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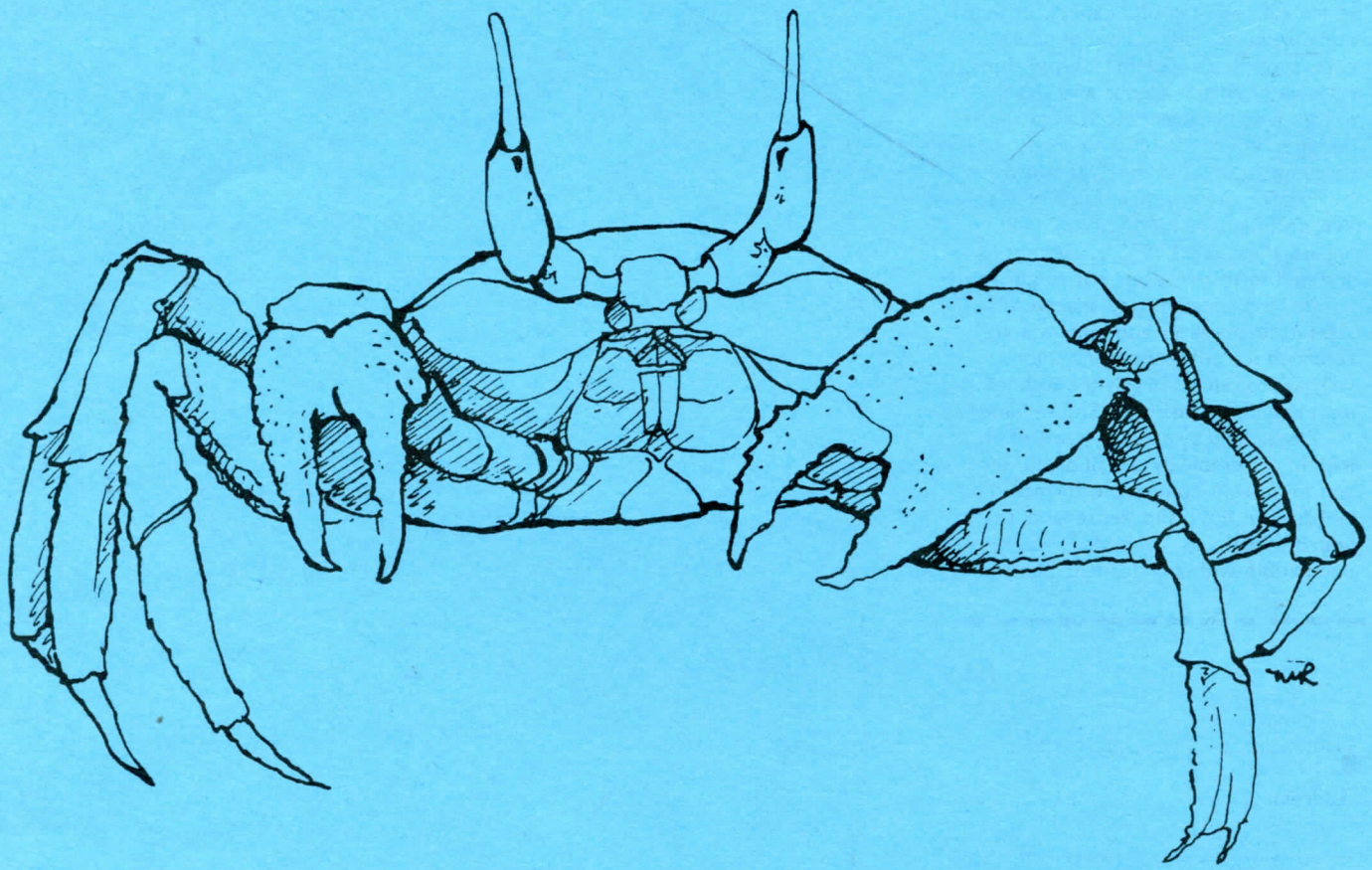
# REEF ENCOUNTER

## Newsletter of the International Society for Reef Studies

Number 21 July 1997



# REEF ENCOUNTER No. 21 July 1997

## NEWSLETTER OF THE INTERNATIONAL SOCIETY FOR REEF STUDIES

**Editor Sue Wells**
**Associate Editors Maggie Watson and David Obura**

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We are very grateful to Margaret Roberts for letting us use her drawing of a ghost crab on the front cover.

**COPY DEADLINE FOR REEF ENCOUNTER 22 (due out Dec 1997) IS OCTOBER 1st 1997**



The **International Society for Reef Studies** was founded at a 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 the Nature Conservation Bureau, 36 Kingfisher Court, Hambridge Road, Newbury, RG14 5SJ, UK. Printed on recycled paper.*

## EDITORIAL

This issue will come out in time for the 1997 annual meeting of ISRS in Fiji, a joint event with the Pacific Science Association's Scientific Committee on Coral Reefs. The meeting will feature a number of presentations reviewing and reporting on activities associated with the International Coral Reef Initiative and the International Year of the Reef. The theme of conservation and management could have been reflected in the contents of this issue of Reef Encounter, but circumstances have dictated a rather different angle and, perhaps perversely, our focus is more on pure science. Some of you may find it a welcome change, remembering that ISRS's primary mission is to promote 'the production and dissemination of scientific knowledge and understanding concerning coral reefs'. Ken Sebens has certainly achieved this in his major article for which we are very grateful, as it goes well beyond the normal 'newsletter' contribution. More contributions of this nature will be very welcome, but we will of course continue to report on efforts to reduce damage to coral reefs.

We would like to apologise for the incorrect information that was given in the item on 'Ethical Considerations in Experimentation' in the last issue. Amanda Vincent has provided an apology and correction on p.6. This, however, is an appropriate moment to remind ISRS members that Reef Encounter is not a peer-reviewed journal like Coral Reefs. As stated on the back page in 'Notes for Contributors', material will not normally be refereed or returned for correction, and opinions expressed and errors of fact are the author's responsibility. We simply do not have time to check facts or send contributions out for review, so do take care when you submit something. If a mistake is made, we will of course publish apologies and corrections provided by readers. Please do not let this deter you – we would like Reef Encounter to remain the vehicle for debate and the airing of topical issues that it has become.

Sue Wells
Maggie Watson
David Obura

## ISRS COMMENT

### FROM THE PRESIDENT

### John Ogden

Your officers and Council are working to implement a number of decisions that were taken at the 8th International Coral Reef Symposium (ICRS) in Panama, June 1996. These initiatives are intended to bring the Society into a greater and more influential role in the promotion of coral reef science and management.

We are in the process of appointing a committee to work closely with the Indonesian organizers on the scientific program for the 9th ICRS in the year 2000. The committee will help to raise funds to bring the top workers in major fields to the meeting and to support the participation of students from developing countries.

The Council approved a US$1200 ISRS Traveling Scholar Award, initially for an Asian/Pacific student to attend a regional ISRS meeting or a meeting of the Australian Coral Reef Society (ACRS). The ACRS has expressed interest and has agreed to work with us to provide a mechanism to select a worthy recipient.

We have learned through the hard work of Steven Miller, how much time and effort was required to select our first Sollins Fellowship Award winner, Melanie Dotherow McField. The donor has tentatively agreed to provide funds for a second fellowship which will be announced later this year. Please think of worthy students who are good candidates for support.

We will establish a committee to work with the Coordinator and Scientific and Technical Advisory Committee (STAC) of the Global Coral Reef Monitoring Network (GCRMN) to help in the implementation of this potentially important global program.

These new initiatives will considerably increase the work load of the Officers and Council and it is our intention to involve enthusiastic, energetic members who are willing to work. Please contact any Officer or Council member to volunteer to serve or to make suggestions or comments.

I think that you will all agree that Terry Hughes' first effort as our new Managing Editor on Volume 16 (1) of CORAL REEFS is outstanding, with a new face, an expanded number of pages, and high quality contributions. Great job!

Finally, I would like to add my personal thanks to the recently retiring members of the Council for their work. I encourage the new Council members to anticipate opportunities to promote the ISRS goals, to increase our membership, and to use the excellent internet communications to maintain a lively exchange and debate within our Society. There will be an ISRS web page in the near future.

Very best wishes to all.

**COMPLEAT REEF ENCOUNTER No. 21**

**It's official! Coral reef research is a 'sexy' topic. An email bearing the memorable return address of NOAA Pubic Affairs brought the editors the following: "Losing a coral reef is like losing a Mozart, a Shakespeare or a Michelangelo, only worse. For along with the poetry of life we lose the prose of survival"**

**Jean Michel Cousteau speaking during a public awareness campaign sponsored by the Earth Communications Office, an entertainment industry organization.**

# ISRS NEWS

## ISRS 1998 NORTH AMERICAN MEETING AND CORAL REEF SYMPOSIUM: BOSTON, JANUARY 4–7, 1998

"Coral Reefs and Environmental Change: Adaptation, Acclimation, or Extinction" will be the topic of a major symposium held at the joint meeting of the Society for Integrative and Comparative Biology (SICB, formerly the American Zoological Society), the Ecological Society of America (ESA), and ISRS in Boston, January 4–7 1998. A regional annual meeting of the ISRS will also be held in connection with the meeting.

Invited papers will be presented on January 6–7, and will include the major results of Working Group 104 "Coral Reef Responses to Global Change: The Role of Adaptation" of the Scientific Committee on Oceanic Research (SCOR), as well presentations on related topics by other researchers. Co-sponsors of the Symposium include SICB, ISRS, SCOR, LOICZ (The Land-Ocean Interactions in the Coastal Zone Project of the IGBP), the Ecological Society of America, and the New England Aquarium. A primary focus of the SCOR Working Group and of the Symposium is the integration of a diverse (and sometimes discrepant) body of findings and concepts from the various disciplines contributing to reef science. Related contributions (papers and posters) are solicited, and may be presented either within the SICB divisional program structure or at theme sessions on January 4–5.

The approximate schedule for meeting-related events is as follows:

Abstract Transmittal Guideline Mailing – Mid-May
Abstract Submission Deadline – late August
1st Advance Registration Mailing – September
Final Program Mails – early December

All ISRS members will receive the abstract transmittal and registration mailings; further information on the meeting venue, schedules, and costs, as well as on ISRS activities, will be included with these mailings.

*Symposium organizers are Robert W. Buddemeier (buddrw@kgs.ukans.edu) and Howard Lasker (hlasker@acsu.buffalo.edu). Information specifically related to the Symposium may be obtained from them; general meeting information, or information about SICB programs and activities, may be obtained from The Society for Integrative and Comparative Biology, 401 N. Michigan Avenue, Chicago, IL 60611-4267 USA. Tel. (312) 527-6697 or (800) 955-1236 Fax (312) 245-1085 Email: sicb@sba.com Home page: http://www.sicb.org/. Up-to date information on the status of the meeting planning can be accessed at: http://bcrc.bio.umass.edu/sicbboston/.*

## 1998 ISRS EUROPEAN MEETING IN PERPIGNAN, FRANCE

The 1998 ISRS European Meeting will be held at the University of Perpignan , from 1–5 September 1998, hosted by the Ecole Pratique des Hautes Etudes (EPHE) which undertakes coral reef research from a field station on the island of Moorea, French Polynesia. The meeting will be also sponsored by ACOR, the French Association for Coral Reefs.

Scientific sessions will include two days of presentations and posters, and a full day for specialized workshops. The organizers wish to encourage presentation of results from multidisciplinary and multi-institution cooperative research. Contributions from students and younger scientists will be particularly welcome. On the fourth day, a selection of field trips will provide an opportunity for participants to catch a glimpse of the Mediterranean natural environment and the cultural heritage of this southernmost part of France.

On-campus, low cost accommodation will be available for conference participants. In addition, accommodation will also be available in a variety of hotels (a few of them within walking distance of the conference venue) offering a range of prices and amenities.

Conference fees are not yet finalized, but are expected to remain close to the following :

| | |
|---|---|
| ISRS or ACOR members | FRF 1200 |
| non-ISRS or ACOR members | FRF 1500 |
| Students (ISRS/ACOR members) | FRF 650 |
| Students (non-ISRS/ACOR members) | FRF 750 |

Registration fees will cover scientific sessions, abstract volume, coffee breaks, lunches, and social events. A registration circular/call for abstracts will be issued in September 1997.

*For further information, please contact Rene Galzin or Michel Pichon , Ecole Pratique des Hautes Etudes, URA CNRS 1453, Université de Perpignan, 66860 Perpignan-Cedex, France. Tel: 33 4 68662055 Fax 33 468503686. Please note new email address:* ephe@univ-perp.fr

## 9TH INTERNATIONAL CORAL REEF SYMPOSIUM – BALI 2000

Indonesia has accepted the offer to host the 9th International Coral Reef Symposium in the year 2000. The offer was formally accepted by Minister Sarwono Kusumatmadja, State Minister for the Environment. Minister Sarwono invites all coral reef scientists, managers and interested individuals to attend this Symposium, irrespective of race, religion or political beliefs. The Department of Foreign Affairs has promised to assist all intending participants in obtaining the necessary travel documents.

Minister Sarwono is particularly concerned that the coral reef resources of Indonesia be sustainably managed and has a strong personal interest in ensuring that the 9th ICRS is successful. As a keen scuba diver he heads what he terms 'the Ministerial Diving Club', encouraging fellow ministers to take up the sport and experience what he is trying to conserve. The minister has appointed the Executive Secretary of his office, Mr. Sudarsono to coordinate government input with assistance from Mr. Aba Sugandhy, who will set up the organising committee. The International Society for Reef Studies has offered the conference organisers considerable assistance in putting together the program and will issue invitations to all intending participants. I am sure that we will see our international coral reef group play a significant role in ensuring that this will be a great Symposium.

Clive Wilkinson

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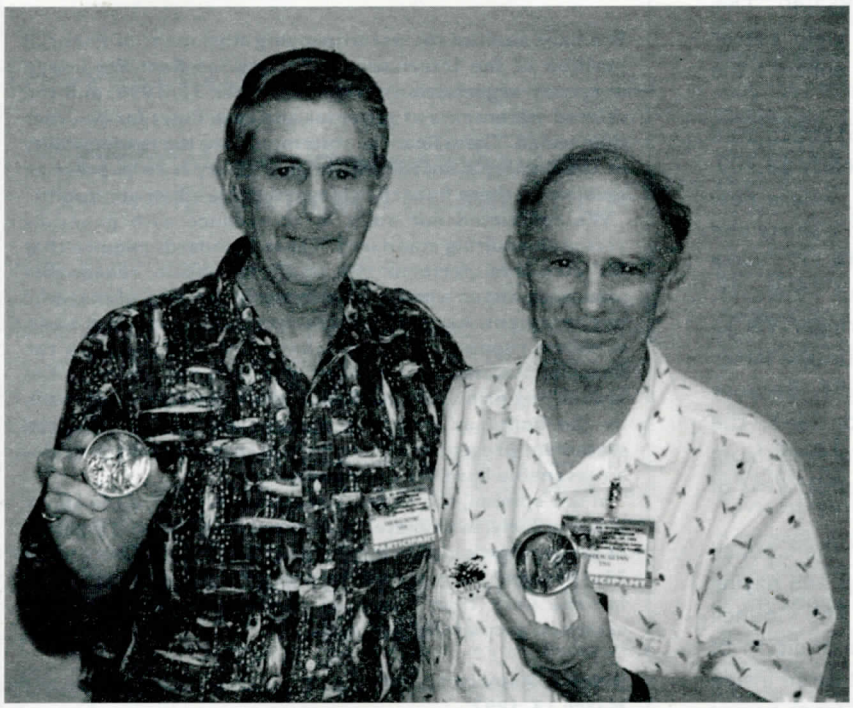
## CHARLES DARWIN MEDAL

Ian G. Macintyre is the third recipient of the Charles Darwin Medal, awarded by the International Society for Reef Studies at the 8th International Coral Reef Symposium in Panama, June 1996. This award, presented every four years to a member of the Society, is in recognition of a record of sustained, highly significant contributions to coral reef studies. Previous medalists are David R. Stoddart (1988), Department of Geography, University of California at Berkeley, and Peter W. Glynn (1992), Rosenstiel School of Marine and Atmospheric Science, University of Miami.

