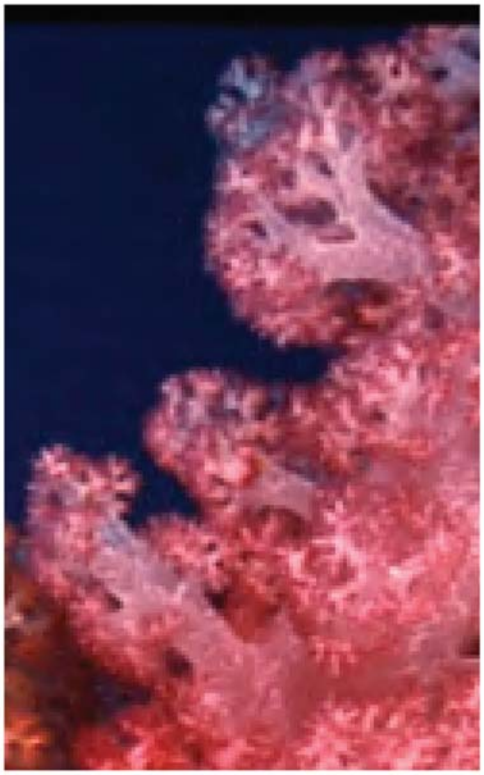
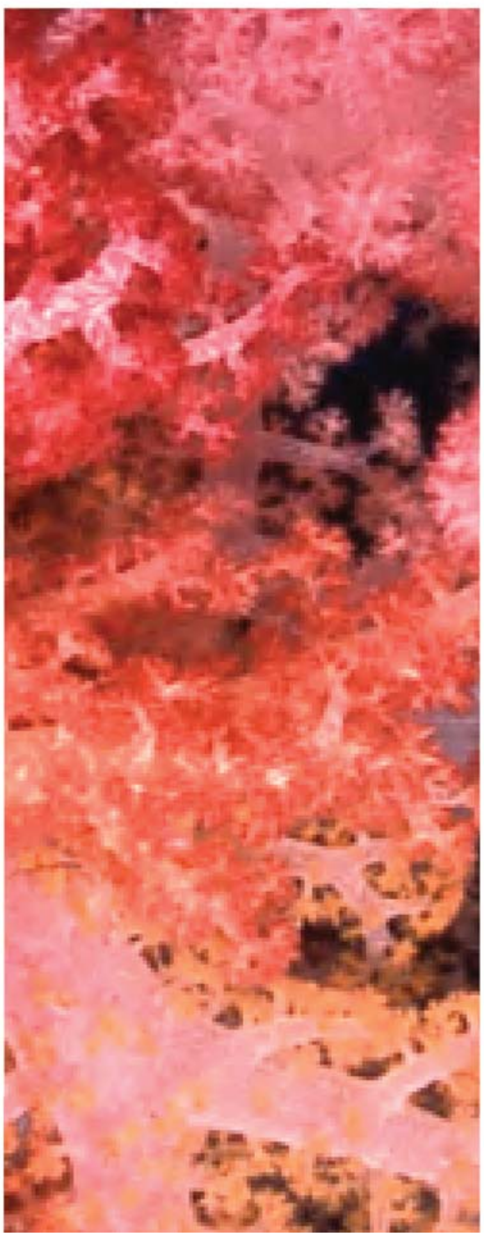
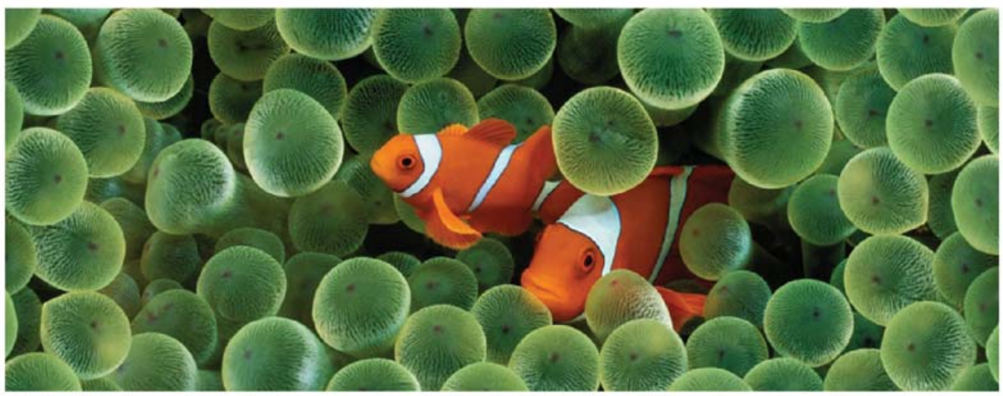


The Coral Reef Alliance

Coral Reefs & Sustainable Marine Recreation

Protect Your Business By Protecting Your Reefs





sustainability

The Coral Reef Alliance

Coral Reefs
and
Sustainable Marine Recreation
Protect Your Business By Protecting Your Reefs

A Resource Guide for Marine Tourism Professionals
Developed by

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Contents

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Welcome

This Resource Guide is essentially a tool box. It's intended to support a professional development workshop–*Coral Reefs and Sustainable Marine Recreation: Protect Your Business By Protecting Your Reefs*–created by the Coral Reef Alliance (CORAL), and it has several uses. First, the Guide is an invaluable participant's tool, as it contains annotated print-outs of all of the workshop PowerPoint® presentations, and other materials used in the interactive exercises. But the usefulness of the Guide isn't limited to the workshop.

How To Use This Guide

Given the limited time of the program, it's impossible to cover all of the subjects in great depth. So, the Guide becomes a very useful post-workshop learning tool. It contains more detailed information on coral reefs and sustainable tourism issues than is possible to discuss during the workshop sessions. In addition, the Guide contains a very comprehensive resource list of books, articles, technical reports, videos, CDs and web sites on coral reef science and management. This resource list also provides the full citation of any source quoted during the workshop.

Lastly, while it's certainly important for you to learn about the challenges facing coral reefs, it's even more vital that you spread the conservation message to others. For this, the Guide is an indispensable reference tool. Workshop attendees are encouraged to communicate what they learn to others, either by informal discussions or by formal presentations. Armed with the accompanying PowerPoint presentations (contained on the CD you'll receive during the workshop), the Guide gives you all the background and directions necessary to effectively present the workshop–or portions of the workshop–to others. This key resource can be used for a wide variety of audiences including diving classes, school or civic groups, and presentations to other tourism or resource management professionals.

We welcome your feedback...

This resource guide will continue to be a work in progress as we incorporate your ideas for improvement. Let us know what you think at info@coral.org.

Acknowledgments

The Coral Reef Alliance would like to thank all of our partners in coral reef destinations around the world who have provided comments, suggestions, ideas, and constructive criticism that aided in the development of this resource guide.

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About This Resource Guide

Coral Reefs and Sustainable Marine Recreation: Protect Your Business By Protecting Your Reefs is a professional development workshop designed to give marine tourism professionals, and organizations who work with the tourism sector, insight into coral reef-based tourism, and the potential role that tourism can play as a conservation tool. The workshop also explores how to incorporate into your business or organization the many lessons learned by the tourism and conservation communities.

Anyone working in the tourism industry knows that both travel and travelers have changed. Many of today's holiday-seekers want a different kind of leisure experience than in the past. Studies, as well as practical experience, have shown that they want to bring home more than a sun tan and some souvenirs. A growing number are interested in learning about the environment they visit. This requires that tour operators be able to provide more than a boat ride to the reef or a hotel room. It also means that operators need staff who can do more for their clients than keep them safe and entertained.

It's also no secret that without a healthy environment, there would be no marine tourism. Yet, the very resources that marine tourism depends upon are in serious trouble. And if something isn't done to turn the tide soon, we could lose the very reason many tourists come to coral reef destinations. To what degree tourism is responsible for this decline is debatable; but however slight, all agree that tourism is one factor.

The need to respond to these and related issues is what is changing the face of the modern travel industry, and has given rise to what's been termed "sustainable tourism." But is "sustainable tourism" really anything more than a buzz word or marketing ploy? If so, what does this really mean to your business or organization? And more importantly, exactly how can you take advantage of emerging trends? Answering these questions is what this workshop is all about.

Target Audience

This guide was written to appeal to a broad cross-section of users but was specifically tailored for use by marine tourism professionals. CORAL has found that marine recreation providers are ready stakeholders in reef conservation, in large part because their livelihoods depend on the health of local reefs. Recreation providers see first-hand the reef changes that result from the increased popularity of a particular site, and since reef damage can translate into financial losses, members of this stakeholder group are often eager to get involved in conservation.

Because they are on the water regularly, recreation providers are also capable of playing an active role in reef monitoring, maintaining mooring buoys, patrolling, and collecting user fees. For all these reasons, we intentionally seek the involvement of marine recreation providers in local stakeholder trainings and projects, along with members of non-governmental organizations (NGOs), residents, and protected area managers. In addition to being natural allies in reef conservation, recreation providers are an important group to engage because, as businesspeople, they carry a great deal of clout in their communities; policy makers care about a healthy economy and listen keenly to a community's business interests. In this way, both enlightened self-interest and tourism dollars are harnessed to support coral reef conservation.

Some of the many groups that will benefit from this resource guide include:

<u>Commercial sector</u>:

- Dive charter boat operators
- Dive retailers
- Dive instructors
- Recreational divers
- Boat rental operators
- Fishing charter operators
- Marina operators

- Nature/Ecotour operators
- Kayak rental and tour operators
- Hoteliers
- Tourism Bureaus
- Chambers of commerce

Non-commercial sector:

- Non-formal/environmental educators
- Environmental organizations
- Fishing clubs
- Diver clubs
- Government officials
- Environmental regulators/policy-makers
- Post secondary educators in tourism and marine studies
- Upper division/graduate students in marine affairs/policy
- Recreational divers or general public with keen interest in the environment

Benefits of Attending the Workshop

The most important thing that you'll get out of this workshop is the ability to better serve your clients. A concern often voiced by many resource managers and those in the tourism industry is the need to improve the environmental awareness of recreationalists—fishers, divers, snorkelers, and boaters—who visit coral reefs. In fact, several studies examining the tourism-related damage to coral reefs have concluded that improved education is the key element in turning tourists from being part of the problem into part of the solution. The job of fostering the necessary awareness and improved behavior among tourists, of course, falls to the tourism professionals who service them. But to do this, these professionals themselves need specialized knowledge and accurate information about the issues at hand. More importantly, they must be able to translate this knowledge into practices which promote more “environmentally-friendly” tourism. Specifically, what you'll take away from the program is as follows:

- ✓ Learn how your business or organization's environmental commitment can translate into improved customer satisfaction and increased profitability.
- ✓ Learn specific techniques to help make your customers more environmentally aware and responsible.
- ✓ Learn how to make your business practices more “eco-sensitive” while improving your bottom line.
- ✓ Learn how to interpret a coral reef in ways your customers will understand and enjoy.
- ✓ Learn what problems coral reefs are facing, and what local actions individuals and organizations can take to stem the tide of destruction.
- ✓ Learn what’s going on in your local region to protect reefs, how this may impact your business, and how you can get involved.
- ✓ Learn ways to instill a responsible environmental ethic into your customers.

How the Workshop Works

This workshop was designed to be conducted over two days and take approximately 3 - 3.5 hours of presentation per day. Alternatively, it can be delivered in a single day consisting of morning and afternoon instruction. The workshop is designed to be presented by a single facilitator. Typically, planning takes about five hours, not including the time it takes to prepare materials.

We recommend 12 - 40 participants for our workshops. Having fewer than 12 does not allow for the lively group discussions that is such an important component of the workshop. Having more than 40 makes whole group discussions unwieldy and can necessitate an additional facilitator. The workshop is structured in such a way that content deliver is balanced with interactive learning activities (see Figure 1). CORAL's philosophy in informal education is based upon what graduate schools of education have demonstrated to be effective strategies for informal learning. Far from lecture-based teaching, CORAL workshops are highly interactive professional development opportunities based on the most up-to-date scientific and educational research.

Figure 1: Sustainable Marine Recreation Workshop Segments

FORMAT	SEGMENT
Interactive	Introduction
Content Delivery	Understanding Coral Reefs: Ecology and Economy
Interactive	Brainstorming session on local issues
Content Delivery	Coral Grief: The Problems
Content/Interactive	Guest speaker on local issues
Interactive	Threat Ranking Exercise I (group break-out)
Content Delivery	Coral Relief: The Solutions
Interactive	Threat Ranking Exercise II (group break-out)
Content Delivery	Marketing Conservation: Merging Business and the Environment
Interactive	Marketing Conservation Exercise (group break-out)
Content Delivery	Promoting Sustainable Attitudes & Practices
Interactive	Sustainable Practices Exercise (group break-out)
Interactive	Closing Comments, Administer Evaluations, Distribution of Certificates

Workshop at a Glance
2–Day Model

Workshop Time: 2 days;
Approximately 3.5 hours/day
Facilitators Needed: 1
Participants Accommodated: 40

Planning and Preparation
5 hours + materials prep

Day 1: Presenting the Workshop Part 1

Introducing the Workshop
Facilitator sets the context for the workshop — 15 minutes
Overview of workshop, goals, and ground rules

Identifying Prior Knowledge and Participant Goals
What do participants know and want to know about coral? — 15 minutes

Understanding Coral Reefs
Ecology and Economy of Coral Reefs — 45 minutes
Addition/Modification of "know" and "want to know" charts

Local Threats Brainstorm
Small group discussion of local reef threats — 15 minutes

Break – 10 minutes

Guest Speaker on Local Issues — 20 minutes

Presenting the Workshop Part 2

Coral Grief
Global and Local Threats to Coral — 30 minutes

Threat Ranking Exercise — 45 minutes
Small group ranking activity to identify top perceived local threats

Summary of Day 1 and Overview of Day 2
15 minutes

Workshop at a Glance
2–Day Model

Workshop Time: 2 days;
Approximately 3.5 hours/day
Facilitators Needed: 1
Participants Accommodated: 40

Day 2: Presenting the Workshop Part 3

Recap From Previous Day
Facilitator sets the context for the workshop — 15 minutes
Review of top ranked local threats

Small Group Solutions Activity
Local solutions that can address local threats — 45 minutes

Coral Relief
Local and global solutions to coral threats — 30 minutes

Break – 10 minutes

Guest Speaker on Local Issues — 20 minutes

Presenting the Workshop Part 4

Marketing Sustainability
Merging business and the environment — 20 minutes

Creative Marketing Activity — 30 minutes
Small group exercise in developing/sharing novel environmental marketing

Promoting Sustainable Attitudes and Practices
Practical tools for sustainable marine recreation — 30 minutes

Concluding the Workshop
Facilitator summarizes the main ideas and key concepts — 10 minutes

How to Use the Presentation Sections

The Powerpoint-delivered content sections of the workshop have been provided in this guide as individual pages with accompanying notes. Each page has a small image of the Powerpoint slide to make it easier to follow along with the presentation (if you so choose). The notes summarize key concepts that the facilitator will touch upon during the presentation.

Notes below each image are structured in the following manner:

- *What's The Issue?* *This is the key concept. The "take home" message.*
- *Need To Know* *Critical points in understanding the key concept.*
- *Nice To Know* *Additional information that deepens understanding*

We have attempted to provide a balance of key concepts and notes without getting too bogged-down in details. The handbooks on coral ecology and sustainable tourism are included as additional resources to more fully explain topics encountered in the presentations or to supplement your understanding of topics you find particularly interesting. This resource guide includes the master library for each topic. We encourage you to customize your presentation by deleting slides to fit your audience needs and time constraints.

Interactive Teaching Strategies

CORAL facilitators regularly use a number of generic activity "structures" which are described in a separate section of the resource guide. These activity structures are referenced and utilized throughout the workshop and are designed to help participants to share their related prior knowledge of a topic, or to distill and summarize what they may have learned from a presentation or activity. These generic structures emphasize short, whole group, small group, or paired discussions. While we make recommendations of appropriate structures to use, they can certainly be mixed, substituted, or modified depending on the audience.

Working In Linguistically Diverse Settings

CORAL encourages all participants to interact and discuss in their primary language. Our workshops have been presented to diverse audiences either through facilitated or simultaneous translation. This resource guide, however, is especially designed to be used with no modifications in linguistically diverse settings with large numbers of English language learners. The activities and presentations were created with high-quality content and language development in mind. They meet the criteria established by linguists and language acquisition experts for Specially Designed Academic Instruction in English (SDAIE).

SDAIE refers to instruction in content areas designed to be delivered in English to participants whose native language is not English but who have reached intermediate or advanced proficiency in English. These participants will find the CORAL workshops comprehensible and challenging at or above their linguistic proficiency.

Essential Planning Steps

Coral Reefs and Sustainable Marine Recreation: *Protect Your Business by protecting Your Reefs* workshop requires planning and preparation. It's important that you go over the following steps to arrive at an understanding of workshop goals and how much time you'll need to accomplish all the necessary planning and preparation. There's a lot to do, including reading through this entire guide, preparing to lead discussions, trying the workshop yourself, arranging for an appropriate space, and collecting materials needed. You'll also want to set aside time after the workshop to evaluate what went well and what could be improved in subsequent workshops.

Before the Workshop

1. Review this guide all the way through. It is essential for you to review this guide before you do any of the planning steps that follow. You may want to flag sections that don't make sense to you, coming back to them as the goals of the workshop become clearer.

2. Prepare materials. Gather and prepare all materials for participants (see materials section). Materials are all common and easily available. Duplicate and prepare all handouts, charts, and Powerpoint slides. To make it easy to set up on the day of the workshop, organize the handouts and charts according to when and where they'll be used.

3. Attend this workshop as a learner. Nothing beats first-hand experience. CORAL presents these workshops as part of our conservation objectives in every destination we work. Contact CORAL at info@coral.org to find out where the nearest workshops to you are being offered.

4. Review the workshop as facilitator(s). If you are the only facilitator, you will be responsible for all aspects of the workshop. If you are co-facilitating the workshop, you might want to assign primary and secondary responsibility for different sections. For example, one of you might introduce the workshop and lead a discussion while the other distributes handouts and keeps time.

5. Practice presenting the presentations. We provide notes for each slide, but they are not meant to be a script. Get comfortable presenting the sections in your own words.

6. Be prepared to set the context. Setting the context for the workshop is crucial. In setting the context, be prepared to explain why you chose to present the workshop. How does it fit with other trainings or professional development experiences the participants have had? How is it related to tourism industry goals or standards? What do you want participants to get from the experience?

7. Plan time carefully. This workshop has a very full agenda. Create a detailed internal schedule for yourself to refer to during the workshop. Note the beginning and ending times for each step. Be sure to include times for breaks. Prepare a simplified version of the schedule for participants, which you can post at the beginning of the workshop. A sample schedule is located in the handouts and charts section. Remember that times given for this workshop are approximate. Initially, you may find that you need more time than is suggested. Build this extra time into your schedule.

On the Day of the Workshop

1. Prepare the room. Set out the necessary materials, set-up and test all electronic materials (computer, projector, etc.). Put the charts and handouts near where you will be using them. If the room does not have a writing board or flip chart stand, tape sheets of flip chart on the walls to use as writing surfaces.

2. Watch your schedule. Refer to the internal schedule you created to keep things on track.

After the Workshop

You and your co-facilitator should take time to reflect on your experiences and address issues of logistics, communication, outcomes,and expectations. The Facilitation Review, included in the handouts section, will allow you to assess the results of your work and identify successes and challenges that can help guide subsequent workshops.

Facilitation Hints for Small-Group Discussions

Listen for Interesting Conversations

Circulate among groups, assist any that need help, and listen for interesting discussions or disagreements that you can refer to during the whole group discussions. You may want to make notes as you move around the room.

Keep Discussions Going

Groups sometimes finish their conversations very early. They may say that they agreed on everything. To get their conversations restarted, you may ask:

Was there anything you initially disagreed about? If so how did you come to agreement?

Asking about actions participants took helps move their thinking out of the abstract and also encourages them to examine the reasoning behind their choices.

Uncover Reasons for Opinions

If groups are stuck in disagreement, encourage each group member to articulate the thinking underlying his or her opinion.

Defer Giving Immediate Answers

Sometimes groups will ask you for immediate answers to questions that they are capable of answering from collective prior knowledge or discussions. Remind them that you want them to clarify and examine the ideas they bring to the discussion from their previous experiences. Giving them a quick answer would short-circuit that process. Ask them to note their differences of opinion and ideas so they can bring them to the whole group discussions.

Facilitation Hints for Large-Group Discussions

Be Prepared

It is essential that the facilitator have a firm grasp of the topics so that he or she can help deal with any confusion that arises.

Paraphrase Questions or Answers by Participants

When questions or answers are given, paraphrase the response so everyone in the room can follow the discussion more clearly.

Defer Giving Immediate Answers

Just as in small-group discussions, sometimes large groups will ask you for immediate answers to questions that they are capable of answering from collective prior knowledge or discussions. Use questioning strategies to turn questions asked back on the group. Add questions that are unresolved to a chart labeled "Things We Want to Know" and refer back to this list towards end of workshop to see if questions have been answered.

More About The Coral Reef Alliance

Founded in 1994, The Coral Reef Alliance began its mission to keep coral reefs alive by focusing on three fundamental catalysts for change: marine protected areas (MPAs), marine tourism, and local communities. First, MPAs have proven to be the most effective way to conserve coral reefs. Better protected against external threats, MPAs such as the Rock Islands Southern Lagoon in the Republic of Palau, Micronesia, enjoy increased coral cover, higher species diversity and size, and improved resilience against bleaching. Secondly, the dive and snorkel community, who are already deeply connected to the resource, are a relatively untapped reserve of financial and volunteer support for reef conservation. Finally, coral reef communities often know the best way to protect their own coral reefs and even the best conservation efforts cannot succeed without local support. These are the cornerstones of our programs – raising awareness of issues threatening coral reefs and the benefits of MPAs and mobilizing local communities and the marine recreation sector in conservation partnership for coral reefs.

While MPAs are a proven keystone component to successful coral reef conservation plans, paradoxically most MPAs are inadequately funded or lack basic capacity for monitoring and enforcement. If well-managed, enforced, and supported by the local and business communities, marine parks protect reefs from anthropogenic stresses. Studies show that even adjacent areas benefit from increased vitality in protected areas. However, of the approximately 700 recognized marine protected areas, only a third have any active management in place and a mere handful have all the necessary pieces to be effective.

CORAL programs offer a response to the lack of resources and support available to marine parks to effectively conserve coral reefs. Answering the need for a practical and effective model, in which unprecedented collaborations between conservation authorities and the marine tourism industry result in sustainable coral reef tourism and improved MPA management, CORAL created the Coral Reef Sustainable Destination

(CRSD) Marine Recreation Model (see Figure 2). CRSD identifies the current conservation capacity of community partners in coral reef destinations, and incorporates key indicators for assessing improvements in conservation management. In short, CRSD measurably reduces damage to coral reefs by encouraging a paradigm shift towards sustainable behavior from marine recreation providers and their clients.

Our early success in implementing this model in a variety of locations is extremely promising. In pilot sites throughout the Pacific, we have gathered marine park managers, dive operators, and community leaders in structured and interactive forums to provide them with management training, seed grants, and technical assistance. Some of the forms this has taken have been trainings to establish mooring systems that prevent anchor damage, implementation of user fees to increase park revenues, or developing public awareness activities such as grade school snorkeling programs.

CORAL also raises awareness of reef issues and engages people in conservation activities through Dive In To Earth Day. Last year, CORAL fostered 367 Dive In events worldwide, mobilizing more than 74,000 people in underwater cleanups, mooring installations, and environmental fairs. Finally, CORAL has built conservation partnerships with tourism businesses, wholesalers, and purchasers to increase environmentally sound marine recreation practices and decrease direct tourism impacts on the reef.

CORAL has a robust track record in the delivery of reef conservation. Some of our successes include:

- Serving as a founding member of the International Coral Reef Action Network to implement a global strategy in support of marine protected area conservation

- Providing over US $650,000 microgrant awards to coral parks and local organizations, including: mangrove restoration in Indonesia; patrol boat engines for St. Eustatius Marine Park; the establishment of the Kadavu Ecology and Marine Resource Center in Fiji; helping establish the Silhouette

Marine National Park in the Seychelles; and providing post-tsunami relief to the Andaman and Nicobar Islands by purchasing a reef survey vessel

- Since 2002, over 850 marine recreation providers from Fiji, Bali, Palau, Indonesia, San Andres, Bonaire, Mexico, Belize and Honduras have been trained in coral reef ecology and sustainable business practices.

- Creating Dive In To Earth Day to increase ocean awareness in Earth Day celebrations and generate support of MPAs. Since 2000, 271,450 Dive In participants have participated in activities supporting 95 coral reef protected areas.

- Installing mooring systems in Indonesia, Bonaire, Honduras, Fiji, and Hawaii as support and assistance for MPA effectiveness.

Coral Reef Sustainable Destination (CRSD) Model

Building Local Conservation Capacity

	Continuum of Increasing Capacity Level 1	Level 2	Level 3	Level 4	Level 5
Sustainable Business Practice	Tourism businesses provide basic awareness to clients	Tourism businesses trained	50% adoption	80% adoption	Full participation and self regulation
Conservation Alliances	Initial contacts and interest cultivated	Community buy-in, collaborative projects	Collaborative projects initiated	Collaboration increased 50%	Collaboration sustained 5 years
Sustainable Financing	Financial needs assessed, funding sources defined	Stakeholder process initiated	Adoption of new finance system	Additional funding sources defined and adopted	Diversified funding in place, sustained 5 years
Threat Reduction	Threats ranked and defined	Threat reduction plan endorsed	Projects implemented	Monitor and evaluate projects	Reassess, redefine if necessary
Effective Management	Management needs and assessment surveys	Stakeholder process, draft management plan	Management plan adopted	Monitor, evaluate, and implement management tools	Management plan updated, revised
Benefit Sharing	Awareness building	Tourism sector hiring locals	Alternative livelihood training	Micro-enterprises initiated, support by tourism sector	Tangible benefits realized for community

Figure 1. Modified CRSD Matrix

Workshop Registration
Coral Reef Alliance (CORAL)

Name	Profession	Business	Contact (Phone/Email)

Workshop Registration
Coral Reef Alliance (CORAL)

Name	Profession	Business	Contact (Phone/Email)

Meeting Ground Rules

- Allow everyone to participate.
- Any question or comment is a good question or comment
- Show respect for others. Be courteous, and listen to what others are saying.
- Those who did not participate in earlier meetings please listen and catch up with what was done before. You will get an opportunity to be heard and contribute.
- Those who have been involved in earlier meetings help newcomers to understand what is going on.
- Explain your comments but also try and keep your comments to the point (we have limited time and we want to hear from everyone!)
- Feel free to speak in whatever language you feel most comfortable.

Remember: 1=least severity, 5=most severity

- AREA – the portion of coral reef that the threat will affect. Will it affect the entire reef or just a small part?

- INTENSITY – the impact or severity of destruction caused by the threat. Within the area, will the threat completely destroy the coral reef or will it cause minor changes?

- URGENCY – the immediacy of the threat. Is it a current threat? Or will it occur 25 years from now?

Threats Worksheet

Location:	Today's date:
Completed by:	

Rank on a scale of 1 to 5 (1 = least severity, 5 = most severity)

	THREATS	Area	Intensity	Urgency	Total
A					
B					
C					
D					
E					
	TOTAL				

Location: Maui	Today's date: Aug.25
Completed by: John, Paul, George and Ringo	

1 = least severity; 5 = most severity

	THREATS	Area	Intensity	Urgency	Total
A	Blast fishing	2	5	5	12
B	Mining	3	4	4	11
C	Mangrove Deforestation	4	3	2	9
D	Ghost Nets	1	1	3	5
E	Global Warming	5	2	1	8
TOTAL		15	15	15	

ADD TOTAL

Coral Reefs and Sustainable Marine Recreation Workshop
Participant Evaluation

(Please answer the questions below, and check the box ☐ as appropriate)

Your name & business (optional): ______________________________

1. What is your profession (tour guide, dive operation manager, scientist, etc.)?

____

If you work in ocean recreation and tourism, please answer **# 2** and **#3**
If you are involved with marine parks, government, or non-governmental organizations, please go to **# 4**

2. Do you give pre-dive/pre-activity briefs to your customers emphasizing environmental best practices?

☐ Yes ☐ No

If yes, how often (check below)?

☐ Rarely (few times a year) ☐ Sometimes (once or twice a month) ☐ Often (weekly) ☐ Always (every day)

If no, why not? ______________________________

3. Has this workshop motivated you to use tools such as CORAL's *Guide to Good Practice* (pictured)?

☐ Yes ☐ No

If yes, how often (check below)?

☐ Rarely (few times a year) ☐ Sometimes (once or twice a month) ☐ Often (weekly) ☐ Always (every day)

If no, why not? ______________________________

4 Has this workshop illustrated new ways for your business/organization to work with other businesses, marine parks, marine protected areas, and non-governmental organizations, eg. Hawaii Wildlife Fund?

☐ Yes ☐ No

If yes, how? If no, why not?

In this next section, please **circle the number** that indicates your responses based on what you believe, ***not*** what you think the answer ***should*** be.

	Strongly Disagree	Disagree	Agree	Strongly Agree
1. Before these workshops, I felt confident in my understanding of coral reef ecology…	1	2	3	4
2. I have a greater understanding of coral reef ecology following these workshops…	1	2	3	4

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Coral Reefs and Sustainable Marine Recreation Workshop
Participant Evaluation

	Strongly Disagree	Disagree	Agree	Strongly Agree
5. These workshops addressed issues important to the local community…	1	2	3	4
	What issues are important to you (most important to least)? 1) 2) 3)			
6. I enjoyed these workshops…	1	2	3	4
7. I can increase my business by using and marketing sustainable approaches…	1	2	3	4
	What approaches might you use?			
8. I found the *Threat Ranking* activity helpful…	1	2	3	4
	What was helpful or not helpful?			
9. I found the *Solutions* activity helpful…	1	2	3	4
	What was helpful or not helpful?			
9. The content/length of the presentations was appropriate for the audience …	1	2	3	4
10. I would recommend these workshops to others…	1	2	3	4
11. These workshops have motivated me to reevaluate my business practice or behavior…	1	2	3	4
12. These workshops were beneficial to me…	1	2	3	4
	Describe:			

Please feel free to provide any other comments:

Thank you! Your opinion is important to us.

SUSTAINABLE PRACTICES SCORE CARD

How Environmentally Conscious is Your Dive Operation?

Directions: Place a check in the box if the practice is part of your normal operating procedures. Add the total number of “checks” for your score.

General Environmental Considerations:

- ❏ Does your company always respect the underwater environment and strongly encourage your clients to do the same?
- ❏ Is your company aware of and adhere to local environmental laws, including special rules in protected areas?
- ❏ Do you suggest refresher courses for clients when appropriate?
- ❏ Does your operation design tours to help clients appreciate and understand the ecosystems you visit?
- ❏ Does your company make sure your staff understands the ecology of the areas you visit so they can teach clients to minimize their affect on dive sites?
- ❏ Does your company support local marine conservation efforts?
- ❏ Is your company certified by any independent organization that assesses how environmentally friendly your operation is run?

Before divers ever enter the water:

- ❏ Do you consider the experience of your clients and take them to the dive sites which they are best suited to handle?
- ❏ Do your divemasters separate experienced and in experience clients into different groups?
- ❏ Does your company provide your clients with educational materials to help them learned about and respect underwater environments?
- ❏ Do your divemasters conduct pre-dive checks to insure that diving equipment is secure and harm the environment?
- ❏ Do your divemasters check to see if all divers are weighted correctly, and make any adjustments away from coral areas?
- ❏ Do your divemasters give clients a pre-dive briefing on of low impact diving and stress the importance of underwater conservation?

(over)

Dive site management

- ❑ Does your company install or use permanent mooring buoys where needed?
- ❑ Does your operation help maintain mooring buoys at sites you use?
- ❑ If you must anchor, does your crew avoid anchoring in sensitive areas?
- ❑ Once anchored, does the divemaster confirm that the anchor is in a suitable place and properly secured?
- ❑ Does your company rotate dive sites to avoid overuse?
- ❑ Do you limit groups size to make sure the divemaster can monitor the behavior of all clients?
- ❑ Does your company make efforts to monitor wildlife and coral cover so you are aware of any degradation?
- ❑ Do you alert local authorities to any environmental damage or disturbance you observe at a dive site?
- ❑ Does your company take measures to prevent the introduction of garbage, pollution or other solid waste into the marine environment?

TOTAL: ________ out of 22

SCORE: (total number of checks)

22 – 100%	11 - 50%
21 - 96%	10 - 46%
20 - 91%	9 - 41%
19 - 87%	8 - 37%
18 - 82%	7 - 32%
17 - 78%	6 - 28%
16 - 73%	5 - 23%
15 - 69%	4 - 19%
14 - 64%	3 - 14%
13 - 60%	2 - 10%
12 - 55%	1 - 5%

Criteria based on the *Green Guide to Scuba Diving: Best Practice Environmental Management for Scuba Diving Tours.* Cooperative Research Center for Sustainable Tourism, Griffith University, Brisbane, Australia.

The Coral Reef Alliance
Speaker Guidelines and Expectations

Thank you for agreeing to participate as a guest speaker at CORAL's workshop. We greatly value and appreciate the expertise and local perspective you will be providing. To assist you in preparing your presentation, we are providing these guidelines that have proven very helpful to previous speakers. If we can provide further explanation, please do not hesitate contacting us with questions at sflumerfelt@coral.org or (415) 834-0900 x 306. Our thanks again, and we look forward to your contribution to the workshop!

Time

Our very full schedule requires that total guest presentation time is no longer than 30 minutes–this includes up to 20 minutes for the presentation and 10 minutes for questions and discussion. It is very important that guest presentations adhere to this time constraint as the entire workshop hinges on efficient time management. CORAL values the opportunity you provide for answering questions or allowing interactive discussion at the end of your presentation. As a friendly reminder, CORAL staff will signal (discreetly) when you have 5 minutes remaining. We thank you for recognizing and honoring our time constraints.

To PowerPoint or Not to PowerPoint…

If you have a standard PowerPoint presentation for your topic, by all means use that. If you are creating a presentation from scratch, we hope the following information proves useful. Almost without exception, PowerPoint presentations have become the standard presentation tool. But like any tool, overuse can dull its effectiveness. You are welcome to use PowerPoint slides to help you in your presentation. CORAL depends on the visual impact of PowerPoint to convey some of our message, but new research into how people learn best demonstrates PowerPoint's limitations. How much text on a slide is too much? When is it better to say it or show it? These are questions we consider in preparing CORAL presentations, and we hope they might be helpful to you as well. A few further points we consider:

• Text-heavy slides. We have found that slides comprised of 8 or more lines of text can distract the audience from your message. In preparing, think how you want the slides to enhance your presentation rather than duplicate what you say or distract from your narrative.

• Timing. Time your presentation. It should not exceed 20 minutes.

• Graphs, tables, or figures. If your slide incorporates data in such formats, ensure it is large enough for audience to interpret. Help audience interpret graphs for best impact.

• Technical jargon. If a slide includes a technical term, please define it on the slide or verbally for the audience.

• Images/Pictures. A picture can indeed be worth a thousand words. The use of images on slides isn't just esthetically pleasing, it sometimes explains far better than text.

• Hardware. CORAL will provide a laptop and digital projector to run your PowerPoint slides. Our experience has shown that we unfortunately cannot rely on using other laptops to drive presentations. Please bring your presentation on a disc or memory stick (see info below for arrival time) or e-mail your presentation to us before we arrive so we can ensure it functions accurately.

Flip Chart/White Board

Each of our workshop venues are unique and may not have whiteboards for writing. CORAL will provide a flip chart and markers should you need them for your presentation, but please specify your needs ahead of time.

Arrival Time

We ask that you arrive approximately 30 minutes prior to the workshop start time. This allows us adequate time to test presentations with our laptop and finalize any last minute changes to the agenda.

Handouts

We encourage the use of handouts or further readings for participants. Please prepare for 30 attendees. Handouts will be distributed after the presentation or included in the participant information packet.

Questioning Strategy

To ensure that all participants can benefit from questions that are asked, please repeat or paraphrase the question. If a question is asked during your presentation, try turning the question back on the group to see if an answer exists in the collective knowledge of the audience. This not only engages the participants, but also honors prior knowledge and recognizes the skills and experiences of the learners.

Interactivity

Don't feel you need to wait until the questions or discussion time to engage the audience. CORAL workshops use interactive strategies throughout to draw the participants into the learning and discussion. For example, querying the audience about their experiences on the reef or what they might provide as local perspectives on your topic will allow them to feel that their field experience is valued. If you would like other ideas for engaging the audience, please do not hesitate contacting us. We are happy to share our strategies.

Facilitation Review

<u>Overview</u>
It's a good idea to set aside some time after the workshop to get together with your co-facilitator and reflect on what worked and what didn't work. You can think and talk about your own facilitation and the workshop design, and consider what adjustments you can make for subsequent workshops.

You'll also want to consider how the group's understanding of coral reefs and sustainable marine recreation developed during the workshop, and where you would like this group to go next in exploring conservation awareness.

<u>4 Steps • Time as needed</u>
1. Acknowledge what you did well, and reflect on goals. Start by taking a few minutes to talk about what went well during the workshop. Share any insights you gained about good facilitation strategies. Identify some things you did that helped groups get over difficult spots. Also, ask yourselves what you might do differently next time to improve the workshop.

2. Go through the workshop from beginning to end. Discuss not only how you facilitated different parts of the workshop, but also what participants did, and what they learned in each part of the workshop:

• Were all participants fully engaged in all parts of the workshop? Were there some sections that seemed particularly difficult or confusing? What could you do to encourage more active participation?

• Did participants demonstrate their understanding in any noticeable ways?

• Were participants enthusiastic about applying new ideas for sustainable marine recreation in their own businesses? Is there anything you could do to help engender more willingness for trying out some of those new ideas?

3. Review the logistics of the workshop.
• Did you remain on schedule?
• Did you ever feel rushed to complete a section or did you finish early?
• What adjustments could you make that would be helpful?
• Is there anything you could do next time to make the workshop run more smoothly?

4. Consider how you worked together with your co-facilitator.
• Were you able to transition smoothly from one part of the workshop to the next?
• Did you communicate effectively with each other during the workshop?
• What would you do to improve transitions and communication?

DRAFT

Introduction to Coral Reef Ecosystems, Threats, and Solutions

Burt Jones and Maurine Shimlock photo

The Coral Reef Alliance: Coral Parks Program Education Series

Introduction

Coral reefs are one of the most spectacular and valuable ecosystems on the planet — and one of the most threatened. Climate change, coastal development and tourism, destructive fishing, and other human activities are endangering their very existence. At the current rate of destruction, more than one-third of the world's coral reefs will be destroyed within our lifetime. This will mean devastating losses in biological diversity, shoreline protection, income, food, and scientific discoveries.

However bad the outlook may seem, there is still hope for coral reefs. With increased education comes an increased appreciation and understanding of the immense value of coral reefs. This has led to exciting initiatives and conservation projects in countries throughout the world. Coral reef protected areas are being established worldwide and are considered one of the best tools for reef protection.

This handbook was designed to provide community members, dive instructors, tour operators, park managers, tourists, non-governmental organizations and government officials with a basic overview of coral reef ecology, benefits of coral reefs, global threats, and solutions for keeping coral reefs alive. We hope that this handbook will raise awareness of the beauty and value of coral reefs, and the urgent need to protect them.

Please send your comments to:

The Coral Reef Alliance (CORAL)
417 Montgomery St., Suite 205
San Francisco, CA 94104
Tel: 415-834-0900
Fax: 415-834-0999
Email: info@coral.org
Website: www.coral.org

Acknowledgements

We would like to thank Kathleen Auterio, Tegan Churcher-Hoffman and Rebecca Thomson for their contributions to this publication.

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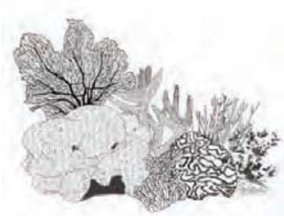

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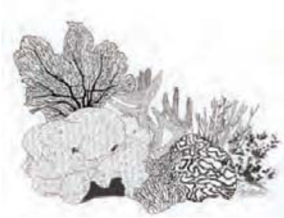

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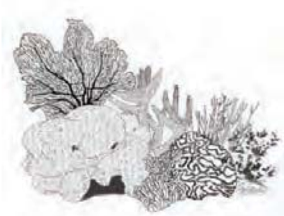

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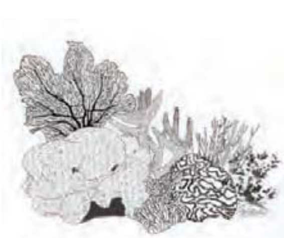
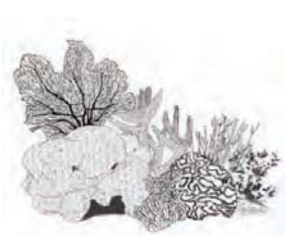


Part I: The Value of Coral Reefs



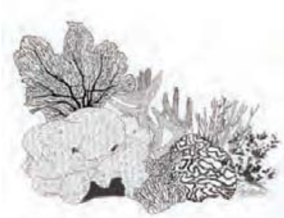
An Introduction to the World of Coral Reefs

Coral reefs support a greater variety of animals and plants than the densest tropical rain forest.

Coral reefs:

- Make up less than 0.1% of the ocean.
- May house over 3 million species of plants and animals.
- 11% of coral reefs have already been lost.
- 32% of coral reefs could die in the next 30 years.

Coral reefs are one of the earth's richest and most beautiful treasures, and one of the most threatened.



Clear turquoise water ebbs and flows at the edge of a tropical shore. Beneath the water's surface exists a breathtaking underwater world. Home to a diversity of colorful exotic fish, corals, and countless other marine creatures — this is the coral reef.

Oceans, seas and fresh water cover more than seventy percent of the earth's surface. While coral reefs take up only a very small fraction of the ocean (less than one-tenth of a percent), they are home to an astonishing variety of animals and plants. Coral reefs have very high biological diversity (biodiversity) — approximately 93,000 species of plants and animals have already been identified in coral reefs, and scientists predict that there may be over three million.

Coral reefs are the primary source of food and income for millions of people, produce valuable chemical compounds for medicines, and provide natural wave barriers that protect beaches and coastlines from storms and floods.

