ISSN 0255-2787

REEF ENCOUNTER

Newsletter of the International Society for Reef Studies

Number 23

July 1998

REEF ENCOUNTER No. 23 July 1998

NEWSLETTER OF THE INTERNATIONAL SOCIETY FOR REEF STUDIES

Editor Maggie Watson
Associate Editors David Obura and Kristian Teleki

CONTENTS

(Contents Continued on Page 50)

COPY DEADLINE FOR REEF ENCOUNTER 24 (due out Dec. 1998) IS OCTOBER 1 1998

The **International Society for Reef Studies** was founded at at meeting in Churchill College, Cambridge, UK in December 1980.

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." In order to achieve its aim, the Society has the following powers:

i. To hold meetings, symposia, conferences and other gatherings to disseminate this scientific knowledge and understanding of coral reefs, both living and fossil.
ii. To print, publish and sell, lend and distribute any papers, treatise or communications relating to coral reefs, living and fossil, and any Reports of the Proceedings or the Accounts of the Society.
iii. To raise funds and invite and receive contributions from any persons whatsoever by way of subscription, donation or otherwise providing that the Society shall not undertake any permanent trading activities in raising funds for its primary objects.

The Society collaborates with Springer-Verlag in producing the quarterly journal *Coral Reefs*. This large-format journal is issued free of charge to all members of the Society, and concentrates on quantitative and theoretical reef studies, including experimental and laboratory work and modelling.

Reef Encounter is produced by Allen Press, Inc., 1041 New Hampshire, Lawrence, KS 66044, USA.. Printed on recycled paper.

EDITORIAL

With this issue we welcome Kristian Teleki to the **Reef Encounter** team. Kristian is based at Cambridge, U.K. and will provide an address and email secure from hurricanes and other such inconvenient disturbances.

We have another bumper edition with several pieces linked to **Reef Encounter No. 22**. As promised, the other side of the Rapid Wasting Disease / Syndrome controversy gets an airing (**Currents**). Moreover, the scientists studying the role of fungi in the syndrome tell us their work is advancing rapidly; though you will have to watch the scientific journals for the latest developments. **Reef Encounter** has a largely professional readership and is therefore an appropriate vehicle for discussion and a little controversy. But is the same approach appropriate in the media? **Upwellings** brings a comment on the situation in Bonaire where some have suggested the high profile damage to coral from parrotfish bites is a reason to resume spearfishing in the marine park.

Talking of controversy, R. Buddemeier and R. Kinzie are happy to tell us where we are going wrong in their **Feature** 'Reef Science—all the wrong questions in all the wrong places?' Thanks to them both for a substantial and thought provoking article. Another contributor was less willing to own up to heretical views, but anonymity will not protect **Spyhopper** from the backlash—if you have comments, air them 'care of' the editors.

Following the sad news of Bob Endean's death, we have a full obituary on page 9. Appropriately, we also have two articles on Crown of Thorns in South African and Japan (**Currents**). Amongst our usual offerings we bring you **ISRS News** and information on **International Initiatives** including the Year of the Oceans, Reef Check 98, GCRMN and also the ICRI sponsored ITMEMS meeting (see **Diary**).

Thanks go to all the contributors, but particularly Mark Spalding (cover illustration), Simon Wilson, David Righton, and Cathleen Bester who responded to our call for drawings. Please keep them coming!

M. Watson, D. Obura, K. Teleki

ISRS COMMENT

From the President

It is election time. Through the efforts of the council and concerned members, we have a fine slate of candidates (see ISRS News). What we need now is the deliberation of the membership to ensure the election of people who represent our global diversity and who will work on our behalf. Please consider carefully and vote! The winners will be announced at the ISRS meeting in Perpignan, 1–4 September 1998.

Our September 1998 meeting in Perpignan will inaugurate the ISRS Student Travel Award Program (STAP). Once each year the Society will join in partnership with the hosts of an ISRS-sponsored meeting to support travel and local expenses for a developing country graduate student. Initially the target region is South/Southeast Asia and the Pacific, but the program will expand to other areas over time. Many thanks to Dr. Gray Multer for pushing hard to gain Council approval of this program.

The winner of this year's ISRS Graduate Fellowship in Coral Reef Ecosystems, Romero Marquez Dizon of the Marine Science Institute of the University of the Philippines, is announced in this issue (**ISRS News**). Congratulations! I hope that you share with me the satisfactions of the growing maturity of the Society—supporting graduate fellowships and travel awards for worthy students, providing substantial support for the growing interest in scientific meetings concerning coral reefs, and reaching out to the global community with scientific input for the management of coral reefs.

Advance planning for the 9th International Coral Reef Symposium (ICRS) in October 2000 in Bali is underway, but communications have been slowed by the regional economic crisis and elections in Indonesia. Dr. Suharsono, the scientific member of the Organizing Committee, attended the meetings of the Council in Boston in January and by July I expect to be in contact with the new Minister of the Environment.

The meetings leading to the International Coral Reef Initiative (ICRI) involved many of us in 1995-96. The International Tropical Marine Ecosystem Management Symposium (ITMEMS) in Townsville, 23–26 November 1998 will review progress and set the future directions of the ICRI and also

provides us with a venue to reaffirm the ISRS commitment to bring the science and the management of coral reefs together. Check our new web page (details in **ISRS News**) for information on this and other meetings of interest.

Finally, I am delighted to welcome Dr. John E. Randall, recently retired from the Bishop Museum in Hawaii to Honorary Membership in the Society. Jack's outstanding career in the systematics and biology of coral reef fishes spans the modern era of scientific and management concern with coral reefs. In addition to being a prolific scientist, Jack has brought coral reef fishes to millions through his field guides and many books.

Very best wishes to all.
John C. Ogden

ISRS News

ADDRESS CHANGE? PLEASE NOTIFY ISRS!

We scientists are an itinerant bunch. Well over 10% of the addresses in any membership such as ours change every year. If your address changes, please notify the ISRS business office of the new address, preferably six weeks in advance of the change. That one notification will serve for copies of **Reef Encounter**, **Coral Reefs** (if your membership category entitles you to the journal), ballots, and other **ISRS** correspondence. Please DO NOT notify Springer-Verlag of the address change: **ISRS**, not Springer, sends **Coral Reefs** to you.

The address of the ISRS business office is ISRS, PO Box 1897, Lawrence, Kansas 66044-8897 USA. Fax: 1-785-843-1274. Changes can be sent by E-mail to <fautin@ukans.edu>.

ISRS ELECTIONS

As you all know, 1998 is election year for the Society. Three of the Society's officers and six Councillors complete their terms at the end of December 1998. John Ogden will be stepping down as President, along with Vice President Rene Galzin and Corresponding Secretary Callum Roberts. Councillors Jorge Cortes, Pat Hutchings, Peter Glynn, Ken Sebens, Jürgen Patzhold, and Clive Wilkinson will also be standing down. Following a call for nominations in the last issue of Reef Encounter, we have now assembled an excellent field of candidates for the forthcoming election. They include Terry Done for President, Barbara Brown and Eric Jordan-Dahlgren for Vice President, Richard Aronson for Corresponding Secretary, and Loke-Ming Chou, Nohora Galvis, Hector Guzman, Lucien Montaggioni, Nicholas Polunin, Robert Richmond, Suharsono, Si Vo Tuan, Carden Wallace and John Ware for Councillors. In sum the nominees hail from ten different countries spanning the entire globe, most of them having coral reefs! Ballot papers were mailed to members in early June so should have reached even the most remote areas of the world by now. The ballot paper provides details of the background and interests of each of the candidates to help you in selecting who to vote for. Voting slips have to be returned to Callum Roberts by the 15th August. The results of the election will be announced at the European Meeting of ISRS in Perpignan in September and the incumbents will take up their positions from January 1st 1998. This election is very important as the Society must build on the strength it has gained to meet the growing challenges that face reef science and management in the 21st Century. Please help in these efforts by voting in the coming election.

Callum Roberts, Corresponding Secretary

ISRS MEMBERSHIP AND FINANCIAL REPORT FOR 1997

MEMBERSHIP was 785 at the end of 1997, 70 fewer than at the end of 1996. There were 72 students, 623 individuals, 6 honorary members, 6 sustaining members, and 78 family members (in 39 family memberships).

FINANCIAL REPORT

INCOME		EXPENDITURES	
Memberships	$60,707.00	Reef Encounter 21 (printing & postage)	$6,180.00
Sollins fellowship	702.53	Tax return and audit	1,300.00
Interest	2,626.03	Coral Reefs 16 supplement	5,000.00
Editorial allowance	2,555.09	Editorial allowance	2,555.00
		Allen Press—	
		Management (includes some postage)	13,801.67
		Membership directory	3,332.28
		Postage	3,126.21
		Bank charges	22.05
		Card charges	700.66
TOTAL	$66,590.65	TOTAL	$36,017.87

OUTSTANDING CHARGES

1. The December printing of REEF ENCOUNTER 22 will amount to about $3,000
2. Nearly $13,000 was paid in early 1998 for CORAL REEFS volume 16
3. CORAL REEFS 16(4) handling charges will amount to about $2,000

Because the dues notice for 1998 was mistakenly sent in October, some of the membership income is for 1998 dues.

Thus, receipts actually for the year 1997 amounted to about $55,000 and actual expenditures for the year totaled about $52,000, which was almost precisely as budgeted (REEF ENCOUNTER 20, page 5). Cash on hand at the end of 1997 totaled US$93,654.39 and $21,643.13 in two savings certificates and $72,011.26 in two checking accounts.

BUDGET FOR 1998

INCOME		EXPENDITURES	
Memberships	$48,000.00	Reef Encounter	$7,000.00
Editorial allowance	2,500.00	Tax return preparation	500.00
Interest	2,500.00	Coral Reefs	16,000.00
Donations	100.00	Editorial allowance	2,500.00
Page charges	400.00	Allen Press—management	13,000.00
		Membership directory	3,500.00
		Postage	5,000.00
		Bank and card charges	1,000.00
		Planning for ICRS9	10,000.00
TOTAL	$53,500.00	TOTAL	$58,500.00

CORAL REEFS AND GLOBAL CHANGE: ADAPTATION, ACCLIMATION OR EXTINCTION?

New and challenging views of how corals and reef systems operate emerged from a symposium and international working group held in Boston, January 3–11 1998. The meeting was held in conjunction with combined annual gatherings of the Society for Integrative and Comparative Biology, the International Society for Reef Studies, and the Ecological Society of America. The working group, formed in 1994 to evaluate the scientific basis for growing concerns about the survival of coral reef ecosystems, was sponsored by the Scientific Committee on Oceanic Research (SCOR) and the Land-Ocean Interactions in the Coastal Zone (LOICZ) core project of the International Geosphere-Bios-

phere Programme (IGBP), with symposium support from the NOAA Coastal Ocean Program. Proceedings of the symposium will be published as an issue of American Zoologist. An interdisciplinary synthesis of the meeting contributions resulted in the following key conclusions:

- The calcification rates of corals, coralline algae, and coral algal communities depend on the calcium carbonate saturation state of surface seawater. Experimental data suggest that community calcification rates have probably already been reduced by anthropogenic increases in atmospheric carbon dioxide, and that at doubled CO_2, coral community calcification will be reduced by roughly 20%, while communities dominated by coralline algae may show an even greater decrease. This represents a global, systemic, threat to the functioning of reef ecosystems that will interact with other climate-related stresses and with the more immediate local and regional anthropogenic stresses.
- Coral reefs and communities are products of processes operating over a wide range of interacting time and space scales, with fundamentally different controls at different scales. Short-term responses will be controlled by local environmental conditions and biotic responses, but longer-term sustainability depends on the recruitment, dispersal, persistence, and interactions of populations over a hierarchy of larger scales.
- Corals, and to some extent reef communities, possess numerous mechanisms for acclimatization and adaptation - diverse reproductive strategies, flexible symbiotic relationships, physiological acclimatization, habitat tolerance, and a range of community interactions. However, current understanding of these mechanisms and the critically important calcification mechanisms, is inadequate to explain the past success of corals and reefs, or to ensure their conservation for the future.

Unlike many terrestrial ecosystems, coral reef ecosystems are directly threatened by globally increasing atmospheric CO_2. Local reef ecosystems and populations are interconnected and interdependent over a wide range of scales. Thus, conservation or management strategies aimed at removing or mitigating only local, human-derived or recently-applied environmental stresses, although essential, are likely to be inadequate in isolation. Corals and reefs are potentially robust and resilient, but realizing that potential requires new approaches and greater integration of fundamental and applied research, conservation, and management.

R.W. Buddemeier, Working Group chair

INTERNATIONAL SOCIETY FOR REEF STUDIES AND CENTER FOR MARINE CONSERVATION 1999 GRADUATE FELLOWSHIP FOR CORAL REEF RESEARCH

Coral reefs are among the most diverse ecosystems on the planet, they are globally distributed, and they support various aspects of coastal economies. Yet coral reefs are widely recognized to be in decline and studies are needed to provide information to manage and understand processes that cause coral reef change. Funds are available, approximately US$13,500, to support one student to work toward a Ph.D. in the general area of coral reef ecosystem research. The focus of the Fellowship is to understand and predict coral reef response to change caused by management or disturbance (human or natural). Research supported by the fellowship should emphasize an ecosystem approach, recognizing the complex interplay among many processes that shape the way coral reefs look and function. For example, projects that focus on factors that control productivity, nutrient dynamics, carbonate accretion or erosion, fisheries recruitment, or the effects of exploitation of coral reef resources are examples of suitable topics. Work is not restricted to

these topics, but mechanistic controls should be emphasized because this information is important in construction of models that will predict reef response to disturbance.

Who can apply?

The Fellowship is available to students, worldwide, who are already admitted to a graduate program at an accredited university. The intent of the fellowship is to help Ph.D. students develop skills and to address problems related to relevant applications of coral reef ecosystem research and management. The fellowship can be used to support salary, travel, fieldwork, or laboratory analyses. Renewal of the fellowship is possible, but is based on annual resubmission. The student can work entirely at the host university, or can split time between developed and developing country universities. Given proposals of equal scientific merit, priority will be based on financial need; strong financial or in-kind support from local sources is also required.

Application materials

A four page proposal, using 12 Font or larger, in English, is required from prospective fellowship candidates. The proposal should include (1) an overview that places the proposed research in context with existing literature and local needs, (2) a detailed methods section that includes hypotheses and experimental design (as appropriate), (3) expected results, (4) evidence of host country management relevance and coordination (e.g. identification of individuals or programs that will benefit from your results), (5) a detailed budget, and (6) literature cited (the budget and literature cited sections do not count against the four page limit). Eight copies of the proposal must be provided. The student's major professor is required to submit a CV (maximum length 3 pages) and a support letter, in English, that detail cost sharing and facility support. If work will be conducted at a second university, a support letter is required from the sponsoring professor. Applications will be reviewed by a panel with ISRS and Center for Marine Conservation participants; evaluation criteria include scientific merit, feasibility, cost sharing, host country coordination, and relevancy to the Fellowship guidelines. Twenty four applications were received for support in 1997, and twelve were received for 1998.

SUBMISSION DEADLINE IS OCTOBER 16, 1998

Administration of the Fellowship

The International Society for Reef Studies (ISRS) and the Center for Marine Conservation (CMC) support the Fellowship through professional and administrative contributions. The mission of the ISRS 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. The CMC is committed to protecting ocean environments and conserving the global abundance and diversity of marine life. Through science-based advocacy, research, and public education, CMC promotes informed citizen participation in order to reverse the degradation of our oceans.

Application materials should be submitted, no later than October 16 1998, to: ISRS Recording Secretary, UNCW, 515 Caribbean Drive, Key Largo, Florida 33037. E-mail <SMiller@gate.net> Please visit the ISRS Homepage (www.uncwil.edu/isrs) for additional information related to the Society and the Fellowship.

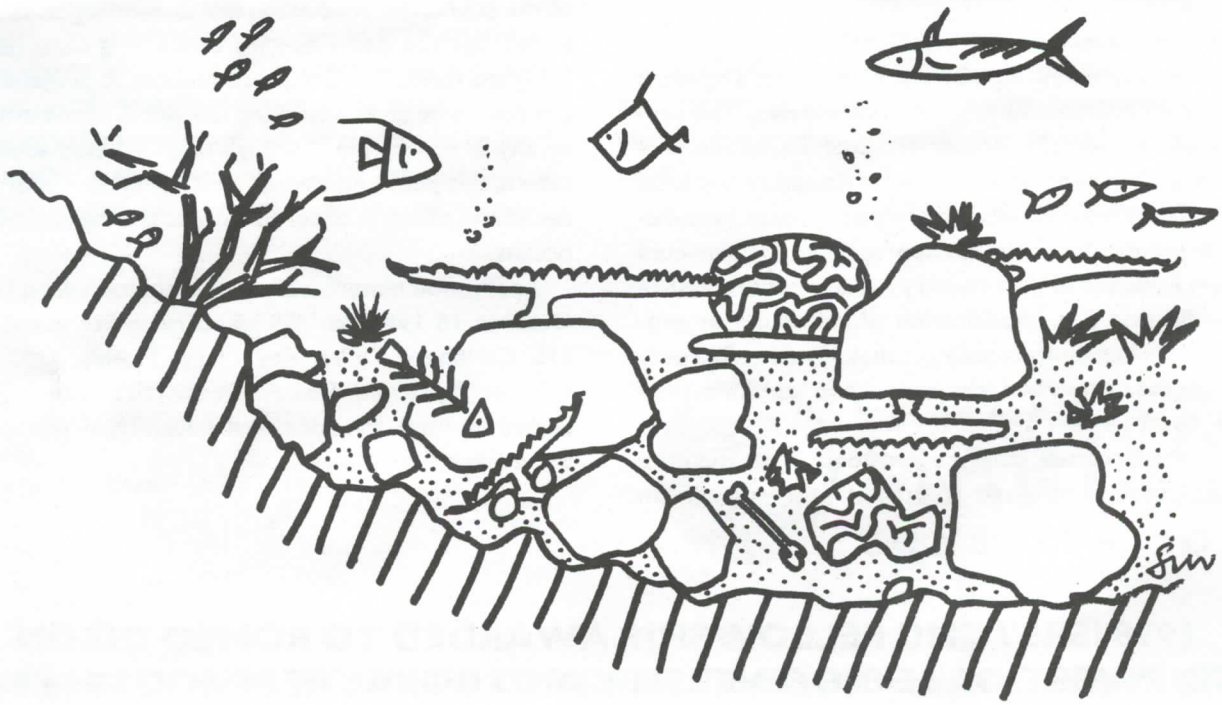
1998 ISRS / CMC FELLOWSHIP AWARDED TO ROMEO DIZON TO INVESTIGATE BIODIVERSITY AND CORAL REEF ECOSYSTEM FUNCTION IN THE PHILIPPINES

The 1998 ISRS Fellowship was awarded to Mr. Romeo Marquez Dizon, of the Marine Science Institute at the University of the Philippines, Diliman. Mr. Dizon's program advisor is Dr. Helen T. Yap. The Fellowship award is for one year and is worth US$13,500. The Fellowship was awarded after extensive peer review of all proposals, including written comments provided by several ISRS Councilors and panel review by ISRS Officers and a Center for Marine Conservation (CMC) scientist; CMC also provides assistance related to financial administration of the award.

Mr. Dizon will work in the Bolinao reef system in the northwestern Philippines. His research, entitled, "Coral Reef Biodiversity in the presence of disturbances" includes field and laboratory studies to investigate: the effects of nutrient pollution caused by the proliferation of legally established fish culture pens; and physical disturbance to the reef caused by blast (dynamite) fishing. In general, Mr. Dizon's research addresses the broad topic of how biodiversity affects ecosystem function. Specifically, he will conduct experiments to investigate relationships among physical and chemical disturbances, biodiversity, and recovery rates.

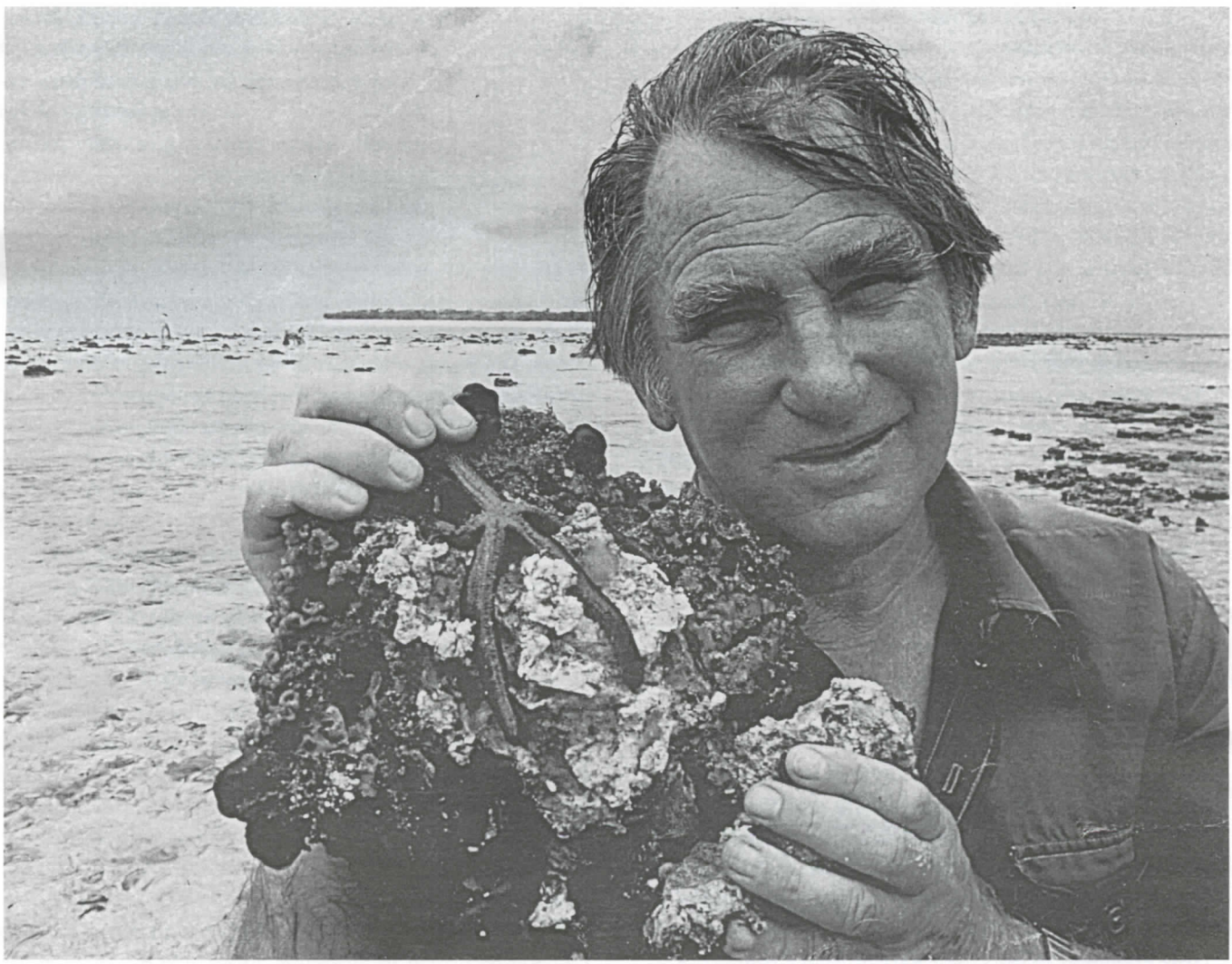
NEW ISRS HOMEPAGE BRINGS THE SOCIETY ON LINE — WWW.UNCWIL.EDU/ISRS

The ISRS homepage is up and running! The purpose of the homepage is to provide ISRS members with news and announcements important to the Society. Additionally, information is available related to Reef Encounter, Coral Reefs, ISRS Fellowships, and upcoming meetings. Future developments will include archives related to Reef Encounter and Coral Reefs. The homepage is hosted at no charge to the Society by the University of North Carolina at Wilmington, which is one of the leading undergraduate marine biology institutions in the United States



OBITUARY

THE MAN WHO SAVED THE BARRIER REEF



Robert Endean, Marine biologist.
Born 27 December 1925, near Lithgow, New South Wales, Australia,
Died 2 October 1997 at Heron Island, Great Barrier Reef

With the death of Bob Endean, the Great Barrier Reef has lost a champion, and Australian science, a larrikin. Bob's life was a celebration of commitment to both science and coral reefs, but a peculiarly Australian one, tempered with a laconic cheek that infuriated the establishment.