Ian's scientific contributions are diverse and have resulted in new and important understanding in the areas of submarine cementation, sea level history, bioerosion, diagenesis of reef carbonates, sclerochronology, coral growth in relation to water motion and irradiance fields, skeletal diagenesis in calcareous algae, and the formation of stromatolites, mangrove peat deposits and algal ridges. After eight years of experience in exploration geology, he earned a Ph.D. in geology at McGill University, Montreal, Canada in 1967. His doctoral research focused on the growth history of submerged coral reefs off the west coast of Barbados, West Indies. This line of research, including studies of the low temperature tolerances of living reef-building corals, was extended to the continental margin of the southeastern U.S.A. while Ian was a member of the research staff at the Duke University Marine Laboratory from 1967 to 1970. Ian moved to the Smithsonian Institution in 1970 where he is currently a Division Supervisor in Sedimentology, in the Department of Paleobiology. He was one of the first to recognize the key role of submarine lithification in coral reefs. He also pioneered a new approach to revealing the internal structure of coral reefs through the use of a diver-operated, hydraulic drill during the mid 1970s. This new direction sparked similar studies of Holocene reef growth worldwide. Besides such various direct contributions to reef research, Ian has also greatly facilitated advances in reef science as president of the International Society for Reef Studies (1983–1986), Geological Editor of Coral Reefs, leader of field trips for the 1977 and 1996 Symposia and most recently as Editor of the Atoll Research Bulletin. It is altogether fitting that Ian Macintyre receive the Charles Darwin Medal in recognition of his outstanding contributions to reef science and exemplary service to the Society.

Peter Glynn



*Ian G. Macintyre and Peter W. Glynn holding up their Darwin Medals at the ISRS Meeting in Panama, June 28th 1996. Peter had a late presentation of his medal that was awarded to him at the ISRS Guam Meeting in 1992.*

# TREASURER'S REPORT

**Financial and Membership Statement for the year ended 31st December 1996**

| **INCOME** | **US$** |
|---|---|
| Dues | 43,876 |
| Sale of Coral Reefs and t-shirts | 3,792 |
| Subsidy for editorial expenses from Springer | 2,765 |
| Miscellaneous | 81 |
| Interest | 2,463 |
| **Total** | 52,977 |

| **OUTGOINGS** | |
|---|---|
| Springer-Verlag for *Coral Reefs* | 22,906 |
| Reef Encounter | 2,600 |
| Editorial expense | 2,760 |
| Allen Press for membership services | 10,331 |
| Bank charges | 998 |
| Miscellaneous | 456 |
| Office supplies | 725 |
| Postage | 170 |
| Visit by officers to Springer-Verlag | 3,171 |
| **Total** | 44,117 |
| **Excess of revenues over (under) expenses** | 8,860 |

| **US$** | **1993** | **1994** | **1995** | **1996** |
|---|---|---|---|---|
| Income | 44,512.51 | 46,380.91 | 45,036.18 | 52,977.00 |
| Outgoings | 35,577.04 | 32,305.85 | 19,440.34 | 44,117.00 |
| Cash assets Jan 1st | 15,911.08 | 24,845.55 | 38,920.61 | 74,658.71 |

Cash assets on 1 January 1997 were US$85,040. This included two certificates of deposit, which yield better interest than checking accounts, and thereby enhance the interest received by ISRS.

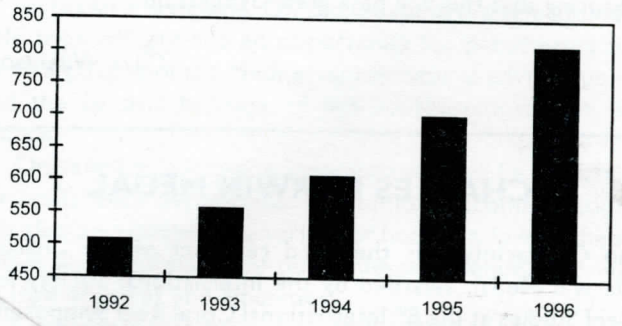
The 1996 budget (*Reef Encounter* 19, page 5) anticipated income of $48,300, which was exceeded by nearly $4,700, thanks largely to the Coral Reef Symposium, where new members joined, and many people purchased t-shirts and copies of *Coral Reefs*. Expenditures of $44,117 were considerably less than the $67,550 anticipated. However, the budgeted amount included payment to Springer-Verlag for both volumes 14 and 15 of *Coral Reefs*, and the latter (about $21,000) was not paid until early 1997. Because Allen Press is now shipping *Coral Reefs* for ISRS, the journal is purchased in bulk, so the bill for *Coral Reefs* from Springer should henceforth be paid in the calendar year of publication.

This healthy financial situation has allowed the Council to explore expanding the length of *Coral Reefs* and paying more for the preparation of *Reef Encounter*. The Council hopes that the modest increase in dues, the addition of the category of Sustaining Members (who are listed inside the front cover), and the savings anticipated from having *Coral Reefs* sent by Allen Press should continue to keep income slightly ahead of expenditures.

**Membership 1992 – 1996**

| | **1992** | **1993** | **1994** | **1995** | **1996** |
|---|---|---|---|---|---|
| Honorary | 7 | 6 | 6 | 6 | 5 |
| Family | 24 | 23 | 23 | 24 | 40 |
| Student | 78 | 77 | 74 | 89 | 109 |
| Individual | 399 | 451 | 506 | 584 | 656 |
| Total | 508 | 557 | 609 | 703 | 810 |

Daphne Fautin, Treasurer




*Total membership of ISRS from 1992 to 1996*

**INDEPENDENT AUDITOR'S REPORT**
**Executive Committee**
**International Society for Reef Studies**
**Snow Hall,**
**University of Kansas,**
**Lawrence, KS 66045**

**We have audited the accompanying statement of financial position of the International Society for Reef Studies (a nonprofit organisation) as of December 31, 1996, and the related statements of activities and cash flows for the year then ended. These financial statements are the responsibility of the Society's board. Our responsibility is to express an opinion on these financial statements based on our audit.**

**We conducted our audit in accordance with generally accepted auditing standards. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by the board as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.**

**In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of the International Society for Reef Studies as of December 31, 1996, and the results of its operations and its cash flows for the year then ended in conformity with generally accepted accounting principles.**

**Roark & Associates, P.A.**
**March 12, 1997**

## ISRS MYSTERY PHOTO COMPETITION WINNER

Congratulations to James Nebelsick at the Institute and Museum of Geology and Paleontology in Tubingen, Germany, who correctly guessed the 'man behind the mask' in the photo published in the last issue of Reef Encounter. Who else would haunt the ISRS booth but Terry Scoffin, from the University of Edinburgh, and long time member of the Society? An ISRS T-shirt is on its way to Tubingen.

Let us know if anyone has further ideas for light hearted competitions, and thanks very much to Gray Multer for dreaming up this one!


# UPWELLINGS

## ETHICAL CONSIDERATIONS IN EXPERIMENTATION – CORRECTION

In my recent note about the ethical treatment of animals in reef research, I cited an experiment in which larval fishes were given electric shocks to keep them swimming in raceways. Discussion with the scientist involved makes it clear that I was entirely mistaken and that the larval fish kept swimming because of their natural tendency to swim into a current, and by encounters with a restraining screen (not electrified). I sincerely regret my error, and any distress or difficulties it has caused the scientist involved. Nonetheless, prolonged swimming by larval fish under artificial conditions still raises issues for scientific peers to discuss... and perhaps to approve.

I return to my original point that all experimentation affecting animals and/or potentially disrupting habitats should be subject to ongoing scrutiny. I chose to cite two specific examples in my original note but the issue is much wider. When, for example, is rotenone sampling of fish acceptable? How can we improve on tagging techniques so as to minimise injury? Does this or that genetic research really justify breaking off pieces of coral? How much damage are we doing by driving metal stakes into corals to mark transects? Could better pre-planning reduce the number of behavioural trials on animals? Can we obtain adequate information from existing samples and transects, rather than sampling anew?

I hope that we can re-evaluate the importance of any potentially intrusive work, design our research to minimise impact, and mitigate the effects of our interventions. Many (even most) current studies may prove entirely acceptable under our current value system but this should never be taken for granted. Approval by committees (where they exist) should be seen as only a first step towards ensuring ethical treatment, not a guarantee. For the record, my passing reference to a separate study that involved swimming beside larval fish (in my original note) should have been construed positively, as an alternative and elegant approach.

Amanda Vincent

## BUTTERFLYFISH AS BIOINDICATORS – A REVIEW

Recently there has been a resurgence of interest in the use of bioindicator species such as corallivorous butterflyfishes (Chaetodontidae) to detect sub-lethal stresses on coral reefs. This interest has been generated in large part by the 'on-line' publication of a methods manual by Crosby and Reese (1996) which describes butterflyfishes as indicators of change on Indo-Pacific Reefs (available from http://coral.aoml.noaa.gov/themes/themes.html). A critical examination of the butterflyfish bioindicator hypothesis now seems timely, before it is incorporated into reef monitoring efforts world-wide. Following Tim McClanahan's call for well-designed reef monitoring programs which assist in management decisions (Reef Encounter 20 p 9–11), I would like to highlight some of the major weaknesses of the butterflyfish bioindicator protocol, particularly when applied to the highly diverse but threatened reefs of the western Pacific, and also to suggest how this or other bioindicator assays can be more effectively designed for developing countries in this region.

### The Rationale for Bioindicators

Bioindicator species have a long history of use for detecting environmental qualities which are otherwise difficult to perceive, with a familiar example being the "canaries in the coal mines" – whilst they sung the miners were safe from odorless, invisible, but toxic gases. While bioindicator species have been used or proposed to monitor a wide range of parameters, from biodiversity to laboratory acute toxicity, they have been used most effectively for in-situ freshwater and temperate marine pollution monitoring

(for recent reviews, see Soule and Kleppel, 1988 and Rosenberg and Resh, 1993). As it is widely agreed that increased levels of sewage, sediment and marine toxins are among the most damaging and insidious of human impacts on coral reefs, reef bioindicator programs are most appropriately designed to provide an early warning of these particular stresses, allowing remedial action before the reefs are extensively damaged. As Crosby and Reese (1996) point out, a sensitive bioindicator species is not needed to detect such obvious impacts as large scale damage by hurricanes, blast-fishing or crown-of-thorns starfish outbreaks.

Bioindicators have been justified for use in marine pollution monitoring programs for at least three reasons. Firstly they only assess pollutants which are bioavailable, ostensibly those which are most important. Secondly, they can reveal biological impacts at contaminant levels below current chemical detection limits. Finally, bioindicators can help assess synergistic or additive antagonistic relationships among pollutants. This is important when dealing with the typical combination of pollution impacts impinging on most reefs in the developing countries of the world.

Perhaps the most compelling justification for bioindicators is their potential as low-cost, low-tech components of monitoring programs. Most developing countries (where the majority of reefs are located) do not have the means to conduct detailed physico-chemical analyses of nutrient loading, sedimentation rates, and ambient marine pollutant levels on reefs, which might be routinely monitored by countries with better resources. Bioindicators may offer an attractive alternative monitoring scheme for developing countries.

### Criteria for Selecting Bioindicator Species

The widespread use of bioindicator organisms in temperate marine ecosystems has led to the recognition of a number of selection criteria for indicator organisms (e.g., Jones and Kaly, 1996). Erdmann and Caldwell (in press) review these criteria as applied to biomonitoring of marine pollution stress on coral reefs of developing countries. Briefly, these criteria include:

1) The indicator organism(s) should be abundant throughout the study area and be easily sampled in an objective, quantitative manner.
2) The bioindicator should provide an early warning of sublethal stress to the hard corals (the primary habitat-structuring organisms), and should respond characteristically to a small number of well-defined anthropogenic stresses.
3) Responses should vary with pollution level.
4) Bioindicators should not be directly exploited by humans (exploitation would obviously confound monitoring efforts).
5) They should have a stable taxonomy which is easily taught to non-specialists.
6) Bioindicator recruitment should be independent of population size at any given site to avoid autocorrelation in abundance measures over time.
7) The protocol for monitoring the organism should be inexpensive and 'low-tech'.

Two other criteria can increase robustness to natural fluctuations and sensitivity to sublethal stresses:

8) The protocol should ideally monitor multi-species assemblages.
9) Monitoring individual-based biological parameters such as growth rate, fecundity, etc., may be more sensitive than measuring overall diversity and abundance.

### The butterflyfish bioindicator hypothesis

Reese (1981) first defined the butterflyfish bioindicator hypothesis, which has been re-stated again in Hourigan et al. (1988), Reese (1994), and Crosby and Reese (1996). In summary, this hypothesis states that a decline in the health of a reef, manifested by decreasing food quality of the stressed coral polyps, will result in a decrease in the abundance and diversity of obligate corallivore butterflyfish. Additionally, feeding rate and agonistic encounters should increase as mated pairs attempt to maintain their nutritional intake by expanding their territories to include more coral colonies. After a time, feeding rates may actually decrease as more time is spent defending territories from neighboring pairs.

Chaetodontids certainly fulfill some bioindicator criteria. They are abundant, easily censused and identified. However, despite anecdotal evidence that they respond to sub-lethal stresses in the manner described above, there has been no conclusive data published in the 16 years since the hypothesis was first introduced. A number of studies have shown a positive correlation between chaetodontid diversity and abundance and percent live coral cover or coral species richness (e.g., Bell and Galzin, 1984; White, 1989; but see Roberts et al., 1988 for a contrary view), but none have yet quantitatively shown effects on abundance, diversity, feeding rate, territory size or aggressive encounters as a result of a chronic, sub-lethal degradation of hard corals. I am unaware of even a simple correlation analysis between these parameters and any of the environmental parameters (levels of pollutants, etc.) which this procedure purports to monitor. Clearly, the ability of butterflyfish to provide an early warning of environmental stress is equivocal and the hypothesis in need of further substantiation.

Additional problems limit the global applicability of the hypothesis, some of which may be intractable regardless of whether the bioindicator hypothesis is substantiated. Most importantly, butterflyfish are subject to direct human exploitation. In Southeast Asia butterflyfish are not only one of the most commonly targeted reef fish for the aquarium trade, they are increasingly caught as food fish where other stocks are severely overfished. In my experience in Sulawesi, chaetodontids are a favourite target of young boys learning to 'spearfish' with rubber bands and sharpened pieces of wire. While this may not be a problem on the reefs of Hawaii or Fiji, where the

butterflyfish program has been used most extensively, it clearly renders this protocol useless in Southeast Asia.

The method, which requires scuba gear, might also be too 'high-tech' for monitoring programs in many developing nations, where diving equipment is often unavailable to the community-based reef monitoring programs which ostensibly need bioindicators the most. Additionally, the protocol involves recording the abundance of individual fish and coral species on line transects in order to monitor changes in feeding rates. Again, while this may be feasible for non-specialists in the relatively species-depauperate waters of Hawaii, it is practically hopeless in a country such as Indonesia, where Moll (1983) reports 262 scleractinian species of 78 genera in south west Sulawesi alone, averaging up to 20 species on a single 10 m transect! The overwhelming diversity of corals in this part of the world was the impetus for the now familiar AIMS-ASEAN benthic life forms monitoring program, with reduced taxonomic resolution for use by non-specialists. If the butterflyfish protocol is to remain viable for use in the western Pacific, it must be adapted to incorporate a similar life-forms monitoring program. Finally, Crosby and Reese (1996) suggest researchers monitor the same transects and even the same pairs of fish over time. Without expensive GPS units this is a difficult requirement in the face of an often voracious 'predation rate' on permanent sampling structures (transects, quadrats, buoys) within the 'unlimited access reefs' of developing countries. A sampling program that does not rely on permanent transects would be more widely applicable.

The response specificity of the butterflyfish assay is also questionable. If butterflyfish are simply responding to a reduction in live coral cover or food quality of coral polyps, monitoring their populations provides no insight into the stress causing these changes. If the cause of a change on a reef is not known, finding the correct management solution is difficult (Wells 1995). Furthermore, Reese and his co-workers' research shows that many corallivorous chaetodontids have several preferred coral prey species (Hourigan et al., 1988). If an altogether natural, perhaps even 'healthy' shift in coral species composition occurs at a site and thereby decreases the abundance of the preferred species, the butterflyfish at this site might respond by either emigrating or enlarging their territory size to include more of the now rare preferred species, thus sounding a 'false alarm'.

Finally, the butterflyfish biomonitoring procedure lacks a well-defined framework, statistical or otherwise, for interpreting the results of monitoring. While the manual does suggest that statistically-significant changes in the parameters measured might indicate change is occurring on a monitored reef, it is rather vague as to interpretation of these changes. This is in sharp contrast to the majority of freshwater biomonitoring programs, which usually result in the calculation of a multimeric index or score for each site, with clearly-defined interpretations of what a change in the score of a certain direction and magnitude might indicate (e.g., Kerans and Karr, 1994). The majority of such programs are based on long-term studies which required extensive (and expensive) environmental sampling to first calibrate and later test the relevant bioindicators. Although such indices may need calibration for use in different regions, they are intuitively appealing and can be used directly by resource managers.

In conclusion, the butterflyfish biomonitoring assay as proposed has a number of problems which limit the widespread applicability of the technique. Furthermore, the recently-published procedural manual may be premature, as the butterflyfish bioindicator hypothesis is not yet fully substantiated and a framework for interpreting the results of this monitoring is not yet presented. While the goals of this monitoring protocol are well-conceived, and the authors deserve praise for this initial effort, I believe that those practicing applied reef science and designing monitoring programs have a responsibility to test such programs thoroughly first, and have in place a well-defined interpretative framework. There is a real danger of developing countries adopting 'sexy' monitoring programs which are of little use to reef management schemes, which as McClanahan (1997) points out, serves only to drain already scant resources and further imperil the very reefs these monitoring programs were designed to protect.

