on the side of the booklet) the size of the polyps. The responses send the user to a "Look-Alike" page showing the "top five" potential genera in a grid of wide-angle, mid-distance and close-up scaled images. The choice is visual and generally easy, provided the user checks for true scale, and confirms the presence of the key characters indicated. The Coral Finder does draw on a small number of technical terms, but these are defined in a visual glossary that is easy to master.

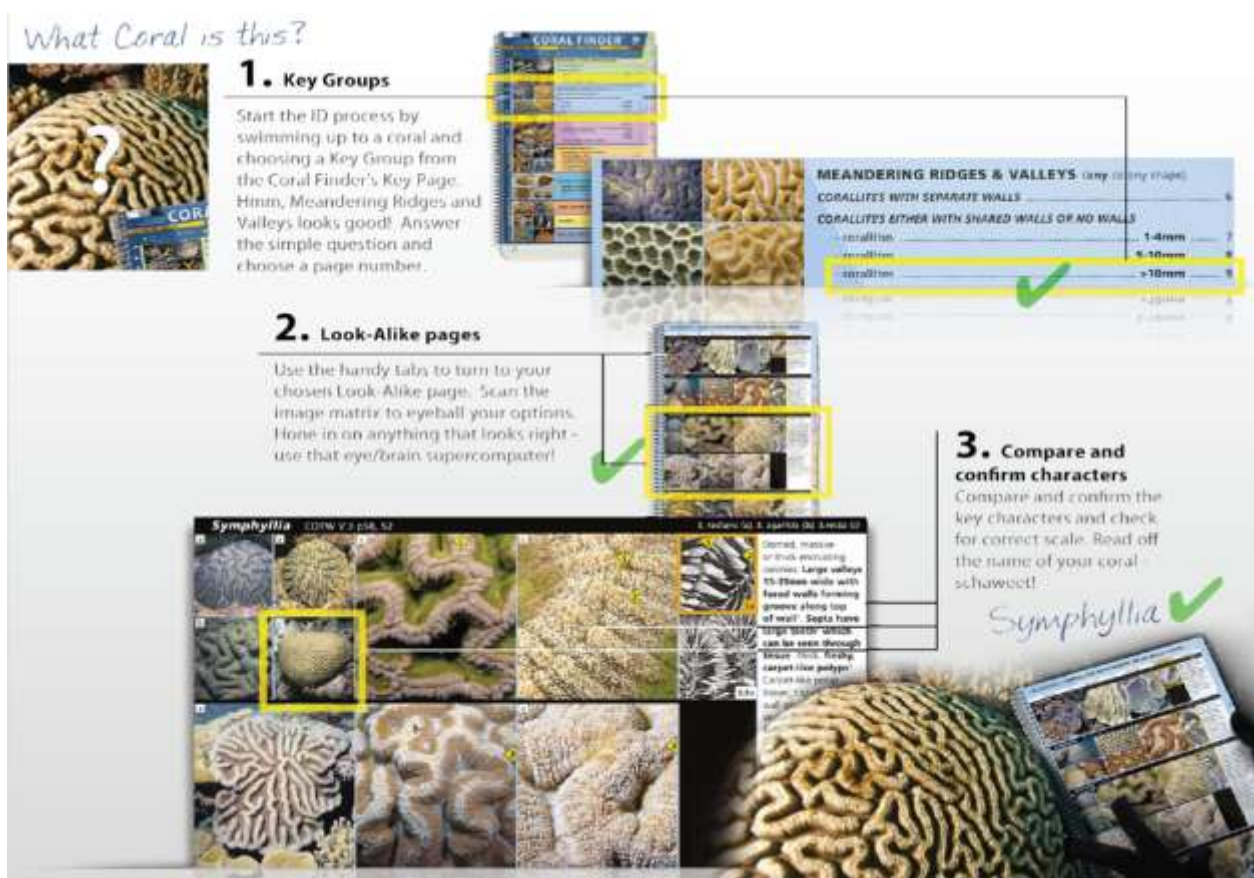


Figure 2. Use that eye-brain supercomputer! Humans can make rapid, visual choices without specialist knowledge. The Coral Finder's logic powerfully harnesses this ability by guiding the user to choose from a small number of visual "best bets".

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The News Journal of the International Society for Reef Studies
Reef Currents: Developing Coral Finder



Our “contract” with the user is in effect: “learn these 10 terms and you can identify 70 Indo Pacific coral genera regardless of growth form variation”. It’s a deal that I believe works, since the Coral Finder is now being used in over 50 countries where it has allowed motivated divers to develop rapidly basic coral identification skills. In addition, since 2009, some 500 people in five different countries have completed a Coral Finder Workshop, all showing strong before-after skill-improvements (Fig. 3). A second edition of the Coral Finder, supported by a free toolkit of training and revision videos, was published in 2011. These resources are now being translated into Bahasa Indonesia.

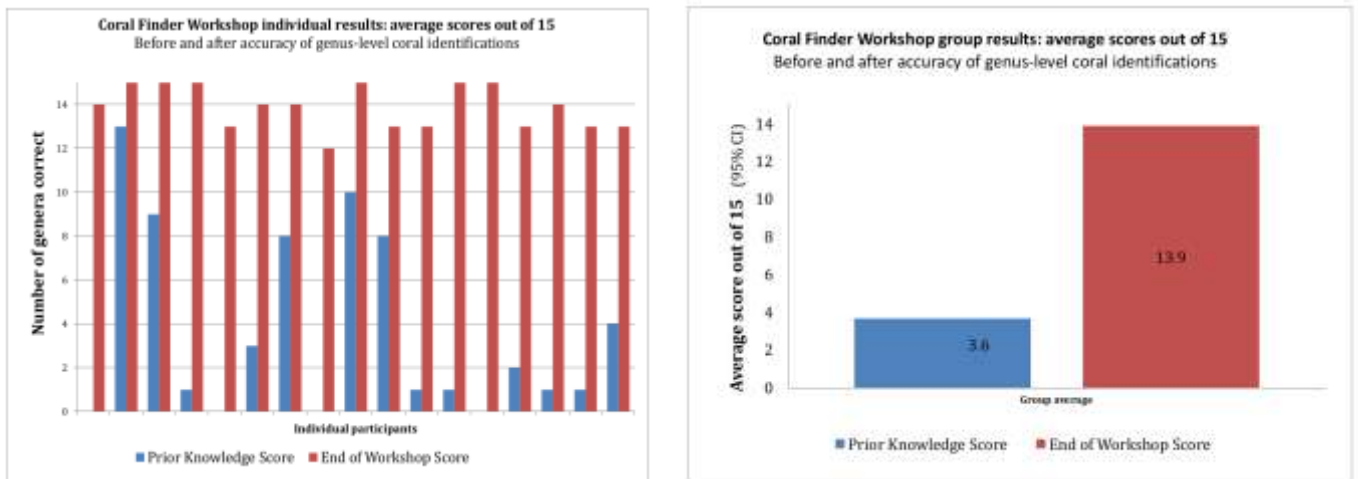


Figure 3. An example of the “before course” and “after course” coral identification scores of participants attending a Coral Finder course.

Keeping It Visual

So what is going on here? Well, in the Coral Finder both the navigation system and the decision-making process have largely been “visualised” (see Figure 3). This approach engages our eye-brain supercomputer. The forthcoming Reef Finder (October 2014) - a tool for identifying reef organisms to “group” (i.e. major taxonomic) level - builds on this approach by deploying a 9-page visual index that allows the user to search rapidly through themed image grids: i.e. search by “tentacles”, “holes” or “shapes” (such as spirals, sausages, spines, fingers). In practical terms this approach lowers the academic price of admission - i.e. prior knowledge or scientific training is not required to get started, (see Figures 5, 6 & 7).

So what can Visual Decision Tool design do for you? This approach has the potential to unlock oceans of factual information produced by scientists. The success of the Coral Finder shows that by adding a visual front end to a complex data set it is possible to bypass problems deemed too hard or unpalatable for the average diver. There is much to be gained from this approach.

Principles for Designing Visual Decision Tools:

Progressive development and testing of the Coral Finder has suggested a number of principles for the design of visual decision tools.

- **Create a graded learning pathway:** Analyse and understand the degree to which assumed knowledge is a roadblock for the self-directed learner. For example “it’s great having the Coral Finder, but how do I know it is a coral in the first place?” Often a simple primer tool is needed to establish the basics before more the complex problem is tackled. The Reef Finder (see Figures 5 - 7) is a response to the “how do I know it is a coral” problem.
- **Visual decisions:** Wherever possible devise visual choices that do not require text interpretation (see Figure 5). Note the use of wide, mid and close-up images to convey diversity and context (see Figures 3). Also note that image quality matters!

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The News Journal of the International Society for Reef Studies
Reef Currents: Developing Coral Finder



Figure 4. An example of the “Workflow” process using the visual index in the new *Reef Finder*.

- **YCOSWYS:** Where text is used follow the principle “You Can Only Say What You See” e.g. sure there are important differences in the folds of the gut between hard corals, soft corals, corallimorphs, anemones and zoanths; but you can't see them in the field - so don't talk about them in a field tool.
- **Limit choices to five or less:** The human eye-brain supercomputer is very good at pattern recognition, but has to work harder as the number of options increases. Our experience agrees with cognition studies that options of five or less keep things fast and fun.

My experience of using the *Coral Finder* to build capacity in coral identification encourages the belief that great strides can be made in raising ocean literacy if the right kind of tools can be provided – both above and below water. The *Coral Finder*'s rapid and widespread adoption confirms there is an unmet need for better ways to explore ocean life. Scientists and communicators can play an important role in this process by re-purposing existing data sets for use by a wider audience. This I suggest is a key step in enabling many more people to appreciate and understand coral reefs – and the problems they face.

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NOAA Coral Reef Watch's Next-Generation 5 km Satellite Coral Bleaching Thermal Stress Monitoring

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Satellite remote sensing has become an essential tool for coral reef environment monitoring. Since 1997, the U.S. National Oceanic and Atmospheric Administration (NOAA) Coral Reef Watch (CRW) has provided satellite-based sea surface temperature (SST) products to pinpoint areas where reefs are at risk for coral bleaching around the globe (<http://coralreefwatch.noaa.gov/satellite/index.php>). This is the world's first and only near-real-time global decision support system (DSS) informing management of tropical coral reef ecosystems.

Although highly successful and widely used by the global coral reef community, the currently operational CRW DSS uses relatively coarse SST data (50 km spatial resolution and twice-weekly temporal resolution) from only one polar-orbiting satellite. Addressing the demand for high-resolution monitoring of thermal stress that leads to bleaching and taking advantage of new satellites, sensors, algorithms, and our growing understanding of coral biology, CRW has developed a suite of next-generation, daily global 5 km products. These experimental products were officially released in May 2014 (<http://coralreefwatch.noaa.gov/satellite/bleaching5km/index.php>). Developed with support from NASA and NOAA, these products use the NOAA National Environmental Satellite, Data, and Information Service's (NESDIS) operational daily global 5 km geostationary-polar-orbiting (geo-polar) blended night-only SST analysis and a climatology (i.e., SST threshold for detecting bleaching related thermal stress) based on the 4 km AVHRR Pathfinder Version 5.2 SST dataset.

The high-resolution products currently include SST (Fig. 1) and SST Anomaly (not shown), as well as coral bleaching-specific products: Coral Bleaching HotSpots (Fig. 2), Degree Heating Weeks (DHW, Fig. 3), and Bleaching Alert Area (BAA, Fig. 4). These products presently use the same algorithms and stress levels used in CRW's established operational twice-weekly 50 km products (Liu *et al.* 2013; <http://coralreefwatch.noaa.gov/satellite/index.php>).

Like CRW's operational 50 km products, the 5 km Coral Bleaching HotSpots product (Fig. 2) measures the occurrence and magnitude of current thermal stress that can lead to bleaching. It is calculated as the difference between the night-time SST value and the average night-time temperature of the warmest month of the year (maximum monthly mean climatology, or MMM) at the same location. CRW's 5 km Degree Heating Weeks (DHW) product (Fig. 3) measures the cumulative impact of thermal stress experienced by corals. The DHW for a given location represents the accumulation of HotSpots of 1 °C or greater at that location over a rolling 12-week period. CRW's 5 km Bleaching Alert Area (BAA) product (Fig. 4) identifies areas where bleaching thermal stress meets or exceeds predefined levels based on CRW's HotSpot and DHW values. This is updated daily but shows the maximum thermal stress of the preceding seven days. The BAA provides coral reef ecosystem managers and other stakeholders with a single, convenient tool for monitoring recent thermal conditions. These daily global 5 km satellite monitoring products significantly advance CRW's ability to accurately monitor near-real-time coral bleaching thermal stress and account for episodes of localized, minor or no coral bleaching. CRW can now provide its services at or close to reef-scales with data from directly over coral reefs all over the world.

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Reef Currents: Next Generation Coral Reef Watch

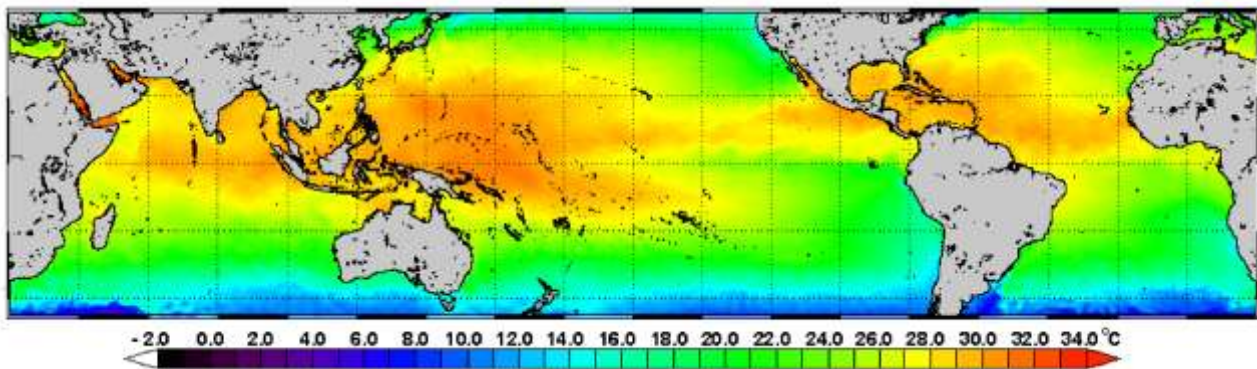


Figure 1. NOAA CRW's daily global 5 km SST product (graphic display of NOAA/NESDIS' operational daily global 5 km geo-polar blended night-only SST analysis) for October 3, 2013.

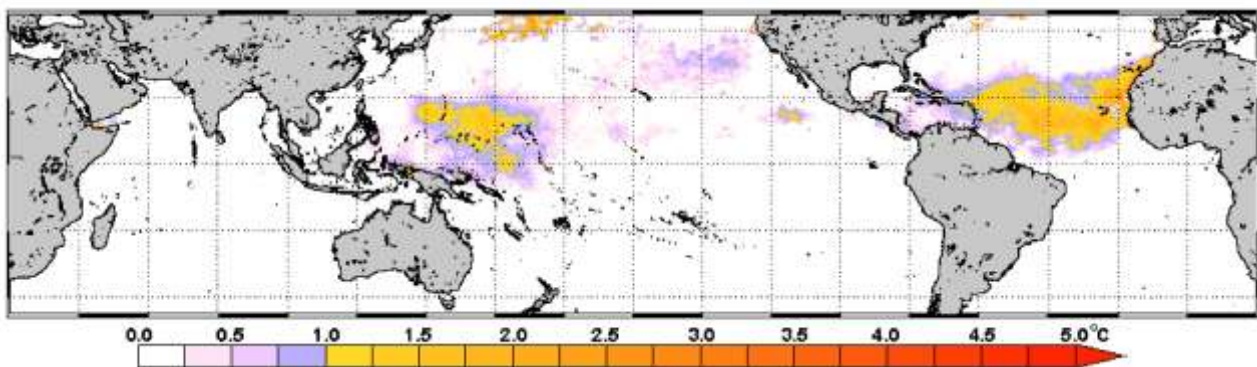


Figure 2. NOAA CRW's daily global 5 km Coral Bleaching HotSpots product for October 3, 2013.

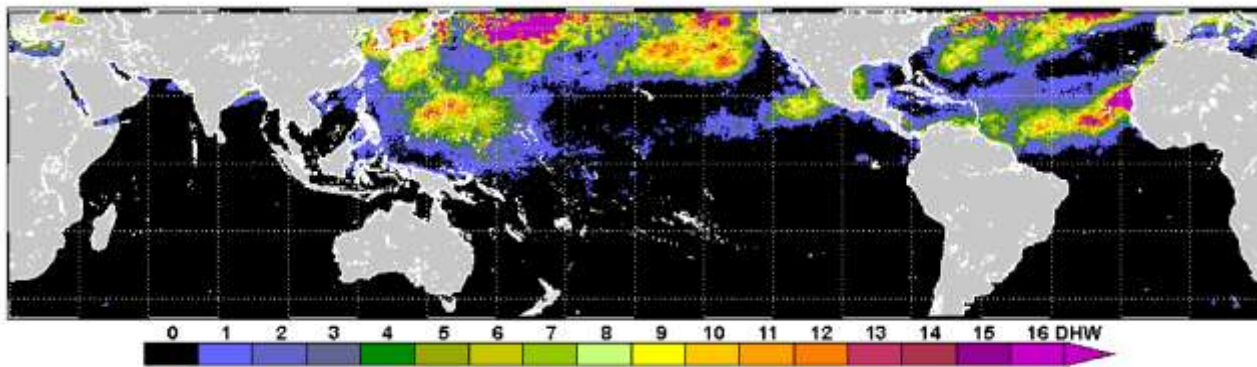


Figure 3. NOAA CRW's daily global 5 km coral bleaching Degree Heating Weeks product for October 3, 2013.

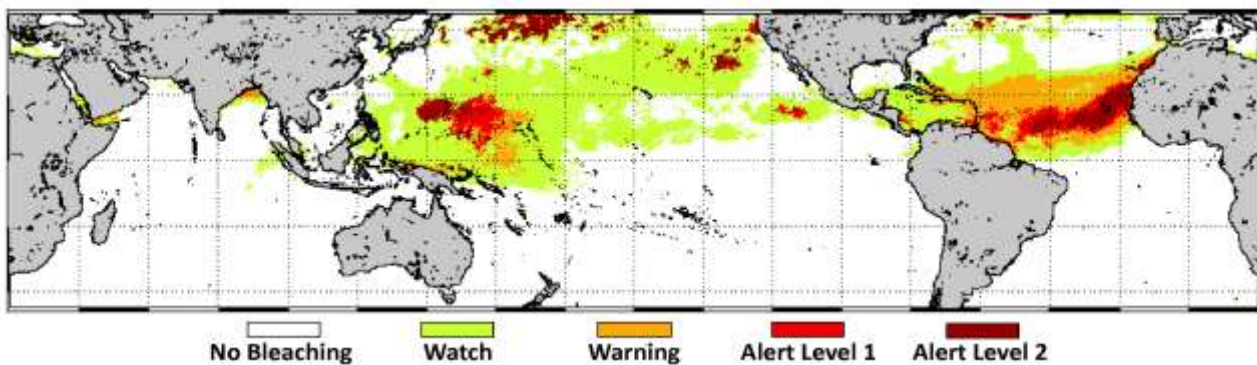


Figure 4. NOAA CRW's 7-day maximum composite of the daily global 5 km Bleaching Alert Area product for October 3, 2013. Note Alert Level 1 and 2 values around Guam and the Commonwealth of the Northern Mariana Islands where bleaching was underway at that time.

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Reef Currents: Next Generation Coral Reef Watch



The 5 km products provide two major improvements over CRW's 50 km products:

1. Next-generation Geo-Polar Blended SST Analysis

The products are based on NESDIS' new operational daily global 5 km geo-polar blended night-only SST analysis (gap-free) using observations from multiple operational geostationary and polar-orbiting satellites operated by NOAA, the Japan Meteorological Agency, and the European Organisation for the Exploitation of Meteorological Satellites. Unlike the current operational twice-weekly global 50 km SST analysis, which is based on at most one pass of a single polar-orbiting satellite each day in the tropical region, the new 5 km blended analysis includes as many as 50 SST observations per day from a combination of geostationary and polar-orbiting satellites. Application of the latest algorithms improves aspects such as cloud screening, gap-filling, and retrieval quality. As a result, the high-resolution 5 km SST analysis is based on more data of higher quality than the 50 km SST. In both the 5 km and 50 km SST analyses, only night-time SST retrievals are employed to ensure consistency of temperature anomalies at the very surface of the ocean with those experienced by corals at depth (Heron *et al.* 2013).