Yet coral reefs are in danger. Already, eleven percent of the world's coral reefs have been lost and another sixteen percent were severely damaged during the 1998 El Niño event. Scientists predict that another thirty-two percent may be lost in the next thirty years if human threats are not reduced.

As our awareness of the value of coral reefs increases, so do our efforts to reduce current threats. Coral reef marine protected areas (MPAs), Integrated Coastal Zone Management (ICZM), sustainable tourism, education and outreach programs and coral reef rehabilitation are just a few of the many steps being taken to conserve and protect these valuable and beautiful ecosystems.

Why Are Coral Reefs Important?

Coral reefs are valuable in many different ways:

- High biodiversity.
- Coastal protection.
- Seafood.
- Jobs and income.

Coral reefs hold tremendous economic and ecological value to coastal communties throughout the world. This value includes:

Biodiversity
Coral reefs have a very high level of **biological diversity**, with 93,000 species already identified by scientists. In fact, coral reefs contain 32 of the 34 recognized animal phyla (see page 6), compared to only 9 phyla found in tropical rainforests. Diversity is critical in maintaining the delicate balance of ecosystems. If one major species or population is removed, the ecosystem can be permanently disrupted.

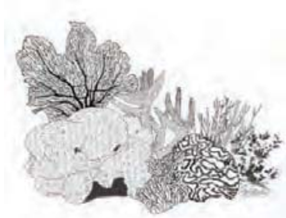
Coastal Protection
Coral reefs protect coastlines and help prevent erosion. They act as natural **breakwaters**, absorbing the force of storm waves and reducing damage to the shore. With more than half of the world's population living within 60km of the sea, coastal erosion is an issue affecting billions of people.

Seafood
Coral reefs have supplied communities with food for millennia. Not only is seafood a major source of animal protein, coral reef fisheries are also important sources of income. If managed properly, reefs can yield, on average, 15 tons of fish and other seafood per kilometer per year.

Economic Value
Coral reefs provide millions of people with jobs and income through fishing and tourism. Studies have shown that on average, countries with coral reef industries derive more than half of their gross national product from them. By one estimate, coral reefs provide economic goods and ecosystem services worth about $375 billion each year.

Approximately 500 million people depend on coral reefs for their livelihoods.

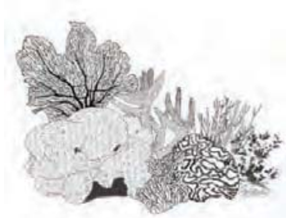
Tegan Hoffmann photo
Coral reef fishes are a primary source of protein for coastal communities throughout tropical regions of the world.



Coral reefs are valuable in many different ways:

- Aesthetic and cultural.
- Medicines.
- Carbon sink.

In dollars per unit area, coral reefs are the most valuable ecosystem on the planet.

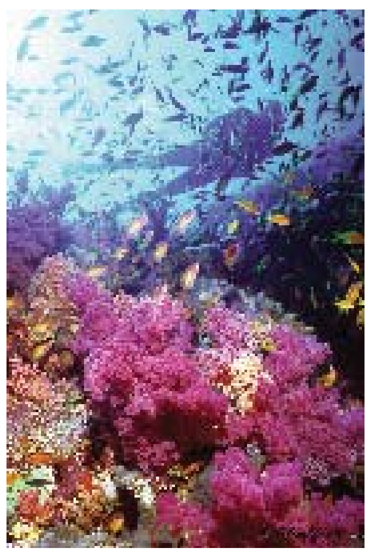


Why Are Coral Reefs Important? (continued)

Aesthetic and Cultural Value
Coral reefs are one of the most colorful and unique environments in the natural world. Humans are drawn to the beauty of coral reefs, which we explore by snorkeling, diving, or through photographs. Coral reefs are also culturally significant to many coastal communities, with legends and religious practices tied to reef life.

New Medicines
More and more species that live on coral reefs have been found to contain compounds that can be used in medicine (biomedical compounds), including some applied to the treatment of human immunodeficiency virus (HIV), cancer, ulcers and cardiovascular diseases. In addition, the unique skeletal structure of coral has been used to make our most advanced forms of bone grafting materials.

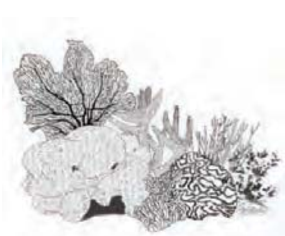
Carbon Sinks
Coral reefs are known as **"carbon sinks"** because they help remove carbon dioxide from the atmosphere. Carbon dioxide is one of the **greenhouse gases** involved in **global warming**, which has been implicated in rising global and sea surface temperatures, rising sea levels and the associated loss of land.



Mary Lou Frost photo

The beauty of coral reefs inspires many people to experierince these natural wonders.

Part II: Understanding Coral Reefs



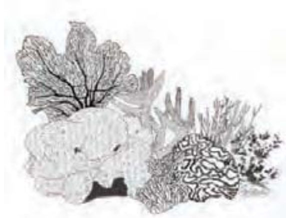
What Are Coral Reefs?

Coral reefs are huge structures built over hundreds, if not thousands, of years.

Reef animals include:

- Sponges.
- Corals.
- Mollusks.
- Worms.
- Crustaceans.
- Echinoderms.
- Marine fish.
- Marine amphibians.

With the invention of SCUBA diving in the 1950's, humans had a whole new way of experiencing, viewing and studying coral reefs.



Coral reefs are massive limestone structures that provide food and shelter for marine life. Hard corals are responsible for much of the solid, limestone (calcium carbonate) framework of the reef. Built over hundreds, if not thousands of years, some coral reefs are so large they can be seen from outer space.

In and around the limestone framework of coral reefs live a complex array of plants and animals. Some of them — like calcareous algae (algae with limestone in its tissues) — help to build the reef up. Others — such as worms, grazing fish, urchins and boring sponges — break it down. Many other animals, including more than 4,000 different species of fish, find shelter on the reef and make it their home. This multitude of life is what we know as the coral reef.

Animals commonly found in and around coral reefs include:

- Soft corals, hard corals, fire corals, anemones.
- Hundreds of different species of sponges.
- Conch, clams, sea slugs, cowries.
- Fireworms, Christmas tree worms, fan worms.
- Crabs, lobster, shrimp.
- Urchins, starfish, basket stars, sea cucumbers.
- Thousands of different species of fish.
- Sea turtles and sea snakes.

These animals co-exist in complex relationships. If one species on a coral reef is removed or dies out from human impacts such as overfishing, its disappearance can have far reaching consequences for the whole coral reef and the balance of the ecosystem can be dramatically changed.

What Are Corals?

What are corals?

- Cnidarians - corals, anemones, hydroids and jellyfish.
- Cnidocytes - specialized stinging cells.
- Polyp - coral animal.
- Colonies - groups of polyps.

Although they are often mistaken for plants or rock, corals are simple animals, belonging to a group of invertebrates (spineless animals) called **cnidarians**. Anemones, hydroids and jellyfish are also cnidarians. All cnidarians are characterized by a large stomach cavity and specialized stinging cells called **cnidocytes**, which they use to capture prey.

Polyps are the actual coral animals. Thousands of these animals cover one coral branch or mound. A polyp has a small cylindrical body, with an opening or mouth encircled by numerous stinging tentacles.

Corals often grow into huge coral **colonies** or coral heads. Each coral head can be made up of hundreds or thousands of individual polyps, which are all linked to their neighbors by connective tissue — including their stomach. So when one eats, they all eat!

Coral polyps can range in size from 1-3 millimeters in diameter (for colonial corals) to 25 centimeters (in some solitary corals).

Cross-section of a coral polyp

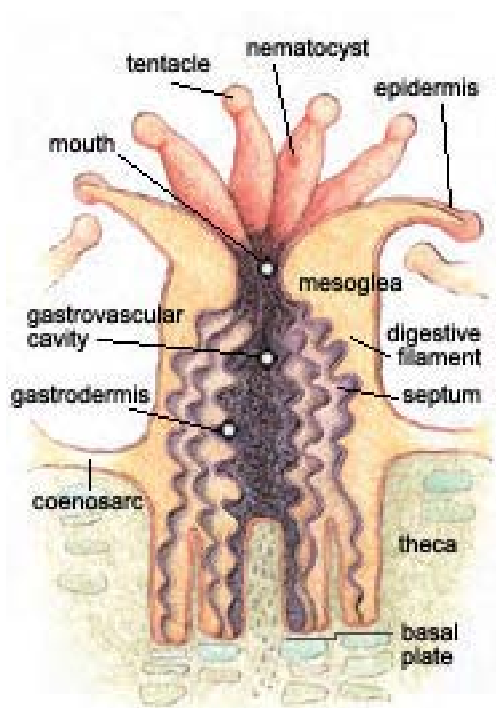
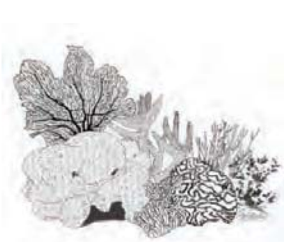


Illustration courtesy of NOAA



Taxonomy and Coral Reefs

The taxonomic hierarchy:

- Kingdom.
- Phylum.
- Class.
- Order.
- Family.
- Genus.
- Species.

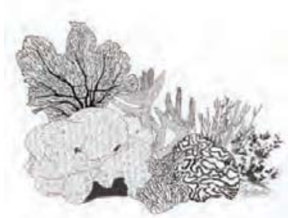
When studying living organisms and ecosystems such as coral reefs, scientists use a structured hierarchy to describe and categorize species based on natural relationships. **Taxonomy** is an ordered classification system that starts with the broadest set of physical similarities between living organisms, and progressively moves towards greater levels of common characteristics.

This system, first established by the Swedish naturalist Carolus Linnaeus in the 18th century, provides a method of universally accepted names for species throughout the living world and across cultural boundaries. The following table is an example of taxonomic classification for humans (*Homo sapiens*) and mushroom coral (*Fungia scutaria*).

Taxonomic level	Example: Humans	Example: Mushroom Coral
Kingdom	Animalia	Animalia
Phylum	Chordata	Cnidaria
Class	Mammalia	Anthozoa
Order	Primates	Scleractinia
Family	Homonidae	Fungiidae
Genus	*Homo*	*Fungia*
Species	*sapiens*	*scutaria*

Although nearly 100,000 species have been identified in coral reefs, there are likely millions yet to be discovered and named by scientists.

Taxonomy helps prevent confusion surrounding common names of living organisms. For example, in Hawaii there is a popular eating fish named *mahimahi*. However, this same fish is called *dorado* in the Caribbean and *dolphin fish* in many other parts of the world. So, although the common name can change from place to place, the scientific name will always be classified according to it's genus and species, that being *Coryphaena hippurus*.



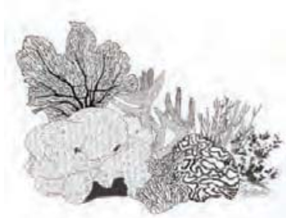
Environmental Conditions Necessary for a Healthy Coral Reef

Corals are very sensitive and conditions need to be just right for them to flourish.

Corals need:

- Sunlight.
- Warm water.
- Low nutrients.
- Sediment-free water.
- Salty water.
- A hard substrate to grow on.

Corals are very sensitive to changes in temperature. Sometimes an increase of just 1 or 2°C can cause coral bleaching.



Corals are very sensitive organisms and need certain environmental conditions. This includes:

Abundant Sunlight

Reef-building corals cannot survive without sunlight, since **zooxanthellae**, their symbiotic algae, require sunlight for photosynthesis. The majority of zooxanthellae reef-building corals do not grow below 45m (150ft).

Warm Temperatures

Corals can only live within a narrow temperature range from around 16°C - 29°C (62°F - 85°F). This explains why corals thrive in the warmer waters of the tropics.

Low Nutrient Levels

Corals are adapted to live in ocean water, which contains very low levels of nutrients. Nutrients, which are needed by all living organisms, are found in food and dissolved in water. Too many nutrients can upset the natural balance of life on the reef, creating conditions that favor other fast growing organisms such as marine plants and sponges.

Clear Sediment-Free Water

Corals prefer clear water with low levels of **sediments** (small particles of earth, rock and sand). Sediments can bury corals, blocking out needed sunlight and killing them. Corals tend to live in areas with some wave action as this helps supply them with food and oxygen as well as keeping corals free of sediment.

Salty Water

Corals are marine animals adapted to live in seawater with a salinity of around 35 parts per thousand. In areas that are too salty, or not salty enough, corals cannot survive.

Hard Substrate

Corals need a hard **substrate** or surface to attach to and cannot successfully colonize loose substrates such as rubble or sand. If the substrate is unstable, young coral colonies will be crushed and killed by wave action and storms.

How Old Are Coral Reefs?

Coral reefs have existed for more than 570 million years.

Coral reefs have survived:

- Sea level changes.
- Mass extinctions.
- Land uplifting.
- Glaciations.
- Natural disasters.

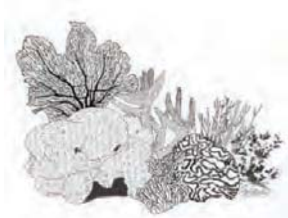
Coral reefs are one of the **oldest ecosystems on earth.**

- The ancestors of modern coral reef ecosystems were formed around **570 million years ago**. During this time, blue green algae and later sponges (not corals), were the major reef builders.
- Modern coral reefs as we know today, have existed for a staggering **240 million years**.
- **T**he tropical seas were divided from **24 to 5 million years** ago and coral reefs were distributed into the regions that we know of today.
- Most existing coral reefs are between **5,000 and 10,000 years old**.

Over geological time there have been several mass extinctions associated with coral reefs. Reefs have survived changing sea levels, uplifting of landmasses, periods of widespread warming and repeated ice ages as well as recurrent short-term natural disasters such as cyclones and hurricanes. Over geological time coral reefs have shown a remarkable ability to adapt and survive.

Unfortunately, human activities now represent a much more immediate threat to the short-term survival of coral reefs than do natural disasters. Loss of coral reefs as a result of human activities has been steadily increasing in recent decades and is now a problem in nearly every region of the world. In Southeast Asia alone, eighty-eight percent of coral reefs are "at risk" from human impacts.

The age of coral can be determined by counting annual growth bands similar to tree rings.



Vibrant coral reef — Kevin Roland photo

Where Are Coral Reefs Found?

Distribution of coral reefs:

• 284,300 square kilometers of coral reefs worldwide.

• Coral reefs live between 30°N and 30°S of the equator.

• Most coral reefs are found in the Indo-Pacific.

Worldwide, coral reefs cover an estimated 284,300 square kilometers. This area represents less than 0.1 percent of the world's oceans and less than 1.2 percent of the continental shelf area.

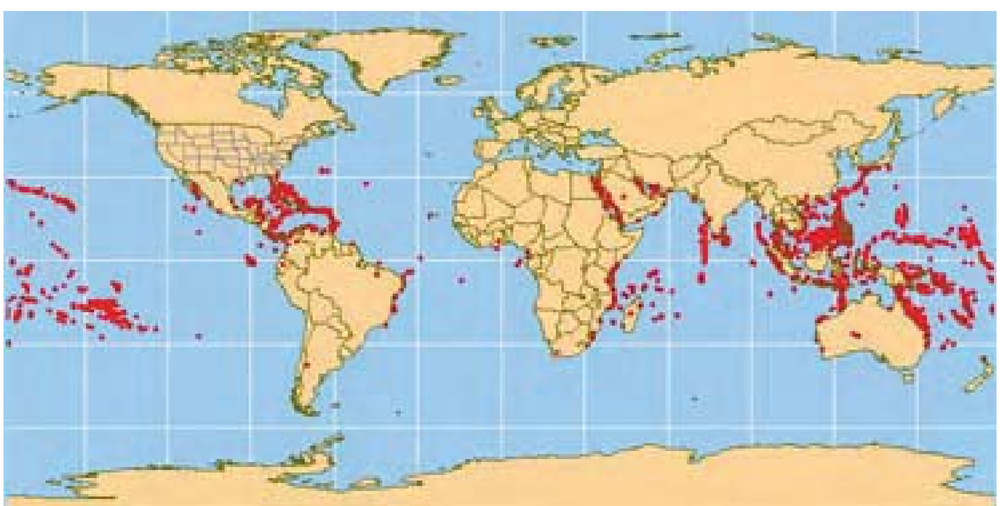
Coral reefs are found all around the world within the tropics (between 30 degrees north and 30 degrees south of the equator). Some are also found farther from the equator in places where warm currents flow out of the tropics, such as Florida and southern Japan.

Coral reefs can be found in 2 broad regions:

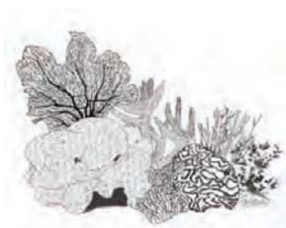
- Indo-Pacific
- Wider Caribbean/Western Atlantic

Most coral reefs are found in the **Indo-Pacific**, an area that stretches from East Africa and the Red Sea to the Central Pacific. This is also the area of highest species diversity among reefs overall. Less than eight percent of the world's coral reefs are found in the **Caribbean and Atlantic**, and species diversity is much lower in these regions.

Indonesia has more coral reefs and greater species diversity than any other country in the world.



The red dots represent areas with coral reefs. Illustration courtesy of NOAA

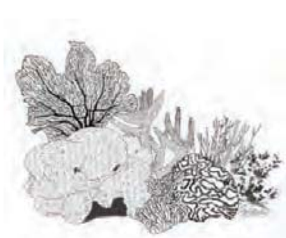


Types of Coral Reefs

There are five main types of reef:

- Fringing.
- Barrier.
- Atoll.
- Bank or platform.
- Patch.

The word "atoll" comes from the Maldivian word *atolu*. Atolls are mainly found in the Pacific, and along a wide stretch in the Indian Ocean.



Scientists generally divide coral reefs into five main classes: fringing, barrier, atolls, bank or platform, and patch reefs.

Fringing reefs lie around islands and continents, and are separated from the shore by narrow, shallow lagoons. They usually parallel the coastline and at their shallowest point can reach the water's surface.

Barrier reefs also grow parallel to the coastline, but are separated by deep, wide lagoons. At their shallowest point, they can reach the water's surface, forming a "barrier" to navigation. The Great Barrier Reef in Australia is the most famous example, and is the largest barrier reef in the world.

Atolls are rings of coral that create protected lagoons and are often located in the middle of the sea. Atolls usually form when islands surrounded by fringing reefs sink into the sea or the sea level rises around them (they are often the tops of underwater volcanoes). The fringing reefs continue to grow and eventually form circles with lagoons inside.

Bank or platform reefs are open ocean reefs that are simple structures with many different origins, yet no clear attachment to the coastline. Most of these reefs have an area that is exposed to wind and a sheltered side where lagoons and small reef patches can be found. Larger and slightly submerged reefs of this type are also called **shoals**.

Patch reefs are small areas of reef that occur in shallow waters and lagoons.

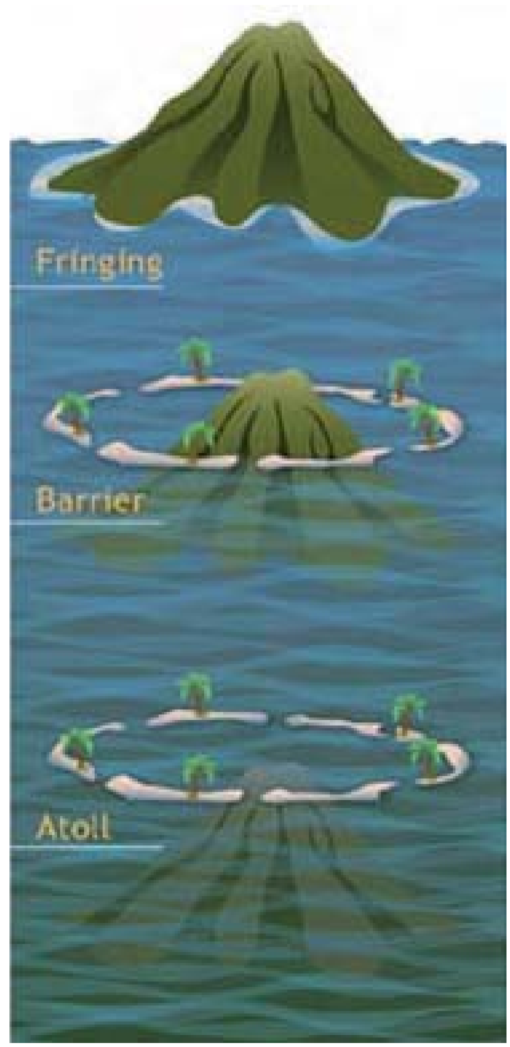


Illustration courtesy of NOAA

Over geological time, the formation and eventual erosion of oceanic islands leads to the creation of several different types of coral reefs.

Reef patterns and zones:

- Intertidal zone.
- Lagoons.
- Reef flat.
- Back reef.

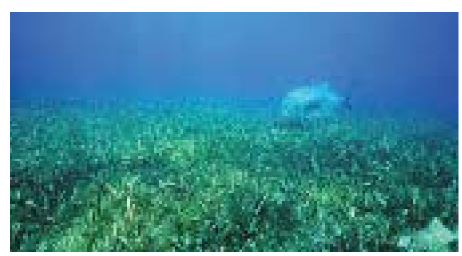
Reef Patterns, Zones and Related Ecosystems

Coral reefs are very unique, differing from one to the next. Yet, there are similar patterns or **zones** (see illustration page 14) that can be identified on most reefs, based on depth, environmental conditions, reef structure, and species composition. The following zones and related ecosystems are found in many coral reefs around the world:

The **intertidal zone** is where the land meets the ocean, and includes beaches, mangroves, lagoons and areas where fresh water meets salt water. **Beaches** are important for coral reefs, as they filter out runoff and sediments from the land. Much of the sand on beaches is produced from the natural breakdown of coral fragments. **Mangroves** are highly adapted plants that thrive in intertidal waters. They are also extremely important for coral reefs, filtering mud and sediments from the land, and acting as nurseries for juvenile reef species. A recent study documented that up to 26 times more fish can be found on reefs near intact mangroves than reefs far from mangroves.

NOAA photo courtesy of Richard Mieremet

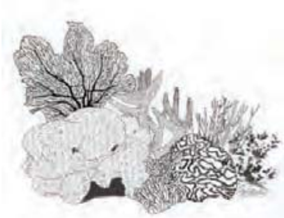
Lagoons are areas of deeper water (3-10 meters deep) that separate reefs from the coast. They are generally filled with sand, seagrasses and patch reefs, and are home to a diverse group of plants and animals. **Seagrasses** provide habitat and nursery grounds for many marine animals, and help stabilize the sand and **substrate**.



NOAA photo courtesy of Heather Dine

Mangroves are being destroyed at an alarming rate. At one time, mangroves lined 75% of tropical coastlines. Today less than half remain.

The **reef flat** is the shallow platform that extends outwards from the shore (1 to 2 meters deep and up to hundreds of meters wide). Exposure to harsh physical conditions limits coral growth, giving way to sand, rubble and encrusting algae. Many small invertebrates are found in the reef flat, including mollusks, worms and crustaceans.



The **back reef** is located where the lagoon rises up towards the shallow waters of the reef flat. The back reef gets a lot of sun exposure with generally calm conditions, and is characterized by a mixture of intricate coral gardens and sandy patches.

Reef Patterns and Zones (continued)

Reef patterns and zones:

- Reef crest/algal ridge.
- Forereef/reef front.
- Spur and groove.
- Buttress zone.

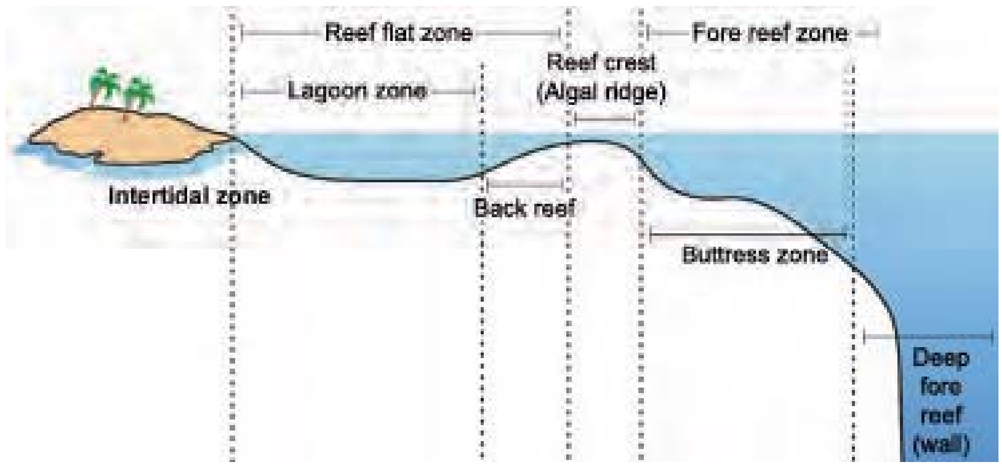


Illustration courtesy of NOAA

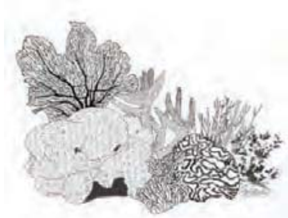
The **reef crest or algal ridge** is the highest point of the reef facing the ocean, and is characterized by a line of waves that break along the edge. Often exposed at high tide, the reef crest ranges from 1-50 meters wide. Constant wave action and exposure limits coral growth, but some branching corals have adapted to this environment. Coralline algae dominates (hence the name "algal ridge"), and small crabs, shrimps and cowries can be found seeking shelter in the nooks and crevices.

The **forereef** or **reef front** is on the seaward side of the reef crest, where the reef slope falls steeply towards the seabed. Conditions change greatly with depth.

The ridges of the buttress zone help coral reefs by dissipating the impact of strong waves, and draining debris and sediment off the reef.

In the shallowest areas there is intense wave action, with limited coral growth (mainly branching corals).

Between 10-20 meters is the greatest diversity and abundance of life on the reef. Massive corals prevail, and extensive **spur and groove** formations — sections of a reef found seaward from the reef flat and made of high ridges of corals (spurs) that are separated by sandy bottom channels (grooves) — often develop in the **buttress zone** (the zone of deep channels separated by high ridges or buttresses). Many animals inhabit the holes and crevices, and large fish, including sharks, jacks, barracudas and tunas patrol the buttress zone in search of food.

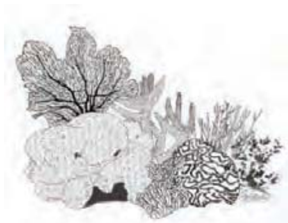


In the deeper, darker waters of the forereef (beyond 20 meters), corals become patchy and are replaced with sponges, sea whips, sea fans and ahermatypic (non-reef building) corals that do not depend on sunlight.

Hard corals:
- Hermatypes (reef-building corals).
- Limestone skeleton.
- 6 tentacles.
- Depend on zooxanthellae.
- Tropical waters

Soft Corals:
- Ahermatypes (non-reef-building corals).
- Soft and bendable.
- 8 tentacles.
- Not all depend on zooxanthellae.
- Live in both tropical and cooler waters.

Hard corals are responsible for building the single largest biological structure in the world – the 2300 kilometers long Great Barrier Reef in Australia.



Hard Versus Soft Corals

Corals are generally classified as either **hard coral** or **soft coral**. Hard corals are the primary reef-building animals, and are responsible for the limestone foundation of tropical coral reefs. Although **soft corals** do not have the reef-building capacity of hard corals, they and their cousins **gorgonians** (sea fans and sea whips), form an important part of the coral reef ecosystem, occurring in most reef habitats and displaying a dazzling array of colors and shapes.

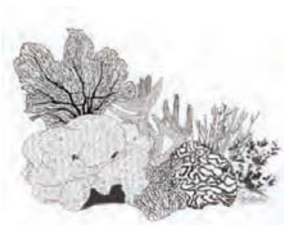
Hard corals	Soft corals
Architects of coral reefs, known as the **reef-building corals** or **hermatypes**.	Known as **ahermatypes** or **non-reef building corals**.
Hard skeletons made of limestone (calcium carbonate).	Soft and bendable skeletons, often resembling plants or trees.
Six tentacles on their polyps.	Eight tentacles on their polyps.
Depend on microscopic plants called **zooxanthellae**, which live within the tissue of the polyps.	Some, but not all soft corals, depend on **zooxanthellae**.
Only found in tropical waters.	Can grow in cool, dark regions like caves, where reef-building corals cannot survive.
Examples include brain coral and elkhorn coral.	Examples include leather coral and tree coral.

How do hard corals build a reef?
Each hard coral polyp grows within its own hard cup or "**calyx**" where it lays down a skeleton of limestone. When the polyp dies, its limestone skeleton is left behind and is used as the foundation for a new polyp. Over time, layer upon layer of limestone builds up to create the framework of the reef. At the surface of the framework is a thin layer of living coral animals.

Hard corals can be divided into a number of different shapes including:

- Branching.
- Elkhorn.
- Digitate.
- Encrusting.
- Table.
- Foliose.
- Massive.
- Submassive.
- Mushroom.
- Flower/cup.

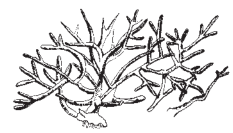
The growth rate of corals varies according to their shape. A massive coral may grow just 4 millimeters per year, whereas a branching coral can grow up to 10 centimeters per year.



Growth Forms of Coral

Scientists currently estimate that there are 794 species of reef-building corals throughout the world. Identifying coral species can be surprisingly difficult even for experts, and in some cases impossible without taking a sample to a laboratory for testing. A simple way to categorize corals is based on their different shapes. Corals can be classified into ten general growth forms:

1) **Branching** - numerous branches with secondary branches.

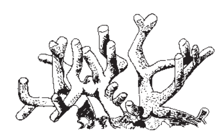


Branching

2) **Elkhorn** - large, sturdy, flattened branches.

Elkhorn

3) **Digitate** - like fingers or clumps of cigars with no secondary branches.



Digitate

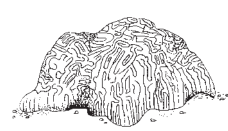
4) **Encrusting** - grows as a thin layer against the hard rocky surface.

5) **Table** - broad horizontal surfaces with fused branches.

6) **Foliose** - plate-like portions rising above the substrate, similar to the open petals of a rose.

Foliose

7) **Massive** - ball-shaped or boulder-like and can be as small as an egg or as large as a house.



Massive

8) **Submassive** - knobs, columns or wedges protruding from an encrusting base.

9) **Mushroom** - resemble the tops of mushrooms, mostly solitary, living unattached to any underlying substrate.

10) **Flower/Cup** - look like flowers, or like egg cups that have been squashed, elongated or twisted.

Cup or Flower

While growth patterns are primarily species-specific, the exact same kind of coral can look very different from one place to the next, changing its shape, color and size to suit its environment. For example, where there are strong waves, corals tend to grow into robust mounds or flattened shapes. In more sheltered areas they grow into more intricate shapes such as delicate branching patterns.

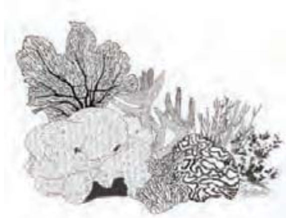
Reef builders include:

- Hard corals.
- Coralline algae.
- Fire coral.
- Sand & sediments.
- Encrusting organisms.

Reef eroders include:

- Sponges.
- Worms.
- Sea urchins.
- Parrotfish.
- Crown-of-thorns starfish.

Coral reefs are constantly in a state of change, being broken down by storms and natural eroders, while they are at work rebuilding themselves.



How Do Reefs Grow?

In order to understand reef growth, it is necessary to look at opposing forces of construction and erosion that occur simultaneously in reef environments. Like all ecosystems, coral reefs are in a constant state of change. Coral reefs naturally grow upward towards the sun, primarily as a result of the symbiotic relationship between living corals and the photosynthesizing algae (**zooxanthellae**) that live within their tissues. Yet there are also forces at work that constantly erode and break reefs down. Reef growth, therfore, can be illustrated by comparing the rate of construction with the rate of erosion:

Reef Growth =
Reef Construction - Reef Erosion

Reef Construction

Hard corals build the reef framework by laying down multiple layers of calcium carbonate (limestone) over time as coral colonies grow. Reef limestone also comes from sediments and other natural materials that fall into open spaces and are glued together by **cementing organisms** such as **coralline algae**, sponges or encrusting fire coral. Cementing organisms make the reef structure stronger and more wave resistant. Over hundreds, if not thousands of years, this accumulation can result in massive limestone structures, some large enough to be seen from space.

Reef Erosion

The structure of the reef is also constantly being broken down and eroded from waves and storms, as well as bioeroders. One massive storm can break and crush several years of coral growth in a very short period. **Bioeroders** are species that constantly eat away at corals or burrow into the reef structure. These include, for example, sponges, polychaete worms, sea urchins, parrotfish, and crown-of-thorns starfish.

M.L. Frost photo

Christmas Tree Worms are natural bioeroders

How Do Corals Eat?

Corals cannot produce food on their own - they need their symbiotic partners.

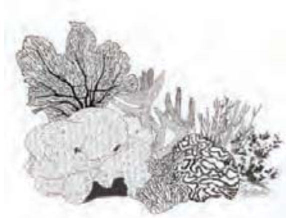
Zooxanthellae:

- Share food with corals.
- Process polyps' wastes.
- Give coral its color.

Corals:

- Provide a safe and sheltered home for zooxanthellae.
- Appear white or "bleached" without zooxanthellae.

A single zooxanthella is about 10 microns in diameter or equivalent to the thickness of a human hair.



Zooxanthellae

Within the tissues of hard coral polyps live microscopic, single-celled algae called **zooxanthellae** (pronounced zo-zan-THEL-ee). Several million of these algae live in just one square inch of coral, and give coral its brownish-green hue.

Zooxanthellae and coral have a **symbiotic** relationship, in which both the coral and the algae benefit. This relationship is complex and not yet fully understood.

Scientists believe that the algae provide coral with:

- **Energy and nutrition** - Zooxanthellae use the energy from sunlight to create sugars through photosynthesis. The algae also process the polyps' wastes, helping to retain important nutrients. Up to ninety-eight percent of a hard coral's nutritional needs can be met by the surplus food produced in this way. This allows hard corals to survive in nutrient-poor waters.

- **Calcium carbonate** - Zooxanthellae help produce calcium carbonate for the polyps' skeleton.

Meanwhile, the coral polyps provide zooxanthellae with:

- **Shelter** - Coral polyps provide the tiny algae with a safe home.

- **Nutrient recycling** - The algae uses the coral's waste matter (such as nitrates and phosphates) to help with photosynthesis.

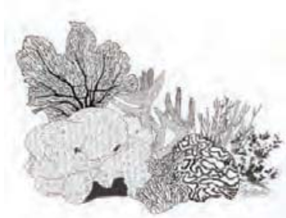
Can corals survive without zooxanthellae?

Hard corals are extremely reliant on zooxanthellae, and often cannot survive without it, unless they are able to acquire enough nutrition by capturing plankton from the water column. Stress can cause coral polyps to expel their zooxanthellae. They then appear white or **bleached**. While most hard corals seem to be able to live without symbiotic algae for short periods of time, they often die over the long-term during intense or extensive bleaching events.

How do corals eat?

- Corals are filter feeders that capture zooplankton (tiny animals) from the seawater.

The origin of the word "zooplankton" comes from "zoo," meaning animal, and the Greek word "planktos," meaning wanderer or drifter.



How Do Corals Eat? (continued)

Filter Feeders

Corals are also known as **filter feeders**, as they filter **zooplankton** (tiny, floating animals) from the water. At night some of the coral polyps come out of their skeletons to feed, stretching out their long, stinging tentacles to capture the zooplankton as it floats by.

The **cnidocytes** (stinging cells) of the polyp are covered with **nematocysts**, which are small, coiled, harpoon-like structures. As zooplankton pass by, the nematocysts are ejected, delivering a painful sting that stuns the prey and draws it back in to the mouth of the polyp.

While soft corals can feed all day long, in most cases, hard corals only feed after dark. During the daytime, coral polyps retract their tentacles into their cups. All that can be seen of hard corals are their skeletons and a thin layer of tissue. This is why people sometimes mistakenly believe these delicate animals are rocks.

Coral polyps Leslie Richter photo

How Do Corals Reproduce?

Coral reproduction is highly varied:

Asexual reproduction:

• Budding.

• Fragmentation.

Sexual reproduction.

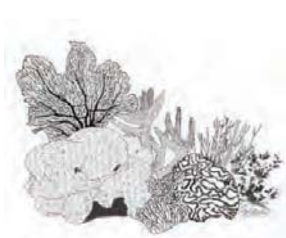
• Hermaphrodites.

• Planula Larva.

• Brooding.

• Spawning.

Coral spawning events on the Great Barrier Reef can be so highly synchronized that the massive slick of eggs and sperm can be clearly seen the next day from the air.



Corals have many strategies for reproducing, which are highly variable and complex. Corals reproduce both asexually and sexually.

Asexual Reproduction
Some corals reproduce asexually in a process called **budding**, in which the parent polyp divides into an exact genetic replica of itself. As new polyps are added, a coral colony develops.

Another type of asexual reproduction is called **fragmentation**, in which pieces or fragments of the coral colony are broken off and distributed by currents and waves. If the fragment settles on solid bottom, it may fuse right there and continue to grow asexually through budding.

Sexual Reproduction
About three-quarters of coral species are **hermaphrodites**, meaning that they are both male and female, and one colony produces both eggs and sperm. The remaining quarter of coral species have separate male and female colonies that produce eggs and sperm separately.

Sexual reproduction can happen in two ways:

- The sperm swims into the mouth of a polyp containing an egg and fertilizes it internally. The young polyp **(planula larva)** then matures within the polyp in a process known as **brooding**.

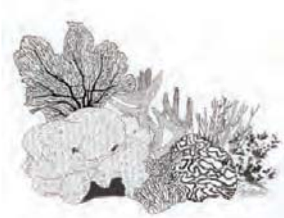
- Most coral species (seventy-five percent) reproduce by **coral spawning**, in which the polyps eject both eggs and sperm into the sea for external fertilization.

Coral spawning — Chuck Savall photo

Reproduction:

- Spawning – release of sperm and egg in the sea for fertilization.
- Gametes – eggs and sperm.
- Planula larvae – baby corals.

Planula larvae travel long distances, and can repopulate coral reefs hundreds to thousands of miles away.



How Do Corals Reproduce? (continued)

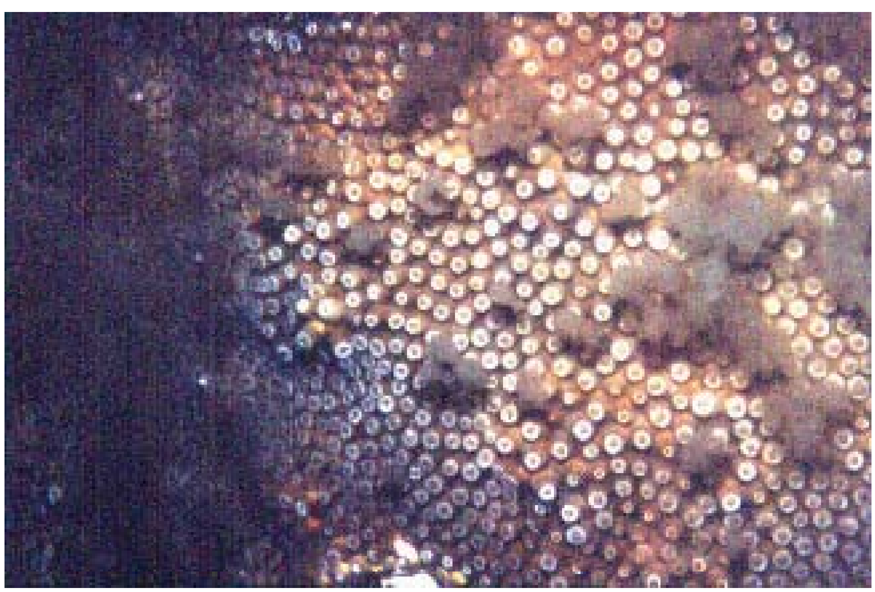
Mass Coral Spawning

Extraordinarily, in some areas of the world, mass coral spawning events occur on the same night once a year, as millions of **gametes** (eggs and sperm) are released into the water. With such a high concentration of gametes in the water, the threat of predators is reduced for each individual. Scientists believe this synchronicity is influenced by the moon, water temperature, and biological factors involving chemicals in the water column.

Life of the Planula Larva

Once the egg is fertilized, a new individual is created called a **planula larva**. It is naturally attracted to the light, and swims to the surface of the water where it remains for several days up to several weeks. The planula larva eventually returns to the bottom of the ocean floor, and if conditions are favorable, it attaches to a hard surface or **substrate** and starts a new coral colony.

Planula larvae can travel long distances, driven by winds and currents. This means that a coral in one part of the world can produce a new coral in another part of the world. This greatly affects species distribution, and has important implications for marine protected area (MPA) managers when setting up networks of marine reserves.



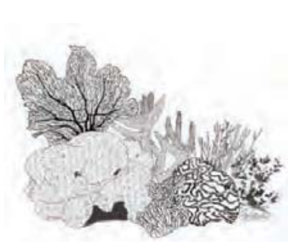
Coral spawning David Colvard photo

Coral reefs are one of the most diverse and productive ecosystems on the planet.

Key concepts:

- Ecology.
- Ecosystem.
- Habitat.
- Community.
- Population.
- Organism.
- Biodiversity.

At least 11% of the world's reefs qualify as biodiversity hot spots: areas of high species uniqueness and diversity that have already been significantly impacted by humans.



Coral Reef Ecology: Key Concepts

Ecology - The study of the interactions among and between organisms and their environment, and the study of the abundance and distribution of those organisms. Ecologists are fascinated by coral reefs, as they are one of the most diverse and productive ecosystems on the planet.

Ecosystem - The combination of living or "biotic" organisms (fish, algae, zooplankton) and non-living or "abiotic" conditions (rain, salinity, sunlight) that make up a particular environment, and make it unique. Coral reefs are one type of ecosystem. Other related coastal ecosystems are seagrasses and mangrove forests.

Habitat - The specific location where a plant or animal lives. For example, the habitat of a particular species of flounder might be sand, coral rubble and seagrass areas near patch reefs.

Community - All the plant and animal species that live together in a particular habitat. For example, all of the cardinal fish, lobster and shrimp that occupy a cave are part of the same community.