**REFERENCES**


Bell JD, Galzin R (1984) Influence of live coral cover on coral reef fish communities. Mar Ecol Prog Ser 15:265–274

Crosby MP, Reese ES (1996) A manual for monitoring coral reefs with indicator species: butterflyfishes as indicators of change on Indo-Pacific Reefs. NOAA, Silver Spring Md.

Erdmann MV, Caldwell RL (in press) Stomatopod crustaceans as bioindicators of marine pollution stress on coral reefs. In: Proc 8th Int. Coral Reef Symp. Panama. June 1996.

Hourigan TF, Tricas TC, Reese ES (1988) Coral reef fishes as indicators of environmental stress in coral reefs. In Soule DF, Kleppel GS (eds.) Marine Organisms as Indicators. Springer-Verlag, New York, pp. 107–135.

Jones GP, Kaly VL (1996) Criteria for selecting marine organisms in biomonitoring studies. In: Schmitt RJ, Osenberg CW (eds.) Detecting ecological impacts: concepts and applications in coastal habitats. Academic Press, New York, 29–48.

Kerans BL, Karr JR (1994) A benthic index of biotic integrity (B-IBI) for rivers of the Tennessee Valley. Ecol Appl, 4:768–785.

McClanahan, TR (1997) Coral reef monitoring–the state of our art. Reef Encounter 20:9–11.

Moll H (1983) Zonation and diversity of Scleractinia on reefs off S.W. Sulawesi, Indonesia. PhD thesis, Leiden, Netherlands.

Reese ES (1981) Predation on corals by fishes of the family Chaetodontidae: implications for conservation and management of coral reef ecosystems. Bull Mar Sci 31:594–604

Reese ES (1994) Reef fishes as indicators of conditions on coral reefs. In: Ginsburg RN (ed.) Proc of Coll on Global Aspects of Coral Reefs. Univ. of Miami, 59–65.

Roberts CM, Ormond RF, Shepherd, AR (1988) The usefulness of butterflyfishes as environmental indicators on coral reefs. Proc 6th Int. Coral Reef Symp 2:331–336.

Rosenberg DM, Resh VH (1993) Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York.

Soule DF, Kleppel GS (1988) Marine organisms as indicators. Springer–Verlag, New York.

Wells SM (1995) Science and management of coral reefs: problems and prospects. Coral reefs 14:177–181.

White AT (1989) The association of Chaetodon occurence with coral reef habitat parameters in the Phillipines with implications for reef assessment. Proc 6th Int Coral Reef Symp 2:427–431.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# FEATURES

## ZOOPLANKTON CAPTURE BY REEF CORALS: CORALS ARE NOT PLANTS!

**Kenneth P. Sebens**

The earliest publications on reef corals and other 'zoophytes' stressed the plant-like aspects of their biology. It was later recognized that corals are actively behaving animals, and that they can feed on a variety of other creatures. New methodologies in the 1970s led to major advances in understanding the biology of zooxanthellae, the energetics of the coral-algal symbiosis, and finally to the realization that photosynthesis by the symbiotic algae could produce more than enough energy to fuel respiration, growth and reproduction of corals under optimal conditions (Muscatine et al, 1983; Achituv and Dubinsky, 1990). In less than optimal conditions, such as in deep reef habitats or turbid water, zooxanthellae provide half or less of the daily respiratory needs of the symbiosis. At about the same time, it was also discovered that zooxanthellae recycle nitrogenous wastes and even remove inorganic nitrogen from seawater at very low concentrations, but that this is generally not enough to meet the needs of coral growth and reproduction (Sebens, 1987a). Furthermore recent studies indicate the amount of carbon dioxide produced by coral metabolism is not sufficient for both coral photosynthesis and skeleton formation, and that diffusion of bicarbonate ions into coral tissues can be a rate limiting step, which is strongly influenced by water motion (Patterson et al. 1991). As a generality then, corals can be considered nutrient (usually nitrogen) limited in high light (and moderate to high flow), and carbon limited in low light (and/or low flow) conditions.

If most corals do not get all carbon, energy, or nitrogen needed for respiration, growth and reproduction from their symbiotic algae, then predation on zooplankton is likely to be critical (Porter, 1974; Sebens, 1987a). Capture of bacteria (Sorokin, 1974; 1991) and sediment particles (Lewis and Price, 1975; Abelson et al., 1993; Stafford Smith and Ormond, 1992; Mills and Sebens, 1996) from seawater represent other potential sources of limiting nutrients for certain coral species. Coral morphologies that enhance gravitational deposition and encounters with resuspended (bedload) particles may specialize on this resource and dominate certain reef habitats (Sebens and Johnson, 1991; Abelson and Loya, 1995). Phytoplankton are rare in most reef systems, and thus have not been considered a food source corals could specialize on. However, certain octocoral species, with thin branched tentacles, appear to have done exactly that (Fabricius et al., 1995). Attempts to quantify phytoplankton consumption by scleractinian corals have shown insignificant ingestion to date (Sorokin, 1991; Witting, unpublished data), and it is unlikely that such corals, with relatively large unbranched tentacles, use phytoplankton as a major food resource. The other potential source of limiting nutrients, such as nitrogen and phosphorus, is dissolved compounds taken

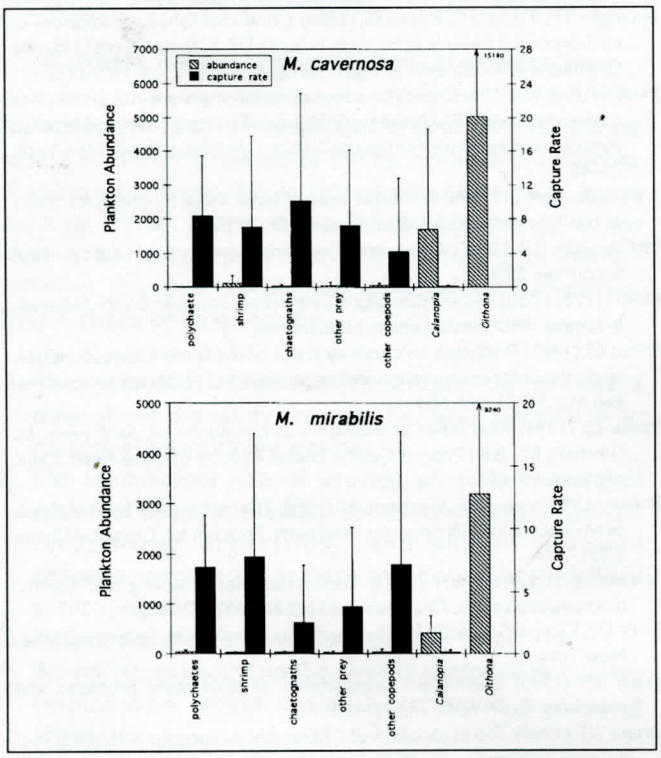



*Fig. 1 Abundance (N/100L, mean ± s.d.) of zooplankton (by category) in near-reef plankton and in coelenteron contents (capture rate) of two scleractinian corals during 17 experiments (Figs. 1-4 replotted from data in Sebens et al. 1996a)*

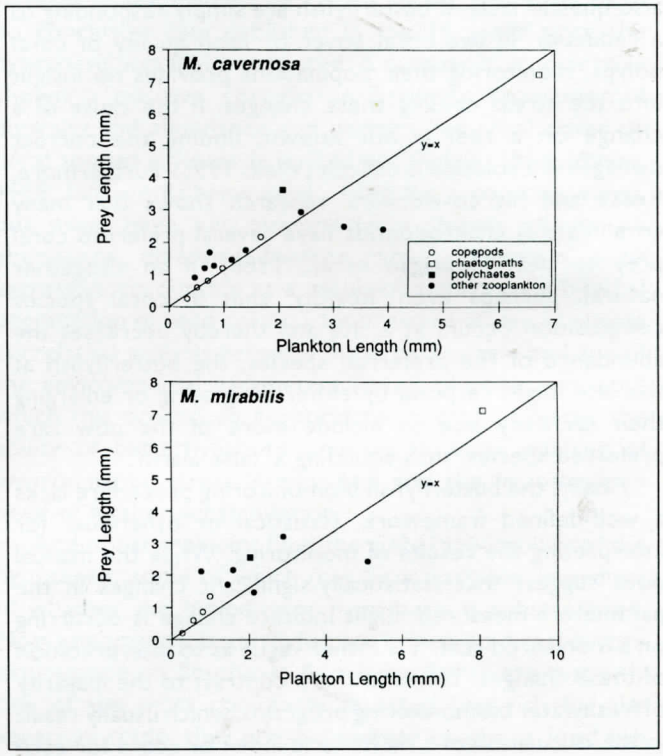



*Fig. 2 Sizes of zooplankton in plankton and in coelenteron contents (means ± s.d.) of* Montastrea cavernosa *(polyps approx. 12mm tentacle crown diameter) and* Madracis mirabilis *(polyps approx. 4mm diameter) during 17 experiments.*

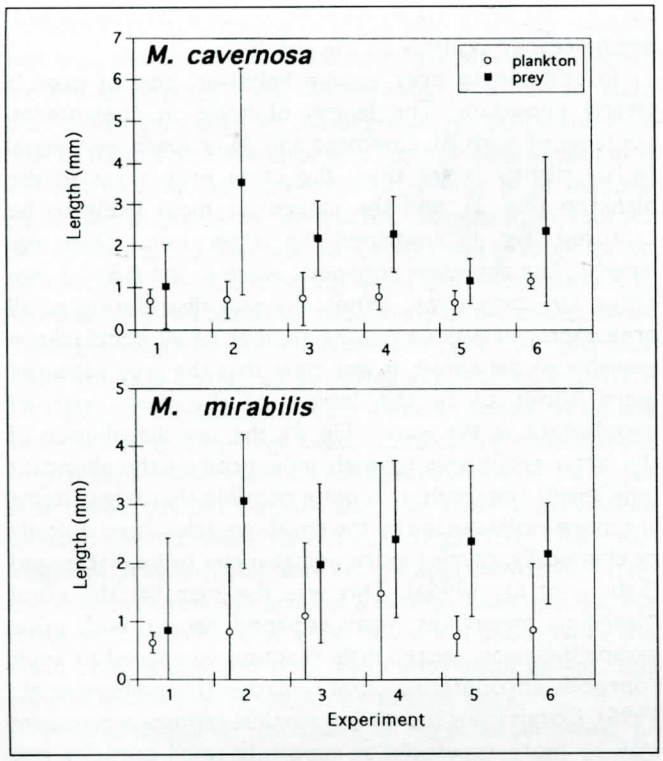



*Fig. 3 Sizes of zooplankton in plankton and in coelenteron contents (mean ± s.d.) of two scleractinian corals in six experiments carried out on different sites.*

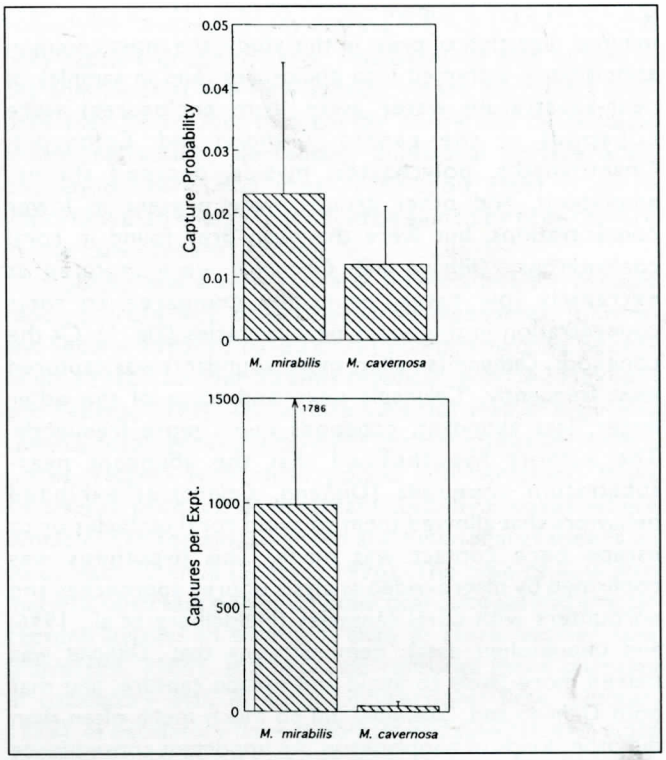



*Fig. 4 Capture rate expressed as, **A.** number of zooplankton captured by an equal biomass of coral (100 polyps* M. cavernosa*, 9000 polyps* M. mirabilis*) during 20 minute experiments, and **B.** probability of capture for each zooplankter that could encounter the tentacle crown during all experiments (means ± s.d.).*

up by zooxanthellae (e.g. nitrate, ammonium) or by coral cells themselves (e.g. amino acids). Uptake is strongly influenced by the diffusional boundary layer over tissue surfaces, and thus by water movement which determines the thickness of the boundary layer over coral tissues (Patterson, 1992).

## Zooplankton as Prey

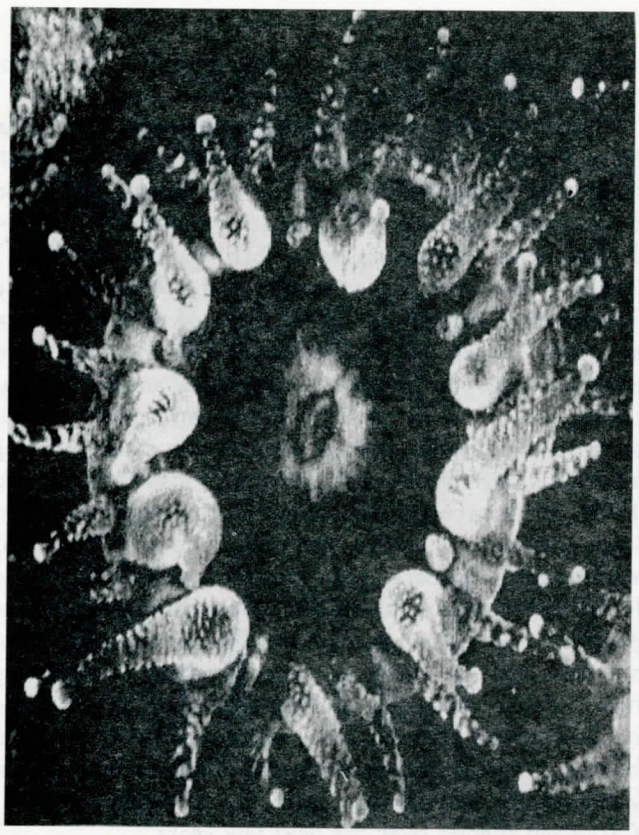
Zooplankton are more abundant in reef waters than would be expected by water column productivity or by phytoplankton stocks, partly because some zooplankton are demersal (on or near the substratum), and because the reefs themselves generate resources (mucus, detritus, bacteria, microzooplankton) that can fuel zooplankton production. Some demersal zooplankton reside on the substratum and consume benthic primary production (attached algae) during daylight hours then migrate from the reef to the water surface at dusk and back at dawn (Porter et al., 1977; Ohlhorst, 1982). Water motion is a critical element affecting zooplankton availability to corals, fish and other zooplanktivores; open water holoplankton are delivered to fore reef habitats at high rates by currents and wave action. Corals thus encounter two major types of zooplankton, those swept onto reefs from the open water planktonic community, and resident reef plankters swimming near the substratum or migrating to and from the water surface layer. The relative abundance of these two groups can be expected to differ greatly among reefs, times of year, and habitats within reef systems.

The first quantitative information on coral diets came from Porter's (1974) study of the Caribbean coral, *Montastrea cavernosa* (large-polyp, mounding), which fed on a variety of zooplankton, but at relatively low rates (< 1 capture per 100 polyps per night). Wellington's (1981) plankton exclusion experiments in the field suggested zooplankton were important for the growth of both large and small polyp corals. The next diet quantification attempted was for *Meandrina meandrites*, another (large-polyp, mounding or plating) Caribbean species which showed much higher rates of zooplankton capture during a period of high plankton abundance (Johnson and Sebens, 1993). More recently, controlled feeding experiments in large enclosures on a Jamaican reef (Sebens et al., 1996a) were used to compare prey capture rates and selectivities for *M. cavernosa*, and for the small- polyp branching species *Madracis mirabilis*, using known zooplankton concentrations and flow speeds. These studies demonstrated relatively high capture rates for both species, for zooplankton concentrations at and above those normal in this reef habitat. Ongoing studies using this experimental system will provide comparative data for at least 15 other Caribbean species over the next few years.