2. Improved Climatology

CRW's products are very sensitive to the quality and compatibility of the climatology (long-term average conditions) used in the analysis. A new climatology at 5 km resolution, matching NESDIS' 5 km SST analysis, was developed and implemented based on years 1985-2012 from the Version 5.2 AVHRR Pathfinder 4 km SST dataset, (i) adjusting for differences between the statistical characteristics of the Pathfinder SST data and the NESDIS 5 km operational SST analysis and (ii) employing the local SST trend through the data record to account for any influence of global warming to ensure consistency of derived products with the established interpretation of CRW's existing 50 km products. The new 5 km climatology also resolves known errors in the operational 50 km climatology in certain areas, such as the Gulf of Panama and Gulf of Oman.

These 5 km products will undergo continuous improvements over the next year as they are tested and ultimately transitioned to full operational support. Development of high-resolution versions of CRW's other operational products, such as the Virtual Stations and the automated Satellite Bleaching Alert (SBA) e-mail system, based on CRW's 5 km products is also underway. CRW will continue to produce the current 50 km products until the 5 km products become operational. We anticipate that there will be some differences between the two sets of products in certain areas, and user discretion is advised.

We encourage users worldwide to report bleaching and non-bleaching events to help us calibrate and validate the new system. Please email bleaching observations to coralreefwatch@noaa.gov and/or enter them into the NOAA/ReefBase online bleaching report form found at <http://www.reefbase.org/contribute/bleachingreport.aspx>. Your feedback is important for us to improve our monitoring products. Please send your comments and suggestions to coralreefwatch@noaa.gov.

Acknowledgements:

Development of the next-generation 5 km products has been accomplished through a collaboration of NOAA Coral Reef Watch, the University of South Florida, NASA-Ames, and the Cooperative Institute for Research in Environmental Science, with funding support from the NASA Biodiversity and Ecological Forecasting program and the NOAA Coral Reef Conservation Program. The contents in this manuscript are solely the opinions of the authors and do not constitute a statement of policy, decision, or position on behalf of NOAA or the U.S. Government.

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Will 2014-2015 be the Next Big El Niño? If so, What Might it Mean for Coral Reefs?

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As of June 2014, the US National Oceanic and Atmospheric Administration’s (NOAA) National Centers for Environmental Prediction (NCEP) has issued an [El Niño Watch](#). There is a greater than 70% chance that an El Niño will develop by late 2014 (Fig. 1). The present consensus forecast calls for a weak-to-moderate event. Additionally, you can see areas likely to bleach up to four months in advance using NOAA Coral Reef Watch's current [Seasonal Coral Bleaching Thermal Stress Outlook](#). Currently, the highest bleaching likelihood can be seen in Guam and the Marianas Islands, the equatorial Pacific around Kiribati, and the eastern tropical Pacific (Fig. 2).

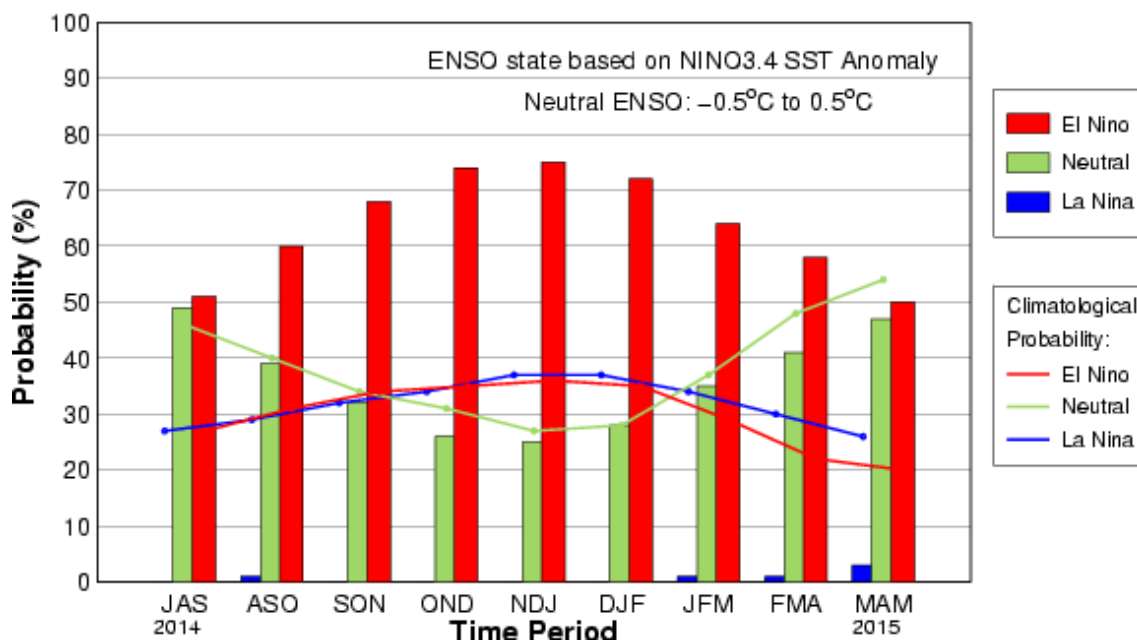


Figure 1: The probability of an El Niño (and La Niña) developing through early 2015 (as of mid-July 2014) from <http://iri.columbia.edu/our-expertise/climate/forecasts/enso/>. The three lines represent the climatological (i.e., normally expected) likelihood of El Niño, La Niña, or neutral conditions during each month of the year. The bars indicate the likelihood of these three conditions during 2014-2015 based on an analysis of various climate models.

1997-1999 ENSO and Patterns of Coral Bleaching

While each El Niño event follows a different spatial and temporal pattern, the following is a brief overview of the pattern and timing of thermal stress that resulted in widespread severe coral bleaching during 1997-1999. Past reports have estimated that over 15% of the world's coral reefs were effectively lost during the 1997-1999 period ([Wilkinson 2000](#)). [NOAA Coral Reef Watch](#) satellite-based observations show widespread prolonged high temperatures that caused the coral bleaching and mortality. Some indices rank the 1997-1998 El Niño as the largest

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Reef Currents: When the Next El Niño



on record. It was followed immediately by a strong La Niña (1998-1999). La Niña frequently causes bleaching by warming many areas that are cooled or unchanged during an El Niño (see [Eakin et al. 2009](#)). The 1997-1999 period was unique as both parts of the El Niño-Southern Oscillation (ENSO) system occurred consecutively with no neutral year between.

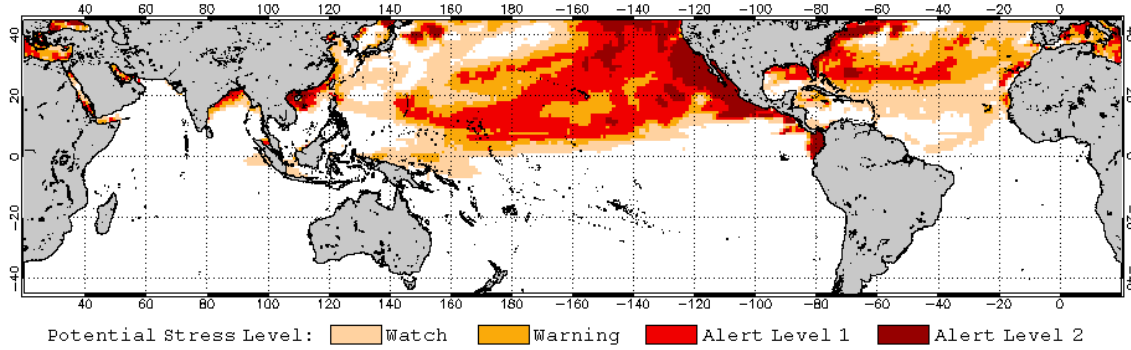


Figure 2: Map of areas where 60% or more of the model ensemble members are predicting thermal stress at each of NOAA Coral Reef Watch’s alert levels through October 2014 (as of mid-July 2014).

In short, the tropical oceans experienced thermal stress sufficient for coral bleaching with impacts covering a 14-month period (May 1997-June 1998, Fig 3-6). Reefs in the central Pacific and eastern tropical Pacific were exposed to thermal stress during the early phase of the El Niño. Thermal stress developed on the Great Barrier Reef and across the islands of the south Pacific during February-April 1998 and the Indian Ocean during March-June 1998. Thermal stress in the Gulf of Mexico and the Caribbean, commonly seen in the second year of an El Niño, peaked in July-October 1998. The mid-1998 onset of La Niña conditions resulted in thermal stress in the northwestern Pacific Ocean from July-October 1998.

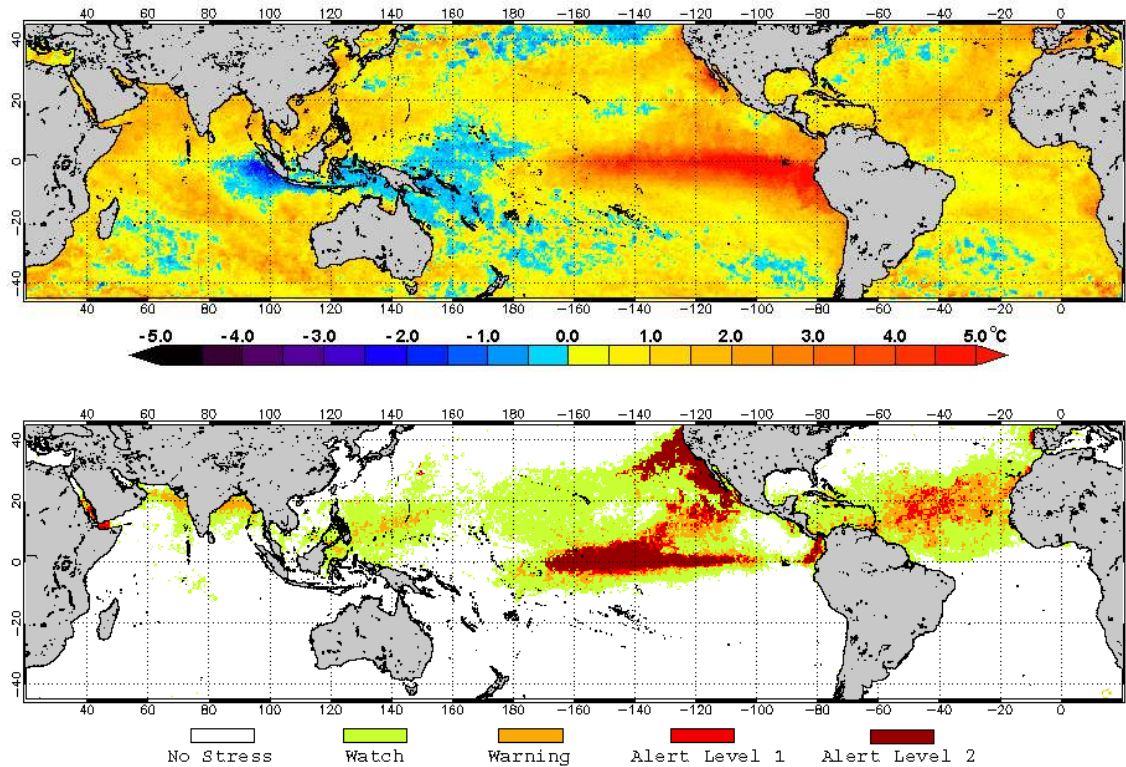


Figure 3: NOAA Coral Reef Watch 50 km satellite [SST Anomaly](#) (top) and [Bleaching Alert Area](#) (bottom) for October 1997.

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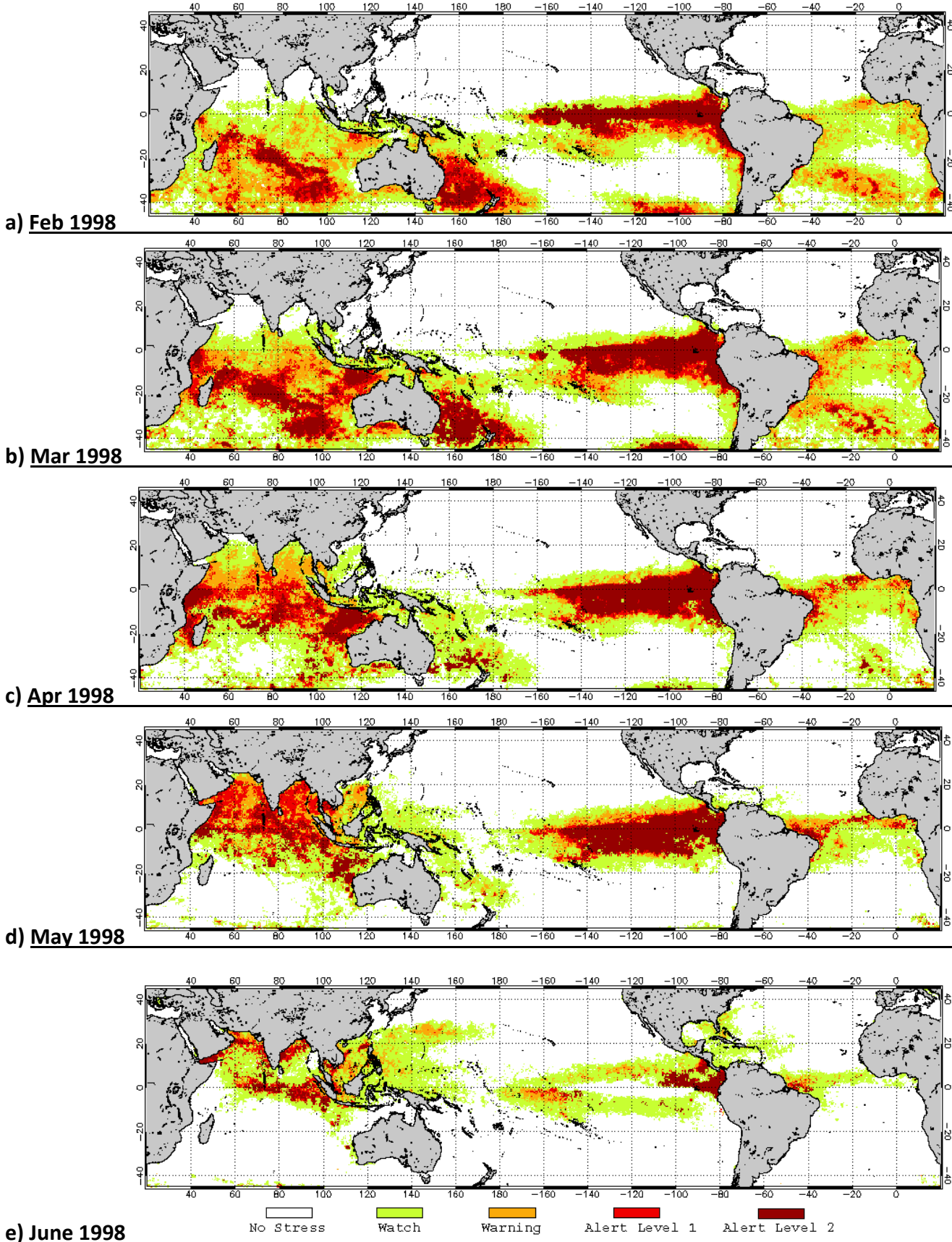


Figure 4: NOAA Coral Reef Watch 50 km satellite [Bleaching Alert Area](#) for February-June 1998 showing progression of the direct El Niño warming in the Pacific and Indian Oceans.

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Reef Currents: When the Next El Niño



The following discussion uses the CRW 50 km [SST Anomaly](#) and [Bleaching Alert Area](#) products (Fig 3-5) to illustrate the events. The Bleaching Alert Area shows patterns of areas with accumulated thermal stress sufficient to cause coral bleaching. The patterns are a bit different, and more coral-focused, than those visible in the SST Anomaly data. More on these products can be found at: <http://coralreefwatch.noaa.gov/satellite/index.php>.

1997: The classical El Niño warming pattern formed by May 1997, with movement of the Pacific warm pool from the western tropical Pacific eastward to the South American coastline. Prolonged thermal stress with the potential to cause bleaching was seen along the equator, from Howland and Baker Islands east to the Galapagos and the Ecuadorian coastline, during the remainder of 1997 (Fig. 3). During this time, warming also proceeded northward along the South American coast to Panama. Additionally, warming was seen reaching northeast to Mexico, and some warming was seen along the Central American Coastline. Limited warming was seen in the Caribbean (Fig. 3).

1998: By early 1998, the classic El Niño pattern was fully developed, with broader areas of high temperature in the eastern Tropical Pacific and extending up the Central American coast past Costa Rica, including all of the eastern Tropical Pacific islands; high temperatures in these regions began to dissipate in June. Thermal stress also caused coral bleaching along the Great Barrier Reef in February-March (Fig. 4). Warming began in the eastern to central Indian Ocean in February, spreading to the eastern Indian Ocean and dissipating after May (Fig. 4).

With the rapid onset of La Niña conditions in July 1998, warming was observed in the western Pacific Ocean, north of the equator (Fig. 5). August-September saw warming in the South China Sea, Philippines, Palau, and the Ryukyu Islands, which spread southeastward through Palau and Micronesia before finally dissipating in November.

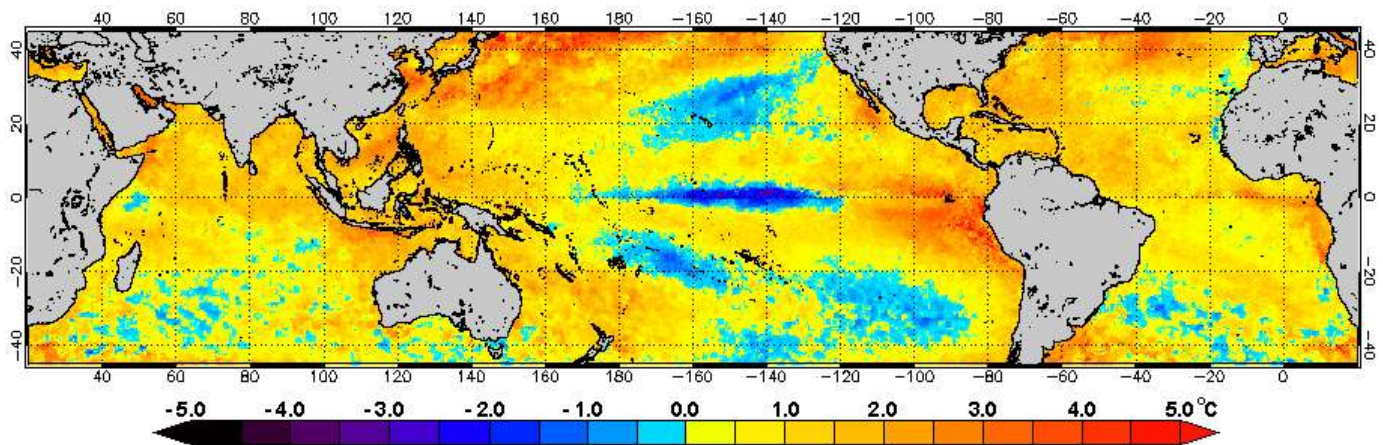


Figure 5: NOAA Coral Reef Watch 50 km satellite [SST Anomaly](#) for July 1998.

Thermal stress in the Western Atlantic/Gulf of Mexico/Caribbean is most commonly seen in the summer-fall (warm) season in the year after the onset of an El Niño (Fig. 6). This results from atmospheric teleconnections whereby warming and wind changes in the Pacific cause large-scale changes in the atmospheric wave and jet stream. These atmospheric disturbances cause warming downstream in the Caribbean. While strong El Niño events regularly result in bleaching in the Caribbean, some mild to moderate El Niños contribute to bleaching in this region as well. Warming sufficient to cause bleaching started to develop in July 1998 in Atlantic regions and peaked in the Gulf of Mexico in August and in the Caribbean Sea in October (Fig. 7).

1999: By 1999, the worst of the thermal stress was over, from a coral bleaching perspective, but only after major losses of coral reefs worldwide in 1998. Some warming was seen along the Great Barrier Reef in early 1999 but was much weaker than the prior year. Conditions were rather quiescent until August, when warming of the western North Pacific led to low bleaching levels of thermal stress that reached down to the Mariana Islands. Warming was again seen in the Caribbean in August-September 1999 but to a lesser extent than in 1998.

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The News Journal of the International Society for Reef Studies
Reef Currents: When the Next El Niño



Each El Niño is different and spatial patterns of warming in the Pacific Ocean can change bleaching in the Indian Ocean and Caribbean Sea. However, bleaching patterns during the weak 2009-2010 El Niño were quite similar to those seen in 1997-1998, only less severe. While the patterns above probably will not be repeated precisely in 2014-2015, the events of 1997-1998 can serve as a guide to likely impacts on coral reefs if this El Niño does develop. We will be watching conditions over the coming months and encourage you to follow El Niño forecasts and observations from organizations such as [NOAA/NCEP](http://www.noaa.gov), as well as [NOAA Coral Reef Watch](http://www.coralreefwatch.noaa.gov) for developments on coral reefs.