The origins of this are not hard to find. He was born on the Western Coalfields of New South Wales, where his father was a mine surveyor, often embroiled in solitary battles with mine owners over safety in the pits. With the blood of Basque, Cornish and Yorkshire miners flowing in his veins, Bob's nature was never in doubt. He studied first at the University College in Armidale (now the University of New England) and then later at the University of Sydney in the war years, and came to the notice of the great William Dakin, the Professor of Zoology, as a 'boy with a real gift'. There he began his lifelong interest in toxicology, after noticing that the rabbits he hunted in the bracken country had tanned guts and high levels of gut cancer.

Never a 'swot', Endean was often at odds with the university authorities. In Armidale, when he and his friends were before a disciplinary committee for discharging guns on campus, he created a 'small explosion' using pistol caps in his defence. The committee was glad to let him off! Later in Sydney, he was nearly caught siphoning off the Vice-Chancellor's precious war-rationed petrol for his motor bike. Nevertheless, he obtained a first class honors degree in zoology and a University Medal. He later completed a Master of Science at Queensland and a PhD at Sydney. Bob was also a first class sportsman, playing both cricket and football, and later played cricket for Somerset during a sabbatical leave at the University of Bristol.

Bob's life was a celebration of commitment to both science and coral reefs, tempered with a laconic cheek that infuriated the establishment.

Queensland must have been zoological heaven in the fifties, where Bob Endean was a freshly appointed lecturer at its only university. Forests and deserts, mangroves and estuaries, and above all, coral reefs — the greatest coral reef, the Great Barrier Reef — all beckoned the natural historian. Endean became absorbed by coral reefs, joining a list of bewitched scientists stretching back to Darwin. He was one of the first to see reefs on their own terms, through the marvel of scuba. He was also one of the first to understand that the stunning variety of life in tropical waters was sustained by complex interactions involving exotic chemicals — venoms, growth inhibitors, attractants and so forth — evolved to project an organism's power over its neighbors. Indeed, nature had created the world's greatest pharmacological storehouse on coral reefs.

During the fifties and sixties, Endean worked assiduously building a brilliant academic career in this exciting new area of 'drugs from the sea'. He played the major role in creating the infrastructure for the world's first serious laboratory-based research on coral reefs by developing the Heron Island Research Station. During this period, he was Secretary and, later, President of the Great Barrier Reef Committee — the ancestor of the present Australian Coral Reef Society — a then venerable and staid scholarly body which promoted expeditions to the Reef in the grand traditions of a bygone age. It also owned the Heron Island Station. He transformed the Committee and found significant funding for the Station from the Swiss pharmaceutical giant, Roche, long before this sort of entrepreneurial behavior was fashionable (or even acceptable) in the groves of the academy.

The scene was set for an often bitter David and Goliath struggle between Bob and the establishment.

He also created an intellectually free, perhaps bohemian, environment at Heron Island far from the stuffiness of the conservative campus, where he, his partner in life and science, Dr. Ann Cameron, and other free spirits could enjoy their research. Bob's performances at the Heron Island bar became the stuff of legend ...

Armed with his own grant from Roche, his laboratory in Brisbane began producing a stream of original research from headline-grabbing work on the venoms of the feared box jellyfish, stonefish and blue-ringed octopus to more far-reaching work on the tumor inhibiting chemicals in some reef creatures. As the sixties marched on and the environmental movement began its modern course, Endean became a public figure, a reliable source of comment on the wonders of the Great Barrier Reef. With Bob, the media were always assured of a headline or TV grab, and on a slow news day, another story of the wonders from the Reef. During this period, Bob forced the pace on coral reef research in Australia. He was instrumental in organizing the Second International Coral Reef Symposium as President of the Great Barrier Reef Committee, the host organization. The Symposium was held in 1973 aboard the *Marco Polo* cruising the waters of the Reef. This meeting firmly established the tradition of leading-edge multidisciplinary science that has come to characterize all later meetings. It was a key event in the history of coral reef science because it made apparent the scientific challenge of coral reefs, and brought together the key individuals who would later found the International Society for Reef Studies.

He also worked with the geologist O A Jones to edit the four volume series, *Biology and Geology of Coral Reefs*, which was published by Academic Press between 1973 and 1977. These books and the 'Marco Polo Proceedings' became the vade-mecum for reef scientists before our journal *Coral Reefs* was born.

And his career could have continued to develop on this conventional path to academic honor had it not been for a spiny starfish he and the physician John Barnes found on the reefs at Green Island near Cairns in 1964. This creature, the crown-of-thorns starfish, was venomous, hence their interest. It was also interesting in a new way: it ate coral. In fact its numbers grew to plague proportions and, over the next months, ate most of the coral on Green Island.

Endean sounded the alarm, and was asked to investigate by the Queensland Government. He reported in 1969 that plagues of the starfish had destroyed a large number of reefs in the Cairns region and the outbreaks were continuing to spread. Reports of similar outbreaks began to come in from

other parts of the Pacific, and there was tremendous interest in the media. Endean became a familiar figure on TV warning that the Reef faced a crisis. The Queensland and Commonwealth governments responded with an inquiry which reported in 1971 that the problem was greatly exaggerated. Bob retaliated, rubbishing the report. The scene was set for an often bitter David and Goliath struggle between Bob and the establishment that continued until his death.

The crisis triggered Australia's first mass environmental campaign, and an outbreak of bright orange 'Save the Barrier Reef' bumper stickers on the nation's car fleet. Governments responded to this growing environmentalism by establishing other committees and inquiries. These recommended against oil drilling on the Reef, and that it be made a national park. By 1975 both the Australian Institute of Marine Science and the Great Barrier Reef Marine Park Authority had been established in Townsville as direct responses to these pressures, even as the starfish outbreaks appeared to be dying away.

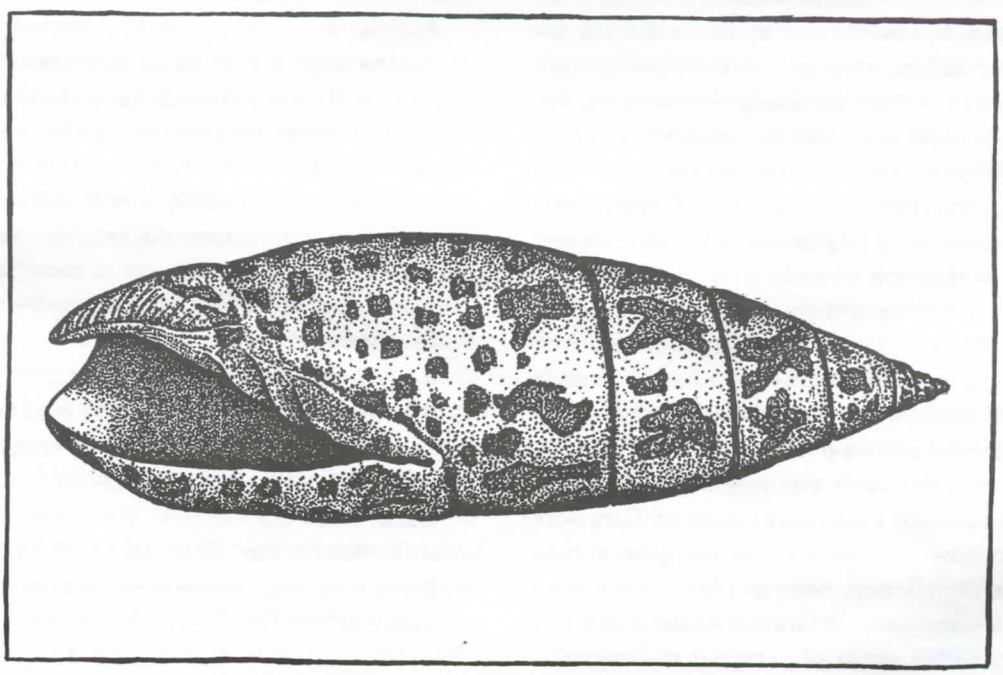
In 1979 the starfish outbreaks came back, and proceeded, once more, to destroy many reefs, including those just recovering from the previous outbreaks. Again the issue flared in the media, and again Bob was pitted against the establishment, which had now grown its own institutional base. It was able to hit back with sober-sided authorities, even if they were no media match for Endean's laconic one-liners. Another inquiry was convened which carefully reported in 1985 that perhaps, just maybe, there might be a problem.

Without Bob Endean, there may have been no crisis. Without the crisis, the reef would not enjoy the institutional and legal safeguards it now has.

The establishment's admission was too little, too late for Endean who had by then developed his arguments further. The outbreaks, he claimed, were man-induced, were causing permanent degradation of the reef ecosystem, and major efforts should be made to control them. These claims were far too hot to handle by the establishment which promptly parked them with another advisory committee. The outbreaks ate themselves out during the next few years. Now, as Endean feared, another series of outbreaks is underway on the Reef.

Bob Endean, the private man, is survived by a daughter, Coralie, from his first marriage. The public man also leaves a legacy. In his forthcoming book 'What is natural? Coral reef crisis' (OUP, 1998), the eminent historian Jan Sapp argues that the crown-of-thorns crisis was the first global environmental issue. Without Bob Endean, there may have been no crisis. Without the crisis, the Reef would not enjoy the institutional and legal safeguards it now has. While it is now up to others to ensure this legacy is protected, Endean could say, with that other outsider, the Moor of Venice: 'I have done the state some service and they know't; No more of that.'

Roger Bradbury, one of Bob's many former students, is the Chief Research Scientist with the Bureau of Resource Sciences, Canberra. An edited version of this obituary appeared in The Australian *newspaper on 29 October 1997 entitled 'Eco-warrior of the Great Barrier Reef'.*



UPWELLINGS

BOOM – BUST CYCLES IN *ACROPORA*

I found the article "White band disease in the Florida Keys—a continuing concern" (W.F. Precht and R.B. Aronson, **Reef Encounter 22: 14–16**) of great interest. I have worked in the Florida Keys reefs since 1972 and consider the abundance and disappearance of *Acropora spp.* to be a very interesting and complex phenomenon. If one reads the publications generated from research and observations at the Carnegie Laboratory, Dry Tortugas from the beginning of this century, there are several references to epidemic losses of *Madrepore* (=*Acropora*) *cervicornis* and *M. palmata* through environmental influences. For example, in 1878 the "black water event" (Feinstein et al. 1955) virtually eliminated all the *Acropora spp.* from Dry Tortugas reefs (Mayer 1902). However, there is some disagreement in this because Agassiz (1882) reported that *A. palmata* was common seaward of Bird, Bush, and Long keys. In 1932, *A. palmata* was still commonly abundant seaward of Bird, Bush, and Long keys (Wells, 1932), but between 1932 and 1977, the species virtually disappeared (Davis, 1982). The loss was approximately from 44 hectares in 1879 to 600 m^2 in 1976. In 1993, the remnant population occupied an area of approximately 1,400 m^2 (Jaap and Sargent, 1993).

As dramatic was the loss of *A. cervicornis* throughout the Keys. A hypothermal meteorological event in 1979 devastated the *A. cervicornis* populations. A resurgence followed the cold-water stress, but in 1981, an epidemic disease severely reduced populations throughout the Florida Keys reefs (and other parts of the Caribbean). In summary, the *Acropora* populations seem to exhibit boom-and-bust population dynamics. This is also apparent in the reef strata. Following a ship grounding (Mavro Vetranic, near Pulaski Shoal in the northeastern corner of Dry Tortugas) in 1989, we saw alternating strata of staghorn (*A. cervicornis* and *A. prolifera*) and head corals in the excavations created by the grounding.

I examined the Wells and Hanna (1992) statement that there was 96 % cover on reefs in 1981. Their text shows it to be an anecdotal statement rather than being based on what we nominally refer to as a published study. Certainly there were areas on some reefs that may have had 100 % elkhorn (*Acropora palmata*) coral cover, such as Carysfort Reef off Key Largo; however, that was not the general case for the majority of Florida Keys reefs in 1981. There is no debating the loss of coral cover at Grecian Rocks that Gene Shinn documented with a series of excellent photographs. The loss was very disturbing. However, there are other reefs in Florida Keys that still have moderate *A. palmata* populations.

The white band disease that infects *Acropora spp.* was studied by Peters et al. (1983). They tentatively identified the pathogen as a gram-negative, rod-shaped bacterium. Several species of damsel fish have probably had as important a role as the white band disease in the loss of *A. palmata* and *A. cervicornis* in the Florida Keys reefs. These highly abundant fish systematically destroy coral tissues, and their impact is substantial on *A. cervicornis and A. palmata*. They stimulate algal growth on the areas of the coral that they destroy by defending the algal patches from herbivores.

Is there hope that *Acropora* populations might recover? The evidence is mixed. West of Loggerhead Key, the evidence is very negative, and the vast acreage described by Davis (1977, 1982) has not recovered. The area is now occupied by low mounds of *A. cervicornis* rubble. However, at White Shoal, northeast of Loggerhead Key, there are many areas that exhibit healthy patches of *A. cervicornis*, staghorn coral. We have observed one patch since 1989, and it has exhibited consistent expansion through September 1997. The small remnant population of *A. palmata* at Dry Tortugas has sustained its area for ten years, and recruits appear to settle and survive.

Sometimes invertebrate populations do recover from epidemic diseases.

Another encouraging outcome has followed two epidemic sponge blights that killed virtually all the commercial sponges in Florida and the Bahamas in 1938-1939 and 1946-1947. By 1967, commercial sponge harvesting off west central Florida, the Florida Keys, and the Bahamas had recovered (Stevely et al., 1978), and is still viable. Sometimes invertebrate populations do recover from epidemic diseases.

References

Agassiz, A. 1882. Explorations of the surface fauna of the Gulf Stream, under the auspices of the United States Coast Survey II. The Tortugas and Florida reefs. Mem. Am. Acad. Arts Sci. Centennial Vol. 2(1): 107-132.

Davis, G.E. 1977. Anchor damage to a coral reef on the coast of Florida. Biol. Conserv. 11: 29-34.

Davis, G.E. 1982. A century of natural change in coral distribution at the Dry Tortugas: a comparison of reef maps from 1881 and 1976. Bull. Mar. Sci. 32(2): 608-623.

Feinstein, A., A.R. Ceurvels, R.F. Hutton, and E. Snoek. 1955. Red tide outbreaks off the Florida west coast. Report To Florida State Board of Conservation by the Mar. Lab., Univ. of Miami, 44 pp.

Jaap, W.C. and F. Sargent. 1993. The status of the remnant population of Acropora palmata (Lamarck, 1816) at Dry Tortugas National Park, with a discussion of possible causes of changes since 1881. Proc. Colloquium on global aspects of coral reefs- health, hazards, and history: 101-105.

Mayer, A.G. 1902. The Tortugas as a station for research in biology. Science 17(422): 190-192.

Peters, E.C., J.J. Oprandy, and P.P. Yevich. 1983. Possible causal agent of "White Band Disease" in Caribbean Acroporid corals. J. of Invertebr. Pathol. 41: 394-396.

Stevely, J., J.C. Thompson, and R.E. Warner. 1978. The biology and utilization of Florida's commercial sponges. Fla. Sea Grant Tech. Pap. 8, 45 pp.

Wells, J.W. 1932. A study of the reef Madreporaria of the Dry Tortugas and sediments of coral reefs. Unpublished manuscript. Cornell University, New York, 138 pp.

Wells, S. and N. Hanna. 1992. The Greenpeace book of coral reefs. Cameron Books, London, 160 pp.

Walter C. Jaap, Coral Reef Studies Group,
Florida Marine Research Institute

DON'T SHOOT THE STOPLIGHT!

Disease?...parrotfishes?...disease and parrotfishes!? There is nothing like controversy to set the blood of scientists racing and Rapid Wasting Disease, alias Syndrome, has got scientists, managers and public worked up into a froth. People often complain that science works too slowly to be of use to management. They argue that we cannot afford to wait for rigorous studies to be conducted and pass through the slowly grinding mill of the scientific publishing process. New phenomena require immediate interpretation and possibly management action. But the faster we jump to conclusions the more likely we are to be wrong. Being wrong is the very stuff of science and fuels progress. But when scientific debates are conducted in public and in advance of thorough data collection and interpretation we risk harm to our credibility and to our ability to manage complex ecosystems like reefs.

Spare a thought for reef managers - saved from the knife of coral disease, perhaps, only to find themselves thrust into the flames of a spearfishing debate.

The enormous publicity that Rapid Wasting Disease/Syndrome/Parrotfish grazing has generated has spawned a reaction which I think none of the protagonists in the debate would have expected or wanted: if parrotfish eat corals then we must kill them to save the reefs. Through this inexorable logic, protecting fish from spearfishing, which is what marine parks like the excellent one in Bonaire do, has caused coral damage and therefore banning spearfishing was wrong. Spare a thought for the reef manager caught in the crossfire. Saved from the knife of coral disease, perhaps, only to find themselves thrust into the flames of a spearfishing debate. In presenting our research to the world we must take the time to explain clearly our uncertainties, and their implications for management.

Despite its problems, Bonaire has some of the most magnificent coral reefs remaining in the Caribbean (Roberts and Hawkins 1994). Like other places it has suffered coral disease outbreaks and a sea urchin die-off, but coral cover remains exceptionally high. What sets Bonaire apart though is its fish communities. Thanks to a very low level of fishing effort, the island has spectacular fish stocks, parrotfishes included. Some parrotfishes enjoy a bit of coral for hors d'oeuvres, but most of the time they eat algae, helping take up the slack the loss of sea urchins has created. Throughout the Caribbean people are working hard to emulate Bonaire's management success by creating marine reserves closed to fishing to rebuild fish stocks, especially herbivores that can help control algal growth. Parrotfish are not the villains of the piece. Instead, their abundance and richly interesting behaviour in Bonaire are a cause for celebration.

References

Roberts, C.M. and J.P. Hawkins. 1994. Report on the status of Bonaire's coral reefs. Part 1: Critical management issues for coral reefs of Bonaire. Part 2: Effects of diving on coral reefs of Bonaire and status of the island's fish communities. Eastern Caribbean Center, University of the Virgin Islands, St Thomas. 56pp.

Callum Roberts, Environment Department,
University of York, York, YO1 5DD, UK
e-mail: <cr10@york.ac.uk>

MARINE SPECIES IN TRADITIONAL MEDCINE

I was glad to read Chuck Birkeland's article on disposable income in Asia and its effects on coral reef resources (**Reef Encounter No. 22: 9–13**). I would certainly agree that economic growth in China (and previously in Asia in general) is putting new pressures on marine resources, and thank him for raising the issue.

My activities in seahorse conservation make it appropriate for me to respond specifically to Birkeland's comment about Asian use of seahorses, as this was somewhat provocative and could be counterproductive in conservation terms. Contrary to his implication, seahorses are not used solely as aphrodisiacs. In Hong Kong SAR and mainland China, they are primarily used in traditional Chinese medicine (TCM) to treat asthma and other respiratory disorders. There and elsewhere, seahorses are also incorporated into remedies for arteriosclerosis, impotence, thyroid disorders, skin ailments, heart disease, and incontinence. And yes, they are also used as aphrodisiacs. But we would be ill-advised to dismiss this range of medical conditions as mere "frivolities" or to imply that seahorses were somehow used in "hoax" treatments.

Quick assessment of traditional medicine practices as nonsense certainly closes avenues of communication

Conservationists have commonly not done a very good job of communicating their concerns to ethnic Chinese and other traditional medicine users in terms that are clear and believable (Parry-Jones and Vincent, 1998). Nor have we listened terribly well. Misinterpretation of TCM and its consumption patterns tends to anger ethnic Chinese who are tired, for example, of hearing Westerners describe rhinoceros horn as an aphrodisiac when it is in fact used primarily for life-threatening fevers. TCM is recognised by the World Health Organisation as a valid form of health care, is trusted by one-quarter of the world's population and has a long and distinguished history. Quick assessment of traditional medicine practices as nonsense certainly closes avenues of communication. Moreover, it may lead us to miss useful remedies. Western medicine continues to benefit from advances made in TCM, for example, by adopting Artemisin as an antimalarial drug and ephedrine for the treatment of asthma; both have long been used in TCM.