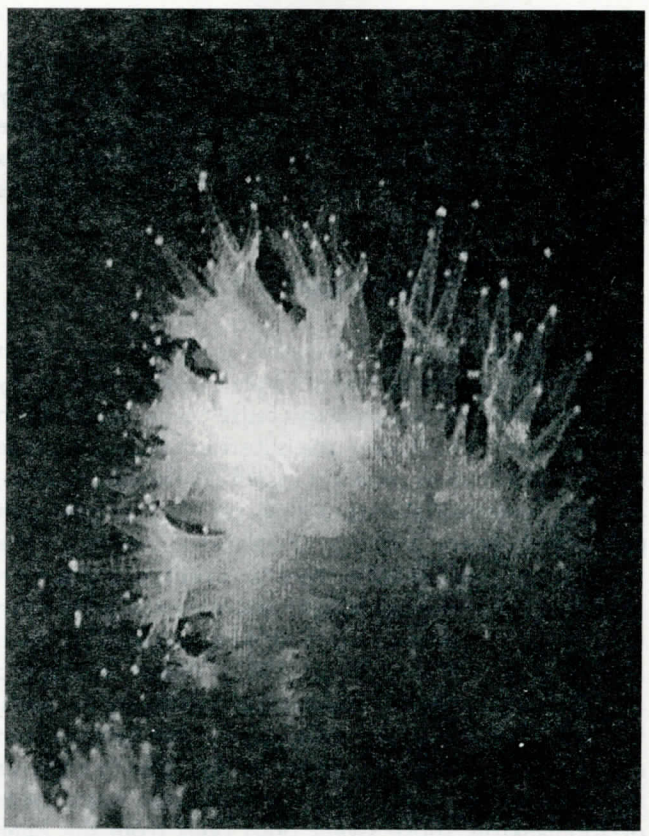
This field study (Sebens et al., 1996a) was the first in which zooplankton abundance within centimeters of coral tentacles could be compared to zooplankton captured by

the corals over a known period of time (15–20 min), with minimal digestion of prey. In this study, the most common zooplankton attracted into enclosures (and in samples of near-substratum water away from enclosures) were copepods in the genera *Oithona* and *Calanopia*. Chaetognaths, polychaetes, mysids, decapod shrimp, amphipods, and other groups were present in lower concentrations, but were the main prey found in coral coelenterons; *Oithona* and *Calanopia* were captured at extremely low rates, especially compared to their concentration in the water near tentacles (Fig. 1). Of the copepods, *Oithona* (smaller, more abundant) was captured least frequently, *Calanopia* next, and some of the other larger, less abundant, copepods much more frequently. The authors hypothesized that the abundant near-substratum copepods (*Oithona*, *Calanopia*) exhibited behaviors that allowed them to avoid coral tentacles or to escape once contact was made. This hypothesis was confirmed by macro-video analysis of prey approaches and encounters with coral tentacles (Heidelberg et al., 1996; and unpublished data), demonstrating that *Oithona* was indeed more likely to avoid and escape capture, and that both *Oithona* and *Calanopia* did so much more often than did other kinds of zooplankton. An important consequence of this study is that local abundance of zooplankton cannot be used as a measure of a coral's prey resource; zooplankton species that dominate by numbers or biomass may, in fact, not be readily available to the corals.

In addition to prey escape behavior, size of prey is clearly important. The length of items in coelenteron contents of both *M. cavernosa* and *M. mirabilis* was equal to, or slightly larger than, the same prey types in the plankton (Fig. 2), and the categories most likely to be captured (Fig. 1) contained the larger items (1–6 mm length). The abundant copepods were in the 0.5–1.2 mm range, by comparison. When the size distribution of all prey captured was compared to that of all zooplankton available to the corals, it was clear that the prey captured were about twice the length of the mean size of zooplankton in the water (Fig. 3); the size distribution of the latter group was strongly influenced by the abundant (and small) copepods. It is quite possible that larger items are more easily sensed by the coral tentacles, mechanically or chemically, causing more nematocysts to be discharged (Sebens et al., 1996a). This was the case for the coral *Meandrina meandrites*; small copepod nauplii, with poor escape behavior, caused little reaction compared to adult copepods encountering coral tentacles (Heidelberg et al., 1996). Corals using mucus as a particle capture mechanism may be more successful at capturing small particles and small zooplankton than those relying primarily on nematocysts and spirocysts.



*M. cavernosa*



*M. mirabilis*

One surprising finding of these field predation studies was that the zooplankton capture rate was much higher for the small-polyp coral *M. mirabilis* (4–5 mm tentacle crown diameter) than for the larger polyps of *M. cavernosa*. (10–15 mm). This difference was most evident when equal biomass of coral was compared (90 polyps of *M. mirabilis* equal one polyp of *M. cavernosa*). Zooplankton capture per unit coral biomass was about 36 times greater for *M. mirabilis* (Fig. 4). Considering individual encounters, *M. mirabilis* captured about twice as many of the zooplankton passing through the tentacle crown area as did *M. cavernosa*. The advantage conferred by having a high tentacle surface area (per unit biomass), for *M. mirabilis*, seems to be the factor allowing these high capture rates. We expected the large polyps of *M. cavernosa* to capture more of the larger prey items, but this was not the case; sizes of prey taken by both species were very similar (Figs. 2,3). The mean length of prey available was usually approximately 1 mm, and that captured was around 2 mm for both species; the tentacle crown diameter of *M. mirabilis* is about twice the mean prey length and thus, even with small polyps, this coral is not limited to capturing smaller prey.

It is tempting to use some of these experiments to estimate the contribution of zooplankton to the energy and nutrient budgets of particular reef coral species. One problem with such estimates has been the lack of good data on abundances of zooplankton near coral tentacles, and how such abundances change daily and seasonally. Capture rates for zooplankton taxa can vary widely, by one to three orders of magnitude (Sebens et al., 1996a), so it is necessary to know the exact composition of that plankton (to genus for copepods). In the near future, we expect to be able to combine capture rate data from the field experiments with abundance data from pumped samples to estimate these dietary contributions for several of the coral species in Jamaica.

## Water Flow Affects Prey Capture

Water motion has positive effects on coral biology, including enhanced uptake of dissolved substances, photosynthesis, calcification, and particle capture (Sebens, 1996), but extreme flows increase the risk of dislodgement, breakage, and mortality. For corals and other passive suspension feeders, laboratory and field studies have demonstrated an optimum flow speed for particle capture (Patterson, 1984; Leonard et al., 1988; Sebens et al., 1996b) near the mean flow speed normally observed in the habitats where that species is most common. Below that optimum, more flow delivers more particles to tentacles; above it, efficiency of retention and capture decrease with greater flow (Sebens, 1984). The positive effects of flow have been demonstrated for octocorals (phytoplankton capture, Fabricius et al., 1995), and for scleractinian corals (Sebens et al. 1996b). Above the optimum flow speed, as prey retention declines substantially and tentacle or polyp deformation reduces tentacle surface area, higher potential encounter rates are offset by lower actual capture rates (Johnson and Sebens, 1993). At the highest speeds, suspension feeders usually retract feeding structures and prey capture drops to zero. This behavior also occurs in sea anemones at low flow speeds, where encounter with prey may be so low that energy conserved by tentacle crown retraction (decreasing diffusional surface area, oxygen delivery, and thus respiration rate) is more important than energy that could be gained by prey capture in low flow (Sebens, 1987a).

Corals show a wide range of flow optima for particle capture, from < 5 cm/s (*Meandrina meandrites*, Johnson and Sebens, 1993) to 10–20 cm/s (*Madracis mirabilis*, Sebens et al., 1996b), to over 30 cm/s (*Agaricia agaricites*, Helmuth and Sebens, 1993). To capture particles well at high flow speeds, corals generally have upright structures (branches, plates, ridges) with small polyps and tentacles; these structures produce downstream turbulent wakes where tentacles can remain expanded and functional at speeds up to at least 50 cm/s (Sebens, 1996). The type of flow also matters; upstream polyps on octocoral colonies had greater capture success in turbulent than in more laminar flow (Patterson, 1984), and hydroids captured more particles in oscillatory than in equal unidirectional flow (Hunter, 1979). In oscillatory flow, upstream and downstream sides of scleractinian coral colonies reverse every few seconds; polyps deformed on upstream sides are thus able to feed when they become downstream polyps again. Polyps in the center of such colonies experience flow that is more turbulent and of lower speed than that at colony edges, which may allow high capture rates even if ambient flow is excessive.

## Polyp Size, Biomass, and Prey Capture

There is a wide range of polyp size and biomass among scleractinian corals, from very thin tissue layers (2–5 mm thick) and small polyps (2–5 mm diameter), to huge polyps (over 10 cm diameter) with long distances between exposed surfaces and deep tissue layers (> 5 mm) far from the source of important dissolved substances. Most coral species have small polyps, spreading biomass over a large colony surface area (Sebens, 1996). Large-polyp corals have been considered specialists at zooplankton capture (Porter, 1976), trading off high surface area which is important for photosynthesis, and gaining the ability to capture more and larger zooplankton. However, certain small-polyp corals can capture almost the same size range of prey as larger polyps, and achieve much higher rates of prey capture per unit coral biomass, because of the greater feeding surface area (tentacles) presented to moving water. The small-polyp *M. mirabilis*, for example, captured 36 times as many prey as the large-polyp *M. cavernosa* for equal coral biomass (Sebens et al., 1996a). An equal biomass of *M. mirabilis* has 12 times the tentacular surface area of *M. cavernosa* and, 90 times the number of mouths. Both factors could affect prey capture and ingestion rates.

The advantage of small feeding units and a large surface area has been demonstrated theoretically in a model of polyp and colony energetics (Sebens, 1979). In this model, a given unit of colony biomass could be deployed as one

large polyp, or as any number of smaller polyps of the same geometry. Energy intake is related to feeding surface area, and energetic cost (metabolic) is related to mass by a power function; cost increases with size more rapidly than does intake, resulting in an 'optimum' size where the difference between intake and cost is greatest (maximizing energy available for growth and/or reproduction). Infinitely small polyps, with biomass spread out over the greatest possible surface area, represent the theoretical energetic optimum. With a variety of prey sizes available, a polyp of a given size can take only a limited range of those prey. Some polyps could be too small to use the most valuable prey, thus losing substantial intake. If prey are extremely small (e.g., photons, phytoplankton, microzooplankton), polyp size should be as small as possible and still maintain all polyp functions. Given a broad range of prey size, polyp size is optimal just above that needed to capture the mean size (by biomass) of prey. Large polyps, with greater tentacle size and more nematocysts to discharge, may achieve better capture of larger prey. A further analysis of the energetics model (Sebens, 1987b) showed that increasing prey availability decreased optimum polyp size when there was a broad spread of prey sizes. For a fixed biomass of colony, it was energetically better to have a greater surface area and capture more of the smaller sizes than to have a lower surface area and capture a few larger prey.

Large-polyp corals are giving up a great deal of capture surface (for prey, other particles, nutrients, or light) by having polyps with large size and a low feeding surface to biomass ratio. Another disadvantage of large polyps is that they often have elongate tentacles that capture swimming zooplankton well, but collapse in high flow (Johnson and Sebens, 1993). To feed in high flow, especially in wave-induced flow, large polyps and tentacles must be sturdy. Some sea anemones have developed exactly this form and can remain expanded in crashing surf, feeding on large invertebrates dislodged by waves (Sebens, 1987a). The internal skeleton of reef corals may preclude this particular adaptive response. Upright branching corals with small polyps can feed in high flows because polyps remain expanded and tentacles are functional in eddies downstream of branches (Sebens et al., 1996b). Some small-polyp corals with very small tentacles; (e.g. *Agaricia agaricites*, Helmuth and Sebens, 1993) feed well up to at least 50 cm/s. Corals with large polyps are generally absent from shallow, high wave energy, habitats (Sebens and Done, 1992), but are present in moderate to deep forereef habitats, and in backreef habitats away from the zone of breaking waves (Sebens, 1996). Light and temperature cannot be the factors producing this disjunct distribution, since the highest values of both generally occur in backreef habitats, not in the surf zone and shallow forereef.

If large polyp size does not result in capture of many more large prey, what other factors could favour the evolution of this morphology? An obvious advantage for large-polyp corals is their competitive superiority (Lang and Chornesky, 1988), which is probably due to the greater length of their tentacles, sweeper tentacles, and mesenteric filaments, or to the greater mass of those organs. A large-polyp coral can usually defend itself successfully when faced by overgrowth from small-polyp corals, resulting in a standoff in competitive encounters, especially in habitats where the small-polyp species have low growth rates. Interspecific competition by sweeper tentacles, sweeper polyps, and mesenteric filaments is likely to be less effective, however, in high flow environments (Genin et al., 1994), another reason small-polyp upright corals would do well in such conditions. Finally, the low S/V colony forms (with large or small polyps) are structurally stable and experience lower drag forces during extreme (storm) flow conditions. This allows them to survive when hurricanes decimate branching corals in shallow reef zones. The combination of defense against overgrowth and greater survival during catastrophic storms is probably enough to offset the energetic and growth rate advantages of the small-polyp, high S/V morphologies and allow coexistence of the broad range of polyp sizes and colony morphologies observed on most reefs.

## REFERENCES


Abelson, A., Miloh, T. and Loya., Y. 1993. Flow patterns induced by substrata and body morphologies of benthic organisms and their roles in determining availability of food particles. Limnol. Oceanogr. 38:1116–1124.

Abelson, A. and Loya., Y. 1995. Cross-scale patterns of particulate food acquisition in marine benthic environments. Am. Nat. 145:848–854.

Achituv, Y. and Dubinsky, Z. 1990. Carbon budgets in marine mutualistic associations between microalgae and cnidarians. In: Mellinger, J. (ed.) Animal Nutrition and Transport Processes in Wild and Domestic Animals. Comp. Physiol. 5:36–48 .

Atkinson, M.J. and Bilger, R.W. 1992. Effects of water velocity on phosphate uptake in coral reef-flat communities. Limnol. Oceanogr. 37:273–279

Fabricius, K.E., Genin, A. and Benayahu, Y. 1995. Flow- dependent herbivory and growth in zooxanthellae-free soft corals. Limnol. Oceanogr. 40:1290–1301

Genin, A., Karp, L., and Miroz, A. 1994. Effects of flow on competitive superiority in scleractinian corals. Limnol. Oceanogr. 39:913–924

Heidelberg, K.H., Sebens, K.P. and Purcell, J.E. 1996. Effects of prey escape behavior and water flow on prey capture by the scleractinian coral *Meandrina meandrites*. Proc 8th Int Coral Reef Symp (in press)

Helmuth, B.S.T. and Sebens, K.P. 1993. The influence of colony morphology and orientation to flow on particle capture by the coral*Agaricia agaricites* (Linnaeus). J. Exp. Mar. Biol. Ecol. 1889:1–28

Hunter, T. 1989. Suspension feeding in oscillating flow: the effect of colony morphology and flow regime on plankton capture by the hydroid *Obelia longissima*. Biol. Bull. 176:41–49

Johnson, A.S. and Sebens, K.P. 1993. Consequences of a flattened morphology: effects of flow on feeding rates of the scleractinian coral *Meandrina meandrites*. Mar Ecol. Prog. Ser. 99:99–114

Lang, J. C. and Chornesky, E.A. 1988. Competition between scleractinian reef corals: A review of mechanisms and effects. Pp 209–252 in Z. Dubinsky, Ed. Ecosystems of the World: Coral Reefs. Elsevier Press, Amsterdam, .

Leonard, A.B., Strickler, J.R. and Holland, N.D. 1988. Effects of current speed on filtration during suspension feeding in *Oligometra serripinna* (Echinodermata: Crinoidea). Mar. Biol. 9:111–125

Lewis, J.B. and Price, W.S. 1975. Feeding mechanisms and feeding strategies of Atlantic reef corals. J. Zool. Lond. 176:527–544.