Population - All the members of one species in a habitat. Therefore, you might refer to a population of shrimp, or a population of frogfish.

Organism - Any living thing that is composed of one or more cells.

Biodiversity - The total diversity of living things and of the ecosystems of which they are a part. This includes genetic variability among individuals within each species (genetic diversity), the diversity of different species (species diversity), and the variety of ecosystems (ecosystem diversity).

Coral Reef Ecology: Diversity and Symbiosis

Coral reef diversity and symbiosis:

Diversity:

• 93,000 coral reef species identified.

Symbiosis:

• Mutualism.

• Commensalism.

• Parasitism.

Coral reefs have very **high species diversity**. In fact, coral reefs have more species per unit-area than the densest tropical rainforest!

- Scientists have identified 93,000 coral reef species.
- Some scientists predict there could be over 3 million reef species.
- There are approximately 4,000 species of coral reef fish (twenty-five percent of all identified marine fish species).
- Coral reefs contain 32 of the 34 recognized animal **phyla** (see explanation of taxonomy on page 12), compared to 9 phyla in tropical rainforests.

With such a multitude of species competing for space on the reef, many have evolved to become very specialized, living in unique habitats with specific diets and defense mechanisms. For example, the octopus will change shape and color to avoid predation. Parrotfish have a specialized beak-like mouth that enable them to scrape algae off of corals. There are countless such examples of specialization on coral reefs.

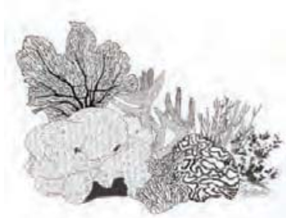
The existance of so many species has also led to a great diversity of interactions, including many complex two-way interactions, known as **symbiosis**. Symbiosis occurs when two species live together and either one or both depend on the other for survival. There are three types of symbiotic relationships:

Some crabs will pick up sponges and seaweed and place them on their backs. The crabs are then camouflaged from predators and the sponges and seaweed can enjoy better food selection.

- **Mutualism** - Both species benefit from the relationship. For example, cleaner fish or "cleaners" have a mutually symbiotic relationship with larger fish such as groupers. The cleaners feed on the parasites and damaged tissues of the skin and mouth of the larger, host fish. The cleaner benefits from the food obtained, and the host rids itself of annoying parasites.

- **Commensalism** - Only one species benefits from the relationship. For example, small fish known as remoras, cling to larger fish such as sharks or rays. Although the shark doesn't have any known benefit, the remora saves energy from swimming, and is nourished by food scraps from the shark.

- **Parasitism** - One species benefits from the relationship while harming the other. For example, parasitic isopods that look like roaches attach themselves to the heads and faces of certain species of fish and can destroy the flesh.



Coral Reef Ecology: Energy Flow and the Food Web

Key components of energy flow and the food web in coral reefs:

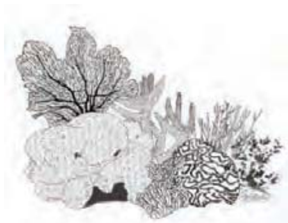
- Organic nutrients.
- Energy flow.
- Photosynthesis.
- Food web.
- Zooxanthellae.

Tropical marine waters are very low in nutrients, so it is difficult for species to survive. Yet, coral reefs are full of life, existing as biologically diverse ecosystems in areas that are low in **organic nutrients** (food derived from living matter). This can be explained by looking at **energy flow** on the coral reef food web and the importance of a tiny algae.

All ecosystems function with energy flowing in one direction from the sun, and through nutrients, which are constantly being transferred through different levels of the ecosystem. Plants are able to use the sun's energy, and convert it to organic matter in a process known as **photosynthesis**. This energy is then passed through the ecosystem in a series of steps of eating and being eaten, otherwise known as the **food web**.

On a coral reef, photosynthesis is carried out primarily by the small algae called **zooxanthellae** (see page 18). These tiny algae live within the tissues of corals in a **symbiotic relationship** and are arguably the most important organisms on coral reefs. Like all green plants, zooxanthellae obtain energy from the sun. The coral benefits from this energy, which can provide up to ninety-eight percent of its nutritional needs. Hard reef-building corals are able to thrive in relatively nutrient free waters, since they can get so much energy

Coral reefs live in shallow, sunny waters because their symbiotic algae needs sunlight for photosynthesis.

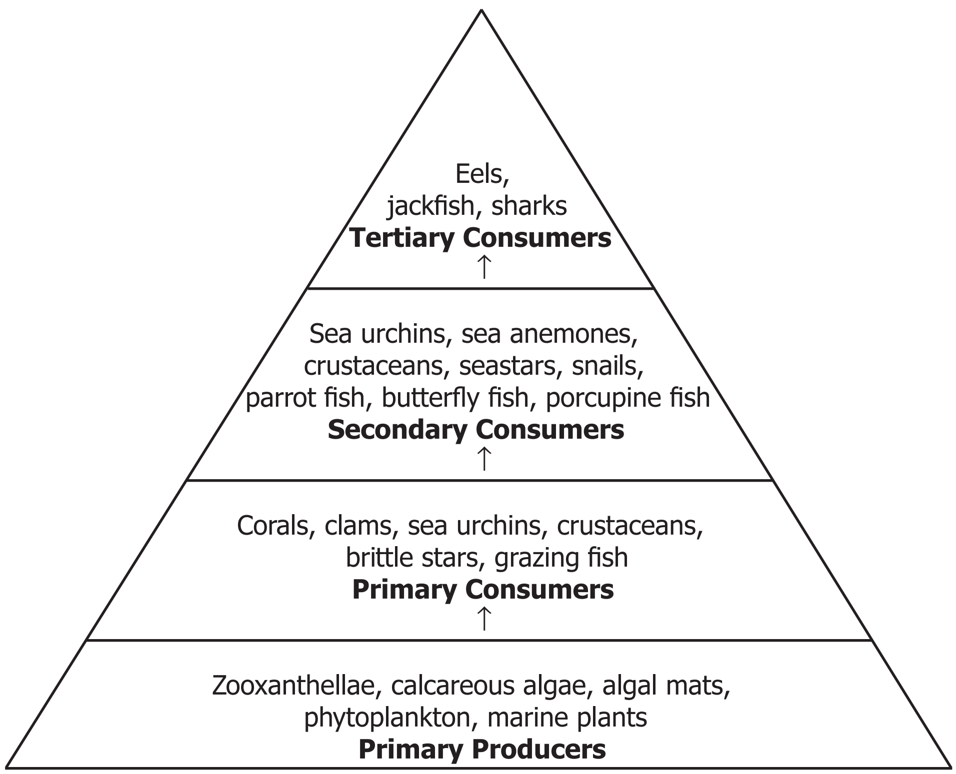


Energy Flow and the Food Web (continued)

The sun is the source of all energy on the coral reef.

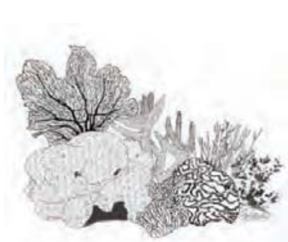
- Producers - produce energy from the sun.
- Consumers - eat plants and animals.
- Detritivores - scavengers that eat waste matter from plants and animals.

Each step in the food web involves a transfer of energy through different feeding or **trophic levels**. Coral reef algae produce energy from the sun, and are therefore called **producers**. Zooxanthellae is a **primary producer**. All other species in the food web are called **consumers**, because they get their energy by eating other organisms. So, for example, a coral is a **primary consumer** as it obtains its energy from zooxanthellae and other tiny animals. A butterflyfish then eats the coral, so is a **secondary consumer.** A barracuda then comes along and eats the butterflyfish, so is a **tertiary consumer**, and so on. Energy is lost in each step of the trophic levels.



Coral reefs are more productive than tropical rainforests.

Also important are the **detritivores** or scavengers, which are animals that feed on dead plants and animals and their wastes. Detritivores help speed up the process of breaking down dead animal and plant material, thus recycling nutrients back into the food web. A sea cucumber is one example of a detritivore.



What does it mean to say a coral reef is "productive"?
This means that the primary producer, being **zooxanthellae**, generates a lot of energy for the ecosystem. Coral reefs have higher productivity than tropical rainforests — one reason that reefs are so fascinating to ecologists.

Competition and Disturbance

Competition and disturbance:

- Corals and reef organisms are constantly competing for space.
- Local disturbance helps maintain biodiversity.

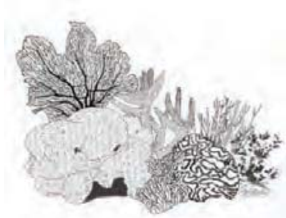
All organisms in nature need both space and habitat in order to survive, and the many species that live among the coral reef are no exception to this general ecological rule. Thus **competition** — striving to survive in a limited space among other organisms — is never-ending in reef environments. As a result, corals and other reef organisms have developed a wide range of both aggressive and defensive mechanisms to help them survive in this competitive environment.

For example:

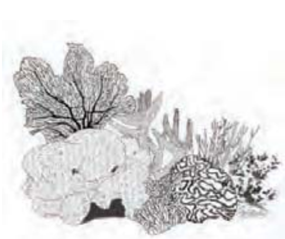
- Branching corals grow more rapidly than encrusting or massive corals, often out-competing them for space.
- Slower growing species survive due to their defensive stinging tentacles, which can prevent faster-growing corals from taking over.
- Soft corals and sponges have toxins that they use for both defense and aggression.
- Some bioeroders, such as segmented worms and some species of urchins, live within holes and tunnels that they have bored into the reef structure.
- Many other creatures make their homes in the natural open spaces of the reef structure.

The saddled butterfly fish, having evolved resistance to their toxins, will rip tentacles from sea anemones if given the chance.

Constant change is another fundamental aspect of any living ecosystem. **Disturbance** to the biological or physical structure of a coral reef — resulting from natural forces such as storms and waves — commonly opens up new places for animals and plants to grow and allows new species to colonize or establish themselves in a particular environment. With such intense competition for space, this type of local disturbance can actually be beneficial. It can prevent individual species from taking over, helping to maintain stability and biological diversity in a coral reef environment.



Part III: Threats to Coral Reefs



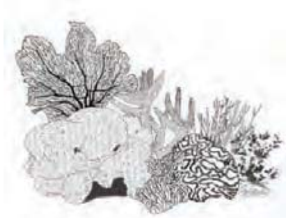
Coral reefs are in peril:

- 11% of the world's coral reefs are already dead.
- 32% of coral reefs could die in the next 30 years.

Scientists identify threats as:

- Natural vs. Anthropogenic (caused by humans).
- Acute vs. chronic.
- Small-scale vs. large-scale.

If human threats are not reduced, coral reefs could be lost forever.



Threats to Coral Reefs

Coral reefs are among the world's most fragile and endangered ecosystems. Eleven percent of the world's coral reefs have already been lost and another sixteen percent were severely damaged during the 1997-1998 global bleaching event. Scientists predict that another thirty-two percent may be lost over the next thirty years if human threats are not reduced.

The loss of healthy coral reefs would mean the extinction of thousands of marine species, as well as the elimination of a primary source of food, income and employment for millions of people around the world.

When scientists identify threats to coral reefs, they generally categorize them as: **natural vs. anthropogenic**; **acute vs. chronic**; and **small-scale vs. large-scale**.

Natural vs. Anthropogenic
Coral reefs have been altered by **natural** events for millions of years, such as storms and hurricanes, volcanic activity, changes in sea level and sea surface temperature, natural predators and disease outbreaks. Natural events are often very slow. For example, changes in sea level can take thousands of years, allowing coral and other organisms to adapt to different environmental conditions.

Natural events, such as hurricanes, can damage and weaken coral reefs. But healthy reefs generally have a strong ability to recover from such natural disturbance. Hurricane events can actually benefit the reef, helping to maintain biodiversity by opening up new space and habitat for coral species to grow.

In the past century, **anthropogenic** or human-induced threats have increased in both frequency and intensity, and what once took hundreds of years to occur now takes hours, days, weeks, and months. This causes severe and sometimes irreversible damage to coral reefs, as the coral has not had time to adapt or recover from these rapid environmental changes. Examples of anthropogenic threats include pollution, sedimentation, destructive fishing and global warming. Scientists believe that human activities actually intensify some natural disturbances (see page 34).

Threats to coral reefs:

- Acute vs. chronic.
- Small-scale vs. large-scale.

Threats to Coral Reefs (continued)

Acute vs. Chronic

Acute disturbances are short-term and often have a significant immediate impact on the environment. Natural events like hurricanes are considered acute, as are human-induced threats such as the one-time dropping of an anchor on a coral head. Given time, corals and reef communities can recover from acute disturbances.

However, chronic disturbances can be more damaging to reefs over time. **Chronic** threats are long-term, low-level, and sometimes undetectable. They include, for example, the day-to-day exposure of reefs to human waste and sewage, or anchor damage from multiple boats that occurs on a regular basis. Scientists have found that it is much more difficult for coral reefs to recover from such chronic threats.

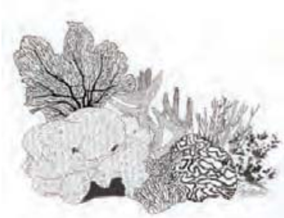
When faced with both acute and chronic threats, coral reefs are at great risk.

Small-scale vs. Large-scale

Scientists also distinguish between small and large-scale disturbances. Small-scale disturbances occur in a localized area for a short period of time. Examples include a small, local bleaching event, the spread of a coral disease, or a Crown of Thorns starfish (COTS) outbreak.

Large-scale disturbances affect a larger area, and often occur more frequently and to a point beyond which the reef can recover. Examples include a mass global bleaching event, a widespread disease outbreak, or a major oil spill.

Coral reefs are at risk from long-term, chronic threats such as pollution, overfishing and global warming.



Natural Threats

Natural threats:

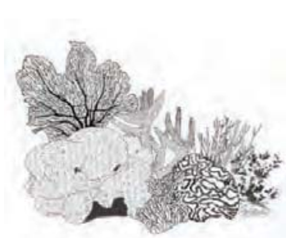
- Low tides and sunlight.
- Hurricanes/typhoons and big storms.
- Volcanic eruptions.
- Sea level change.
- Sea surface temperature change (SST).
- Predators.
- Disease.

Natural disturbances can cause severe changes to coral communities, but coral reefs are resilient, and have managed to survive and adapt to these pressures for millions of years.

- Environmental threats such as **low tides** and **sunlight** can expose shallow corals to air and ultraviolet radiation, which can overheat and dry the coral's tissues.
- Powerful **volcanic eruptions, hurricanes, typhoons or storms** can flatten a reef in minutes. This can lead to compounded problems, such as **phase-shifts**, in which fast growing algae replaces the slower-growing corals.
- **Increased sea surface temperatures** and **changing sea levels** can also have a profound effect on corals, leading to exposure and coral bleaching.
- **Predators** consume the tissue of coral polyps, such as fish, marine worms, snails, barnacles and starfish.
- **Disease** also occurs naturally in coral reefs, causing mass mortality in corals, sea fans and other reef creatures.

Coral reefs generally recover from natural threats. However, if subjected to numerous and sustained threats, such as those influenced by humans, the survival rate is sigificantly decreased.

Corals are more susceptible to disease when they are already stressed by other factors, such as sedimentation and pollution.



Natural Threats Influenced by Humans

Scientists believe that human activities are increasing the rate and severity of natural threats, such as:

- Mass bleaching events.
- Disease outbreaks.
- Predator outbreaks.

In the past few decades, natural threats to coral reefs have become more frequent and intense. **Coral bleaching** events correlated with **climate change** have become widespread disasters, and disease and predators of the coral reef ecosystem have exploded in **outbreaks**. Scientists have found direct connections between human activities and the increase in natural threats to coral reefs, including:

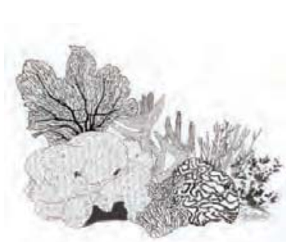
- **Mass Bleaching Events and Climate Change:** Increases in carbon dioxide emissions is changing the climate, increasing sea surface temperature and ultraviolet light, leading to mass bleaching events around the world.

- **Disease Outbreaks:** Sewage effluent is correlated with the outbreak and spread of disease, such as Black Band Disease in the Caribbean.

- **Predator Outbreaks:** Over-fishing and increased nutrients in the water column from agro-industry and sewage effluents are causing predator outbreaks, such as Crown of Thorns Starfish (COTS).

Between 1979 and 2002 scientists documented over 65 mass bleaching events. Only 9 were documented between 1960 and 1979.

Bleached coral Wolcott Henry photo



PHASE SHIFT
Often, when a coral dies, other reef life immediately tries to gain access to the valuable space. The first species to colonize the empty spaces are usually algae and soft corals, which grow much faster than hard corals. When this happens, a coral reef changes into a community comprised primarily of algae and soft coral. This is called a phase shift.

Mass Bleaching Events and Climate Change

Climate change causes:

- Increased sea surface temperatures.
- Rising sea levels.
- More storms.

Impacts to coral reefs include:

- Coral bleaching.
- Slower coral growth.
- Physical damage.

Over the last twenty years, human-induced climate change has been a growing concern for scientists, policy makers, and environmentalists. Coral reefs are one of the ecosystems most vulnerable to climatic influences.

The **greenhouse effect** is a natural occurrence in which heat-trapping gases — primarily carbon dioxide, methane, and nitrous oxide — act as a blanket, preventing the heat of the sun from escaping. Without the greenhouse effect, the earth would be too cold to live on.

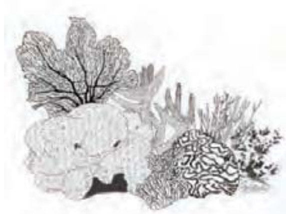
However, in recent years the temperature of the earth has increased significantly in what is known as **global warming**. Most scientists believe that global warming is the result of human activities that have increased greenhouse gases in the atmosphere. This is mainly due to the burning of **fossil fuels** (coal, oil and gas) to run cars, power industries, and heat and cool homes. Increased agriculture, deforestation, landfills, industrial production, and mining also contribute to the problem. The resulting side effects have been:

- Increase in sea surface temperatures (SSTs).
- Rising sea levels.
- More frequent and severe storms.

These climatic changes have had devastating consequences for coral reefs:

In 1997, the United States emitted about one-fifth of total global greenhouse gases of the industrialized world.

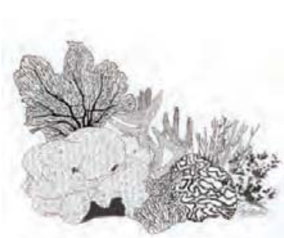
- **Coral Bleaching** – Coral polyps exposed to heat, utraviolet (UV) light and other stressors expel their symbiotic algae (zooxanthellae), and appear white or bleached. Corals can survive some degree of bleaching, but as the length and severity of the stress increase, so does coral mortality.
- **Slower Coral Growth** – Sea level is expected to increase between 15 and 95 centimeters over the next century. The growth rate of coral is likely to be slower than this. As a result, corals will be deeper, receive less sunlight and grow at a slower rate.
- **Physical Damage** – Increased coral mortality is expected as storms and cyclones become more frequent and intense. Coral reef growth may not be able to keep pace with these destructive events.



Examples of coral reef disease outbreaks include:

- White band disease in hard corals.
- *Fibropapilloma* in sea turtles.
- *Aspergillus* in sea fans.
- Coralline Lethal Orange Disease in coralline algae.

During the 1970s and 1980s, white-band disease spread throughout the western Atlantic, eliminating up to 95 percent of the elkhorn and staghorn corals in some locations.



Disease Outbreaks

The incidence of disease on coral reefs has only recently been recognized. The first observations were recorded in the Caribbean as recently as the 1970's and in the past few years the number of recorded diseases has increased dramatically.

Diseases have contributed to the die-off of seagrasses, corals, sea fans, sea urchins, sponges, fish, and other organisms. Diseases can modify the structure and composition of reefs by removing locally abundant species. Examples of disease outbreaks include:

- **White-band Disease**, affecting staghorn and elkhorn corals, devastated Caribbean coral populations by as much as ninety-five percent in the 1980's.
- ***Fibropapilloma**, a* tumor-forming, debilitating and often fatal disease, has affected sea turtles globally.
- ***Aspergillus,*** a fungus of terrestrial origin, has caused tissue destruction, skeletal erosion and death in Caribbean sea fans.
- **Coralline Lethal Orange Disease (CLOD)** has affected coralline algae in the Pacific.

People have observed hundreds of coral reef diseases all over the world, but scientists have only documented approximately 10 official coral reef diseases, including black-band, CLOD, white plague and yellow blotch disease.

Diseased coral Wolcott Henry photo

Disease Outbreaks (continued)

What causes disease?

• Natural conditions.

• Stress.

• Contact with polyps.

• Nutrients.

What causes disease outbreaks?

- Outbreaks can occur **naturally** on a local level. Oftentimes, disease outbreaks start locally but then expand to affect a wider region.

- Any **stress** to corals can make them more vulnerable to disease. Stresses include: sedimentation, pollution, physical damage, increased nutrients, extreme temperatures, extreme salinities.

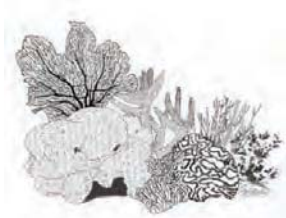
- **Contact with coral polyps** (such as diver or anchor damage) removes its protective mucus and causes tissue damage that can make the coral vulnerable to attack from disease.

- There is a correlation between certain disease outbreaks and **increased nutrients** in the water column from sewage.

DIADEMA
During the early 1980's the black spiny urchin, *Diadema*, got sick and died by the thousands all around the Caribbean. Up until then divers had considered Diadema to be nothing more than a nuisance and scientists had not given it much thought at all. However *Diadema* is an herbivore. It spends its life grazing on the marine plants (algae) that live on the reef and compete with corals for space to grow. Without Diadema to keep the plants in check many reefs became quickly overgrown with algae and the corals were killed.

Coral diseases have become a chronic and often catastrophic problem for reefs in the Caribbean.


Magnificent Sea Urchin Jeff Dawson photo



Crown of Thorns and Other Predator Outbreaks

Population explosions:

- Drupella (coral-eating snail).
- Crown of Thorns Starfish - COTS.

Predator population explosions occur when a species of animal on a reef increases dramatically, threatening the health and well being of the reef. This is particularly damaging when the animal preys on coral.

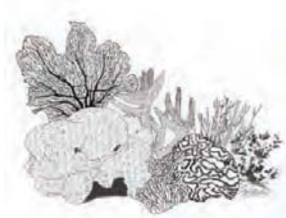
- **Drupella** is a small snail that eats away at the tissue of branching corals. It is a common predator in the Indo-Pacific, and has caused significant damage to some coral reefs.
- The **Crown of Thorns Starfish (COTS)** is a predator of corals, able to eat extensive sections of reef in one night's grazing. Recent population outbreaks in the Pacific have devastated whole reefs, with up to ninety percent mortality in some areas. COTS generally prefer branching corals over large massive corals.

What causes COTS outbreaks? Scientists belive there are several possible explanations:

- It could be a natural cycle of the species, with populations reaching these numbers only once every hundred years.
- Nutrient pollution from the land could increase the plankton food for Crown of Thorns larvae.
- Overfishing of predators of juvenile COTS such as snappers.
- Overfishing of predators of adult COTS such as Tritons.
- Rising sea temperatures may favor COTS by increasing its ability to reproduce.

In 1978-79 a massive COTS outbreak devastated 90% of the coral reefs of Fagatele Bay in American Samoa.

CROWN OF THORNS
Early attempts to contain Crown of Thorns outbreaks failed because people did not take into account the biology of the predator. Divers would remove all the COTs they could find from a reef, chop them up and throw them back into the water. Unfortunately COTS can regenerate arms and other parts quickly, so the divers were literally doubling and tripling the problem.

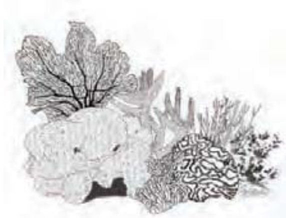


Anthropogenic (Human-Caused) Threats

The four tops threats, according to the World Resource Institute include:

- Over-fishing and destructive fishing.
- Marine-based pollution.
- Land-based pollution.
- Coastal development.

Human threats could destroy 32% of coral reefs within the next 30 years.



Human activities are threatening the world's reefs at an alarming rate. In the last century human pressures have increased dramatically with rapid and unplanned coastal development, pollution, overfishing, coral mining, and other damaging activities. The scale and rate of impacts affecting tropical waters is increasing, and the intensity of disturbances are becoming more **chronic** and **long-term** so that the corals are not able to recover.

The main anthropogenic threats reviewed in this section include:

1) Destructive Fishing Practices and Overfishing
2) Marine-based Pollution
3) Marine Debris
4) Mining, Harvesting and Trade
5) Land-based Pollution
6) Coastal Development and Sedimentation
7) Tourism

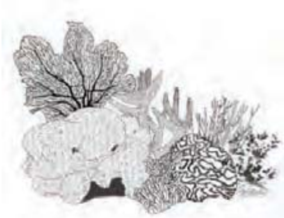
Wolcott Henry photo

Coral destroyed by destructive dynamite fishing.

Unsustainable fishing practices include:

- Dynamite or "blast" fishing.
- Cyanide fishing.
- Muro Ami.
- Bottom trawling.
- Overfishing.

According to the 2002 Reefs at Risk Report, 56% of the coral reefs in Southeast Asia are at risk from destructive fishing practices.



Destructive Fishing Practices and Overfishing

In many areas, coral reefs are threatened by destructive fishing practices and overfishing. As fish catches get smaller, there is increased pressure for fishermen to use more extreme methods to catch fish and find an income. Although this may yield short-term economic benefits, it endangers the long-term sustainability of the fishing industry and other related coral-reef industries.

Destructive fishing techniques destroy coral reefs habitats, reduce fish stocks, and prevent coral growth as a result of sedimentation. Types of destructive fishing include:

- **Dynamite or "blast" fishing** - Fish are killed by an explosion and then skimmed off the surface or collected from the bottom. The explosion kills large numbers of fish and other marine organisms, and destroys the physical structure of the reef.

- **Cyanide fishing** - Fishers squirt cyanide, bleaches and other poisons in reef crevices to stun fish, making them easy to catch. This is a popular method for capturing live fish for the aquarium and food trades. The poisons cause bleaching and kill surrounding corals and marine life.

- **Muro Ami** - A line of divers smash the reef with rocks and poles to drive the fish into waiting nets, causing physical damage to the reef structure. Muro ami has recently been replaced by a more sustainable technique know as **paaling** in which the divers hold hoses with compressed air and drive the fish towards the nets with bubbles.

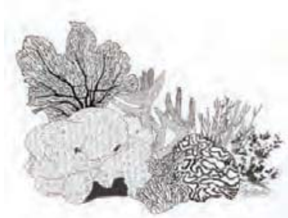
- **Bottom-trawling** - A bottom trawl is dragged along the bottom of the sea floor in order to catch a target species. The trawl net is dragged over everything in its path, indiscriminately capturing virtually all marine life in the habitat being fished.

- **Overfishing** occurs when fish and marine creatures are harvested at rates faster than they can reproduce. In some areas, overfishing has already resulted in the local extinction of highly-valued species such as giant clam and grouper. Changes in fish populations can greatly affect the reef ecosystem. For example, the removal of algal grazers such as parrotfish may lead to algal blooms that smother living corals.

Sources of marine pollution:

- Oil discharge from boats and planes.
- Tanker accidents.
- Oil leaks.
- Ballast and bilge discharge.
- Radioactive waste.

A 1986 oil spill in Panama led to a decrease in live coral coverage of 50-75% in the shallow water reefs.



Marine-based Pollution

Marine-based pollution is harmful to coral reefs, although the degree of its impact is still unknown.

Marine pollution comes from:

- Deliberate discharge of oil from tanks and vessels.
- Tanker accidents causing oil leaks.
- Oil leaks from tanks and pipelines.
- Dumping of fuel from airplanes.
- Ballast and bilge discharge containing oil, tar and other pollutants as well as non-native species that can become **invasive**.
- Radioactive waste from military activity.

Marine-based oil and toxic chemicals damage coral reefs by:

- Altering coral reproductive tissues, growth, behavior and development.
- Harming zooxanthellae.
- Preventing juvenile coral from settling on the reef and growing.
- Deteriorating the physical reef structure.
- Reducing the resilience of coral reefs to other stresses.

Although tanker wrecks and oil spills receive a great deal of press coverage, the damage is often **acute** and **short-term**. Coral reefs are far more threatened by the **chronic**, **long-term** leakage of fuel from boats and land.

Marine Debris

Sources of marine debris:

- Land.
- Boats.
- Ship wrecks.

Garbage is harmful to coral inhabitants because it:

- Strangles and chokes marine life.
- Spreads alien species.
- Reduces the beauty of a location.

Marine debris or garbage is also harmful to coral reef inhabitants. Marine debris comes from:

- Garbage washed into the sea from land.
- Materials discarded from boats.
- Fishing nets that have been lost or discarded by commercial fishing vessels (otherwise known as **ghost nets**).
- Ship and plane wrecks from battles and bombing raids that often release toxic paints and chemicals into the marine environment.

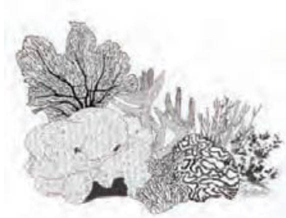
Free-floating nets and garbage can be deadly to marine life — smothering, suffocating, entangling and destroying corals, fish, sharks, sea turtles and marine mammals. Sea turtles often mistake plastic bags for jellyfish, and as a result, eat them and die. Alien (non-native) species that are attached to marine debris are sometimes transported far from their place of origin and introduced in remote reefs, altering the natural ecosystem.

Garbage can also destroy the beauty of beaches and coral reefs, which lessens the appeal of a location for tourists. This can result in significant economic losses to coastal areas dependent on the tourism industry.

In the Northwestern Hawaiian Islands more that 300 tons of debris - primarily discarded fishing nets - has been removed by government divers.

NOAA photo

Marine debris, particularly discarded fishing nets, can cause extensive damage to coral reefs and other marine species.



Mining, Harvesting and Trade

Coral reefs are exploited for many different things.

Mining and harvesting may be for:

- Construction.

- Souvenirs/Jewelry.

Coral reef species are harvested and traded in numerous domestic and international markets for:

Construction
Corals are mined for limestone and construction materials. Sometimes coral pieces are removed for use as bricks or road-fill. Sand and limestone from coral reefs are also made into cement for new buildings.

Jamie Oliver photo

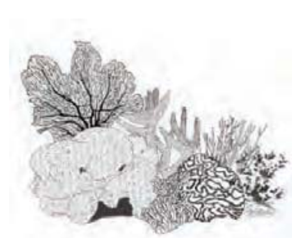
Corals are commonly harvested for construction materials on both a local and commercial scale in many places around the world.

Souvenirs/Jewelry
Coral species are used in the dried ornamental trade business, where they are collected and traded for souvenirs and jewelry.

Wolcott Henry photo

The sale of corals as souvenirs and jewelry poses a serious threat to the helath of coral reefs in many regions of the world.

According to one study, Indonesia supplies 95% of the world's coral trade, while the United States imports 85% of the dead coral and 98% of the live coral.



Coral reefs are exploited for many different things.

Mining and harvesting may be for:

- Aquarium trade.
- Medicines.

Mining, Harvesting and Trade (continued)

Aquarium trade

Coral, fishes and **"live rock"** (dead coral rock covered with encrusting organisms such as algae and sponges) are collected for the marine aquarium industry.

Chuck Savall photo

In addition to living coral and "live rock," milions of coral reefs fishes are harvested every year from around the world to support the aquarium industry.

Medicines

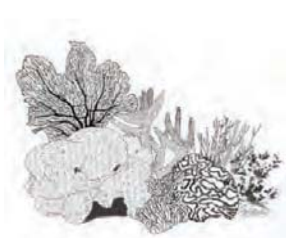
Coral reef species are collected for Eastern medicines (such as seahorses) and Western medicine (coral used for bone grafts).

Burt Jones and Maurine Shimlock photo

Medicines can be derived from a variety of coral reef organisms, including hard corals, gorgonians and others.

Experts estimate that 95% of the fish sold in the saltwater aquarium trade are wild-caught.

While these practices provide short-term economic benefits, if not managed in a sustainable way, they result in long-term damage.



CITES

The Convention on International Trade in Endangered Species (CITES) regulates the international trade of certain animals and plants. Under the terms of the convention, species are classified based on their vulnerability to extinction. Species listed under "Appendix II," including many corals, sea turtles and shellfish, cannot be imported without special permits.

Land-based Pollution

Land-based pollution is a serious threat to coral reefs. Sources of pollution can be:

- Non-point source pollution.
- Point-source pollution.
- Pollution causes eutrophication (excess nutrients) leading to phytoplankton blooms.

As coastal populations increase, so does the discharge of **effluents** (liquid waste products) in coral reef areas. It has been estimated that about forty percent of marine pollution is land-based, and ninety percent of this collects in shallow, coastal waters, where coral reefs thrive.

Seventy-five percent of pollutants entering the sea come from **non-point sources**, meaning that they come from a general area rather than one single source such as a discharge pipe. Examples include:

- Storm-water runoff from urban areas and industry.
- Agricultural runoff (pesticides, herbicides, fertilizers).
- Atmospheric discharge of soot (airborne materials generated from the burning of various fossil fuels) and toxic chemicals.

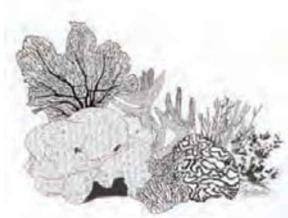
Point-source pollution comes from a specific, easily identifiable source that discharges directly into the water. It often leads to small areas of contamination that impact shallow, near-shore coral reefs. Examples include:

- Pipes that discharge industrial pollutants and toxins directly into the water.
- Sewage overflow.

More than 400 million gallons of oil enter the oceans every year, but only about 37 million gallons of it is from major oil spills – the rest is primarily from industrial waste and automobiles.

The main impact of pollution is the resulting excess in nutrients, primarily caused by human waste and agricultural runoff. **Eutrophication** (high nutrient levels) can produce increased algal cover, and can result in **phytoplankton blooms** (algal plankton) that turn the water green and block out the sunlight needed for hard corals to survive.

Pollution may also increase coral diseases and predators, and help the growth of animal competitors such as filter-feeding sponges, boring mollusks, and polychaete worms, which overtake living corals.



Coastal Development

Poorly managed coastal development can lead to:

- Acute physical damage from construction.
- Chronic, long-term damage from sedimentation and pollution.

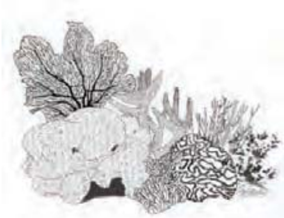
Almost half a billion people live within 100 kilometers of a coral reef. This number is expected to double by 2050, with the greatest increases in population likely to take place in the poorer developing countries in the tropics. Coastal development is necessary to support growing populations. However, unplanned development is one of the major causes of coral reef damage.

Construction to support growing human populations can cause **acute physical damage** to coral reefs. Coastal development damages coral reefs from:

- **Direct physical damage** from the construction of piers, resorts and airports, dredging of marinas or shipping lanes and land reclamation (shoreline filling) to build airports and hotels.
- **Pollution** from agricultural chemicals, sewage and other pollutants draining into the sea.
- **Sedimentation** from construction and inland erosion that reaches reefs from storms and rivers.

Singapore has lost an estimated 60% of its coral reefs through land reclamation.

Coastal development in Cancun, Mexico   Wolcott Henry photo



Sedimentation

Sedimentation is caused by:

- Dredging.
- Forestry.
- Agriculture.
- Over-grazing.
- Land-clearance.
- Land reclamation.
- Mangrove deforestation.
- Bottom-trawling.

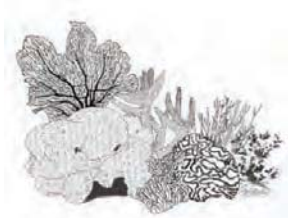
Sedimentation — suspended earth, rock and sand particles in the water — is a **leading cause of coral reef damage**. A main impact of coastal development has been increased sedimentation in near-shore waters. Corals cannot thrive in water containing high levels of sediment which:

- Makes the water cloudy or **turbid**, blocking out sunlight.
- Smothers and buries corals.
- Prevents **planula larvae** (juvenile corals) from finding a suitable **substrate** to colonize.

Sediment is washed into the sea from runoff in rivers and rainwater. It is also stirred up from the ocean floor. Sedimentation comes from:

- **Dredging** of ports and boat marinas.
- **Forestry**, particularly clear-cutting.
- **Agriculture**, especially ploughing between crops.
- **Over-grazing** of cattle and other animals.
- **Land-clearance** for housing, industrial development, agriculture, etc. Land cleared for logging or agriculture is most susceptible to erosion. Heavy rains wash the loose mud and silt directly into the ocean and onto coral reefs.
- **Land reclamation** and shoreline filling for coastal development.
- **Clearing of mangrove forests** for firewood and shrimp farms (mangroves filter sediments from the reef).
- **Bottom trawling** for fish.

Silt from dredging and runoff buries corals and suffocates sensitive reef organisms.



Tourism

Impacts from tourism are mainly produced from:

- Tourism development.
- Hotels, lodging and restaurants.
- Marine recreation.

The damaging impacts of tourism are primarily caused by:

- Coastal development.
- Hotel, cruiseships, lodging, and restaurant operations.
- Marine recreation.

Coastal Development for Tourism

Tourism related coastal construction includes the development of resorts, stores, restaurants and parking lots; the construction of piers and marinas; and the development of artificial beaches and beach replenishment. These activities lead to:

- **Physical damage** to the coral and reef structure.
- Increased **sedimentation**.
- Increased **industrial and toxic pollution**.

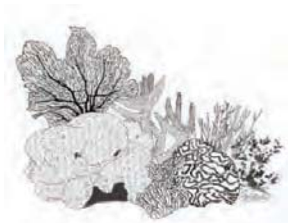
This can greatly affect the health of coral reefs, which can in turn, negatively affect the tourism industry.

Hotels, Lodging and Restaurants

Hotels, cruiseships, and lodging operations create solid and liquid wastes from landscaping, sewage, laundry, and other guest services. Restaurants that sell local endangered fish and shellfish are depleting the local marine resources. These activities cause:

- Increased **sedimentation**.
- Increased **sewage** and other **land-based pollutants.**
- Increased **destructive or overfishing** of marine resources.

It takes only a second to break a small piece of coral off, but it can take up to 25 years for it to grow back.



Marine recreation causes:

- Physical damage.
- Marine pollution.
- Sedimentation.
- Destructive fishing.
- Disturbances to marine life.

Tourism (continued)

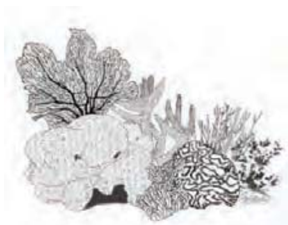
Marine Recreation

Specific activities such as snorkeling and diving can have negative effects on coral reefs, including:

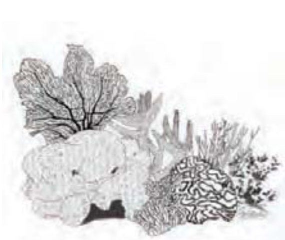
- **Physical damage** caused by anchors and ship groundings. In Guam there were at least 15 ship groundings and 13 sinkings between 1992 and 1996. Divers, snorkelers and swimmers also cause physical damage by kicking and walking on living corals.
- **Marine pollution** from boat maintenance and operation and improper sewage and garbage disposal.
- **Sedimentation** from poor boating practices, divers, and snorkelers.
- **Destructive and overfishing** of marine resources for souvenirs.
- **Disturbing marine wildlife** while viewing, such as turtles, whales, dolphins, and other wildlife.

For more information on tourism and coral reefs see CORAL's Handbook on Sustainable Tourism for Marine Recreation Providers.

According to NOAA, over 23 million Americans spend over 290 million boating days a year in coastal waters, primarily in coral reef areas.

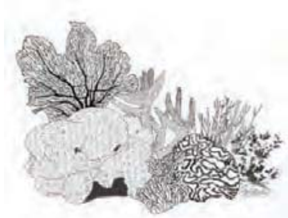


Part IV: Searching for Solutions



Coral reef conservation efforts include:

- International, Regional, and National projects.
- Community-based Conservation.
- Coral reef protected areas.
- Integrated Coastal Zone Management.
- Awareness/Advocacy.
- Sustainable Tourism.
- Coral Reef Recovery and Rehabilitation.
- Individual actions.



Searching for Solutions

Human activities are a serious threat to the future of coral reefs. If immediate action is not taken to reduce human impacts, many of the world's coral reefs could be lost forever. By promoting and participating in the conservation of these unique marine ecosystems, we protect the lives and homes of millions of sea creatures. We also enhace jobs, food, income and places of incredible natural beauty for local communities and tourists alike.

As public awareness of the value of coral reefs increases, so do efforts to protect them. Conservation programs range from international and regional projects `and laws to the day-to-day actions of individuals.

This section highlights the following solutions:

- International, Regional and National Efforts.
- Community-based Conservation.
- Coral Reef Protected Areas.
- ICZM – Integrated Coastal Zone Management.
- Awareness and Advocacy.
- Sustainable Tourism.
- Coral Reef Recovery and Rehabilitation.
- Individual Actions.

International Efforts

International programs:

• ICRI.

• ICRAN.

• GCMRN.

• ICRIN.

• Reef Base.

• Dive In To Earth Day.

• Reef Check.

• REEF.

International
Experts and policymakers from around the world have joined forces on several international initiatives to help understand, monitor, and reverse the decline in coral reef health. International programs address:

- Global trends.
- Shared lessons.
- Funding from international agencies and programs.
- International laws and conventions.

The central international body for coral reef conservation is called the **International Coral Reef Initiative (ICRI)**. ICRI draws on various international experts to develop solutions to coral reef problems, and draws attention to coral reef issues at international forums. ICRI has several operating units including:

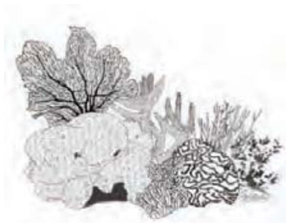
- **International Coral Reef Action Network (ICRAN)** – Improves marine protected area management and effectiveness (www.icran.org).
- **Global Coral Reef Monitoring Network (GCMRN)** – Central body for coral reef monitoring information (www.gcrmn.org).
- **International Coral Reef Initiative (ICRIN)** – Spreads awareness and education of coral reef issues (www.coralreef.org).