All that notwithstanding, we do need to understand how TCM consumption patterns - and Asian economic changes - are affecting marine species. For some species, at least, demand exceeds supply and wild populations are at risk (Vincent, 1996). Despite possible conservation threats, the use of marine species in traditional medicine has been neglected as attention has focused predominantly on large mammals. Yet hundreds of marine species have been recorded in the TCM pharmacopeia alone (Tang, 1987), although their current use remains uncertain.

On 1 June 1998, we will launch a new initiative in Hong Kong to gain a better understanding of the use of marine species in TCM, to document their trade and to promote wise management of their exploitation. In addition, a symposium on "The use and management of marine species in traditional medicine" will be held in Cebu, Philippines in July 1998. It will draw together fishers, traders, aquaculturists, social workers, TCM practitioners, and conservationists, primarily from around Asia. In support of these and future activities, we would be grateful for any information on the use of marine species in any form of traditional medicine.

A project is also underway to gather information on extraordinary fisheries, essentially those where the targeted finfish species is/are not used for dead table food. Dr. Yvonne Sadovy (University of Hong Kong) and I are keen to obtain even anecdotal comments or vague hints about fisheries for live food, medicines, bait, curios, cosmetics, research, mariculture seed, the aquarium trade, or anything else of that ilk. Suggestions of data sets are, of course, particularly welcome.

References

Parry-Jones, R. and A.C.J. Vincent. 1998. Traditional Chinese medicine and conservation. New Scientist. 3 January 1998: 26-29.

Tang, W-C. 1987. Chinese medicinal materials from the sea. Abstracts of Chinese Medicine 1(4):571-600.

Vincent, A.C.J. 1996. The International Trade in Seahorses. TRAFFIC International, Cambridge, UK. vii + 163 pp. ISBN 1 85850 098 2

Amanda Vincent, Department of Biology, McGill University, 1205 Ave. Dr. Penfield, Montreal, Quebec, Canada H3A 1B1
Tel: 1 (514) 398-6455/ 5112 Fax: 1-514-398-5069
E-mail: <amanda_vincent@maclan.mcgill.ca>

SPYHOPPER

INTRODUCING - *SPYHOPPER*

My dictionary tells me that the meaning of the word 'spyhop' means to poke one's head above the surface of the water to have a quick look around. How appropriate then for a columnist intending to take a different perspective on topical issues in the human world of coral reef research.

Spyhopper notes with interest the recent development of coral cultivation techniques which should in theory make it possible to replenish or re-seed reefs depleted by environmental degradation or worse, the actions of coral plucking aquarium enthusiasts. But it's a short step from coral cultivation to the 'creation' of artificial reefs and general back slapping about just how 'environmentally friendly' such a technology is. 'Good in theory' could easily be subverted into yet another profit generating scheme for entrepreneurs and feel-good environmentalists with a quick fix 'insurance policy' leading to complacency in the public at large.

Surely to ensure reefs survive into perpetuity we must protect the ones we have, not invest in new creations. One way is to prevent all those nasty Crown of Thorns Starfish from munching our lovely coral. Spyhopper observes there is no trouble getting the public behind this issue. What could be more disgusting than the idea of a creature that regurgitates its stomach over its victim, spits acid digestive juices over it, sucks living tissue from the bones of its prey, then swallows its stomach again before heading off for the next kill.

Why not have squads of avenging divers removing COT infestations from reefs before selling the harvested starfish to the curio trade or the luxury food market (someone out there must eat them!)? With inventive marketing, perhaps they could challenge the attractiveness of natural COT predators to the self same trades (attractiveness which is probably partly to blame in the first place).

And another thought—has it gone unnoticed by readers that there are few collective nouns for the denizens of coral reefs? Schools of fish! I hear you all cry, but is that the best we can manage? There is no denying the poetry of collective nouns in terrestrial systems. The imagination is fired far more by a 'skein of geese veiling the sky' than 'a big flock of geese flapping about'. Spyhopper would like to know if any readers have any particular ideas for collective nouns, but to get you going, a few suggestions. A cluster of starfish, a flock of parrotfish, an army of urchins, a band of hermit crabs, a carousel of *Hippocampus*, a risk of lobster, an audience of clams. Get those letters in, and a prize for the most inventive...

Spyhopper

NEWS

MOLECULAR MARKERS FOR CROSS BOUNDARY MANAGEMENT

Coral reef fish and invertebrate genetic information may be used to address management questions for populations or reef systems. In recent years, information from mating systems, sources of migratory individuals and the analysis of population structures based on molecular genetic markers (e.g. isozyme and DNA material) have had a significant impact on the management of pelagic fisheries resources. Is it possible to use these same methods on coral reef resources, mainly to complement ecological studies and as a guide for resources management?

The Population Interdependencies in the South China Sea Ecosystems or PISCES project is an initiative along these lines. PISCES is an attempt to apply the theory and technology of molecular genetic markers to the management question of coral reef resources sharing between Malaysia, Indonesia, the Philippines, Vietnam, Taiwan and the Solomon Islands. PICSES was prompted by the growing need for information on the interdependent nature of the reefs in the area.

On average, over 60% of the larvae from organisms in coral reefs remain in the pelagic phase for at least 21 days before they recruit into an existing population. Given the magnitude and direction of the surface current patterns, this period allows transport of juveniles across country boundaries. Yet the extent and direction of movement is not very clear.

Our model of reef interdependencies will be based on genetic information from populations of three species of reef fish and one invertebrate. These are *Heniochus acuminatus*, *Thalassoma hardwicke* and *Dascyllus trimaculatus* and the starfish, *Linckia laevigata*. These species are ubiquitous within the wide latitude covered by the study, and are sub-

jects of ongoing research in the collaborating institutions.

Aside from developing a model on reef interconnectivity, the project provides an opportunity for the participating institutions to relate their current research (e.g. investigations on reef fish recruitment, distribution in relation to pollution activities, environment gradients, etc.) to the study and to avail themselves of training. Though very limited in its scope and participation, the project is a major start towards regional cooperation and management of coral reef resources.

For further information contact: Maria Carmen A. Ablan, PISCES Project Coordinator, International Center for Living Aquatic Resources Management (ICLARM) MCPO Box 2631, 0718 Makati, Metro Manila, Philippines. Fax: (632) 816-3183. E-mail: <m.ablan@cgnet.com>

TROUBLED WATERS

The world's marine scientists have been instrumental in building awareness about the declining health of the sea, because they are knowledgeable witnesses to changes from human activities. Troubled Waters: A Call for Action was initiated to express this concern and suggest solutions to policy makers and the public. Drafted by Elliott Norse, President of Marine Conservation Biology Institute, and amended by a number of leading marine scientists, the statement made its debut at the Symposium on Marine Conservation Biology held last June in Victoria, British Columbia. Beginning with clipboards, tables and telephone calls, the effort then zipped across the Internet to find additional support - a nerve had been struck. To kick off the International Year of the Ocean, MCBI released Troubled Waters to a packed press room in the United States Capitol Building on January 6th with over 1,600 signatures from conservation biologists and marine scientists from over 70 countries.

Troubled Waters calls for immediate action by governments and peoples around the world towards implementing five groups of recommendations:

1. Identify and provide effective protection to all populations of marine species that are significantly depleted or declining, take all measures necessary to allow their recovery, minimize bycatch, end all subsidies that encourage overfishing and ensure that use of marine species is sustainable in perpetuity.

2. Increase the number and effectiveness of marine protected areas so that 20% of Exclusive Economic Zones and the High Seas are protected from threats by the Year 2020.

3. Ameliorate or stop fishing methods that undermine sustainability by harming the habitats of economically valuable marine species and the species they use for food and shelter.

4. Stop physical alteration of terrestrial, freshwater and marine ecosystems that harm the sea, minimize pollution discharged at sea or entering the sea from the land, curtail introduction of alien marine species and prevent further atmospheric changes that threaten marine species and ecosystems.

5. Provide sufficient resources to encourage natural and social scientists to undertake marine conservation biology research needed to protect, restore and sustainably use life in the sea.

Efforts to implement these suggested solutions can be aided by taking the support for Troubled Waters to those that will listen. There have already been encouraging signs that this approach is effective. United States Representative Curt Weldon (Republican from Pennsylvania), a champion of marine conservation who spoke at the news conference on January 6, later presented the 10-meter scroll with the names of endorsers to other United States lawmakers at the Year of the Ocean kick-off in Washington DC. Then, in Stockholm, he presented the scroll to an international meeting of government leaders at the Advisory Committee on Protection of the Oceans (ACOPS). In countries around the world, government agencies embroiled in discussions of marine conservation efforts have referenced Troubled Waters to point out the need for strong marine conservation policy. The International Year of the Ocean affords many more opportunities to highlight the work of marine NGOs, government agencies, and citizens.

The message of Troubled Waters is this: For humanity to benefit from the oceans in the future, we must change our ways today. The priorities of governments around the world must be shifted to pay much greater attention to improving our understanding and conservation of the marine environment. You can still add to the momentum by using the Troubled Waters statement (posted on MCBI's web site <www.mcbi.org>) in policy meetings and discussions, public education and media alerts. As Sara Lourie, a recent endorser with Project Seahorse of the Zoological Society of London stated, "I fully endorse the points raised and agree that we must mobilize people for a fundamental change in attitudes towards the oceans. Tomorrow is too late."

Aaron Tinker, Program Assistant Marine Conservation Biology Institute, 15806 NE 47th Court, Redmond, WA 98052-5208 USA. Tel. 1 (425) 883-8914 (office) 883-3017 (fax) E-mail <atinker@u.washington.edu> web page http://www.mcbi.org

TORTUGAS 2000: PLANNING FOR A NEW MARINE RESERVE IN THE FLORIDA KEYS

"The Tortugas, Florida, probably surpasses any other situation in the tropical Atlantic, in the richness of its marine fauna and in natural advantages for the study of tropical life..." (Mayer 1903). Alfred Goldsborough Mayer's observation about the Tortugas written 95 years ago still holds true, and is even more relevant today with the degradation of coral reef ecosystems in the Keys and around the world. However, one thing that hasn't changed much since the days of Mayer's Tortugas Marine Lab (1904-1939) and Louis and Alexander Agassiz's Tortugas explorations in the mid- to late 1800's is the relatively pristine quality of the water and marine resources of the region. It is for this reason that the Florida Keys National Marine Sanctuary (FKNMS) plans to designate an area in the vicinity of the Dry Tortugas as an ecological reserve in the year 2000. The FKNMS is one of twelve National Marine Sanctuaries in the United States designated to protect significant natural and cultural resources, and its 'no-take' zone network is the largest in the USA.

COMPLEAT REEF ENCOUNTER No. 23

Generations of Japanese medicine men have testified to the benefits of drinking fluids impregnated with mineral rich coral sand. Now you can buy coral sand, farmed in Japan under the strict supervision of government inspectors, to treat your hiatus hernia, rheumatoid arthritis, gastroenteritis, cataracts, ulcerative colitis, hyperacidity, oh yes, and indigestion. "I was skeptical, but it really is a miracle cure" said Peter Galbraith, an osteoarthritis sufferer for 12 years. Reef Encounter wonders whether an unprecedented outbreak of indigestion amongst Caribbean Parrotfishes might not have a lot to answer for...

Extracted from an Advertiser's announcement in The Northern Echo. 12 Aug. 1997.

The Tortugas are a remote area located 112 km west of Key West and over 224 km from mainland Florida. The clearest and cleanest waters in the Florida Keys archipelago bathe its coral reef, hard bottom, and seagrass communities. The area is virtually a swirling vortex of marine biodiversity fueled by the Gulf Stream, one of the world's strongest currents. Based on recent research by Roberts (1997) the Tortugas has a high potential for receiving larvae from a wide area in the Caribbean as well as exporting larvae to a large area including the entire Keys archipelago and the east coast of Florida.

This plan, called Tortugas 2000, began in April with an Ecological Characterization Forum and meeting of the Tortugas Working Group. The working group is charged with developing boundary alternatives and a draft Environmental Impact Statement for the Tortugas reserve. Throughout the summer the working group will gather ecological and socioeconomic information on the area from knowledgeable locals and scientists, develop criteria for the reserve, and in the fall start to draft boundary alternatives for public comment.

Ocean zoning (e.g. marine reserves) is increasingly becoming a preferred management option for protecting in situ biodiversity and, in some cases, fisheries. This movement toward reserves represents a significant evolution in our thinking about ocean conservation because it is a precautionary approach that explicitly recognizes uncertainty in our ability to predict nature (see Ludwig et al. 1993; Roberts and Polunin 1993; and Pauly et al. 1998). The Tortugas ecological reserve will protect biodiversity in the area, maintain ecosystem integrity, and act as a reference site to help scientists discriminate between natural versus human-induced changes to the Keys ecosystem.

References

Ludwig, D., R. Hilborn, and C. Walters. 1993. Uncertainty, resource exploitation, and conservation: Lesson from history. Science 260: 17.

Mayer, A.G. 1903. The Tortugas, Florida as a station for research in biology. Science 17: 190-192.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese, and F. Torres. 1998. Fishing down marine food webs. Science 279: 860-863.

Roberts, C. 1997. Connectivity and management of Caribbean coral reefs. Science 278: 1454-1457.

Roberts, C. and N.V. Polunin. 1993. Simple solutions to managing complex fisheries. Ambio 22: 363-368.

For more information on the Tortugas Ecological Reserve, contact Joanne Delaney and Ben Haskell Tel. (305) 743-2437 Fax: (305) 743-2357 E-mail: <bhaskell@fknms.nos.noaa.gov> or visit the Tortugas 2000 website at: www.fpac.fsu.edu/tortugas.

CURRENTS

RAPID WASTING SYNDROME OR CORAL PREDATION BY STOPLIGHT PARROTFISH?

Andrew W. Bruckner and Robin J. Bruckner

There is a general consensus among marine scientists that coral reefs are being degraded at an alarming rate. Since the first published account of coral disease 25 years ago, the incidence of coral disease and associated coral mortality has escalated significantly (Santavy and Peters, 1997). In addition to an emergence of new coral diseases observed in the past decade, many diseases are appearing at a greater frequency, over a wider distribution, and among species thought to be resistant to diseases (Anonymous, 1996; Bruckner and Bruckner, 1997a,b; Richardson *et al.*, in press; Santavy and Peters, 1997). Although coral diseases are now receiving greater attention from the scientific community, most diseases appearing on coral reefs have not been thoroughly characterized, and their etiologies, including the causative agent, often remain unknown (Peters, 1997).

Several factors immediately lead us to believe that parrotfish bites were mistaken for a new coral disease

The three morphotypes of star coral (*Montastraea annularis, M. faveolata* and *M. franksi*) are the dominant massive reef-builders on most Caribbean reefs. Throughout their range, they are susceptible to chronic partial mortality from disease (black-band, white plague, and yellow-band diseases), predation by corallivorous molluscs and fish, algal lawns created by damselfish, and progressive overgrowth by macroalgae and bioeroding, encrusting invertebrates (Santavy and Peters, 1997; Bruckner and Bruckner, 1997b,c). In the journal *Science* a sidebar entitled "New Caribbean Coral Killer" (June 26, 1997) featured a colony of *Montastraea annularis* with tissue loss and skeletal destruction extending in a narrow strip along the convex, uppermost surface of the coral. This damage was attributed to a new coral disease which was predicted to become a major source of coral mortality in the Caribbean in the next year (Cervino *et al.*, 1997).

Cervino and Goreau first identified colonies of *Montastraea* spp. and *Colpophyllia natans* (brain coral) with this supposed new disease in 1997 on southern Caribbean reefs, and hypothesized that it spread over 9000 km to distant locations in the Caribbean within six months (Cervino et al., 1997). This syndrome was named "rapid wasting disease" (RWD) because of the rapid rate of tissue destruction combined with concurrent "dissolution" of the top layers of calcium carbonate skeleton. In affected colonies, live tissue formed a sharp boundary with areas denuded of tissue and upper layers of skeleton; exposed skeletal surfaces were described as crumbly to the touch, and appeared as if concentrated acid had been poured on them (Cervino *et al.*, 1997). "Rapid wasting disease" (recently renamed Rapid Wasting Syndrome, RWS) was presented as a new phenomena unknown from reefs in the western Atlantic before December 1996.

Field observations by ourselves and others concluded that this damage results from overlapping bites by stoplight parrotfish *Sparisoma viride*. Several factors immediately lead us to believe that parrotfish bites were mistaken for a new coral disease:

- Rapid wasting syndrome had been characterized by removal of tissue and the top layers of the skeleton whilst all known coral diseases damage coral tissue alone.
- Elevated portions of *Montastraea* spp. colonies are particularly affected whilst live, apparently healthy tissue always remains within depressions and at the base of affected lobes.
- Coral tissue at the margin of the tissue-denuded, abraded skeleton appears fully pigmented and does not exhibit any signs of disease or necrosis.
- Calcium carbonate skeletal fragments may be found on or near affected corals.
- Extensive damage occurs in areas with a high abundance of large, territorial stoplight parrotfish, and does not encompass the entire vertical distribution of the corals.
- It is physiologically unlikely that any microorganism could maintain a low pH adequate to dissolve such large quantities of calcium carbonate in the presence of seawater.

These conclusions are supported by studies of the biolo-

gy and ecology of *S. viride* from Barbados, Bonaire, and the Virgin Islands where stoplight parrotfish have been observed to create large lesions on colonies of *M. annularis* since at least the late 1970's (Frydl, 1979; Bruggeman *et al.*, 1994; Van Rooij et al., 1996; Bythell et al., 1993).

Feeding mode and diet of parrotfish

The parrotfish (family Scaridae) are an abundant group of herbivorous reef fish with fused, beak-like jaws used primarily to graze epilithic algae from reef substrata. Two distinct groups have been distinguished, scrapers and excavators, based on the morphology of their jaws and their behavior (Bellwood and Choat, 1990). Excavating species take fewer bites per minute when compared to scrapers; their bites are slower, and involve deep gouges of the substrata which often leaves distinct scars. Bellwood and Choat (1990) noted that excavating parrotfish primarily bite convex surfaces, which may have a significant impact on the topographic complexity of the reef structure.

Although parrotfish are widely recognized as a major component of the herbivorous reef fish community, certain species have been known to bite live coral for over 100 years (Frydl, 1979) and parrotfish predation on corals was recorded by Darwin. In Australia, over 50% of the diet of one species of parrotfish (*Bolbometopon muricatum*) consists of live coral; other Indo-Pacific parrotfish species occasionally graze coral, and include both excavators and scrapers (Bellwood and Choat, 1990). Researchers in the Caribbean report four *Scarus* species which occasionally bite live coral. Extensive feeding on live coral is limited to adult *S. viride*. Large initial phase (IP) and territorial terminal phase (TP) *S. viride* graze predominantly on *M. annularis, M. faveolata, C. natans* and *Porites astreoides*, and less frequently on *Acropora palmata, Agaricia agaricites, Diploria* spp., *Eusmilia fastigiata, Madracis mirabilis, M. cavernosa, P. porites, Siderastrea siderea, Stephanocoenia intercepta* and the hydrozoan *Millepora* spp. (Frydl, 1979; Bruckner and Bruckner, in press).

Certain species have been known to bite live coral for over 100 years

S. viride employ an excavating feeding mode, which leaves deep grazing scars on limestone substrates. In Bonaire, Bruggemann *et al.* (1994) noted that *S. viride* graze on algal turf associated with dead coral, with 9.3% of the bites by territorial TP males taken from living corals, primarily *M. annularis*. Individual fish returned to the same coral to bite repeatedly, creating conspicuous white spots on the upper surfaces of lobate colonies. White spot marking by *S. viride* occurred near territory boundaries, and was hypothesized to function in consolidating social interrelationships between conspecifics (Bruggemann *et al.*, 1994).

Figure 1. S. viride. *A large terminal phase male biting a lobe of* M. annularis. *This fish returned to this lobe 14 times during a 60 minute dive, taking one or more bites on each visit.*

Impact of *S. viride* on *M. annularis*

Predation by stoplight parrotfish was the most serious cause of chronic coral tissue loss to *M. annularis* in the U.S. Virgin Islands (Bythell *et al.*, 1993). These authors documented that parrotfish grazing on live coral affected over 10% of the surface area of individual genets and 25% of the monitored colonies during a one year period following Hurricane Hugo. In the Florida Keys, Shinn (1989) recognized head corals with lesions caused by the bites of parrotfish at an abundance that outnumbered abrasions made by divers. Frydl and Stearn (1978) concluded that stoplight parrotfish were the only species that caused significant bioerosion in Barbados. Damage was most apparent on *M. annularis*, where *S. viride* created grazing scars from 1 to 200 cm^2 in size, usually forming a narrow band (approx. 3 cm wide) that follows the natural contours of the lobe (Frydl, 1979). Although obvious grazing scars are not always apparent in low density coral skeletons such as *M. annularis*, Frydl (1979) reported that the width and shape of the excavations corresponds closely to the dimensions and curvature of the beak of *S. viride*. Frydl (1979) concluded that repeated bites by *S. viride* on *M. annularis* may kill large parts of the colony, re-

Figure 2. M. annularis. *Several lobes of star coral with recent lesions created by* S. Viride, *and signs of older* S. viride *lesions. Stoplight parrotfish create large lesions on the upper surfaces of* M. annularis *lobes removing tissue in a band, while rarely killing the entire lobe. Although the coral never completely regenerated tissue over lesion, the coral continues to grow upwards, forming a donut-shaped rim of live tissue encircling the lesion. Because territorial parrotfish may live for up to 17 years, this makes the coral vulnerable to predation at a later date.*

tarding its growth, and thus having a profound effect on the shape of the coral heads.