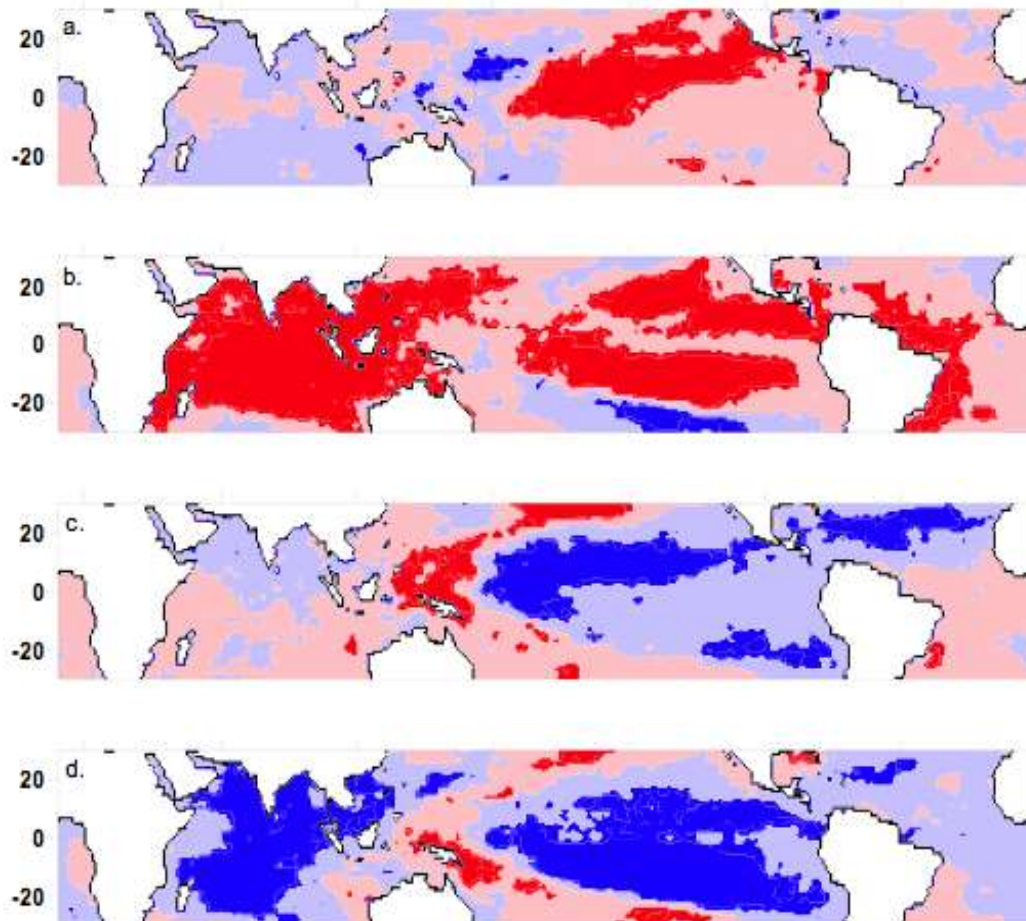


Figure 6: Significantly (at 5% level) warmer (*red*) or cooler (*blue*) annual maximum SST difference during: (a) the onset year of an El Niño, (b) the year after onset of an El Niño, (c) the onset year of a La Niña, and (d) the year after onset of a La Niña. Figures represent average values calculated for 20 El Niño events and 20 La Niña events, and tested for significant differences from 20 ENSO-neutral years. The groups of years were identified from Southern Oscillation Index (SOI) updated by the Australian Bureau of Meteorology (from [Eakin *et al.* 2009](#)).

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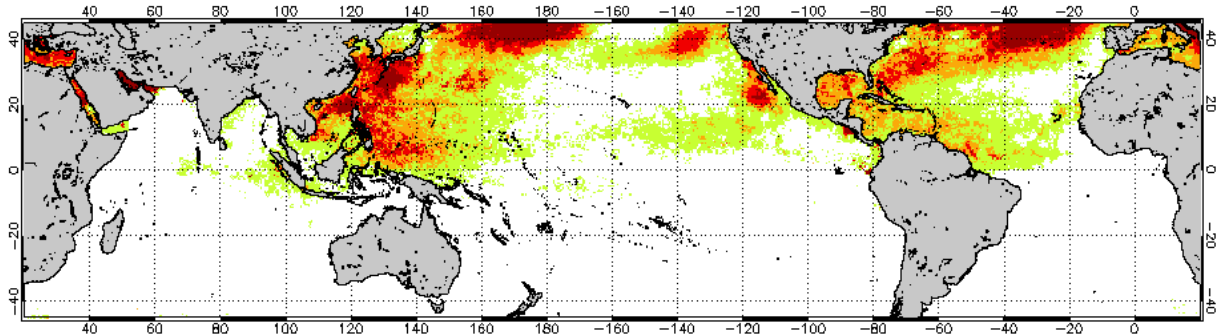
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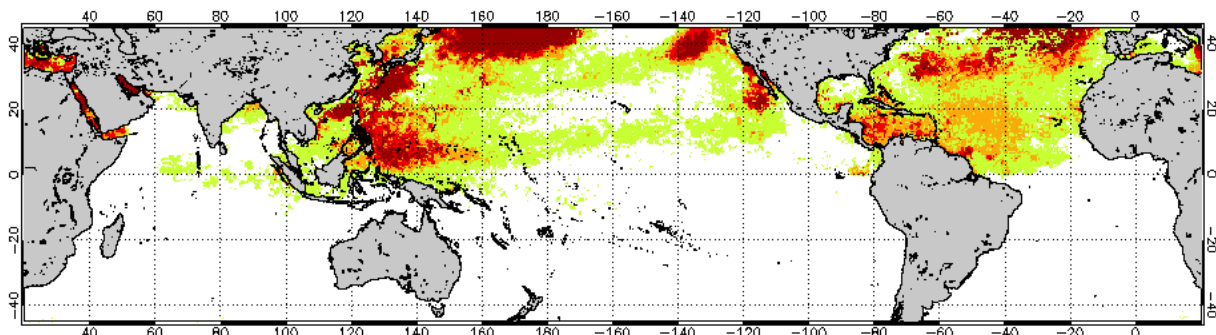
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a) August 1998



b) September 1998



c) October 1998

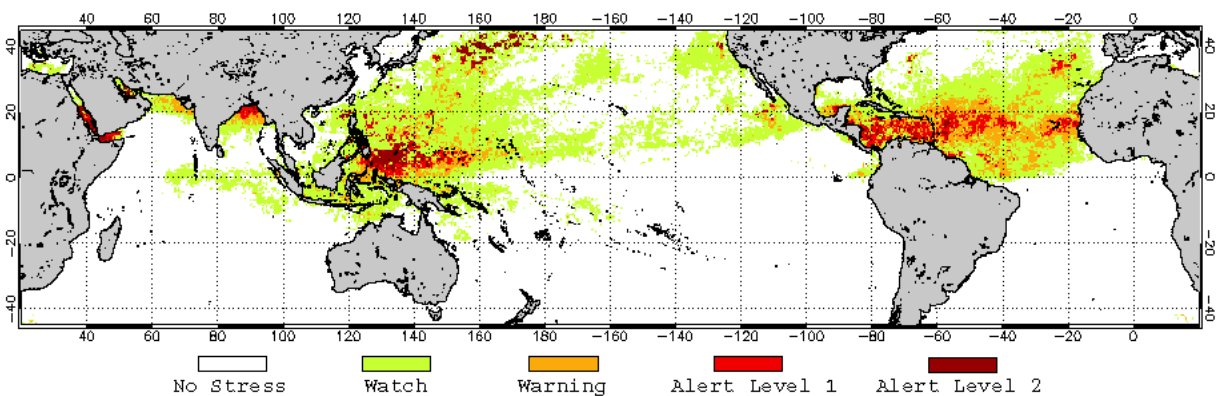


Figure 7: NOAA Coral Reef Watch 50 km satellite Bleaching Alert Area for August-October 1998 showing progression of the teleconnected El Niño warming in the Gulf of Mexico, Caribbean, and western Atlantic.

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Reefs Form Friendship Groups on the Great Barrier Reef

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How many of us can claim to know all of our work colleagues? Very few I'll wager, especially amongst those of us who work in universities, where the colleague "population" often reaches into the thousands. If you only look within your department however, you've probably met a much higher percentage of your fellow workers, and if you just look within your research group, chances are you've met them all and you're probably heading to the pub with them on Friday night.

In much the same way, if we were to take a reef in any large coral reef ecosystem and ask which other reefs it "connects" with, we would probably find it is much more likely to connect with other reefs in its "friendship group" than those outside of it. What do I mean by reefs connecting? Simply put, exchanging any kind of information with each other – for instance in the form of coral or fish larvae.

We might expect that these reef "friendship groups" would simply be roughly circular groupings of nearby reefs, after all basic intuition would tell us that reefs are more likely to be connected with their immediate neighbours than with far-flung outposts. In fact, the complex topology around reef ecosystems – and the correspondingly complex water currents that result – often conspire to form groups of strange and surprising shapes, by connecting reefs that appear far apart and isolating other reefs that are geographically close to each other.

How can we identify connected reef communities?

Before proceeding any further we will define more precisely what we mean by a "friendship group" of reefs. We will define a so-called *reef community* as a group of reefs whose members are strongly connected amongst themselves but weakly connected with reefs outside the group. In other words, a self-contained group of reefs, which exchange a lot of material with each other but are relatively isolated from the other reefs around them. The use of the word *community* in this context stems from the mathematical definition of a community in network science – as we will see later on – and is unrelated to the ecological use of the term as an ensemble of organisms inhabiting a reef.

In order to find the locations and configurations of reef communities in a given coral reef ecosystem, we have two main avenues we can pursue: genetic tools or numerical modelling (see Leis et al. 2011 for a full discussion of these different approaches). The first option involves measuring the genetic similarity of populations of a given species residing on physically separate reefs, and deducing that reefs whose populations are more "similar" to each other must be exchanging genetic information (i.e. coral or fish larvae) more frequently, and are therefore better connected. This indirect approach allows us to gain a firm understanding of connectivity patterns in the here and now, but doesn't tell us much about the physical processes driving them.

The other option is to use numerical modelling to simulate the motion of the water currents around the entire reef ecosystem, and then to see how strongly these currents are connecting every pair of reefs in the domain. This approach allows us to gain an understanding of the physical processes causing connectivity, and to simulate connectivity patterns for specific years.

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Reef Currents: Friendship Groups on the GBR

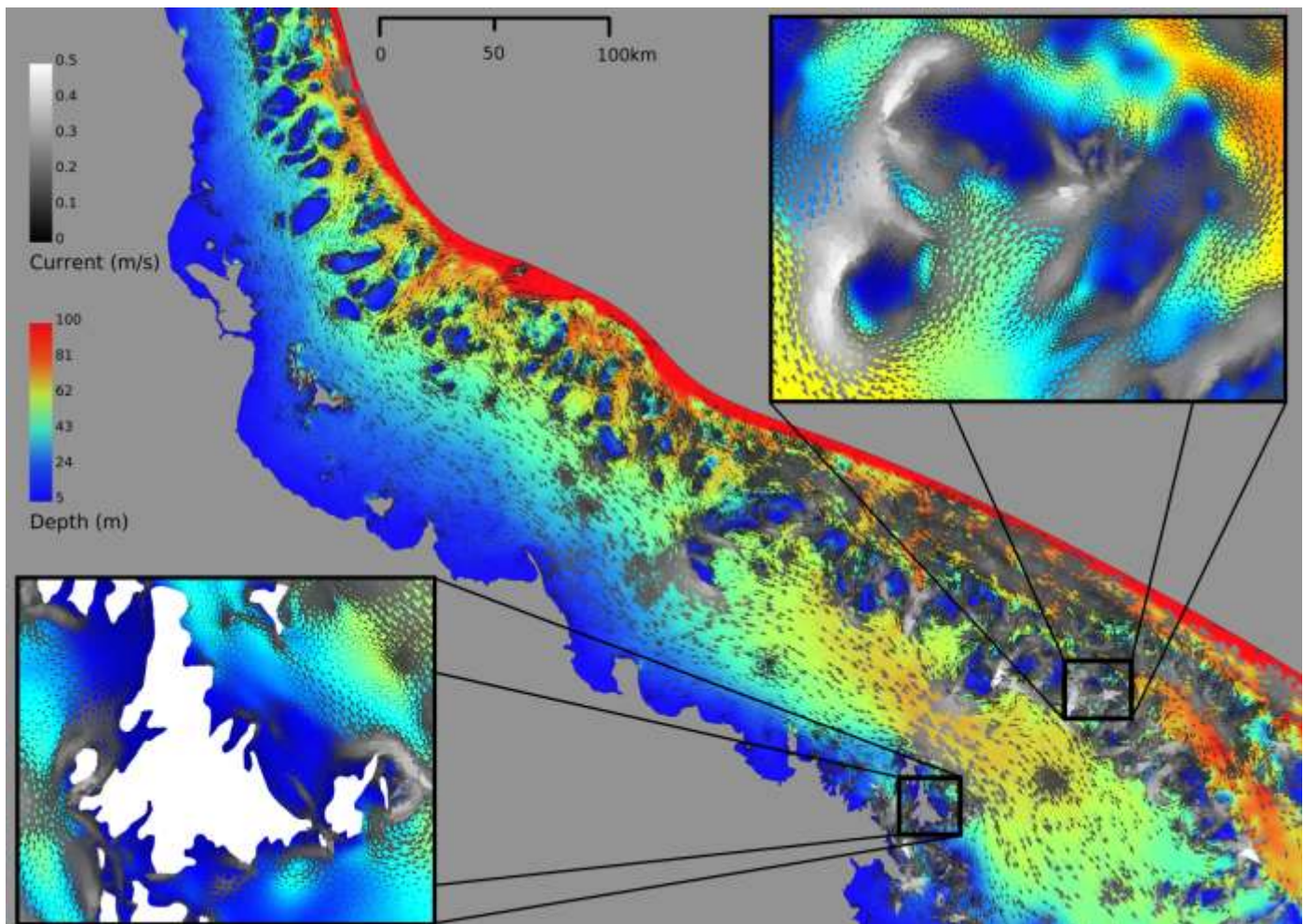


Figure 1: Bathymetry of the central GBR (in colour) with depth-averaged currents overlaid (arrows), as obtained using the SLIM ocean model, averaged over the period 22 November – 27 December 2010. We can see how complex the circulation patterns are at both small and large scales, with strong horizontal current gradients and a large number of eddies in the wakes of reefs and islands.

Looking for reef communities in a multi-scale region: the Great Barrier Reef

A numerical modelling team led by Professors Emmanuel Hanert and Eric Deleersnijder at the Université catholique de Louvain in Belgium has been working to find the shapes and placements of reef communities in Australia's Great Barrier Reef (GBR) – probably the most topographically complex coral reef ecosystem in the world, and as a result one of the most challenging to handle numerically. It is a region where small-scale circulation features are known to have a significant impact on large-scale flow, making it necessary to model water currents down to the scale of individual reef wakes and reef passages – on the order of 100m (see Wolanski et al. 2003 for more details about the hydrodynamics of the GBR). Figure 1 gives an idea of the complexity of the flow in the GBR.

The challenge posed by simulating water flow in such a large region (the GBR measures over 2000km by 200km) down to such fine resolution is best met using a multi-scale ocean model. The researchers in Belgium used SLIM⁴ – a finite-element ocean model whose the resolution can be varied in space. This means it can be increased in areas where small-scale flow is most important, such as close to reefs and shorelines, whilst being kept coarser in open-sea areas where flow is more uniform. In this way reef-scale resolution can be obtained in key areas whilst computational costs are kept acceptable.

⁴ SLIM is the Second-generation Louvain-la-neuve Ice-ocean Model – see <http://sites.uclouvain.be/slim> for more information

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Reef Currents: Friendship Groups on the GBR



Once the marine currents have been modelled, the process of coral or fish larval dispersal can be simulated by adding millions of “virtual larvae” into the domain and tracking their trajectories over a given period, typically 1-2 months. To model the dispersal of larvae which don't have directional swimming abilities, the virtual larvae are assumed to be passively transported by the ocean currents. This assumption is generally used when modelling coral larvae. Clearly, for species whose larvae have more complex swimming behaviour, such as most species of fish, more complex models are needed to account for their known behavioural characteristics (see Leis 2007 for a discussion on how dispersion of fish larvae may be affected by their behaviour).

The results from larval dispersal simulations can contain a huge quantity of information – for the entire GBR, which has around 3000 reefs, there are up to 9 million potential reef-to-reef connections to consider. This is where Network Science tools can come in handy to extract useful information. Network Science is an area of research concerned with studying the properties and characteristics of networks, generally large and complex ones, for instance by quantifying to what extent a network is clustered, or how well connected all the nodes in the network are to each other.

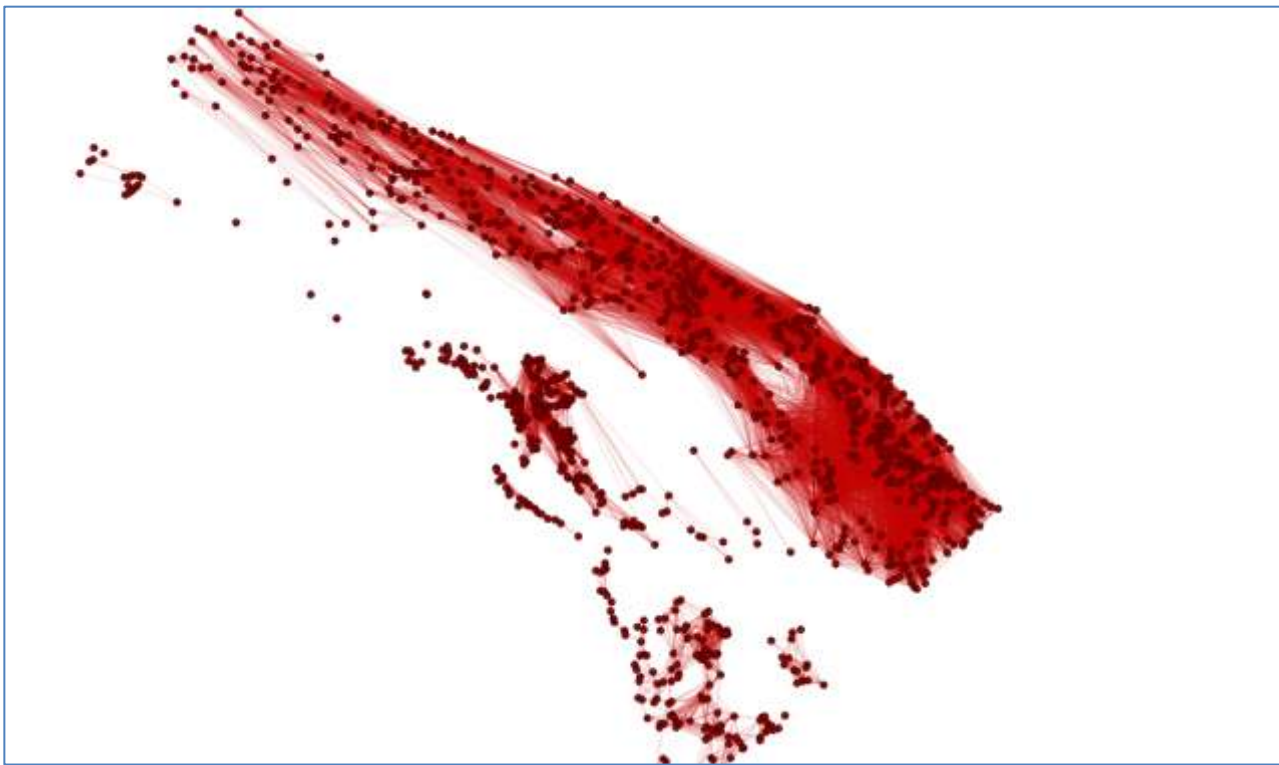


Figure 2: Representation of the central GBR as a large network of interconnected reefs. The dots (*nodes* in network science terminology) represent individual reefs. Lines linking two reefs (*arcs*) have been drawn wherever a significant exchange of larvae between those reefs was predicted by the SLIM model. In this simplified illustration, the arcs are all directionless and of equal weight; in reality however some arcs carry more weight than others (depending on whether higher or lower numbers of larvae are exchanged) and all arcs are directed from one reef to another. Even in this simplified example however, it is possible for the untrained eye to spot clear community structures in the network.

By considering the GBR as a large network of interconnected reefs, as in Figure 2, we can use these tools to reveal important properties of larval dispersal patterns. In particular, we can try to identify reef communities in the GBR using community detection methods. Community detection is a branch of Network Science concerned with the detection of clusters of nodes whose members are strongly connected to each other and weakly connected to nodes outside their cluster – in other words, reef communities exactly as we defined them above. Many different community detection methods exist, and the reader is referred to Fortunato (2010) for an introduction to the topic.

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Reef Currents: Friendship Groups on the GBR



One of the most popular community detection approaches in recent years is the method known as modularity optimisation. This involves first defining a quantity called “modularity”, which is a mathematical measure of how strongly a network is divided into clusters compared to a random network, and then using an algorithm to repeatedly repartition the network into different sets of clusters until the network’s modularity is at its maximum value. At this point the network is considered to be partitioned into its optimal set of communities. This community detection approach has been used in a myriad of different applications, from analysing global financial transactions, to improving search results on social networking sites by finding communities you’re likely to be a part of, to – more interestingly – studying marine connectivity (e.g. see Kininmonth et al. 2010).