There are many other international coral reef initiatives that exist, such as:

- **Reef Base** - Online information system about coral reef ecosystems around the world (www.reefbase.org).
- **Dive In To Earth Day** - Grassroots coral reef conservation events held in more than 50 countries each year (www.coral.org/divein).
- **Reef Check (**www.reefcheck.org**)** and **Reef Environmental Education Foundation (REEF)** (www.reef.org) - Volunteer networks for global coral reef monitoring.

Coral reef conservation begins at home, yet there are lessons to be shared by experts and communities around the world.

International agencies such as the **United Nations Environment Programme (UNEP)**, and several non-governmental organizations such as the **Coral Reef Alliance**, the **World Wildlife Fund**, and **The Nature Conservancy**, also work at an international level to help reverse coral reef degradation.



Coral reef initiatives include:

- National programs.
- Regional programs.
- International programs.

Regional and National Efforts

Regional

Coral reefs regularly pass through more than one country, such as the Mesoamerican Barrier Reef, or the Red Sea. Even seemingly distant and remote coral reefs are interconnected by larval distribution, or are affected by the same weather patterns or human disturbances. It is therefore important to approach coral reef conservation from a regional perspective to address shared coral reef issues within a geographic region. Examples include the Caribbean Environment Programme (CEP), and the Eastern African Regional Seas Programme.

Regional initiatives help to:

- Identify and understand patterns such as coral bleaching events or disease outbreaks.
- Establish networks of marine protected areas (MPAs).
- Understand larval distribution.
- Monitor species distribution.
- Establish policies and programs that prevent and/or solve threats.

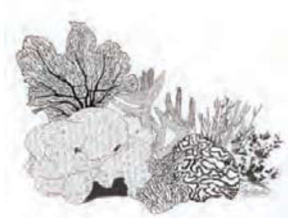
National

Coral reefs exist in more than one hundred countries, and national laws and policies vary greatly from one country to the next. In some, coral reef protection is incorporated within broad environmental policies. In other situations, there are particular agencies and laws that deal specifically with coral reefs. Involvement at the federal level is necessary to:

- Establish national laws and policies.
- Enforce legislation.
- Set up marine protected areas (MPAs).
- Collect user-fees (based on who are the "users" of a MPA) and taxes.
- Prioritize national funding for conservation projects.

Examples of national projects include the United States Coral Reef Task Force and the Indonesian Coral Reef Working Group.

The South Pacific Regional Environment Program supports coral reef conservation projects throughout Polynesia, Melanesia, and Micronesia.



Community-Based Conservation

Community involvement and support is key to the success of a conservation program.

- Key stakeholders: People who rely on coral reef resources for their livelihood.

Although it is important to address coral reef conservation from a global perspective, without the support of the local community, most conservation projects will not succeed. **Community-based conservation** involves the active participation and support of the local communities who depend on the coral reef for food and income.

Conservation planning should involve representatives from **key stakeholder groups** (people who rely on coral reef resources for their livelihood). Examples of key stakeholders include:

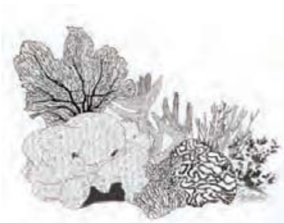
- Boat taxi drivers.
- Community members.
- Developers.
- Dive and tour operators.
- Fishers.
- Investors.
- Local government officials.
- Local merchants.
- Non-governmental organizations (NGO's).

It is also important to incorporate local knowledge and wisdom in coral reef conservation planning. In many parts of the world coral reefs have been successfully managed and protected by indigenous communities for hundreds of years.

In Fiji and other Pacific Island nations, reefs were sustainably harvested for millennia using wisdom passed down through generations.

There are many different ways that communities can be involved in coral reef conservation. For example, dive operators can collect user fees from tourists to support local marine protected areas. Fishermen can help patrol the reefs from illegal poaching. Community groups can organize regular beach cleanups and educational programs. In some cases, non-governmental organizations (NGO's) can be hired to manage the marine protected areas.

Every place is different, with its own reefs and unique problems. Models cannot always be replicated, but sharing lessons and information helps everyone improve their conservation efforts.



Different types of protected areas:

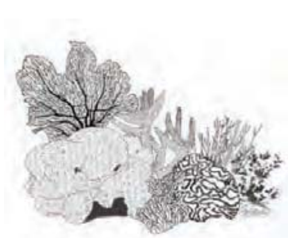
• MPAs.

• Reserves.

• LMMAs.

• Coral Parks.

The Great Barrier Reef Marine Park is the largest coral reef protected area in the world, covering 344,800 square kilometers.



Coral Reef Protected Areas

A **coral reef protected area** is an area that has been set aside to provide lasting protection for part or all of the coral reef and related ecosystems within its boundaries. Coral reef protected areas have been used as a management tool to protect, maintain, or restore natural and cultural resources in coastal and marine waters that contain coral reefs. They have proven to be one of the most promising solutions for the survival of coral reefs and the many benefits they provide to people.

There are many different types of coral reef protected areas that can vary in name, official designation and management approach.

- **Marine Protected Area (MPA)** generally refers to a protected area that is officially recognized by a government body. For example, Arrecifes de Cozumel in Mexico, Bonaire National Marine Park, or the Great Barrier Reef Marine Park in Australia.

- **Marine Reserve** is a protected area that prohibits fishing and harvesting of marine resources in order to protect fish stocks and other reef organisms. An example is the Hol Chan Marine Reserve in Belize.

- **Locally Marine Managed Area (LMMA)** is a community designated and managed protected area, such as the coral reef of Waitabu, Fiji. Each LMMA may have a different conservation strategy. For example, one may be a marine reserve, prohibiting fishing and harvesting of marine organisms, while another might balance different uses of local resources.

- **Coral Park** is a broad term used to describe any protected area that includes a coral reef within its boundaries and allows visitation (such as dive tourism). Just like parks on land, coral parks combine sensible recreation and management to help protect the park's ecosystem. Examples of coral parks are Bunaken National Park in Indonesia and Apo Island in the Philippines, both of which are also recognized MPAs.

Coral Reef Protected Areas (continued)

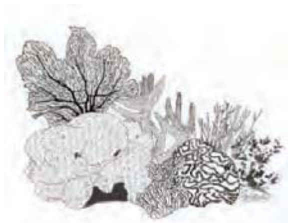
Benefits of MPAs include:

- Renewed fish stocks.
- Social and economic benefits.
- Research.
- Biodiversity.

Benefits of coral reef protected areas
If properly managed, coral reef protected areas can benefit from:

- **Renewed fish stocks.** Areas with **"no-take" zones** (no fishing) have shown to have:
    - Increase in fish **biomass** (weight of fish catch) both inside and outside the protected area.
    - Higher fish density and biodiversity.
    - Larger carnivorous fish and invertebrates.
    - Increase in fish larvae, which also repopulate neighboring areas as larvae is transported by currents.
- **Social and economic benefits**
    - Improved quality of life for local communities, as cultural heritage is preserved, and increased fish stocks lead to more food and income.
    - Reef-based tourism can be a non-extractive industry (an practice that uses the reef without harvesting resources) that attracts millions of divers and snorkelers each year. This income can replace the community's reliance upon destructive activities with short-term benefits such as dynamite fishing.
- **Research**
    - Researchers can learn about the natural functioning of intact coral reef ecosystems.
    - Scientists can conduct biomedical research in healthy coral reef ecosystems in order to find cures for diseases.
- **Biodiversity**
    - Protection of natural biological diversity and food web stability.
    - Protection of reproductive spawning grounds for fish and other reef-based organisms.

In 2000, there were an estimated 660 coral reef marine protected areas worldwide.



Coral Reef Protected Areas (continued)

Ten Ways Effective Parks Protect Coral Reefs

Coral parks and other types of coral reef protected areas have proven to be one of the most effective ways at protecting and conserving coral reef ecosystems. A coral park is a marine protected area (MPA) that includes a coral reef in its boundaries and allows visitors. The coral parks program of the Coral Reef Alliance (CORAL) helps tourism and conservation to work in partnership for the benefit of coral reefs, the tourism industry and local communities.

1. **Address Specific Threats.** Each coral park has its own goals and objectives, depending on what activities and threats are present. In general, parks protect against threats such as overfishing, coral collecting, dynamite fishing, mining, sedimentation, and pollution.

2. **Provide Active Management.** Staff or volunteers patrol the park, enforce rules, anticipate and address new threats, and provide services, facilities, and information to users.

3. **Supply Visitor Education.** Information is available to visitors and community members about the rules of the park and the life found there.

4. **Support Local Education.** Outreach and education programs for local communities help ensure protection of coral reefs. Examples include snorkeling programs for local children, seminars for those who work in or near the park, and resources and materials for teachers.

5. **Promote Dive Briefings.** Dive operators are active partners in frontline protection by briefing divers about ways to reduce recreational damage.

6. **Partner with Local Dive Operators.** They are the eyes and ears of the park and can report violations and encourage visitors to follow regulations.

7. **Collect Admission Fees.** Financial support comes from park visitors, ensuring that the park is self-sustaining and providing an insurance policy for the reef, allowing visitors to return to a protected spot. A self-financed park is not subject to politics or current fads.

8. **Install Mooring Buoys.** Moorings are in place, used and maintained. They protect fragile reefs from anchor damage caused by tour boats and fishermen.

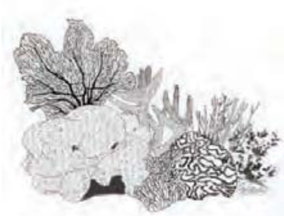
9. **Conduct Research and Monitoring.** Ongoing programs scientifically monitor the state of the reefs.

10. **Provide Protection for Critical Habitat and Endangered Species.** Parks are poised for action when development plans or overfishing threaten particular species. Parks can exert pressure to leave turtle nesting grounds undisturbed or fight the removal of nearby mangrove forests.

Integrated Coastal Zone Management:

- ICZM manages activities in all parts of the coastal zone.
- Communication and cooperation are keys to success.

A coast is more than just a beach. The coastal zone is the transitional area between land and sea.



Integrated Coastal Zone Management (ICZM)

ICZM takes a comprehensive approach to coastal zone management, with the goal of coordinating all uses of the coastal zone. This includes ocean-based activities such as fishing and diving; beachside activities such as beach replenishment and hotel development; and inland activities such as agriculture and forestry. ICZM views the coastal zone as a complete system, not as separate parts.

The underlying concept of ICZM is that **no part of the physical environment exists independently** — actions in one impact another. So, for example, if a mangrove forest is cut down, this could lead to coastal erosion and flooding, which could impact coastal settlements and destroy near shore coral reefs.

ICZM depends on **communication and cooperation** between all management bodies and stakeholders. For example, if the parks department of a local, state or federal government establishes a marine reserve — but does not use a comprehensive ICZM approach to coordinate with other coastal zone activities — the reserve may be threatened by impacts resulting from a large private sector development that is planned within the next five years. In an ideal scenario, stakeholders, government officials and community members involved in ICZM planning would be aware of these development proposals, and would communicate with the developers to come up with a compromise or alternative plan of action that minimizes impact to the environment.

Sustainable Tourism

Sustainable Tourism:

- Sustainable tourism allows future generations to use the resource.
- Unsustainable tourism destroys the resource.

Tourism is the fourth largest industry in the world and is growing rapidly. Eighty-five percent of all global tourism is in coastal areas. Reef-based tourism is a big draw for tourists and is vital to many tropical countries — especially small islands and developing states.

What is sustainable vs. unsustainable tourism?

- **Sustainable Tourism:** Tourism that provides economic benefits to local communities, respects cultural values, and minimizes environmental degradation for the long-term benefit of present and future generations.

- **Unsustainable Tourism:** Tourism that provides limited economic benefits to communities, disrespects cultural values, and degrades and destoys the natural resources that support the economy of a region.

What are the benefits of sustainable tourism?

- It is a non-extractive industry (uses the reef without harvesting resources) that can provide income to local communities while sustaining healthy reefs over the long-term.

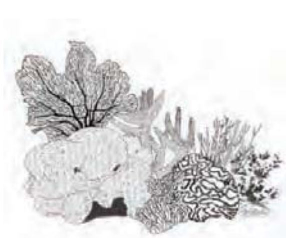
- It can help generate income and much needed revenue to keep a Marine Protected Area functioning. There is a demand for sustainable tourism from divers in particular, who are willing to pay more for the best dive spots, and are willing to do so through MPA user fees.

- It can educate tourists about the coral reef through environmental literature and briefings aboard boats and other tour operations and a general sense of businesses engaging in good environmental practices.

- It is estimated to be the largest growth area in tourism over the next decade. This growth can simultaneously benefit the environment and businesses and communities that adopt good environmental practices.

Sustainable tourism is estimated to be the largest growth area in tourism in the next decade.

For more information, see CORAL's Handbook on Sustainable Tourism for Marine Recreation Providers.



Awareness/Advocacy

Through education, people gain:

- Appreciation
- Respect
- Pride
- Foresight
- Empowerment
- Motivation

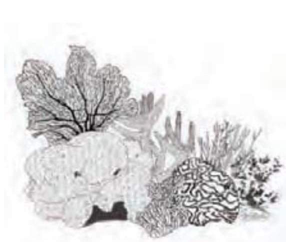
Outreach and education — to local communities, key stakeholders, policy makers, tourists, and other target audiences — is critical to any successful conservation program. We are all responsible for educating others about the value of coral reefs. Help coral reefs by sharing your knowledge.

Through education, people gain:

- **Appreciation** of the beauty and complexity of coral reef ecosystems.
- **Respect** for the value of coral reefs as sources of protein, income, medicine and recreation.
- **Pride** in local coral reef resources.
- **Foresight** and understanding of the long-term consequences of our actions, which might ultimately change our behavior.
- **Empowerment** with the knowledge necessary to make informed decisions and participate in management discussions.
- **Motivation** to participate in or support coral reef conservation projects through donations or time.

Fijian dive operators celebrate the completion of a CORAL workshop in Taveuni, Fiji, 2003.

The United Nations declared 1997 the International Year of the Reef to spread global awareness of the plight of coral reefs.

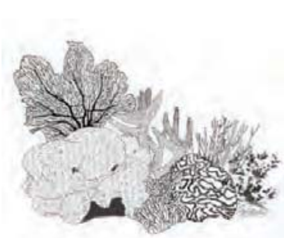


CORAL has educational and outreach materials such as good environmental practice guidelines for the marine recreation sector, issue briefs for policy makers and influential community leaders, and handbooks on other coral reef-related topics (See appendix, page 76). For more information, visit our website at www.coral.org or email us at info@coral.org.

Coral reef recovery and restoration:

- Restocking marine life.
- Transplanting coral fragments.
- "Planting out" artcficially reared corals.
- Enhancing coral growth rates.
- Artificial reefs.

Low-tech and low-cost restoration projects have been implemented in Komodo National Park using rock piles to help create places for corals to settle and grow.



Coral Reef Recovery and Restoration

Reef recovery occurs when a coral reef returns to the condition it was in before being damaged by threats such as hurricanes, oil spills, bleaching events, or other impacts.

Scientists are studying various ways to help restore reefs and restock marine life in damaged or depleted areas:

- **Transplanting coral fragments.** In areas that have been damaged by storms or development projects, biologists can take coral fragments and reattach them to the substrate to establish coral colonies in new areas.
- **"Planting out" artificially reared corals**. This process involves taking corals grown in farms — both in the ocean and in artificial tanks — and placing them out in living coral reef areas.
- **Enhancing coral growth rates**. Scientists are looking at various ways to enhance the growth rates of living corals. One method, called mineral accretion, uses low voltage electrical current to speed up the growth rates of marine organisms with limestone skeletons.
- **Artificial reefs**. Often constructed of such items as old tires, rocks and "reef balls," artificial reefs can contribute to the recovery of marine life in previously damaged or depleted areas.

Some scientists question the value of such approaches in comparison to natural recovery processes. Furthermore, the high cost of such activities makes them unrealistic options for most coral reef communities. At a minimum, efforts should be made to reduce human threats, educate people, and create Marine Protected Areas (MPAs) that prevent damage from occurring in the first place.

Divers survey a reef in Indonesia.

We can all make a difference:

• In our communities.

• In the water.

What We Can Do As Individuals

Everyone Can Help Keep Coral Reefs Alive and Healthy

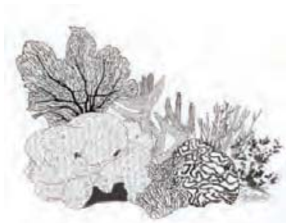
As a community member:

- Learn about and obey local laws designed to protect coral reefs.
- Support local MPAs and other coral reef protected areas by paying user-fees, even if they are voluntary.
- Participate in community stakeholder discussions.
- Volunteer your time or money to help with a conservation project (organize a Dive In To Earth Day event www.coral.org/divein).
- Share your knowledge with others.

In the water:

- Do not step on or touch coral.
- Do not disturb or harass marine life. *(Download CORAL's Diving, Snorkeling, Whale & Dolphin Watching, and Turtle Watching Guidelines at www.coral.org.)*
- Be a responsible boater: avoid dropping anchors on coral reefs, dispose of waste in a proper receptacle, navigate carefully, use clean-burning 4-stroke outboard engines, perform regular maintenance on engines and fuel tanks, safely dispose of waste, etc. *(See CORAL's Handbook on Sustainable Tourism for Marine Recreation Providers).*

Dive in to Earth Day 2003 in Apo Island, Philippines.



We can all make a difference:

• At home.

• If you live on a small island.

What We Can Do As Individuals (continued)

At home:

- **Reduce, reuse, recycle**. Try to keep trash to a minimum and dispose of batteries in a safe way. Try to avoid excess packaging and plastic bottles, which often end up on in the ocean.

- **Save energy**. Turn out lights you are not using. Run dishwashers and washing machines with full loads. Buy energy efficient appliances. Wrap your water heater to save heat. Use compact florescent bulbs.

- **Drive less**. Take public transportation to help reduce fossil fuel emissions. Join a car pool. Walk or bike to work.

- **Avoid fertilizers or other pesticides** in your garden.

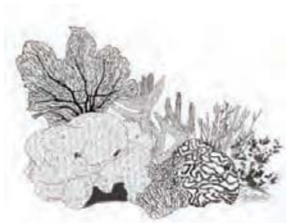
If you live on a small island:

- Avoid non-biodegradable items such as styrofoams and plastics, which can threaten marine life if they get into the ocean.

- Buy non-threatened fish species that are harvested in a sustainable manner and do not deplete local fisheries.

- Avoid dumping toxic chemicals and household cleaners down drains and sewers that flow directly into the ocean.

- Promote and support community programs aimed at protecting local coral reefs and other natural areas.



Dive in to Earth Day 2003, cleaning trash from the beach in Barbados.

We can all make a difference:

• As a consumer.

• As a business owner.

What We Can Do As Individuals (continued)

As a consumer:

- Avoid purchasing souvenirs made from coral or other marine organisms.

- Buy the least toxic household products, such as biodegradable cleaners or water-based, low biocide/volatile organic compound (VOC) paints.

- Avoid ordering seafood that is harvested in an unsustainable way. For more information, check out www.seafoodchoices.com.

- Support businesses that make an effort to protect the environment.

As a marine recreation business owner or operator:

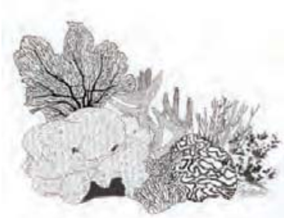
- Avoid selling items that threaten local natural areas, such as coral jewelry, shells or threatened fish species.

- Support environmentally responsible boating practices such as the use of moorings as an alternative to anchoring (See CORAL's handbook, *Sustainable Tourism for Marine Recreation Providers*).

- Support and promote sustainable fishing practices.

- Educate tourists about how to minimize their impact on the environment during marine recreation activities.

- Support work being done by local non-governmental organizations (NGOs) to protect the environment.



Wolcott Henry photo

Avoiding the purchase of ornamental items such as coral jewelry can go a long way towards protecting coral reefs.

Activities to help reduce threats to your reefs

Here are some creative ideas to help reduce threats to your reefs:

Overfishing and Destructive Fishing

- **Conduct fish or reef surveys.** Monitoring species diversity and abundance on the reef helps track changes and improves our understanding of the threats impacting those changes, such as overfishing. You can take part in reef monitoring programs such as Reef Check or REEF.

- **Make friends with local fishers**. Teach a fisher how to dive, or hire local fishers to give them an alternative source of income. Talk to fishermen about the benefits of marine reserves and coral reef protected areas.

- **Involve children.** Children are our future fishers - and our future ambassadors for coral reefs. Teach them about the beauty and importance of coral reefs. Plan a lesson or event with the local school that teaches about over-fishing and destructive fishing. Have a conservation poster contest and display the entries in local business windows.

- **Bring the underwater world to the non-diving community.** Show slide shows and videos of beautiful coral reefs to your community. Set up a touch tank for local kids and adults to experience some of the amazing creatures that inhabit the reef. This can help educate them about species that are affected by destructive fishing practices.

- **Hold a fair or festival.** You can use a variety of activities at a festival to involve and educate, including art displays, environmental displays, music and speakers. You can also raise funds with sales of food or merchandise and donate those funds to your local coral reef protected area. Involve the community in planning and execution by soliciting participation by businesses, clubs, or other community groups.

Anchor Damage

- **Install mooring buoys**. Even a carefully placed anchor can drag and destroy reefs. Installation and use of mooring buoys dramatically reduces anchor damage on reefs. *Borrow ideas from CORAL's Handbook on Mooring Buoy Installation and Maintenance.*

- **Throw a fundraiser** to raise money for new buoys and for mooring buoy maintenance.

- **Plan a community meeting.** Build community support and awareness by holding a slideshow that contrasts healthy and anchor-damaged coral.

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Coastal Development

- **Invite local government** and policymakers on a glass bottom boat tour. The opportunity to experience the reef first-hand can leave a lasting impression and stimulate interest in coral reefs.

- **Mangrove restoration**. Support mangrove restoration in your local community and talk to your local government about the importance of mangroves to coral reef health.

- **Have children conduct a natural history of your area**. Talk to the elders and find out where vibrant reefs and mangroves used to be. This helps preserve cultural traditions and illustrate the impacts of development.

- **Help your community adopt a reef, coral park or beach.** You can personalize efforts by focusing on one area to protect and preserve.

- **Have a coastal/underwater clean up.** Keep track of the types and total quantities of garbage to help determine what is impacting the reefs.

- **Start an indigenous plant nursery**. Removal of vegetation for development increases erosion and increases sedimentation in coastal waters. Planting native plants helps protect the reefs.

Diver / Snorkeler Damage

- **Distribute Coral Friendly Guidelines.** These guidelines help raise awareness of ways that divers and snorkelers can reduce damage to the reef. You can download copies at www.coral.org**.**

- **Participate in community events such as *Dive In To Earth Day*.** This helps build a community network of concerned citizens. Visit www.coral.org/divein.

- **Offer buoyancy clinics.** This can be a fun way to strengthen bonds within the dive and snorkel community and refresh basic skills in a casual setting.

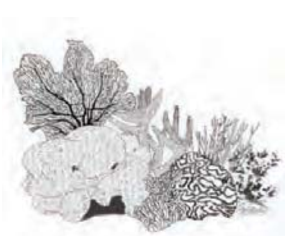
- **Give environmental dive briefs** to your clients on every dive. Studies have shown that divers who have been given an environmental brief cause far less damage to reefs.

- **Are your dive sites too crowded?** If the same dive groups tend to visit the same dive sites, consider rotating through several different sites. This helps to reduce stress on the reef and makes sites more attractive places to dive.

- **Form a Dive Operator Association.** Work with others in the dive industry to develop local codes of conduct and environmental standards. A unified voice can make a big difference.

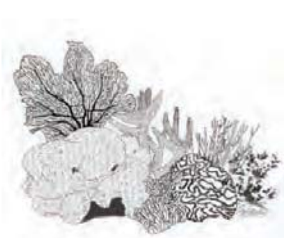
We can all help to keep coral reefs alive for future generations.
Thank you for doing your part - The Coral Reef Alliance (CORAL)

Part V: Appendix



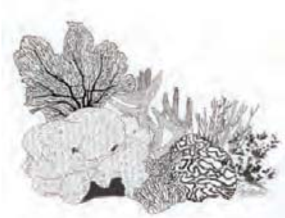
Glossary

Acute threat: A threat that is short-term and dramatic.
Ahermatypic (non-reef building) corals: Corals with a soft, bendable skeleton and eight tentacles; also known as soft corals.
Annelids: Worms that have a segmented body form. Marine worms are called polychaete worms.
Anthozoans: Marine organisms with radial segments that grow individually or in colonies (corals, anemones, gorgonians).
Anthropogenic threat: A human-induced threat to the natural environment.
Asexual reproduction: A form of reproduction that takes place without the formation or union of gametes (eggs and sperm).
Atoll: A type of coral reef that develops as a ring around a central lagoon; commonly the result of sinking islands or volcanoes.
Back reef: The inner section of a barrier reef or atoll that rises up towards the shallow waters of the reef flat.
Bank or platform reef: Open ocean reefs that are simple structures with many different origins, yet no clear attachment to the coastline.
Barrier reef: A type of coral reef that generally is found at some distance from the coast. At their shallowest point they can reach the water's surface and form a "barrier" to navigation.
Biodiversity: The total diversity of living things and of the ecosystems of which they are a part (including species, genetic and ecosystem diversity).
Bioeroders: Any living organisms that naturally breaks down coral by burrowing, scraping away, or eating the coral. Examples include urchins, parrotfish and some polychaete worms.
Biomass: The total weight of living organic material in an environment.
Bleaching: Symbiotic algae (zooxanthellae) are expelled by reef corals causing the coral to look white or "bleached"; generally a response to stress.
Bottom trawling: A method of fishing where large nets are weighted and dragged behind a vessel, often catching many target and non-target species and well as causing significant physical disturbance to bottom habitats.
Branching: A type of coral growth form where colonies branch out to maximize surface area; commonly found in calm, shallow waters.
Breakwater: A barrier that protects a shore from waves and coastal erosion.
Brooding: A form of fertilization where planula larvae develop within the stomach-like structure of corals before they are released into the water.
Budding: A form of asexual reproduction in which a new individual is produced as an exact gentic replica of the parent polyp.
Buttress zone: Deep channels outside of a reef crest where spur and groove formations commonly occur.



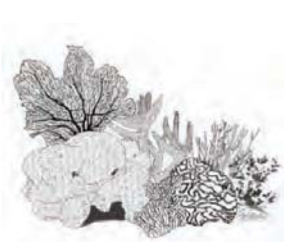
Glossary

Calcareous algae: Algae that secretes calcium carbonate from seawater and deposits it in its tissues. When the algae dies, it leaves a fossil "skeleton" behind.
Calcium carbonate: A mineral that hard corals secrete from sea water to create their limestone skeletons.
Calyx: A small, cup-like skeletal depression which is home to the coral polyp.
Carbon sink: Ecosystems, such as oceans and forests, that absorb carbon from the atmosphere.
Chronic threat: A threat that is persistent over time.
Cnidarians: Invertebrates with stinging cells and a large stomach cavity (corals, anemones, jellyfish).
Cnidocyte: A type of cell which releases a harpoon like structure (called a nematocyst) for capturing prey and defense; found in Cnidarians.
Colonies: The collection or family of polyps that make up a coral head.
Commensalism: A symbiotic relationship in which one species benefits without harming the other.
Community: All the plant and animal species that live together in a particular habitat.
Coral park: A broad term that is used to describe any protected area that includes a coral reef within its boundaries and allows visitation.
Coral reef protected area: An area that has been set aside to provide lasting protection for part or all of the coral reef and related ecosystems within its boundaries.
Coral spawning: The release of coral gametes (eggs or sperm) into the water for external fertilization.
Crown of Thorns starfish: A starfish that eats living reef corals.
Crustaceans: Animals with a segmented body and an external skeleton or shell made of calcium carbonate (crab, lobster, shrimp, barnacles).
Cup/flower coral: A form of soft, ahermatypic coral that is commonly found in caves or overhangs where hard, hermatypic corals are rare.
Cyanide fishing: The process of using cyanide to poison and stun fish for capture on a coral reef; commonly used to catch live fish for restaurants or the aquarium trade.
Detritivores: Organisms that feed on dead plants and animals and their wastes (sea cucumbers, bristle worms, certain starfish).
Digitate: A type of coral growth form also known as finger or columnar; commonly found in calm or deep waters, below the reach of normal wave action.
Disturbance: An event that brings about biological or physical change to an ecosystem.



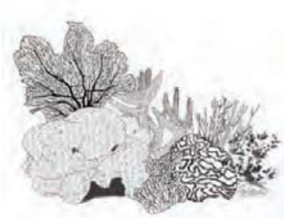
Glossary

Dynamite or "blast" fishing: The process of using dynamite or other explosions to capture fish from a coral reef or other marine environment.
Echinoderms: Sea animals with a radially symmetric body, a water-vascular system, and tube feet (sea stars, urchins, sand dollars).
Ecology: The study of the interactions among and between organisms and their environment, and of the abundance and distribution of those organisms.
Ecosystem: The combination of biotic (living) organisms - fish, algae, zooplankton - and abiotic (non-living) conditions - rain, salinity, sunlight - that make up a particular environment, and make it unique.
Effluent: Something that flows into waterways or into the ocean, including outflow from sewers or discharge of liquid waste.
Elkhorn: A type of coral growth form that has large, sturdy, and flattened branches; often found in calm waters.
Encrusting: A type of coral growth form that is generally flat, spread out and grows in a thin layer on a hard surface; commonly found in areas of very high-wave energy or very poor sunlight.
Erosion: The process of wearing away or gradually destroying.
Eutrophication: Pollution caused by an increase in plant nutrients in coastal marine environments.
Filter feeder: Feeders that filter food particles from the water column (corals, sponges).
Foliose: A type of coral growth form with wide flattened plates.
Fragmentation: A form of sexual reproduction. Coral broken off into pieces as a result of wave action or storm surges may still have living tissue and can re-attach and eventually begin to grow again as living coral colonies.
Fringing reef: A type of coral reef that develops as a narrow structure close to the shoreline. They usually parallel the coastline and at their narrowest point can reach the water's surface.
Gamete: A type of reproductive cell (eggs, sperm) that develops into a new individual after its union with another gamete.
Ghost nets: Nets that have inadvertently or purposefully been discarded from fishing or other vessels. Theses nets are known to drift around the ocean for several years and in many cases lead to the death of marine animals that become entangled or coral reefs that they wash up onto.
Global warming: An increase in the natural phenomenon known as the "greenhouse effect" as a result of an increase of carbon dioxide and other gases in the atmosphere.
Gorgonians: Anthozoans with a skeleton made of protein (sea fans, sea whips).



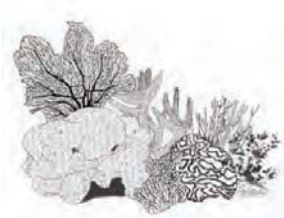
Glossary

Greenhouse gases: Various types of gases in the earth's atmosphere that contribute to a natural warming of the planet through the greenhouse effect.
Habitat: The specific location where a plant or animal lives.
Hermaphrodite: An organism that has both male and female sexual organs.
Hermatypic (reef-building) coral: A coral that builds reefs through the deposition of calcium carbonate, usually contains zooxanthellae.
Intertidal communities: The community of organisms found in the zone between the high and low tide.
Invasive/Exotic or "non-indigenous" species: A foreign species introduced into a new environment by humans.
Invertebrates: Animals lacking a backbone.
Lagoon: A shallow and generally sheltered body of water separated from the open sea by coral reefs, and/or barrier islands.
Land reclamation: Modification of land in order to make it suitable for cultivation or development.
"Live rock": Dead coral and other calcium carbonate deposits on a reef that provide habitat for numerous reef dwelling organisms.
Locally marine managed area (LMMA): A community designated and managed area that protects coral reefs and other marine resources.
Mangroves: Shrubs and trees that live along the seashore in tropical and sub-tropical regions and have a high tolerance for the chemical composition of saltwater.
Marine protected areas (MPAs): An area of coastal land and water that is specifically designated to protect natural resources and ecosystems.
Marine reserve: A type of marine protected area that prohibits fishing and other extractive resource use.
Massive: A type of coral growth form that is ball-shaped or boulder-like. Massive corals tend to be found in areas of high wave action; can be as small as an egg or large as a house.
Mollusks: Invertebrates with a soft, unsegmented body, a muscular foot, and sometimes a shell (bivalves, squids, octopuses, snails).
Muro Ami: A method of fishing where free divers collectively bang a reef with rocks, sticks and other objects in order to lure fish into nets.
Mushroom: A type of coral growth form that is not attached to the reef, and resembles the tops of mushrooms.
Mutualism: A symbiotic relationship in which both species benefit.
Natural threat: A natural occurrence that can threaten living ecosystems, such as storms, El Nino cycles, or geological events such as earthquakes and volcanic eruptions.



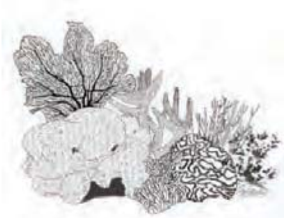
Glossary

Nematocysts: Small, harpoon-like structures possessed by cnidarians which contain stinging cells and are used to capture prey.
Non-point source pollution: Pollution whose origin is not easily identifiable (e.g. runoff from a parking lot or pollution in a river generated from a variety of sources.)
"No-take zones": A general description for areas where fishing and commercial extraction is prohibited.
Organism: Any living thing which is composed of one or more cells.
Overfishing: Fishing an area beyond the capacity for fish stocks to remain sustainable over time.
Parasitism: A symbiotic relationship in which one species benefits while the other is harmed.
Patch reefs: Small areas of reef that occur in shallow waters and lagoons.
Phase shift: When a main component of a reef, such as hard corals, die off, this process takes place in which new organisms, such as algae or soft corals, fill in the open ecological niches.
Photosynthesis: The chemical process of taking energy from the sun and producing organic matter.
Phylum: A major division of a biological kingdom, consisting of closely-related classes (e.g. Cnidaria, Porifera).
Phytoplankton bloom: An excess growth of algal plankton in the marine environment, often caused by eutrophication.
Planula larva: The young larva of corals.
Point-source pollution: Pollution that enters the environment from an identifiable source, such as a sewer or pipeline.
Polychaete worms: Invertebrate worms that have a segmented body form. There are nearly 8,000 species, many of which are found in coral reef ecosystems.
Polyp: An individual cnidarian or member of a cnidarian colony.
Population: All the members of one species in a habitat.
Porifera: Invertebrates that are commonly known as sponges.
Primary consumer: Organism that feeds on primary producers.
Primary producer: Organism that produces energy from the sun (e.g. plants).
Reef crest: The shallow and sloping outer edge of a coral reef; often forming the highest portion of the reef.
Reef flat: The wide and typically shallow upper surface of a coral reef that extends outwards from the shore.



Glossary

Reef front (fore reef): The outer part of a barrier reef or atoll where the reef slope falls steeply towards the seabed; typically where the greatest diversity on the reef is found.
Reef recovery: The process in which a reef recovers to its previous condition prior to damage incurred from such things as hurricanes, oil spills or bleaching events.
Secondary consumer: An organism that feeds on primary consumers.
Sedimentation: The build-up of natural material such as earth, rock and sand that settles to the bottom or stays suspended in the water column.
Sexual reproduction: Reproduction that involves the union of gametes.
Submassive: A type of coral growth form that develops as knobs, columns or wedges protruding from an encrusting plate.
Substrate: The bottom-type or material on or in which an organism lives.
Shoals: Shallow sand banks or sand bars in the marine environment.
Spur and groove: The section of a reef found seaward from the reef flat and is made of high ridges of corals (spurs) that are separated by sandy bottom channels (grooves). Wave and wind dominated regions often lead to the development of spur and groove formations.
Sustainable tourism: Tourism that uses natural resources in such a way as to leave them healthy and undamaged for future generations.
Symbiosis: A close relationship between two species that generally benefits at least one of the organisms; different types include commensalism, mutualism, and parasitism.
Taxonomy: An ordered scientific classification system that starts with the broadest set of similarities between living organisms, and progressively moves towards greater levels of common characteristics.
Tertiary consumer: An organism that feeds on secondary consumers.
Trophic levels: Levels of feeding within an ecosystem.
Table: A type of coral shape that is flat or "table-like" and is often found in calm, well-lit water and has broad horizontal surfaces with fused branches.
Turbidity: Suspension or stirring up of sediment and foreign particles in water.
Unsustainable tourism: Tourism that degrades and destroys the natural resources that support the economy of a region.
Zooplankton: Animal plankton that live within the aquatic realm.
Zooxanthellae: Small algae (or dinoflagellates) that live within the tissues of reef corals and other marine animals. Zooxanthellae, as photoynthesizers, provide some corals with the majority of their nutrition.



About the Coral Parks Program

What is a coral park?

A coral park is a protected area that includes a coral reef in its boundaries and allows visitors. The coral parks program helps tourism and conservation to work in partnership for the benefit of coral reefs and the tourism industry.

The goal of the Coral Parks Program of the Coral Reef Alliance (CORAL) is to help coral park managers leverage sustainable tourism to build local investment in the conservation of coral reef parks. We work to achieve this goal by providing training, tools and resources to partners in local coral reef communities, including dive operators, conservation groups, and community leaders, and through our global partnership with the International Coral Reef Action Network (ICRAN). Our current geographic focus is on the Western Pacific, the Caribbean and the Mesoamerican Barrier Reef.

Training and technical assistance for coral parks: CORAL provides on-site training and technical assistance to communities and businesses that depend on coral reefs, helping to ensure the success of local coral parks. Topics include sustainable financing, preventing anchor damage, sustainable marine tourism, and coral reef ecology. CORAL works with marine recreation providers, bulk purchasers (such as cruise lines and tour operators), park managers, and other community members involved in the coral reef tourism industry. Through the development of partnerships between tourism and coral parks, CORAL builds cooperation that enhances both environmental and economic sustainability.

Financial support of park conservation programs: CORAL's microgrant program has provided much needed financial support to local conservation programs around the world. Since 1995, CORAL has provided over $350,000 in microgrants to support grass-roots conservation. Currently, CORAL provides seed money to local partners participating in CORAL's training program. Through microgrants we help coral parks pay for mooring buoys to stop anchor damage, purchase functioning boats to patrol and enforce fishing rules, and publish brochures to educate visitors of park rules. Read more about past microgrant recipients on the CORAL website.

Information and Resources: The parks program provides tools and resources, as well as education and outreach materials (see page 76), to help park managers and communities to more effectively protect their coral reefs. Visit our website at www.coral.org to find information on:

- Coral Reef Fact Sheets for the general public
- International Directory of Coral Reef Organizations
- Online Coral Reef Education Materials Library
- Coral Reef Photobank

For more information:

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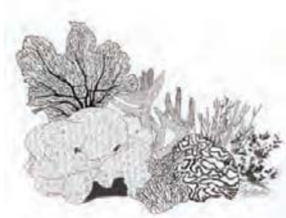


CORAL's educational and outreach materials:

• Guidelines for good environmental practices.

• Issue briefs for policy makers and community leaders.

• Handbooks on:

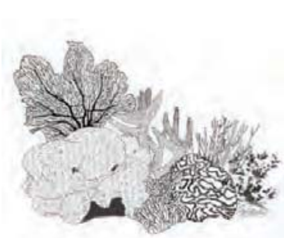
Coral Reef Ecology, Threats and Solutions.

Sustainable Tourism for Marine Recreation Providers.

Mooring Buoy Installation and Maintenance.

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."

-Maragaret Mead



CORAL's Educational and Outreach Materials

The Coral Reef Alliance (CORAL) has developed a broad selection of outreach and educational materials to promote the conservation and protection of coral reefs. Some of our materials include the following:

Guidelines for Good Environmental Practices - CORAL's guidelines reflect the most commonly accepted "good practices" around the world for marine recreation activities and give essential advice on how to protect coral reefs while enjoying activities in and around them. Guidelines are available in English, Spanish, Indonesian and Japanese, and address the following topics:

- Diving
- Snorkeling
- Whale and Dolphin Watching
- Turtle Watching
- Underwater Cleanup

Environmental Issue Briefs - CORAL's issue briefs discuss some of the most important issues being addressed by CORAL and the partners of the International Coral Reef Action Network (ICRAN), and are designed to assist policymakers, business leaders and other influential community members to make informed decisions on issues that affect the health of coral reefs. Issue briefs are available in English and Spanish, with topics including:

- Coral Reefs and Global Climate Change
- Coral Reefs and Sustainable Coastal Development
- Watersheds and Healthy Reefs
- Exploitive Fishing
- Effective Coral Reef Marine Protected Areas (MPAs)
- Coral Reef Mining, Harvesting and Trade

Handbooks - CORAL's handbooks provide a comprehensive look at the nature of coral reefs, threats to these marine ecosystems, and practical solutions to promote and implement conservation and sustainable business practices. Our handbook series includes the following publications:

- *Introduction to Coral Reef Ecology, Threats and Solutions*
- *Mooring Buoy Installation and Maintenance.*
- *Sustainable Tourism for Marine Recreation Providers*

For more information on available materials and resources, visit our website at www.coral.org or email us at info@coral.org.

TEACHING STRATEGIES

In this Teaching Strategies section you will find directions for several generic activity "structures." CORAL regularly uses these activity structures to help participants talk and share their related prior knowledge, or to distill and summarize what they have recently learned.

These generic activity structures emphasize short, small group discussions. You will find the activity structures referred to in specific places within each section of the guide. In these cases, content-specific questions or statements pertaining to the activity are provided along with the note to "see the Teaching Strategies section for how to present this activity." The questions or prompts to use are provided within each activity, and the description of how to present the strategy is found only here in the Teaching Strategies section.

Constructivist learning theory maintains that learners construct new concepts only when new information builds on and is compared with their prior knowledge. These activity structures are meant to be simple and accessible, and to help participants to build their knowledge and understanding of the topics being explored.

KWL EXERCISE

KWL is a quick way to do needs assessment for the group you are working with. The acronym represents **K:** those things you already know, **W:** those things you want to know or learn and **L:** those things that have been learned during the course of the workshop. The K and W parts of the exercise are done at the beginning of the workshop. The L part of the exercise is done at the conclusion of the workshop. The exercise will take place in two parts. Part I is the K & W portion, which takes places at the beginning of the workshop. Part II is the L portion that is touched upon following each presentation and at the conclusion of the workshop.