Recent Observations of *Sparisoma viride* behavior

Over the past year we have monitored S. viride territories in Puerto Rico, Curacao and Bonaire to quantify the extent of damage on live corals caused by repeated fish bites and to determine the impact of this behavior on coral survivorship. Initially, we monitored colonies of Montastraea and Colpophyllia with large, rapidly progressing lesions to determine if S. viride were actively biting these colonies. In Bonaire we observed S. viride approach and bite at the interface between tissue denuded, eroded skeleton and undamaged tissue within 15 minutes in over 90% of our randomly chosen colonies. In all cases, a territorial TP S. viride took one or more bites from affected lobes every 1-15 minutes throughout the day. TP fish often had a harem of IP females which also attacked fresh lesions, taking 1-5 bites per visit. Typically, IP fish approached corals more frequently than TP S. viride, biting in a sequence which initiated with the largest fish and progressed to smaller individuals. Bites were concentrated in the same area on an individual lobe, with skeletal destruction advancing in a band across the lobe. After tissue and skeleton was removed from the top

portion of the lobe, fish focused on an adjacent lobe, repeating the process for several days to weeks until multiple lobes were damaged. On occasion S. viride preyed simultaneously upon several adjacent lobes on individual colonies, or on multiple colonies within their territory. Bites on live coral by TP males were often associated with territorial interactions (chases) with conspecific TP fish, and occurred immediately before or after spawning. In all monitored colonies of Montastraea spp., S. viride never completely killed the affected coral, and progressive recovery is underway in all colonies we have observed fish to bite. These fish also bite C. natans, typically beginning at the edge of the colony, and removing coral tissue and skeleton methodically in a band that advances across the coral; occasionally they denude the entire colony (Bruckner and Bruckner, in press).

Currently the role of the fungus remains unknown, but our recent work suggests that the damage attributed to RWS occurs only during daylight when *S. viride* are active

The RWS researchers observed a fungus in some tissue samples removed from colonies characterized as having RWS. Currently the role of the fungus remains unknown, but our recent work suggests that the damage attributed to RWS occurs only during daylight when *S. viride* are active. If a fungus was directly involved in this process, it is likely that damage would progress throughout the evening. In *C. natans* and *Montastraea* spp., caging experiments conclusively demonstrate that tissue necrosis and skeletal erosion halt once *S. viride* are excluded. Furthermore, attempts to infect apparently healthy colonies by attaching tissue and skeletal material removed from a region of active *S. viride* destruction failed to initiate patterns of damage associated with RWS. Once parrotfish stop biting an affected lobe, exposed skeleton remains white for several days and colonization by filamentous algae is not immediately visible. Because the RWS researchers were unaware of the role of *S. viride* in these processes until recently, tissue samples they analyzed may not have been taken from a region of active necrosis, and it is possible that the fungus identified in samples represents a secondary colonizer which invades the tissue once the fish stop biting.

Coral-biting parrotfish can be observed easily in Bonaire, where fish and coral populations have been protected over 17 years by the Bonaire Marine Park. Similar lesions have been found in other locations throughout the western Atlantic, however, and were reported in the literature for several decades. Lesions by *S. viride* are highly aggregated and patchy, and some reefs exhibit considerably higher rates of damage than others. It has not been conclusively demonstrated whether or not the amount of damage can be directly related to the abundance or biomass of *S. viride*, or the density of their territories. The abundance of macroalgae has increased on many Caribbean reefs since the loss of the important herbivorous urchin *Diadema antillarum* in the mid 1980's. A greater biomass of algae may support a larger population of herbivorous fish such as *S. viride*; this may result in a greater number of fish per reef, a higher density of territories, more territorial interactions, and consequently more territorial markings on live coral.

It is important to note that *S. viride* rarely, if ever cause total mortality to *Montastraea* spp. Coral tissue always remains in a band encircling the base of the colony. This tissue continues to grow upward, but typically does not completely regenerate over large lesions. In colonies which have old grazing scars, coral tissue eventually forms a steep-walled, donut-shaped rim around the remnant of the scar, which may make that colony attractive to fish years later. The RWS researchers have recently acknowledged that *Sparisoma viride* are responsible for the large lesions on colonies of *Montastraea* and *Colpophyllia*, which they previously identified as a new coral disease. The abundance of literature documenting *S. viride* predation on corals clearly illustrates that this is not a new phenomena. Evidence that this process has occurred for decades is visible in the morphology of the affected corals, and thus would be preserved in the geologic record.

S. viride rarely if ever cause total mortality to *Montastraea* spp.

References.

Anonymous 1996. Coral disease hot spots in the Florida Keys. Science 274:2017.

Anonymous 1997. New Caribbean coral killer. Science 276:1979.

Bellwood, D.R. and J.H. Choat 1990. A functional analysis of grazing in parrotfishes (family Scaridae): the ecological implications. Environmental Biology of Fishes 28:189-214.

Bruckner, A. W. and R. J. Bruckner 1997a. Outbreak of coral disease in Puerto Rico. Coral Reefs 16:260.

Bruckner, A.W. and R.J. Bruckner 1997b. The persistence of black-band disease in Jamaica: impact on community structure. Proc. 8th Int. Coral Reef Symp. 1:601-606.

Bruckner, R.J. and A.W.. Bruckner 1997c. Life history strategies of *Coralliophila abbreviata* Lamarck (Gastropoda: Coralliophilidae) on the southwest coast of Puerto Rico. Proc. 8th Int. Coral Reef Symp. 1:627-632.

Bruckner, A.W. and R.J. Bruckner. In press. Destruction of coral by *Sparisoma viride*. Coral Reefs.

Bruggemann, J.H., M.J.H. van Oppen and A.M. Breeman 1994. Foraging by the stoplight parrotfish *Sparisoma viride*. I. Intake and assimilation of food, protein and energy. Mar. Ecol. Prog. Ser. 106:41-55.

Bythell, J.C., E.H. Gladfelter and M. Bythell 1993. Chronic and catastrophic natural mortality of three common Caribbean reef corals. Coral Reefs 12:143-152.

Cervino, J., T.Goreau, G. Smith, K. DeMeyer, I. Nagelkerken and R. Hayes 1997. Fast spreading new Caribbean coral disease. Reef Encounter 22:16-18.

Frydl, P. 1979. The effect of parrotfish (Scaridae) on coral in Barbados, W.I. Int. Revue des Hydrobiol. 64:737-748.

Frydl, P and C.W. Stearn 1978. Rate of bioerosion by parrotfish in Barbados reef environments. J. Sedim. Petrol. 4:1149-1158 .

Peters, E.C. 1997. Diseases of coral-reef organisms. Pages 114-139 in C. Birkeland ed. Life and Death of Coral Reefs. Chapman & Hall, New York.

Richardson, L.L., R.B. Aronson, W.M. Golberg, G.W. Smith, K.B. Ritchie, K.G. Kuta, J.C. Halas, J.S. Feingold and S.L. Miller In Press. New coral plague on reefs of the Florida Keys. Nature.

Santavy, D.L. and E.C. Peters 1997. Microbial pests: Coral disease research in the western Atlantic. Proc. 8th Int. Coral Reef Symp. 1:

Shinn, E.A. 1989. What is really killing the corals. Sea Frontiers 35: 72-81.

van Rooij, J. M., F.J. Kroon and J.J. Videler 1996. The social and mating system of the herbivorous reef fish *Sparisoma viride*: one-male versus multi-male groups. Environmental Biology of Fishes 47:353-378.

Andrew W. Bruckner and Robin J. Bruckner, University of Puerto Rico, Department of Marine Sciences, Lajas, PR 00667 USA. e-mail <andy.bruckner@noaa.gov>.*

**current address: NOAA/NMFS, Office of Protected Resources, Silver Spring, MD 20910*

REEF FISH RESPONSE TO DIVERS IN TWO 'NO TAKE' MARINE RESERVES IN HAWAII

Jim Bohnsack

Most studies of diver carrying capacity and impacts on coral reefs have concentrated on corals (e.g. Hawkins and Roberts, 1992; Rouphael and Inglis, 1997). While spearfishing and other extractive activities have been shown to impact population abundance, size, and behavior (Bohnsack, 1983; Sluka and Sullivan, 1998), few studies have examined effects of non-extractive diving activities on fishes. Gaudian and Medley (1995) found little impact of divers on fishes in the Turks and Caicos and Pollard *et al.* (1996) indicated that sport divers, who had "very little instruction or advice ... on how to behave amongst ... sharks", had minimum effects on the behavior of protected gray nurse sharks (Carcharias taurus) at Seal Rocks, New South Wales, Australia.

> Previous experience indicated most fishes were extremely shy and almost impossible to photograph where spearfishing occurred

The impacts of divers on fishes is particularly important in 'no-take' marine reserves, areas protected from fishing and other extractive activities. Dr. Bill Ballantine, based on his 20 years experience with a no-take marine reserve in New Zealand where divers, snorkelers, and swimmers are very frequent, commented that "In places where fish have never been killed, they treat human beings as they treat cloud shadows" (Gustaitis 1996). Here I report an informal test of fish responses to divers at two extremes of diving intensity in Hawaiian no-take reserves. I hope these observations may spur others to undertake more formal and comprehensive research.

A 1996 workshop of the Marine and Coastal Ecosystem (MACE) Dictorate of the U.S. Man and the Biosphere (MAB) program included a one day visit to observe two 'no-take' marine reserves off Maui, Hawaii. The two sites represented extremes of visitation intensity. Molokini Crater, declared a 'no-take' Marine Conservation District in July 1977, is one of the most intensively used diving sites in Hawaii. Unpublished data show that over 700 divers and snorkelers can be present at peak times in a day (Ernest. Reese, University of Hawaii, pers comm.). In contrast, Koho'olawe has been protected from fishing and diver access since 1952. It began as a Navy bombing and target range and was returned for use by native Hawaiians under the Native Hawaii Island Commission in 1991. Its protection from fishing and diving has continued because of hazards associated with unexploded ordinance and cultural and religious traditions that declared the island and surrounding area Kapu (off limits). The only diving activity allowed at Koho'olawe was limited to permitted research.

My previous experience in Hawaii indicated that most fishes were extremely shy and almost impossible to photograph where spearfishing occurred. In Guam, even butterflyfishes dove for cover or departed when I attempted to get even within 4 to 5 m. Based on these experiences, I had decided just to photograph habitat with a Nikonous V camera and a 28 mm wide angle lens using natural light. A wide angle lens is ideal for taking habitat pictures but is not normally used to take close up photographs of most fishes because the subject must be very close (<30–50 cm). When it became obvious that I could get close enough to get reasonable photographs, I shifted my emphasis to fishes.

Only when I was within approximately 40 cm did it respond to me by turning its head

In attempting to photograph fishes, I made informal observations of behavioral responses to divers based on their reaction distances to me. Reaction distance was defined as the closest point of approach before an organism either took shelter, fled with increased swimming speed, or changed its orientation away from me. My goal was to get a good lateral photograph of common reef fishes. I approached slowly using a regular pattern of kicks while attempting to get as close as possible without alarming the subject. The closer that I approached, the larger the image.

At Koho'olawe, we found the fishes to be rather indifferent to our presence. Since most of the time was spent well away from the research site, it is probable that many of the organisms encountered had little or no previous experience with humans. While snorkeling, I was able to approach within 0.5 m and photograph a wide variety of common reef fishes without apparent alarm, including many butterflyfishes and several blue-spotted argus grouper (*Cephalopholis argus*), a favorite fishing target, that I had not seen on previous trips to Hawaii except in the protected Hanauma Bay marine reserve.

Humans are now an interactive part of the coral reef ecosystem. We have an important role to play, but how we interact and what our role will be is still being determined.

For over 20 minutes, approximately 15 snorkelers followed and closely observed a green sea turtle (Chelonia mydas) foraging under coral. Only when I was within approximately 40 cm did it respond to me by turning its head. When I moved away slightly, it resumed its foraging behavior. At no time did it appear alarmed by our presence. In my experience elsewhere, most sea turtles quickly flee in the presence of a diver. Because of its small size (~ 24" carapace length), there is a reasonable chance that it was a resident and possibly had never previously encountered a human.

Fishes at Molokini Crater had the same behavioral response to divers as at Koho'olawe with one major exception: when divers first entered the water, a cloud of fishes initially rose off the bottom and surrounded the divers coming within an arm's reach. Divers commonly feed fishes at Molokini and these appeared to be looking for food. Once they determined that we were not going to feed them, most returned to the bottom and resumed what appeared to be normal behavior, essentially ignoring us for the rest of the dive. Again I was able to closely approach and photograph most all observed species.

Ballantine (1995, 1997) makes a strong case that public access to no-take marine reserves is essential for increased public understanding, appreciation, acceptance, and support for marine conservation and marine reserves. Public access also can facilitate enforcement and discourage poaching. Ballantine's quote about humans being no different than passing clouds implies that divers can be accepted as just another fish in no-take zones. My observations support Ballantine's hypothesis. Most fishes allowed divers to approach within less than a meter with no visible indication of alarm. Like a passing cloud, divers may startle or elicit a response from organisms when closely approached, but these impacts are inconsequential. Even the green sea turtle at Koho'olawe showed no response to divers unless approached quite closely. In areas where spear fishing was practiced in Hawaii, Guam, and Fiji, I found it virtually impossible to get near most fishes, including some of the same species.

In conclusion, the mere presence of people has negligible impact on the behavior of fishes and other marine organisms. It is the type of human activity and behavior that are issues. While fish feeding clearly attracts fishes and alters their behavior, it did not appear to be a problem except perhaps for an occasional bite on an unwary diver. Compared to the impacts of people removing hundreds of millions of tons of fish from the sea each year, the impact of fish feeding seems insignificant.

Nobody questions that fact that human beings have expanded into, and now are a "natural" part of almost all terrestrial habitats. Likewise, it is time to recognize that humans are now an interactive part of the coral reef ecosystem. We have an important role to play, but how we interact and what our role will be is still being determined.

Acknowledgments

I thank E. Reese, B. Ballantine and B. Bohnsack for helpful comments.

References

Ballantine, W.J. 1995. Networks of "no-take" marine reserves are practical and necessary. Pages 13-20 in Shackell, N.L. and J.H.M. Willison (eds). Marine Protected Areas and Sustainable Fisheries. Science and Management of Protected Areas Association. Wolfville, Nova Scotia. 300 pp.

Ballantine, W.J. 1997. 'No-take' marine reserve networks support fisheries. Pages 702-706 in 'Developing and Sustaining World Fisheries Resources: The State and Management', D.A. Hancock, D.C. Smith, A. Grant, and J.P. Beumer (eds.). 2nd World Fisheries Congress, Brisbane, Australia, 797 p.

Bohnsack, J.A. 1983. Changes in reef fish populations at Looe Key National Marine Sanctuary. American Zoologist 23(4): 986.

Gaudian, G. and P. Medley. 1995. Evaluation of diver carrying capacity and implications for reef management in the Turks and Caicos Islands. Bahamas J. Sci. 10/95: 9-14.

Gustaitis, R. 1996. The case for "no-take" marine reserves. California Coast and Ocean. Summer 1996: 30-33.

Hawkins, J.P. and C.M. Roberts. 1992. Effects of recreational SCUBA diving on fore-reef slope communities of coral reefs. Biol. Conserv. 62: 171-178.

Hawkins, J.P. and C.M. Roberts. 1997. Estimating the carrying capacity of coral reefs for SCUBA diving. Proc. 8th Int. Coral Reef Symp 2: 1923-1926.

Pollard, D.A., M.P.L. Smith and A.K. Smith. 1996. The biology and conservation status of the grey nurse shark (Carcharias taurus rafinesque 1810) in New South Wales, Australia. Aquatic Conservation Marine and Freshwater Ecosystems 6(1): 1-20.

Sluka, R.D. and K.M. Sullivan. 1998. The influence of spear fishing on species composition and size of groupers on patch reefs in the upper Florida Keys. Fish. Bull. 96: 388-392.

Davis, D. and C. Tisdell. 1995. Recreational scuba-diving and carrying capacity in marine protected areas. Ocean & Coast. Manag. 226: 19-40.

Rouphael, A.B.and G.J. Inglis. 1997. Impacts of recreational SCUBA diving at sites with different reef topographies. Biol. Conserv. 82: 329-336.

CULTURING CORAL FOR MANAGEMENT

C.A. Muhando and H. Franklin

James A. Bohnsack, Southeast Fisheries Science Center, National Marine Fisheries Service, 75 Virginia Beach Dr. Miami, FL 33149

Anthropogenic pressures on the coral reefs of Tanzania are high. Over-exploitation, destructive fishing practices, unplanned tourism and high sedimentation load are amongst the most evident contributing factors whilst the poor economy and increased human population density along the coast is an underlying problem. There is a clear need for alternative sources of livelihood and effective ways to manage coral reef resources sustainably. Mariculture is becoming a common component in coastal zone management in Tanzania.

Experiments on coral culturing have been conducted in the Chumbe Marine Sanctuary, Zanzibar during 1994-96. The principal objectives have been to assess the possibility of culturing fragments of different sizes from branching corals, and to assess the effects of lesions on the upper surfaces on fragment growth and survival. The idea behind this was to minimize the damage caused to the harvested coral colony. Instead of breaking off many small branches, it may be better to break off a few longer branches which can be sub-divided into smaller pieces. These small pieces will thus have one surface submerged in cement and a lesion on the upper surface. The results indicate that the growth of coral fragments does not seem to be inhibited by having lesions on the upper surface, and fragments as small as two cm survive and grow well. However, management aspects of coral culture warrant further analysis and there are no plans at this moment to implement this in practice in Tanzania.

Mariculture is becoming a common component in coastal zone management in Tanzania

Coral can be cultured through either fragmentation or larval settlement onto artificial substrates. Part of the project focused on seasonality in recruitment of scleractinian corals in order to identify an appropriate season for submerging substrates. Preliminary observations indicate that there is a seasonal trend with higher recruitment during the warmest months of the year.

Coral reef management could benefit from the use of cultured corals in many ways. One idea might be to create a "coral garden" from which small branches are harvested and subsequently reared to commercial sizes. Uses might include reef restoration, supplying the aquarium market with cultured instead of wild specimens, and experimental research. The most 'environmentally sound' approach would be to put out substrates onto which coral larvae can settle. However, considering

the limited growth of newly settled corals, perhaps a combination of both fragmentation and settlement enhancement is necessary. For commercial purposes, such as the aquarium trade, guarantees for the authenticity of sustainably cultured corals must be developed.

The intention is to continue with further studies concerning various aspects of coral culturing and recruitment on the coral reefs off Zanzibar. This work was partly presented at the 8th ICRS in Panama, June, 1996 and further data analysis is still underway.

Christopher A. Muhando, University of Dar-es-Salaam, Institute of Marine Sciences (IMS), P.O. Box 668, Zanzibar, Tanzania. E-mail: <muhando@zims.udsm.ac.tz> and Henrik Franklin, Aquaria Water Museum, Falkenbergsgatan 2, S-115 21 Stockholm, Sweden. E-mail: <henrik_f@algonet.se>.

CROWN OF THORNS STARFISH IN THE WESTERN INDIAN OCEAN

M. Schleyer

Increasing numbers of crown-of-thorns starfish (COTs) *Acanthaster planci* are being found in the Indo-Pacific region (Engelhard 1996, Lassig and Engelhard 1994, Stump 1996). However, there appears to be a gap in the information presented by Lassig and Engelhard (1996) for the Western Indian Ocean (WIO). The Oceanographic Research Institute (ORI) in Durban has been involved in coral reef research in a number of areas in the WIO during this decade and has encountered COTs outbreaks since September 1994. The following brief account summarizes these observations.

ORI coral research started on the reefs in northern KwaZulu-Natal in 1991. Schleyer (1995) provides a review on the nature and extent of the reefs (Fig. 1) which are rich in biodiversity but dominated by soft corals. The coral communities are at the limits of their distribution and are atypical in community structure. No COTs were initially found during extensive surveys of these reefs but sport divers reported their presence on the most heavily used reef at Sodwana Bay in 1993. Outbreaks were also reported for this area in 1994. COTs were found by ORI divers in September 1994 at the start of a reef damage survey (Schleyer and Tomalin submitted) and monitoring has continued. Historically, COTs were seen in some numbers circa 1970 but were not encountered in the intervening years up to the time of these records.

> These outbreaks are small, localized and isolated. However, so are the reefs, and the damage is commensurately large and important

The COTs outbreaks at Sodwana Bay were all found on Two-mile reef (TMR), with only a single 30 cm specimen found at Four-mile Reef (FMR). The COTs appeared to aggregate at the deeper fringe of TMR (24–27 m) where the reef shelf emerges from sediment covered bedrock (27-30 m). Once aggregated, they moved onto the reef as a feeding party, tending to move with the generally strong southward current.

While the hard coral genera *Acropora*, *Montipora* and *Fungia* were initially favored prey of the COTs, even colonies of *Pocillopora*, which are frequently avoided (Endean and Cameron 1990) were finally eaten. A few COTs stations were included in a survey of reef damage in the area (Schleyer and Tomalin submitted) and provided the highest levels of damage encountered. Soft corals also manifested severe damage, possibly resulting from the "fall-out" of digestive enzymes while the COTs were consuming adjacent hard corals, as no soft corals were observed being eaten.

It was fairly easy to locate the COTs in summer, but difficult in winter when they appeared to disperse. Field dissections indicated that their gonads developed in spring and summer, reaching a peak in February, followed by greatly reduced gonads in March. These limited observations suggest spawning does take place in South African waters and occurs in summer. The dispersion of the COTs as the summer (and the reproductive season?) passed gave the impression that their purpose in aggregating was for breeding rather than feeding. Scars were evident on the arms of some specimens collected and a number of the COTs were regenerating arms; showing they are predated in South African waters.