Lesser, M.P., Weis, V.M., Patterson, M.R. and Jokiel, P.L. 1994. Effects of morphology and water motion on carbon delivery and productivity in the reef coral *Pocillopora damicornis* (Linnaeus): Diffusion barriers, inorganic carbon limitation, and biochemical plasticity. J. Exp. Mar. Biol. Ecol. 198:143–179

Mills, M.M. and Sebens, K.P. 1996. Particle ingestion efficiency of the corals *Siderastrea siderea* and *Agaricia agaricites*: effects of flow speed and sediment load. Proc 8th Int Coral Reef Symp (in press)

Muscatine, L., Falkowski, P.G. and Dubinsky, Z. 1993. Carbon budgets in symbiotic associations. pp. 649–658. In, Shenk HEA, Shwemmler W, eds., Endocytobiology II, de Gruyter, Berlin

Ohlhorst, S. L. 1982. Diel migration patterns of demersal reef zooplankton. J. Exp. Mar. Biol. Ecol. 60:1–15.
Patterson, M.R. 1984. Patterns of whole colony prey capture in the octocoral *Alcyonium siderium*. Biol. Bull. 167:613–629
Patterson, M.R. 1992. A chemical engineering view of cnidarian symbiosis. Amer. Zool. 32:566–582
Patterson, M.R., Olson, R.R., and Sebens, K.P. 1991. In situ measurements of forced convection on primary production and dark respiration in reef corals. Limnol. Oceanogr. 36:936–948.
Porter, J. 1974. Zooplankton feeding by the Caribbean reef– building coral *Montastrea cavernosa*. Proc. 2nd Int. Coral Reef Symp. 1:111–125
Porter, J.W. 1976. Autotrophy, heterotrophy and resource partitioning in Caribbean reef building corals. Am. Nat. 110:731– 742
Sebens, K.P. 1979. The energetics of asexual reproduction and colony formation in benthic marine invertebrates. Amer. Zool. 19:683–697
Sebens, K.P. 1984. Water flow and coral colony size: Interhabitat comparisons of the octocoral *Alcyonium siderium*. Proc. Natl. Acad. Sci. 81:5473–5477
Sebens, K.P. 1987a. Coelenterata. In: Vernberg FJ, Pandian TJ (ed) Animal Energetics. 1 Academic Press, New York, pp 55–120
Sebens, K.P. 1987b The ecology of indeterminate growth in animals. In: Johnston RF (ed) Annual Review of Ecology and Systematics. Annual Reviews Inc., Palo Alto, (18) pp 371–407
Sebens, K. P. 1996. Adaptive responses to water flow: morphology, energetics, and distribution of reef corals. Proc. 8th Int. Coral Reef Symp. (in press).
Sebens, K.P. and Done, T.J. 1992. Water flow, growth form and distribution of scleractinian corals: Davies Reef (GBR), Australia. Proc 7th Int Coral Reef Symp 1: 557–568
Sebens, K.P. and Johnson, A.S. 1991 The effects of water movement on prey capture and distribution of reef corals. Hydrobiologia 226:91–101
Sebens, K.P., Vandersall, K.S., Savina, L.A. and Graham, K.R. 1996a. Zooplankton capture by two scleractinian corals *Madracis mirabilis* and *Montastrea cavernosa*, in a field enclosure. Mar. Biol. (in press)
Sebens, K.P., Witting, J. and Helmuth, B. 1996b. Effects of water flow and branch spacing on particle capture by the reef coral *Madracis mirabilis*. J. Exp. Mar. Biol. Ecol. (in press)
Sorokin, Y. I. 1974. Bacteria as a component of the coral reef community. Proc. 2nd Int. Coral Reef Symp. pp. 3–10.
Sorokin, Y. I. 1991. Biomass, metabolic rates and feeding of some common reef zoantharians and octocorals. Aust. J. Mar Freshwat. Res. 42:729–741.
Stafford-Smith, M.G. and Ormond, R.F.G. 1992. Sediment-rejection mechanisms of 42 species of Australian scleractinian corals. Aust. J. Mar. Freshwater Res. 43:683–705.
Wellington, G.M. 1982. An experimental analysis of the effects of light and zooplankton on coral zonation. Oecologia 52:311–320.

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## CURRENTS

### AGEING INFAUNA FROM HOST CORAL GROWTH BANDS

Coral growth has been relatively well studied, but what of coral infauna? Corals lay down annual bands which can be revealed by soft-X rays and fluorescent-microscopy, radio-isotopes or, more recently, laser techniques. Seasonal variations in growth rate form distinct alternating bands of high and low density skeletal deposition. A pair of bands represents one years growth. Tube worms settle on the coral and their mouths keep pace with the growing colony, so the number of growth bands from the settlement point to the surface represents the worm's age to the nearest half year (one light or dark band). Thus coral growth bands overlying polychaete calcareous tubes have been used to age *Spirobranchus* tube worms (Nishi and Nishihira 1996) and this method is probably applicable to many infauna. The method works well in massive corals and is also applicable to some plate or branching forms. However, this technique is restricted to non-boring infauna and also assumes that the tube or shell does not extend beyond the surface of the coral colony, that single individuals occupy each tube with no movement between holes and finally that the worm is still alive and the tube is not being maintained by another animal. *Spirobranchus* and vermetid tubes are sometimes maintained by crustaceans or small fishes after the worm dies. This of course would bias age estimation. Because of this, ageing fossil tubes is difficult, although it may be possible with careful examination of the tube. For example, *Spirobranchus* usually has an extended keel on the tube mouth during life, which is often absent from empty tubes.

We sectioned dried massive coral samples into 2 to 5mm thick slices (although it is also possible to obtain growth bands from slices 10mm or more thick) and took radiographs (fig. 1). Fig. 2 shows how the tube diameter changes over time. *Spirobranchus* grows at a rate of 0.2 to 1mm per year in diameter but *Hypsicomus* sp. (Sabellid polychaete) maintains a nearly constant tube diameter for more than 5 years. This means it must be boring into the coral skeleton to accommodate it's growth, so age estimation by counting coral bands is not appropriate.

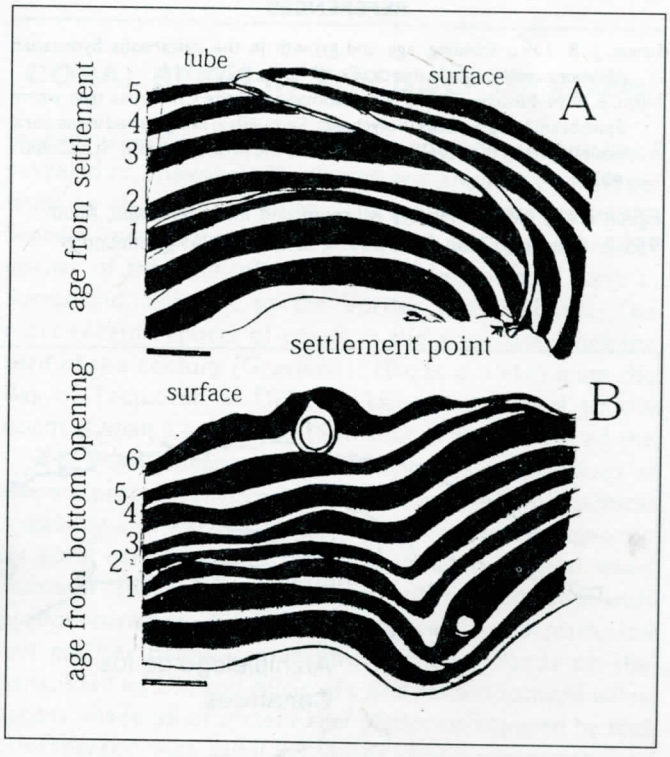


*Fig. 1. Generalized drawing from soft X-ray micrographs of coral skeletons and tubes of* Spirobranchus corniculatus *(Grube) a) age since settlement and b) two openings for the same tube formed several years apart. Scale bar is 1 cm.*

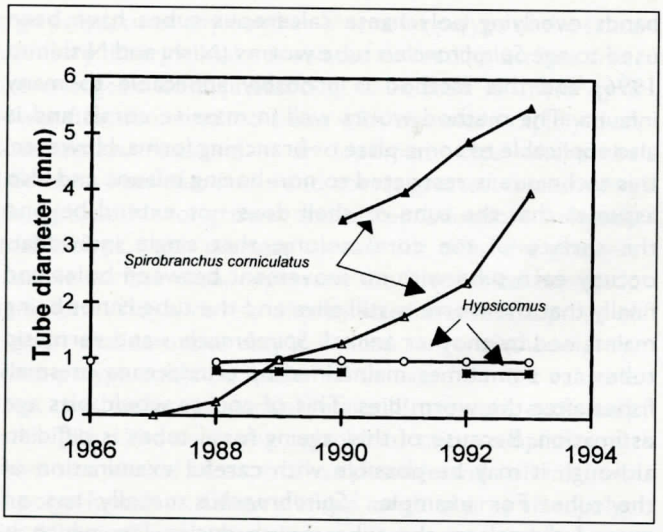


*Fig. 2. Tube diameter for two individuals of* Spirobranchus corniculatus *(Grube) and* Hypsycomus *sp. (sabellid polychaete) against time as estimated by reading coral annual growth bands.*

The method does work for *Spirobranchus corniculatus* (Grube) (Polychaeta, Serpulidae), *Idanthyrsus sp.* (Sabellariidae), *Pedum spondyloideum*, some coral associated barnacles and other epizoic bivalves including *Pedum spondyloideum*. Bands in some species of coral, such as *Millepora* can actually be counted in the field (Lewis 1991). Although the method described here needs laboratory facilities, similar field techniques for infauna may not be so far away.

**REFERENCES**

Lewis, J. B. 1991. Banding, age and growth in the calcareous hydrozoan *Millepora complanata* Lamarck. Coral Reefs, 9;209–214.

Nishi, E. & M. Nishihira. 1996. Age-estimation of the Christmas tree worm Spirobranchus giganteus (Polychaeta, Serpulidae) living buried in the coral skeleton from the coral growth band of the host coral. Fish. Sci.,62;400–403.

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# NEWS

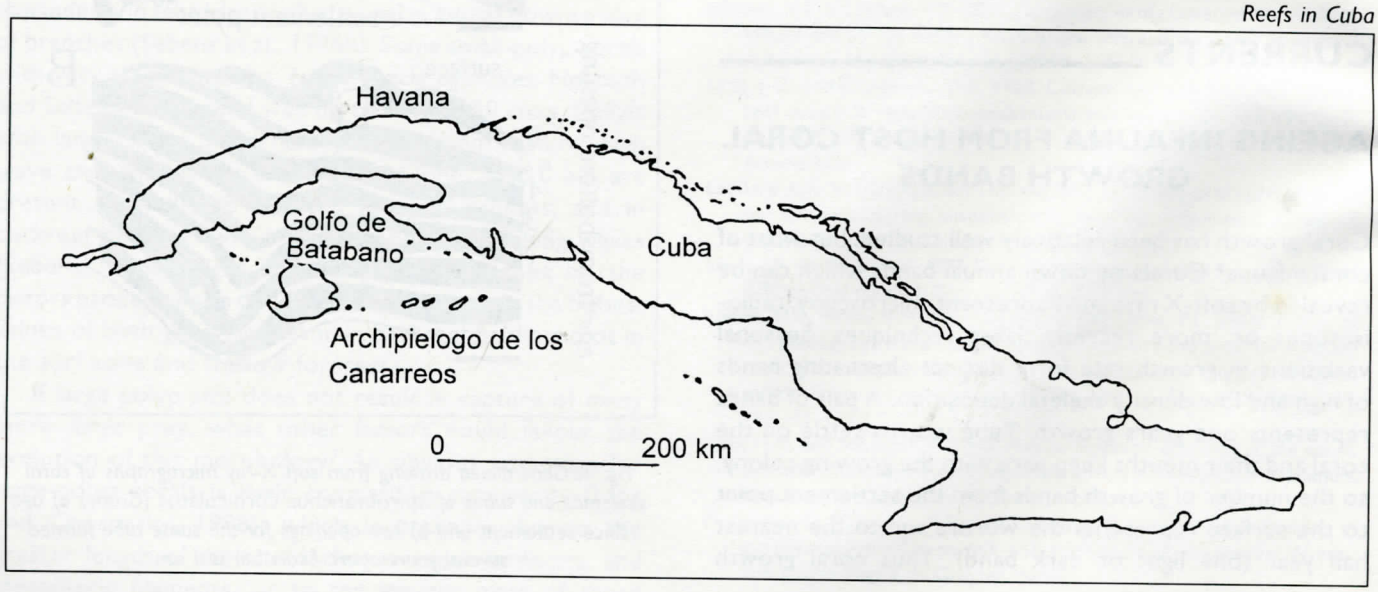
## CANADIAN SCIENTISTS TO STUDY LITTLE-KNOWN CUBAN REEFS

Four members of the Centre for Coastal Studies and Aquaculture of the University of New Brunswick in Saint John, Canada have been awarded a $1.1 million Canadian International Development Agency (CIDA) grant over five years to work on human resource development and coastal management in the Cuban marine sector. Although the goals of the CIDA project are mainly the education and training of Cuban students and scientists by the Canadian team, there are opportunities for research. Already small joint projects have been initiated on the reefs and associated environments in the Havana area. However, the main research thrust will come from other funding sources and will be focused on the chain of cays known as the Archipielogo de los Canarreos, which stretches for about 150 km along the southern edge of the shelf of the Golfo de Batabano.

The reefs in this area are in virtually pristine condition and it is particularly important to obtain baseline data now, before the advent of tourism, oil exploration and other anthropogenic influences in this area. The development, community structure and biodiversity of these reefs is believed to be similar to those of the nearby Cayman Islands, with an *Acropora-Millepora* fringing reef and rubble zone separating lagoonal sands and seagrasses from a coastal fringe of mangroves. The fringing reef is succeeded seawards by shallow and deep reefs at about 10 m and 20 m depth, respectively.

This project allows Canadian marine scientists to examine little-known Cuban reefs at first hand, an opportunity which has been denied U.S. reef workers since 1959. The Canadian and Cuban teams' combined expertise (drawn mainly from the University of New Brunswick, N.B. Canada, the Centre for Marine Research

*Reefs in Cuba*



of the University of Havana and the Institute of Oceanology in Havana) covers coral reef ecology, algae, seaweed and seagrasses, microbiology, fish reproduction and ecotoxicology.

*Further details from Alan Logan, University of New Brunswick, Saint John, N.B., Canada, Email* logan@unbsj.ca

## THE MARINE AQUARIUM FISH COUNCIL: A MARKET INCENTIVE FOR ECOLOGICALLY SUSTAINABLE AQUARIUM FISH COLLECTING

Display of reef organisms in public and private aquaria is one of the best means to enhance public awareness of reef biodiversity and the need to conserve reef ecosystems. However, some collection practices in the aquarium trade, such as the use of sodium cyanide and other harmful chemicals, cause destruction or irreversible damage to coral reefs, as has been well-documented in the Philippines and Indonesia. Numerous individuals and organizations familiar with the aquarium trade, including conservation organizations, government agencies, public aquaria, hobbyists, scientists, and the trade itself, have publicized the problems and have designed programs to address the issues in part (for example training fisherfolk to convert cyanide users to nets instead; improved animal husbandry). However, the problem has yet to be addressed comprehensively from reef to consumer, and there has been no market incentive to encourage proper collection. The central question that arises is: What can be done to create the necessary market incentive to encourage the utilization of best management practices for the harvest of fish and other marine organisms for the aquarium trade?

To address this question, a cross-section of interested organizations representing the private trade, conservation organizations, public aquaria, and scientists have been working together to establish a Marine Aquarium Fish Council (MAFC) that would act as an industry-independent governing council to establish standards, oversee environmental certification and promote conservation education. Actual certification would be undertaken by MAFC-accredited certification institutions that would apply the standards developed by MAFC. The goal of MAFC will be to ensure that collection, handling, and sale of marine products from coral reefs is ecologically sustainable, socially beneficial, and economically viable.

Establishing an effective environmental certification program will be difficult because all steps in the value chain must be addressed, from collection at remote coral reef areas through various stages of handling and transport until fish are sold in retail stores. The failure to date in management of the trade is that efforts have focused only on parts of the chain. The MAFC Working Group has developed preliminary Collection and Handling Principles, which are currently being field tested with the assistance of Scientific Certification Systems, an independent certification company, and Mr. John Tullock, the founder and President of the American Marine Life Dealers Association (AMDA). AMDA is a growing association of retailers and wholesalers who are committed to sourcing fish that would meet MAFC standards.

The MAFC will build on existing field programs that are underway in major source countries. For example, WWF-Indonesia and Kabang Kalikasan ng Pilipinas (KKP) are coordinating a cyanide-free campaign in Southeast Asia that is dealing with the aquarium trade and the live food fish trade, as well as working in various sites where collectors would be candidates for certification. The MAFC is also collaborating with the International Marine Life Alliance – Philippines (IMA), and The Nature Conservancy (TNC) which have relevant field programs, and with appropriate TRAFFIC offices. While preliminary advice suggests that MAFC would be established as a U.S. non-profit entity, it nonetheless would be structured to facilitate reciprocity and/or recognition of parallel certification efforts in other demand countries (for example, the United Kingdom, Japan) and build on source country certification and enforcement capabilities.

*Copies of the list of participating organizations, the draft collection and handling principles, and other information are available from Jamie Resor, WWF-US, 1250 24th St, N.W., Washington D.C. 20037-1175, USA. Fax: (1) 202-293-9211; Tel: (1) 202 778 9766; e-mail:* jamie.resor@wwfus.org.