Materials needed:

- Flip chart paper with headings of Know About Coral and Sustainable Tourism, Want To Know About Coral and Sustainable Tourism, and Learned About Coral and Sustainable Tourism
- Flip chart markers

Exercise:

- Explain to participants that you would like to have a sense of the knowledge base in the room & that the exercise is being used so that there is the best opportunity to draw on their knowledge, provide information about what they want to know and acknowledge what they have learned.
- Ask participants to write down three ideas for each category (K & W). Explain that the L part will be done at the end.
- After a few minutes, ask participants to share what they know and want to know. If the group is quiet, ask participants to turn to a partner near them and discuss their lists. Following discussions, ask participants to share what they heard from their partners (this takes some of the pressure off of participants having to share their own lists).
- If a participant repeats something already mentioned, place a check mark next to the entry and query the entire group if others had the same idea.

Important: Accept all answers in this activity. Do not correct or modify the responses that participants provide. Also, do not provide immediate answers to things participants would like to know/learn. Periodically return to the list to see if answers have been uncovered through presentations or discussions.

BRAINSTORMING

Brainstorms are effective tools for getting groups to generate original or creative ideas, solutions, or thoughts on any topic. The most important part about facilitating a brainstorm is to capture the ideas and paraphrase comments for all to hear.

Ideas and Guidelines for Effective Brainstorming

- Write down whatever participants contribute without correcting, editing, or evaluating the content. If a contribution is a misconception or is challenged by another participant, you can circle it and say that there is a question about this, and the workshop may help to figure out if it is a correct statement or not. If, after the workshop, the group still isn't sure, then you can say this is a topic for more exploration beyond the workshop. If a misconception is not challenged, record it on the chart and make a mental note to address and correct the misconception in the context of the workshop.
- Give all participants the opportunity to contribute to the brainstorm.
- Ask the participants if you are recording their ideas accurately.
- If some participants don't contribute ideas, start the brainstorm in small groups, or pairs, and have one participant act as the spokesperson for the group. The spokesperson can say the name of the participant who contributed the idea.
- Always record the brainstorm sessions on paper rather than the board so they can be preserved, reflected on, and added to.

THREAT RANKING ACTIVITY

This activity allows participants to: 1) use a brainstorm to identify perceived local threats to coral reefs; 2) select those which they feel they could realistically help reduce, and; 3) rank those selected threats from most severe to least severe. The threat ranking promotes small group discussion and helps to identify local priorities for community-based conservation solutions.

BRAINSTORMING THREATS (15-20 minutes)

Purpose

- Gather different perceptions about local threats.
- Generate new information, perspectives and ideas.

Materials:

- Flip-chart paper & markers

Steps

A **(IF THERE IS TIME) –**

1. Ask a participant to draw a basic map of the coral reef area being discussed.
2. Have the volunteer mark or label the sites where the group identifies as recreation sites.

(This step gives participants a visual aid and gets them thinking about dive sites where they work, thus making threats more personal and addressing threats that specifically impact their businesses.)

B (if time is too limited to do part A, then ask participants to brainstorm without the map) Ask: "What issues concern you when you think about these sites?" Capture participant responses on flip charts. If issues are raised more than once, place a "+" symbol next to it. See description of Brainstorming activity for further tips on facilitating a productive brainstorm session.

Select Threats That Community Can Impact

1. Ask group to consider the list and select 5-10 threats that they feel impact their business the most. Stress, however, that they should select threats which can be mitigated by local action. So, for example, bleaching caused by global warming is a difficult issue to take on and show progress towards relieving on a local level. So ideally bleaching due to climate change will not be included in the top five.

RANKING THREATS (30 minutes)

Purpose

- To determine which threats are a top priority to the group.

Materials

Photocopied threat ranking worksheets
Pens for participants
Calculator (if needed)
flip-chart and colored markers

Steps

Divide participants into groups of 3-5 people
Explain to the group that they will rank the threats on a scale of 1 to 5 (1 = least severity, 5 = most severity) by:
AREA – the portion of coral reef that the threat will affect. Will it affect all of the reefs or just a small part?
INTENSITY – the impact or severity of destruction caused by the threat. Within the area, will the threat completely destroy the coral reef or will it cause only minor changes?
URGENCY – the immediacy of the threat. Is it a current threat? Will it occur only 25 years from now?

Each group will receive a worksheet and will be asked to fill it out and do the calculations together. After they are finished, facilitator will add the total numbers to see what the group as a whole considers to be the top threat.

Worksheet
Site Name:
Site Description:
Today's date:
Completed by:

	THREATS	Area	Intensity	Urgency	Total
1.					
2.					
3.					
4.					
5.					

SOLUTIONS CAROUSEL

This activity allows participants to work in small groups to brainstorm practical solutions that might help relieve the identified top threats to local coral reefs.

Materials:

Flip chart paper – one for each local threat and some extra sheets in case participants run out of room.
Felt tip marking pens – a different color for each group of 4-6 participants
Masking tape for posting flip chart paper

For the Solutions Carousel:

1. Decide how many "solution sheets" you would like to use. The number will depend on the number of participants you have in the group (teams of no fewer than 2 participants and no more than 5 will rotate around the room—your minimum number of response sheets should equal the number of teams you have as each team needs to be at a response sheet). The number you decide on also will depend on the number of threats you want the teams to respond to.

2. Label each piece of butcher paper with the threat you would like the participants to respond to. Post these along the walls and spread them out around the room.

Possible Questions to Mix In To Reduce Group Size:

- What challenges might make some solutions difficult to put into place?
- What indicators can we use to show threat reduction?

1. Inform the group that they will be taking part in a group solutions activity. Point out that they will work in teams to identify local solutions to a series of threats already identified from the threat ranking activity.

2. Show them the large sheets of paper with threat and questions posted around the room. Read each one out loud.

3. Assign teams up to the number of response sheets you have posted. Let them know that their group will be assigned to begin at one of these sheets. Explain that each group will have a specific color of marking pen to share, and that they will use it to record their groups' solutions to each of the threats or topics listed. The sheet of paper has a topic at the top, and the group will brainstorm and record everything that they can remember about the topic.

4. When they arrive at a station where others have already recorded their responses, their first task will be to read all the previously recorded statements on the sheet. If their group generally agrees with a statement, they should make a "+" (plus) sign next to it. They may also add to the statement. If they disagree with a previously recorded statement, their group should make a "-" (minus) sign.

5. Tell them that they will have only a few minutes to respond to each prompt and that you will make an announcement when it is time for the groups to rotate to the next question or topic. Indicate the direction in which they will be rotating. They will have approximately 5 minutes at their first station, but as the activity progresses, it will become more difficult to come up with new statements, so you will give them slightly less time to write.

6. Ask if there are any questions. Tell them they may begin brainstorming and writing. Announce the rotation time approximately every 5 minutes, reminding them in which direction to rotate.

7. When each group has been to every station, and has returned to their original station, give them some time to read what the others groups have written. After a few minutes, ask them to return to their seats for a discussion of the activity.

Debriefing the Solutions Carousel

After each group has contributed responses to each sheet (and can do a final cycle through to add + or – symbols to new ideas), gather the group to walk through each threat and discuss the practicality of suggested solutions. Ask participants to elaborate on solutions that seem vague.

LINE UP
PLACE OF BIRTH

In large groups or groups where some tension may be apparent, this is a great opening activity to allow everyone to work cooperatively right from the start.

Directions

Participants are asked to think about the place where they were born and how far (in miles or kilometers) it is from the place they are now.

Students are asked to line up according to how far away from this place their birthplace is. Facilitator designates where the line should start and indicates that participants should line up from that spot according to how close/how far away their birthplace is.

Once everyone has settled on a spot in the line, facilitator asks participants to check with the person on either side to make sure that s/he is in the right place. Also, if more than one participant shares a birthplace, they need to develop a rationale for their order, and the first one should share that with the group.

Discussion

How willing were you to get up and go around to ask questions about where people were born?

How did you decide where your spot in the line was?

Did most people come to you or did you go to them?

Did you learn anything that impressed or surprised you?

Reflections

What were you feeling when you went up to people?

Do you feel any different now from when you first walked into the room?

How would you describe your group, given what you learned during the introductions?

PARTNER SHARE

Another great starter activity that gets people to mingle, talk, and allows the facilitator to test prior knowledge.

Materials

- prepared questions

Directions

For this activity to work, remind participants everyone needs to cooperate, follow directions, and talk quietly with each of their partners.

Place two short strips of masking tape on the floor about an arms length apart. Have the participants select a partner (someone they don't know well) and then form two lines on the strips so that each person is facing a partner on the opposite strip.

Pose a question for participants to discuss with their partner. When you call time, check for understanding by calling for volunteers to report what they discussed with their partners. After you debrief each question, one of the lines moves down one person and the person at the end moves to the front of the line. Everyone now has a new partner.

Have each person greet their new partner before the new question is asked. After you have posed several questions, you now have the opportunity to break participants up into heterogeneous groups of two, four, or six based on where they are in line.

Understanding Coral Reefs: Ecology and Economy

Before one can understand how tourism and other factors have affected coral reefs, one must first understand how coral reefs work. That's the primary goal of this presentation.

Coral reefs are among the oldest and most unique ecosystems on earth. The framework of the reef is constructed by organisms called coral polyps, which are rarely bigger than a fingernail. Yet, they can build structures as large as Australia's Great Barrier Reef, a feature so big that it can be seen from outer space. Coral also has the unique characteristic of being, in a sense, an animal, a plant and a stone—or what some have called a *zoophytolite.* Rather than just consume food, which they do, coral polyps capture and hold hostage tiny single-celled algae called *zooxanthellae*, which act as diminutive food factories within their host's tissue. The algae also enables the coral to create its limestone home. Over hundreds of millions of years this symbiotic relationship has developed into one of the most successful forms of mutualism ("you scratch my back and I'll scratch yours") in the natural world.

It takes tens of thousands of coral polyps to make up a coral colony. But once in place, this formidable fortress in the sea provides a home for what may be millions of species, including more than 3,000 kinds of fish. None of this would be possible without the successful and efficient relationship between the coral host and its algal partner.

As prodigious as coral reefs can be, they cannot occur everywhere in tropical seas. To take hold and thrive, coral reefs require specific conditions found only in specific locations around the world. Often, coral reefs also live at the edge of their environmental tolerance, making them very susceptible to even the slightest change in their surroundings.

A fact that eludes many is that coral reefs are important to everyone on our planet, not just tourists or those who depend on them for their livelihoods. Besides being worth nearly $400 billion to the world economy each year, coral reefs are a storehouse of biodiversity—nature's reserve in her fight for survival. Reefs also host an unknown but certainly vast number of potential medications and other chemical compounds that could cure countless human diseases. The physical size and strength of coral reefs enables them to protect a sixth of the world's coastlines from storm damage, and provide the primary protein source for a sixth of the world's population. Even the December 2004 tsunami, that deviated much of southern Asia, would have been much worse without the protection of local coral reefs and their associated mangrove forests. So, it doesn't matter if one lives in Bali or Baltimore, coral reefs are vital resources for the health of our planet and, therefore, are essential to everyone who inhabits the big blue marble that we call home.

Understanding Coral Reefs: Ecology & Economy

"A society is remembered not for what it has built but for what it has chosen not to destroy."

-E.O. Wilson

POINTS TO MAKE DURING INTRODUCTION:

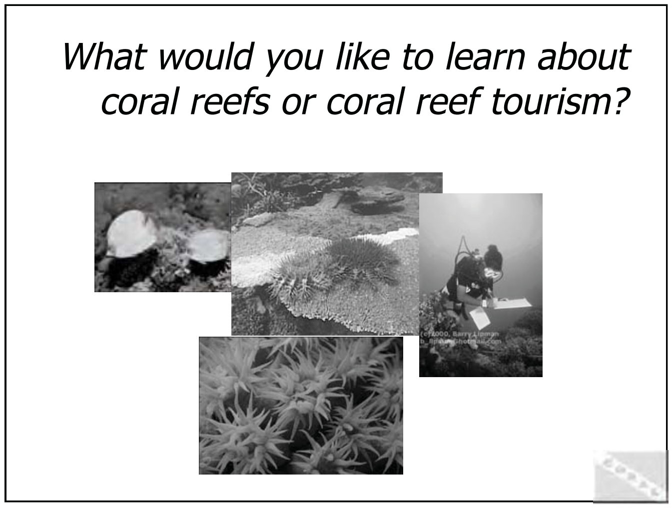
• Before one can understand how tourism and other factors have affected coral reefs, one must first understand how coral reefs function, or are supposed to function, in the first place. That's the primary goal of this presentation.

• As prodigious as coral reefs can be, they cannot occur everywhere in tropical seas. To take hold and thrive coral reefs require specific conditions found only in a few locations around the world.

• Coral reefs also live often at the edge of their environmental tolerance, making them very susceptible to even the slightest change in their surroundings.

• Participants must understand that the purpose of this training is not only to inform them personally about the function and important of coral reefs, but communicate this knowledge to their clients and others with the hope of building a constituency of informed coral reef advocates.

• It doesn't matter if one lives in Bali or Baltimore, coral reefs are a vital resources for the health of our planet and, therefore, are essential to everyone who inhabits our planet.



INTERACTIVE ACTIVITY:

To begin the presentation, use the KWL activity found in the Teaching Strategies section.

Periodically, check off those items as they are addressed or do a summary check-off at the end of the presentation.

Review the list before concluding this presentation to see what questions remain unanswered.

Emphasize that there is no “dumb” question, no matter how simple.

A Coral Reef Ecology Quiz

1. Coral reefs can form anywhere there's warm, tropical water.
2. A coral reef food chain is not "plant-based," like on land.
3. As long as the water stays clear and at the right temperature, coral reefs can survive no matter what happens.
4. There are so many different kinds of organisms found on coral reefs, losing one group (like sea urchins) doesn't have any serious impact.
5. When a coral reef bleaches, it dies soon after.
6. Compared to things such as hurricanes (cyclones), El Nino and other natural disasters, what humans are doing to coral reefs is relatively unimportant.

WHAT'S THE ISSUE?

The quiz is another optional way of involving participants in the presentation. It is designed as an introductory activity to stimulate thinking and help raise issues related to how coral reefs function.

INTERACTIVE ACTIVITY:

Answer Key

1. (FALSE: Reefs have many requirements beside water temperatures.)

2. (FALSE: All ecosystems, aside from some deep-sea communities, are based on "plants"—primary producers.)

3. (FALSE: Many factors can affect coral reef health beside temperature and water clarity.)

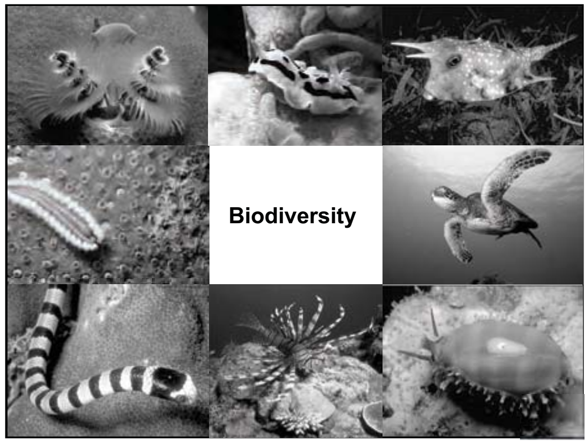
4. (FALSE: While there is often redundancy in a reef ecosystem, some organisms or groups of organisms are so vital that their eliminate can destroy a reef.)

5. (FALSE: A reef may live or die after bleaching, depending on how long it remains bleached and how healthy it way before it bleached. It's not an automatic death sentence.)

6. (FALSE: Reefs have dealt with natural disasters for hundreds of millions of years. They have begun to collapse only after humans—and modern society–entered the picture.)

[Many answer may seem counterintuitive, and this "mismatch" of reality versus what seems logical is what creates *cognitive dissonance*. This helps focus participant interest/engagement.]

[Determine if the quiz inspired any new questions that the class would like answered, and add them to the posted list.]



WHAT'S THE ISSUE? Coral reefs offer much more than their beauty. They provide a vital biological/ecological function in helping to maintain the biosphere.

NEED TO KNOW:

• We hear a lot about "biodiversity," but exactly why it it important?

•[Use Paul Ehrlich's "airplane analogy": Rivets hold together an airframe, like species hold together the biosphere.]

• The point: Lose enough rivets, or only a few of the critical ones, and the plane (and biosphere) can come crashing down.

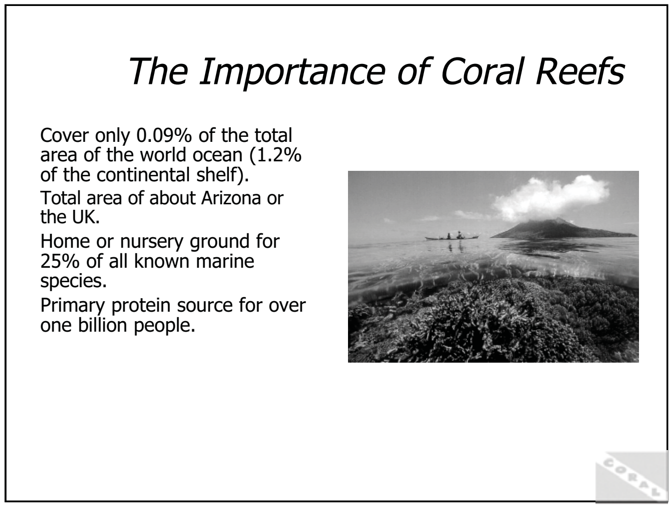
• We'll discuss later an unfortunate example of how things can go terribly wrong when biodiversity is lost (Jamaica).

NICE TO KNOW:

Biodiversity refers to the diversity of life on earth at the genetic, species and habitat level. It's defined as, "The sum total of all the plants, animals (including humans), fungi and microorganisms, along with their individual variations and the interactions between them. It is the set of living organisms and their genetic basis that make up the fabric of the planet earth and allow it to function as it does, by capturing energy from the sun and using it to drive all of life's processes."

• The more species there are in an ecosystem, the more efficiently energy can be transferred through the variety of pathways. As some reef scientists have remarked, "coral reefs don't leak much."

• Greater numbers also insure redundancy— ecosystem functions will have a "back-up" if one species is lost. This redundancy allows an ecosystem to persist as environmental conditions change.



WHAT'S THE ISSUE?

Coral reefs are incredibly valuable and important because the small area that they occupy accounts for so much of earth's biodiversity.

NEED TO KNOW:

• While tropical rainforests are rich in species, mainly due to insects, coral reefs are more phylogenetically rich—far more kinds (phyla) of organisms occur there than in rainforests.

• Total area of the world's coral reefs is only about the size of Arizona or the UK. Yet, they're home or nursery ground for 25% of all known marine species (probably over one million species).

• If a similar situation occurred on land, these regions would probably have some of the highest protected status known; but in the sea things are often "out of sight and out of mind."

NICE TO KNOW:

• 275,000 of all 1.6 million identified species on earth are marine, and 93,000 live on coral reefs.

• No one know how m,any species there are on earth, but probably more than 30 million. There are also likely more marine than terrestrial species. The reason the number of identified marine species is lower than terrestrial species currently is because we know so much less about the ocean.

• The total estimated area of all coral reefs worldwide is about 285,000 km^2/110,000 mi^2.

The Importance of Coral Reefs

When it comes to environmental change, coral reefs are excellent indicators of ecological change *("canaries in the coal mine").*

WHAT'S THE ISSUE?

[Depending on the participant's background, you may have to explain "canary in the coal mine" analogy: Canaries (used during early years of industrial coal mining) that suddenly died indicated potentially deadly levels of carbon monoxide in mine shafts.]

NEED TO KNOW:

• Because reefs are easily accessible, and linked to other marine ecosystems via currents, they're good indicators of the status of other shallow marine environments worldwide.

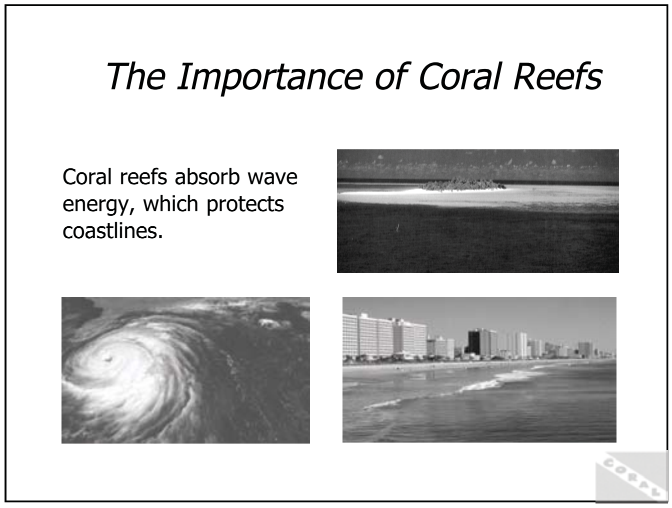
• As reefs generally live at the edge of their environmental tolerance, they're easily affected by even slight changes. This makes them excellent barometers of ecological change.

NICE TO KNOW:

• Coral reefs live within a very narrow range of tolerance with respect to light, temperature and nutrition. Some have called it the world of "little toes." If the water gets just a little too warm or cool, corals can die from thermal stress. If the water gets a little too turbid or nutrient-laden, they can die from starvation (the zoo being unable to produce enough food) or by being out-competed and overgrown by nutrient-loving macro algae. Or if the sea level rises just a little too fast, the reef can't grow quickly enough and slowly dies.

• This means that because of their sensitivity to even the slightest change in environmental conditions, coral reefs are likely to be one of the first ecosystems affected by pollution or alterations of the atmosphere.

• The extreme sensitivity of coral reefs to environmental change is why climatologists and others interested in climate change have become so interested in them.



WHAT'S THE ISSUE?

• Coral reef offer physical protection to coastal areas by helping to absorb wave energy.

NEED TO KNOW:

• Coral reefs act as coastal barriers protecting islands and coastal communities from storms, wave damage and erosion.

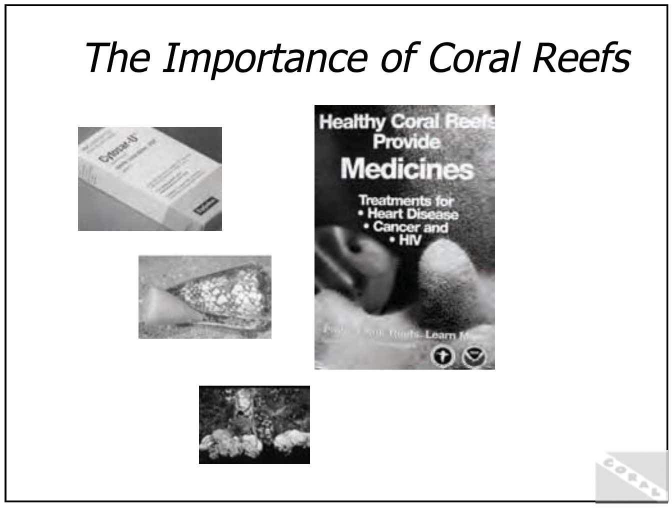
• Many low islands owe their existence to coral reefs that absorb incoming wave energy.

• In total, coral reefs protect one-sixth of the world's coastlines, which is important because 500 million people live in these regions.

NICE TO KNOW:

• Damage assessments done after the December 2004 tsunami showed that that human destruction of coral reefs that had formerly protected some coastal areas was a significant factor in the loss of life and damage in the area. Mangrove forests perform a similar role.

• a study conducted more than ten years ago showed that each square meter/yard of coral reef protects about $47,000 (US) in property value.



NEED TO KNOW:

• Like tropical rain forests, corals are the source of countless pharmaceutical products (most not yet discovered).

• More than half of all prescription medications are manufactured or derived from natural products.

• Half of current cancer medications are derived from marine organisms.

• Sessile (attached) marine organism often have to depend on chemicals (poisons) for defense and competition; and they have evolved some of the most complex natural chemical compounds known. Many of these have biochemical properties that could make them important for medicine. So, if reefs die, so does the potential to cure some diseases.

NICE TO KNOW:

• *Bioprospecting,* and up and coming field, is the search for new chemicals in living things that will have some medical or commercial use.

• Corals use enzymes called *secosteroids* as a chemical defense mechanism against disease. May be used in a similar way in humans, controlling tumor growth. Already being used to treat asthma, arthritis, and inflammatory disorders.

• Other examples of drugs derived from coral reefs so far:

-*Prostaglandin:* from gorgonian; used for cardiovascular disease, asthma and gastric ulcers.

-*Acromycin:* from sponge; antibiotic second only in importance to penicillin.

-*ET-743:* anticancer drug from tunicate.

-Azidothymidine (*AZT)*: from sponge; HIV/AIDS treatment.

-*Prialt:* from cone shell; stronger than morphine.

Economics of Coral Reefs

Coral reefs worldwide yield a total value of over US$375 billion per year (US$100 from food alone).

-Constanza et al. 1997

The Value of the World's Ecosystem Services and Natural Capital. (Nature)

WHAT'S THE ISSUE?

Aside form their ecological role, coral reef have significant economic value.

NEED TO KNOW:

• Most coastal tourism takes place in tropical regions dependent on healthy coral reefs. For example, beaches are often the most important tourism draw for any tropical destinations. They are formed from sand eroded from nearby coral reefs, so without a healthy reef there would be no beaches.

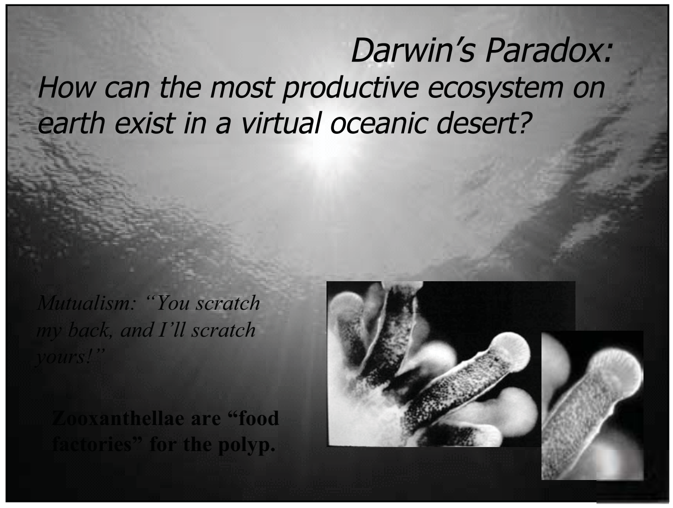
• If the coral reef that supplies a beach with its sand dies, then the beach will quickly disappear.

• Coastal tourism generates a US$ 385 billion (thousand million) per year worldwide.

NICE TO KNOW:

• Although coral reef are incredibly valuable, the annual worldwide investment in research, monitoring and management is less than US$100 million.

• Worldwide, tourism (all forms) generates more than 25 times the income of all marine fisheries (Birkeland, 1997).



WHAT'S THE ISSUE?

The mutualistic symbiosis between the coral polyp and its millions of algal symbionts called *zooxanthellae*—zoox, for short—is the key to understanding coral reef ecology.

NEED TO KNOW:

• Tropical water is so clear because it has very little in it in (sediment, plankton, or even dissolved nutrients). So where does the nutrient come from to feed the reef?

• Symbiosis: mutualism. commensalism, parasitism.

• Zoox get nutrients (polyp waste), CO2 and protection. Polyp gets food and low acid conditions to facilitate calcification.

• The polyps/zoo association is the corner stone of coral reef ecology. It's analogous to how important never holding your breath is to scuba diving. This isn't the only nutrient source on a reefs, but it's the most important.

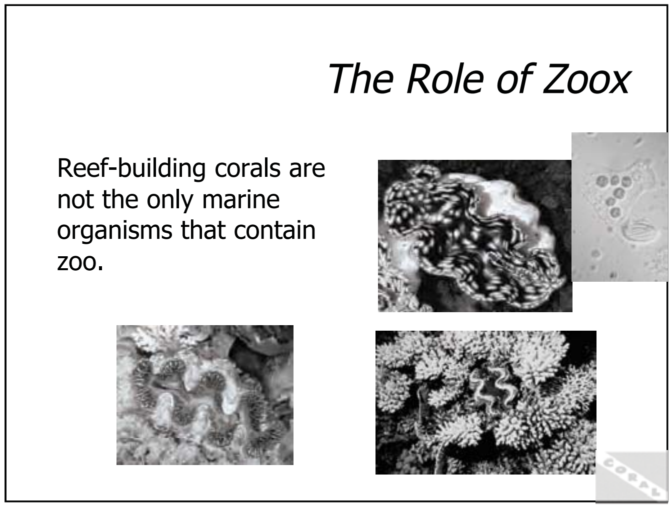
NICE TO KNOW:

• Zoox enable corals form limestone (calcium carbonate) 10 times faster than without them; without zoo there could be no large coral reefs.

• Some corals, like orange cup coral (*Tubastraea*), do not have zoo (azooxanthelate). In these species, the tentacles are much larger than in the zooxanthellate species.

• Zoox produce food (sugars), acids and lipids during photosynthesis and give off oxygen. Polyps give zoo carbon dioxide and ammonia (nitrogenous waste).

• Coloration of corals is largely due to level of chlorophyll, a photosynthetic pigment, within zoo, not the number of zoo, (Light-adapted corals are lighter, shade-adapted corals are darker), and possible the presence of mycosporine-like amino acids or MMAs (sun block).



WHAT'S THE ISSUE?

• Zoox are vitally important to a variety of marine creatures. Although common in corals, symbiotic relationships with algal symbionts are not unique to to them. This is a very complex and poorly understood phenomenon.

NEED TO KNOW:

• Corals are not the only marine organisms that contain zoo. They are seen in a variety of jellyfish, anemones, sponges, anemones and mollusks (like the giant *Tridacna* clam).

• Most of food produced during photosynthesis by the zoo are given over (taken) by the host.

NICE TO KNOW:

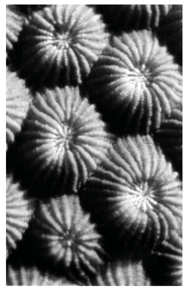
• "Zooxanthellae" (Greek: *"yellow-brown animal algae")*

• Much of this insight has come from studying coral bleaching, and one theory holds that coral may bleach in an attempt to get rid of poorly heat-adapted zoo in an attempt to find more heat-tolerant ones.

• Because zoo are in the coral tissue, the algae cannot be washed from the reef, and the nutrients can be exchanged by the coral animal (carbon dioxide, nitrate and phosphate) and zoo (oxygen and sugars) directly to each other without cycling outside in the water first, where it might be lost.

Polyp Anatomy

Corals build their own “apartments” termed ***corallites***



tentacles contracted

tentacles extended

WHAT’S THE ISSUE?

Understanding the anatomy of coral can provide valuable insights into its lifestyle and requirements for survival.

NEED TO KNOW:

• Corals are very simple organism, lacking any specialized organs. Basically, they’re made up of a sack surrounded by tentacles.

• Living in colonies is one way that organisms can overcome the disadvantage of small size. Coral colonies can share resources such as food; and the colony can survive even if a few individuals die.

• In most species, the tentacles can contract. As plankton (mainly, the larval forms of reef residents) is more active at night, most coral feed at night.

NICE TO KNOW:

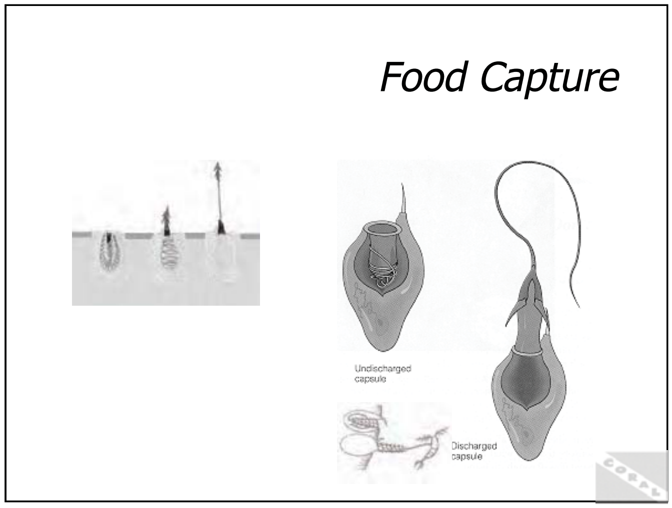
• Branching corals have proportionally more zoo and rely on their zoo for the vast majority of their nutrition, where many massive corals have fewer zoo and rely more on capturing plankton.

• Corals can also absorb nutrients directly from the sea water, although not much is there.

• Some zooxanthellate corals consist of a single polyp (such as mushroom corals.) But most are colonial with the various individual coral animals (polyps) occupying small cups (corallites or callices) in the massive skeleton.

• Each corallite has a series of sharp, blade-like structures (septa) rising from the base.

• The pattern of these septa differ from species to species and is one basis for separating coral species.



WHAT'S THE ISSUE?

• The method corals—and their relatives—use to capture food sources (plankton) that provide nutrition not supplied by their zoo.

NEED TO KNOW:

• Like all cnidarians (from the Greek <u>cnidae</u> for "nettle")—corals, sea anemones and jellyfish—corals have a harpoon-like sting cell called a ***nematocyst*** contained within specialized cell (***cnidocyte***).

• While the zoo provide mostly carbohydrates (starches), polyp gets their protein by capturing plankton. (Like some have said, *"Zoox provide the potatoes, while the plankton provides the meat.")*

NICE TO KNOW:

Corals nourish themselves in a remarkable number of ways.

• Zooxanthellae are the most important source of nutrition.

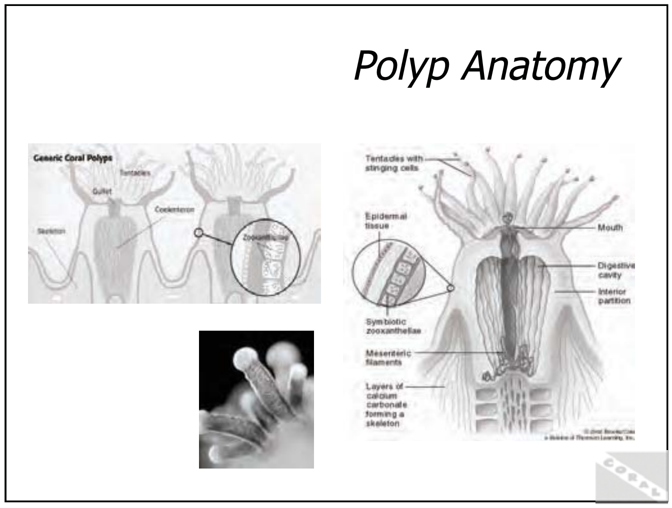
• Corals can also capture zooplankton with tentacles or mucus nets

• Digest organic material outside the body with mesenterial filaments.

• Absorb dissolved organic matter (DOM) from the water.

• Cnidocytes are "one-time-use," and regenerate after firing.

• The cell is triggered both tactually and by chemoreception.



WHAT'S THE ISSUE?

• Coral polyps carry out their life processes with an amazingly simple anatomy.

NEED TO KNOW:

• Each polyp is a two-layered animal (epidermis separated from internal gastrodermis by a non-living jelly-like substance (mesoglea).

•Zoox reside in the inner layer (gastrodermis).

NICE TO KNOW:

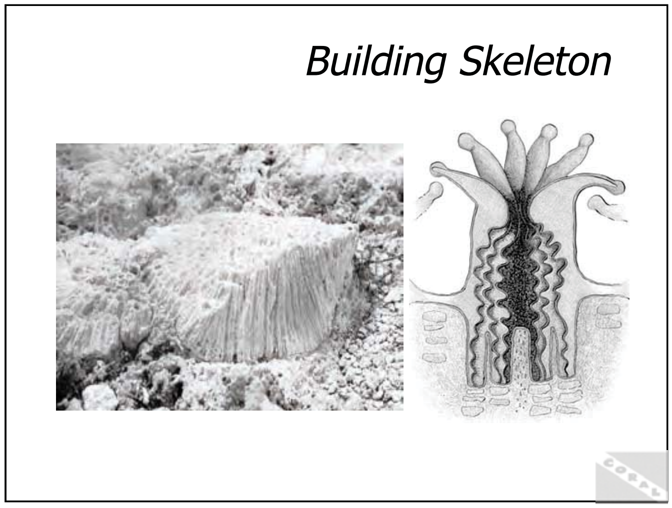
• A connective membrane (coenosarc) joins all polyps in a colony and is capable of transporting nutrients from polyp to polyp.

• The symbiotic zooxanthellae, a dinoflagellate (yellow-brown algae--Division Pyrrhophyta), reside in the gastrodermis. (Currently disputed whether zoo comprise different species or only different strains.)

• Zoox derive their name because Pyrrhophyta (yellow-brown algae) have an auxiliary pigment called xanthophyl.

• In addition to food from zoo and capture of zooplankton, coral can extend ***mesenterial filaments*** from their" sack" (colenteron) to digest organic matter from sediments. These are also used for competition and defense.

• Some corals have no tentacles and instead use mucus to capture food.



WHAT'S THE ISSUE?

• The reason corals are often confused with rocks is because of their ability to create the limestone structure that houses the polyp. Without this ability, there would be no reef.

NEED TO KNOW:

• The constituents of limestone—calcium and carbonate—are dissolved in seawater, but they don't come together to form limestone (calcium carbonate) under normal conditions.

• Organisms like shells and hard corals can create the conditions inside their tissues that allow limestone to form.

• Most hard coral grow by creating successive layers of limestone.

• In a sense, pew polyps build their "homes" on the graveyards of the siblings.

NICE TO KNOW:

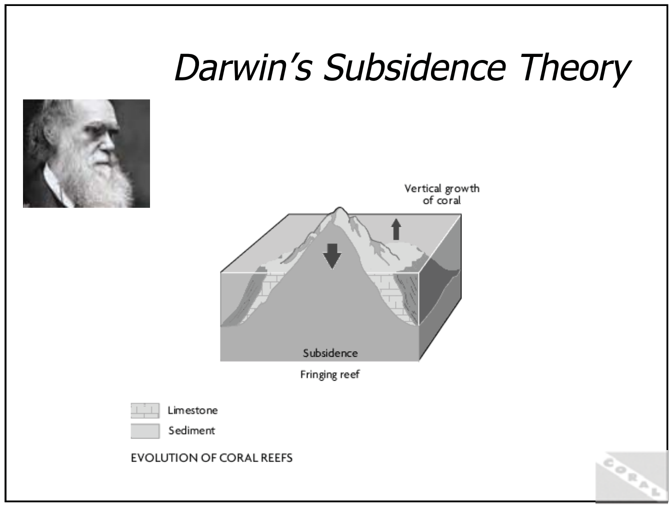
• Zoox significantly increase the calcification rate–and thus the growth rate—of corals.

• Growth rates of coral colonies differ between species, age of the colony, and in different areas of a reef, but there are some general rules. Young, small colonies tend to grow more rapidly than older, larger colonies.

• Branched corals generally grow more rapidly than massive corals. branching coral can grow 5-10 cm in diameter and 2-5 cm in height per year, while boulder coral only 0.5-2 cm in diameter and 0.25-0.75 cm in height per year.

• Not known for certain how long corals can live. Most are probably decades old, but some very large massive corals may be 100 years or older.

• A healthy reef can add almost 4,000 tons of new material per square mile per year, but even among a given species growth rates may vary considerably according to location on a reef.



WHAT'S THE ISSUE?

• Exactly how coral reef form has been a subject of hot debate and, as with many aspects of science, often does not involve a single process.

NEED TO KNOW:

• In 1842, Charles Darwin published *The Structure and Distribution of Coral Reefs—based on his five-year voyage on the HMS Beagle*—and in it he hypothesized how reefs form via a process he called "subsidence."

* During subsiding, the island/coral reef scenario go through the three stages of development—fringing, barrier and atoll.

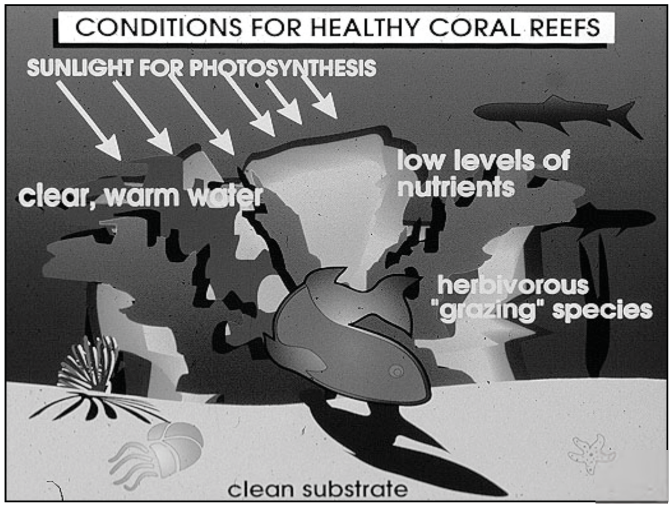
• Darwin's theory was verified in the 1950s, but it does not explain the evolution of all reefs (like many in the Atlantic).

NICE TO KNOW:

• In 1919, a geologist named Glacial Reginald Daly proposed a theory that sea level change, not subsidence, determined how coral reefs form. This was termed "glacial control theory," and is probably a better explanation for most continental reefs, particularly in the Caribbean.

• Reefs in different parts of the world developed in different ways depending on how tectonic forces, glacial periods and temperature changes affected their development.

• For example, while coral reefs of Hawaii were created by subsidence, not so the reefs of the Florida Keys and Bahamas. These were created by changing sea level conditions that provide the appropriate conditions for reef development.



WHAT'S THE ISSUE?

• Coral reefs don't simply appear anytime and anywhere the sea is warm. They require very specific and consistent physical conditions, and do not survive well when these conditions change.

NEED TO KNOW:

• These five conditions are required for healthy reefs, and when one or more isn't present—or is eliminated—then the reefs is compromised.

• For example, turbid water means less light penetration, excess nutrients allow the proliferation of algae.

NICE TO KNOW:

• Zooxanthellate coral can survive at depths of 100 m, but reef construction occurs at only half the depth at which they can grow, (Most reefs grow in depths of 25 m or less.)