More recently, ORI staff found COTs feeding scars on *Acropora austera* on FMR and have received reports of COTs on a reef at Kosi Bay and on Leadsman Shoal and Aliwal Shoal (Fig. 1). ORI staff also gathered evidence of COTs elsewhere in the WIO (Table 1), although this list is not exhaustive. Poisoning with sodium bisulphate was recommended to control outbreaks at Bazaruto Island and Sodwana Bay. Most of the COTs were physically removed by volunteers at Bazaruto within a year (pers. obs.) but the conservation authority at Sodwana Bay, the KwaZulu-Natal

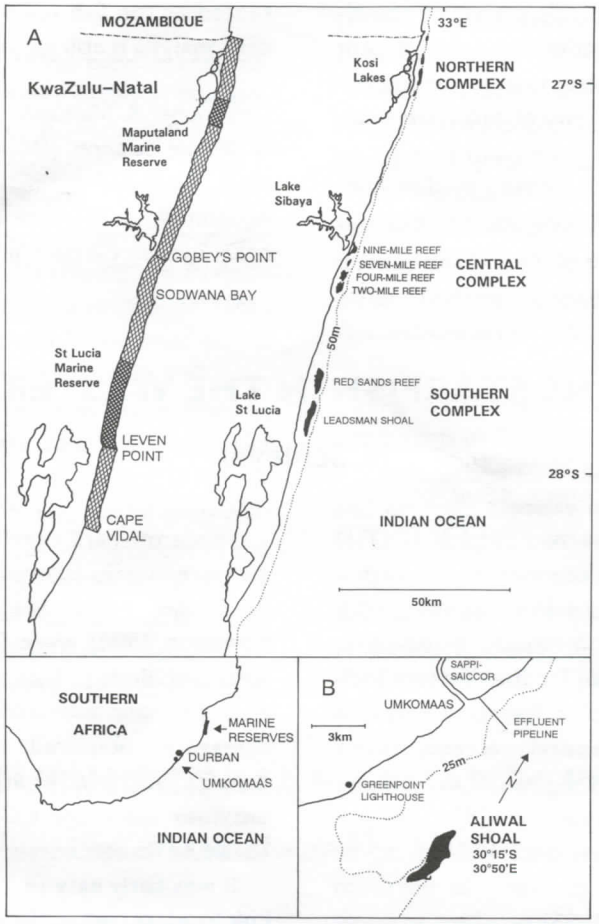


Figure 1. The major coral reefs in South Africa are found in marine reserves (shaded areas), which include sanctuary areas (dark shading), in northern KwaZulu-Natal (A). Corals are also found in Aliwal Shoal (B) which is south of Durban and referred to in the text.

Table 1. ORI record of COTS damage and outbreaks on reefs at other localities in te WIO.

Date	Locality	Co-ordinates	Depth (m)	Observations
Oct.'94	Two-mile Reef, Bazaruto Archipelago, Mozambique	21°48.6'S 35°29.9'E	13	Observed ±40 COTS and extensive reef damage in a 70 min dive. Size estimated to be 30–35 cm.
Feb.'96	Baixo de San Joao, Mozambique	26°21.5'S 32°58.4'E	23	Observed 5 COTS on severely damaged reef; measured one (58 cm); very little left alive on the reef.
Feb.'96	Reef S of Baixo de San Joao, Mozambique	26°24.1'S 32°58.3'E	26	Observed considerable reef damage but no COTS.
Feb.'96	Ponta Techobanine, Mozambique	26°37.8'S 32°54.8'E	19	Observed no COTS but very extensive feeding scars in a band through a bed of *Acropora austera*.
April'97	"Nakuru Gate", Dahlak Archipelago, Eritrea	15°41.9'S 39°55.0'E	5	Observed 4 COTS, ±20 cm in size.
April'97	Entere Island, Dahlak Archipelago	15°38.5'S 39°53.6'E	9	Observed extensive damage but no COTS; only a few hard corals were left with few sponges, tunicates and soft corals.

Nature Conservation Services, has decided upon a policy of cosmetic control only at intensively used dive sites, and to date only research material has been removed.

A notable feature of these outbreaks is that they are small, localized and isolated. However, so are the reefs (Fig. 1), and the damage is commensurately large and important. Further information is needed before recommendations can be made concerning the management of COTs in South Africa and the ORI has submitted a proposal for funds to undertake research on the dynamics of the outbreaks and subsequent reef recovery.

Acknowledgements.

Financial support was through a number of agencies, notably the South African Association for Marine Research. Many staff and volunteers assisted in the field but chief among these was Tim Kay.

References

Engelhard U (1996) COTS Comms. Reef Research 6(1): 18-20.

Endean R and Cameron AM (1990) *Acanthaster planci* population outbreaks. In: Dubinsky Z (ed) Coral reefs of the world. Ecosystems of the world Vol 25, Elsevier, Amsterdam, pp 419-437.

Lassig B and Engelhard U (1994) COTS Comms. Reef Research 4(4): 18-24.

Schleyer MH (1995) South African coral reef communities. In: Cowan GI (ed) Wetlands of South Africa. Department of Environmental Affairs and Tourism, Pretoria, pp 137-146.

Schleyer MH and Tomalin BJ (submitted) Ecotourism and damage on South African coral reefs with an assessment of their carrying capacity. Coral Reefs.

Stump R (1996) An investigation to describe the population dynamics of *Acanthaster planci* (L.) around Lizard Island, Cairns section, Great Barrier Reef Marine Park. CRC Reef Research Centre Technical Report (10), CRC research Centre, Townsville, pp 1-56.

Michael Schleyer, Oceanographic Research Institute, P.O. Box 10712, Marine Parade, Durban 4056, South Africa

ERRATIC DISTRIBUTION OF CROWN OF THORNS STARFISH (COTS) AROUND OKINAWA

K. Reed

Acanthaster planci (Crown of Thorns Starfish) outbreaks are extremely erratic around the islands near Okinawa (Japan). Highly diverse scleractinian reefs with over 300 species of coral are found in these islands at Ie Shima (north of Sesoko I.), west of Motobu peninsula, and in the Kerama group of islands (west of Naha, Okinawa). The Kerama group is a primary tourist dive destination for mainland Japanese tourists as well as Americans working on Okinawa.

During more than 300 dives at 34 different sites (26°10' N to 26°44' N on the East China Sea side of Okinawa, from Spring of 1993 through Spring of 1998) I have noted presence and absence of COTs. In general, reefs and islands separated from the main island of Okinawa were minimally damaged or devoid of COTs, with the exception of Minna Island between Sesoko I. and Ie Shima. However, adjacent to Okinawa there are locally heavy infestations. The worst damage and heaviest outbreaks of 30 to 45 cm adult COTs were at Onna peninsula, Minna I., and south of Okuma peninsula. In July 1995, both northern and southern reefs of Minna Island, and southern reefs of Okuma peninsula were devastated and numerous adult COTs were out in the open. Large numbers of adult COTs were also seen at Manzamo on north side of the Onna peninsula (1997 and 1998), Onna Son (1998), and Okinawa (1998). Though COTs have been reported from Aka Jima in recent years, I have dove eleven islands in the Kerama group in 14 different months of the last five years and never seen a COTs on these reefs. Likewise, in six different months of diving at Ie Shima, I have never seen any COTs, though it is very close to Minna I. which is totally devastated by COTs.

An article in the Okinawa Times said 38,000 COTs had been collected in one day

The combined efforts of Japanese fishers associations and biologists in COTs eradication efforts have yielded incredible culls of adult seastars in Okinawa in recent years. COTs are typically hand-collected and destroyed on shore. An article in the Okinawa Times newspaper (October 8, 1996) said 38,000 COTs had been collected in one day. The same newspaper (March 15, 1998) reported 273,800 COTs collected by Onna fishermen in 11 months between late 1996 through early 1998. The fishermen did not use injectable poison in the water, so as to prevent collateral damage to other reef animals. From 1970 to 1983, approximately 13 million COTs were destroyed throughout the 700 km long Ryukyu archipelago (Yamaguchi 1986).

I have tried to analyze rainfall data for correlation with

the Birkeland's (1982) high island hypothesis. I examined precipitation data for central Okinawa for six years between 1991 and 1996. 1991 had the driest pre-spawning months and 1992 the wettest spawning season of those six years. However, the erratic appearances of the *A. planci* outbreaks on Okinawa probably have multi-factorial causes; i.e., human disturbances (such as agricultural/golf course runoff), natural variation in precipitation before and during COTs spawning seasons, and natural meanders of major ocean currents.

I have wondered about larval dispersal and possible movement of adult COTs from Onna peninsula to other islands. Within 8 kilometers of almost any part of Okinawa, water depth is approximately 600 meters. However, there are sea floor paths between Motobu peninsula to Ie Shima that don't exceed 42 m depth, and the 40 km to the Kerama group of islands could be traversed on the sea floor from Naha, Okinawa without exceeding 60 meters depth. Scuba divers have seen COTs in > 60 m near Seragaki, Okinawa (R. F. Bolland pers. comm.). In a drift card experiment designed to model dispersal of coral larvae, almost ten percent of 1000 cards released in from ten different sites on Aka Jima, in the Keramas, were recovered on Okinawa after traveling at least 40 km (Kimura et al, 1991). One wonders if the COTs larvae and scleractinian planulae drift at similar levels in the water column and which is more carnivorous as they go through metamorphosis?

References:

Birkeland C. 1982. Terrestrial Runoff as a Cause of Outbreaks of *Acanthaster planci* (Echinodermata: Asteroidea). Marine Biology 69:175-185.

Kimura T, Hayashibara T and Shimoike K. 1993. Drift card experiments to know dispersal of coral larvae in Akajima Island, Kerama Island Group, Okinawa. VII Pacific Science Symposium, Naha, Okinawa 27 June-03 July 1993.

Yamaguchi M. 1986. *Acanthaster planci* infestations of reefs and coral assemblages in Japan: a retrospective analysis of control efforts. Coral Reefs 5:23

Cdr. Keven Reed, Director for Ancillary Services, U.S. Naval Hospital, Okinawa, Japan. PSC 482 Box 2754. FPO AP 96362-1670. e-mail: <okil kcr@okil 0.med.navy.mil>

FEATURES

REEF SCIENCE: ASKING ALL THE WRONG QUESTIONS IN ALL THE WRONG PLACES?

Robert W. Buddemeier and Robert A. Kinzie III

As the present and probable future extent of human impacts on the natural environment of the planet become ever clearer and ever more frightening, issues, organisms, and ecosystems queue up for their turn in the conservation spotlight. Corals have become the "doe-eyed invertebrates," and coral reefs are widely touted as "rainforests of the sea," in emulation of the terrestrial ecosystem best equipped with fan clubs, lobbyists, and websites.

Attention to environmental threats and to the imperatives for improved understanding, conservation, and resource management is unquestionably good. However, with this attention come demands for popular explanations and for management strategies and tactics that outstrip our understanding of the system we would save. Gaps in scientific understanding combine with ingenuous anthropocentrism and terrestrial biases to produce concepts of corals and reefs that not only miss critical points, but also foster well-intentioned attitudes or actions that may actually be damaging to reefs.

With attention to environmental threats comes demands for popular explanations and for management strategies that outstrip our understanding.

Like the country music lament about the human tendency to be "lookin' for love in all the wrong places," this paper focuses on what we see as an unfortunate preoccupation with research questions, subjects, or sites that may be attractive or have the sanction of tradition - but that offer us little potential for consummating a truly productive scientific relationship.

THE ISSUES

Both rediscovered wisdom and recent findings challenge long-standing assumptions about corals, reefs, and research strategies. We identify the following critical issues:

(1) What exactly is meant by a "healthy reef", what conditions foster "health", and how do we operationally recognize "health" or "sickness"?

(2) How do nutrients interact with coral reefs, in sickness and in health?

(3) The clonal nature and reproductive strategies of many dominant reef organisms require substantial rethinking of existing models of the population biology of these species.

(4) Lability in the make-up and dynamics of the zooxanthella-host relationship make extrapolations from static models of symbiosis questionable.

(5) Models of carbonate chemistry and reef biogeochemistry on scales ranging from cellular to global must be rethought, and more importantly, integrated.

In the sections that follow we discuss each of these issues, with examples and some of their implications. Following our theme, we identify specific "wrong questions" and "wrong places" — our nominations for the honky-tonks of coral reef science.

THE "HEALTHY" CORAL REEF COMMUNITY

Wrong places

Our present concept of what constitutes a "healthy" reef may relate to anomalous environments that are unimportant on evolutionary time scales. Reasons for selection of a particular reef system for study typically do not emphasize "representativeness"; rather, reefs have commonly been selected because they are already impacted and therefore unhealthy but worthy of concern (generally for management reasons), because they appear to be examples of unimpacted or pristine conditions, or because they are convenient (close to laboratories and/or transportation facilities). These selection "criteria" have provided a biased view of "normal" reefs and reef processes and may skew the concept of reef health.

Atolls and oceanic island or shelf-edge reefs are often chosen to represent archetypal reefs. This choice results in mature — possibly senescent — sea-level-limited reefs with substantial limestone accretion being accepted as an "ideal." Within those environments, we tend to become excited by annual sea-level changes of a few mm, because eustatic sea level has probably not varied by more than a few meters over the past 5,000 years. In fact, a sea level rise or fall of a

Sea level rise of a cm/year or more is a much more "normal" condition

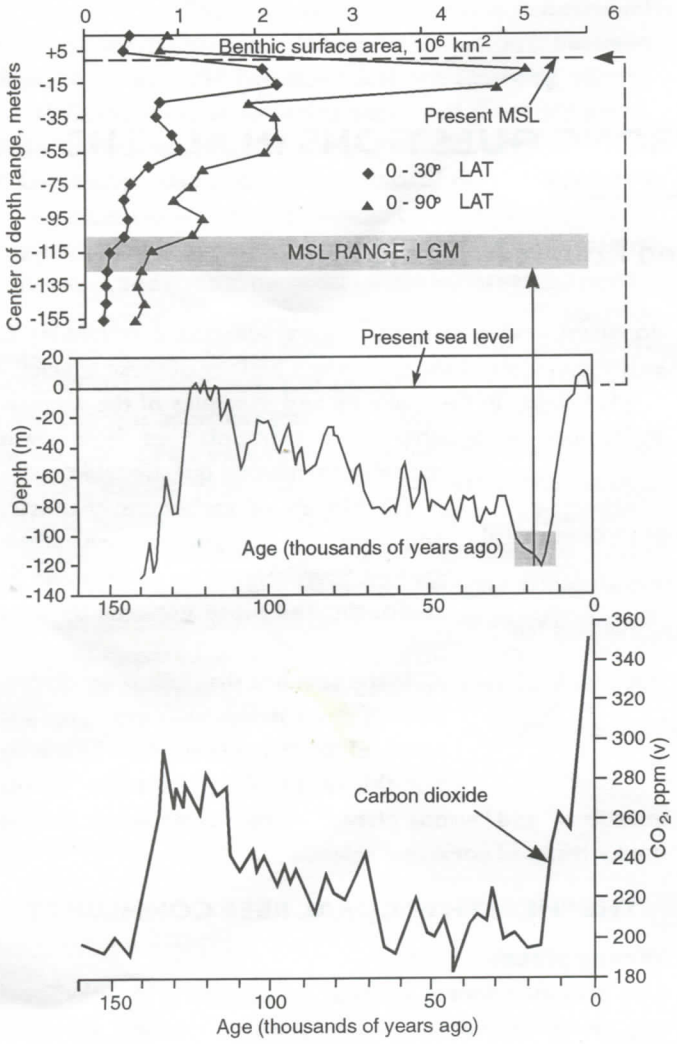


Figure 1. Sea level and carbon dioxide fluctuations during the late Quaternary (lower graph) are typical of the last several million years. The benthic area available for reef development (0 to –20 m depth range in the 0–30° plot, upper graph) is no more than 50% of the present value at "average" sea level, and may be as little as 10% at extreme lowstands. Factor-of-two CO_2 fluctuations drive carbonate saturation state changes that will cause community and organism calcification rates to change by tens of percent.

cm/year or more is a much more "normal" condition (Figure 1) — and with this comes order-of-magnitude variations in the shallow benthic area on which reefs can develop. The suggestion that up to 40% of present reef area may be degraded beyond recovery within 20 years seems dramatic by present standards of "normality," but in the context of Quaternary environments it actually brings the global inventory of reef real estate (Figure 1) somewhat closer to the norm of the last 160,000 years!

We fixate on reef communities characterized by big carbonate accumulations because: 1.) that is what we see now, although these accumulations result from recent anomalous sea-level history; 2.) that is what is best-preserved (rather than most representative) in the geologic record, and 3.) the geologists got there first and defined terms before the biologists woke up. These limestone lumps may be extraneous and even quasi-pathological features in terms of the biological propagation of species and communities over geologic and evolutionary time. Like obesity, a massive reef accumulation may be the result of remaining stationary for too long under good conditions. The focus on oceanic reefs in oligotrophic waters has led to the perception that reefs closely associated with continental margins are somehow second rate — but it has been postulated that much of the species diversity of corals is a consequence of shelf dynamics. The "right places" to study the survival and dynamics of reef ecosystems are more likely to be the not-yet-reefs, the sort-of-reefs, and the used-to-be-reefs.

Like obesity, a massive reef accumulation may be the result of remaining stationary for too long under good conditions

Wrong Questions

Wrong questions flow naturally from misleading contexts (= wrong places). The questionable assumption that a specific reef type represents "health" leads to research questions aimed at elucidating the environmental conditions that have led to this "optimal" reef development. Even more dangerous (because less testable) is the implicit biological assumption built into: "How are the species that make up this community co-adapted to enhance or stabilize this optimal assemblage?" The old argument about whether the "tropics are stable because they are complex" or "tropics can afford to be complex because they are stable" is wrong on both sides — reef environments are not stable, and the important question is: "What are all these supposedly co-adapted organisms doing when and where the 'optimal assemblage' isn't around?"

NUTRIENTS — GOOD, BAD OR UGLY

Elevated nutrient levels are commonly regarded as intrinsically damaging to coral function, in spite of evidence that corals can grow well at high nutrient levels, and that scleractinian corals can persist in close juxtaposition to macroalgae that are commonly regarded as superior competitors in high nutrient situations. High-nutrient environments may enhance bioerosion, and have caused inhibition or destruc-

tion of reef and carbonate platform formations in the past — but this observation relates primarily to the fate of the reef community products (carbonate accumulation), not necessarily of the organisms that produce them. Nutrient levels have been shown to affect the populations and physiology of the symbiotic algae, but these studies have generally not addressed the potential time scales and mechanisms (e.g., algal exchange) involved in real-world acclimatization.

Overall, our nutrient preoccupations have resulted in a succession of disagreements supported on all sides by the results of experiments that are neither equivalent to each other nor representative of the actual time scales and organism or community characteristics involved in real-world nutrient responses.

Our nutrient preoccupations have resulted in a succession of disagreements supported on all sides by experiments that are neither equivalent to each other nor representative of the actual time scales and organism or community characteristics involved in real-world nutrient responses

Wrong places

Short term laboratory or field experiments are directly extrapolated to ecosystem — or larger scales of space, time, and complexity. Pursuit of reductionist approaches implies that the larger questions and hypotheses have been defined and that a valid model exists for the integration or upscaling of results. If those conditions were met, we might be in the right place…

Wrong question(s)

"What is the effect of (ambient water) nutrient concentration rates on._____" (without regard to some or all of the issues involving: loading, inventory, delivery rates, uptake rates, community structure/function, specification of time scales, etc. etc.).

LIFE HISTORY, CLONALITY, AND REPRODUCTION

Human reef animals tend to think about other coral reef species from a thoroughly zoological background, with emphasis on the physiological, morphological and behavioral responses of individuals, and on the genetics of sexually reproducing individuals (Figure 2). This ignores the life history and evolutionary implications of clonality, sexuality, hybridization, and somatic mutation, particularly in relation to adaptation and acclimatization.

Wrong (conceptual) places

(1) A narrow focus on within-species sexual reproduction; and

(2) Phylogenetic analysis limited to morphospecies.

Most corals and many other reef organisms are colonial and/or clonal. This points to the importance of asexual or vegetative reproduction — typically regarded by anthropoid researchers as what animals resort to when they can't have sex. In fact, these modes of reproduction and their combination with sexual reproduction are probably central determinants of the character of reefs and reef organisms. The potential for rapid build-up and transmission of somatic mutations by asexual reproduction provides a mechanism by which selection can operate within the lifetime of the organism or clone, as is the case with many terrestrial plants.

Sexual reproduction in these organisms is also much more flexible than would be expected on the basis of terrestrial zoologists' concept of a species as a reproductively isolated population. Hybridization now seems relatively probable and potentially successful on reefs — so, how can we account for the apparent evolutionary stability of scleractinian "species" seen in the fossil record, given this reproductive plasticity? If introgression is a common phenomenon, then a species-specific focus will provide misleading results. For example, suites of "sibling species" may represent "evolutionary experiments" in progress, with outcomes (recombination, extinction, or further divergence) — and hence their ultimate phylogenetic significance — still uncertain.

Temperate aquatic and terrestrial communities respond to environmental change with major shifts in species composition that are interpreted as evidence for responsiveness of the system. On reefs, however, we see what appear to be the same species, or complexes of species, or even assemblages of species, persisting through repeated, major changes. Is it extreme stability, or inability to respond? Survival of some clones (or hybrids) over others may result in a very different genetic landscape with little or no change in apparent species composition or relative abundance — metrics we often use to gauge reef health. As long as environmental variation stays within the tolerance range of the "extended species," the community will appear stable to the observer of morphospecies. However, the system may be ramping up to a threshold, which may not be noticeable because the shifts are occurring among clones within

Survival of some clones over others may result in a very different genetic landscape with little or no change in apparent species composition or relative abundance.

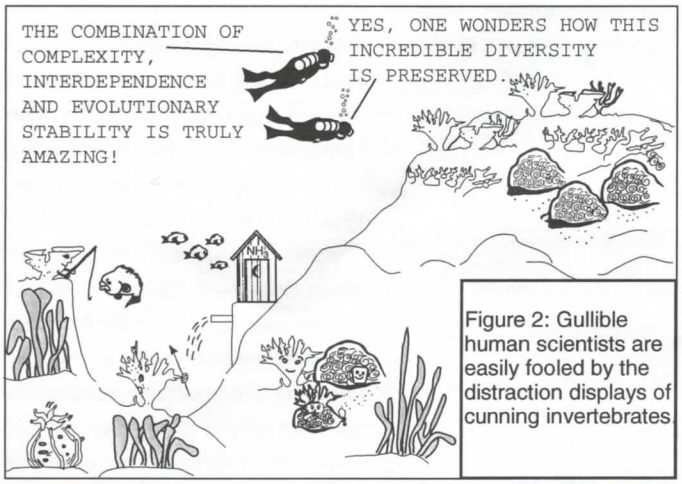


Figure 2: Gullible human scientists are easily fooled by the distraction displays of cunning invertebrates

Figure 2. Submarine psychology: faunal interactions on a coral reef.

species or among cryptic species. When the last available clone type can't track changes any more, a major restructuring event would take place, apparently triggered by a small environmental perturbation. This model provides a genetically-based mechanism for catastrophic transitions in reef communities. It also raises serious questions about the ability of simple descriptive community monitoring to detect trends in ecosystem structure, much less "health".