What do reef communities look like in the GBR?

A recent article in *Ecological Modelling* shows how Community Detection tools using the modularity optimisation approach were used to identify reef communities in the central GBR for 4 different species of coral larvae (Thomas et al. 2014). The results showed that the GBR is indeed partitioned into a number of reef communities, and that their exact shapes and sizes are species-specific.

The study showed that larval dispersal patterns can vary significantly from one species of coral to the next. These differences exist because the time taken for larvae to develop the ability to settle onto a reef (the so-called pre-competence period) can be very different for each species. For instance *Acropora millepora* larvae have a relatively long pre-competence period, and therefore dispersed further than *Platygyra daedalea* larvae, which have a shorter pre-competence period. Dispersal distances varied up to fivefold amongst the 4 coral species studied.

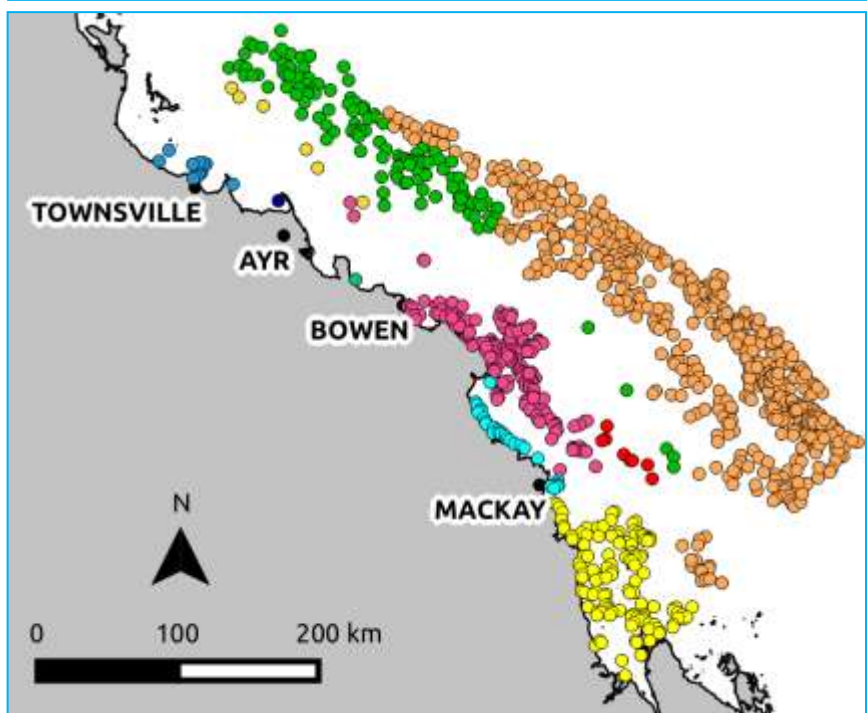
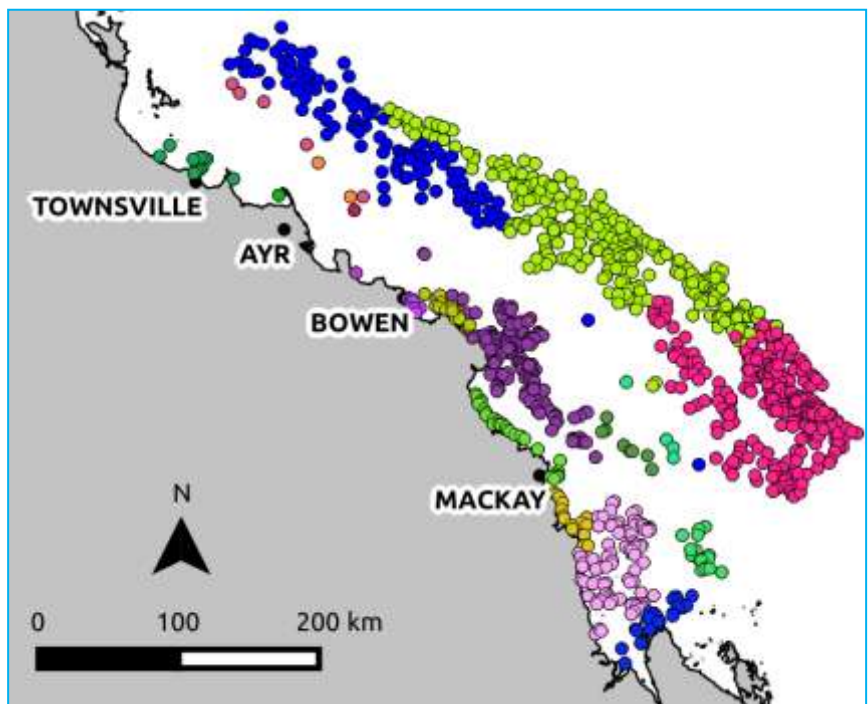


Figure 3: Map showing reef communities in the central GBR for *Platygyra daedalea* (top) and *Acropora millepora* (bottom), two scleractinian coral species common in the GBR. The coloured dots show the positions of reefs and the colour identifies the community they belong to, as found using the SLIM model. We can see that colonies of *A. millepora*, a species has a greater dispersal distance, form slightly larger communities; however the large-scale patterns are broadly similar. In both cases the proportion of larvae settling outside their natal community is very low (<4%).

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Reef Currents: Friendship Groups on the GBR



The species whose larvae dispersed the furthest formed the largest reef communities, as would be expected. This can be seen in Figure 3, which shows the reef communities formed in the central GBR by both *A. millepora* and *P. daedalea* coral larvae. The more “outgoing” *A. millepora* larvae form fewer, larger communities, whilst *P. daedalea* larvae, which tend to travel shorter distances, form slightly smaller communities. Despite some differences in community size however, many common features are clearly visible between the two species, such as the strong separation between offshore and nearshore reef communities.

When looking at the results, it is important to bear in mind that each reef community represents a self-contained ecological “unit”, and that the vast majority of the larvae released by its members will settle within the community. There is therefore very little larval exchange between different communities, and so it may be reasonable to expect that community boundaries correspond to boundaries separating areas with different water circulation regimes. If this were the case, we may expect that dispersal patterns would be different inside each community. Indeed, this was found to be the case, and both dispersal distances and self-recruitment rates could be very different from one community to the next. For instance for *P. daedalea*, larvae spawned in the reef community around the Whitsunday Islands dispersed on average 35km before settling, whilst larvae spawned in the neighbouring nearshore reef communities dispersed only 1-5km before settling.

This findings could have a potential use in informing MPA placement in the area. For instance, if it is desirable to maximise MPA-to-MPA connectivity, then it may be useful for MPA spacing to reflect the average dispersal distances in each community. Likewise if the aim is for MPAs to connect with the highest number of unprotected reefs, then it may be fruitful to include an MPA in every large reef community, since MPAs in different communities will very likely remain unconnected with each other.

A question which naturally arises when we look at maps of reef communities is: what is the “best” scale at which to study inter-reef connectivity? Larval dispersal is a process that occurs over a wide range of scales, from a few hundreds of metres for larvae that stay close to home, to hundreds of kilometres for the most adventurous larvae. On the other hand reef managers often want to set policy at a specific scale, for instance by defining large-scale zoning maps. Clearly, tools are needed which can synthesize information across all scales to draw conclusions at the larger scale. Community Detection may well be a useful addition to this toolbox.

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Reef Currents: Tubbataha Reef Natural Park



Tubbataha Reef Natural Park – a beacon of hope for coral reefs

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Real reef conservation success stories tend to be few and far between these days. Amidst the general trend of declining corals and reef fish populations, ineffective management, and lack of political will, the Tubbataha Reefs in the Philippines stand out as something of a success story.

Located in the middle of the Sulu Sea some 150 km from land (Fig. 1), the Tubbataha Reef Natural Park consists of the two Tubbataha atoll reefs and the submerged Jessie Beasley Reef to the north. The park, which is a no-take area, covers 970 km² and is surrounded by a 10 nautical mile wide buffer zone, bringing the total area that is protected to 3,565 km². It includes an estimated 100 km² of coral reef, all within the no-take zone, and contains a diverse and abundant array of fish, corals and marine wildlife in clear and pollution free waters. Studies to date have recorded 13 cetaceans, 7 sea grasses, 79 algae, 372 corals, 11 sharks, about 600 other fish species, several turtle species, at least 27 resident birds and a further 100 migrants.

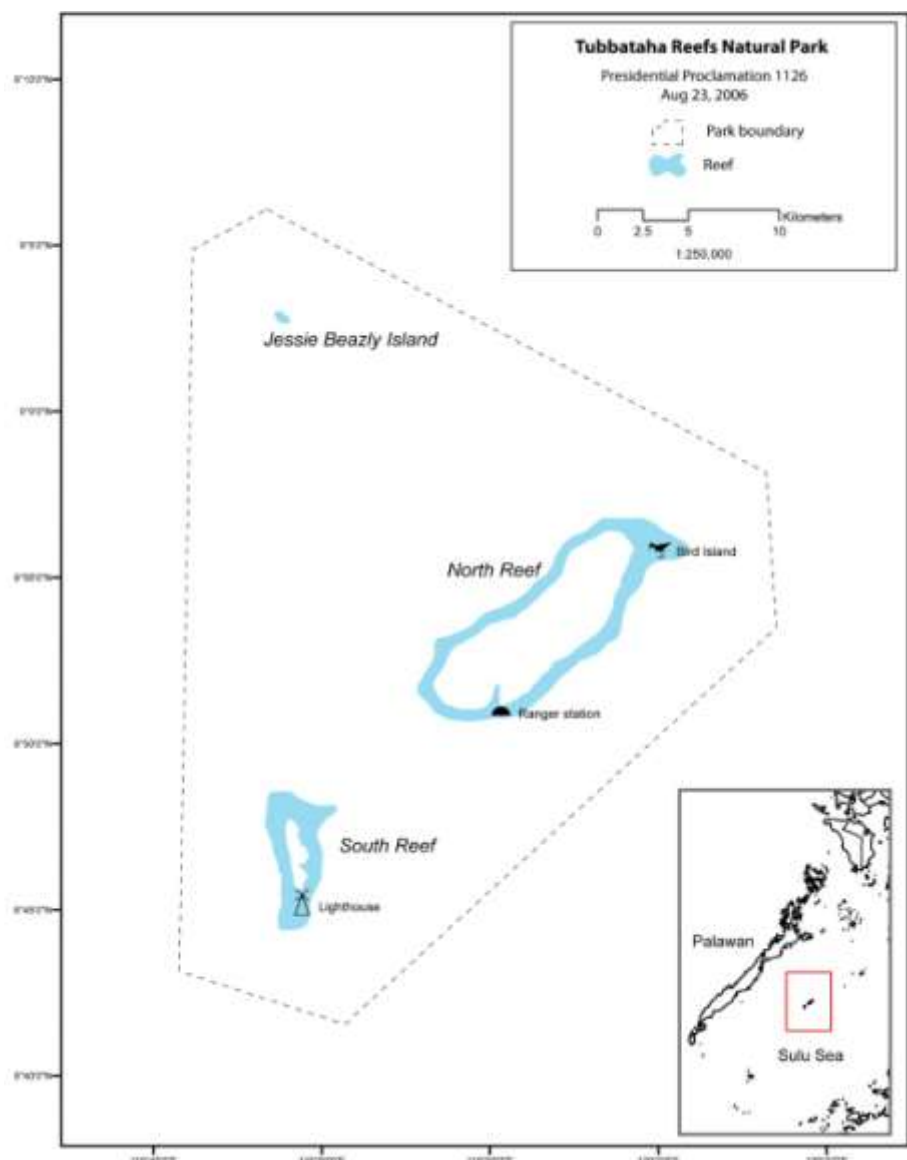
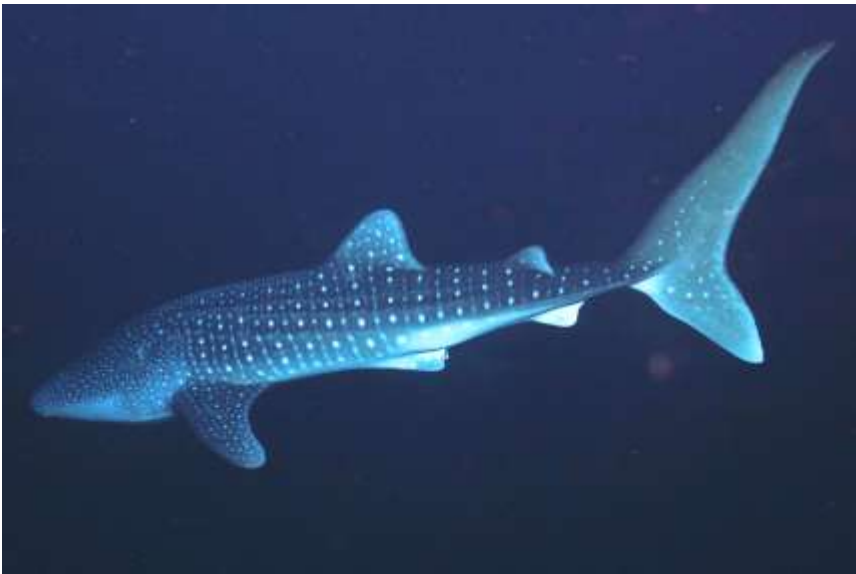


Figure 1. Map showing the Tubbataha Reefs Natural Park, in the Sulu Sea, south-east of Palawan Island in the western Philippines.

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Reef Currents: Tubbataha Reef Natural Park



Initially protected as an MPA in 1988, and declared a World Heritage Site in 1993, the more recent TRNP Act of 2009 lays out the governance arrangements for the park. The Tubbataha Protected Area Management Board is responsible for formulating conservation policies which are then implemented by the Tubbataha Management Office (TMO). TMO, with its enthusiastic staff, undertakes the day-to-day operations in the park, in line with the management plan.

Enforcement is undertaken by about 8 rangers comprising park employees working jointly with Philippine Navy and Coast Guard personnel. They all stay on the unique, isolated ranger station. A new research station is being planned that will allow round the year research, and will have improved living facilities for the rangers. The park receives significant support from both local and national government, and the Governor of Palawan is the co-chair of the Management Board which comprises representatives from government agencies, scientific institutions and NGOs. Only two activities are allowed in the park – research and tourism - and these are currently confined to three months of the year because of the remote location and weather constraints. This means that for the rest of the year, the reefs are impacted mainly by natural events, or by shipping incidences such as the grounding of the USS Guardian in 2013, and marine debris. As a premier diving destination in Southeast Asia and rated among the top ten dive sites in the world, the park receives about 1500 visitors a year.

Tourism is the only source of income generation through user-fees and operators permits so that the live-aboard boats that ply the waters in April-June generate some 30% of the park's revenue, the rest coming from national government subsidies, grants and donations.

Tubbataha Reef Natural Park is therefore probably one of the most well enforced large no-take areas on the planet. Unusually for such remote reefs, we can also be fairly confident that this is an objective judgement of effective management, thanks to the regular monitoring work undertaken by the TMO and also by visiting expeditions such as the Saving Philippine Reefs (SPR) project of the Philippine NGO, The Coastal Conservation and Education Foundation (CCEF).

Whale shark (*Rhincodon typus*) were seen on several dives within the Tubbataha Reef Natural Park. © Laurent Boillon



Tubbataha ranger station, with one of the remotest volley ball pitches in the world, though available only at low tide! ©Sue Wells

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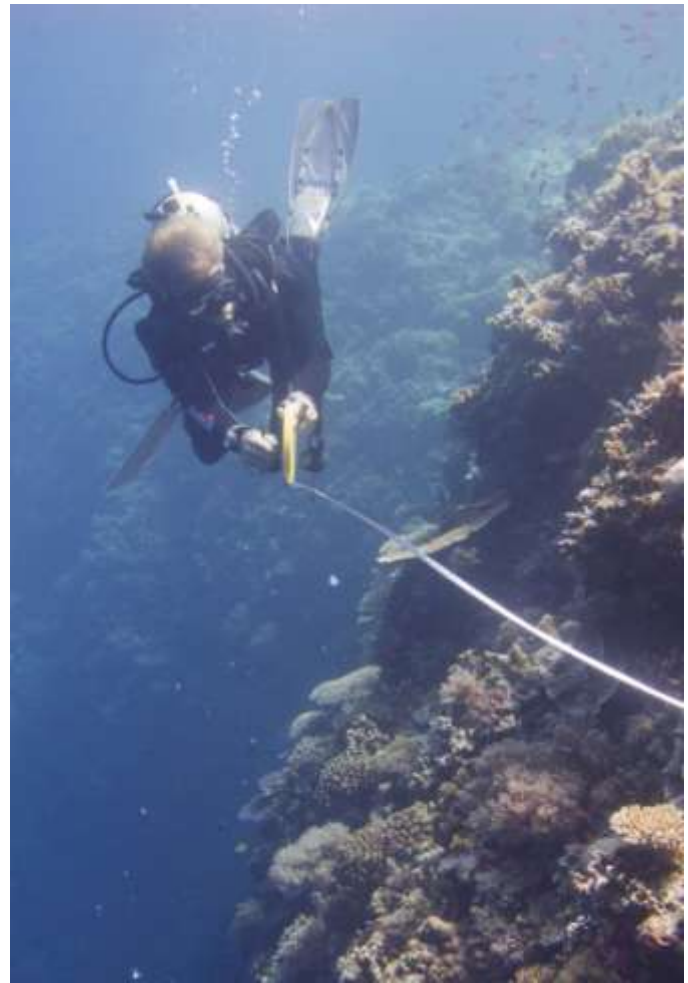
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Reef Currents: Tubbataha Reef Natural Park



In April 2014, the seventh SPR visit was made to the National Park, previous visits having been made regularly since 1984. Expedition members ranged in age from 14 to 80 years, and included diving volunteers from Australia, USA and UK, complemented by the Philippine staff from CCEF. The method used is very simple and is similar to that of ReefCheck. The same method has been used on all visits, with minor modifications, and many of the volunteers are regulars and have taken part in previous trips which helps to ensure consistency in the way that the data are collected. The data collected include:

- bottom cover of living coral, and living and non-living substrates (according to broad categories)
- Fish species diversity and abundance (volunteers with more experience collect this data)
- Abundance of indicator species such as giant clams, lobster, crown-of-thorns starfish
- Presence of large marine life
- General information on threats and conservation efforts within the area

The 2014 expedition found that the living coral cover is stable and higher than it was prior to the bleaching in 1998 so the reef is very healthy and there were few signs of disease or damage. The biomass of fish recorded was higher than it has ever been (Fig. 2), although the density of fish (no. per unit area) appears to be declining which may reflect the increase of larger, predator type fish on the reef. The number of smaller fish has definitely declined.



Laying a transect on the coral covered reef edge of Tubbataha Reef. ©Julia Cichowski



Alan White receives an award from the Tubbataha Management Office for his contribution to protecting the park. © Sue Wells

Overall the results compare well with those obtained through the Park's own monitoring programme on the seven transect sites set up for benthic and fish community surveys. Monitoring over the last 15 years has also shown that the live coral cover has been stable after the bleaching of 1998, when coral cover declined by about 22%. The combined biomass and density of families belonging to commercially important fish such as Acanthuridae, Labridae, Lutjanidae, Scaridae, Siganidae and Serranidae show an increasing trend from 1998 to 2011, which also help to confirm that that fishing activities are absent or very minimal (Dygico *et al.* 2013).