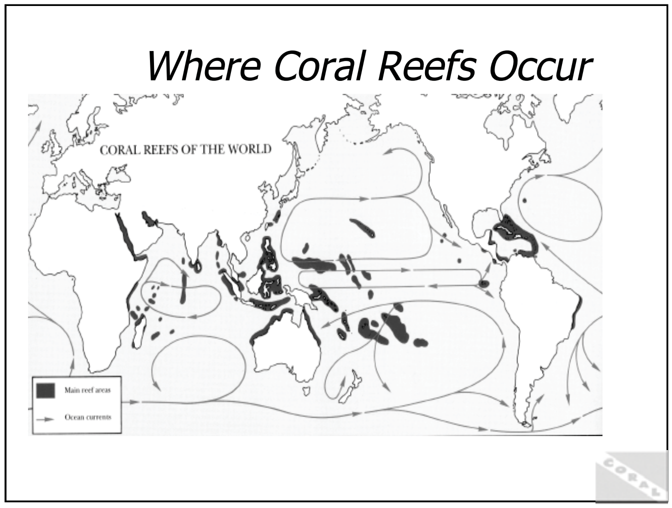
• Reduced photosynthesis causes a reduced secretion of calcium carbonate (limestone) which produces the reef.

• Zooxanthellate corals are so sensitive to light that calcification can drop 50% on a cloudy day versus a sunny day.

• Zooxanthellate corals cannot tolerate salinities deviating significantly from that of normal sea water, 32-36 ppt. This is why they're absent near river deltas, such as the Amazon.

• Heavy sedimentation smothers and clogs feeding structures and reduces the light necessary for photosynthesis. (Coral species vary in their tolerance to sedimentation.)

• Reef development tends to be greatest in areas subject to moderate wave action. Wave action provides a constant source of oxygenated sea water, prevents sedimentation and continually renews the supply of plankton (food source).



WHAT'S THE ISSUE?

• In addition to the physical conditions present, reef develop also depends upon ocean currents largely because these dictate the overall water temperature.

NEED TO KNOW:

• Note that most (+85%) occur in the Indo-Pacific.

• Coral reefs aren't strictly tropical. Their distribution depends on the path of warm ocean currents. Which is why they can survive as far north as Okinawa and Bermuda.

• Coral reefs are found where surface waters do not drop below 20C/68F.

• Coral reefs are absent from large areas on the west coast of South and Central America and also from the west coast of Africa. These coasts have strong, cold currents—Humboldt Current (South America) and the Benguela Current (West Africa).

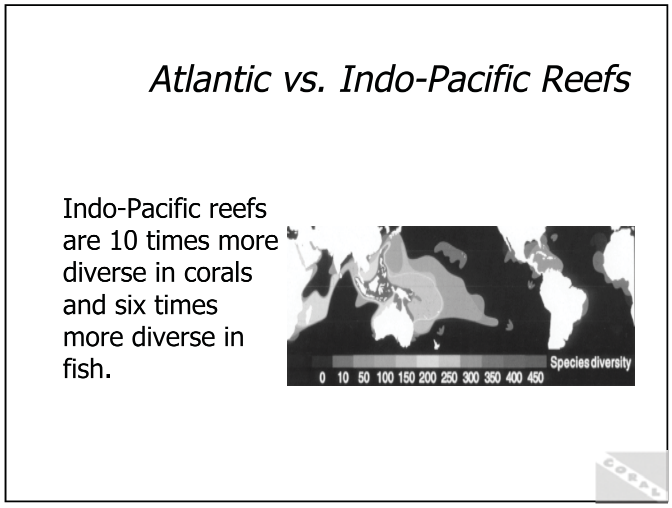
NICE TO KNOW:

• Zooxanthellate corals live near the limit of their maximum temperature tolerance, adapted to the local mean summer temperature.

• Although zooxanthellate corals can survive for periods below 20C/68F, no reefs develop where the annual minimum temperature is below 18 degree C/65F. (Cold robs corals of too much energy for reproduction even if they can survive.)•

• Between 14-16C/58-61F lose ability to capture food, and at 16C/61F growth rate will about equal erosion. Below 14C/58F, many species will die in a few hours.

• Optimal reef development occurs in waters where the mean annual temperatures are about 25-29C/77-84F.



WHAT'S THE ISSUE?

• Not all coral reefs are the same. Differences in geologic history, plate tectonics and ocean currents have resulted in major differences between Atlantic and Pacific reefs.

NEED TO KNOW:

• The Indo-Pacific is the most diverse region, particularly the "coral triangle" around Southeast Asia.

NICE TO KNOW:

• Atlantic has only about 40 genera and about 70 species of coral with around 500 species of fishes.

• Indo-Pacific has in excess of 80 genera over 700 species of corals and more than 4,000 species of fishes.

• Atlantic reefs commonly have a profusion of sea fans and whips (gorgonians), which are much less evident in Indo-Pacific.

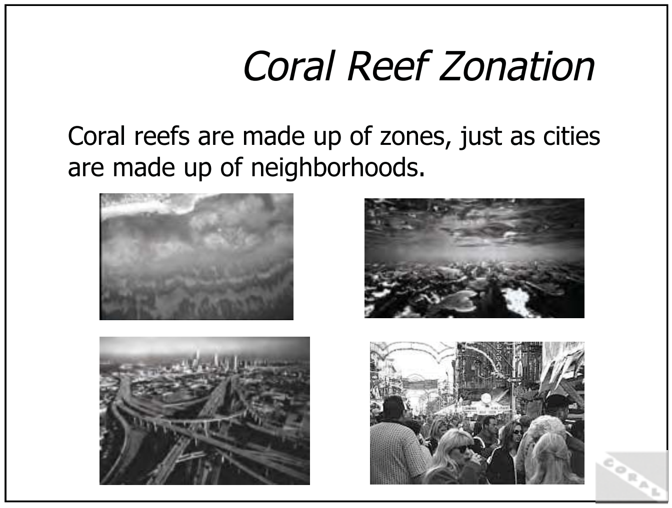
• Indo-Pacific reefs have large numbers of alcyonarian (soft) corals.

• Part of the reason for fewer species of coral in the Caribbean than the Indo-West Pacific the is a result of their isolation (closure of the Isthmus of Panama) and effects from ice ages (cooling water temperate and sea lower sea level).

• Corals survived in Indo-West Pacific region, around Indonesia and New Guinea, while many species became extinct in other regions.

• After ice age ended, corals spread out again across the Pacific, recolonizing areas where they had died out.

• The Caribbean was not recolonized because the Isthmus of Panamá blocked their dispersal. It"s thought that the Caribbean contains only those coral species that managed to survive the ice ages there.



WHAT'S THE ISSUE?

• Communities and associations on reefs are not random. Like neighborhoods, reef communities occur due to a variety of factors.

NEED TO KNOW:

• Coral reefs may appear chaotic to the uninitiated, but there is a logic to their make-up.

• A city's neighborhoods, like zones on the reef, are determined by local-scale conditions, such as the presence of absence of disturbance/disruption and access or lack of access to resources.

• For example, in the photos on the left, access is "restricted." The highways of this city create isolating zones in which neighborhood develop. On the reefs, the water is "restricted" in terms of its deeps, and how the energy of the water is affected by the reef structures.

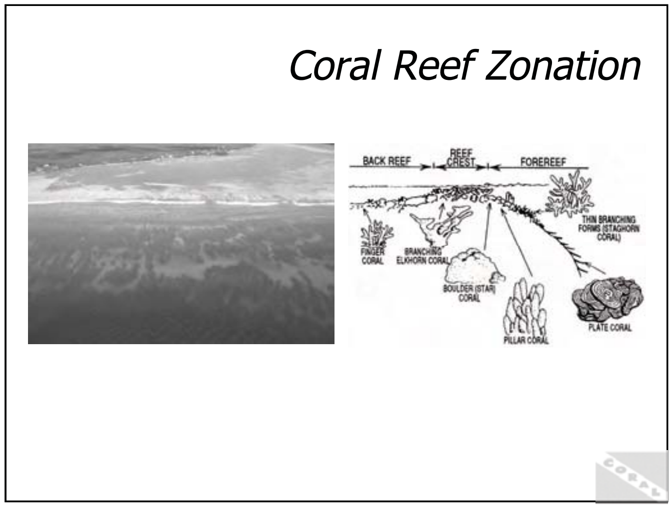
• Organisms/communities on the seaward side of the reef have first access to food approaching from the sea, but must deal with high energy (waves).

Organisms living in the lagoon are sheltered from waves, but must deal with fluctuating salinity from off-sure water flow, and high sedimentation.

[The next slide provides greater detail.]

NICE TO KNOW:

• Different patches of a reef may be at different stages in recovery from disturbance—just as neighborhoods can be at different stages of development or redevelopment—creating a regional mosaic of greater diversity.



WHAT'S THE ISSUE?

• The physical characteristics of a reef determine the character of its biological communities.

NEED TO KNOW:

• Coral reefs are best understood not as a single habitat but complex associations of numerous "sub-habitats" all present in the same system (hard bottom, sand bottom, heavy wave action, minimal wave action).

• The organisms in each sub-habitant require a different set of adaptations. This is one reason for the great diversity of life in coral reefs.

• While it's impossible to characterize all coral reefs as fitting within a single pattern, a general zonation can be described. Typical reefs are comprised of three major areas—shore, crest and fore reef.

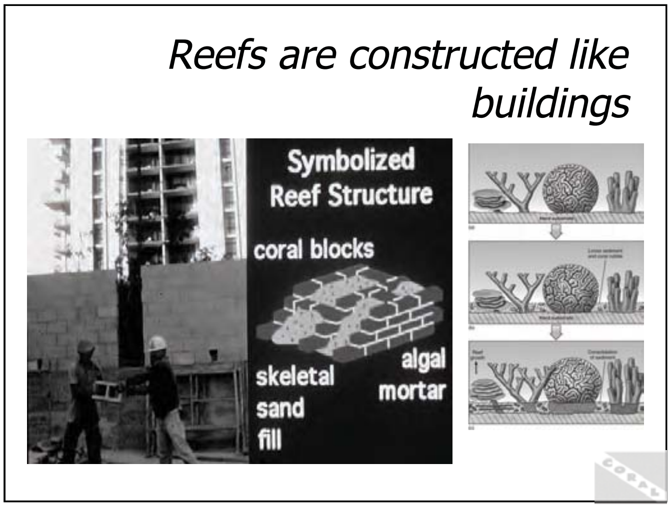
•. Each zone has distinct populations and characteristics, particularly concerning the coral species.

• Zonation varies according to location, but the basic factors influencing it—depth, temperature, current, wave action, access to food— are essentially the same.

NICE TO KNOW:

• Zonation is most pronounced on very exposed windward reefs and least on sheltered, leeward reefs.

• Maximum diversity occurs in places where no species has a particular advantage.



WHAT'S THE ISSUE?

• Corals are the basis of of the reef ecosystem because of their ability to literally build the framework of the habitat. Yet, other organisms contribute to the reef's structural integrity.

NEED TO KNOW:

• A healthy reefs is like a well constructed concrete structure. It's made of blocks, but they alone don't give it strength. Mortar (calcareous algae) must provide strength.

• Reefs also grow abiotically by accumulation of debris. The sand and calcareous debris provides strength, as does aggregate in concrete.

NICE TO KNOW:

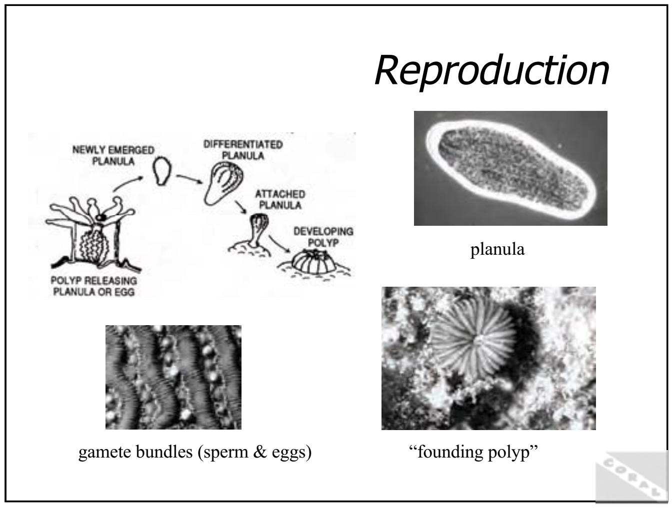
• Consolidation: For wave-resistance, the framework must be bound together physically by cementing organisms and forming the framework. Without this reefs could not exist.

• The structure of a reef is formed as much by the accumulation of calcareous sediment as by the growth of corals.

• In addition to encrusting algae, some invertebrates, notably sponges and bryozoans, also help bind the sediments.

• Although the main reef-framework components are the scleractinian corals and coralline algae, over 70 percent of the calcium carbonate in the reef is composed of sand particles and debris of even finer grain sizes.

• Most of these sediments are skeletal—derived from reef organisms—fragments of: calcareous algae (especially Halimeda), forams tests, remnants of mollusks, arthropods, sponges and eroded reef fragments.



WHAT’S THE ISSUE?

• Corals reproduces by a variety of methods and strategies.

NEED TO KNOW:

• Corals reproduce both sexually and asexually. Individual colonies grow by asexual reproduction (budding or fragmentation), while species disperse by sexual reproduction.

• Asexual reproduction is accomplished by budding a new individual from the parent. Over time this will increase the size of the colony, but will not produce any new colonies. Branching corals can also grow asexually by fragmentation.

• Sexual reproduction results in the production of a free-swimming planula larva. Settlement of the planula is how new colonies form.

• *Planula* can remain in plankton from days to months, but can take hold only on clear, consolidated substrate. Grazers play in important role in making substrate suitable for settlement.

• Most corals reach sexual maturity at between 7-10 years (about 10 cm in size).

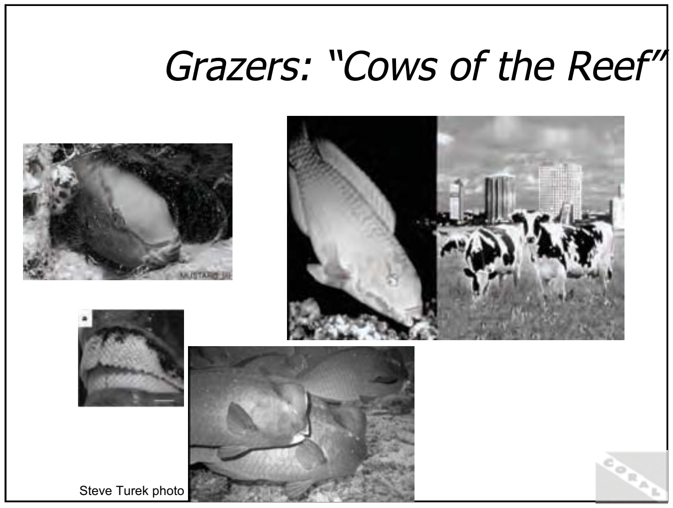
• Chemicals such as copper and TBT from bottom paint and oily bilge discharge—perhaps even sun tan lotion—can disrupt coral spawning.

NICE TO KNOW:

• All polyps within an individual colony are all clones of the original “founding polyp.”.

• Budding can be extratentacular, where new individuals form outside ring of tentacles (star coral); or intratentacular, where new individuals form inside tentacle ring (brain coral).

• Corals may be male or female, but 75% are hermaphroditic, and they can release eggs, sperm or gamete bundles (sperm and eggs).



WHAT'S THE ISSUE?

• Without grazers, the reef cannot survive; it would be quickly covered by algae.

NEED TO KNOW:

• Without constant grazing, reefs would soon be overrun with algae, but there's another role grazing plays.

• Grazing enhances algae productivity by keeping in an exponential growth phase (like mowing the lawn often).

• Fewer rapidly growing algae produce more new food in a given period than a greater number of slower growing algae.

• Important herbivorous grazers, including damselfishes, surgeonfishes and parrotfishes.

• Beside fishes, sea urchins are also an important grazer.

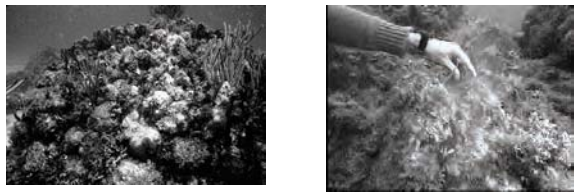
NICE TO KNOW:

• Algal farming by territorial damselfishes also retards coral growth by preventing growth of coral and coralline algae. Algal patches, in turn, become refuges for juvenile invertebrates and plankton.

• Algae is normally keep low because of intense grazing. Rates estimated over 40,000 bites per day on a square meter of reef! No surprise that herbivores make up to 50% of fish biomass on average reefs, even though by species only 10%.

• At low densities, urchins remove algae allowing coral colonies to become established. But at high densities, urchins will sometime eat coral planula as well as algae, preventing coral growth.

Jamaica’s Collapse: A“Phase Shift” From a Coral to Algal Reef



1970: 80% fishing removed biomass from the reef.
1980: Hurricane Allen devastated the reef.
1983: *Diadema* die-off was the final blow.

WHAT’S THE ISSUE?

• The consequences of the loss of biodiversity in a coral reef ecosystem can be disastrous.

NEED TO KNOW:

• There’s no better example of what the loss of biodiversity can do than what has happened in Jamaica on the past 35 years.

• Disease killed 98% of black sea urchins in Western Atlantic in less than a year, from which the region has yet to fully recover.

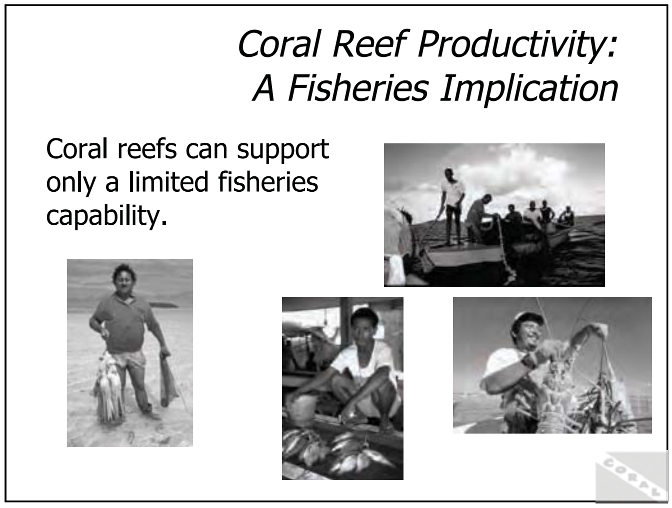
• But Jamaica isn’t alone. Similar shifts appear to be occurring worldwide on degraded reefs from Florida to Indonesia.

NICE TO KNOW:

• Ecological relationships are extremely complex and not well understood. So, it no surprise that humans rarely anticipate the consequence of eliminating species.

• Perhaps the best advise for how to manage our ecosystem was given by ecologist Aldo Leopold who said, “A wise tinkerer saves all the parts.”

• Or, as the bumper sticker says, “What goes around, comes around.”



WHAT'S THE ISSUE?

• Coral reefs can support only a limited fisheries capability.

NEED TO KNOW:

• Coral reefs, while very productive, do not produce much excess (net productivity).

• This means that the amount of biomass(fish and other organisms) that can be taken from a coral reef on a sustainable basis is relatively limited compared to temperate marine ecosystems. This is one reason a coral reef may adequately support a limited sustenance fishery for centuries, yet collapse within a matter of a few years once commercial fishing is introduced

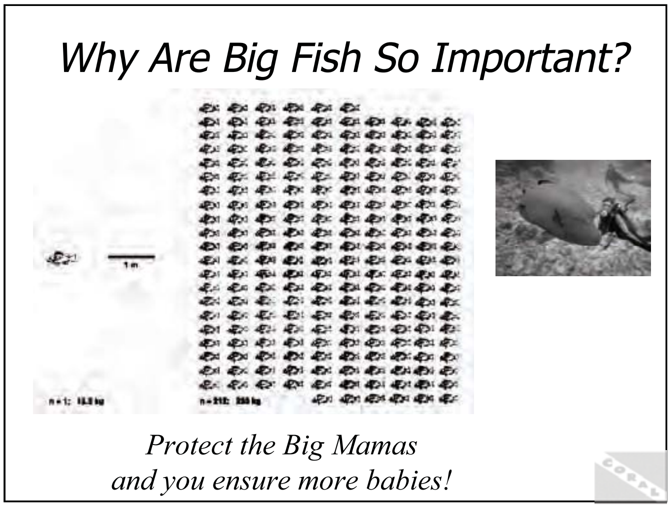
NICE TO KNOW:

• Primary productivity is the rate at which light energy is converted to organic compounds by autotrophs (plants), or the change in biomass (total organic matter) per unit of time. The ecosystem's biomass depends on the primary productivity of the autotrophs.

• Secondary productivity is the rate that heterotrophs incorporate organic material into new biomass. At each successive trophic level, the amount of energy derived by that consumer decreases (only about 10% of the energy is passed on to the next level; 90% is lost).

• This results in a decrease in the potential biomass that can be supported at each level. This is why it's most accurate to represent energy flow in an ecosystem as a food pyramid.

• The gross primary production of reefs is very nearly balanced by what it consumes. Net productivity is often only 2-3 percent of the gross, and only slightly higher than the net productivity in the surrounding ocean water.



WHAT'S THE ISSUE?

• Conserving fish populations is a key to reef conservation, but how to do it isn't always obvious. Science has gleaned may new insights recently.

NEED TO KNOW:

• Although it seems counterintuitive, gamete (sperm and egg) production in fish is not linear in proportion to size, but exponential.

• This case of snapper and other common reef fish, a doubling in size can result in a 20 to 100-fold increase in fecundity (reproductive capacity).

• For example, a single 24-in/61-cm female snapper produces the same number of eggs as 212 16-in/41-cm female snappers!

• Similarly, a 40cm/15.5in grouper produces 1 million eggs, but a 100cm/40in grouper produces 15 million!

• Fisheries biologist now know that, to protect fish populations, we have to save both the very young (who haven't yet reproduced), and the very big (who have the most reproductive capacity and best gene pool).

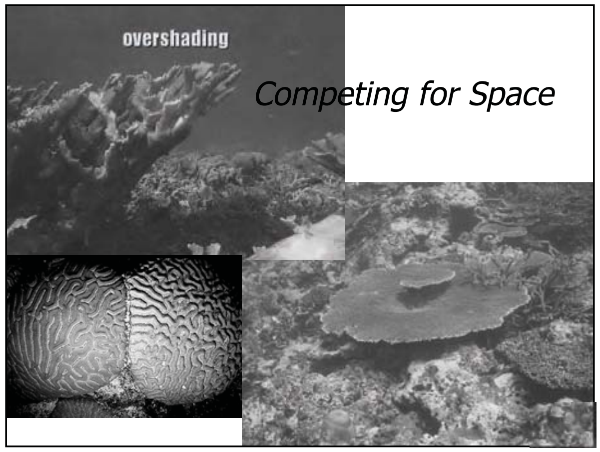
NICE TO KNOW:

• Not only do larger females produce more eggs, the progeny of larger fish have a much great growth and survival rate, compared to that of smaller fish.

• In one study of Pacific black rockfish *(Sebastes melanops),* survival rates were almost three times higher and growth rates 3.5 times faster for larvae of older mothers. (This is because older fish produce larger oil globules).

• Older fish are also critical from an evolutionary standpoint. Without this older stock, the maximum size of species declines in a matter of decades.

• Some places, like Florida, now regulate legal-sized fish not by minimum length, but by a "slot," meaning that only fish between a specified size may be taken. This protects both ends of the population.



WHAT'S THE ISSUE?

• For corals, the most precious resource of all is space, and how to hold on to it.

NEED TO KNOW:

• Like a large tree in a forest, fast growing species can out compete their neighbor by casting a shadow and reducing or eliminate light.

• Coral can also "attack" each other.

NICE TO KNOW:

• Branching corals grow more rapidly than encrusting or massive corals

• Left unchecked, algae would extend over massive coral, excluding air and retarding or precluding growth. The reason slow-growing species survive is because of interspecific aggression.

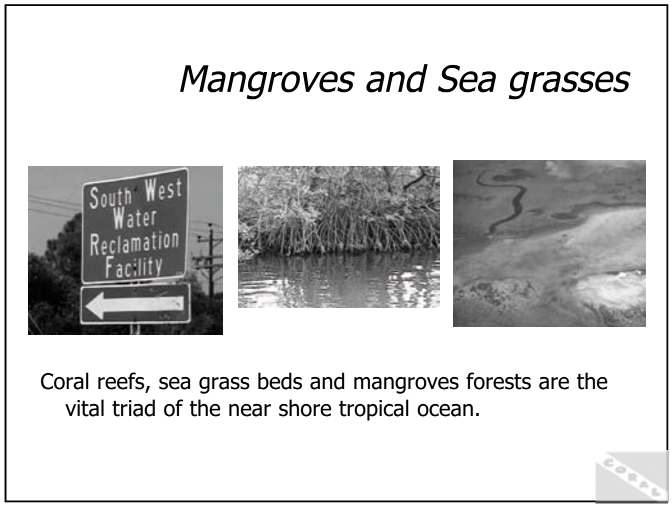
• The slow-growing coral species fight back by extending mesentary filaments from their gastrovascular cavities. When a competitive species is encountered, its tissue is digested by the filaments. (Can extend out to 10 cm.)

• This prevents faster-growing corals from overshadowing slow-growing species.

• An "aggressive pecking order" has been identified and prevents the monopolization of space; therefore diversity is maintained.

• Coral pecking order seems to vary according to region, so that every reef has a unique combination of competitors.

• In Eastern Pacific, the fast growing coral is also the most aggressive (Porcillopora), which is controlled in shallow water primarily by damselfish farming.



WHAT'S THE ISSUE?

• Coral reefs, sea grass beds and mangrove forests are interdependent systems.

NEED TO KNOW:

• Seagrass beds are "speed bumps." They slow water float and allow settlement of sediments. They also provide a vital nitrogen source to the reef (much is transported via fish feces).

• Mangroves act like waste water treatment plants, trapping and processing excess nutrients and pollutants. Both ecosystems help maintain the water quality of nearby coral reefs.

• Conversely, if the coral reef dies, it can no longer protect the shore from wave action. So mangroves and seagrasses are uprooted and can't regenerate.

• Also, if mangroves and seagrasses die or are eliminated, there's less nursery ground for juvenile species, and runoff from land can't be trapped and processed.

NICE TO KNOW:

.• Mangroves are not a single family of tree, but represent eight different families and 12 genera. They describe a variety of tropical ecosystems dominated by several species of trees or shrubs that can grow in salt water.

• From 60-75 percent of the coastline of the earth's tropical regions are—or were—lined with mangroves. They're disappearing faster than tropical rain forests.

• Microbial action of bacteria and fungi act to break down plant matter, serving as basis for detritus food chain Root system also provides habitat for host of invertebrate (mussels, sponges, tunicates, hydroids, oysters, etc.) and juvenile stages of many fish.

Coral Grief—The Problems Facing Coral Reefs

With an understanding of the way coral reefs are supposed to work, this segment turns attention to the reality—what's actually happening to them today.

Coral reefs cover about 280,000 square kilometers of the seafloor, which is a mere 0.09 percent of the sea bottom. They occur in widely disparate regions of the world, so some of the problems confronting them are unique and localized. However, while each reef faces problems unique to its locale, there are some commonalities that explain why today virtually all reefs are in some state of decline.

Coral reefs have always faced challenges. In the hundreds of million of years that they've been a feature of earth's oceans, they have been threatened with everything from continental drift to ice ages to asteroid impacts. Even today they face a continual onslaught from natural events such as catastrophic storms, El Nino and changes in the population structure of the organisms that make up reef communities. However, coral reefs have evolved to accommodate the ebb and flow of nature. But what coral reefs never evolved to deal with are the effects wrought by humans, or what's termed "anthropogenic change." As human impact on the ocean has accelerated since the Industrial Revolution—and particularly within the past half century—coral reefs are simply incapable of dealing with both the extent and pace of the problems now thrown at them.

Most scientists agree that coral reefs aren't likely to disappear completely; but what future generations will know as a coral reef will be vastly different from what we or those before us knew. What the future holds for coral reefs will depend upon us. However, the situation will not change for the better unless there's the political will to make it happen, and that's where coral reef educators—like you—can make a difference. Those in the marine tourism sector, because of their continual contact with the public, are in a better position than almost anyone else to raise public awareness about the dire state of coral reefs, and what must be done to save them.

Coral Grief:
The Problems Facing Coral Reefs

"On spaceship Earth, there are no passengers; everyone is part of the crew."

-Marshall McLuhan

POINTS TO MAKE DURING INTRODUCTION:

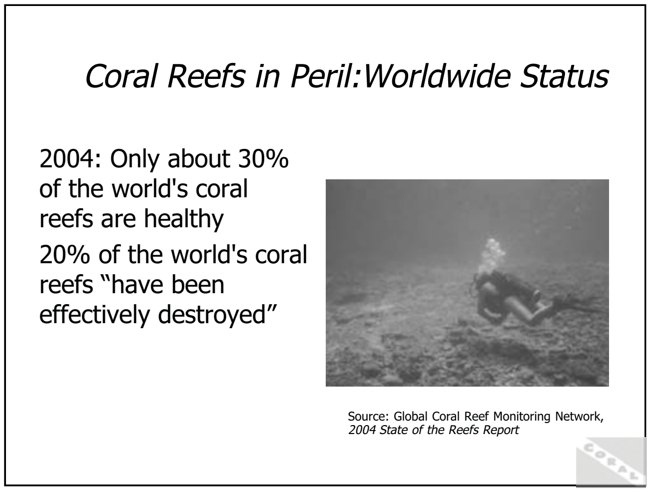
• The previous section explored how coral reefs are supposed to function. Here we'll look at the reality—what's actually happening to them today.

• Although each coral reef is unique, there are some commonalities that explain why virtually all are in some state of decline.

• Most scientists agree that coral reefs aren't likely to disappear completely; but what future generations will know as a coral reef will be vastly different than what we or those before us knew.

• The most important point to remember is that nothing will happen unless there is the political will to make it happen, and that's where you—in your role as coral reef educators—can be of enormous help.

• Because of your role, you are in a better position than almost anyone else on earth to raise public awareness about the continual decline of coral reefs.



WHAT'S THE ISSUE?

• Coral reefs worldwide are in serious decline. It was once assumed that only those reefs close to population centers were in danger. Now, because of climate changes, all coral reefs are under serious threat regardless of how remote.

NEED TO KNOW:

• It's tough to pin down an exact figure for the global status of reefs, because many reefs are so inaccessible.

• The best global snapshot is provided every two years in a report, *Status of Coral Reefs of the World*, published by the Global Coral Reef Monitoring Network at the Australian Institute of Marine Science. (Copies are available free online.) Compiled by more than 240 contributors from 98 countries.

• According to the World Conservation Union (IUCN), without intervention half of the world's coral reefs will be gone by 2045.

• The bottom line is that virtually no coral reef in the world today can be considered "pristine" (in its original state).

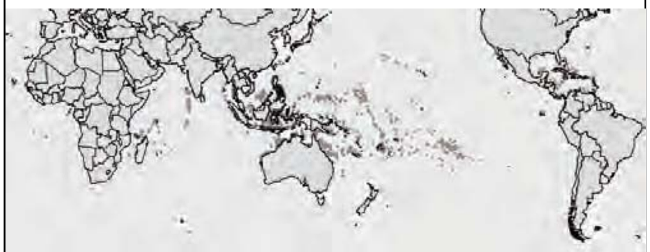
NICE TO KNOW:

• Twenty-four percent of the world's reefs are under imminent risk of collapse through human pressures, and a further 26% are under longer-term threat of collapse.

• Caribbean reefs have suffered an 80% decline in cover during the past three decades (80 to 98% of the elkhorn and staghorn is gone).

• Currently, coastal development threatens 33% of the reefs, land-based sources of pollution 35%, and over-fishing more than 60%. Up to 32% of coral reefs may be destroyed by human activities in the next thirty years.

Coral Reefs in Peril: Worldwide Status



(Source: World Resource Institute)

RED = high risk YELLOW = medium risk BLUE = low risk

WHAT'S THE ISSUE?

- Threats to coral reefs are not consistent, and range from low to medium to high, depending generally on their proximity to human population centers.

NEED TO KNOW:

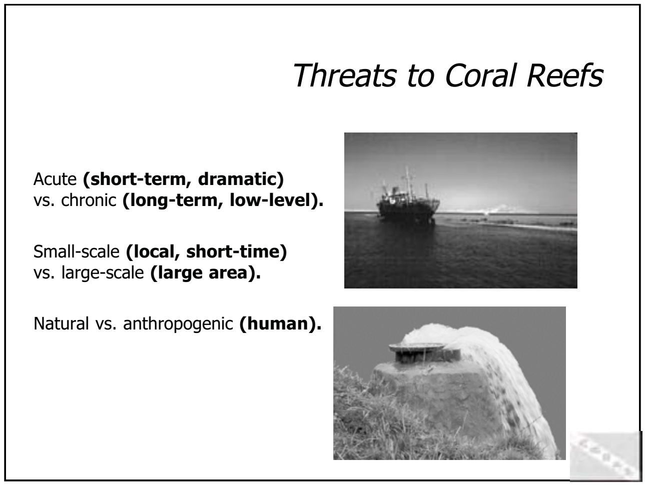
- 2004: 70% of coral reefs "are under imminent risk of collapse through human pressures," or "are under a longer term threat of collapse." (Up from 58% in 2002.)
- Not all the news is bad. Reefs still in relatively good condition in the Red Sea, Gulf of Aden and much of the South Pacific, with significant recovery in East Africa. Also, growing awareness of need for protection. In July 2004, GBRMP increased the amount of no-take areas from 5% to 33%.

NICE TO KNOW:

The World's 10 most vulnerable reefs (Source: Roberts et al., *Science* 2002):

1. Philippines
2. Gulf of Guinea Islands off West Africa
3. Sunda Islands in Indonesia
4. Southern Mascarene Islands near Madagascar
5. Eastern South Africa
6. Northern Indian Ocean near Sri Lanka
7. Southern Japan, Taiwan and southern China
8. Cape Verde Islands off West Africa
9. Western Caribbean, from Cozumel Mexico to Columbia
10. Red Sea and Gulf of Aden

- Although these areas comprise only 0.012 percent of the oceans, they harbor 34 percent of restricted-range species.



Wolcott Henry

WHAT'S THE ISSUE?

• Threats to coral reefs are varied, can be interrelated and many are poorly understood.

NEED TO KNOW:

• Threats to reef vary in terms of their intensity, consistency and range

• Some threats are completely natural, and have occurred as long as reefs have existed. Others are entirely or partially human-caused.

• Chronic stress does the same thing to coral reefs as it does to humans—it makes them much more susceptible to health problems; and it can turn what may have otherwise been a minor problem into a struggle for survival..

NICE TO KNOW:

Top 10 threats to coral reefs (Source: GCRMN/AIMS)

<u>Global Change</u>

1. Coral bleaching, caused by elevated sea surface temperatures due to global climate change;
2. Rising levels of CO_2, causing decreased calcification rates;

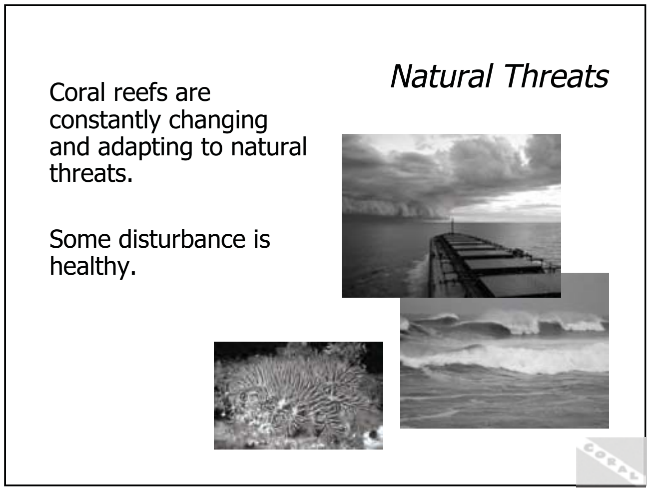
Increases in diseases and plagues of coral predators;

<u>Direct Human Pressure</u>

3. Over-fishing and DFPs;
4. Sediments from poor land use, deforestation, and dredging;
5. Nutrients and chemical pollution;
6. Development of coastal areas;

<u>Governance and Awareness</u>

7. Rising poverty and increasing populations;
8. Poor capacity for management and lack of resources;
9. Lack of political will.



WHAT'S THE ISSUE:

• Coral reefs have dealt with natural change for their entire existence.

NEED TO KNOW:

• Disturbance is not only natural, it's necessary to maintain a diverse ecosystem.

• Natural threats include: predators, storms and cyclones, sea level change, variations in sea surface temperature and volcanic eruptions.

• Problems arise when disturbance is too little or too much.

NICE TO KNOW:

[Review the following if not covered in the segment on "Ecology & Economy"]

• High species diversity among coral reefs was once thought to be the result of stability.

• Current "intermediate disturbance theory" holds that diversity on reefs, like rainforests, is maintained at high levels by constant natural disturbance (storms, predators, etc.) rather than consistency. In the absence of disturbance, some species would out-compete others and diversity would be lower.

• Thus, different patches of a reef may be at different successional stages, creating a regional mosaic of even greater diversity.

• Others say that high coral diversity is a combination of disturbance and growth rates, largely controlled by depth. (In shallows, rapid growth rates overcome disturbance, excluding some species.)

What are some natural treats to coral reefs that are made worse by human impact?

Increased greenhouse gases.

Overpopulation and urbanization.

Global climate change.

WHAT'S THE ISSUE:

• The factor that coral reef evolution never counted on was human beings.

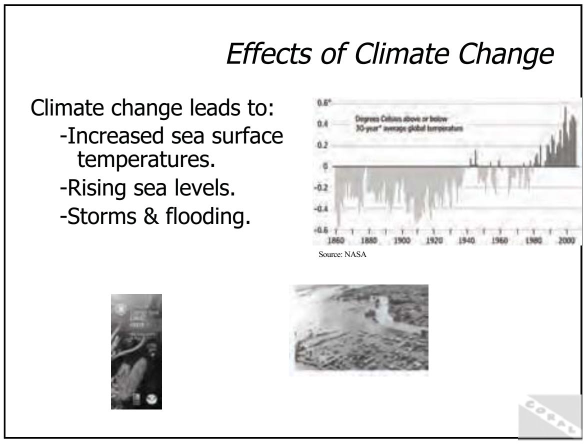
NEED TO KNOW:

- Humans appear to have tipped the scales against coral reefs by: overpopulation, massive urbanization, and increasing greenhouse gases leading to climate change.

NICE TO KNOW:

Additional insights on climate change:

- Ozone depletion may impact coral reefs by permitting the passage of greater quantities of potentially damaging UV radiation. Changes in cloud cover could increase the level of UV and incidental light.
- The combined effect could be catastrophic damage to both mature reefs as well as to their eggs and larvae.
- There has been an unprecedented increase in the number of coral bleaching events during the past two decades (which have had some of the warmest years in history).
- Increased carbon dioxide levels on the sea may structurally weaken coral reefs due to chemical erosion from increased acidity.
- Global warming trends may also lead to more extreme and unpredictable weather. An increase in tropical storms could do extensive physical damage to coral reef ecosystems.
- Rapidly rising sea levels may become a serious threat to coral reefs and to small island nations based on coral reef atolls.



WHAT'S THE ISSUE?

• Regardless of what's done on the local level to protect coral reefs, it may all be fruitless if human activity continues to alter the atmosphere.

NEED TO KNOW:

• The ocean and atmosphere are interconnected, so what happens to one affects the other.

• Global warming trends may also lead to more extreme and unpredictable weather. An increase in tropical storms could do extensive physical damage to coral reef ecosystems (in essence, exacerbate a natural threat).

• Rising sea levels may become a serious threat to coral reefs and to small island nations based on coral reef atolls.

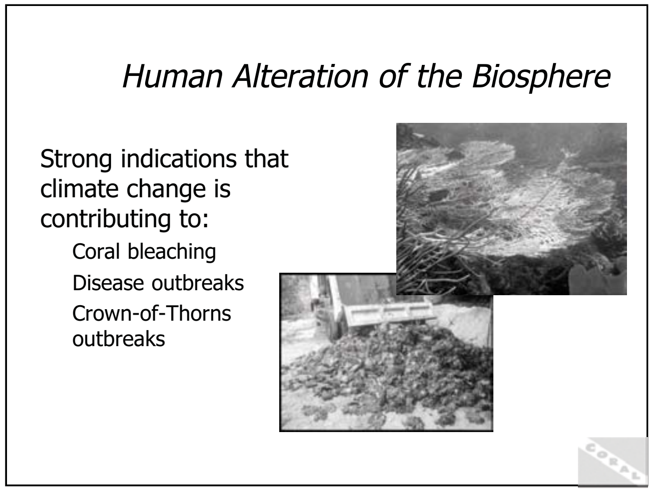
• Due to the interaction of seawater and carbon dioxide, when CO_2 is added to the ocean, it becomes more acidic.

• Increased acidity (decreased pH) makes it more difficult for reefs to form limestone, and makes existing reefs structurally weaker. (For example, you immerse apiece of limestone in vinegar—a mild acid—the rock will begin to dissolve.)

NICE TO KNOW:

• The acidity of the ocean has increased dramatically since the Industrial Revolution. (pH of seawater has decreased by 0.1).

• If emissions of CO_2 continue to rise as predicted, there will be another drop in pH by 0.5 units by 2100, a level that has not existed in the oceans for many millions of years.



WHAT'S THE ISSUE?

• What human activity does to the atmosphere has great impact on the ocean because the two systems are inextricably linked.

NEED TO KNOW:

• While localized bleaching can occur for a varied or reasons (detailed later), the massive events of the past several decades appear to be related to high sea surface temperatures. Most believe these events are linked to atmospheric warming.

• Increased temperature stressed could also be a factor in explaining the proliferation of many coral diseases.

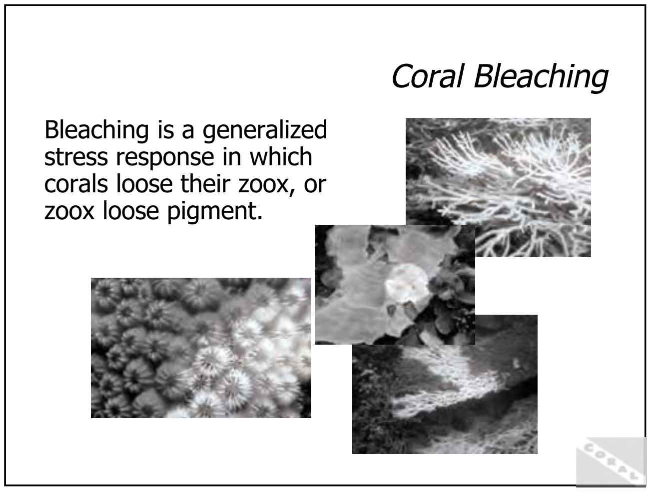
• Climate change has caused increased rainfall in some regions, leading to more runoff from land. Nutrient-rich runoff is suspected of contributing to COTS outbreaks by aiding the survival of larval COTS.