## CORAL REEFS IN THE GULF OF ADEN

In February this year a brief expedition to Somaliland revealed an unexpectedly diverse and abundant coral reef fauna in the Gulf of Aden. The coral reefs are in the Saardin (or Saad ed Din) Islands in the western-most corner of the Gulf, off shore from the town of Zeila in Somaliland, adjacent to the border with Djibouti. The most recent reports of corals in the area date from the turn of the century (Gravier, 1910a, b, c, 1911) from the Bay of Tadjourah in Djibouti. Upwelling waters to the north (Oman ) and south (Somalia) of the mouth of the Gulf of Aden (Sheppard et al. 1992) led to expectations of a poor coral reef environment. This combined with political instability and war has resulted in the area being ignored by coral reef scientists. The area is a 10 nautical miles diameter shallow bank adjacent to the mainland with predominantly sandy bottoms, giving way to rock platforms and patches below 2 m depth. The two islands on the bank, Saad ed Din and Aibat, are one to two nautical miles across, made up of ancient reef platforms covered by and interspersed with sand and dunes. Their vegetation was sparse grasses and scrub, and a small mangrove area providing the northern-most record of the red mangrove, *Rhizophora mucronata*. Birds of prey, including ospreys, were seen nesting on the islands.

A total of 99 species of corals and 132 species of reef-associated fish were found in 4.5 and 3.5 hours of sampling respectively, in depths < 10 m. Common Indo-Pacific coral assemblages predominated (*Porites spp., Acropora spp.*, faviids), though characteristic Red Sea morphologies were seen (*Stylophora pistillata* and *Echinopora cf. fructiculosa*), along with two Red Sea species, *Merulina· scheeri* and *Porites nodifera*. (Sheppard and Sheppard 1991). Coral reef structure was well developed, with spur and groove formations at 3–8 m depth with vertical heights up to 3 m. Parts of the submerged windward reef flats (0.5–2 m depth, low tide) had the most highly developed *Acropora* communities we have seen in Eastern Africa, with over 100% cover and a high diversity of table, staghorn and bushy colonies. The diversity of fish was also comparable to undisturbed coral reefs of the Indian Ocean and Red Sea, though the species composition was unique, with a mix of species from the Indian Ocean, Red Sea and Arabian Sea. The number of planktivorous fish (*Chromis*, triggerfish and pelagics) on windward reefs was extremely impressive, suggesting high levels of water-column productivity from the nutrient rich waters upwelling at the mouth of the Gulf of Aden. In addition the size of the top predators and scavengers (Serranidae – groupers, and Lethrinidae – emperors) was exceptional, some reaching up to 1 m in length and probably close to or over 100 kg. in weight.

The trip was manned by the Coral Reef Conservation Project (Tim McClanahan and David Obura), and organized as part of a European Union effort to develop fisheries activity in the shattered economy of Somalia, with IUCN coordinating biodiversity conservation aspects. In agreement with the findings of a recent UNDP/GEF expedition to Socotra and Abd al Kuri, there are clearly unexpectedly rich and diverse coral reef environments along the coast of Somalia. These reefs have clearly benefited from minimal levels of exploitation due to instability in Somalia; the Zeila fishing community has had no boats for over 5 years! With stability and economic development, these reefs face a potential surge in exploitation levels, already evident in the shark fishing industry by non-Somalis. The proximity of Djibouti and export facilities could lead to devastation of this discreet and easily exploited location. Hopefully the Somali people, with assistance from projects such as the EU/IUCN initiative, will manage to avoid overexploiting their reefs before functioning management structures are in place to control exploitation and conserve these rich and scientifically valuable environments.

#### REFERENCES


Gravier, C. (1910) Sur les recifs coralliens de la Baie de Tadjourah et leurs Madreporaires: Gulf of Aden. C. r. hebd. Seanc. Acad. Sci. Paris 151: 650–652

Gravier, C. (1910) Sur quelques formes nouvelles de Madreporaires de la Baie de Tabdjourah: Gulf of Aden. Bull. Mus. natn. Hist. nat. Paris 16: 273–276

Gravier, C. (1910) Sur quelques particularites biologique des recifs madreporiques de la Baie de Tadjourah: Gulf of Adean. C.r. Ass. Avanc. Sci. 39: 167–169

Gravier, C. (1911) Les recifs de coraux et les madreporaires de la Baie de Tadjourah: Gulf of Aden. Ann. Inst. Oceanogr. Paris 2: 99

Sheppard, C., A. Price, and C. Roberts. (1992). Marine Ecology of the Arabian region: Patterns and processes in extreme tropical environments. Academic Press, London.

Sheppard, C. and Sheppard, A. (1991). Corals and Coral Communities of Arabia. Fauna of Saudi Arabia, 12. 170 pp.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# INTERNATIONAL INITIATIVES

## PROGRESS REPORT ON IYOR

IYOR activities are underway in over 40 countries, and possibly as many as 50 – the April update, which runs to 19 pages has been compiled largely through e-mail, and organisations that are not yet connected may therefore have been overlooked.

- The South Pacific is well represented as a result of a regional YOR initiative being developed by the South Pacific Regional Environment Programme (SPREP), which covers 17 countries.
- As might be expected, there are numerous initiatives in the USA and Europe (notably U.K., Germany and Switzerland).
- Australia has recently developed an active IYOR programme.
- There is some activity in countries in Central and South America, but the island nations of the Caribbean are poorly represented. This may change with the recent involvement of the UNEP Caribbean Environment Programme.
- Several countries in South-east Asia are involved, but others are noticeably absent (e.g. Thailand).
- The Middle East and entire Indian Ocean (including East Africa, the Western Indian Ocean islands, India and Sri Lanka) are least involved and represent major gaps.

IYOR Committees and/or co-ordinators have been appointed in several countries (e.g. Malaysia, UK, Guam, Germany). In others, a more ad hoc approach is being used. The IYOR leaflet has been translated into French and Spanish (by UNEP, Caribbean Regional Co-ordinating Unit), German (IYOR-Germany) and Japanese (WWF Japan) and several thousand have been distributed worldwide. Over 12 Web sites carry IYOR information, and IYOR has been promoted extensively through newsletters, magazines and other media outlets (unfortunately, we have not managed to obtain copies of all IYOR publicity material produced).

At least 115 organisations are taking part in IYOR activities, and there are probably many more. Most activities are directed towards public awareness and education, and by the end of 1997 we can expect an extensive body of coral reef education and awareness material to exist in

several languages. IYOR stamps are being issued in the Bahamas, Malaysia and Gibraltar. Several organisations are increasing their survey work (largely with volunteers and non-professionals) throughout IYOR, and Reef Check 97 (see last issue of Reef Encounter, and below) will be a major achievement in uniting divers and scientists in a global 'spot check' of reefs later this year.

We have recommended that the next phase of IYOR should:

- involve other countries and regions to give a truly global coverage
- translate the increasing awareness into on-the-ground improved reef management
- develop mechanisms, preferably through ICRI, to ensure that the work started in 1997 continues on a long-term basis.

IYOR still needs your help and participation! Please contact Paul Holthus (see below) if you would like a copy of the IYOR information pack or a recent IYOR update.

*For further information in general contact: Robert Ginsburg, University of Miami/RSMAS, 4600 Rickenbacker Cswy., Miami, FL 33149, USA. Fax 305-361-4094; Tel. 305-361-4875. Email: rginsburg@rsmas.miami.edu*

*Sue Wells, WWF-International, Ave du Mont Blanc, 1196 Gland, Switzerland. Fax: (41) 22-364-5829; Tel: (41) 22-364-9545; Email: swells@wwfnet.org*

*Paul Holthus, IUCN, rue de Mauverney, 1196 Gland, Switzerland. Tel: (41) 22-9990251; Fax (41) 22-999-0025; Email: pfh@hq.iucn.org*

*Stephen Colwell, Coral Reef Alliance (CORAL), 809 Delaware St, Berkeley, CA 94710, USA. Fax 510-528-9317; Tel: 510-528-2492; Email: IYOR1997@aol.com*

*IYOR World-Wide Web Home Page: http://www.coral.org/IYOR/*

## INTERNATIONAL CORAL REEF INITIATIVE (ICRI) NEWS

There have been a number of developments since the last report on ICRI in Reef Encounter. The most significant of these was the transfer of the responsibility for the ICRI Secretariat from the United States to Australia in mid 1996. The Secretariat functions are now being undertaken by the Great Barrier Reef Marine Park Authority with John Baldwin of the Authority's office in Townsville, Queensland as the responsible officer. John is happy to field ICRI enquiries and can be contacted by email at: j.baldwin@gbrmpa.gov.au

On 8 and 9 April, this year the ICRI Coordinating and Planning Committee (CPC) met in Canberra, Australia. Representatives from many countries and agencies involved in ICRI spent a productive two days examining progress on ICRI related activities and mapping out a strategy for ICRI over the next two years including a program of activities for the Secretariat. Major matters discussed included the completion of the regional structure of ICRI and the enhancement of the capacity of the regions to progress work on issues relating to coral reefs and associated environments on a local and regional scale. Also discussed was the possibility of establishing an ongoing forum for both reviewing ICRI actions and providing skills development and training through a quadrennial symposium on tropical marine environment management.

One of the conerstones of ICRI is communication, and accordingly it is appropriate that ICRI has established a presence on the Internet. There are several ICRI sites around but as an initial access point readers can try http://www.mbnet.mb.ca/vps/icri which provides useful information about ICRI and its activities. In the near future it is hoped that a more extensive and comprehensive Internet presence will further assist in spreading positive messages about coral reef conservation and management around the world.

*John Baldwin can be contacted at PO Box 1379, Townsville, Queensland 4810, AUSTRALIA. Tel. 61 77 500743 Fax: 61 77 242264 or 61 77 726093*

## IOC-UNEP-IUCN GLOBAL CORAL REEF MONITORING NETWORK: FIRST YEAR'S PROGRESS REPORT

The Global Coral Reef Monitoring Network (GCRMN), reported in Reef Encounter 20: 20–22 has grown considerably from its beginnings in the small office of Co-ordinator Clive Wilkinson. The GCRMN Pilot Monitoring Project, which aims to establish a cooperative network, help developing countries get started in reef monitoring and demonstrate that such networks can function, has started with approximately 50 institutes in all six coral reef regions participating. Status reviews for all regions were presented during a session on the Global Status of Coral Reefs at the 8th International Coral Reef Symposium, in Panama (June 1996). These are being edited to produce a 'baseline' summary report.

The GCRMN Strategic Plan will be widely distributed by the Intergovernmental Oceanographic Commission (IOC) and the Survey Manual for Tropical Marine Resources (2nd Edition), which will form the basis for monitoring, is currently being reprinted by the Australian Institute of Marine Science. A database (ARMDES) has been set up to collate data, and ICLARM's ReefBase will be the final repository. Reports and information material have been lodged on the Internet in the NOAA (USA) home page area.

Major support for the GCRMN has come from International Coral Reef Initiative (ICRI) partner countries

including organisations such as the USA State Department; the United Kingdom's ODA; Australia's AIMS and co-sponsors IOC, UNEP, IUCN and ICLARM with the Governments of Japan and Sweden and the World Bank also making contributions. Other countries have provided indirect support by funding ICRI Regional Workshops. International leaders such as the US President, Bill Clinton have urged improved coral reef monitoring and the GCRMN has even received press coverage in *Time*. This support must be used to catalyze coral reef management and conservation.

### Regional summary

After the ICRI meeting in Dumaguete, Philippines 1995, all six coral reef regions held (or will hold) ICRI Regional Workshops, endorsing the establishment of monitoring networks. These meetings allow countries to outline present capacity and highlight their monitoring needs. Participants usually stress the need to involve community groups, NGOs, schools and colleges, as well as the requirement for government monitoring programs, whilst the scientific community is asked to provide training in monitoring and database activities, assist with problem solving and data quality control.

### Middle East Region

A preliminary ICRI Technical Workshop was held in Aqaba, Jordan (15th 17th December 1996) with representatives from Egypt, Israel, and Jordan. A larger ICRI Regional Workshop for the Red Sea and Gulf of Aden is now scheduled for September, 1997.

### Western Indian Ocean – Eastern Africa Region

The ICRI Regional Workshop (Seychelles March 1996) was attended by eight Indian Ocean countries which decided on two GCRMN Nodes, one on Mauritius (hosted by the Indian Ocean Commission) for Western Indian Ocean island states, and one in Kenya (hosted by Kenya Marine Fisheries and Research Institute for Eastern Africa). A GCRMN temporary coordinator, funded by the European Union Regional Environmental Programme, trained about 20 people in the island states. GCRMN methodology and approaches were discussed at a coral reef workshop in Mombasa, Kenya (see page 21) and Eastern African countries nominated national nodes to coordinate monitoring and database activities. The IUCN Tanga Coastal Zone Management Project in Tanzania has developed social, cultural and economic parameters to assess community attitudes, and uses of coastal resources. These parameters are being tested in Mozambique before being used world wide.

### South Asia Region

A major funding boost for the GCRMN came from the UK's ODA which, in collaboration with IOC and IUCN, will support an interim coordinator to assist India, Maldives and Sri Lanka. Operational funds are available for initial training and monitoring over the next 18 months. SACEP (South Asia Cooperative Environment Programme) in Colombo will assist with coordination.

### East Asian Seas Region

There have been two ICRI regional Workshops in the region. The first in Bali, attended by 11 Asian countries and three observing nations in March 1996, outlined regional capacity and needs whilst the second in Okinawa (February 1997), resolved that most nations would become separate GCRMN nodes, maintaining their own databases. The UNEP East Asian Seas/Regional Coordination Unit in Bangkok was identified as most suitable coordinator and repository for regional summary data. Training is an urgent necessity for Burma/Myanmar, Cambodia and Vietnam. Other ASEAN partners have offered to coordinate programs to bring these countries up to a common standard. Training for North Asia will be coordinated through a new coral reef centre in Okinawa, Japan.

### Pacific Region

The ICRI Regional Workshop, Fiji (November 1995) was attended by 21 Pacific countries. SPREP in Apia, Western Samoa, was designated as the regional coordinator and is now overseeing many IYOR projects across the Pacific. These projects, which have involved many government leaders, will be excellent platforms for the GCRMN. The President of French Polynesia has offered to host a Polynesian node and similar nodes are being discussed for Fiji and Palau, based at the Palau Coral Reef Conservation and Research Center. A GCRMN meeting and workshop will be held during the Pacific Science Inter-Congress and IYOR meeting in Fiji (July–97), in conjunction with a Symposium on Coral Reefs.

### Tropical Americas – Caribbean Region

The ICRI Regional Meeting in Jamaica (July 1995) was attended by 32 countries. The UNEP Regional Coordinating Unit in Jamaica will oversee projects. CARICOMP already has a strong monitoring capacity. Some smaller states and islands, notably the British Virgin Islands, Turks and Caicos and Netherlands Antilles have shown strong interest in the Pilot Monitoring Project. Interest is also developing in Mexico and Cuba.

*Clive Wilkinson, Coordinator GCRMN*

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## REEF CHECK UPDATE

Reef Check 1997 is an exciting volunteer initiative to carry out the first global survey of coral reefs as part of the International Year of the Reef. Teams of recreational

divers are being trained by experienced reef scientists who will also lead the field work. The surveys will be carried out between 14 June 1997 (Oceans Day) and 31 August. Simple techniques have been selected to detect specific human impacts such as spearfishing, cyanide fishing, sea cucumber harvesting, anchor damage to corals etc. The twin Reef Check objectives are to obtain a global overview of human impacts on coral reefs and to focus the attention of the public, business and government leaders on the value and status of coral reefs and potential threats to their health. This publicity should help to generate more support for coral reef research and conservation.

As of 30 April, more than 100 teams from 35 countries have pledged to undertake Reef Check surveys. Many teams are planning to survey more than one site, therefore well over the initial goal of 100 reef sites will be surveyed as part of Reef Check 1997.

Since the initial announcement in Reef Encounter No. 20 p 22, Reef Check Headquarters has been formerly set up in the recently renamed Institute for Environment and Sustainable Development at Hong Kong University of Science and Technology (HKUST). The HKUST Research Centre has kindly provided funds to hire an Assistant Coordinator, Australian Ms. Suzie Geermans, as well as donating office space, clerical and computer support. In addition, there are now eleven National and Regional Coordinators located around the world to help organize team activities.

The Web site (http://www.ust.hk/~webrc/reef.html) has been up-dated, and new pages have been added to cover fund-raising, media interactions, data collection and analysis, as well as photographs of many of the common species to be recorded. Even hardened reef scientists will want to have a look at the holothurian photos prior to attempting underwater identifications!

Data will be collected throughout the summer. Press conferences will be held in each country on 10 September to announce the local, regional and national results, and an international press conference will be held in Hong Kong. Both CNN and BBC have expressed interest in covering these events.

In April, a California film production company, Thomas Horton Associates, experienced with producing Cousteau-type underwater documentaries agreed to produce a Reef Check video series to be shown on the Discovery Channel. This is a major selling point for potential resort and hotel sponsors. We will be selecting a number of sites to be featured in the documentary.