Wrong Questions — anything that results in an answer in any of the following (implicit or explicit) formats:

(1) By intensive study of specimens collected from a well-defined spatial and temporal regime, we have determined the characteristics of the species to be..."

(2) "Based on the responses and characteristics of (specimens of) this species, we conclude that scleractinian corals..."

(3) "Through intensive study of a particular process under carefully controlled experimental conditions we can say that corals will..."

CORAL-ALGAL SYMBIOSES AND GENETIC DIVERSITY

Related to the problems associated with the extensively clonal nature of many reef organisms is the question of how these different clades interact with each other. Recent work indicates that there is a complex skein of associations between several clades of zooxanthellae and multiple coral species. If this sort of flexibility in coral-algal associations is general, experiments on particular coral+alga "ecospecies" will not give results representative of the larger suite of symbiotic associations, or of what might be occurring on reefs where the lability and plasticity of the symbiosis could be more generally expressed.

Much effort has been put into determining, often *in vitro* and in a very reductionist way, "the" relationship between algal symbionts and their hosts, and its response to environmental factors. However, the results of these studies, elegant as they might be, must now be viewed with caution verging on skepticism. A laboratory-based approach to the study of symbiosis is at best a secondary component of the research needed to understand the ecological and evolutionary implications of the complex and shifting confederations among algal symbionts and invertebrate hosts.

Wrong place

For studies of characteristics related to the algal symbiosis, any host-symbiont pair that is not fully characterized with respect to present partners, with at least some consideration of the potential for alternative partners.

Wrong questions

See Life History, above, but with emphasis on failure to consider the genetic, taxonomic, and functional variability in the algal partner and in host-alga interactions — at one time, and through time.

CARBONATE CHEMISTRY AND THE BENTHOS

It has long been known that light- (or symbiotically-) enhanced calcification is a reality in terms of the geology and biogeography of reef-forming organisms — although light has only recently shown signs of displacing temperature as "everyone's favorite [coral reef] abscissa." It has also long - albeit not universally — been recognized that calcification consumes carbonate ions and is therefore (in the bicarbonate-dominated marine environment) a source of carbon dioxide. It has been suspected that carbonate saturation state is a control on both organism and community calcification; experimental evidence confirming that is now accumulating rapidly. In spite of abundant quantitative evidence based on past and present chemical budgets and experiments, many contemporary reef researchers have found it convenient to ignore the critical role played by calcification and the inorganic chemistry of carbon.

Efforts to portray reefs or other marine calcifiers as CO_2 sinks have the potential to define as normal or desirable some of the most critical symptoms of reef decline.

We may have uncertain definitions of reef health, but we can be reasonably confident that the transition from a calcification-dominated system to a system primarily describable in

terms of organic carbon budgets represents a major deterioration — and probably collapse — of a coral reef ecosystem. Efforts to portray reefs or other marine calcifiers as carbon dioxide sinks have the potential to define as normal or desirable some of the most critical symptoms of reef decline. With light and saturation state, as well as temperature, identified as significant biogeographic controls on reef distributions, and with experimental data showing that a doubling of atmospheric CO_2 is likely to lead to reductions of tens of percent in community calcification rates (J.-P. Gattuso and C. Langdon, personal communications and submitted mss.), it might just possibly be time to come to grips with some of the real issues of environmental controls on reef development.

Using coral alpha taxonomy to address the larger issues of evolution, symbiotic interactions, and biogeography is like using a collection of city street maps to navigate across a largely non-urban continent.

Wrong place(s)

(1) Studies of symbiotic organisms that do not calcify, or that do calcify but in which no attention is paid to the rates, mechanisms, or patterns of calcification.

(2) Environmental response studies that do not determine or control the "big three" — temperature, light and saturation state.

(3) Short-term community level studies that do not define the system under study or scale up to community-relevant scales of space and time.

Wrong question(s)

Any questions that address (skeletal) growth or calcification rate without quantitative consideration of the carbonate-system chemistry of the water. Any questions that ignore the effects of carbonate uptake on the carbon dioxide metabolism of the coral-algal system, or vice-versa. Questions posed and "answered" at very different scales (e.g., geologic-scale source-sink relationships addressed by empirical short-term local flux or metabolism studies).

SUMMARY

Phylogenetic trees have been likened to cartographic maps in that no single scale, projection, or selection of attributes is uniquely true or — more importantly — useful for all applications. The use of coral alpha taxonomy based on host skeletal morphology for addressing the larger issues of evolution, symbiotic interactions, and biogeography is like using a collection of city street maps to navigate across a largely non-urban continent. The detail is so disconnected and irrelevant that we end up proceeding by dead reckoning — but we continue to cite the street maps because they are our only published authorities!

Both reef organisms and communities appear far more plastic than previously thought. The answers to how reefs and corals survive and develop will more quickly be found by studying the range of intermediate states rather than end-members in a continuum, but only if we recognize that the environmental conditions we currently consider "normal" are in fact end-members in the geological, climatological, and evolutionary scheme of things.

It is time to rethink reef biogeochemistry, and to integrate our fragmented view of N, P, and especially C (and especially inorganic carbonate C!) metabolisms over time and space scales relevant to real reef communities and to organisms not isolated in laboratory containers. New levels of experimental sophistication are required, but this needs to be conceptual sophistication to qualify, reformulate, rescale, and integrate the findings of the technically sophisticated reductionist answers to the "Wrong Questions."

There already exists a broad-brush, "top-down" picture of corals and reefs that is substantially different from the view based on "bottom-up" assembly of the bits and pieces of individual research (e.g., see http://coral.aoml.noaa.gov/themes/coral_cg.html). It's time to stop crying in our beer, get out of the honky-tonks, and find True Love — or at least real science at a scale appropriate to our subject.

ACKNOWLEDGMENTS

We are grateful to the members of SCOR/LOICZ Working Group 104, most of whom are otherwise blameless. Maggie Watson insisted that we not write like scientists, and that we pare down our reference list, which made it easier to offend people generically rather than specifically. D. Archer supplied the benthic surface area data, D. Fautin provided review and advice, M. Schoneweis assisted with figure preparation. This is an update and revision of a paper originally prepared for the ICRS8 proceedings, but which took a wrong turn somewhere in the camera-ready revisions.

RECOMMENDED REVISIONIST READING—with some interdisciplinary background material:

Buddemeier RW, Hopley D (1988) Turn-ons and turn-offs: causes and mechanisms of the initiation and termination of coral reef growth. Proc 6th Int Coral Reef Symp 1:253-261

Buddemeier RW, Fautin DG (1993) Coral Bleaching as an Adaptive Mechanism: A Testable Hypothesis. BioScience

43:320-326

Buddemeier RW (1994) Symbiosis, calcification, and environmental Interactions. In Doumenge F (ed) Past and Present Biomineralization Processes, Bulletin de l'Institut océanographique, Monaco, numéro spécial 13, pp. 119-137

Buddemeier RW, Fautin DG (1996) Global co2 and Evolution among the Scleractinia. In: Allemand D and Cuif J-P (eds) Biomineralization 93, Proc. 7th Int. Symp. on Biomineralization. Bulletin de l'Institute océanographique, Monaco, Numero spécial 14,4. pp. 33-38

Buddemeier RW, Fautin DG (1997) Saturation State and the Evolution and Biogeography of Symbiotic Calcification. In: Allemand D and Cuif J-P (eds) Biomineralization 93, Proc. 7th Int. Symp. on Biomineralization. Bulletin de l'Institute océanographique, Monaco, Numero spécial 14,4. pp. 23-32

Buddemeier RW, Fautin DG, Ware J (1997) Acclimation, Adaptation, and Algal Symbiosis in Reef-Building Corals. In: J. C. den Hartog (ed) Proceedings of the 6th International Conference on Coelenterate Biology. National Museum of Natural History, Leiden, pp 71-76

Buddemeier RW (1997) Symbiosis: Making light work of adaptation. Nature, 388:229-230

Fautin DG (1997) Cnidarian reproduction: assumptions and their implications. In: J. C. den Hartog (ed) Proceedings of the 6th International Conference on Coelenterate Biology. National Museum of Natural History, Leiden, pp151-162

Kleypas J (1997) Modeled estimates of global reef habitat and carbonate production since the last glacial maximum. Paleoceanography 12:533-545

Gill DE, Chao L, Perkins SL, Wolf JB (1995) Genetic mosaicism in plants and clonal animals. Annual Reviews of Ecology and Systematics 26:423-444

Kinsey DW (1991) The coral reef: an owner-built, high-density, fully serviced, self-sufficient housing estate in the desert — or is it? Symbiosis 10:1-22

Kinzie RA (in press) Caribbean contributions to coral reef science. In: Benson K, (ed) Proc 5th Int Congr History of Oceanography, San Diego, CA, 1994

O'Hara RJ (1993) Systematic generalization, historical fate, and the species problem. Systematic Biology 42(3):231-246

Opdyke BN, Wilkinson BH (1993) Carbonate mineral saturation state and cratonic limestone accumulation. American Journal of Science 293: 217-234.

Pimm SL (1991) The Balance of Nature? University of Chicago Press, Chicago

Potts DC (1985) Sea-level fluctuations and speciation in Scleractinia. Proc 5th Int Coral Reef Congr 4:127-132

Rowan R, Knowlton N (1995) Intraspecific diversity and ecological zonation in coral-algal symbiosis. Proc Natl Acad Sci USA 92:2850-2853

Rowan R, Knowlton N, Baker A, Jara J (1997) Landscape ecology of algal symbionts creates variation in episodes of coral bleaching. Nature 388: 265-269.

Smith SV (1981) The Houtman Abrolhos Islands: carbon metabolism of coral reefs at high latitude. Limnology and Oceanography 26:612-621

Smith SV, Buddemeier RW (1992) Global change and coral reef ecosystems. Annual Reviews of Ecology and Systematics 23:89-118

Veron JEN. 1995. Corals in Space and Time. Sydney: UNSW Press, Sydney

Ware JR, Fautin DG, Buddemeier RW (1996) Patterns of coral bleaching: modeling the adaptive bleaching hypothesis. Ecological Modeling 84:199-214

Robert W. Buddemeier, Kansas Geological Survey, University of Kansas, Lawrence, KS 66047and Robert A. Kinzie III, Zoology Department, University of Hawaii, Honolulu, HI 96822

COUNTRY PROFILE

OMAN

Geography and Distribution

Three very distinct bodies of water surround Oman's 1200km long coast: the Arabian Sea to the south, the Gulf of Oman to the North East and the Arabian Gulf in the extreme North West. Each has its own characteristic features which shape the nature of the coral communities in each area, but most striking is the difference between the Arabian Sea and the Gulf of Oman.

Northern shores of the Arabian Sea experience intense upwelling during the summer monsoon (July till September), bringing cold (averaging 18°C, but falling to 15°C), nutrient rich waters to the surface and stimulating explosive macroalgal growth. Competition with algae, cold water and high wave energies appear to be the major constraints to coral growth and reef development here, although at a very small number of sites there are diverse coral communities with a high percentage cover, and even some reef development in isolated, sheltered bays. Further north, where the principal constraint of upwelling is reduced, reef formation is more pronounced and can be prolific. However, conditions in the Gulf of Oman are very different. During summer months sea temperatures regularly rise above 32°C (Coles, 1997) which are some of the highest temperatures recorded for corals; but despite this the coral fauna around Muscat is the most diverse in the country.

Large temperature fluctuations, substrate availability and the relatively turbid waters constrain coral distribution, generally to depths less than 10 meters.

Apart from large temperature fluctuations, the availability of suitable substrate and the relatively turbid waters also severely constrain the distribution of corals, generally to depths less than 10 meters or so. Under such marginal conditions, reefs in Oman exhibit a number of peculiarities. Large stands of monospecific reefs are common, particularly those of *Pocillopora damicornis*, *Porites lutea* and *Montipora foliosa*. *Pocillopora* monospecific reefs appear to be capable of developing in areas of unconsolidated sediment which contain large fragments of coral rubble, something which gives the genus a competitive advantage in areas where all available space on hard substrates is already occupied.

Porites cores several meters long may yield valuable information about the intensity of upwelling over recent decades.

Research

Sultan Qaboos University (SQU) and the Marine Science and Fisheries Centre (MSFC) are the two principal institutions concerned with reef related research in Oman, while the Ministry of Regional Municipalities and Environment (MRME) is taking the lead on reef-related policy. However, all scientific research has been a series of small isolated studies focused on a variety of topics rather than an integrated program, so apart from extensive surveys establishing the distribution of corals in Oman, there is only a relatively small body of scientific literature.

The influence of Oman's marine environment on shallow water habitats has received research interest, in particular sea water temperature in the Muscat area. For example, during his time at SQU, Dr. Steve Coles undertook a number of interesting studies on the reefs of the Muscat area including monitoring temperature fluctuations (Coles, 1997) and investigating coral cancers and links to UV filtering compounds. More recently, the Planetary Coral Reef Foundation has collected samples and data from various sites in Oman for research groups based in the U.S.A. which should provide useful information on the state and history of the country's reefs. Cores several meters long were taken from large *Porites* colonies and are awaiting analysis of their oxygen isotopes which may yield valuable information about the intensity of upwelling over recent decades.

The Marine Pollution Section at MRME has also instigated a pilot project to establish the potential of artificial reefs as a means of enhancing shallow habitats for fisheries or as a compensatory measure following the creation of protected areas which exclude fishing. To date, an experimental module constructed from concrete tubes and car tyres has been deployed in the Muscat area and initial results have shown rapid colonisation of the structure by fish and algae.

Threats

Oman's reef face a number of natural threats. Being situated where conditions in the marine environment are by no

means optimal for reef development, it would seem that periodic large-scale mortality is a major factor in the history of reefs here. As described above, temperature stress can be extreme. Outbreaks of Crown-of-Thorns Starfish (*Acanthaster planci*) have been recorded in Omani waters and their chronic infestation at various sites is probably influencing the rate of recovery of reefs affected by both previous outbreaks as well as extensive storm damage. Wide-scale bleaching, unidentified coral diseases and even skeletal cancer have all been observed to cause partial colony mortality and no doubt exert an influence on reef community structure.

The principal human threat to Oman's coral is fishery-related.

The principal human threat to Oman's coral is fishery-related: gill nets are often set close to reefs since reefs attract the large pelagic fish which the artisanal fishery targets. Occasionally gill nets become entangled in corals and are either removed by force or discarded intact where they continue to damage the reef by both destroying its structure and by ghost-fishing. Anchors, fish traps, ropes, line and other fishing gear also damage corals and reefs. Other threats are more localised: coastal construction and development, littering, recreational use and oil pollution are all activities addressed in the national coral reef management plan.

Management

Following the IUCN's efforts in the development of an integrated coastal zone management plan (IUCN 1991), the Government of Oman has initiated a series of resource-specific surveys to address specific resource-user conflicts. The implementing agency is the Ministry of Regional Municipalities and Environment (MRME), although certain components of the plan are the responsibility of the Ministry of Agriculture and Fisheries. Major components are:

- Training Omani personnel in marine natural resource management;
- Education of fishermen as a first step towards community involvement in reef management projects;
- Improvements to National Nature Reserve management, and expansion of the existing network of protected areas;
- Improving the enforcement of environmental impact assessments to specifically address impacts to reefs where they occur;
- Sustainable tourism and recreation, including the raising funds from dive permits and admission fees;
- Monitoring;
- Research, concentrating on the interaction between ecosystems and their economic value;
- Fisheries enforcement as part of a monitoring, surveillance and control effort;
- An Oman Coral Reef Organisation is to be created as an NGO to assist with research and management.

Mooring buoys have been installed at the most popular dive sites

Conservation

The conservation ethic is stronger in Oman than many other states in the Middle East and in recent years several sites have been given special status in order to conserve their wildlife resources and wilderness value. One such area is the Daymaniyat National Nature Reserve, a series of nine islands 17 kilometres off the Batinah coast in the Gulf of Oman. As well as supporting some excellent reefs the islands are an important nesting site for hawksbill turtles, sooty falcons and various species of tern. Various other protected areas with both important terrestrial and marine areas are under consideration by the Government.

Today, tourism in Oman is low volume. However, as word about the beauty of the country is passed around and tourism infrastructure is developed, visitor numbers are rising steadily. In parallel with this expansion of tourism, dive operations have grown to cope with demand. As a result, steps are required to ensure no significant damage to the reefs and that some revenue returns to the Government with which it may implement its environmental protection policies. Recently, for example, mooring buoys have been installed at the most popular dive sites of Fahal Island and at the Daymaniyat Islands.

Education

In terms of educating the Omani people about reefs and their value to society, the Government's strategy is to target the principal users as an immediate priority and follow this with a general education program in schools. The largest user group are the artisanal fishermen who are widely dispersed along the coast although the greatest concentrations are found near the major fish landing sites. Fisheries extension officers have been discussing the importance of reefs to fishermen who have previously considered coral as rock.

Although the human population is low, the growth rate is amongst the highest in the world. Therefore, the key group which will benefit most from education about natural resource conservation and use will be the emerging generation of 10–16 year olds. To this end, MRME has co-ordinated the publication of a series of booklets targeted at this age

group which cover Fish, Sea Turtles, Whales & Dolphins. Another edition in the series is being planned to cover Coral Reefs and will include basic coral biology, ecological roles, threats and ways to look after reefs.

The Future

The Government has been following a responsible policy in the sustainable and wise use of reef related resources and they provide a structure around which the process can evolve further. Through the efforts of IUCN over many years, plans have been in place for an integrated approach to coastal management and recently the first signs that action is being taken to implement such plans are emerging. Perhaps the greatest constraints to effective management is the lack of suitable Omani personnel coupled with the lack of awareness among the general public. However, from a regional perspective Oman leads the way in coral reef management.

The key group will be the emerging generation of 10-16 year olds

References

Coles, S. L. 1997. Reef corals occurring in a highly fluctuating temperature environment at Fahal Island, Gulf of Oman (Indian Ocean). Coral Reefs 16:269-272.

Glynn, P. W. 1992. Monsoonal Upwelling and Episodic *Acanthaster* Predation as Probable Controls for Coral Reef Distribution and Community Structure in Oman, Indian Ocean. Atoll Research Bulletin (0(379): 1 -66)

IUCN. 1991. Oman Coastal Zone Management Plan - A Framework for Action. Published by IUCN, Gland, Switzerland.

Salm, R. V. 1992. Coral Reefs of the Sultanate of Oman. Atoll Research Bulletin (0(380): 1-85)

Salm, R. V. and Sheppard, C. R. C. 1986. Corals and Coral Reefs of the Capital Area, Oman. Ministry of Commerce and Industry. Published by IUCN.

Sheppard, C. R. C. and Salm, R. V. 1988. Reef and coral communities of Oman, with a description of a new species (Order Scleractinia, genus *Acanthastrea*). Journal of Natural History 22, 263 - 279.

Further information from: Simon Wilson or Robert Baldwin, P.O. Box 2531, C.P.O. 111, Sultanate of Oman. Tel. & Fax: 00 968 501708. E-mail: <106422.2221@compuserve.com> (for SW), and <wosoman@gto.net.om> (for RB)

INTERNATIONAL INITIATIVES

1998 INTERNATIONAL YEAR OF THE OCEAN

The International Year of the Ocean (IYO) is an attempt to bring ocean issues to the attention of decision-makers and the general public. The idea originally came from UNESCO's Intergovernmental Oceanographic Commission (IOC), which was subsequently adopted by the UNESCO General Conference in 1993, and by the UN General Assembly in December 1994. Its aims are to:

- raise awareness of the oceans and coastal areas as finite-sized economical assets;
- to obtain commitments from governments to take action, provide adequate resources and give the oceans the priority that they deserve;
- emphasise that it is only through global scientific co-operation that we can begin to improve our understanding of how the oceans work.

A vast range of initiatives are underway throughout the world, in celebration of IYO. These include:

EXPO '98: which takes place in Lisbon, Portugal (May-September) and has the theme 'The Oceans: a Heritage for the Future'. The UN pavilion will highlight the entire range of ocean-related activities of the UN system

The Ocean Charter (see box): governments are being encouraged to sign this document (which is not legally binding) launched during the Summit of the Sea Conference in St John's Newfoundland, Canada in September 1997.

The Independent World Commission on the Oceans will release a major report on the oceans, the result of the deliberations of its six study groups, in August at EXPO. This will cover ocean governance, peaceful uses of the ocean, economic uses of the ocean, science and technology, equity issues, and public awareness and participation.

IUCN — The World Conservation Union and WWF — the World Wide Fund for Nature — will be releasing their global strategy for marine conservation at EXPO on World Oceans Day.

Numerous other activities are underway at national and regional levels, through governments and NGOs, involving education, science, conferences, public awareness, research and training cruises, and publications. November 1998 will be the a month in which IYO activities will center on coral reefs and tropical marine ecosystems. The focus for this will be the ITMEMS meeting in Townsville (see **Diary**)

For further information on IYO contact: Iouri Oliounine, Co-ordinator, International Year of the Ocean, IOC, UNESCO. Fax 33 1 45 68 58 12; Web site: http://ioc.unesco.org/iyo

THE OCEAN CHARTER

The oceans and their resources are a necessary element of life on this planet.

The health of the oceans, and the wise, safe and sustainable use of the ocean resources, should be an axiom for all governments to accept and honor for the long-term benefit and existence of their respective and collective peoples.

The acquisition of the knowledge necessary for the understanding and stewardship of the oceans and their adjacent seas for the adoption of policies, standards and regulations to protect the ocean environment and to husband their resources, are goals to be pursued both nationally and internationally.

There should be mutual assistance and the will to work together to achieve common goals for the oceans - adjacent and regional coastal states should co-operate in the adoption of local policies and action — countries with knowledge and resources should assist less fortunate neighbors — data and information for global and regional problems should be readily available — States should make use of international and intergovernmental organizations to generate global programs and agreements.

We recognize the wisdom of acting in unison to protect the oceans and to use their resources in a sustainable manner and accept this Ocean Charter as a basis for future action.

OC-UNEP-IUCN GLOBAL CORAL REEF MONITORING NETWORK

This report updates that in Reef Encounter 21 (July 1997). Coral reefs are still high on the political agenda, as evident through strong support from Dr Ismail Serageldin, (Vice President, World Bank), and Mr. Tim Wirth, (US Undersecretary of State for Global Affairs) at the World Bank ESSD meeting in October 1997 (see **Meeting Reports**); where ICRI and the GCRMN were featured as plenaries. The GCRMN also held a Management Group meeting to refocus on the immediate needs and strategies and also reported to the second ICRI coordination meeting for 1997 (another will be held in Singapore in June 1998).