NICE TO KNOW:

• The effects of global warming are likely to be complex and uncertain.

• Another downside of global warming may be a decrease in biological diversity whereby organisms tolerant of warmer water invade the reef. Plus, some species may be killed outright by the higher temperatures.

• However, a possible benefit may be that warmer oceans might expand the geographical range of coral reefs (assuming their growth isn't reduced by other factors such as increasing acidity).



WHAT’S TH EISSUE:

• Bleaching is an increasing common and complex phenomenon that’s not well understood.

NEED TO KNOW:

• Bleaching can be the result of: disease, excess shade, increased levels of ultraviolet radiation, sedimentation, pollution, and salinity changes.

• But mass bleaching appears to be related to increased SST (sea surface temperature).

• Bleaching generally occurs as a result of high relative (not absolute) water temperatures. This may be why bleaching often, though not always, occurs in association with El Niño events (dispersion of warm water from the western through the eastern Pacific).

NICE TO KNOW:

• Bleaching from high water temperatures occurs because it slows or halts the photosynthetic reaction that converts carbon dioxide into sugar. This results in a build-up of products that poison the zooxanthellae. To save itself, the coral spits out the zooxanthellae and some of its own tissue, leaving the coral a bleached white.

• One controversial idea is the so-called "Adaptive Bleaching Hypothesis," which holds that bleaching is a mechanism that allowing corals to find zoox that are better adapter to changing environmental conditions.

• There is evidence that this occurs, but the question whether it can happen fast enough to enable them to respond to the quickening pace of climate change.

• Most researchers believe that the polyp expels zoox, but some maintain that it’s the zoox that cause the polyp to expel them by releasing oxygen radicals.

WHAT’S THE ISSUE?

• Bleaching isn’t necessarily fatal.

NEED TO KNOW:

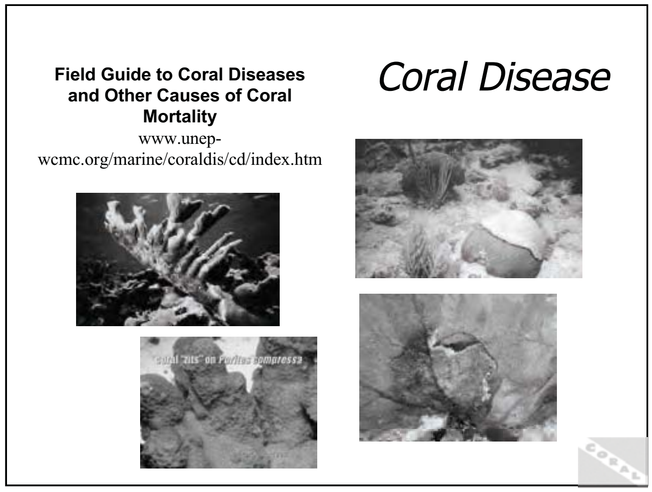
• Whether a bleached reef dies or survives depends on how long the colony goes without zoox (food), and the overall healthy of the colony.

• The better shape a reef is in, the more likely it will recover (just like a person).

NICE TO KNOW:

• Recent studies have show resistance/recovery to bleaching depends on factors such as:

1. Local upwelling of cold water.
2. Natural exposure to heat stress (such as reefs that are emergent at very low tides).
3. High species diversity.
4. Ample larval supply and good distribution.
5. Healthy populations of grazers.



NEED TO KNOW:

• About two dozen diseases or disease syndromes have been recognized in corals and coralline algae.

• Most are poorly understood, and even the cause is unknown for many.

• Harmful bacteria found in human and animal waste may cause disease.

• ***Black band disease*** (a blue/green algae in association with bacteria) and ***aspergiliosis*** (a fungus) are two cases were we know the cause.

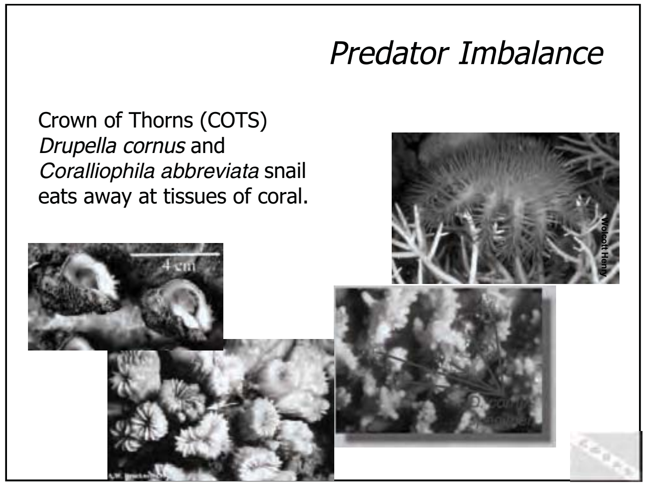
NICE TO KNOW:

• Disease seem to be stress related, and anthropogenic stresses can increase a coral's susceptibility to these diseases.

• The exact methods of diseases transmission are unknown.

• Some disease affected the reef indirectly. Diseased coralline algae dies, leaving the reef unstable and subject to erosion.

• In addition to diseases, corals are also susceptible to tumors and parasitic worms.



WHAT'S THE ISSUE?

• As in all ecosystems, reef health depends upon balance.

NEED TO KNOW:

• An overabundance of coral predators can lead to serious problems.

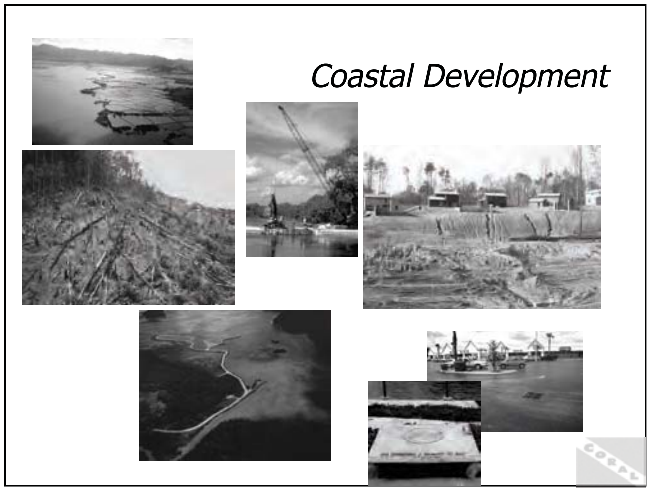
• Evidence points to human impact in many cases such as *Drupella* and *Coralliophila* snails (overfishing of predators, especially lobsters) and COTS (eutrophication)

• COTS outbreak cycles, which were once every few centuries, are now decadal events, and reefs don't have the time to recover.

NICE TO KNOW:

• One way to understand the dynamics of a coral reefs is to view the relationship between reef growth (accretion) and reef loss (bioerosion). The the former exceed the latter, the reef grows. The the latter exceeds the former, the reefs becomes gradually less healthy, and eventually disappears.

• One what the balance is upset, is for conditions to occur allowing coral predators (bioeroders such as sponges, sea urchins and some mollusks) to proliferate.



WHAT'S THE ISSUE?

• While global problems such a climate change may seem insurmountable, some threats are very much within our control on a local level.

NEED TO KNOW:

• Deforestation, mining, over-grazing, and poor land uses cause erosion and sedimentation.

• Agricultural activities and sewage discharge cause nutrient loading, or eutrophication. This shifts the competitive balance in favor of algae, sponges and other organisms that erode coral.

• Some corals tolerate high levels of sediment and build reefs in silty environments, where some even feed on the organic-rich sediment particles.

• Turbidity (cloudiness) - blocks out sunlight. Smothers & buries corals. Prevents juvenile corals from growing. Less food for grazing animals (parrotfish, sea urchins).

• Non-point source pollution is caused by construction of impervious surfaces, such as parking lots, that increase runoff rates by 40 times or more, and carry dissolved substances to the water.

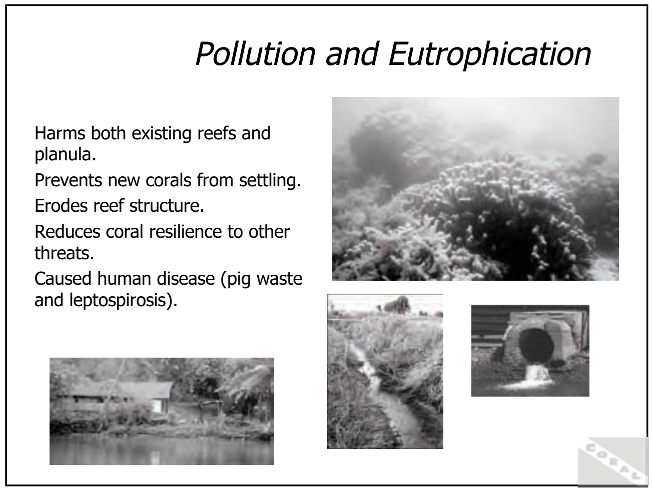
• Coastal development and habitat destruction often affects mangroves and sea grasses, which normally act as filters for sediment. This has increased the sediments and nutrients reaching coral reefs. Mangrove forests are often cut for firewood, removed to create open beaches and resorts, or destroyed by aquaculture projects to create prawn farms.

NICE TO KNOW:

• Paved surfaces create pathways for oil, grease, and toxic pollutants to such an extent that every eight months nearly 11 million gallons of oil (the same amount of oil spilled by the *Exxon Valdez)* run-off enters the ocean.

• In the US alone, 20,000 acres (8,000 hectares) of wetlands are destroyed each year.

• Average erosion rates: Forested (0.004-0.05 tons/ha/yr.); Deforested (30-40 tons/ha/yr.)



WHAT'S THE ISSUE?

• While some forms of pollution are obvious, other forms—such as eutrophication—are not.

NICE TO KNOW:

• Even small amounts of oil can disrupt coral reproduction as the planula larvae are very susceptible to poisoning.

• Sources of eutrophication (excessive nutrients), mainly nitrates and phosphates:

-Both land and boat sewage disposal.

-Septic tanks and injection wells—effluent seeps through porous limestone directly into the fresh water aquifers, into canals, and eventually near shore waters, where currents can transport it to the reef.

-Fertilizers – lawns and farming.

-Cleaning products high in phosphates.

NICE TO KNOW:

• More than half of all the synthetic nitrogen fertilizer ever used was deployed after 1985.

• Why has agriculture become such an important issue in the demise of coral reefs? One reason is because worldwide more land has been converted to agricultural use since 1945 than in the 18th and 19th centuries combined!

• Eutrophication, particularly from sewage, can shift competitive balance to boring sponge *(Cliona)* and other eroding organisms that can weaken the reef.

WHAT'S THE ISSUE?

• Solid waste disposal can pose a serious risk to reef communities, but is one the easiest problems to fix and prevent.

NEED TO KNOW:

• Trash smothers, tangles and destroys corals and other marine life.

• Turtles and other animals may confuse plastic bags for jellyfish and die from suffocation or GI blockage after they ingest them.

• Fishing gear entangles coral and slowly kill the polyps by continuously rubbing against them.

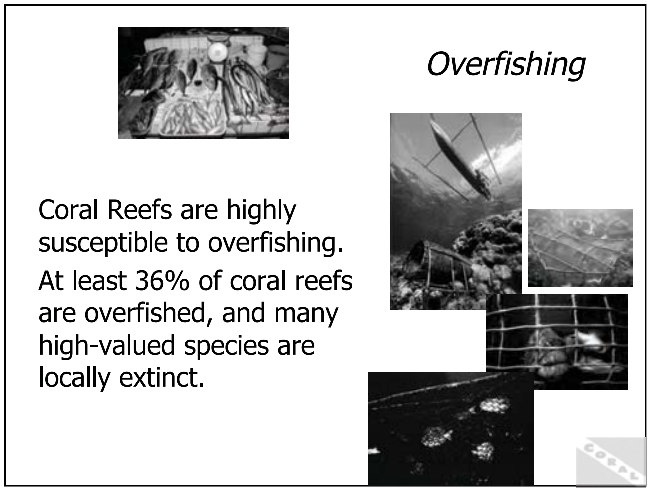
• Aesthetic pollution makes area less desirable, and economy suffers as a result.

• Exotic species are spread when they attach to floating debris.

• Ruined aesthetic quality of the reef can make it undesirable to tourists.

NICE TO KNOW:

• Removing trash from a reef is always as simple as just picking it up. It sometimes becomes encrusted and incorporated into the substrate, require delicate handling and knowledge in how to avoid damaging the reef more than leaving it in place. (More on this will be covered in the "Sustainable Practices & Attitude" segment.)



WHAT'S THE ISSUE?

• Coral reef have been shown to be far more susceptible to fishing pressure than anyone realized.

NEED TO KNOW:

• The trophic (feeding) dynamic of coral reefs doesn't enable them to produce much excess, making them very susceptible to overfishing.

• New research is showing that overfishing is a far more important reason for reef decline than was once thought.

• Many now believe that overexploitation is having as great an effect on coral reef communities as sedimentation and excess nutrient input.

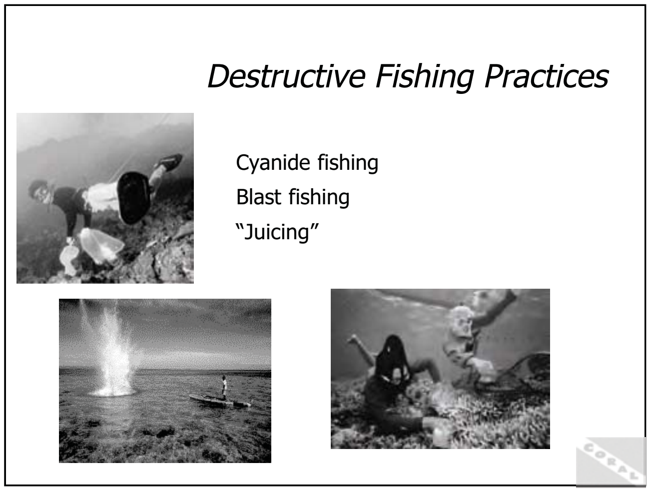
• Still, more than a billion people rely on reefs for their primary source of protein, so overfishing won't be an easy problem to solve.

NICE TO KNOW:

• While the gross productivity is the highest of any ecosystem in the world, most of what's produced is consumed, and therefore recycled.

• The gross primary production of reefs is very nearly balanced by what it consumes. Net productivity is often only 2-3 % of the gross, and only slightly higher than the net productivity per unit area in the surrounding ocean water.

• The inability to sustain large commercial fisheries is a direct result of the low net productivity of coral reefs.



WHAT'S THE ISSUE?

• It's not just the fact that coral reefs are overfished, it's the methods used to fish than can be devastating.

NEED TO KNOW:

• Destructive practices such as blast fishing and cyanide fishing affect the entire reef, not just the target species.

• Even in regions where dynamite and cyanide fishing aren't a problem, the practice of using bleach or concentrated chlorine ("*juicing*") to stun or kill lobster or nocturnal food fish can be an issue.

NICE TO KNOW:

• A one-kilometer beer bottle bomb can leave a rubble crater approximately 1 to 2 meters in diameter, killing 50 to 80% of the coral.

• The average income from bombing 1 km^2 of reef is about *US$15,000* (World Bank).

• The average income from tourism activities is *US$2,833,000* per km^2 (Jour. of Land Use and Environmental Law).

• Other destructive methods:

-Muro ami fishing- line of swimming (normally children) smashing the reef with rocks and polls to drive fish into netted pens).

-Gleaning- the practice of walking over the reef at low tide removing virtually any organism of potential value.

• In one nation alone, the Philippines, degraded reefs and overfishing have lead to an 18% decrease in protein for diet.

WHAT'S THE ISSUE?

• Some reef destruction is driven by consumer demand.

NEED TO KNOW:

• Collection results in removal of important reef species, and affects ecosystem balance.

• The structural integrity of the reef is also weakened by removal of coral.

• Even live rock and coral fragments that are taken from "rubble zones" reduces locations for planula settlement.

• For more information on marine aquarium trade see: www.ems.org/marine_aquarium_trade/facts.html

NICE TO KNOW:

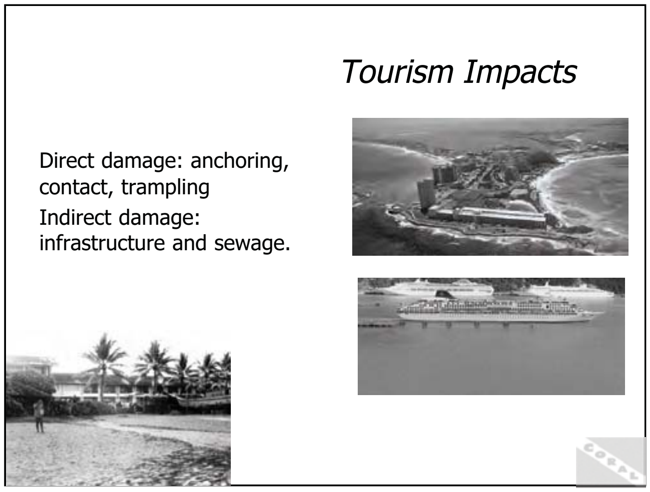
• Coral is mined for building material and burned to produce lime used in the manufacturing of cement.

• Mined coral used for building material yields only about 3 cents per pound, but when sold as "live rock" to the aquarium trade, it goes for ten times that.

• About 750 tons of coral enter international trade each year for use in aquariums (Source: Ornamental Aquatic Trade Association).

• Each year, the US imports more than 80% of all the live coral in trade, representing at least 350,000 pieces(Source: Ornamental Aquatic Trade Association).

• Each year about 10 million individual marine specimens are sold in pet stores in the US at an average retail price of $10 each, earning retailers more than $100 million in revenue (American Marinelife Dealers Association).



WHAT'S THE ISSUE?

• Tourism, if not managed sustainably, can "love the reef to death."

NEED TO KNOW:

• Some damage occurs to reefs from activities such as sport fishing, anchoring and accidental contact by snorkelers and divers. But in the big picture, this is relatively minor.

• The major damage is caused by the infrastructure tourists need. Main drivers are allowing untreated or partially treated sewage to pollute reef areas, sedimentation from construction projects and building faculties in ways that destroy coastal habitats such as beaches, mangrove forests and seagrass beds.

• Large numbers of poorly managed visitors have led to extensive physical damage, sewage pollution, and degraded water quality such that few impacted reefs are now recovering.

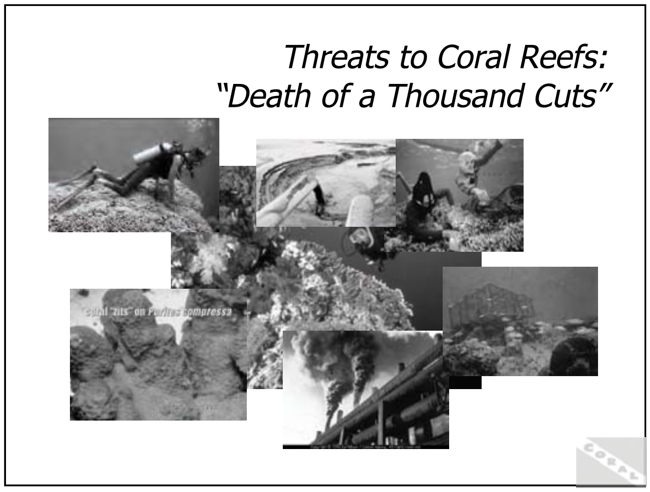
NICE TO KNOW:

• Although tourism can be an environmentally-friendly way of generating income from coral reefs, this happens only when resort development and operation are carefully controlled,

• Some damage certainly occurs from activities such as fishing, anchoring and contact by snorkelers and divers. However, in most cases this is a relatively minor source of degradation.

• The bigger culprit is allowing sewage and other wastes from tourist facilities to pollute reef areas, and citing resorts in ways that promote destruction of coastal habitats such as beaches, mangrove forests and seagrass beds.

• Other issues include: 1) uncontrolled development in areas with little environmental legislation or recognition of cumulative impacts; 2) displacement of locals from sites of tourism interest; 3) little benefit from large resorts to local communities; and 4) undesirable social impacts on indigenous culture.



WHAT'S THE ISSUE?

• Coral reefs are dieing for a host of reasons.

NEED TO KNOW:

• There's no single reason for the decline of coral reefs; instead it's a "death by a thousand cuts." Reefs could probably weather any one of the threats they face, but not the continuous onslaught and so many, such as:

destructive fishing practices

overfishing

tourism damage

disease

climate change

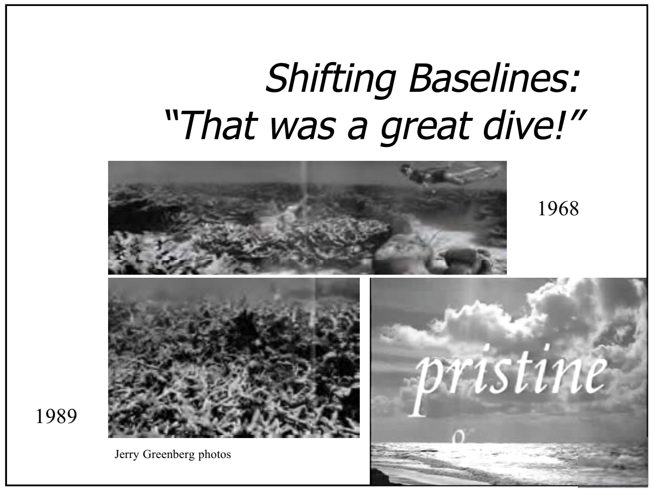
• These cumulative effects are interacting and come from both natural and human-induced stresses.

• Multiple stressors—both chronic and acute—can lead to disease, slow growth and weakened immune system, just like what happens in people.

• Coral reefs, more or less, as we know them have existed since the time of the dinosaurs, but what the future holds is up to us!

NICE TO KNOW:

• There is much debate over how we can best stem the tide of reef degradation. Many think that anything other than addressing climate change is fruitless. Other believe that if enough of the localize stresses are removed from reefs, they may be able to deal with the global insist. The thing that we know that absolutely will not help is to do nothing.



WHAT’S THE ISSUE?

• Without perspective, it’s easy to assume that the current state of an ecosystem is normal and healthy.

NEED TO KNOW:

• What does “shifting baselines” mean? A baseline is a reference point from the past—how things used to be. If we allow these reference points to shift, we lose track of our standards, and eventually accept the degraded state as being “natural.”

• Providing tourists with the perspective may be the most important issue that we face on the tourism sector.

• We must try to make people understand that what they’re seeing on a coral reef today is a pale image of the past.

• If we don’t address this misperception, many tourists will leaving thinking that nothing is wrong—and the consequences of that attitude will be tragic.

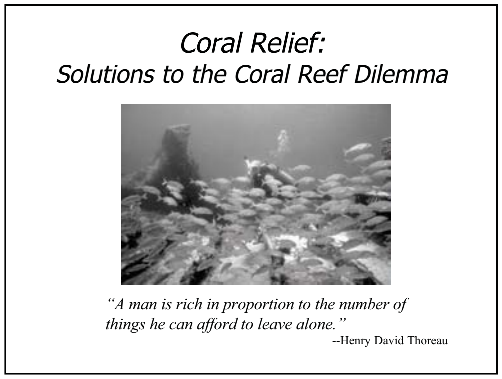
NICE TO KNOW:

Visit www.shiftingbaselines.com for more perspective on the shifting baselines phenomenon.

Coral Relief—Solutions to the Coral Reef Dilemma

Understanding the function of coral reefs and the problems that they face is important, but the more vital concern is what we can do to halt their demise. It's easy to conclude that, given the scale and severity of the stress on coral reefs today, there's little cause for optimism. But this simply isn't so. There are numerous examples where, through creativity and commitment, people all over the world are starting to slow the progression of reef decline, and tilt the scale in the opposite direction. While the problems are daunting, the situation is far from hopeless.

This segment discusses the measures that coral reef experts and resource managers believe are necessary to save these vital ecosystems. In addition, it will explore some effective locally-based solutions that don't require huge sums of money, or marshalling the support of millions of people. It concludes with some simple steps everyone can take to protect coral reefs. Although the task before us may seem impossible, remember the advice of a Chinese proverb: "A journey of 10,000 miles begins with a single step." Small actions do add up and can make a difference.



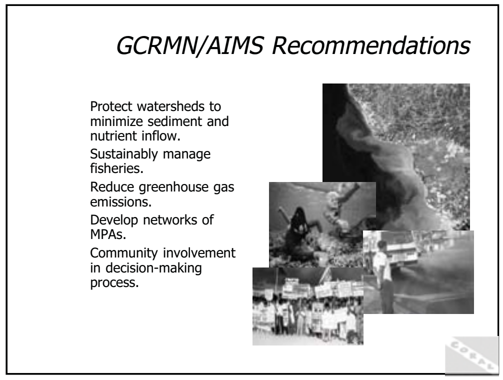
POINTS TO MAKE IN INTRODUCTION:

• You now have a basic understanding of how coral reefs function, and the problems that they face. While those problems are daunting, the situation is far from hopeless.

• This presentation will start off by exploring what experts think should be done to halt the decline. We'll then explore a few effective locally-based solutions from around the world that don't require huge sums of money or marshalling the support of millions of people.

• We'll conclude with some simple steps everyone can take to protect coral reefs.

• The most important thing to remember is the advice of a Chinese proverb: "A journey of 10,000 miles begins with a single step." Small actions do add up and can make a difference.



WHAT'S THE ISSUE?

• Actions required to deal with coral reef decline.

NEED TO KNOW:

• In their *State of the Coral Reefs of the World* 2004 report, the Global Coral Reef Monitoring Network at the Australian Institute of Marine Science, made several recommendation on how we can reverse help restore coral reefs. Let's look at those briefly before exploring the details.

[Quickly review slide, as each point will be more thoroughly discussed later.]

NICE TO KNOW:

• Reduce or remove the direct pressures on coral reefs through integrated catchment and coastal management to minimize the inflow of polluting sediments and nutrients into reef waters.

• Manage coral reef fisheries to make them sustainable and prohibit damaging fishing practices.

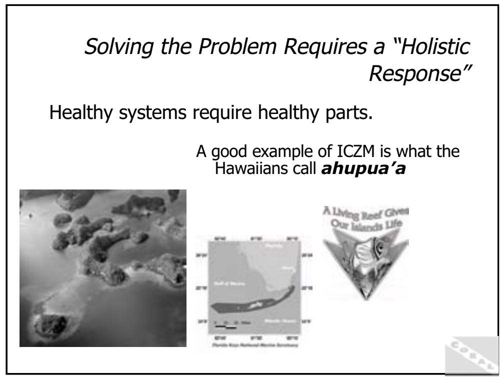
• Improve fisheries yields by protecting breeding stocks in no-take MPAs, protecting spawning sites, and use selective breeding programs to satisfy the
• Asian restaurant market for live reef fish.

• Reduce emissions of greenhouse gases.

• Involve local communities in the design and management of MPAs, and the enforcement of regulations.

• Develop networks of MPAs that contain the most resistant and resilient organisms, and are connected to ensure a free larval transfer.

• Successful management uses a "bottom-up" approach. In doing so, management is done through a collaborative, community-based strategy that begins by engaging and involving those effected by regulatory decisions; all the while taking into account the impact on local people, their culture, historical use of the resource as well as political realities.



WHAT'S THE ISSUE?

• Coral reefs cannot be managed effectively in isolation from other ecosystems.

NEED TO KNOW:

Why is integrated coastal zone management (ICZM) so important?

• Coral reefs do not exist in isolation and cannot be managed as discrete patches within the sea.

• Instead, reef management must include the associated watershed and nearshore communities, such as seagrass beds and mangrove forests.

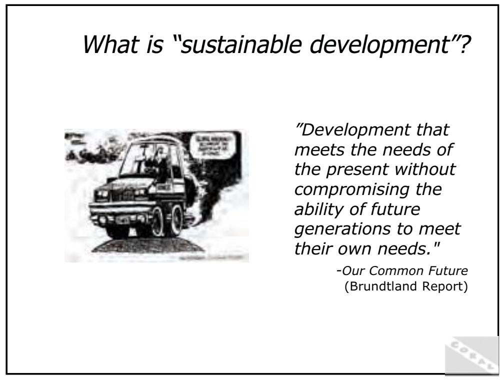
• Although a relatively new approach to managing resources, ITCZ is actually based on a very old concept (*ahupua'a)* that you can't manage a resource in isolation; you can't just draw a boundary around a coral reef and think that that's all you need to protect it.

NICE TO KNOW:

• Management practices have historically focused on the coral reef alone and have not considered associated communities or defined watersheds in a meaningful manner.
• Modern management strategies recognize the importance of including reefs as part of a larger system, incorporating comprehensive management and conservation plans.

• When reefs are considered as part of a larger watershed, the recognition of the complexity of environmental stresses can be more readily understood.

• Effective management of coral reefs—or any region of the sea—must approach the problem not in piecemeal, This follows the idea that an ecosystem is greater—and far more complex—than simply the sum of its parts. This is termed "ecosystem-based management."



WHAT'S THE ISSUE:

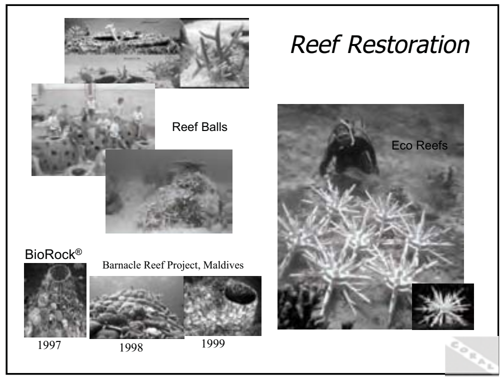
• We can no longer manage our resources in ways that ignore the impact on future generations.

NEED TO KNOW:

• In addition to ICZM, resources must be managed based not only on current but on future needs, as well. This is termed "sustainable development."

• Some question whether sustainable development is even possible, or view the term as an oxymoron. Still, what's the alternative? Continuing "business as usual" certainly is no answer.

[There is no need to delve into detail here as the issue of sustainable development will be addressed more thoroughly in the "Marketing Sustainability" presentation.]



WHAT'S THE ISSUE?

• Sometimes humans can give Mother Nature a helping hand.

NEED TO KNOW:

• A number of innovative techniques exist to restore damaged reefs such as Reef Balls.

• Other techniques include replacing the bulk of the reef structure with massive concrete blocks, then gluing small coral colonies to them. (Used in the Florida
• Keys as a restoration after ship groundings).

• Eco Reef modules are made from a ceramic materials designed to emulate branching coral colonies. They eventually erode, leaving behind only nature coral. Very light and easily deployed.

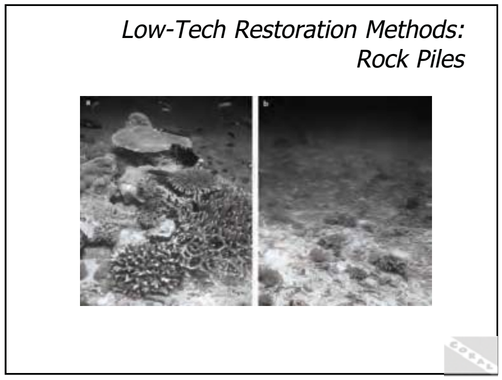
• A Biorock reef uses an electrically conductive frame, usually made from rebar or wire mesh, welded together, submerged and anchored to the bottom.

• A low voltage direct current is then applied. (Power sources can include chargers, windmills, solar panels or tidal current generators.) This initiates an electrolytic reaction causing mineral crystals naturally found in seawater to grow on the structure at a rate 3 to 5 times faster than normal growth, giving them extra energy that allows them to survive in conditions that would otherwise kill them.

NICE TO KNOW:

• While these methods may work over a limited area, restoration is not a viable large-scale solution to reef degradation.

It's also important not to infer that these kinds of remedial actions should be used in place of preventive actions.



WHAT'S THE ISSUE?

• Simple, inexpensive methods for reef restoration.

NEED TO KNOW:

• Restoration doesn't necessitate high technology, materials and expense.

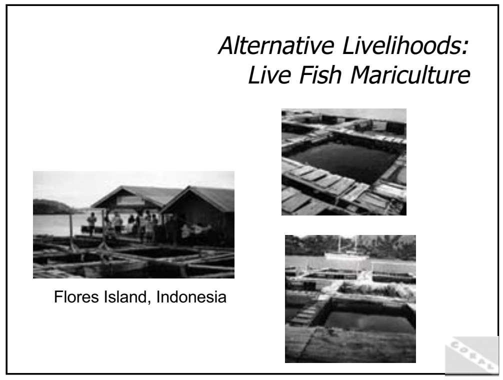
NICE TO KNOW:

• Rubble fields of dead coral fragments, like those from blast fishing, are persist for decades to centuries with little natural recovery. This has prompted reef rehabilitation efforts in damaged areas in Komodo National Park (KNP), Indonesia.

• Pilot research from 1998–2000 tested three low-tech rehabilitation methods at small 1·1 m2 scales (rock piles, cement slabs, and netting pinned to the rubble). Rock piling was the most successful method and was scaled up (10–100 m2 plots) at nine sites in May 2000.

• The network of rocks recreates the three-dimensional structure of an intact reef, providing surfaces for coral recruitment and refuges for fish and invertebrates. Recent monitoring of these plots show continued coral growth, with some tabulate and branching Acropora colonies reaching 60–80 cm in diameter after 4.5 years (left).

• Rubble encroachment remains a problem at the highest current sites, but where successful, the transformation of rubble fields to reefs is dramatic.



NEED TO KNOW:

To make coral reef fisheries sustainable:

• Stop all destructive practices.

• Recognize that, due to the nature of coral reef ecosystems, they cannot support fisheries on the scale of those in temperate or polar regions. Coral reefs cannot provide the full demand for protein in tropical countries, especially with the large increases in coastal populations..

• Protect both the smallest and the largest fishes.

• Provide alternative livelihoods for fishers.

• The photos are of a TNC-sponsored facility that has had much success in addressing the “live fish” issue in the Komodo region.

WHAT'S THE ISSUE?

• Using consumer knowledge and pressure to reduce coral reef threats.

NEED TO KNOW:

• MAC is an international, not-for-profit organization that brings marine aquarium animal collectors, exporters, importers and retailers together with aquarium keepers, public aquariums, conservation organizations and government agencies.

• MAC's mission is to conserve coral reefs and other marine ecosystems by creating standards and certification for those engaged in the collection and care of ornamental marine life from reef to aquarium.

NICE TO KNOW:

• A one-minute PSA on the issue of taking ornamental fish with poisons and other inappropriate methods is available from MAC.

• The PSA and lots of other excellent material can be seen and downloaded form the MAC web site: *www.aquariumcouncil.org*

WHAT’S THE ISSUE?

• Using consumer knowledge and pressure to reduce coral reef threats.

NEED TO KNOW:

• Know where the seafood you eat comes from and how it’s obtained.

• Consumer pressure has a powerful affect. Just consider the success of the “dolphin safe” tuna program in the US (one of the most successful environmental campaigns ever).

• Your choice of what you spend your dollars on can make a difference.

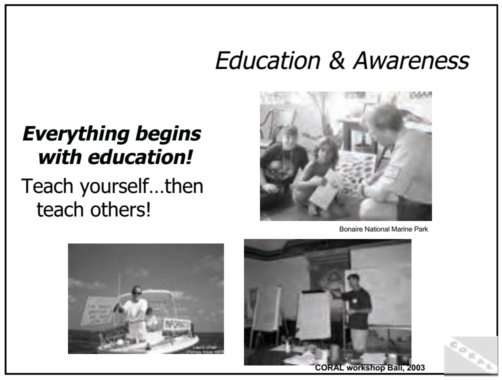
• Ask where the seafood you are eating at a resort comes from, and if it was caught using unsustainable practices (if so, refuse to buy it).

• Don’t help deplete the reef. When possible try to avoid eating reef fish—grouper, snapper, parrotfish—and opt for pelagic species like tuna, wahoo (ono) or mahi.

• CORAL is a member of the Monterey Bay Aquarium's Seafood Watch Program (past out copies of the wallet card guidelines).

NICE TO KNOW:

• The Monterey Bay Aquarium Seafood WATCH program is designed to raise consumer awareness about the importance of buying seafood from sustainable sources. They recommend which seafood to buy or avoid, helping consumers to become advocates for environmentally friendly seafood. Seafood WATCH also partners of the Seafood Choice Alliance where, along with other seafood awareness campaigns, they provide seafood purveyors with recommendations on seafood choices.



WHAT'S THE ISSUE?

• In addition to knowledge, change require the ability to communicate what you know.

NEED TO KNOW:

• Education is a vital aspect of resource management for two reasons:

1) It enables people people to understand the consequences of their actions;

2) It empowers people so that can effectively participate in the decision-making process.

• Education can change perceptions and values to encourage voluntary compliance and care ("ownership")

NICE TO KNOW:

• Education is not the same thing as interpretation. The later is context specific.

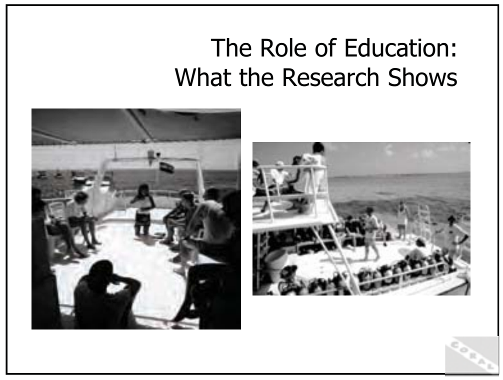
• According to the National Association for Interpretation, interpretation is *"a communication process that forges emotional and intellectual connections between the interests of the audience and the meanings inherent in the resource."*

• Interpretation is NOT:

- Simply the communication of facts. (Facts are important in interpretation but not enough.)

- The interpreter's personal soapbox ("Interpreganda"), which oversimplifies and ignores multiple points of view.

- Entertainment without a message ("Interpretainment"), arranging facts around a punch line, shows that you don't believe the audience is interested in the resource, and/or you don't care what the audience thinks.



WHAT'S THE ISSUE?

• The ability for education to change attitude and behavior is well-documented.

NEED TO KNOW:

• A consistent conclusion from researchers is that <u>education</u> largely determines the level and nature of interaction with coral reefs, and one's attitude toward conservation.

• A short sentence to "don't touch the reef" isn't enough. Don't overdo it, but be thorough.

• Provide in-water supervision, and intercede when you see inappropriate behavior.

NICE TO KNOW:

<u>Townsend Study, 2000</u> (British Virgin Islands)

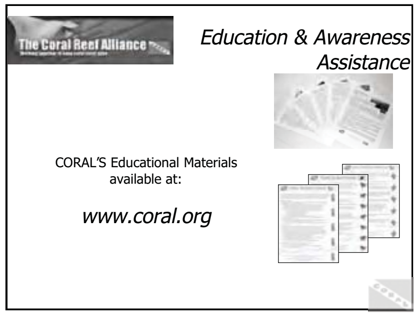
• The control (no briefing) group had an average touch rate 26 per dive.

• The experimental (briefing) group showed an average of only 7.8 contacts.

<u>Medio Study, 1996</u> (Red Sea)

• With no briefing, divers made contact with the reef 8 times per dive, and 80% of those contacts were damaging (65% of all contacts were voluntary).

• After a short briefing, contact fell to an average of only 1.5, with less than 30% of those damaging (20% of all contacts were voluntary).



WHAT'S THE ISSUE?

• Many tools already exist that can be issued to educate and inform others.

NEED TO KNOW:

• Coral has five "policy briefs" covering these topics.

• Each provides a well-documented, two-page overview of the listed issues.

• These are available for download on the CORAL web site. You may reproduce and use these as you wish, provided CORAL is credited.

• In addition, CORAL provides a host of educational and reference materials such as tourism guidelines and handbooks, resource library, photo bank, directory of coral reef organizations and discussion board.

• Copies of many of these materials are on your CD, and they can be downloaded from our web site.

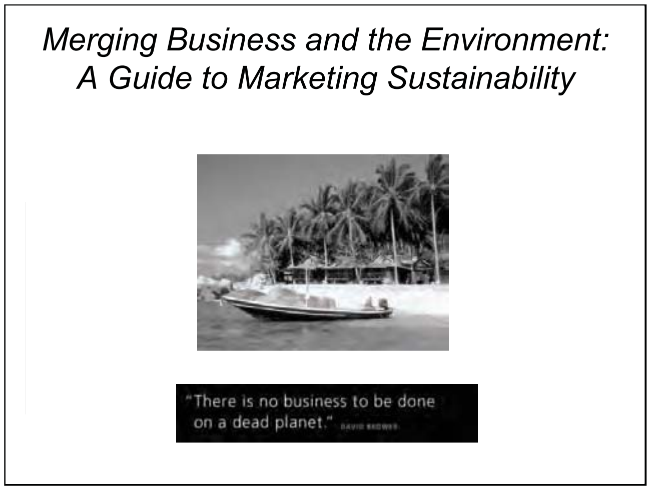
Merging Business and the Environment—A Guide to Marketing Sustainability

People want to protect coral reefs for a multitude of reasons. Some simply because of their innate beauty and a sense of responsibility toward nature. Others have a much more practical outlook. Many people, especially those in the tourism sector, are dependent upon coral reefs for their livelihood. So for them, the continued health of coral reefs—particularly the ones right outside their door—is a very important and practical matter.

Those responsible for running tourism-related businesses, while not uncaring, have as their first duty keeping their doors open. To them, everything else must be a secondary consideration. While environmentalists, businessmen and resource managers may have the common interest of protecting coral reefs, the lens through which they each view the world can be vastly different. This is neither good nor bad; it's simply a fact that we must understand and factor into any conservation effort aimed at coral reefs.

Traditionally, people have viewed conservation and business as incompatible; one progresses only at the expense of the other. But this view is counterproductive, as well as basically wrong. The truth is that there can be no marine tourism without a healthy resource. Therefore, taking steps to assure that local coral reefs are as healthy as possible is perhaps the most important step that any marine tourism business can take to succeed. Conservation and business are not contradictory but complimentary. Without healthy reefs there can be no business; but without healthy businesses, a primary motivation and mechanism for conservation cannot exist.