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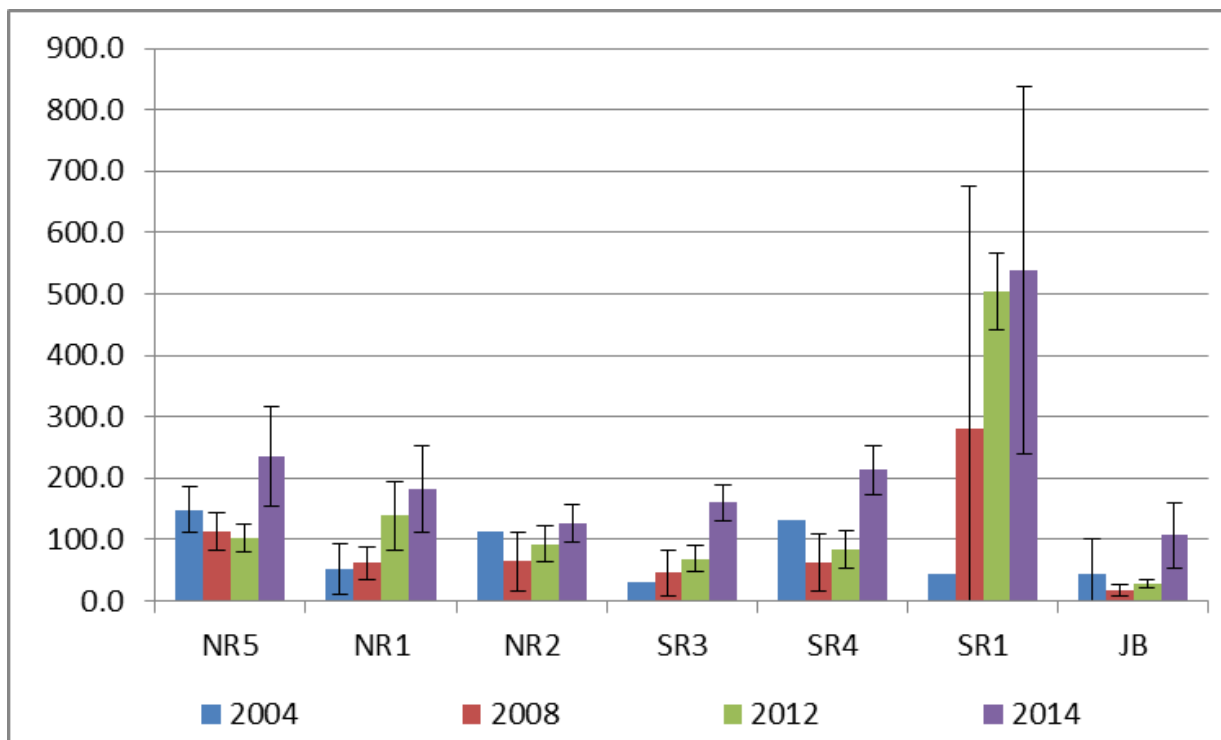


Figure 2. Fish biomass (kg/500 m² – vertical axis) has been monitored at seven locations (SR = South Reef, NR = North Reef, JB = Jessie Beazely) in Tubbataha since 2004 and is shown to be higher in 2014 than in past years.

To have such positive outcomes for an MPA that is located in the global centre of marine biodiversity, central to the Coral Triangle, is a major achievement. This is not to say that there are not threats. There are concerns about the potential impact of ship groundings and pollution given the marked increase in international shipping; there was a 59 % increase in ships passing through the buffer zone from 2009 to 2013. However, an information paper to the Marine Environmental Protection Committee of the International Maritime Organisation (MEPC 67/INF.25) submitted by the Philippines and UNESCO on 8 August 2014, signals the start of a process to seek more formal protection from the impacts of international shipping. This healthy coral reef reflects the consistent planning and implementation of Park management activities conducted by the Tubbataha management team and the joint support of several Philippine government agencies as well as the private sector tourism operators.

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REEF EDGE

Scientific letters or notes describing observations or data

First record of the gold-ribbon soapfish (*Aulacocephalus temminckii*) from Tahiti

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The second author caught an unusual fish (Fig. 1) by handlining off Arue Bay, Tahiti in 350 m at 17°30.3'S, 149°31.3' E on April 9, 2014. It was identified as a soapfish, *Aulacocephalus temminckii*, type locality Nagasaki, Japan. Tahiti is noteworthy as the easternmost record for the species and the most tropical. This species was described by Dr. Pieter Bleeker in honor of Coenraad Jacob Temminck, a famous Dutch zoologist who was the first director of the Natural History Museum in Leiden. Bleeker must have thought highly of him; he named six species of fishes *temminckii*.

The first author collected and photographed this species (Fig. 2) in 1968 in Japan at a depth of 20 m during a visit to the Seto Marine Biological Laboratory in Sagami Bay. That the species could also be found in 350 m seems most unusual until one knows of its antitropical distribution: Japan, China, Korea, and Taiwan in the North Pacific and New Zealand, Kermadec Islands, and Rapa in the South Pacific; in the Indian Ocean, the cool Gulf of Aqaba in the north, and Mauritius and KwaZulu-Natal in the south. To survive in warm Tahiti, this fish needs to live in the cool depth of 350 m. The bulging eyes of the specimen are a result of being brought rapidly to the surface from such depth.

The Gold-Ribbon Soapfish is a moderately rare species. It is very difficult to approach underwater. The first author has been able to take only one fleeting underwater photograph while diving at Norfolk Island in the South Pacific (Fig. 3).

This species is a highly prized aquarium fish, despite its attaining a total length of 35 cm. It should be provided with a dimly lit tank of at least 75 gallons and maintained at a cool 19–22°C (Michael 2004). The common name soapfish was first given to fishes of the genus *Rypticus* of the western Atlantic and eastern Pacific. If soapfishes are confined to a small aquarium and harassed, the surface will become frothy. If other fishes are in the tank, they will soon show stress, and if not removed to clean water, they will die.

The first author learned how potent this toxin is when he speared an adult of the soapfish *Rypticus saponaceus* in the Florida Keys. Not wanting to make a special trip to the dive boat for a single small fish, he put it down the front of his swim trunks. He soon discovered that the skin toxin is a powerful urethral irritant. The skin toxin is very bitter. Suspecting that *Belonoperca chabanaudi* is a soapfish, the author tasted the skin of one he collected at Majuro in the Marshall Islands. It was reclassified as a soapfish in a confirming study by Randall, Smith and Aida (1980).

Aulacocephalus temminckii was classified in the subfamily Grammistinae of the seabass and grouper family Serranidae, along with the genera *Grammistes*, *Rypticus*, *Pogonoperca*, and *Diploprion*. Gosline (1960) elevated the subfamily to a family, and Randall et al. (1971) followed with their study of the toxin (which they named grammistin). They found *Aulacocephalus temminckii* and the two species of *Diploprion* to be the most primitive in having unicellular epidermal glands producing the toxin, instead of the large multicellular dermal glands of the other species. The soapfishes are now back in the Serranidae, currently grouped with *Pseudogramma* and allied genera in the subfamily Grammistinae.

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Reef Edge: Soapfish in Tahiti



Figure 1. *Aulacocephalus temminckii*, off Arue, Tahiti, French Polynesia (T. Tremblay).



Figure 2. *Aulacocephalus temminckii*, Shirahama, Japan (J.E. Randall).



Figure 3. Underwater photograph of *Aulacocephalus temminckii*, Norfolk Island (J.E. Randall).

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Variability in reef connectivity in the Coral Triangle

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The Coral Triangle (CT) is not only the global center of marine biodiversity [Carpenter et al., 2011], but it also supports the livelihoods of millions of people. Unfortunately, it is also considered the most threatened of all reef regions, with rising temperature and coral bleaching already taking a toll [Oliver et al., 2009]. Connectivity between reefs plays a critical role in the reef's capacity to recover after such disturbances [Fernandes et al., 2012]. However, our understanding of the degree of connectivity between reefs is limited by the paucity of observations. Thus, oceanographic modeling efforts to understand patterns of reef connectivity [e.g., Wood et al. 2014] are essential to the effective design of a network of Marine Protected Areas (MPAs) to conserve marine

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Reef Edge: Reef Connectivity in Coral Triangle



ecosystems in the Coral Triangle [McLeod et al., 2010; Ministry of Marine Affairs and Fisheries, 2008]. We combine a Regional Ocean Modeling System developed for the Coral Triangle (CT-ROMS) with a Lagrangian particle tracking tool (TRACMASS) to investigate the probability of coral larval transport between reefs. Here we used a 46-year hindcast run to investigate the variability in larval transport following the annual mass spawning event in April.

Modeling reef connectivity in the Coral Triangle (CT)

Our approach separates the physical and biological processes of connectivity (Figure 1, following Mitarai *et al.* [2009] and Watson *et al.* [2012; 2010]). Here we present initial results of the “potential connectivity” between reefs in the Indonesian sub-region of the Coral Triangle following the annual spring mass spawning event. Potential connectivity represents the role of physics in larval dispersal and is calculated as the probability of larval transport between a source reef and a destination reef [Watson *et al.* 2010]. In future work, we will combine the potential connectivity with biological factors such as reproductive output, larval mortality and competency to settle to calculate “realized connectivity” (Figure 1).

We use the offline particle tracking tool TRACMASS [Watson *et al.*, 2012] to calculate the trajectory path of particles representing coral larvae passing through each grid cell of a high-resolution model of the Coral Triangle region (CT-ROMS). CT-ROMS has an average spatial resolution of 5 km, explicitly solves the tides, and accurately captures regional temperature and circulation patterns [Castruccio *et al.*, 2013]. As in previous coral connectivity modeling studies [e.g., Wood *et al.* 2014], we model coral larvae as passive tracers because swimming behavior of coral larvae is not strong enough to fight horizontal currents and vertical migration is observed primarily after larvae have become competent and are actively exploring the substrate for places to settle [e.g., Szmant and Meadows, 2006; Pizarro and Thomason 2008]. The particle trajectories are calculated offline using the CT-ROMS velocity fields, which makes it possible to calculate many more trajectories than particle tracking performed online.

This work improves upon previous attempts to simulate reef connectivity in the region, as the 5-km resolution better simulates reef-scale circulation features that drive larval transport (e.g. Figure 1) and

the 46-year simulation allows the interannual variability in reef connectivity to be assessed. Particles representing coral larvae were released from each coastal cell at midnight on the evening of the April full moon each year over the 1960-2006 historical simulation. Particles were released from each of four oceanic coastal CT-ROMS grid cells, which together we define as a site in order to optimize the number of particles released at each site and total number of sites. The Lagrangian probability density function (LPDF) of particle displacement was calculated after the end of the typical advection period of coral larvae (the pelagic larval duration or PLD) following Mitarai *et al.* [2009]. We released twenty-five particles from each grid cell as an initial proof of concept, realizing that this may not fully sample the Lagrangian PDF. Potential connectivity, the probability that a particle from one site reached another site at the end of the PLD, was then calculated for each pair of source and destination sites by normalizing the Lagrangian PDF by the area of each destination site [Watson *et al.* 2010]. Potential connectivity is strongly dependent on PLD, such that the longer the PLD, the greater the chance for long-distance dispersal. In reality, many coral species have larvae that settle over a wide range of PLDs from 3 to >30 days and in rare instances to >100 days. Here we present the connectivity for a PLD of 30 days, as the majority of settlement occurs within the first few weeks of spawning [e.g., Nozawa and Harrison 2008, Tay *et al.* 2011].

Historical Connectivity (1960–2006)

Consistent with previous work [e.g., Gilmour *et al.* 2009; Kool *et al.* 2011; Wood *et al.* 2014], we find a high probability of self-seeding for reefs throughout the CT region at the patch-scale we have used (Figure 2c), with a higher probability of self-seeding with shorter PLDs (results not shown). Notable exceptions highlight key source reefs and potential pathways for larval dispersal that may promote diversity and recovery following disturbance events. For example, as observed by Kool *et al.* [2011] and Trembl and Halpin [2012], connectivity was high among nearby reefs within and across ecoregions defined by Veron *et al.* [2009] (Figure 2), particularly among reefs within the Halmahera, Banda/Molucca Seas, and Makassar Strait. Although long-distance dispersal (over a few hundred km) was generally rare, a high probability of long-distance dispersal was observed between a few key source and destination regions. In particular, there

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The News Journal of the International Society for Reef Studies
 Reef Edge: Reef Connectivity in Coral Triangle

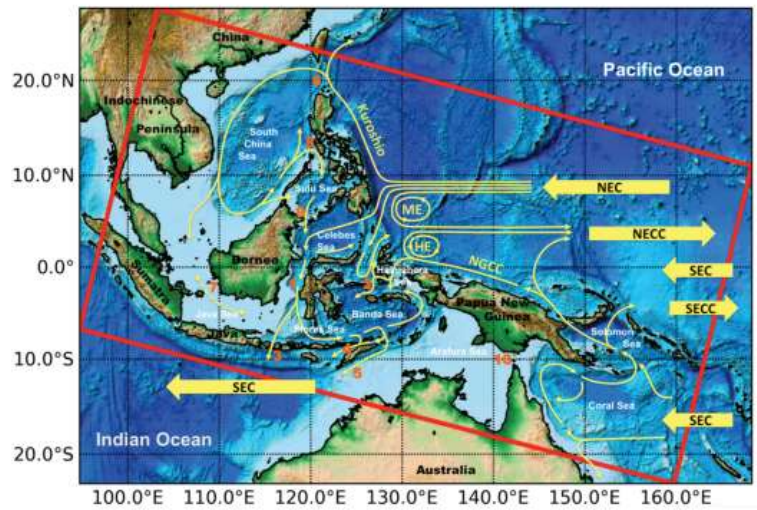
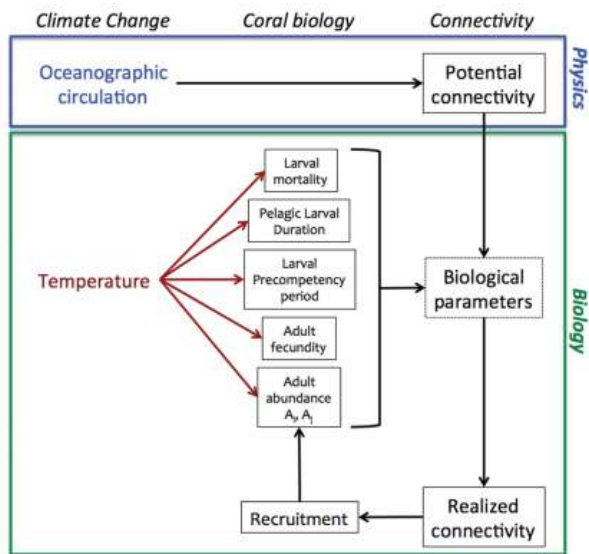


Figure 1: (left) How climate-driven changes in ocean circulation and temperature affect different aspects of connectivity. (right) Schematic of ocean circulation in the CT region [Castruccio et al., 2013]. Dashed orange line delineates the Coral Triangle [Veron et al. 2009].

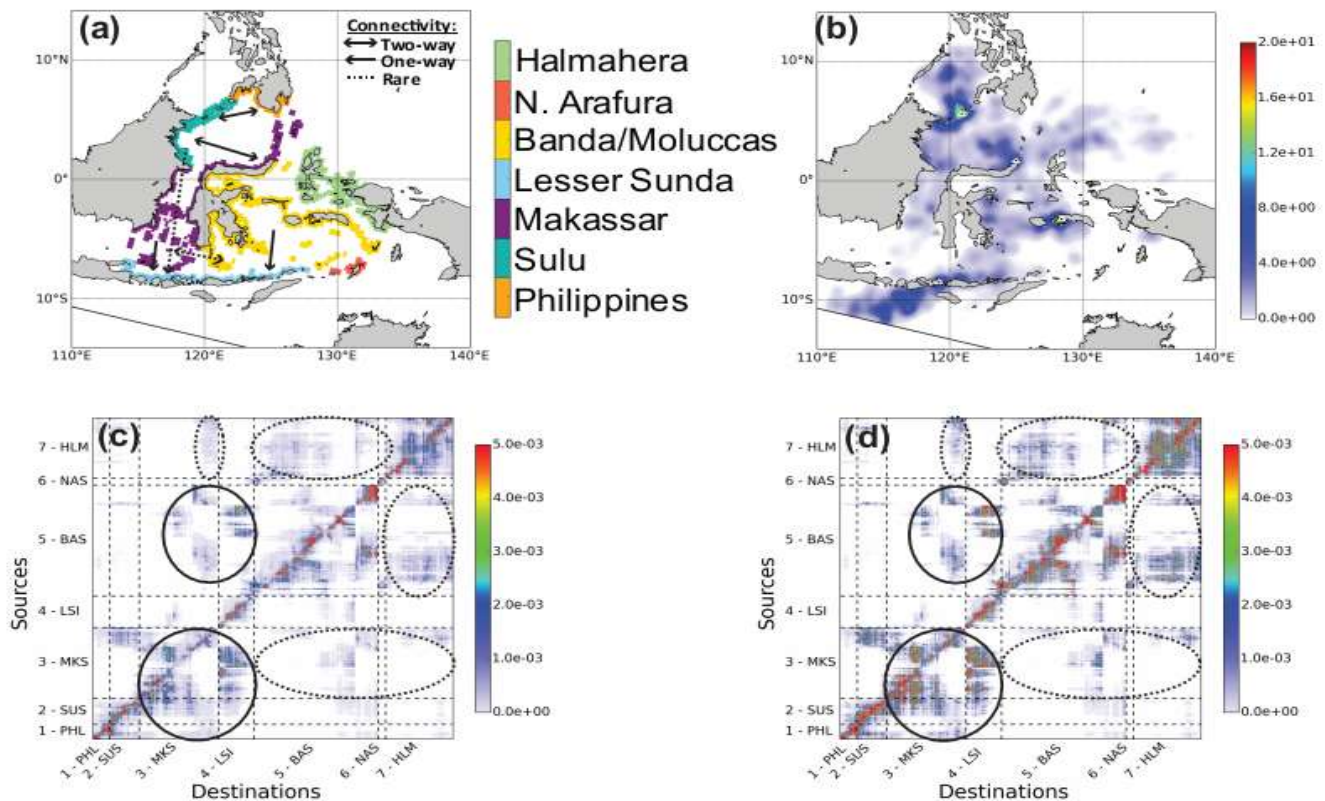


Figure 2: Potential connectivity in the central CT region based on yearly April releases and a 30-day pelagic larval duration over the entire 1960–2006 historical ROMS simulation. (a) Particle release sites based on ecoregions defined by Veron et al. [2009]: Halmahera (HLM), North Arafura Sea (NAS), Banda/Moluccas Seas (BAS), Lesser Sunda Islands (LSI), Makassar Sea (MKS), Sulu Sea (SUS), Philippines (PHL); (b) An example of the Lagrangian PDF 30 days after release from four reefs (black triangles); (c) Mean and (d) standard deviation of potential connectivity calculated from the Lagrangian PDF for all reef sites shown in (a); sources (y-axis) and destinations (x-axis) are subdivided (dashed lines) by ecoregion. Self-seeding (particles settling within their release location) plots along the diagonal. Solid (dashed) lines highlight key common (rare) pathways of larval connectivity discussed in text.

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The News Journal of the International Society for Reef Studies
Reef Edge: Reef Connectivity in Coral Triangle



was a high probability of dispersal between the Makassar and Banda/Moluccas Seas regions and the Lesser Sunda Islands (>300 km), consistent with the southward flow of the Indonesian throughflow towards the Lesser Sunda Islands (Figure 1). Although more rare, some long-distance transport was also observed along this southward flow between the Sulu Sea and the Lesser Sunda Islands (>1000 km). Kool et al. [2011] and Trembl and Halpin [2012] also found connectivity between reefs of the Makassar and Banda/Moluccas Seas and the Lesser Sunda Islands, but long-distance dispersal between the Sulu Sea and the Lesser Sunda Islands was absent or limited in these previous studies.

We also calculated the source and destination power of each site within the domain to identify the reefs that may play a key role in connectivity and serve as potential targets for Marine Protected Areas (MPAs). Source power was calculated as the sum of the probability that particles released from the site successfully reached a settlement cell (including self-seeding), while destination power was calculated as the sum of the probability of larvae arriving to the reef from any source location (including the settlement location itself). Over the historical simulation, the Banda/Molucca and Halmahera Seas were on average both major source and destination regions for coral larvae following mass spawning in April, including high levels of self-seeding. The Lesser Sunda Islands also served as a major destination region for coral larvae advected southward by the Indonesian throughflow transport.

Dominant modes of connectivity variability

Strong temporal variability was observed about the mean pattern of connectivity over the 1960-2006 simulation such that the standard deviation of connectivity over the historical period was the order of the connectivity probabilities themselves (Figure 2d). The degree of self-seeding and connectivity within ecoregions was highly variable from year to year, particularly among reefs in the Halmahera, Banda and Makassar regions. Strong variability was also observed in the connectivity between the Makassar and Banda/Moluccas Seas regions and the Lesser Sunda Islands, consistent with interannual variability in the strength of the Indonesian throughflow.

As a result, the power of the key source and destination reefs also varied considerably over the

historical simulation, with the standard deviation of source and destination power typically about twice that of the mean (Figure 3, center). Potential connectivity calculated from April releases during only major El Niño (1966, 1983, 1987, 1998) and La Niña (1974, 1975, 1989, 1999, and 2000) years revealed that some of this year-to-year variability in source and destination power may be driven by changes in circulation associated with El Niño-Southern Oscillation (ENSO) (Figure 3, right). For example, the increase in source and destination power (self-seeding) in the Halmahera eddy (HE) region during La Niña years may be associated SE migration of the HE (Figure 3, red; [Kashino et al. 2013]). Further, the overall decrease in destination power throughout the CT region during La Niñas (Figure 3, blue) may be attributed to a greater loss of larvae from the domain associated with an increase in the strength of the Indonesian throughflow. The stronger throughflow and SE shift in the Halmahera eddy during the La Niña phase resulted in greater settlement in the Halmahera region (Figure 3, red), and less in the Lesser Sunda region (Figure 3, blue).