Most of the preparation and planning for the GCRMN has been completed. The GCRMN Strategic Plan was published by IOC, and is available either in printed format from the Co-Sponsors (IOC, UNEP, IUCN), the GCRMN Coordinator (Clive Wilkinson) and Chair of GCRMN STAC (Bernard Salvat); and will be placed in the NOAA Home Page. The 2nd edition of the Survey Manual for Tropical Marine Resources is available from AIMS and a receiving database is available either on diskette or over the Internet (AIMS Home Page). A 2nd Edition of ReefBase has been released by ICLARM in Manila and is ready to incorporate GCRMN Pilot and regular monitoring data.

All regions have held ICRI Workshops with over 85 countries participating and most agreeing to join the GCRMN. The last was in Aqaba Jordan in September, with Djibouti, Egypt, Israel, Jordan, Oman and Yemen participating. Another workshop is planned in Oman for the remaining countries.

At a GCRMN meeting during the Suva Pacific Science association meeting July 1997, six GCRMN Nodes were provisionally designated: Polynesia, based in Moorea; Hawaiian islands in Honolulu; Central Pacific high islands in Suva; Central Pacific Atolls in Kiribati; Micronesia in Guam; and Melanesian High Islands in the Solomons. GEF proposals are being prepared to fund some of these Nodes. How to monitor reefs around Hawaii will be discussed in Honolulu in June.

The Indian Ocean Commission and GCRMN outlined an approach to monitoring at an international symposium in Madagascar, October 1997 hosted by the Madagascan Government, IOCINCWIO (UNESCO) and the European Union via Regional Environment Programmes. The Comores, Madagascar, Mauritius, Reunion and Seychelles will establish a GCRMN Node and have started monitoring. Training is now underway in the Maldives, as is the development of a regional GCRMN database linking the raw data (ARMDES) and the summary database (ReefBase).

Meanwhile the UK has funded a GCRMN interim regional coordinator for South Asia in Colombo (Jason Rubens).

GCRMN training will be held in Vietnam with participants from Burma/Myanmar and Cambodia (funded by the Japanese government). The workshop will probably be held in September.

Reef Check is planning an expanded 1998 exercise (see **Support Reef Check 1998**), building on the success of 1997. Reef Check and the GCRMN are combining to strengthen monitoring — the GCRMN working with governments, and Reef Check continuing to emphasize volunteers with expansion to include communities and schools in developing countries. Modifications to Reef Check protocols such as the addition of more parameters that communities feel are important will be discussed in Hawaii in June.

The gap in assessment of social, cultural and economic parameters is being closed, following a workshop to develop a methods manual at the University of Philippines Marine Science Institute station in Bolinao (hosted by Drs. Helen Yap and Ed Gomez in August 1997). Here, 12 social scientists and economists selected the parameters and strategies included in a draft manual intended for field trials during 1998. The Japanese Government showed their commitment to the GCRMN by funding the workshops and assisting in production. Coral reefs were also featured at the US-Japan Common Agenda Open Forum in Tokyo, March 1998.

The GCRMN will report on the status of reefs around the world at the ICRI International Tropical Marine Ecosystems Symposium (see **Diary**), and determine the agenda for the next 2 years. A monitoring coordination workshop will be held immediately afterwards to assist GCRMN coordinators develop consistent training protocols for reef monitoring. Data from the Pilot Monitoring Project and other exercises will be reported as a monitoring session on Sunday, 22nd November.

Clive Wilkinson (GCRMN Coordinator) and
Bernard Salvat (Chair GCRMN STAC)

SUPPORT REEF CHECK 1998

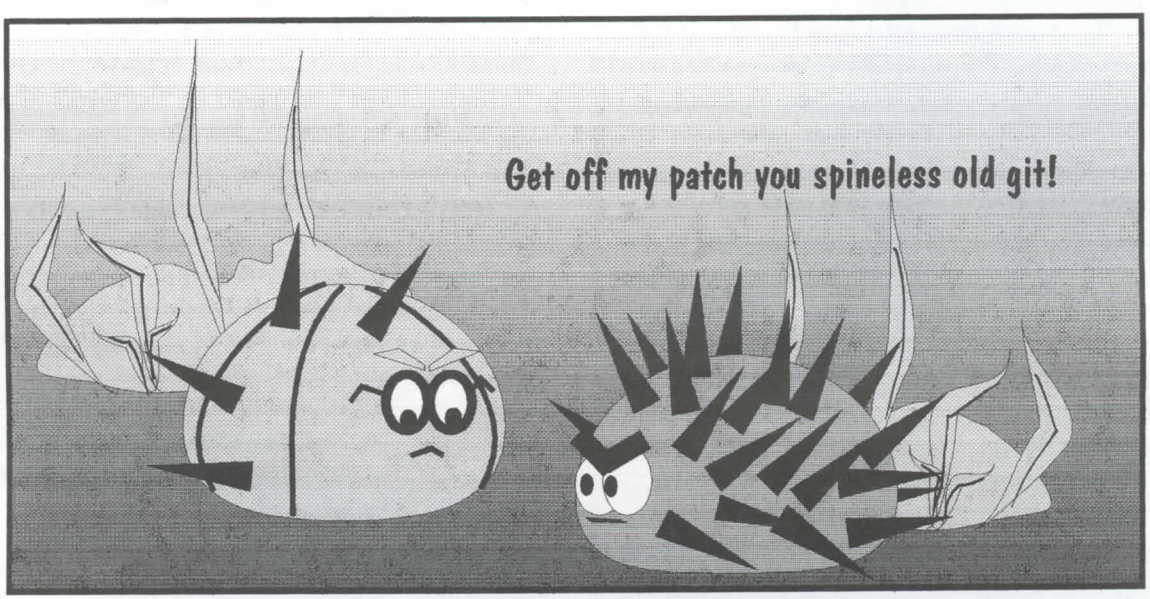
We would like to invite all reef scientists to participate in Reef Check 1998. Taking a weekend or two to train and lead recreational divers in basic underwater surveys is one way of giving something back to the community where you live or work, and to build up public support for reef conservation. If you are already involved in such surveys, consider taking a couple hours of time to adapt your data collection to include the simple Reef Check parameters. While 300+ surveys in 31 countries was a remarkable achievement in 97, it is a small sample of the world's reefs. We need your help to improve and expand Reef Check 98. This year we have extended the survey period (1 April–30 September) and widened the survey zones.

We would also like to invite Reef Check 97 participants to prepare papers for presentation at upcoming meetings/workshops. In particular, there will be special human impacts/Reef Check sessions in Perpignan, France in September 1–4 (Contact: Michel Pichon) and in Townsville in November 23–27 (Contact: Clive Wilkinson) 1998. Please contact us if you would like to make a presentation or be involved in these events.

Reef Check policy is to promote collaboration and cooperation in coral reef monitoring and management on a global scale. One reason that collaboration is helpful is that funding agencies have often responded negatively to what they see as too many different groups claiming their method is the ONLY way to survey reefs. We don't claim that Reef Check is the best, but many groups have used it successfully to detect human impacts on reefs and to raise public awareness globally. By joining forces we can improve all groups' chances of gaining funding. Equally importantly, collaboration gives reef conservationists a bigger voice.

In 1997, Reef Check and GCRMN (the government led effort) worked in parallel to promote each other. In 1998, GCRMN has made a decision to adopt the Reef Check program as the centerpiece of its community-based monitoring program. While the exact details of this arrangement are still being worked out, this closer relationship will allow GCRMN to make use of the global Reef Check network, methods and teams. In turn, if GCRMN obtains funding from UN or government sources, these can be used directly for Reef Check training and surveys. To assist GCRMN, we are also working on the design of a snorkelers' Reef Check to be tested this year and launched in 1999.

Gregor Hodgson, Institute for Environment and Sustainable Development, Hong Kong University of Science and Technology, Clearwater Bay, Kowloon, HONG KONG New (shortened) Reef Check E-mail: <reefchck@ust.hk> Tel: (852) 2358-8568 Fax: (852) 2358-1582, Registration information and complete instructions are found at: http://www.ust.hk/~webrc/ReefCheck/reef.html



Desmond always knew that his baldness would be a problem one day

MEETING REPORTS

WORLD BANK CORAL REEF CONFERENCE

This past October, 1997, the World Bank hosted a two and one-half day conference in Washington, D.C. entitled *Coral Reefs: Challenges and Opportunities for Sustainable Management.* The conference was co-sponsored by the World Bank and the International Center for Living Aquatic Resources Management (ICLARM), based in Manila, Philippines. The conference was held as part of the Bank's Fifth Annual Environmentally Sustainable Development (ESD) Conference, a week-long series of meetings and presentations dedicated to sustainable development issues. Over 125 technical and management specialists from around the world attended the conference with World Bank staff.

The theme for the ESD meetings was "Science, Economics and Law", focusing on ways to better integrate each of these disciplines in the search for solutions to problems related to sustainable development. The ESD and Coral Reef conferences were both dedicated to the memory of Captain Jacques-Yves Cousteau for his commitment to increasing awareness of the importance of marine resources in the face of an increasing global human population.

The World Bank is a partner to the International Coral Reef Initiative. Because coral reefs are critical economic assets for many of its member nations, the Bank has been working to integrate coral reef conservation and management measures into its operations and lending practices. Ismail Serageldin, Vice President of the World Bank and head of Environmental and Socially Sustainable Development is a strong supporter of coral reef conservation, and as an active recreational diver, is well versed in the management issues facing coral reefs and their importance to the economies of many developing countries. This is the second forum that the World Bank has hosted on coral reefs; the first was a one-day workshop in June, 1995, exploring sustainable financing mechanisms for coral reef conservation. The more recent conference focused on five selected management themes, in which panelists presented information and held open discussions with the audience.

The major themes addressed were:

- Reef Destructive Practices (for example, dynamite and cyanide fishing; coral mining), in contrast to Opportunities for Sustainable Reef-based Mariculture (such as, sustainable production *in situ*, community-based production) and Low-Impact Extraction (alternative fishing methods/product substitution).
- Illegal and Unsustainable Trade in Reef Products (for example, in the live food fish, aquarium and ornamentals trade) in contrast to Certified Trade and Sustainable Bioprospecting.
- Marine Protected Areas and identification and discussion of ways to improve their success. Self-financed Marine Management Areas (e.g., through sustainable marine eco-tourism, fisheries stock enhancement, and options for income-generating activities).
- Marine Information Management and Environmental Education (e.g., the Global Coral Reef Monitoring Network, Reef Check and electronic databases such as ReefBase, FishBase, CoralBase; role of the civil society in information dissemination and public awareness).
- Economic Valuation of Coral Reefs (including a discussion of analytical tools for strategic decision-making, such as application of cost-benefit analysis and valuation methods for coral reefs).

Many of the presentations identified alarming trends observed in reef quality on a global scale, particularly from over-fishing and destructive fishing practices, such as the use of explosives and cyanide. However, other presentations addressed various management strategies, sustainable harvesting, factors to consider in marine protected area establishment, techniques used in valuing coral reef resources, and economic conditions needed to balance resource use. The panels generated broad reaction and participation from the audience. Also, progress of the regional efforts of the International Coral Reef Initiative were summarized and discussed in a working session on Saturday, October 11.

At the conference's conclusion, specific recommendations were developed by working groups in each of the thematic areas to develop partnerships with donors, governments, public and private organizations, and to leverage resources and effort to more effectively conserve and manage coral reefs. A limited number of copies of the conference proceedings will be available to resource managers worldwide. Additional reprints will be made available through the World Bank's Public Information Center later in 1998. 1818 H. Street NW, Washington, DC 20433.

For additional information contact: Andy Hooten, AJH, Environmental Services, 4005 Glenridge Street, Kensington, MD 20895-3708, USA. Tel. 301-942-8839, E-mail <Environmental_Services@Compuserve.com> or <AHooten@Worldbank.org>.

BOOKSHELF

PLATES-FORMES CARBONATÉES ET ATOLLS DU CENTRE ET SUD PACIFIQUE.
(Carbonate Platforms and Atolls of the Center and South Pacific.)

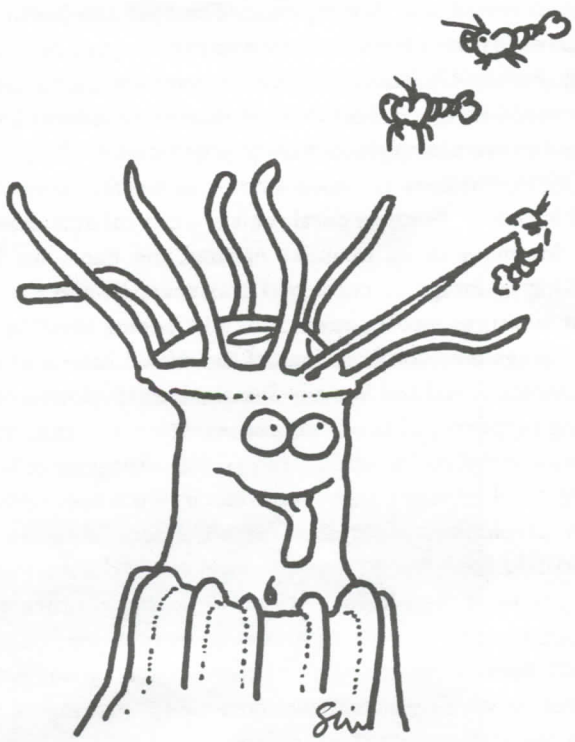
Stratigraphy, sedimentology, mineralogy and geochemistry. Diagenesis and emersions: aragonite, calcite, dolomite, bauxite and phosphate.
F.G. Bourrouilh-Le Jan.
Documents du BRGM 249, 1996. 365pp. 215 figures. ISBN 2-7159-0829-6. French with English figure captions. 670 Francs, Eurocheque or Traveler's cheque in French francs to: Centre de Sédimentologie Comparée et Appliquée.
Available from F.G. Bourrouilh-Le Jan, Université Bordeaux 1, Laboratoire CIBAMAR, Avenue des Facultés, 33405 Talence Cédex, France.

THE CORAL DISEASE PAGE
http://ourworld.compuserve.com/homepages/mccarty_and_peters/coraldis.htm

The Coral Disease Page is designed to exchange information about diseases of corals and other reef organisms. It provides a brief introduction to diseases of coral reef ecosystems, hard corals, sea fans, and coralline algae that have been recognized on reefs thus far. In addition, a key allows you to identify a potential disease based on characteristic visual signs of each disease (abnormalities in appearance, behavior, or morphology). There is also a list of links to related sites and some ideas for what you can do to help.

This site is intended to be a living document, at present holding information on over a dozen known diseases. Authors Harry McCarty and Esther Peters plan to add more information as it becomes available, and will be happy to collaborate on postings of other diseases and links to related web sites. A stand-alone version is now available for use in the field. For this version, all of the links to the web have been disabled or eliminated, so that the system will run on any PC with a browser, but without the need to connect to the web itself. You can download the Offline Version (a 630 kb file) through the webpage.

The only condition the authors have is that you not use the text or photos for any other purpose. In other words, don't take this apart, add to it, or redistribute it. As appropriate, please cite the source in any publications that result from its use. The authors welcome your comments.



Book Reviews

COOKING WITH CORALS

Survey Manual for Tropical Marine Resources.

S. English, C. Wilkinson, . & V. Baker

ISBN 0 642 25953 4. Australian Institute of Marine Sciences, Townsville, Australia, (2nd Edition). 1997. 390 pp.

For those who did not receive the first widely distributed version of the AIMS survey methods, a second edition was released last year with financial assistance from a number of international and environmental organizations. The broad distribution and support for this manual has made it one of the more popular survey handbooks, particularly in the Asian region. Consequently, for those readers wishing to coordinate with programs using this manual, now is the time to order it from AIMS (by writing them or contacting their web site http://www.aims.gov.au.)

If you have the first edition you probably will not require the second because the changes are minor. In fact, rather than an attempt to modify or update the methods, the second edition appears to be largely a response to the high demand for the manual or to the call for environmental organizations to support coral reef monitoring. Monitoring methods should not change much if they are to be of long-term value so it may be welcome news to groups using this manual that they can relax and continue business as usual. I would, however, have liked to see a few simple modernizations added to this new addition.

For instance, the manual advises us to take water temperatures with a hand-held thermometer. Most contemporary monitoring programs can, however, afford simple automated temperature gauges that cost as little $100 and can make temperature measurements every few seconds for many years. Taking a single temperature measurement with a hand-held thermometer once every few months is not a very effective method of monitoring temperature. One might be better off downloading the NOAA satellite data for the studied reef, though I believe this is not as good as automated temperature gauges because the NOAA data underestimates mean temperatures by as much as a degree centigrade. Also, much of the variation that is experienced in near-shore waters is averaged out by the large spatial integration of the satellite data. From my experience, near-shore waters can typically vary in temperature by as much as 3 to 5°C on a daily basis and neither NOAA nor infrequent hand-held thermometer data will pick up this variation.

A related criticism concerns the manta tow method where the authors suggest a '2 minute tow'. Well, two minutes can produce very different distances depending on the size of the boat and engine used. I would prefer that a hand-held GPS were used and the distance traveled was calculated. Since hand-held GPS are cheap and common this would seem to be a reasonable improvement that would not really change but rather improve the accuracy of measurements. Simple modernizations or improvements like this should be incorporated into new editions, in my opinion, and I wonder if investigators will stop using manuals that do not update themselves.

The actual meat of most monitoring is the specific types of transects and the categories that are used while sampling. The AIMS manual has the usual focus on taut 20 m line transects for corals and 250 m^2 belt-transects for fish, which are now standard fare for many coral reef studies. I don't have any devastating criticisms of these common methods, but I wish monitoring programs would focus on ecological processes like herbivory and recruitment which often drive ecosystems, rather than state variables like the percentage of coral and numbers of fish. Making measurements of states and processes together is really the only way to begin to untangle the complex patterns found in coral reefs (McClanahan 1997). Despite the lack of criticism of the presented methods, I would prefer the manual presented a greater variety of methods and let the investigators choose the most digestible and tasty selections from the manual.

I do, however, have a real problem with the manual's suggestion to place fish population density data into eight logarithmic categories for their 250 m^2 belt transect. Most coral reef fish species have low population densities that either will not fit within log-based categories, because they are below the detectable limit of 1 individual per belt transect (they have no category for 0 fish per transect which is a very common occurrence) or fish populations will seldom fluctuate outside of a single category, making it impossible to pick up any trends. To illustrate this point, consider the average density of 135 preselected fish species from a study of East African reefs. Eighteen percent of the fish species had a density of zero, 50% of the species had population densities below 1 fish per 250 m^2 and only 10% of the species had

population densities of greater than 5 individuals per 250 m^2. Not a single one had a density which exceeded 64 individuals per 250 m^2, which is the upper limit of the fourth of the eight suggested categories. What is the point of having categories 5,6,7 and 8 if no species have populations this high? I really doubt that any group using these categories will pick up trends in fish populations and I suggest observers count the best they can, recognize that they are only estimating numbers, and keep away from broad categorizations as suggested in this manual. In general, the manual gives some of the basics for monitoring reefs, but, like even the best cookbooks, you need to think for yourself and decide which ingredients to add, subtract or throw down the kitchen sink.

Reference

McClanahan, T.R. 1997. Monitoring - the state of our art. Reef Encounter 20: 9-11

Tim McClanahan, Coordinator for Coral Reef Programs, The Wildlife Conservation Society. P.O.BOX 99470, Mombasa, Kenya. Email: <crcp@africaonline.co.ke>

CORAL KINGDOM

CD ROM Version 1.1, CyberLearning Collection
Ron S. Nolan and Susan A. Nolan.
Digital Studios, Aptos California 95003 1996 179 page manual

Marine science teachers are always searching for new tools and innovative ways to instruct their students. Maintaining student attention and interest is vital for learning. Thus, it is not surprising that teachers prefer audio-visual teaching aids, especially for pre-College students. Movies, slide shows and film strips have been standard fare for years.

Enter the computer age. New technologies have totally transformed traditional methods. The computer revolution has provided teachers with tools to enhance their effectiveness in the classroom. Educational opportunities for student learning are just beginning to be realized. Development of CD ROM technology has brought a vast storehouse of knowledge just a keystroke away.

This CD ROM, produced by Ron and Susan Nolan at Digital Studios should be a valuable asset to teachers and the accompanying 179 page manual will be especially useful as it presents classroom objectives, activities, topics for discussion and more.

An audio narration introduces each section and the user may interrupt, repeat or exit at any time. Coral Kingdom uses beautiful underwater photography to explore the studies of reef biology, marine ecology and biodiversity. The program is organized into four major units covering Adaptations, The Coral Reef Ecosystem, Interrelationships and Human Impacts. Each unit presents a series of narrated slide shows with an accompanying research mission. Each research mission uses a simulated SCUBA dive where you control the direction and other aspects of the dive. Students can store information gained for use in discussion, reports or other classroom activities.

Whilst 'researching', students can 'click' on an organism, taking them immediately to the Sea Life Catalog, an extensive database of marine life. The catalog can also be accessed using the scientific or common names. Each entry provides a photograph and information about color and form, behavior, relationship to the environment, specializations and human impact. However, the research missions, slide shows and Sea Life Catalog notably emphasize Pacific marine life and ecosystems and most of the simulated locations are in the Hawaiian Islands, although naturally, the ecological concepts are applicable anywhere.

The manual contains ideas and support material for worksheets and research reports, designed to help the student analyze and present the results of each mission. Narratives for the slide shows will help teachers prepare the students for each 'mission'44, and additional material in the manual augments the slides.

Two appendices at the end of the manual provide a brief bibliography and a list of organizations dedicated to coral reef preservation.