Also in April, the Reef Check methods underwent another round of field testing in Hong Kong thanks to the support of recreational volunteers from the South China Divers' Club and YMCA. Some minor fine tuning was suggested to smooth operations and these changes have been added to the web page instructions. A brief summary of regional contacts is given below:

**INDONESIA**: Gayatri Lilley of WWF
Email glilley@wwfnet.org or Fax: 62 21 739-5907
**KAUAI, USA**: Carl M. Stepath
Email sos@aloha.net Fax: 808 826-7770 Web page http://planet-hawaii.com/sos/
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# MEETING REPORTS

## CORAL REEF ECOLOGY AND CONSERVATION IN THE WESTERN INDIAN OCEAN: A WORKSHOP (February 25th to March 1st, 1997)

The Western Indian Ocean started its International Year of the Reef (IYOR) with a workshop held near the recently created Mombasa Marine National Park. Participants reviewed the regional status of coral reefs, compared rapid assessment survey methods, and reviewed the information and monitoring needs of the region. The regional reviews indicated coral reefs of the region are in need of better status assessments. Some regions are severely lacking in basic scientific description and only a few have the personnel to monitor both the environmental and human factors that influence reefs. Nearly all regions are lacking reliable funding. There are, however, some hopeful signs such as the increased level of trained personnel and the existence of a few monitoring or long-term scientific studies, particularly in Kenya, South Africa and Reunion.

A highlight of the workshop was the comparison of a number of simple and effective rapid assessment survey methods to measure the ecological health of coral reefs. Methods were demonstrated for fish, corals, sponges, epifuanal suspensivores, herbivory and carnivory. The densities of boring sponges and other epifauna on massive *Porites* heads were used as indicators of pollution. The

frequency of sea urchin and herbivorous fish bites on a common seagrass was also shown to be related to fishing intensity, with fish bites increasing and sea urchin bites decreasing in the new Marine Park. The loss rate of tethered sea urchins was well correlated with the number of fish and triggerfish observed and was also closely dependent on fishing pressure. Participants showed that rapid assessment is possible and may be preferable to more effort-consuming line transect studies that are troubled by limited site selection, high spatial variation, and several observer-bias problems.

Some case studies from the region are addressing processes of reef restoration. An experiment to restore the well-studied and polluted reefs of Reunion Island involved manually removing algae and found that the effects can persist for many years. A similar 'pest-reduction' experiment on Kenyan reefs found that after the removal of sea urchins, there was a significant recovery of many herbivorous and scavenging fishes. These initial experiments open the possibility for restoring reefs that are in decline throughout the region.

The workshop also included sessions on plans for the Global Coral Reef Monitoring Network (GCRMN) in the region, presented by representatives of the United Nations Environmental Program (UNEP) and the Intergovernmental Oceanographic Commission (UNESCO-IOC). The need for monitoring studies to assist local management, as well as to contribute to global-level adaptive management was emphasized. RECOSCIX, (a Western Indian Ocean regional library and database center) also presented plans for expansion, including regional taxonomic and personnel databases, a journal, improved communication, and linkages with the GCRMN.

Presentations and outcomes of the workshop will be collated in a book, 'Reefs of the Indian Ocean: Their Ecology and Conservation'. Sponsors of the meeting included The Pew Charitable Trust, The Wildlife Conservation Society, Kenya Wildlife Service Wetlands Program, and Blue Lagoon Water Sports.

*T.R. McClanahan, Coordinator for Coral Reef Programs, The Wildlife Conservation Society*

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## WORKSHOP ON CORAL REEFS OF BRAZIL: RESEARCH, INTEGRATED MANAGEMENT AND CONSERVATION

**9–15 March 1997, Tamarande, Brazil**

The marine science community of Brazil has decided that the 1997 International Year of the Reef (IYOR) is the time for coral reef research and management in the south Atlantic to come of age. Following on from their strong showing at the Panama symposium, people involved in the study and use of coral reef resources in this vast country met on the coast at Tamarande (100 km South of Recife) between 9 and 15 March for the "Workshop on Coral Reefs of Brazil: Research, Integrated management and Conservation". Virtually every national researcher currently working on Brazilian coral reef natural or social science, several managers of reef resources and government policy makers, plus a sprinkle of foreign scientists, managers and resource persons comprised the 100-strong group.

The goals of the gathering were to review the status of knowledge and resource use of Brazil's extensive reef ecosystems, to consider the relevance of research and management results from other nations, and to formulate a policy statement and list of specific recommendations for relevant agencies. All were achieved thanks to the efforts of the organizers and hosts (Dr. Mauro Maida, Dr. Beatrice Ferreira, the Federal University of Pernambuco, Dr. Clovis Castro, Dr. Debora Pires, the Federal University of Rio de Janeiro, the Northeastern Centre of Fisheries Research - Cepene, and the Brazilian Institute of the Environment - IBAMA), and the extraordinary commitment by the participants. Poster sessions and plenary addresses were separated from the deliberations of five working groups by a day of field trips to nearby reefs.

During the final two days considerable effort was made by all working groups to prioritize requirements for research and management. Measurement of resource use and its effects, ecosystem-based approaches to research for management, nomination of marine protected areas, and community-based approaches to management were consistently highlighted. The presence of senior government staff from both the granting and management agencies, as well as representatives from major international development and funding agencies added focus and realism to the "wish lists".

Typically, the meeting was numerically dominated by biologists, with a sprinkling of geologists and managers: many of them young university faculty and students. The high quality of the posters and presentations is to be expected from Brazil's well-established academia and the enthusiasm of the scientists. None-the-less their numbers are small relative to reef area and user population, and entire disciplines of direct relevance to reef science were missing from the meeting (and apparently from the reef research scene), notably physical oceanography, biogeochemistry, palaeoecology and population genetics. The social, managerial and political sciences were represented by only a few individuals, despite the fact that every working group identified the human aspects as the most urgent components of the problems of reef degradation and conservation. As is so often the case, natural scientists found themselves grappling with the problems others are better trained to deal with, but often don't.

Like the trade winds cooling the evenings at this time of year, the winds of change in Brazil were obvious throughout the meeting. The cohort of scientists at Tamandare already hold or will soon be assuming leadership roles in their various university faculties and government departments. Funding agencies are beginning to award on merit alone within disciplines, and coastal marine research

is slowly emerging from the large shadow of rain forest biodiversity. Senior government policy makers and management agencies are now willing to consider coral reefs explicitly as significant ecosystems worthy of directed research and management units and the meeting should make a major contribution to this end.

*Bruce G. Hatcher, CFRAMP Resource Assessment Unit.*

## BOOKSHELF

### SCIENCE, USE AND MANAGEMENT FOR THE GREAT BARRIER REEF; CONFERENCE PROCEEDINGS.

A report of proceedings from the recent Great Barrier Reef conference has been launched by the Cooperative Research Centre for Ecologically Sustainable Development of the Great Barrier Reef and Great Barrier Reef and Great Barrier Reef Marine Park Authority. the five day conference on Reef, held in November 1996 at James Cook University, Townsville, reviewed and reported in contemporary scientific research and future initiatives in a range of GBR human use, public policy and ecological issues.

CRC Reef Research Centre Director, Professor Chris Crossland said the proceedings will add a significant bank of knowledge for better science-based management and decision making.

"We looked at more than a decade of tropical marine research and brought together the present state of knowledge on how reef systems work in response to human influence and use." said Professor Crossland.

Conference themes outlined in volume one include pressures on reefs. islands and cays; changing world heritage area values; people and the reef; effects of mainland activities; oceanography and reed connectiveness. More than 40 leading Australian marine scientists addressed the conference as invited speakers and 50 participants submitted short poster papers for publication in volume two of the proceedings. Limited hard copies of both volumes are available from the CRC Reef Research Centre for $45.00 (plus $5.00 postage).

*Further information from: Don Alcock, Communication and Extension Manager, CRC Reef Research Centre, James Cook University, Townsville Australia. Tel: 077 81 5247 Fax: 077 81 4099, Email: don.alcock@jcu.edu.au. Web-page:http://www.gbrmpa.gov.au/~c?creef*

### STATUS OF CORAL REEFS IN THE PACIFIC

The Pacific Science Association's Scientific Committee on Coral Reefs has published a book on the "Status of Coral Reefs in the Pacific". The book contains chapters on the health and status of coral reefs in the Pacific in 1997, the International Year of the Reef. Chapters cover the Eastern Pacific, Hawaii, the Central Pacific, Guam and Northern Marianas, Okinawa, Taiwan, the Philippines, Indonesia, Thailand and French Polynesia. The book was produced with funding from the International Coral Reef Initiative awarded to the PSA via the International Year of the Reef and Robert Ginsburg. Richard W. Grigg and Chuck Birkeland are the editors of the book. The book can be ordered from the University of Hawaii Sea Grant Program, for $20 which includes handling and postage. Phone: (808) 956-7401; for more information see http://www.soest.hawaii.edu/seagrant.

### DARWIN ON CD-ROM: THE STRUCTURE AND DISTRIBUTION OF CORAL REEFS

ISBN: 1-889175-01-3. Lightbinders Inc., 2325 Third Street, suite 324, San Francisco, 94107

Darwin's book, the Structure and Distribution of Coral Reefs (first edition, 1842) is now available on one CD Rom, along with The Origin of Species, The Descent of Man, The Voyage of the Beagle, The Expression of the Emotions in Man and Animals, On the Various Contrivances by which British and Foreign Orchids are Fertilised by Insects, The Zoology of the Voyage of the Beagle and a number of Darwin's diverse and seldom published short papers.

Michael Ghiselin introduces the work by discussing how Darwin formulated the theory of barrier reef and atoll formation whilst studying South American shorelines long before he first experienced coral reefs in Tahiti. Ghiselin sets the book in the context of Darwin's interactions with fellow scientists and the importance of his discovery decades before the theory was incorporated in to the general understanding of plate tectonics. Besides the full text, you will find reproductions of the original woodcuts, diagrams and maps alongside links to Darwin's other works, biographical information and suggestions for further reading. The 'scholarly journal Coral Reefs' even gets a mention!

### THE NATURAL HISTORY BOOK SERVICE MARINE BIOLOGY AND RESOURCES CATALOGUE

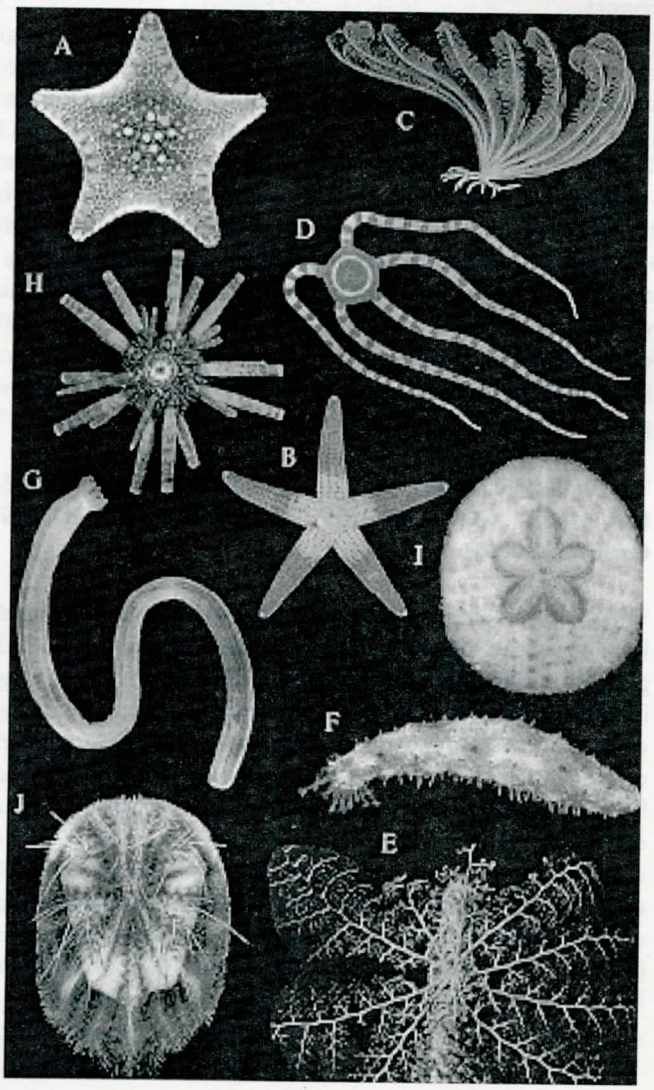
The Natural History Book Service Marine Biology and Resources catalogue carries a good selection of books and grey literature on corals and coral reefs, including identification guides that range from the simple to the esoteric, the latest literature, and best selling titles. Their catalogues are free and can be obtained from 2-3 Wills Road, Totnes, Devon, TQ9 5XN, United Kingdom. You can also search their online catalogue at http://www.nhbs.co.uk or request a monthly email bulletin covering your particular discipline. NHBS pride themselves on efficient mailorder service and they can be contacted by Fax : + 44 1803 865913, Tel. + 44 1803 865280 or Email nhbs@nhbs.co.uk.

# BOOK REVIEWS

## SEA STARS, SEA URCHINS, AND ALLIES: ECHINODERMS OF FLORIDA AND THE CARIBBEAN

*G. Hendler, J.E. Miller, D.L. Pawson and P.M. Kier*
391 pp. ISBN 1-56098-450-3. 1995. Smithsonian Institution Press, Washington, DC. Price US$39.95.

Hubert Lyman Clark's (1933) handbook of Puerto Rican echinoderms was the first, and long the standard, guide to echinoderms of the West Indian region. Now, after 62 years, appears the second. Information on echinoderms of the tropical Western Atlantic is available from other sources, but they are too technical (e.g., Miller & Pawson, 1984, Hourglass holothurians), rare (e.g., Kier & Grant, 1965, echinoids of Key Largo), expensive (e.g., Clark & Downey, 1992, seastars of the Atlantic), or incomplete and inaccurate (as for all general field guides to marine life for the area). This guide is suitable for the educated layperson and the specialist; it is reasonably priced but richly illustrated. The authors are specialists in four of the five echinoderm classes, and their collective knowledge of crinoids is reflected in the adequate treatment of them.




This is a complete guide to the shallow-water echinoderms of Florida and the Bahamas and should be useful throughout the tropical and subtropical Caribbean Sea, Gulf of Mexico, and Bermuda. It includes brief descriptions of habitats and of the phylum; practical chapters on collection, preservation, and photography; sections on morphology, systematics, and ecology of each class; and a helpful glossary, bibliography, and systematic index. Most species are illustrated by superb color photographs (some taken in the field); black-and-white photos or line drawings are provided for all but four remaining species. Supplementary black-and-white plates are given for many brittlestars, sea urchins, and sea cucumbers. Taxonomic keys are used sparingly and judiciously.

Errors are hard to find, a testament to the usual neurotic attention to detail given by these four authors. One unfortunate blunder is the inclusion of a photograph (figure 123) of *Encope michelini* that is mislabelled *Encope aberrans*; the reader should refer to figure 136c for a correct specimen. Also, Hendler's inclusion of three new brittlestars here and in another 1995 publication might stir disputes over taxonomic authority. The authors' choice of chemical terminology for 2-phenoxyethanol (ethylene glycol monophenyl ether) might trouble those wanting to purchase "propylene phenoxytol (PPO)" from suppliers.

The most striking feature of the book is its color photography of individual specimens; whether posed in the laboratory or poised in nature, the richness of color, sharpness, and composition are almost incredible. The owner of this book will be torn between taking it into the field for technical use and leaving it at the bedside for nighttime perusal. One surely will not want to use the metric scale on p. 391 to measure a soggy sea cucumber.

Richard L. Turner

## LIFE AND DEATH OF CORAL REEFS

*Charles Birkeland* (ed)
536pp. ISBN 0-412-03541-3. 1997. Chapman & Hall, New York. Price: US $79.95, UK £59.00. Order online from http://www.thomson.com

One thing in life that can be relied upon is the ability of science publishers to create awful covers from excellent pictures. Judging by its cover this one should be called the 'Death and Decay of Coral Reefs'. Living and dead reefs merge indistinguishably in a mess of blue and grey that appears to have been the product of an art editor's hangover. Never judge a book by its cover though – this one is excellent inside!