Although some regional patterns of potential connectivity variability may be associated with changes in transport between ENSO phases, singular value decomposition of the connectivity matrices over the full historical period suggest that potential connectivity variability is stochastic and is not significantly associated with any of the main modes of Indo-Pacific climate variability. The top two principal components (PCs) explain only ~15% of the variance and are not significantly correlated with the Dipole Mode Index (an index of Indian Ocean Dipole variability, Saji et al. [1999]), Niño 3.4 SSTs (an index of ENSO variability, Smith et al. 2008), the El Niño Modoki index (an index of central-Pacific style ENSO events - Ashok et al. 2007) or the Interdecadal Pacific Oscillation index (an index of Pacific decadal variability - Parker et al. 2007). These results suggest that the physical drivers of reef connectivity (i.e., advection) relate to local small-scale eddies within the CT, which can be modeled as a stochastic process (although some of this stochasticity may be due to under-sampling of the Lagrangian PDFs); nonetheless, the temperature anomalies in the CT region associated with these major modes of variability (Kleypas et al. [in prep]) are likely to play a role in realized connectivity variability (through the effects of temperature on the pre-competency period and mortality, for example).

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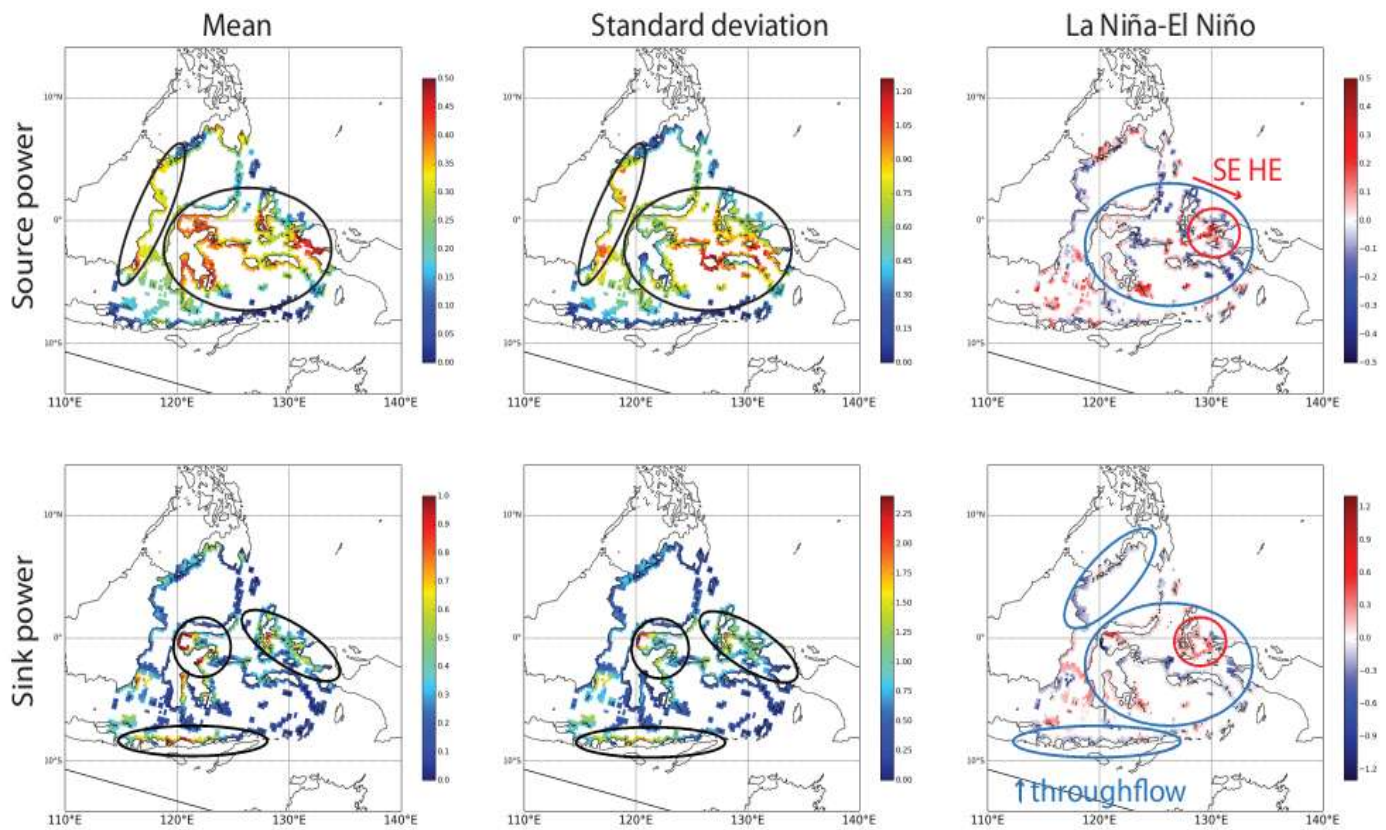


Figure 3: The mean (left), standard deviation (center) and difference between La Niña and El Niño (LN-EN, right) years of source power (top) and destination power (bottom) for a 30-day PLD. Source power is the sum of the probability that particles released from the site successfully reached a settlement cell (including self-seeding) and destination power is the sum of the probability of larvae arriving to the reef from any source location (including the settlement location itself). We highlight key source and destination regions and variability associated with the Halmahera eddy (HE) and Indonesian throughflow discussed in text. Source and destination power for ENSO years were calculated from the potential connectivity for the April releases that occurred during the major La Niña and El Niño events of the historical period (La Niña: 1974, 1975, 1989, 1999, 2000; El Niño: 1966, 1983, 1987, 1998). Red indicates where La Niña conditions result in stronger source or destination power, and blue where El Niño produces stronger source or destination power.

Conclusions and ongoing work

We present the first high-resolution analysis of potential connectivity and its variability through time over the historical period in the Coral Triangle region. The results highlight key source and destination regions that may serve as targets for MPAs, particularly the Banda and Halmahera Seas and the Lesser Sunda Islands. However, we find that the strength of the source and destination power of these regions varied considerably between 1960 and 2006. Although some regional patterns in connectivity variability may be associated with differences in transport between ENSO phases, connectivity variability in the Coral Triangle was highly stochastic over the full historical period.

These initial results are part of a larger project that aims to identify reefs in the Coral Triangle that may act as refugia from climate change [Kleypas et al., in prep.] and those that may promote connectivity and recovery following disturbances [Thompson et al. in prep.]. After expanding the analysis of potential connectivity to the full CT-ROMS domain with enough particles to effectively sample the LPDF, we will add biological factors to model realized connectivity in the Coral Triangle (e.g., including the effects of temperature and vertical advection of the coral larvae). Finally, to assess how reef connectivity may change in response to rising temperature and changing circulation patterns, we will also model reef connectivity under two future climate change scenarios (the two extreme end members with estimated warming of 2.6 or 8.5 W m⁻² in the year 2100).

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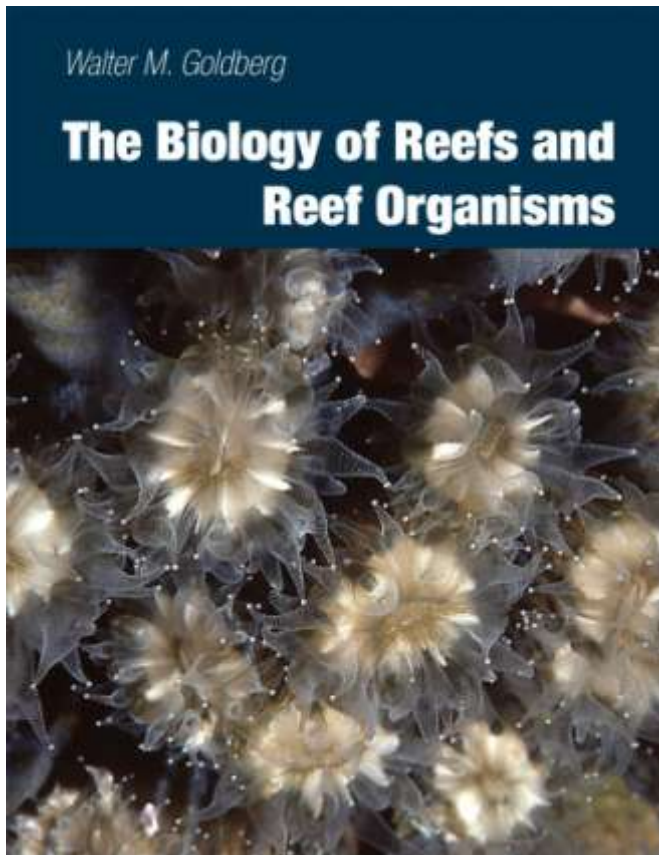
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BOOK & PRODUCT REVIEWS

Reviews of books, software, hardware and other products

A New Basic Training Bible for Coral Reef Scientists and Conservationists



The Biology of Reefs and Reef Organisms, Walter M. Goldberg. University of Chicago Press, e book \$7 to \$44, paperback \$55, clothbound \$145.

Reviewer: Les Kaufman, Boston University Marine Program and Conservation International

When my colleagues and I were graduate students we were totally into coral reefs simply because they and a life of studying them were both so incredibly cool. Decades have passed, and while we all still see ourselves as young and continue to tackle hair-brained feats of field work, our knees and our telomeres tell a different story...and they are not all that's changed. Near their best when we were at ours, in the stunningly short space of half a lifetime the world's coral reefs have melted before our eyes into other things, from multihued to brown, from labyrinthine to

flattened, from hard and waxing to brittle and waning, from boom towns glutted by fishes to ghost towns gutted of inhabitants. Geologically we stand at a spectacularly exciting temporal crossroad: the terminus of an epoch of spectacular carbonate accretion and wild marine biological diversification on tropical reefs. If only it weren't also so incredibly depressing. Now it is our job to train a new generation of coral reef scientists- natural, social, and synthetic- on whose shoulders fall a massive exercise in clinical ecology: the stewarding of our most diverse, productive, and beloved of marine ecosystems into a more certain future in spite of all that we are and all that we have done.

Fortunate are those who can snorkel or dive in the company of master naturalists, learning the names and meanings of all the biological bits and pieces that make up a reef in a first-person apprenticeship. With the explosive growth of molecular biology, the mass of basic information that students are expected to absorb has mushroomed, and natural history has largely been relegated to the top-heavy pile of stuff that students are expected to "get on their own." It is good that we have great and readily available illustrated field guides to underwater life these days, but field guides fail to place particulate information, rife with disconnected names and facts, into the context required for most folks to retain and make use of it. As a result, students simply fail to become good naturalists, meaning they also risk failing to become good scientists: for professors, a torturous dilemma. Thus, as a staunch opponent of mental anguish, I celebrate Goldberg's "The Biology of Reefs and Reef Organisms." This is a book I wish we'd had at our own beginning.

At first, the book may strike some as shockingly old-fashioned, progressing as it does through fundamental material on the biology and geology of coral reefs, followed by the familiar and somewhat taxing taxonomic parade of reef-dwelling phyla. Others may fault the book for not being focused more on the causes and consequences of coral reef decline. If so, they are missing something, big-time. The last five chapters of the book do an excellent job of broaching issues fundamental to coral reef conservation while

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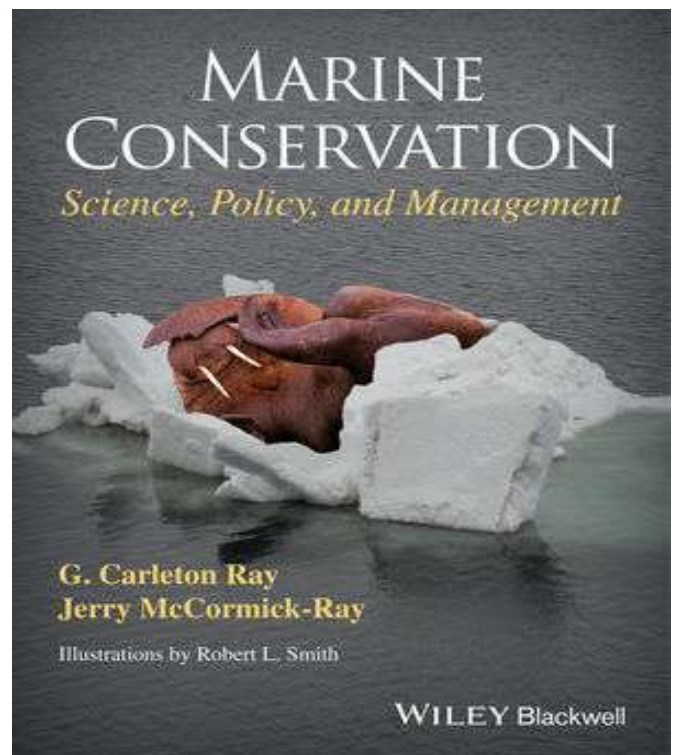


avoiding both emotional hyperbole and the frequently jarring jump from science to policy that we see in other treatments. Chapter 12, on the functional roles of fishes on coral reefs, lays down one foundational pillar of the science-policy bridge by exploring drivers of coral reef community structure through the windows of herbivory, corallivory, and eutrophication. Chapter 13 offers a concise but comprehensive review of tropical reef history, obviating the need for students to digest the excellent but massive (and expensive) primary sources that are available on this subject...and making collateral readings from that literature that the professor may assign much more approachable. Chapter 14's overview of coral reef biogeography confronts important and interesting issues in diversity, evolution, dispersal, and community structure of corals and other reef organisms. At this point the student is at last truly ready to consider the status and future of coral reefs in the context of human impacts. This is accomplished beginning in Chapter 15, "Reefs now and in the next 100 years." What I love about this chapter is that it moves from first principles to issue writ large, moving through the carbon cycle, CO₂ in the ocean, and matters of public well-being. The narrative then glides smoothly into effects of atmospheric chemistry on calcification, coral bleaching and the potential confound between temperature and irradiance as driving factors in coral bleaching. The relationship between climate cycles and climate change, bleaching and disease, and the nature and interpretation of coral disease more broadly are all thoroughly considered. The chapter concludes with an explanation of direct, indirect, and cumulative human impacts on coral reefs, bringing herbivore-coral dynamics back into the fold from a systems perspective. The final chapter of the book covers coral reef conservation from this larger point of view, encompassing the concepts of resilience, phase shifts, the functional role of biological diversity, and relevant case studies. The chapter concludes with a brief discussion of conservation interventions. I would have preferred a much more in-depth treatment of how all of the science so well explained in earlier chapters could now be brought to bear in the interest of keeping coral reefs around for our own benefit (they'll be fine again, as they've been before, once we've been off the stage for a while). Can't have everything.

This book has few comparables. For example, Sheppard, Davy and Pilling's 2009 "Coral Reef Biology" is a good one, smaller and half the price of Goldberg in soft cover, but understandably not as thorough, nor as

impressively crafted and illustrated. The softcover version that I have is well bound and also will soon be bound for a field course in Belize, so we'll see how well it actually holds up under real world conditions. It is large and heavy, so current baggage restrictions being what they are, it is available as an e-book. Of course, we are blessed with a plethora of more specialized texts, scientific anthologies, and disciplinary treatments about all of the topics covered in Goldberg's book, and most college-level courses will be making extensive use of these and the primary literature as supplementary readings. As a general text on coral reef biology for college undergraduates, entry-level graduate students, or very advanced high school students, this one as yet has no equal. It is the best this reviewer has seen and I've adopted it for the mixed upper level undergrad and graduate courses on coral reef ecology and conservation that I teach. Hopefully, in coming years Goldberg's treatise will see both frequently updated editions, and pretenders to its throne. We are witnessing an event of majesty and horror that is both preventable (though too late for that) and reversible (if we act hard and soon). This book is an essential tool in the campaign to ready our successors for the wonder, the discoveries, and the battles that lie ahead.

Conserving the Marine Environment in the First Century of the Anthropocene.





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Book & Product Reviews: Marine Conservation

Marine Conservation: Science, Policy & Management, G Carleton Ray & Jerry McCormick-Ray.

Wiley Blackwell, 370p. (ISBN 978-1-118-71444-7), e-book \$63.95, paperback and Wiley e-text \$79.95, hardback \$149.95.

Reviewer: John Ogden, Emeritus Professor, University of South Florida. jogden@usf.edu

Since the founding of the International Society for Reef Studies, the population of the world has nearly doubled to over 7 billion. Five decades ago, our founders were entranced by the beauty of coral reefs and fascinated by the patterns of distribution and abundance of reef biodiversity. Insidiously, relentless population growth and resource needs have extended the human footprint to even the most remote corners of the world's oceans. Once viewed as remote from most threats, coral reefs have relatively narrow environmental requirements and have suffered from human impact to the extent that there are few reefs anywhere which appear or function as they did a half a century ago. Their decline has attracted the attention of scientists, conservationists and the public. Thus there are many management and conservation plans, but these have generally not been sufficient to reverse the trend. The current almost complete dominance of global ecosystems and resources by humans has given rise to the compelling jargon-- Anthropocene.

The plight of coral reefs reflects the general worldwide decline in the marine environment. This is ample justification to gather the myriad skeins of research and practice in marine conservation into a clearly written and superbly illustrated large format book. Following their 2004 book (*Coastal-Marine Conservation: Science and Policy*, Blackwell) the book is intended to be a text for advanced undergraduate and graduate students. It continues and expands their earlier emphasis on the key role that understanding of the biology and ecology of species and ecosystem science play in conservation and the important lessons gained from case studies around the world. The list of 46 strategically recruited authors of case studies and text boxes includes 9 international colleagues and reads as a *Who's Who* in marine research and conservation practice.

The first 5 chapters by the authors outline the history of marine conservation, the major issues, the various

policy instruments of conservation and governance, and the key characteristics of marine ecosystems that are the targets of conservation. The summary of US and international conservation policy reflects its *ad hoc* development, overlap and duplication. Yet with leadership and political will, management and conservation are being implemented in places that are functioning ecosystems with unique characteristics and responses to environmental change. We may expect that a diversity of places around the world will respond to management by similar policy and management actions.

The next 7 chapters are case studies written by experienced practitioners and covering unique places where conservation has had some success. Three of the cases are the focus of much of the authors' research and appeared in their 2004 book: the Chesapeake Bay, an extremely well-studied area in a very populous region; the Bering Sea with charismatic walruses; and the tropical island nation of the Bahamas with coral reefs and an early marine protected area. Additional case studies are: the relatively remote regions of the Isles of Scilly and the Gwaii Haanas National Park in British Columbia with indigenous populations; the coastal and shelf areas of South Africa and Argentine Patagonia dominated by major ocean currents, strong seasonal variations and important fisheries. The Patagonia seascape chapter, written and beautifully illustrated by Claudio Campagna and colleagues is particularly fascinating for its seasonal gathering of charismatic whale, pinniped and penguin species on the remote Patagonian coast of Argentina. Notable are the spatial conservation techniques which the authors have proposed for the enormous continental shelf and ocean area which sustains them as well as major offshore fisheries.

While one might quibble that the case selection does not include sites in the Mediterranean, Asia, the Wider Caribbean or the Pacific, where marine conservation is well-advanced in some places, the case studies nevertheless provide global coverage and illustrate the diversity of approaches and techniques used in contemporary marine conservation.

Scattered through the book are 37 tightly written and informative text boxes by prominent scientists, conservationists and policy-makers highlighting particular concepts and adding relevant details. These short essays, most of which can stand alone, are useful

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The News Journal of the International Society for Reef Studies
Book & Product Reviews: Marine Conservation



gems of clarity and composition but they unfortunately are not listed by title in the Table of Contents and appear in the Index only by page number. Unfairly singling out several text box authors out of so many, I particularly liked Paul Dayton's lead essay on the importance of studying nature outdoors. James Estes's summary of the lessons learned from the effort to protect sea otters in Alaska shows that conservation has surprises and that preconceptions can be wrong. Other boxes cover management of particular fisheries, marine protected areas, invasive species and restoration to name just a few topics. Conservation requires a deep naturalist's sense of place which only develops over time and experience--precisely the attributes that are getting scarce in this era of computer technology, social media and the compulsions of instant communication.

The list of human disturbances to the oceans is reasonably well known and the mechanisms of disturbance are generally understood. Not so well understood is the geographic scale on which any particular disturbance operates and the scale at which it must be managed. Clearly global impacts including ocean warming and acidification linked to increasing atmospheric CO₂ and greenhouse gases cannot be managed locally or regionally and will require international policies with incentives for the many nations struggling to develop their economies. Land-based pollution and nutrification are coastal and regional in scope and have proven manageable where there is political will to implement contentious and expensive treatment of runoff, effluents and waste disposal. Other impacts, such as fishing of demersal and reef-dwelling species, have been successfully managed almost everywhere through reasonable fishing regulations and spatial management measures, such as marine protected areas and seasonal closed or no-take zones.

The structure of the book is very similar to 2004. An opportunity is missed to extend the seascape concept as an organizing principle, which is presented in Chapter 5, to coastal and marine spatial planning (CMSP) and ocean zoning. These are given very short shrift in the text which is notable given recent major policy developments, to say nothing of major spatial planning and zoning programs in Europe and elsewhere. While it is true that spatial approaches to ocean management and conservation are politically contentious, largely because they are opposed by entrenched sectors such as the fishing and minerals

VOLUME 29 NUMBER 2 August 2014

industries, they also have an undeniable logic given what we know about connectivity in the marine environment. The sea is different from the land, but spatial approaches and zoning have been used with success in landscape planning almost anywhere humans gather into villages, towns and cities. There is little doubt that the approach will work in the ocean.