This CD ROM makes an excellent addition to a science classroom, lab or library. The hands-on approach of a simulated SCUBA dive is a great way to encourage student interest. The simulation is easy to understand and users can quickly access all parts of the database. Coral Kingdom is part of the CyberLearning Collection that provides tech support, online projects and new products. You can contact them through their web site www.cyberlearn.com or E-mail: nolan@cyberlearn.com

Clive Petrovic, H. Lavity Stout Community College, Box 3097, Road Town, Tortola, British Virgin Islands. E-mail <clivep@caribsurf.com>

THE REEF AQUARIUM, VOL. 2

Julian Sprung and J. Charles Delbeek

ISBN 1-883693-13-6 Ricordea Publishing Inc., Coconut Grove, Florida 33133 1997 546pp

AND

THE MODERN CORAL REEF AQUARIUM

Svein A. Fossa and Alf Jacob Nilsen

ISBN 3-928819-29-1 Birgit Schmettkamp Verlag, Bornheim, Germany 1996 367pp

Some years ago, I met Robert P. L. Straughan and visited his aquarium shop in Miami, Florida. As a young student and newcomer to the undersea world, I was fascinated by the specimens he was able to keep in captivity. Small, metal framed aquaria, under gravel filters, bleached white coral skeletons and sand produced a sterile appearance. But it was fascinating compared to the hum drum fresh water aquaria everyone else had. Straughan's aquaria contained animals I never knew existed. He was successful in a field few others even considered. In fact, he summarized most of the information known about marine aquaria in a book of less than 300 pages. How far we have come since then!

In the Foreword to **The Reef Aquarium** (vol. 2) Sprung states that marine aquarium care is now a "serious discipline and a valuable research tool." How true! The serious marine aquarists, and there are legions, have gone well beyond the "hobby" stage, garnering a wealth of information, which has literally exploded in the last two decades. Degrees in physics, chemistry and biology seem almost a necessity to understand all the technical information available today. Calcium reactors, complex lighting schemes, downdraft protein skimmers, UV sterilizers are all part of the arsenal of this science. Sometimes it seems more like the realm of science fiction.

The Modern Coral Reef Aquarium (Fossa and Nilsen) is the first of a four volume set on marine aquarium keeping. The amount of technical information on setting up and maintaining a marine aquarium is staggering. In fact, sometimes the explanations seem to go well beyond what the hobbyist needs to know, as in the detailed description of the light spectrum (pages 204-211). Then there is the interesting section on the importance of moonlight and its affects in the aquarium (pg. 201-202). All the forms of filtration and water quality maintenance are discussed, and the authors repeatedly emphasize the primary importance of using a protein skimmer. I concur with their assessment and that the blend of devices selected depends on the specific requirements of the aquarium.

The interest and experience of the authors in the Indo-Pacific region is clear from the chapter on Zoogeography. The Caribbean is allocated only half a page of text, even less for West Africa. It is also obvious throughout that the book was translated into English from a foreign language. Awkward style, such as "Already at this point, however, we would like to point out a..."(page 252) is common. At times the translation can be comical as when Stomatopods are described as able to "murder bypassing organisms" (page 185). Many more examples suggest more careful editing would have been appropriate. Frequent proofreading slips also detract from the book. Furthermore, over 70 citations in the text were not listed or were incorrectly listed in the bibliography, almost a third of which are non English references (which I did not check for accuracy). Hopefully the editors will do a better job on future volumes.

Nonetheless, the occasional awkward style and numerous errors cannot detract from the significance of **The Modern Coral Reef Aquarium**. It is packed with useful information for anyone contemplating the purchase of a marine aquarium. Lots of step by step photos and explanations will help the beginner get started. While much of the discussion and all the photographs emphasize large aquaria of several hundred litres or more capacity, the reader can easily extrapolate downward to a more moderate sized tank. This comprehensive text is a must on the bookshelf of the serious hobbyist as well as the determined beginner.

The number of invertebrate species that can be kept successfully in a coral reef aquarium is increasing, though this is still a relatively new area for the marine aquarist and requires a resonable level of expertise. In **The Reef Aquarium** authors Sprung and Delbeek disseminate their considerable knowledge of invertebrate care. They have done an admirable job of sharing their experience of marine aquarium science. This is a serious text providing much useful information on the taxonomy and care of corallimorphs, soft corals, zoanthids and anemones. The first four chapters present 124 pages of detailed information on the basic biology of these groups, and would make a welcome addition to many a college course in Invertebrate Zoology. In fact, numerous line drawings are taken from the scientific literature including the classic 1940 text by Hyman. Chapter six presents "how to" information for individuals interested in propagating these animals in the aquarium. Step by step instructions describe the methods used to sever living tissue and start new colonies(sustainable culture in captivity is

possible). There are even instructions for the use of antibiotics to help prevent bacterial infections of the new cuttings. However, the real contribution of this book is the wealth of taxonomic data and photographs. This treatment makes a valuable addition to the typical technical literature of taxonomic keys and black and white line drawings. Thus, this book makes an excellent field guide as well. Each species is presented with both scientific and common name followed by a brief description of color and distinguishing characteristics. Next, data is provided on the natural habitat and, of course, care and reproduction in the aquarium. Chapter eleven could have been titled The Good, The Bad and The Not So Ugly, because it describes lots of little creatures that usually enter the aquarium as stowaways. While much is known about coral pests and predators, much more remains to be learned. Here, the authors encourage the aquarist not to "annihilate any creature they think might cause a problem." The obvious answer is to watch, observe and learn.

Fossa and Nilsen (**The Modern Coral Reef Aquarium**) also emphasize the imperative of a natural balance through the use of live rock in the aquarium. Here they tread on some dangerous ground. Chapter seven contains 24 pages on the importance of live rock and the various associated organisms. Only one column on page 192 deals with the issue of conservation and that comes across as self serving at best. While I agree that the use of live rock is advantageous if not vital to a healthy marine aquarium and that coral reefs worldwide face more serious threats than specimen collectors, the authors should have been more sensitive to environmental criticisms. There is little doubt that they genuinely care about the health of tropical reef ecosystems and the destruction of coral reefs from all causes. So it is unfortunate that they expend more effort justifying the continued taking of live rock than encouraging and promoting sustainable harvesting practices and aquaculture. By contrast, Sprung and Delbeek receive high marks for sensitivity to the environmental impacts of the aquarium industry. The authors deserve praise for their "intention... to promote the marine aquarium hobby, sustainable harvest, aquaculture and coral reef conservation." Through the example of clownfish, they advocate captive breeding to reduce demand for wild caught fish, reduce risk of introducing disease and ensure a steady supply of popular species. Marine specimens can be "harvested" on a sustainable yield basis and aquaculture projects can further reduce negative impact on natural populations. It is only through education, care for the environment and proper management that the marine aquarium industry can avoid bad publicity and restrictive intervention. Practitioners of aquarium science must lead the way in this effort.

The Modern Coral Reef Aquarium is full of color photographs which lends a certain coffee table quality to the book and helps justify the hefty price tag (US$ 84.95 on my copy). While most of the pictures are attractive, some stunning, a few are disappointing. Some shots could have benefited from better use of a strobe while others misplaced the strobe to give a washed out and overexposed foreground. One wonders why some photographs clearly out of focus (pgs. 53, 65, 70, 85, 113, 131) were used at all.

Where it not for the wealth of technical data crammed into the 500 plus pages of **The Reef Aquarium**, one might also be inclined to view this as just another book of beautiful photographs of marine life. Much of the photography is truly outstanding, as if it were lifted from the pages of National Geographic. A yellow seahorse on page 215 hardly seems real. The cover photograph is but a sample of what is inside. The hard work and vast experience of the authors shines throughout the text. To make this book more user friendly to the amateur, a glossary of technical terms has been added near the end. This saves much head scratching and searching of technical literature. For the serious minded, the bibliography lists some 1000 references for further reading, although here as well there is an occasional goof. Finally, the text ends with a series of beautiful photographs entitled "Spectacular Reef Aquariums from Around the World." Spectacular, indeed!

Clive Petrovic, H. Lavity Stout Community College, Box 3097, Road Town, Tortola, British Virgin Islands. E-mail <clivep@caribsurf.com>

WHO'S WHO

SCCAR : THE COLOMBIAN SOCIETY FOR REEF STUDIES AND CONSERVATION

The Colombian Society for Coral Reef Studies and Conservation (SCCAR: Sociedad Colombiana para el Estudio y Conservación de los Arrecifes Coralinos), was concieved when 26 Colombian reef scientists attended the 8th ICRS, Panama, June 1996. A few months later, during a national marine science congress, more than 50 people signed a foundation memorandum, which led to the legal constitution of SCCAR by the end of 1997. Now, the society has about 50 active members. The main purpose of this society is to promote the study and knowledge of coral reefs, as well as the exchange of information between scientists and research institutions, in order to conserve this valuable ecosystem.

The society is developing an electronic information network through the internet (contact <scar@santamarta.cetcol.net.co>, soon to be changed to <sccar@invemar.org.co>), a web site (http://biologia.univalle.edu.co/~sccar), and is contributing to a course 'Past, Present and Future of the Colombian Caribbean Coral Reefs'.

During 1998, the society will develop 'Pólipos', an informal newsletter about research, meetings, publications and any other interesting activities related to the coral reef world. We also want to set up a divers network to watch and warn about the condition of Colombian coral reefs. We will also organize the second General Assembly of SCCAR, which will take place during the XI Seminario Nacional de Ciencias y Tecnologías del Mar and run a workshop on a coral reef topic to coincide with the General Assembly.

Further information from Gabriel R. Navas S., Secretario Ejecutivo, SCCAR, INVEMAR, Cerro de Punta de Betín, Apartado Aéreo 1016, Santa Marta, Colombia, Sur America. Tel. (57)(54) 214774, 214775, 211380 Fax (57)(54) 211377 E-mail <colref@santamarta.cetcol.net.co>

DIARY

ITMEMS WILL BE CO-ORDINATED THROUGH ICRI

The International Tropical Marine Ecosystems Management Symposium (ITMEMS) will be held from 23 to 26 November, 1998 in Townsville, Australia. ITMEMS will be coordinated by the International Coral Reef Initiative (ICRI), a global partnership of parties ranging from local communities to regional government alliances, sharing and promoting the message of sustainable management of coral reefs and their related ecosystems. ICRI seeks to provide for the protection, restoration, sustainable use and understanding of coral reefs and related ecosystems. ICRI operates through a regional structure (based on the existing UNEP Regional Seas Program) supported by a small Secretariat. The Secretariat is currently hosted by Australia, one of the founding partners of ICRI, through the office of the Great Barrier Reef Marine Park Authority.

Objectives of ITMEMS

ITMEMS will provide a forum for review, on a global basis, of action over the last four years to arrest the decline in the world's coral reefs. The Symposium will directly relate to one of the four cornerstone principles of ICRI - that of review and continual improvement. The Symposium will be an opportunity for coral reef managers from Australia to hear and discuss management practices from around the world and to then take those lessons and apply them to the local situation. Conversely it will also offer the chance for such lessons learnt in Australia to be transmitted to the wider coral reef management community. The major outcome of the Symposium will be a clear direction for management of the world's reefs for the next four years. The major output of the Symposium will be an action statement to that effect.

That action statement will form the basis of continuing ICRI activity into the next century.

The whole concept of the Symposium is one of an interactive workshop — experts from Australia and overseas working together to improve the manner in which coral reefs and related ecosystems are managed. The Draft Program for ITMEMS focuses on interactive workshop sessions with plenary conference sessions minimized as far as practicable. ITMEMS seeks to attract coral reef managers from as many of the world's coral reef countries as practicable. It is anticipated that at least 75% of the anticipated 300 - 400 delegates will be from overseas.

ITMEMS Outcomes

This will be the inaugural Symposium in what is planned to be an ongoing ITMEMS series held quadrennially. It is intended that ITMEMS parallels the International Coral Reef Symposium (ICRS) series with both ITMEMS and ICRS feeding into each other on a rolling basis. ITMEMS will arguably be the major event for Australia during 1998 — the United Nations International Year of the Oceans. It will certainly be among the premier coral reef events world-wide during the Year of the Oceans.

Costs for ITMEMS

The costs for ITMEMS are anticipated to be approximately $AUD350 for the four days which includes the cost of the reception and the formal dinner. A day delegate fee will also be available.

For further information contact: Symposium Management Company: Harvey Events Group Pty. Ltd., P.O. BOX 1811, Aitkenvale, Qld 4814 Australia. Tel: (+61) 07 4771 5755, Fax: 4771 5455. E-mail: <info@harveyevents.com.au> or visit the GBRMPA ICRI Homepage: <http://www.gbrmpa.gov.au/~icri/secretariat/itmems/> or contact the ICRI Secretariat at <icri@gbrmpa.gov. au>

CORAL REEFS OF THE PACIFIC REGION: PAST, PRESENT AND FUTURE.

The Pacific Science Association Scientific Committee on Coral reefs is organizing a symposium at the XIX Pacific Science Congress in Sydney, Australia, 4–9 July 1999 entitled: "Coral Reefs of the Pacific Region: Past, Present and Future" Within this symposium, the following topics will be covered:

PAST: Coral reefs through time — geological development, ecosystem changes, corals as archives of past climate changes.

PRESENT: The current status of coral reefs, local traditional use and sustainable resource management.

FUTURE: Effects of future climate change (e.g., frequency of coral bleaching events), sea level rise, etc., on the sustainability of coral reefs and associated communities; direct effects of increasing human use on the sustainability of coral reefs and associated communities.

The theme of the XIX Pacific Science Congress is "Science for Pacific Posterity: Environments, Resources and Welfare of the Pacific People". For further information on the Congress, contact Pacific Science Congress Secretariat, GPO Box 2609, Sydney, New South Wales 2001, AUSTRALIA. e-mail: <reply@icmsaust.com.au> FAX: (61) 2-9251-3552 TEL: (61) 2-9241-1478

Abstracts for the coral reef symposium should be sent to Dr. Malcolm McCulloch, Research School of Earth Sciences, Australian National University, Canberra, ACT 0200, AUSTRALIA. E-mail: <malcolm.mcculloch@anu.edu.au > FAX: (61) 249-5443 TEL: (61) 249-4227 or to Dr. Charles Birkeland, Marine Lab-UOG, Mangilao, Guam 96923 USA. E-mail: <birkelan@uog9.uog.edu> FAX: (1) 671-734-6767 TEL: (1) 671-735-2184

1998 ANNUAL SCIENTIFIC CONFERENE OF THE AUSTRALIAN CORAL REEF SOCIETY.

The 1998 Annual Scientific Conference of the Australian Coral Reef Society will be held at Radisson Reef Resort in Port Douglas from the 16–18th October 1998.

Registration is midday on the 16th. In the afternoon there will be plenary talks, followed by an ice breaker. Contributed paper sessions as well as major thematic papers will be given during Saturday and Sunday. There will be a get together on Saturday evening with the tourist operators to explore ways in which the Australian Coral Reef Society and the industry can work together. Both have a vested interest in the long term use of the reef. We will be inviting people from the reef

tourist industry to talk but all tourist operators will be welcome to attend. Sunday night will be reserved for an informal barbeque at the Resort around the pool. A public lecture is also being considering for one evening to improve the profile of the Society within the general community.

Very attractive hotel rates are available and a large number of 2 bedroom Villas (which can accommodate 4 people, 4 singles or 2 doubles) with self catering facilities are reserved for $35 per person per night. Twin hotel rooms are also available (without self catering facilities) at a cost of $35 per person per night. Registration costs for the Conference will be kept to a minimum with reduced rates for students.

Participants arriving by plane from Cairns will be able to take advantage of cheap weekend fares (21 day advance, return Ex Townsville-$184, ex Brisbane $339, ex Sydney $497 and ex Melbourne $581— but quotes may change before next October). There is a bus service from Cairns Airport to all the major hotels in Port Douglas, and the timetable is geared to the times of flights. It takes about an hour from Cairns to Port Douglas on the bus.

Port Douglas is a small town with easy access to the reef, and day excursions are planned either before or after the meeting to Low Isles where Queensland University has a small field station. Lizard Island Research Station has also offered to host a pre and post society Workshop which the organising committee will be investigating. Suggested topics for the Workshops include coral and fish identification or possibly a sediment theme. Flights to Lizard Island leave from Cairns.

For further information contact Pat Hutchings (tel 02 9320 6243) or visit the Web page : www.tesag.jcu.edu.au/ACRS

PALEOCEANOLOGY OF REEFS AND CARBONATE PLATFORMS: MIOCENE TO MODERN.

An international Symposium entitled Paleoceanology of Reefs and Carbonate Platforms: "Miocene to Modern" will be held in Aix-en-Provence, France, in 27-30 September 1999.

The meeting is sponsored by the International Association of Sedimentologists and the International Society for Reef Studies

Aix-en-Provence has a long university tradition and now hosts the new CEREGE, (Centre Européen de Recherche et d'Enseignement de Géosciences de l'Environnement, Université Aix-Marseille III, CNRS, ORSTOM).

The Scientific committee comprises :
G.F. CAMOIN, CEREGE, Aix-en-Provence, France.
A. DROXLER, Rice University, USA.
W.-Chr. DULLO, GEOMAR, Kiel, Germany.
P. FLOOD, University of New England, Australia.
W. HANTORO, RDCG, Indonesia.
M. PICHON, EPHE - Perpignan, France.
A. STRASSER, Université de Fribourg, Switzerland

Scientific themes include:

Effects of paleoceanographic and climatic changes in the evolution of reef and carbonate platfrom biota.

Paleoceanographic boundary conditions of reefs and carbonate platform formation: tropical vs. cool water carbonate systems.

Causes and effects of rapid sea level changes on reefs and carbonate platforms.

Paleoclimatic and paleoceanographic signals in reef organisms.

Cyclicity and sequence stratigraphy in carbonate systems and quantitative modeling.

Impact of recent environmental changes on reefs.

The carbon budget in reefs and carbonate platforms: sinks and sources.

Hydrocarbon potential of cenozoic reefs and carbonate platforms.

Information and registration forms are available at http://www.cerege.fr. Further information from G.F. Camoin, E-mail <camoin@cerege.fr> or <prcp@cerege.fr>

MEMBERSHIP

The annual subscription for individual membership of ISRS is currently US$70, provided renewal payments are made by 1st March each year. Individual and Family Members receive the journal *Coral Reefs*, the newsletter *Reef Encounter* and other periodic mailings. Family membership is US$80. Student membership costs US$20 and benefits include all of the above except the journal *Coral Reefs*.

The category–Sustaining Member– is for those supporting the society with a subscription of $150. In addition to other benefits sustaining members will see their names printed in each issue of *Reef Encounter*.

Renewals received between 1 March and 30 April will cost US$320 for a student member, US$80 for a full member and US$90 for a family membership. Those received after 1 May will cost US$35, US$90 and US$100 respectively. New memberships will be at the base rate of US$20, US$70 and US$80 regardless of what time of year they join.

Institutional subscriptions to *Coral Reefs* must be placed directly with Springer-Verlag.

Subscriptions to the Society should be addressed to: *International Society for Reef Studies, P.O. Box 1897, Lawrence, Kansas 66044-8897, USA.*

NOTES FOR CONTRIBUTORS

The aim of *Reef Encounter* is to provide a magazine-style newsletter on any aspect of reefs, the livelier the better. In addition to news, meeting and expedition reports and announcements, we aim to have discussions and debates about particular issues concerning ISRS or the broader field of reef science in general. *Reef Encounter* does not publish original scientific data, so please do not submit such papers. The newsletter aims to complement the journal which carries scientific paper, in that it provides an outlet for book reviews, discussion of issues of general interest and a correspondence column (**Upwellings**). It also carries short reviews of recent trends and developments in reef research or events that bear on reef studies. In the tradition established by the first editor, *Reef Encounter* is cheerfully illustrated, with cartoons, newspaper cuttings and other entertaining material.

Please note that *Reef Encounter* is an entirely voluntary effort. We do not have funds to pay authors, and the editors are also unpaid. Please Help ISRS by submitting material on a regular basis and in a form that does not require too much editing.

To save time and postage, we shall not normally acknowledge submitted material and this will not normally be refereed or returned for corrections. Opinions expressed and errors of fact will have to remain largely the authors' responsibility. No published item should be taken as ISRS opinion unless indicated.

Please help by sending items of not more the 2,000 words in length, preferably by e-mail or diskette using Word or ASCII text and in an IBM compatible format. You can expect some gentle editing for flow and sense and to address our readership as appropriately as possible. Illustrations should be of a size compatible with our format. Black line drawings are preferable. Diagrams should have legends and/or captions to explain all symbols, abbreviations and shading patterns etc. Maps should have a scale and indication of orientation. Use *World List* abbreviations in references.

References are to be styled in the format as prescribed by *Coral Reefs*. Please use metric, or imperial-with-metric units, but not imperial units on their own. Do not forget to give your name and full address, or any other contact address where applicable.

We have no regular reprint systems, but contributors will receive a free copy of the relevant issue.

DEADLINE FOR COPY FOR REEF ENCOUNTER 24 (DUE OUT DEC 1998) IS OCTOBER 1st 1998; please send to one of these addresses:

Maggie Watson, ICLARM Caribbean Marine Protected Areas Project, c/o Conservation and Fisheries Department, P.O. Box 3323, Road Town, Tortola, British Virgin Islands. Fax: (1-284) 494 2670 Phone: (1-284) 494 5681 e-mail: iclarm@caribsurf.com

David Obura, The Wildlife Conservation Society, Coral Reef Conservation Project, P.O. Box 99470, Mombasa, Kenya Fax: 254-11-472215 Phone: 254-11-485750 e-mail: dobura@africaonline.co.ke

Kristian A. Teleki, Cambridge Coastal Research Unit, Department of Geography, University of Cambridge, Downing Place, Cambridge CB2 3EN United Kingdom Fax: +44 1223 355674 Phone: +44 1223 339775 e-mail: kat1003@cus.cam.ac.uk

APPLICATION FORM FOR MEMBERSHIP

Name: .....

Address: .....

.....

.....

Title: .....

Fields of interest: .....

.....

.....

.....

I/we enclose a cheque (in US$ ONLY please) of:

..... US$70 for FULL membership

..... US$20 for STUDENT membership

..... US$80 for FAMILY membership

..... US$150 for SUSTAINING membership

Credit Card Payment: VISA/Mastercard

No. ..... Expir. Date .....

Signature .....

Bank drafts and cheques to be made payable to: INTERNATIONAL SOCIETY FOR REEF STUDIES. If a receipt is required, please request it at the time of payment.

Send completed application form and your cheque to: *International Society for Reef Studies, P.O. Box 1897, Lawrence, Kansas 66044-8897, USA*