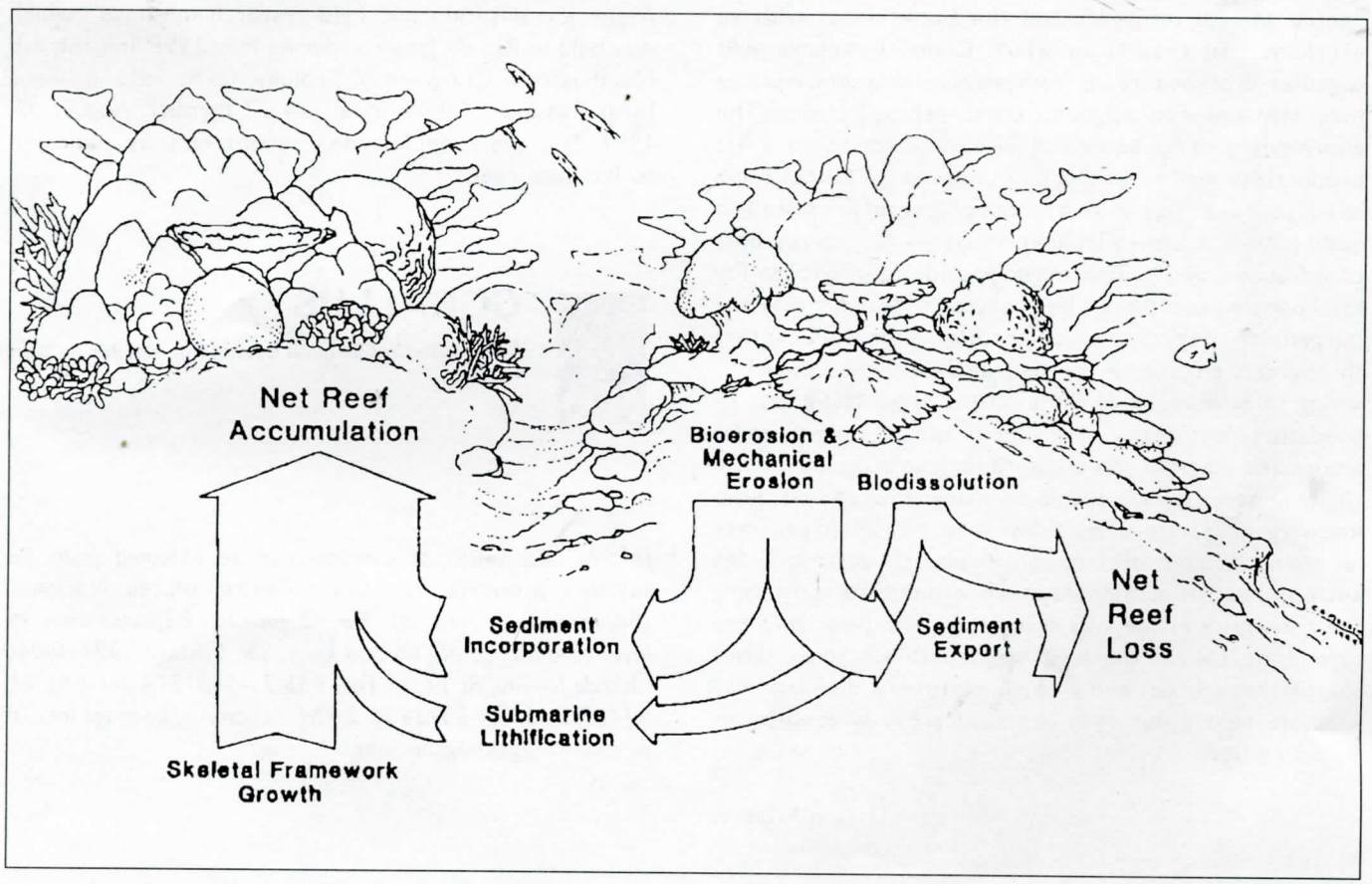
Why write another book about coral reefs? Several other perfectly decent books have been published in recent years so it might seem that there is much redundancy, especially since this shares some authors in common with previous books. What sets it apart is that the editor, Chuck Birkeland, has charged his distinguished group of seventeen contributors with examining the ebb and flow of life on reefs, and how this can be affected by

people. Why exactly is it that a geologically highly robust system, for what else could you call the ecosystem that has given birth to thousands of atolls and islands, can be compromised by people in a matter of decades? What are the triggers that can be pulled to shoot a reef in the head and those who use it in the foot?

Answers to these questions build gradually as the reader works their way through the history and biology of reefs toward chapters on human use and management. Chuck Birkeland opens the book with an introduction studded with quotable information that will no doubt get recycled as efficiently as nutrients on reefs. Did you know, for example, that one sixth of the world's coastlines are fringed by coral reefs, or that 75–80% of the world's sediment run-off is from land in the tropical western Pacific? Pamela Hallock takes over with a fast and fascinating journey through the history of reef forming creatures, showing how they have shaped marine habitats and left their geological imprint on the planet. Dennis Hubbard continues in a geological vein, describing some of the proximate and historic factors controlling reef growth. Funnily enough, it appears that reef edifices are far from the rock ramparts they seem, but instead consist principally of sediment – sand castles in the sea. The latter is a theme picked up by Peter Glynn in the next chapter as he sketches a 'bioeroders gallery' of those who bear the heaviest responsibility for converting corals into dust.

Sediment is a recurring theme. Who would have imagined twenty years ago the multitude of ways in which a bucket of mud could wreak havoc with a coral reef? The complexity of reefs and our inability to alter things in isolation is eloquently testified to by the effects of sediment. It is an interaction strewn with feedback effects and unexpected indirect influences. Hubbard's chapter and that of Giselle Muller-Parker and Chris D'Elia emphasise the critical role of light intensity in reef calcification and growth. The first evil of sediment is to reduce light intensity. Muller-Parker and D'Elia go on to suggest that the "probable greatest effect of sediment on coral relates to the accumulation of particles on coral surfaces and interference with feeding". Reading through the remainder of the book suggests not. Once sediment settles and is shed by corals (reducing growth and reproductive output in the process – Richmond) it slops around on the bottom scouring delicate tissues and opening up corals to attack by bioeroders (Glynn). More bioeroders means less reef growth and weakened skeletons which collapse more readily come the next cyclone.

Esther Peters extends this catalogue of disaster by showing how sediment-stressed corals eventually run out of energy to produce mucus leaving them open to infection by pathogens. Increasing frequency of disease outbreaks suggests that reefs are becoming widely stressed. Of course, sediment isn't just sand but always brings with it raised nutrient levels and synergisms abound. Increased nutrients cause greater algal growth which reduces light reaching corals...and so we return to all of the problems that causes. Algae trap sediments and can lead to more coral mortality. Of course nutrients are bad because coral reefs are always nutrient poor, or are they? Bruce Hatcher



delves into the complexities of reef energy and nutrient budgets, a subject which can initially seem as tortuous and dark as the inside of a parrotfish gut. After reading his chapter I think I saw the light at the end of the tunnel(!).

In Bob Richmond's chapter the hooded menace of sediment strikes again. Sediment reduces survival of newly settled corals by smothering and scour, but did you know that it can also prevent coral larvae from detecting chemical cues necessary for settlement? While adult corals may be able to hang in there under a rain of mud, their offspring don't even get the chance to set up shop. Hodgson provides a nice summary of his study of the impact of sediment released by logging onto Philippine reefs. His remains one of the few studies of sediment effects which has been conducted at an ecosystem scale and one of the very few where scientists have got out of the water and looked at what is going on upstream in the watersheds. Before sediment gets all the blame, Barbara Brown points out in a chapter on disturbances how difficult it can be to separate its effects from those of the nutrients or toxins carried with it. Of course sediment in the right place can be a very good thing and John Ogden revisits nursery and feeding roles of those great sedimentary habitats, seagrass beds and mangroves, showing their positive feedbacks with coral reefs.

Not all of the book is sediment laden. There are stimulating chapters on invertebrates (10s to 100s of thousands per square metre!) by Bob Carpenter, fishes by Mark Hixon, indirect interactions by Steven Pennings, differences in reef processes among oceans by Chuck Birkeland and the origins of reef diversity by Gustav Paulay. Bob Johannes, again convincingly champions local people as reef managers and the book closes with an excellent final chapter in which Chuck Birkeland pulls together all of the threads from previous chapters, weaving them into a new paradigm for coral reef exploitation. The enormous gross productivity of coral reefs belies a net productivity that is but 2–3% of this. Yet we cannot hope to harvest even this much as most of it wouldn't taste too good (unless you are a blenny). What we can tap amounts to a fraction of 1%. This might provide food enough for local people but it cannot be expected to feed for ever the burgeoning populations of tropical shores. Chapters throughout emphasise the difficulties we get into when trying to take more of the available production: loss of predators, outbreaks of problem species, phase shifts from coral to algae and so on. Birkeland's arguments are richly illustrated with examples, many trawled from little known grey literature. He shows that reefs could generate far more income for tropical peoples through activities such as tourism and aquaculture without compromising their integrity in the way that fishing and poor land use now does. Unless we wake up to this fact soon, those magnificent edifices and all their enormous diversity may crumble before our eyes like sandcastles washed by an incoming tide.

Callum Roberts

# WHO'S WHO?

## CORALLUS – THE BRAZILIAN SOCIETY FOR REEF STUDIES

Corallus, the Brazilian Society for Reef Studies, was founded in July 1994, during a Congress on Zoology. The founding ethos was to enhance the exchange of ideas and information among groups working in different areas of Brazil. Although the society originated at a Zoology meeting, topics such as botany, ecology, geology, geomorphology, and oceanography have always been amongst member's specialities. Most of the Society's 90 or so members have a scientific/technical background. Members come from all over Brazil and the primary role of the Society has been to enhance information exchange.

Recently the society initiated a "Workshop on Brazilian Reefs: Research, Integrated Management and Conservation", held in Tamandaré (Northeast Brazil, near Recife) in March 1997 (see meeting report page 22). Over one hundred people attended, including almost all reef research leaders in Brazil, personnel from all Brazilian conservation units that include reef areas, scientific and environmental policy makers (Federal and State levels), as well as some foreign researchers and environmentalists. The goals of this meeting were to review what is known of Brazilian reefs, indicate gaps in the knowledge, and to formulate a policy statement and list of recommendations for relevant agencies.

The Society supports members in ventures such as the "Workshop on the Ecology and Taxonomy of Coralline Algae: identification and field research methods" which was held in Rio de Janeiro during May 1997 and the 7th Northeastern Congress of Ecology, to be held in Ilheus (near Salvador, Bahia), from July 27 through August 02, 1997. This event will include a session entirely dedicated to Brazilian reefs.

**CORALLUS**

**Sociedade Brasileira de Estudos de Recifes de Coral**

*Further information or contacts can be obtained from the society's president, Dr. Clovis Castro, Museu Nacional/ Universidade Federal do Rio de Janeiro, Departamento de Invertebrados, Quinta da Boa Vista, São Cristóvão 20940-040 - Rio de Janeiro, RJ, Brazil. Fax. +55-21-5681314 Tel. +55-21-974091 3+55-21-5373964 Email:* cbcmnrj@omega.lncc.br *or* cbcmnrj@omega.lncc.br.

## DIARY

13–16 July 1998, Southampton, England
INTERNATIONAL SYMPOSIUM ON TROPICAL FISH BIOLOGY 1998

The symposium will consider all aspects of tropical fish biology, conservation and exploitation, with the aim of drawing upon the strengths of different disciplines to tackle common questions. Suggested topics include Fishes and Ecosystems; Population and Conservation Genetics; Evolution and Speciation; Conservation and Resource Management; and Behaviour, though any papers on the general theme will be considered by the Organising Committee. Keynote speakers confirmed so far are Prof. John Beddington (MRAG, London), Prof. Axel Meyer (SUNY, New York), Prof Daniel Pauly (UBC, Vancouver), Prof. Robert Vrijenhoek (Rutgers, New Brunswick), Dr. V.Christensen (ICLARM, Denmark), Prof. R.R.Warner (Santa Barbara, USA).

Every effort will be made to keep the costs to a minimum. Financial assistance will be available for some students and delegates from developing countries. Inquiries, stating circumstances, should be addressed to the committee.

Abstracts should be submitted no later than Friday 14 November 1997. The refereed proceedings will be published as a supplement to the Journal of Fish Biology within six months of the Symposium.

To receive further details of the Symposium, registration forms and guidelines for the preparation of abstracts, or for any other inquiries regarding the symposium contact: Dr. George F.Turner (FSBI Symposium Organiser) Biodiversity and Ecology Division, School of Biological Sciences, University of Southampton, Bassett Crescent East, Southampton England, SO16 7PX Tel: + 44 1703 594394 Fax: + 44 1703 594269/594793 E-mail: gft@soton.ac.uk

16–18 December 1997, Asia-Pacific Economic Cooperation, Hong Kong
WORKSHOP ON THE IMPACTS OF DESTRUCTIVE FISHING PRACTICES ON THE MARINE ENVIRONMENT

Themes of the Workshop:
1) Impacts of Destructive Fishing Practices
2) Protection of the Coral Reef Environment
3) Promotion of Environmentally Friendly Fishing Practices
4) Legislation, Enforcement and Management Strategy

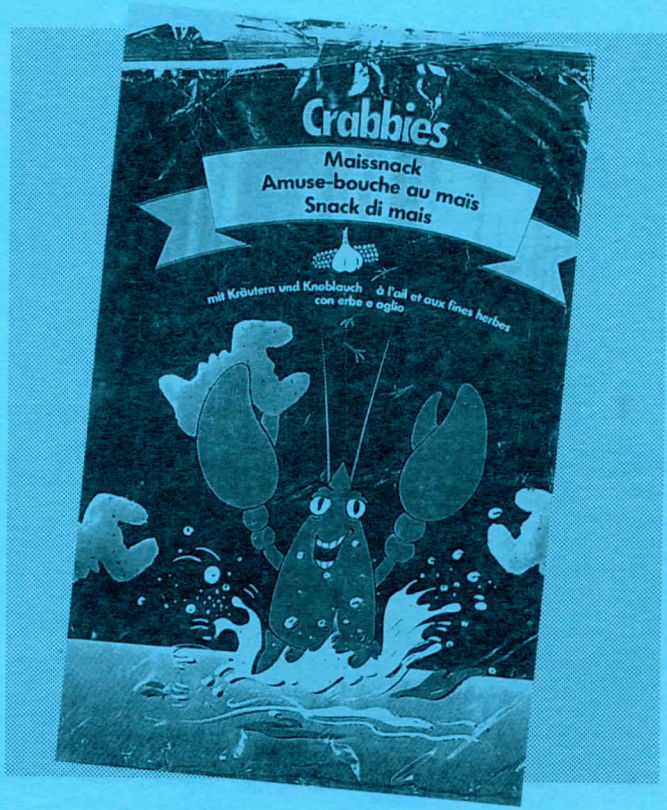
For further information, contact the Workshop Secretariat, Workshop on the Impacts of Destructive Fishing Practices on the Marine Environment, c/o Aberdeen Fisheries Office, Agriculture and Fisheries Department, 100A Shek Pai Wan Road, Aberdeen, Hong Kong. Tel: (852) 2843 8331 Fax: (852) 2814 0018

## ANNOUNCEMENTS

### POSTDOCTORAL ASSOCIATE – BENTHIC ECOLOGY

The Cooperative Institute for Marine and Atmospheric Studies, a joint activity of the University of Miami's Rosenstiel School of marine and Atmospheric Science (RSMAS) and the National Oceanic and Atmospheric Administrations's Southeast Fisheries Science Center (SEFSC), invites applications for a postdoctoral position for research on a wide-range of problems involving hard-bottom benthic ecology, coral reefs, habitat restoration, and the Florida Keys National Marine Sanctuary. The appointee will be responsible for scientific investigations dealing with life history, ecology, and population dynamics of attached organisms on coral reefs, live bottom, and other hard bottom habitats in the Atlantic and Gulf of Mexico. A significant portion of time will be directed towards restoration and surveys of coral reef communities. This position will allow substantial interaction among scientists at both NOAA and RSMAS. The initial term of the appointment is one year beginning in 1997. With a satisfactory review of performance, it is renewable for a second and third year. Screening of applications will begin June 1, 1997 and will continue until the position is filled.

Written applications (electronic applications cannot be accepted) consisting of a curriculum vitae, a statement of research interests, and the names, addresses, and telephone number of three referees should be sent to: Dr. Joseph M. Prospero, Cooperative Institute for Marine and Atmospheric Studies, 4600 Rickenbacker Causeway, Miami, FL 33149



## 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*.

A new category – Sustaining Member – has been added 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$30 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 ISRS should be addressed to: *International Society for Reef Studies, PO 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 papers, 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, newpaper 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 than 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. 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 system, but contributors will receive a free copy of the relevant issue.

**DEADLINE FOR COPY FOR REEF ENCOUNTER 22**
**(Due out Dec1997) IS OCTOBER 1st 1997;**
**please send to one of these addresses:**

**Sue Wells, WWF-International, Ave du Mont Blanc, 1196 Gland, Switzerland.**
**Fax: (41) 22-364-5829; Tel: (41) 22-364-9545;**
**e-mail: swells@wwfnet.org**

**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: (1-809) 484 2670 Phone: (1-809) 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: crcp@users.africaonline.co.ke**

## APPLICATION FORM FOR MEMBERSHIP

Name: .....

Address: .....

.....

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Title: .....

Fields of interest: .....

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.....

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. ..... Expiry 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.*