Conservation must take into account and protect not only charismatic flora and fauna, but also the surrounding, inter-connected habitats that sustain and support biodiversity. CMSP is a natural outgrowth of informatics and visualization techniques which are used to organize what is known and to test future scenarios. CMSP strengthens the conviction that the geographic scale of conservation and management must be increased to match the scale of human disturbances and of the ecological and oceanographic processes that sustain biodiversity.

No one knows what nearly 11 billion people, predicted at the end of the century, will do to the earth's support systems. In spite of much that we read and hear, no one can reliably predict the future beyond a few years. The current threatened state of the ocean environment and coral reefs has caused some to provocatively declare that conservationists value hope over truth and that corals and reefs, for example, have no future. They will exist only in a few places under intense management and husbandry, akin to agriculture (Bradbury and Seymour 2009). This prediction is at best a gross over-simplification, but I agree with them that coral reef management will have to invent whole new approaches which take into account the geographic and time scales of human impacts. We must embrace new techniques in restoration and approach management simultaneously at local, regional and global levels if reefs are to have a future and this book helps to show the way forward.

A new generation of conservationists, scientists and managers is needed with field experience, a naturalist's sense of the biology and ecology of marine organisms, a solid grounding in science and the increasingly quantitative tools of informatics and modeling, and a global view. Carleton and Jerry McCormick-Ray have spent their combined century-long careers in the study of marine biodiversity and in the practical application of science to management and conservation. This thorough, accessible, scholarly and lavishly illustrated text book with diverse contributions from many experienced scientists and

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Book & Product Reviews: Coral Finder

practitioners will provide a solid underpinning for future careers in conservation as well as informing the public, holding in turn the possibility of future success in living sustainably with the marine environment.

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Identify that Coral!

Indo Pacific Coral Finder (First edition)

Russell Kelley, Australian Coral Reef Society, 2009



BYO Guides & Russell Kelley, P.O. Box 1859, Townsville, QLD 4810, Australia

ISBN 978-1-646-52326-2 (durable plastic spiral-bound) US\$67 plus shipping

Reviewer James Maragos, U.S. Fish & Wildlife Service and Affiliate Faculty, University of Hawaii (This is a previously unpublished review of the first edition of *Coral Finder*, the second edition of which has recently been published, and is further discussed in the article beginning page 23)

Finally there is a stony coral guide available that can be

used in the field by anyone! *Coral Finder* is a concise 35-page guide relies on excellent organization, simplicity, and an exceptional array of coral photographs to identify 71 genera of stony corals found on coral reefs in the Indian Ocean, Coral Triangle, Pacific Ocean, and adjacent seas, including 66 of the most common scleractinian genera and five other octocoral and hydrozoan genera. Russell Kelley has done a tremendous job in organizing and producing a guide that covers all coral genera, except for a few rare Indo-Pacific genera and genera limited to Caribbean-Atlantic region.

Reef corals have always been difficult to identify and describe because they are able to change their shape and color depending on habitat and depth. Most are part animal, part plant and colonial, with the living parts only a small fraction vis-à-vis their skeletons. They don't resemble "higher" animals, and the English language is not particularly useful for describing them. Photographs are really the best means to learn stony corals, and the *Coral Finder* emphasizes photographs of living corals but also includes coverage of the essential fundamentals of their taxonomy, skeletal features, tissue features. Even for users turned off the technical terms, they can simply leaf through the 30 plus pages of coral photos to identify a particular coral during a dive, take photographs and identify it to genus after the dive, or consult *Corals of the World*.

There is not a wasted page in the *Coral Finder*: the innovative front cover serves as the starting point that is both a table of contents and a key, including photos, of the eight morphological categories within which the 71 coral genera are assigned. The key is simple and short. This arrangement allows more experienced coral enthusiasts to move directly to the "correct" page in the guide but also helps novice enthusiasts understand the full range of the growth forms and morphology of corals. It can be taken underwater, and the front cover may be placed near any coral in question to determine which of the photos and categories best resembles the coral in question. A clear plastic sheet protects this critical page from being scratched during dives.

The inside front cover of the guide, "How to Use", is a concise, well written introduction covering organization, definition of a genus, and tips and tricks on how to use the guide. The facing page includes a well illustrated diagrammatic glossary that sticks to the

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Book & Product Reviews: Coral Finder



basics and includes a vignette, "Coral Lingo" that defines only the essential technical terms to help differentiate various genera. This page also helps the user navigate through the rest of the *Coral Finder* and better understand the same terms often used in other guide books on corals. The next introductory page includes an "A-Z Index" that lists pages where each genus is mentioned, a useful shortcut for the experienced.

The heart of the *Coral Finder* are numbered pages 1-29 that include 580 photos and other guidance for all 71 genera, with each assigned to one or more of the eight morphological categories of the key introduced on the front cover of the guide. All main pages within each category are coded the same color and include page tabs to allow the user to access the pages and categories without leafing through the rest of the guide. This is especially important for divers and snorkelers distracted by their surroundings and impaired by limited vision and dexterity.

The top of each main page lists the defining terms of the category, and the rest of the page includes 15 photos of corals, arranged three each on five rows that include full colony and close-ups of living corals. Along the right page margin are five additional photos (one for each row) that illustrate the skeletal features together with a listing of the key morphological characters of the coral genus covered in each row. Along the top of each row are the volume and page numbers of the genus covered in *Corals of the World* (J.E.N. Veron 2000) for those who want to identify a particular coral to the species level. The left page margin includes the name(s) of the genera covered on each page. The species names of all photographed corals are also listed near the top of each page, and comments on similar genera and their pages are listed along the bottom margin of each page. Photographs used on these pages and the rest of the guide are excellent and contain the important characteristics of each coral genus. It is clear that Russell Kelley solicited coral photos from many sources, and all contributors are acknowledged.

The back inside page of the guide includes a white sheet bordered with various color scales. The top margin of the page includes a reference scale for photo color corrections, useful for underwater photography. The top margin includes a 20 cm long scale bar that can be used underwater to measure

various parts of corals. The left and bottom margins are additional color scales, with alphanumeric codes corresponding to those published by *CORALWATCH*. Color scales can be used to estimate and record the color and condition of *in situ* corals. This is useful because the perceived colors in available light will change at greater depth due to attenuation of especially the red and orange parts of the color spectrum. Thus, use of the color scales underwater may assist accurate recording of coral color.

The rest of back inside page is blank to serve as a white balance reference for photographers or to record notes during a dive using a soft pencil. The next page is clear plastic, protecting notes from being accidentally erased. Both sides of the back cover are blank white, and the cover itself is thick (2 mm) and strong enough to protect the guide during dives and serve as a writing tablet for additional notes. Alternatively, underwater writing paper can be clipped to the back cover that would then function as a clipboard. The back cover extends 2.5 cm beyond the bottom of the rest of the guide and includes two 1-cm diameter holes for attaching the *Coral Finder* to a line or clip.

My overall evaluation is that the *Coral Finder* is magnificent and recommended for all coral enthusiasts, even for experts like me who occasionally forget a genus name during a dive. Although the *Coral Finder* is intended for identification of stony corals to the genus level, the guide lists the names and provides photos for more than 170 species of corals. I was able to use the *Coral Finder* over a month long period and found it still durable and intact after more than 100 dives. The plastic materials used in the guide, including the spiral binder, did not weather, corrode, or break, and the guide was maintained by rinsing in fresh water and drying with a towel. The *Coral Finder* would also be useful as a textbook for students, reef lovers, and law enforcement officers charged with the responsibility of protecting corals and reefs.

Some may find the *Coral Finder* a bit pricey, but I've never seen anything else out there like it.

REEF SHELF

Details of new on-line reports and manuals

Reef Rehabilitation for Managers

Reef Rehabilitation Manual. Edwards, A.J. (Ed.) (2010). Coral Reef Targeted Research & Capacity Building for Management Program: St. Lucia, Australia. ii + 166 pp. ISBN 978-1-921317-05-7.



Reef restoration continues to be a topic of immense interest and debate. Some of the issues and dilemmas surrounding it were touched on in *Reef Encounter* 36 (June 2008)¹ and others are discussed in the *Reef Rehabilitation Manual*² published in 2010. The latter is freely available to managers and others interested in coral reef rehabilitation (<http://gefcoral.org/Tools/tabid/3279/language/en-US/Default.aspx>) and was the result of collaboration by researchers working on the GEF/World Bank Coral Reef Targeted Research (CRTR)

program, the European Commission's REEFRES (*Developing ubiquitous practices for restoration of Indo-Pacific Reefs*) project, and the Coral Reef Initiatives for the Pacific program championed by France.

At the core of the Manual is a summary of advances made in both asexual and sexual rearing of corals for reef rehabilitation. Thus one chapter focuses on how to construct and manage sea-based nurseries to farm coral fragments and another on how to rear coral eggs or larvae, settle them on to substrates and then grow them until large enough to be transplanted to degraded reef patches. Both give detailed guidance on how to rear tens of thousands of coral transplants in ways which minimise collateral damage to source reefs and are cost-effective.

The rest of the Manual mainly seeks to put these active reef restoration techniques into a broader coastal management context. This is important because already there are those who read of "reef restoration" and mistakenly think that the technology is there to routinely create (with artificial reefs) or transplant coral reef ecosystems. Thus why not approve the destruction of this reef for a port development or that reef for an airport? There is the danger that a perceived ability to carry out active restoration may therefore be (mis-)used as an excuse for destroying reefs by some decision-makers. The Manual therefore stresses the limitations of our current knowledge, the small scale of the limited successes achieved to date, and the significant risk of failure for restoration projects as a result of unpredictable disturbances such as bleaching events, storms, predation and disease. It also suggests ways in which such risks might be minimised. Some active restoration projects appear to be both short-term and lack any integration into broader coastal planning and suffer as a result. The Manual stresses that a long-term outlook is needed and it is only by understanding the broader environmental, social, economic and political context of what you are attempting in reef restoration that you are likely to succeed.

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Shelf: New on-line Publications



For those charged with managing reef areas, active restoration should be seen as just one tool in their armoury of management approaches. Because effective management of local human activities that are damaging the reef needs to be in place before active techniques have a reasonable chance of working, active restoration techniques such as coral transplantation should be seen as a weapon of last resort. That is, only when it appears that natural recovery processes are not working despite effective management, does the manager resort to active restoration. There are exceptions such as ship-groundings where small, discrete areas of reef are damaged and funds are usually readily available from insurers. However, the costs of active restoration, with coral transplantation starting at tens of thousands of US dollars per hectare, mean that for most managers, the effectiveness of using scarce resources for active restoration must be very carefully weighed against a range of alternative management options. E.g. Do I employ several more rangers to enforce existing regulations or spend the same funds on transplanting corals to one hectare?

These are the kinds of issues and dilemmas facing managers. As scientists we provide information on how to go about active rehabilitation in a responsible and cost-effective way (given current technologies) but the hardest part is designing and managing real reef rehabilitation projects that take account of social, economic, educational and public awareness issues without compromising their ecological basis.

Alasdair Edwards

¹ Edwards AJ (2008) What role for reef restoration in the face of climate change? *Reef Encounter* No. 36: 12-14

Farming and Outplanting Corals

Methods of Farming Sexually Propagated Corals and Outplanting for Coral Reef Rehabilitation; with list of references for coral reef rehabilitation through active restoration measure. M. Omori and K. Iwao, 2014. 63pp. Published by Akajima Marine Science Laboratory, Okinawa, Japan. Available from: www.amsl.or.jp/eng/body34.html.

Methods of Farming Sexually Propagated Corals and Outplanting for Coral Reef Rehabilitation;

with list of references for coral reef rehabilitation through active restoration measure

Makoto Omori and Kenji Iwao

有性生殖を利用したサンゴ種苗生産と植え付けによるさんご礁修復のための技術手法：付、積極的なさんご礁修復再生事業のために役立つ参考文献集

大森 信・岩尾研二



This manual describes a method of reef rehabilitation using sexually propagated corals that has been developed through research at the Akajima Marine Science Laboratory (AMSL) in Japan. This technique involves the collection and cross-fertilization of gametes from gravid coral colonies, and the subsequent maintenance of the larval culture. Since 2006 AMSL has planted out over 6000 juvenile corals of >6 cm in diameter, that have been cultured from eggs, onto limestone outcrops at Akajima Island, Okinawa. Most of these colonies reached sexual maturity four years later, and spawning has been confirmed every year since 2009. Despite the potential cost and intensive labour involved, this technique allows for production of far greater numbers of genetically diverse offspring and, unlike some other methods, is non-destructive, as it does not harm existing adult populations.

Makoto Omori

CONFERENCE REPORTS

Informative overviews of recent conferences and meetings

The Third Asia-Pacific Coral Reef Symposium

Report by: Allen Chen, Biodiversity Research Centre, Academia Sinica, Taiwan, and Li-Hsueh Wang and Hsing-Hui Li, National Museum of Marine Biology/Aquarium, Taiwan.

The 3rd Asia-Pacific Coral Reef Symposium (APCRS) was hosted by the National Museum of Marine Biology/Aquarium (NMMBA) over 5 days, between 23rd and 27th June 2014, at the Howard Beach Resort Hotel, Kenting, Taiwan. 512 participants from 39 nations/ states attended the conference, at which 225 oral presentations and 125 posters were presented. There were also nine keynote speeches, 18 mini-symposia, and four on-site workshops, organised to explore the 3rd APCRS theme - "Challenges of Asia-Pacific Coral Reefs under the Changing Ocean"

The consensus of participants at the 3rd APCRS identified the Asia-Pacific region as having more than 30% of the world's coral reefs and the highest scleractinian species richness. The reefs provide

ecosystem services with an estimated value of US\$2.2B for reef fisheries, \$258M for tourism and \$782m for shoreline protection, in Indonesia and the Philippines alone (the two countries with the world's largest reef-associated human population). Such benefits have been eroded since the mid-1960s as heavy anthropogenic pressures, driven by rapid economic expansion and a fast-growing human population, have resulted in extensive reef degradation. Presently more than half of the region's reefs are considered under a high threat. While human activity has contributed directly to a localized decline of reef resilience, climate change and ocean acidification operating at the global scale will exacerbate reef species loss, at further expense to the already compromised ecosystem integrity. Reef ecosystems will suffer additional disruption as species range shifts occur at different temporal rates and spatial scales. Thus, a growing challenge for the nations and states of the Asia-Pacific region is how to sustain the coral reef ecosystem and safeguard its ecological and functional services for the benefit of future generations of human society.



Participants at the 3rd APCRS

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Conference Reports: APCRS3



To express this concern the “Kenting Declaration on Coral Reef Conservation” was produced and released following the symposium. It is available at: [www.apcrs2014.com /KentingDeclaration/ Kenting Declaration.html](http://www.apcrs2014.com/KentingDeclaration/KentingDeclaration.html).

Travel awards and registration fee waivers were given to 65 students and participants from 15 nations/states, with the funding provided by the NMMBA, the Ministry of Science and Technology (MOST), the Ministry of Foreign Affairs (MOFA) Taiwan, the Korean Institute of Science and Technology (KIOST) Korea, and the Japanese Coral Reef Society (JCRS) Japan.

Prizes for the best student presentations were given as follows: Pui Yi Apple Chui, Chinese University of Hong Kong, for her thesis work entitled “Interactive Effects of Temperature and Salinity on Fertilization and Early Embryonic Development of the Coral *Platygyra acuta* in Hong Kong”; Tai Chong Toh, University of Singapore for his thesis work entitled “Augmenting Post-Transplantation Growth and Survivorship of Scleractinian Coral Juveniles via Nutrition Enhancement”; and Ho-Leung Ryan Tsang, Chinese University of Hong Kong, for his work on “Effects of Corallivory on Temperature Stressed *Acropora valida*”.

At the conclusion of the meeting there was a one-day field-trip, by 13 international coral reef scientists from the 3rd APCRS, to the Dongsha Atoll Marine Research Station (DARS), located on the Dongsha Atoll, in the north South China Sea (dongsha.mr.nsysu.edu.tw/files/13-1253-72641.php?Lang=en). Dongsha Atoll was established in 2007 as the first no-take marine protected area, under the administration of Marine Park Authority, Ministry of Interiors, Taiwan. DARS was established by MOST in January, 2013, with facilities currently under construction; it is operated by National Sun Yat-sen University, Taiwan.

The next (4th) Asia-Pacific Coral Reef Symposium will be hosted by the Philippine Association of Marine Science in Cebu, Philippines, in 2018.



Prof. Loke Ming Chou (chairperson, International Organizing Committee of the 3rd APCRS) gives an art plate to Prof. Yoshimi Suzuki (President, JCRS) in recognition of their support of travel awards.



Best student presentation awards. From left to right, Tai Chong Toh, Prof. Loke Ming Chou, Pui Yi Apple Chui, and Ho-Leung Ryan Tsang.



Participants from the 3rd APCRS visit the Dongsha Atoll Marine Research Station (DARS), Dongsha Atoll, South China Sea.

PROGRAMME OVERVIEWS

Information about Institution & Organisation Research & Conservation Programmes

Green Fins:

Managing marine tourism threats to coral reefs in the Philippines, South East Asia and the Indian Ocean

In June the United Nations Environment Programme, The Reef-World Foundation and local non-governmental organisation “The El Nido Foundation” co-hosted a study tour for national and international journalists to showcase the environmental impacts and resulting management practices in place as a result of the dive and snorkelling industry, in the popular and growing tourist destination of El Nido, Palawan, Philippines.

Marine tourism is amongst the fastest growing tourism sectors, with diving and snorkeling in particular attracting more than one million new recruits each year. With increasing numbers of divers and snorkellers travelling to the coast, hoping to see an abundance of marine life on coral reefs, the impacts caused as a result of unmanaged, unsustainable common industry practices continues to rise.

Green Fins, a unique conservation management approach, initiated by the UNEP in 2004, seeks to tackle this issue by harboring the passion of these industries. Green Fins creates a network of dive and snorkel operators, local communities and government departments and agencies, in order to educate and create awareness amongst these stakeholders and the public of the threats posed to the coral reefs as a result of diving and snorkelling. Green Fins members adopt a Code of Conduct (COC) consisting of 15 points that target the environmental threats caused by these industries, both on land and underwater, including environmental briefings, solid waste management and diver behaviour that damages reefs. Members are equipped with the necessary information, tools and training to mitigate each threat, implement sustainable practices, promote environmental education and awareness amongst the marine tourism

industry and limit their impact on the environment thus enhancing the resilience of the reefs to more widespread threats such as climate change. Members are assessed annually via a scoring system ([GEARS](#)) in order to record yearly progress and provided with environmental consultation to guide them towards achieving each of the 15 COC's. To date over 260 dive and snorkel operators across six countries in South East Asia and the Indian Ocean have joined Green Fins; and over 300 assessments have taken place and over 1250 staff members been trained in environmental standards.



A snorkelling operator who is a Green Fins member in El Nido, Palawan, Philippines. (Photo by J Tamelander)

In El Nido, the great majority of dive centres and over 30 snorkel tour operators have joined the Green Fins initiative. The study tour enabled those that coordinate Green Fins in El Nido and internationally to monitor the challenges and successes of the initiative whilst also spreading awareness, of the environmental threats caused by marine tourism, to a wider audience.

Few people, even within the industry have a grasp of the cumulative effects that poor dive and snorkel practices can have on reefs. It can also be a challenge for stakeholders to harness the knowledge they possess as a positive tool for awareness. Green Fins

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Programme Overviews: Green Fins



One of the mooring buoys deployed around El Nido.

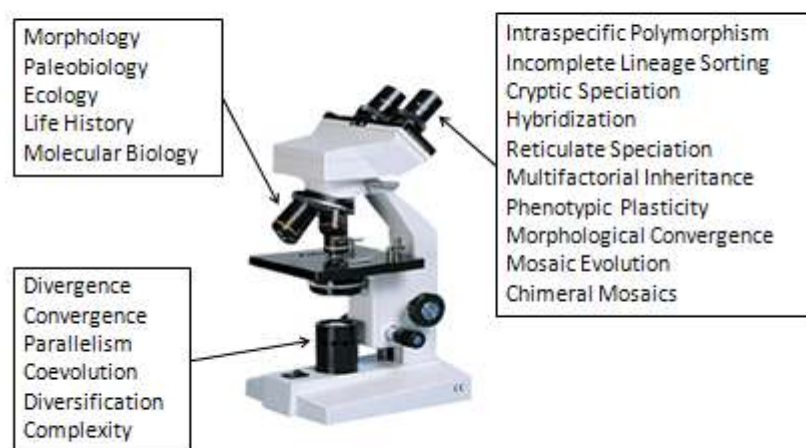
creates a system through which members share their successes and experiences not only with the public but also with each other, so facilitating the spread of successful policies and practices.

The journalists attending the study tour had a chance to interact with and interview dive centre and snorkel operators that are active Green Fins members; most are keen to share their knowledge and passion for the

reefs. The journalists also had the chance to participate in a snorkel tour and witness first hand the practices in place to mitigate the impact of the marine tourism industry - for example, the use of mooring buoys instead of anchors, to avoid the damage to corals which anchors can cause. As a result each journalist went away more environmentally conscious, with greater knowledge that will enable them to be a more discerning traveler, tourist or reporter, and to spread this awareness to others.

For further information please see www.greenfins.net, or contact us at info@greenfins.net or @Green_Fins.

About The Reef-World Foundation: The Reef-World Foundation is a UK charity that seeks to inspire and empower people around the world to act to conserve and sustainably develop coastal resources, particularly coral reefs. Reef-World are the International Coordinators for Green Fins and oversee the implementation and management of the initiative in the Green Fins active countries: Philippines, Thailand, Indonesia, Malaysia, Vietnam and Maldives.



The Microscope Analogy – a conceptual model of the integrative character of contemporary scleractinian research.

(see letter overleaf)



CORRESPONDENCE

Comment, feedback, thoughts and ideas

Conceptual Model of the Integrative Character of Contemporary Scleractinian Research

Very recently, Dr. J.E.N. “Charlie” Veron published an extremely informative overview of the taxonomy of zooxanthellate Scleractinia¹. The consecutive chapters “The Tyranny of the Past,” “The Reality of the Reef,” “The Last Frontier,” and “Mapping a Future Pathway” summarize the remarkable experience and challenges faced by the author in his research. Few are lucky to have enjoyed coral reefs as Charlie four decades ago. At that time, the reefs were magnificent, although our knowledge and methods for studying them were limited. One person was able to realize individually a considerable project and produce a large monograph. That time is gone, but the work continues to be just as exciting, although in a very different way. Today, coral reefs have lost much of their splendor, but what is known about them has grown, and continues to grow exponentially. We now have five sources of scleractinian information. Each sheds intriguing light on the species concept and taxonomic practice and gives the research an interdisciplinary and holistic character². Publications are often co-authored with colleagues and across disciplines. The reef-scape has deteriorated considerably, but the problems are neither fewer nor less challenging. They require the application of new methods, teamwork, and decisive action to save the ecosystem. There is in fact a new romance to the research, driven by the need frequently to improve working concepts and to arrive at effective operational actions.

One way to untangle the existing challenges could be by distinguishing conceptual from operational efforts³ and by looking for conceptual models for integrative study. Starting with the five sources of scleractinian knowledge (morphology, paleobiology, ecology, life history, and molecular biology) as a microscope’s objective lenses, we can shed light on identifying evolutionary trends (divergence, convergence, parallelism, coevolution, diversification, and

complexity), and use the microscope’s eyepieces to clarify the nature of the speciation quandary (intraspecific polymorphism, incomplete lineage sorting, cryptic speciation, hybridization, reticulate speciation, multifactorial inheritance, phenotypic plasticity, morphologic convergence, mosaic evolution, and chimeral mosaics). No doubt, the microscope stage will need adequate sampling size and type material. The focus knobs could concentrate attention to variability on different levels of biological organization, and could capture existing Lazarus and Elvis taxa⁴, and the competent use of nomenclature would optimize the functioning of the microscope system.

Another conceptual taxonomic model based on the skeletal variability of Caribbean extant scleractinians revealed the dynamic nature of the speciation process, underscoring the necessity of adequate sampling and collecting not only “clear” species⁵. The integrative character of contemporary coral research makes conceptual models especially necessary. But even the most sophisticated new generation of microscopic tools will not replace the decisions of researchers, who bear the ultimate responsibility, challenges, and rewards of this continually fascinating work.

Acknowledgments: Thanks to Dr. Joel L. Stake for his technical assistance with the figure and to my daughter Vera for improving the English.

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REEF DEPARTURES

Memories of recently departed members and reef scientists

Ivan Miles Goodbody 1926-2014 **Founder of Marine Science Centre,** **Mona, Jamaica**

Ivan Goodbody, Emeritus Professor of the University of the West Indies (UWI), who died in April 2014, was internationally renowned as an expert on ascidians (sea squirts) but also made an immense contribution to coral reef science, both through his own work and through the large number of students that he nurtured in the Caribbean. Known and respected throughout the region, he was a key player in UWI's marine research, starting in Jamaica in 1955 as a lecturer, then as Head of the Department of Zoology (1964-1986), and subsequently as one of the founders and the first Director of the Centre for Marine Sciences, Mona, which subsequently included the Discovery Bay Marine Laboratory. He also served as Vice-Dean (1973-5) and Dean (1975-7) of the Faculty of Natural Sciences, Jamaica.



Starting life in Ireland, Ivan graduated from Trinity College Dublin in 1949 and completed his PhD on ascidians at the University of Aberdeen in Scotland. In 1955 he and his family moved to Kingston, Jamaica, where his tropical career took off at UWI. Many reef scientists will have benefited from Ivan's work to promote marine science in the early days when resources and facilities were limited. He played a major role in the founding and development of the Port Royal Marine Laboratory (under the Department of Zoology) of which he was Director (1972-89), and of the Association of Marine Laboratories of the Caribbean (AMLC), of which he was Executive Director for a period; he was also associate editor of the *Bulletin of Marine Science* for over 30 years.

His primary research interest was in ascidians within the mangrove root epifauna, and mangrove lagoons were his first passion (a boat channel through the mangroves at Port Royal is named in his honour). It was this interest that led to his invitation in 1970 to join the US National Museum of Natural History team studying the Meso-American Barrier Reef off Belize, and to studies which occupied him until 1985. He greatly enjoyed this opportunity, describing the natural beauty of the environment as "stunning", the programme's field research laboratory being based in the central sector of the reef at Carrie Bow Cay, Belize. In the course of the programme, he identified 70 species from the Pelican Cays and 40 from Twin Cays and documented his findings in 8 scientific papers.

Although his research interest lay in a rather specific group of invertebrates, Ivan was among the first to realise the importance of inter-disciplinary research. This became a guiding principle in his development of both teaching and research programmes at UWI and led to a number of applied research initiatives, ultimately embracing pollution, fisheries and conservation. He played a leading role in the study of "fouling" communities, triggered much of the work to address pollution in Kingston Harbour, and in later years led the Caribbean Coastal and Marine Study to investigate the influence of the Kingston Harbour on the Hellshire coastline, a major inter-disciplinary project with Dalhousie University, Canada. He also initiated a large programme to prepare a fisheries management plan for Jamaica, that was led by John Munro. As pollution and overfishing became increasing challenges in the Caribbean, Ivan became concerned with the wellbeing not only of the mangroves but of the entire Caribbean Sea and with the conservation of marine habitats and species from ascidians to manatees.

Ivan also found time to contribute much to Jamaica, his adopted country. He served on the Natural Resources Conservation Authority, the Beach Control Authority, the Scientific Research Council, and was a member of the Institute of Jamaica. Jamaica not surprisingly honoured him with numerous accolades including the Silver Musgrave Medal for contributions

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Departures: Obituaries

to science, the Order of Distinction, Commander Class (Honorary) in the Jamaican National Honours 1979 for contributions in the field of Marine Biology, the Centenary Medal (1980) from the Institute of Jamaica, and the Petroleum Corporation of Jamaica Award for Environmental Sciences (1993). He was appointed as Chairman or Member of numerous national and international committees and workshops on aspects of marine sciences. He was an elected Fellow of the American Association for the Advancement of Science and awarded an Honorary Lifetime Membership of AMLC in 2003.

He returned to the University of Aberdeen in 2007 as Honorary Research Fellow in the School of Biological Sciences and continued working up to the end, finalising papers on Jamaican and Caribbean ascidians and the conservation of marine biodiversity. The generations of undergraduate students that he taught and his large pool of graduate students, including many who are now eminent reef ecologists and leaders of tropical marine science institutions, all owe him a great debt of gratitude.

Sue Wells, with input from George Warner, Liz Sides

Richard W. Grigg 1937-2014 Oceanographer, Ecologist and Big Wave Surfer

Ricky Grigg dedicated his life to two passions: surfing and marine science. He often commented that this dual life was not easy since many scientists doubted that a surfer could achieve excellence in science. Perhaps this pushed him to work harder. His contributions to coral science and to ISRS were immense, and he was for a time the number one surfer in the world.

After completing his undergraduate studies in biology at Stanford in 1958, by which time he was already well known in the surfing world, endorsements, commercials and a surf film helped Rick to pay for his Masters at University of Hawaii, Manoa, on black corals (1964) and his PhD at Scripps on California gorgonians (1970). Not all of us are perhaps aware of his starring role in *Blue-Surfari* – a clip of which is available on-line, along with some not so flattering reviews – and other films!



Rick Grigg, scientist and surfer.

After sailing to Tahiti in 1959, Ricky learned to free dive to 30 m for pearls – it helped that he could hold his breath for 3 minutes. There, he started to wonder about the sustainability of such fisheries. As a result, after returning to Hawaii, Ricky studied the ecology, life history and physiology of black coral, producing information that was used to help create the first management plan for a coral fishery in the world. After joining the faculty of the Oceanography Department at University of Hawaii in 1970, Ricky began a research programme on deep sea precious corals that ultimately led to the discovery of 93 species, of which 12 were new to science (including the black coral *Antipathes griggsi* Opresko, 2009) and 24 were new records for Hawaii. His interest in the deep sea paralleled his enthusiasm for big waves on the surface.

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Departures: Obituaries



In 1965 he was an aquanaut in the U.S. Navy Project Sealab II, off the coast of Scripps in La Jolla, and spent 15 days living in a 12-by-60-foot steel chamber at a depth of 205 feet.

From then on, his scientific passion took hold and he led and took part in a range of research activities on the ecology and paleoceanography of reef building corals in Hawaii and the Pacific Ocean at large. His research on the origin of the Hawaiian Archipelago and "Darwin Point," explained why islands drown at the northwestern end of the island chain, and is a milestone in the field. He told the story for a general audience in his 2012 book, *In the Beginning, Archipelago, the Origin and Description of the Hawaiian Islands*.

Ricky published over 100 papers in scientific journals and six books including an autobiography entitled *Big Surf, deep dives and the islands: my life in the Ocean*. He served as Managing Editor of *Coral Reefs* from 1990 to 1995 and was on the ISRS Council for many years. In 1999 he was awarded a NOGI (a lifetime achievement award to annually recognize leaders in the field of skin and SCUBA diving) by the US National Academy of Underwater Arts and Sciences. In 2003, after 33 years of service, Ricky officially retired from the University of Hawaii, although he retained the position of Professor Emeritus.

Ricky was also highly influential in promoting the urgency of both coral species and coral reef conservation. As a result of his work on black corals, he was involved in advising on managing precious coral fisheries in several areas of the world, and played a key role on getting both red and black precious corals listed on CITES, the Convention on International Trade in Endangered Species. Ricky played a central role in the first International Year of the Reef (IYOR) in 1997, dreamed up by a group of coral reef scientists at a meeting in 1993 convened at the University of Miami by Bob Ginsburg. The aim of this initiative was to promote coral reef science and publicize the immense threats that reefs faced. IYOR spawned several major initiatives including Reef Check, a global citizen-science monitoring program; Ricky was one of the key Advisory Board members who helped to design and refine the Reef Check monitoring protocol now used in over 90 countries.

Ricky grew up with his mother Gena and sister Robin near the beach in Santa Monica, California where he learned to swim, surf, and free dive to collect sand

VOLUME 29 NUMBER 2 August 2014

dollars and catch lobster, which he sold to tourists. His surfing instructor was Buzzy Trent, a lifeguard and one of the top surfers of the 1940s, and he used a 10' 6" (3.2 m) board made from wood and Styrofoam. Wetsuits had not yet been invented. At 16, using his savings from shining shoes, he flew to Hawaii for the summer to surf. By 1958, Ricky had joined a group of pioneering California surfers who were the first to surf truly giant (>10 m) waves at Waimea Bay on the north shore of Oahu. Millions of people surf, but only a tiny fraction can surf big waves. Ricky became one of the best big wave surfers in the world and won the prestigious world championship Duke Kahanamoku contest at Sunset Beach in 1967. We perhaps owe much to his mother who apparently issued an ultimatum during his senior year in high school: "go to college or lose the board"!



Ricky in Sealab (outside shown above)

Few coral reef scientists have had as diverse a career as Ricky Grigg. His teaching and scientific contributions cover wave forecasting, coral ecology, environmental impact assessment, coral fisheries, the origin of the Hawaiian islands and paleoceanography of the Pacific. He lived out his dream of being a surfer and oceanographer. For those who knew him well, he was a true friend and will be greatly missed.

Steve Dollar, Gregor Hodgson, Sam Khang

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Departures: Obituaries



Gerard M. Wellington 1948-2014 California, Galapagos and Texas

Jerry was born in San Francisco, California on 2 May 1948. He met his wife, Patricia Ellison, at a high school firehouse dance. An immediate and lasting bond ensued. Their marriage, an affectionate and mutually supportive 44 year relationship, resulted in two beautiful and talented daughters, Simone Wellington Welch and Katherine Emily Wellington. Not unexpectedly, both have entered the teaching profession and have a keen interest in natural history. Jerry's love for marine biology began on the northern California coast where he and Pat spent many hours exploring tide pools. Jerry's research interests in marine biology began to gel during his undergraduate studies at San Jose State University (SJSU) and its affiliated Moss Landing Marine Laboratory. He graduated SJSU in 1971 with a BA degree in Biology.

Soon after graduation, Jerry and Pat joined the US Peace Corps Program. Their first assignment was in Barbados; Pat worked in a children's malnutrition program, and Jerry with the fisheries department. After one year in Barbados they were transferred to Cahuita, on the Atlantic coast of Costa Rica, with Pat serving as a "jungle nurse" and Jerry involved in coastal biological survey work. Jerry began field work with the Costa Rica National Parks Service on assessing and mapping near shore, biotic assemblages, with particular attention to the Cahuita coral reef. This assignment resulted in the first description of the coral reef at Cahuita and was instrumental in the creation of the Cahuita National Park. The completed study, "An Ecological Description of the Marine and Associated Environments at Monumento Nacional Cahuita", served as a critical guide for the implementation of an effective protection plan.

After completion of the Costa Rican assignments, Jerry and Pat were transferred to Ecuador, arriving in the Galápagos Islands in November 1973. Pat continued with public health duties at the Puerto Ayora medical clinic, and Jerry with coastal biotic surveys. In the summer of 1973, a planning team composed of Ecuadorean Park officials, UN and FAO park planners, and a UNESCO scientist drafted the report, "Master Plan for the Protection and Use of the Galápagos National Park" with the primary objective of protecting this valuable resource while still permitting

commercial, local, and scientific uses. It was recognized, however, that little attention was ever given to the marine environment, and in fact little was known of the nature and distribution of marine communities anywhere in the Galápagos Islands. Enter Jerry Wellington, under the auspices of the Charles Darwin Research Station, and CDRS director Dr. Craig MacFarland. Jerry immediately began an island-wide survey and assessment of the coastal marine biota. In a period of just two years he completed the following report, which was the first ever inventory and documentation of the types, structure and distribution of coastal marine communities – "The Galápagos Coastal Environments: A Resource Report to the Department of National Parks and Wildlife, Quito". This cornerstone study brought the diverse and unique Galapagan coastal seascape front and center, and served as a valuable guide for its numerous benefits and protection. For this important resource, Jerry was awarded the Charles Darwin Foundation Medal for Conservation in 2000.



Jerry in the Galapagos in the 1970s

Having completed the Galápagos work, Jerry embarked on graduate studies at the University of California, Santa Barbara in pursuit of the Ph.D. degree. He carried out elegantly designed experimental studies on coral reefs in the Pearl Islands, Panama with the support of a Smithsonian Pre-doctoral Fellowship (1978-79). This work demonstrated the important role of indirect biotic effects in structuring eastern Pacific coral reefs. He earned a Ph.D. degree in Biology at UCSB in 1981.

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Reef Departures: Obituaries



Jerry Wellington (above) and with Peter Glynn (below)

Jerry joined the faculty in the Department of Biology and Biochemistry at the University of Houston in 1982 and served there for 24 years. He graduated 7 PhD and 10 MS students in his career and taught courses in Ecology, Marine Biology, Introductory Biology (Honors), Invertebrate Zoology, and Evolution of Life Histories. He published 60 journal articles and 7 book chapters on topics ranging from coral reef ecology, paleoceanography, and fish ecology and systematics. His scholarship had a large impact on coral reef science with publications in *Nature*, *Science*, *Coral Reefs*, *Marine Ecology Progress Series*, and other prestigious journals. One of his proudest achievements was his 1983 book on the "Corals and Coral Reefs of the Galapagos Islands" that he published in collaboration with his mentor and friend, Peter Glynn. He also served on the Editorial Board of the journal *Coral Reefs*, and was a trusted Advisor to the Charles Darwin Foundation for many years. In addition to the Charles Darwin Foundation Medal for Conservation, his dedication to research and conservation were recognized with his receiving the Antarctic Service Medal (1989), and two best paper awards as co-author

in the journal *Coral Reefs* with authors Robert Dunbar (1996) and Andrea Grottoli (1999). Jerry leaves behind a rich legacy in coral reef science. He was at his most enthusiastic on the reef SCUBA diving and exploring the natural world. He touched the lives of thousands of school children through his participation in the Jason Project (Galápagos 1991, Belize 1994, Florida 1996). His numerous graduate students continue his legacy through their current research in marine science. They are: Daniel Gleason, Malcolm Hill, Andréa Grottoli, Zac Forseman, Chris Caldw, Laura Gutierrez, Tom Wilcox, Jeff Villinski, Tammy McGovern, John Schmerfeld, Ann McMillen, Sean Craig, Ken Meyer, Chad McNutt, Rachel Angel, Leslie Williams, and David Bushek.

Another measure of Jerry's intellectual stature and scholarly accomplishments in the field of marine science can be appreciated from a sampling of messages received in the first few days following his death:

"Sad news...a great friend. I'm proud to have been a co-author with Jerry." (Alan E. Strong)

"This is a sad day - Jerry was an exceptional scientist and a great thinker. His passing is a great loss to our field and discipline. We will miss him here in Brisbane, as I am sure he will be missed the world over." (Ove Hoegh-Guldberg)

"He was a great man and leaves a great legacy. I, for one, feel fortunate to have been with him on at least one Galápagos trip and to have seen the magic in action." (Tyler Smith)

"And it is not an exaggeration to say that his work was critical to establishing the marine protected areas in Galápagos. Not a bad legacy." (Johannah Barry)

"When we checked in at the airport on Baltra Island, three young park wardens came up to him and asked, 'Are you Dr. Jerry Wellington?' He said, 'Yes.' One of them said, 'Man, you are a legend here!' I would have paid them to do that but it was totally spontaneous and it made him feel good." (Patricia Wellington, recounting an incident from Jerry's last visit to the Galápagos in 2007)

Yes Jerry, you are a legend, farewell, *un millón de gracias* for all your commendable achievements and good deeds. You will be sorely missed.

Peter W. Glynn, Andréa Grottoli, Danny Gleason, Andy Hooten

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
ISRS Membership



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
E-mail: 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 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/member_login.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)

REEF ENCOUNTER

The News Journal of the International Society for Reef Studies
Notes for Contributors



Types of Article

Reef Encounter accepts three distinct type of "Scientific Article". Note that it is normally a requirement that one or more authors of any of these types of article should be a member 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 in English and divided into paragraphs in a logical manner.

Reef Perspectives and Reef Currents articles are set as a single column across the page. 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.

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 the full word "Figure" e.g. **Figure 1** within the main text or to start a caption, but the abbreviation "Fig." when referring to the figure within parentheses or brackets (e.g. **Fig. 1**).

Tables are normally two-thirds page width (within the Reef Perspectives or Reef Currents sections) or single column width within the Reef Edge or News sections. Large tables are not normally suitable for publication in Reef Encounter. Each table 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 the society's journal *Coral Reefs*, with the exception that in the general articles and opinion pieces (Reef Perspectives or Reef Currents sections), to make the articles easier for the general reader to use, journal titles are spelt out in full. Otherwise within the text and the reference list there are commas inserted between the authors and the date, and semi-colons are used to separate references within the same set of parentheses or brackets. In the reference list, as in *Coral Reefs*, there are no points or stops after initials or abbreviations. Example citations are:

Conley DJ, Schelske CL, Stoermer EF (1993) Modification of the biogeochemical cycle of silica with eutrophication. *Mar Ecol Prog Ser* 101:179-192

Sorokin YI (1993) *Coral reef ecology*. Springer, Heidelberg

Bosence DWJ (1991) Coralline algae: mineralization, taxonomy, and palaeoecology. In: Riding R, Jones FR (eds) *Calcareous algae and stromatolites*. Springer, New York, pp 98-113

Author's instructions for *Coral Reefs* can be downloaded from <http://www.springer.com/life+sciences/ecology/journal/338>

A convenient list of journal abbreviations can be found at: <https://mc.manuscriptcentral.com/societyimages/coral/Coral%20Reefs%20Journal%20Abbreviations.xls>