Conservation shouldn't be viewed by entrepreneurs as something you do solely for the "greater good" because, when marketed properly, a conservation ethic can be as important to the success of a tourism business as anything else done to bring in customers. No conservation program or goal is achievable unless it's economically viable; and this presentation is designed to show the nexus between protecting your reef and enhancing your business success.



NOTES TO PRESENTER:

• While some audience members are doubtlessly committed to protecting coral reefs based solely on their deep love and commitment to the resource, that's probably not the case with all.

• Business owner and managers, while not uncaring, have as their first duty keeping their businesses running. Everything else is a secondary consideration. Never lose sight that, while environmentalists, businessmen and resource managers may have the common interest of protecting coral reefs, the lens through which they each view the world is probably vastly different. This isn't good nor bad; it's simply a fact.

Points to make in the introduction of this segment:

• There is no marine tourism without a healthy resource, so making sure that your reefs are as healthy as possible is perhaps the most important factor in the success of your business.

• But conservation shouldn't be viewed as something you do solely for the "greater good" because, when marketed probably, it can be as important to your bottom line as as anything else you do to bring in customers.

• No conservation program or goal is achievable unless it's economically viable; and this presentation is designed to show you the the nexus between protecting your reef and enhancing your business success.

What's the World's Biggest Industry?

Tourism

Source: World Travel and Tourism Council

WHAT'S THE ISSUE?

• Tourism is not some tiny and insignificant industry.

NEED TO KNOW:

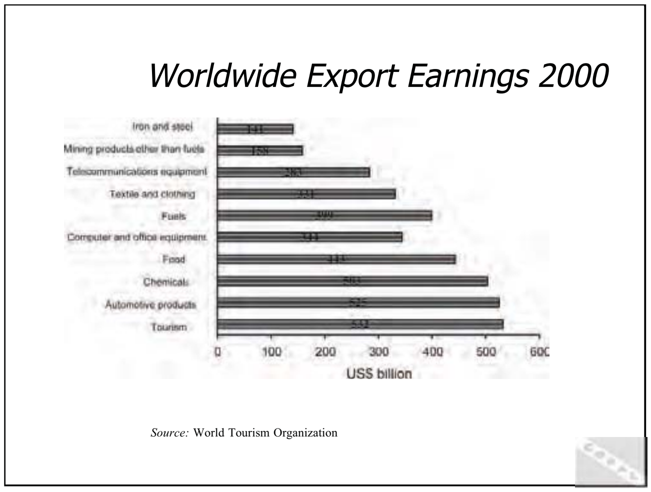
• Tourism accounts for 11.4% of all consumer spending, and is now the world's largest employer, accounting for more than 255 millions jobs (10.7% of the global workforce).

• Each year nearly 700 million international travelers embark on holidays—a figure that's expected to double by 2020.

• Worldwide tourism generates 27 times more income than all fisheries combined.

• In the day-to-day business of fixing compressors, keeping boats running and creating happy customers, we sometimes forget the big picture. Many also think that "tourism" is a relatively modest economic force compared to other "real" businesses, and that it has relatively little influence on decision-makers. If that's how you feel, then you're in for a surprise.

• We in the tourism business often don't realize that we're part of the largest economic endeavor on earth. This gives us considerable clout in making governments and resource managers appreciate just how important we are, or should be, in the decision-making process. We are not minor players!



WHAT'S THE ISSUE?

• The size of the tourism industry alone means that it can't be ignored.

NEED TO KNOW:

• Here's how tourism stacks up to other industries in terms of export earnings.

• Tourism is slightly larger than the auto industry—532 versus 525 billion US dollars in export earning for 2000—but do we have the same level of influence as other industries?

NICE TO KNOW:

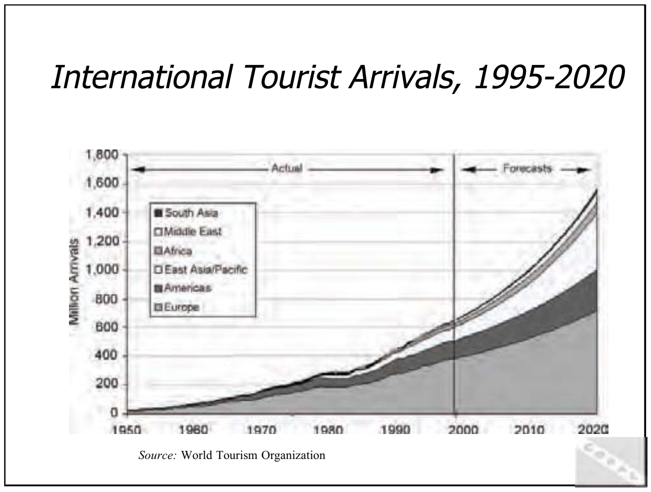
Some facts regarding international tourism:

- It accounts for 36% of trade in commercial services in advanced economies and 66% in developing economies.

- It constitutes 3–10% of GDP in advanced economies and up to 40% in developing economies.

- It's one of the top five exports for 83% of countries, and the main source of foreign currency for at least 38% of countries.

Source: World Tourism Organization



WHAT'S THE ISSUE?

• If tourism growth isn't balanced with accommodation of its environmental consequences, we're in for some big problems.

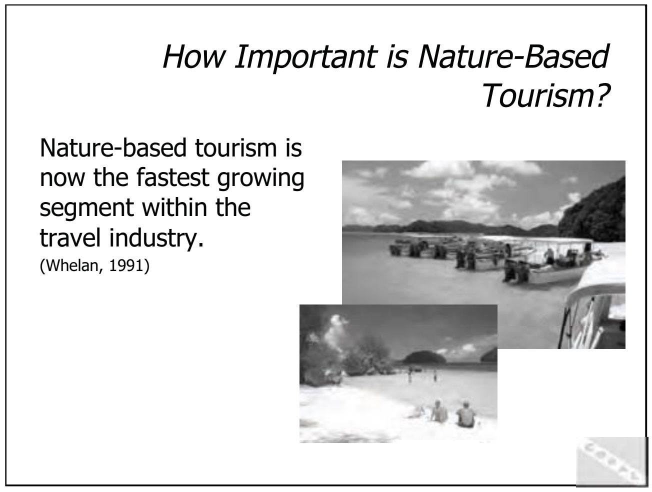
NEED TO KNOW:

• Here's both the good and bad news: Although it's already the biggest industry on earth, the forecast is for tourism to double by 2020!

• However, if we proceed in a "business as usual" fashion—without regard to our impact on the environment—we're in for some really serious problems.

• The economic boon of doubling your business is obvious, but think for a moment about what this will really mean, other than it's profitability. What demands will it place on local infrastructure, such as sewage treatment, and environmental resources, such as coral reefs? How will it change the local lifestyle and culture?

• The result could be a very frightening double-edged sword.



WHAT'S THE ISSUE?

• The size of the tourism industry means that it's a sector that should have significant influence on decision-makers.

NEED TO KNOW:

• Marine tourism is part of this fastest growing segment of tourism—nature-based tourism (Growing at a rate of nearly 30% per year, and accounting for more than 10% of all tourism dollars).

NICE TO KNOW:

• Nature based tourism is defined as "any type of tourism that relies on attractions directly related to the natural environment."

• Core nature based tourism activities include:

– Adventure Tourism

– Ecotourism

-Environmental/cultural education, appreciation, and conservation

– "3S" (Sun, Surf, and Sand) Tourism

– Extractive tourism (Fishing)

–Tourism to wildlife parks and other natural attractions

How Important is Marine Tourism?

Generates 85% of all tourism (or US$ 385 billion in revenue).

Source: Orams, 1999

10 - 14 million people each year engage in scuba diving (most seeking out coral reef destinations)

Source: Viders, 1997

WHAT'S THE ISSUE?

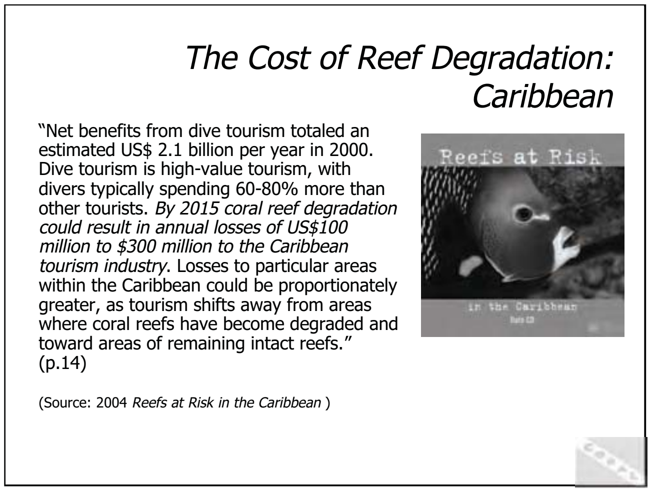
• Most tourism is marine oriented, and much of this occurs in tropical —often coral reef—regions.

NEED TO KNOW:

• The data here from Mark Orams considers ALL marine tourism—everything that goes on in or around the sea—not just that involving coral reefs. But the majority of marine tourism takes place in the tropics, on or around coral reefs.

• While marine tourism represents tremendous opportunity, it also represents and equally tremendous risk to the resources that support it.

• Note that Hilary Viders estimated diver figures includes ALL forms of scuba diving, including introductory (uncertified) divers. The number of introductory/resort divers probably matches or exceeds the number of certified divers.



WHAT'S THE ISSUE?

• The degradation of coral reefs in some region can mean opportunities for other regions.

NEED TO KNOW:

• Sorry for all the text, but read this carefully and see what you could lose. Pay particular attention to the red text.

• While is conclusion comes from the Caribbean, there's no reason to believe it's any different elsewhere.

• Degradation of coral reefs, regardless of where they are, won't occur uniformly throughout the region; it will happen at different rates in different locales.

• Therefore, if YOUR destination takes care of its reefs, then you're likely to be one of the beneficiaries when divers begin to search out those reefs that are still in good shape.

• The idea that "good environmental management means good business" isn't just a catch-phrase–it's reality.

NICE TO KNOW:

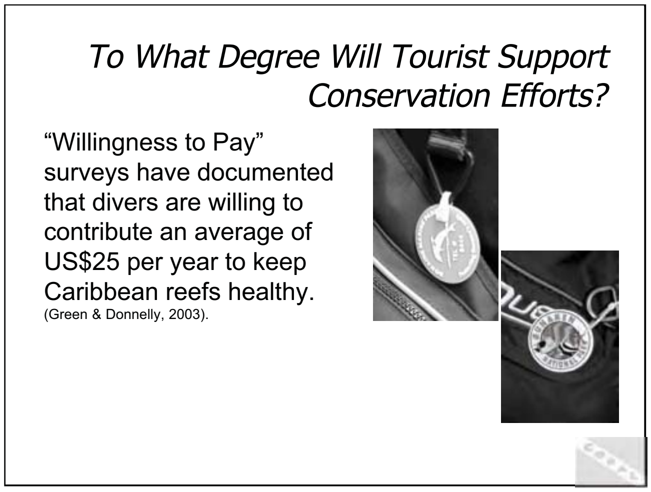
• Scuba divers are especially desirable tourist because they spend much more than the average tourist.

• In the Caribbean, while divers make only 10% of all visitors

but contribute about 17% of all tourism revenue (and there's no reason to believe that this is unique to the Caribbean).

• The average diver spends about US$2,100 per trip to the

Caribbean, compared to US$1,200 for tourists in general.



WHAT’S THE ISSUE?

• Tourists will support conservation if the understand how funds are administered and spent—and can these positive results.

NEED TO KNOW:

• The Bonaire Marine Park has already increased its admission fees$10 to $25 for divers, and has begun charging $10 for non-divers (something not done in the past).

• However, tourist will not support user fee unconditionally. Their acceptance requires certain conditions, especially reasonable assurance that:

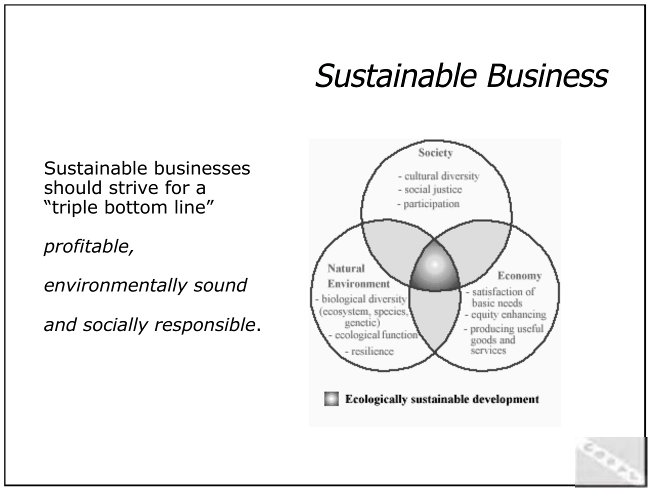
-funds collected must remain in and be used for the specific resource they’re supporting.

-funds are used appropriately.

•This requires a systems that’s both honest and “transparent.”

NICE TO KNOW:

• The issue of government mistrust can sometimes be remedied by establishing a separate authority, or allowing a non-governmental organization, to run the resource in question.



WHAT'S THE ISSUE?

• For long-term survival, business people can no longer look at economics as the sole factor is success.

NEED TO KNOW:

• Many progressive and successful business people understand that traditional economic models focusing solely on profitability, and ignoring issues such as social responsibility and environmental impact, will not work in the long run.

• A relatively new idea is that the traditional concept of business success—how profitable a business is (the "bottom line")—only takes into account the short term.

• Today, many of the most successful business entities in the world have come to understand that, without addressing the social and environmental impact of their ventures, they cannot sustain a business in the long term. This has lead to the concept of the "triple bottom line."

• Note that this isn't altruism, but rather a clear, far-reaching and practical recognition that success cannot just be measured by narrowly focusing on short term profitability; businesses must look to long-term viability (sustainability) for success.

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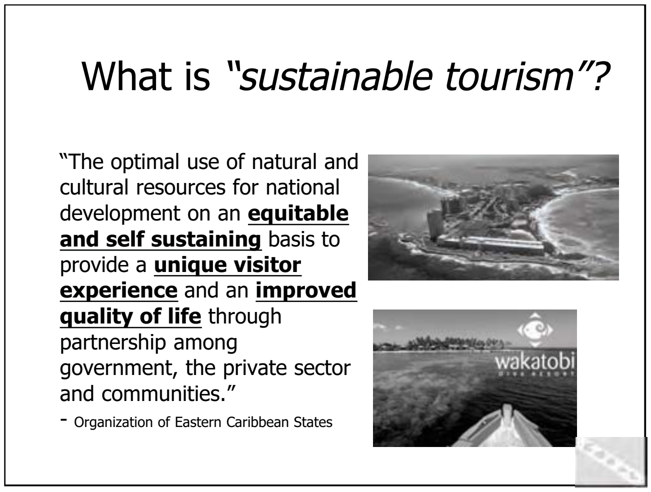


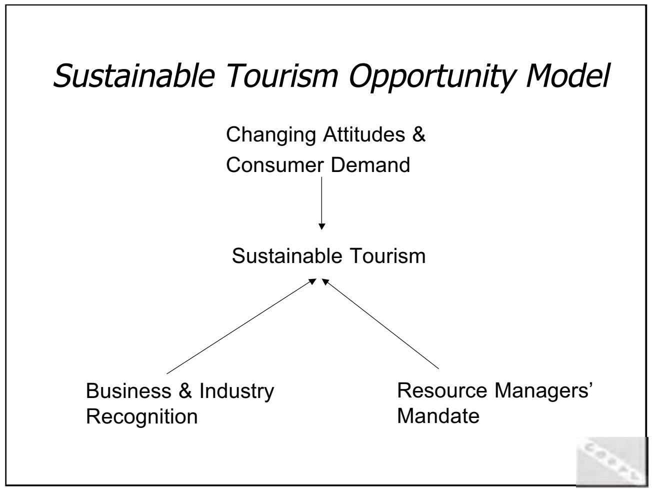
WHAT'S THE ISSUE?

• Conducting business in consideration of economic success, as well as its affect on the local people and the environment is the only path to true long-term success.

NEED TO KNOW:

• We could teach an entire seminar just on the definition of "sustainable tourism," and in fact, many prefer the term "responsible tourism" to avoid the debate over what sustainability really means. But let's not get bogged down in terminology.

• Sustainable tourism is not just "ecotourism" or even nature-based tourism. The concept can, and many believe it must, be applied to all forms of tourism. Anything that is "unsustainable," by definition, cannot continue.



WHAT'S THE ISSUE?

• The merging of three trends in society, economics and environmental concern present an opportunity like never before.

NEED TO KNOW:

• The "triangulation" of a 1) changing consumer mind-set, 2) mandate for resource managers to stop the destruction of reefs and 3) the increasing recognition that new business opportunities are possible, have all created an unprecedented opportunity to realize the "triple bottom line" of profit, environmental sustainability and social responsibility.

• To savvy business people there are no such things as problems, just unfulfilled opportunities. So, if you view these merging trends as "obstacles" to be avoided or eliminated, the result will be fewer opportunities to grow.

• Success requires that we stop viewing what we need to do to make a business sustainable as a "cost"—money out the window—and view it instead as an opportunity for "investment"—money that will be returned with a premium.

What are the goals of sustainable tourism?

1. Minimizes environmental impacts.
2. Protect the environment by maintaining biological diversity.
3. Minimize use of non-renewable resources.
4. Ensure cultural integrity, local ownership and social cohesion.
5. Provide a high quality experience for tourists.

WHAT'S THE ISSUE?

• The goals of sustainable tourism go far beyond economic considerations.

NEED TO KNOW:

• Here are some quick indicators of what tourism operators should be doing to fulfill the requirements of sustainability. [Review slide.]

• But the question remains, how can you achieve these goals?

To What Degree Does Your Business Consider Its Impact on the Local Community?

- Does your company patronize local food, craft, lodging and equipment vendors?
- Does your company use local guides?
- Have you initiated any joint business agreements with local communities?
- Do you work with community leaders and institutions to increase the region's standard of living?

WHAT'S THE ISSUE?

• Indicators that a business is truly committed to sustainability.

NEED TO KNOW:

• While most understand that sustainability has both economic and business dimensions, fewer recognized that it contains a social component, as well.

• To become truly sustainable, social dimensions must be considered because what you do in your business clearly has some effect on the community at large.

• Again, taking these social issues into account is not altruism. It is vital to the long-term success of your business operation, particularly one owned or operated by expatriates in developing countries.

Why is understanding sustainable tourism so important?

83% of US travelers support "green" travel companies, and are willing to spend on average 6.2% more for environmentally responsible travel services and products.

Travel Industry Association of America, 1997

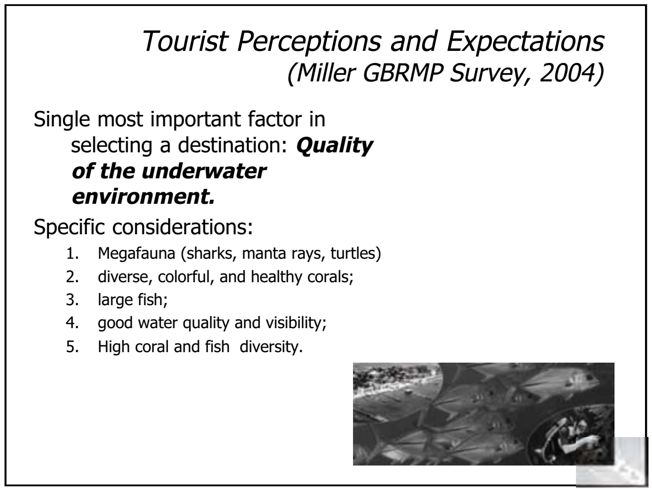
WHAT'S THE ISSUE?

• Many consumers are already aware and supportive of measures that make business more environmentally-friendly.

NEED TO KNOW:

• While many debate the specifics of how much consumers are willing to spend, there's no doubt that today's tourist is willing to patronize, and pay some premium, to operators that they **clearly** **recognize** as doing business responsibility. Here's one such survey, but there are many others.

• Therefore, a savvy and responsible tourism professional not only implements but **markets** it's good practice and commitment to social and environmental sustainability.



WHAT'S THE ISSUE?

• Protecting your local resources (environment) isn't just something to do because it's right, the resource is also your business's most important asset.

NEED TO KNOW:

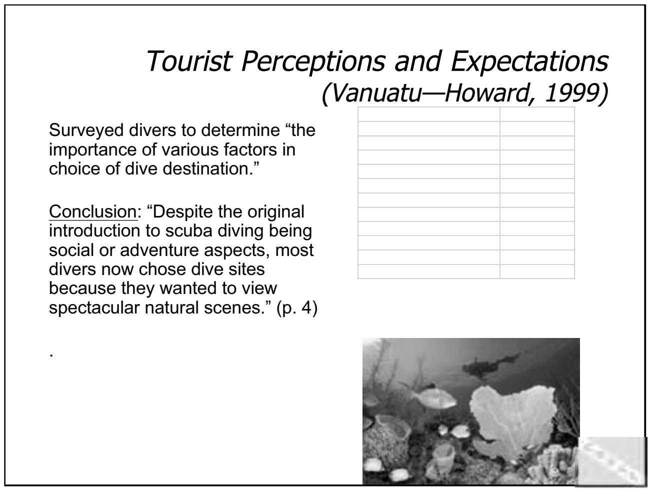
• Although it may seem obvious, it must be emphasized that the single most vital consideration for many nature-based tourists in selecting a destination is the quality of the environment. To divers this, of course, means the underwater environment.

• Some studies have tried to document exactly what constitutes a "quality" environment, and the next few slides will look at what various researchers have found.

• Note that any study for any study cited in the slides, a full citation is contained in the "Resource Guide" on your CD.

NICE TO KNOW:

• Here we have findings from Dean Miller from research he did for his doctoral dissertation. This is based on experience with high-end liveaboard divers on the GBR.



WHAT'S THE ISSUE?

• When it comes to selecting a tourism destination, the quality of the environment is often a customer's most important criterion.

NEED TO KNOW:

• Some in tourism believe that a poor-quality product can be overcome by marketing, but research says otherwise. Note in this study that a factor such as advertising was regarded as relatively unimportant in choosing a destination.

• This is not to say that "special attractions" like artificial reefs can't help enhance a degraded destination.

• Another conclusion one could draw from the research is that a divers' continued motivation to stay active is greatly affected by the quality of his/her experience. And the quality of experience is related to the quality of the environment.

NICE TO KNOW:

• Artificial reefs are often associated with diving and coral reefs, and are popular in many regions. However, a issue to consider is what impact artificial reefs can have on the ecosystem.

• Resource managers are now of a mind that, without high levels of fisheries protection ("no-take" status), artificial reefs just make it easier to empty the local ocean of fish by concentrating them and making fish easier to catch.

Tourist Perceptions and Expectations
(Roatan—Pendelton, 1999)

Most important factors in determining what a diver considered a "high-quality" reef:

1. amount of coral cover;
2. fish diversity;
3. clear water.

WHAT'S THE ISSUE?

• Studies have documented how importance the quality of the environmental is to tourists, particularly those who scuba dive.

NEED TO KNOW:

• UCLA researcher Linwood Pendleton, in a study from Roatan, Honduras in 1999, found the following [review slide]

• These factors far outweighed issues such as cost, amenities and convenience.

• These findings should come as no surprise to anyone familiar with dive tourism, but it is good to know that our suspicions have been validated.

Tourist Perceptions and Expectations
(GBRMP—Shafer & Inglis, 2000)

Found that the two most significant factors influencing the enjoyment of day use visitors to GBRMP are:

1. quality of corals and fishes; and
2. ***staff interactions.***

WHAT'S THE ISSUE?

• Environmental quality is vitally important, but so are "human factors" such as your staff.

NEED TO KNOW:

• It's easy to understand how important the quality if the environment is to the tourist, but don't discount the human factor.

• The quality of staff, and the interaction customers have with them, is another prime determinant in the perceptions and measures of satisfaction of tourists.

• These results are consistent with research from terrestrial settings, as well. Be it on land or sea, tourists what a high quality environment, and have positive interactions with knowledgeable, personable and professional staff.

WHAT'S THE ISSUE?

• Many organizations in the tourism industry now recognize the importance of sustainability, and offer assistance to businesses that want to embrace good environmental practice.

NEED TO KNOW:

• Tourism operators are fast waking up to the importance of sustainability, even if they don't fully understand all the nuances, benefits and implications.

• They realize that a growing segment of their customers—often the most discerning and affluent—are the most environmentally responsible and socially conscious.

• Here's just a sampling of the organizations and resources that now exist to promote sustainable tourism. An hour searching the Internet will yield even more.

Is there any sign that "mass tourism" is listening?

Some important players <u>are</u> paying attention.

WHAT'S THE ISSUE?

• Large, main-stream tourism operators are increasingly paying attention to issues relating to sustainability and good environmental practice.

NEED TO KNOW:

• There's a big difference between a passing fad that will soon fade, and a market trend that will likely drive business in a particular direction for some time to come. Much of this has to do with not only <u>how many</u> follow the trend, but <u>who</u> follows it. Opinion-makers are important.

• When Hilton Hotels starts to pay attention, you know that a issue has hit the mainstream of mass tourism.

• Many large resorts and other tourism entities now employ specialists whose only responsibility is to help make their operations more sustainable. But that's a luxury that small operators just can't afford. So, it has to be one of the many roles that you assume in managing your business.

True Commitment Versus "Greenwashing"

"Greenwashing" may work in mass tourism, but not in any business model dependent on developing customer loyalty for return business.

Sophisticated customers can't be fooled!

WHAT'S THE ISSUE?

• You'll gain no advantage—and possible do much harm—if your commitment to good environmental practice is merely lip-service or a scam.

NEED TO KNOW:

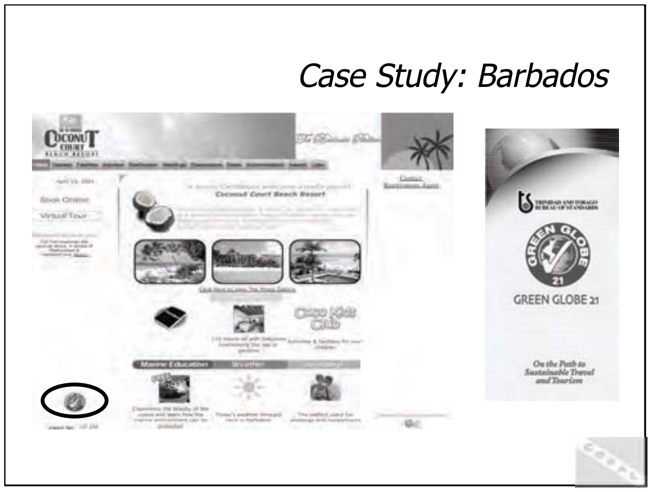
• Failing to market your commitment to sustainability is a mistake, but lying is even worse.

• It's easy to <u>appear</u> to be a responsible business, but appearance isn't enough.

• "Greenwashing" is a false, and often purposeful, attempt by organizations to promote sustainability when little or nothing is really done to minimize their impact on the natural or social environment; it's hollow "hype" at its worst.

• Greenwashing is probably more destructive to your business in the long run than doing nothing in the first place. Customers may understand ignorance, but they won't accept being lied to. Many tourism veterans subscribe to the belief that, "Customers may tell a few friends about a good experience, but they'll tell all their friends about a bad one!"

• Here we see an airboat tour marketed as an "eco-tour" even though, for Florida's Everglades, there is probably no more environmentally destructive practice. An eco-tour must mean more than just "seeing some wildlife."



WHAT'S THE ISSUE?

• Many small operators are now using their environmental commitment in ways that also assist in their marketing, at very little or no added cost.

NEED TO KNOW:

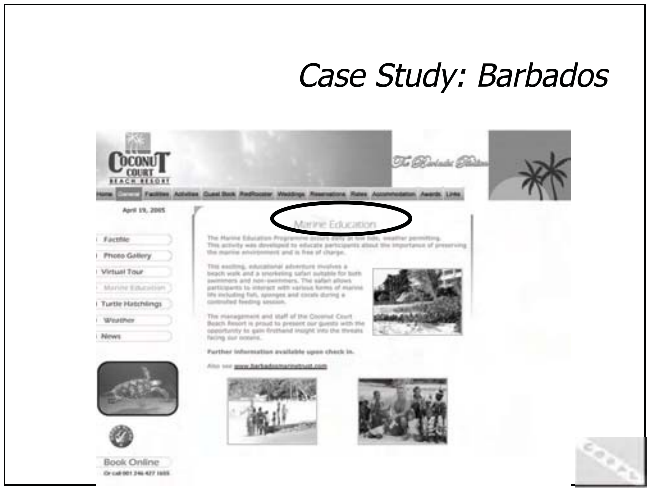
• Coconut Court is a small, family- owned hotel in Barbados that has not only made a sincere commitment to sustainable practice, they've also taken steps to promote it through the "Green Globe" certification program.

• Remember that there's a big difference—and bigger return—in not just <u>doing</u> something but <u>marketing</u> it.

NICE TO KNOW:

• GREEN GLOBE 21 is the worldwide benchmarking and certification program which facilitates sustainable travel and tourism for consumers, companies and communities. It is based on Agenda 21 and principles for Sustainable Development endorsed by 182 governments at the United Nations Rio de Janeiro Earth Summit in 1992.

• You can get more information on the Green Globe certification program at **www.greenglobe21.com**



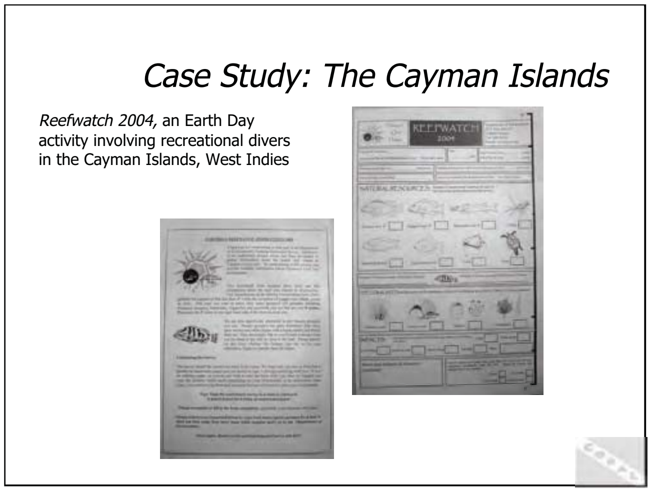
WHAT'S THE ISSUE?

• Many small operators are now using their environmental commitment in ways that also assist in their marketing, at very little or no added cost.

NEED TO KNOW:

• Demonstrating that their certification isn't just hype, or that their commitment ceased once they were certified, Coconut Court has made marine education one of the "unique features" of their resort; and they market it on their web site.

• At low tide each day, staff members conduct a beach walk for guests, and for those interested, a snorkeling excursion to the reef in front of their property (which Coconut Court is involved in restoring).



WHAT'S THE ISSUE?

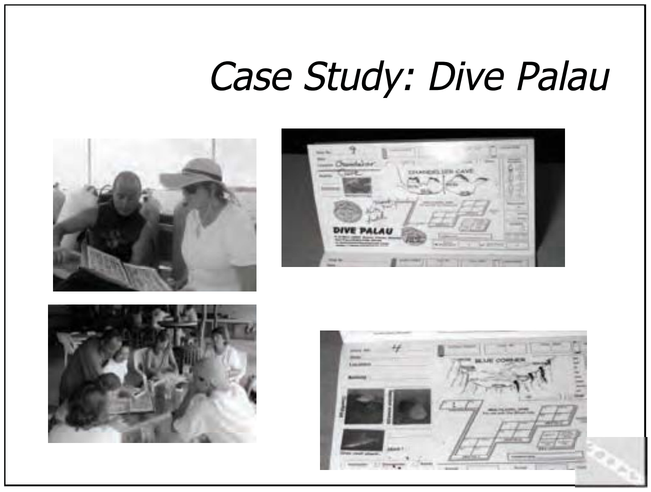
• Many small operators are now using their environmental commitment in ways that also assist in their marketing, at very little or no added cost.

NEED TO KNOW:

• Partnerships between tourism operators and local resource managers are often possible, and can be highly successful.

• For Earth Day 2004, a cooperative program between dive operators on Grand Cayman with the Cayman Islands Department of the Environment used data collected by divers to assess the status/health of their reefs. This information was used in making resource management decisions.

• This simple survey requires no prior training. Operators also gave out T-shirts (paid for the the government) to 500 participants.



WHAT'S THE ISSUE?

• At very little or no added cost, some operators have organized their entire business operation around their environmental commitment in ways that also assist in their marketing.

NEED TO KNOW:

• One excellent example of superb customer service is Dive Palau, which has taken the customer experience several steps above of the norm. At top left, the Divemaster provides a detailed briefing, using a full album of the representative marine organisms. These albums are customized for each dive site. More than the typical briefing, the staff provides a thorough, engaging and personal overview for all groups prior to each dive. But that's not all…

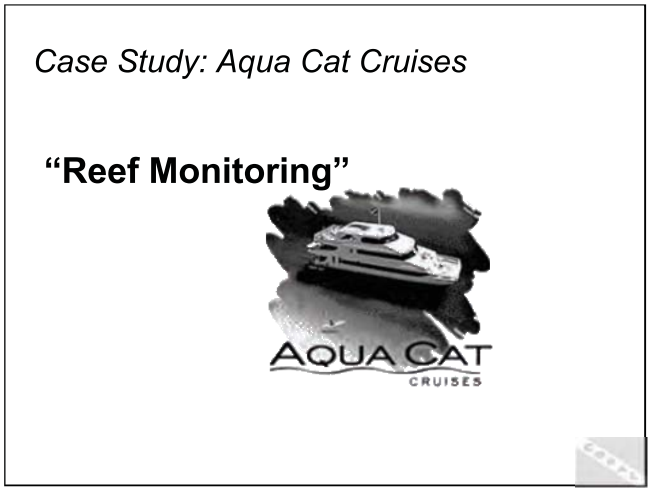
• Divers are not left to the their own resources once they're off the boat. Instead, the tour is lead by the Divemaster, while he points out organisms and phenomenon divers would certainly never notice on their own.

• Back at the dock (lower left), rather than saying good-bye and wishing customers well (hoping for a tip), the Divemaster convenes the group at the bar to discuss what they saw.

• There, Dive Palau distributes, free of charge, specially-produced decals as souvenirs for each dive site (right). Customers are thereby initiated as "Keith's Kids," (Keith is Dive Palau's principle, Keith Santillano) and will receive a quarterly e-mail update from Dive Palau.

• Who do you think these folks will dive with the next time they visit Palau?

• Dive Palau does absolutely no advertising except for it web site (www.palaudive.com), but is consistently booked almost entirely with repeat customers. The reason is no mystery. It's the unique and personal level of service—and knowing that what they're selling is the environment.



WHAT'S THE ISSUE?

• Some operators have used environmentally-oriented projects as a way to attract business during off-peak season.

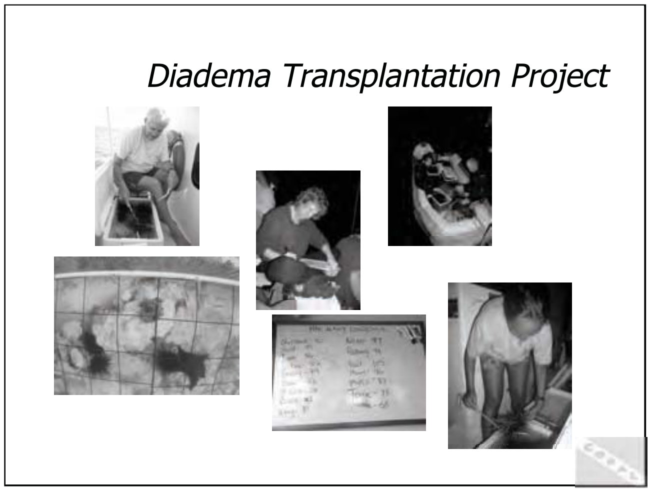
NEED TO KNOW:

• Aqua Cat not only has a deep commitment to the environment, but they go the next step and <u>advertise</u> it; it's part of their marketing plan.

• They provide not only RECON and REEF courses, but recently began working to transplant diadema to reefs in the Bahamas (see the next slide). Where do they get the manpower to do this? The trips are marketed to their regular customers for a "reduced price." Plus, part of the trip proceeds are donated to an environmental cause. These trips takes place during their off-season, when their boats often aren't fully booked, anyway. Again, a win-win situation for Aqua Cat and the Bahamian reefs that they regularly visit.

NICE TO KNOW:

• More information about Aqua Cat can be found at **www.aquacatcruises.com**



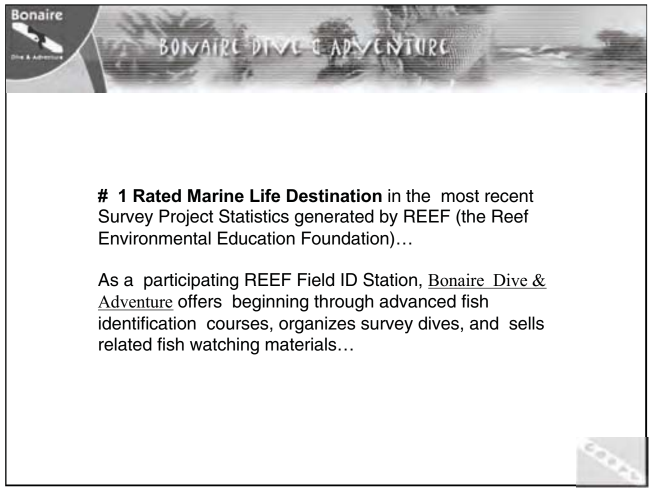
WHAT'S THE ISSUE?

• Some operators have used environmentally-oriented projects as a way to attract business during off-peak season.

NEED TO KNOW:

• Aqua Cat sponsor diadema transplantation trips to both benefit the reefs they dive and to fill their boat during the off-season.

• Sponsoring and promoting these trip also provides an opportunity to make known the important ecological role that diadema play on Caribbean reefs.



NEED TO KNOW:

• Here's a web site from Bonaire Dive & Adventure. The entire thrust of this marketing message is based on the island's healthy marine environment.

NICE TO KNOW:

• More information is available from: **www.bonairediveandadventure.com**

WHAT’S THE ISSUE?

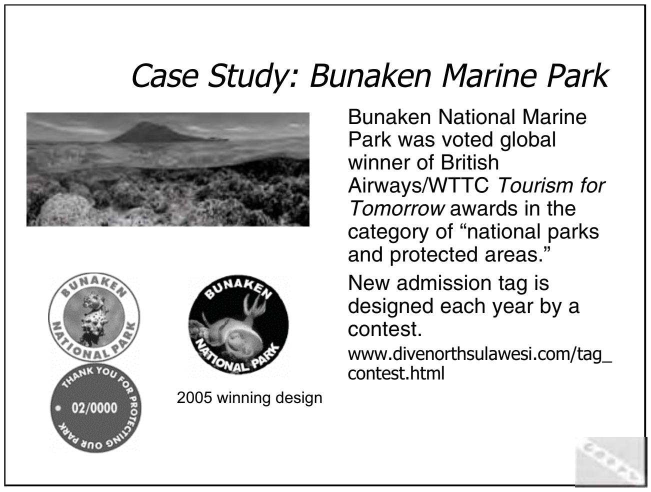
• Some countries are marketing the destination cooperatively, emphasizing their environmental commitment, and providing tools to enable wholesalers and retailers to sell their product conveniently.

NEED TO KNOW:

• Here’s a wonderful example of partnership in action. It’s not just individual operators on Bonaire that have recognized the value of “environmental marketing,” so has the government.

• Local operators, in combination with the Bonaire Tourism Authority, have a number of tools and campaigns to keep their island in the minds of both consumers and, particularly, dive professionals.

• This site contain everything one needs to conduct trips to the island. It’s a “one stop shopping” experience that even dive professionals who’ve never been to Bonaire can use to plan and run a trip.



WHAT’S THE ISSUE?

• Some operators are marketing their environmental commitment a cornerstone of the marketing.

NEED TO KNOW:

• While Bonaire is the shining Caribbean-based marine park success story, it’s Sulawesi’s Bunaken Marine Park that’s often cited in the western Pacific.

• Clear evidence that this isn’t greenwashing is their recent BA/WTTC award.

• Note that divers are incorporated into the management of the park via the admission tag contest, held each year.

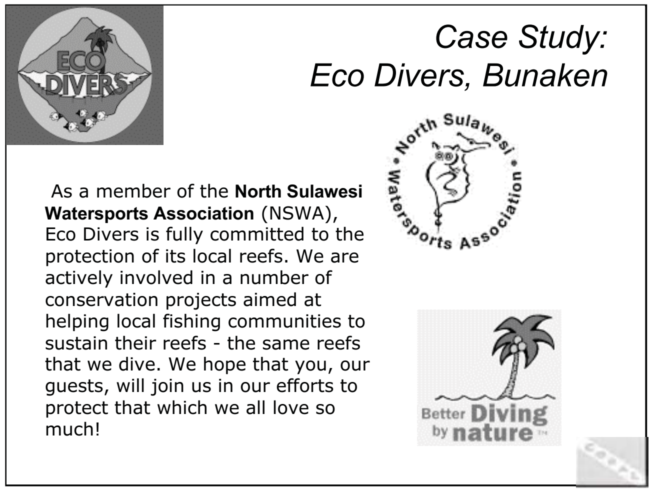
NICE TO KNOW:

• You can find much more about Bunaken at **www.divenorthsulawesi.com**

WHAT'S THE ISSUE?
• There's now clear evidence that marketing a business's environmental commitment has demonstrable benefit.

NEED TO KNOW:
• Effective marketing requires putting the product before the consumer as much as possible. So, even after an initial success, such as a new release or event, continual follow-up is just as important.
• Bunaken is a good example of how to do this: Here's one way they're keep the park in the news. Bunaken Marine Park won *Conde' Nast's* 2005 "Green List" top pick for best destination. Pictured here is the article from the September, 2005 issue.
• The award was given based on not only how well the destination preserved the environment, but also its contribution to the local community and the quality of guest experience.

NICE TO KNOW:
• More information about *Conde' Nast's* Green List Award, including applications, can be found at **www.concierge.com/cntraveler/greenlist**



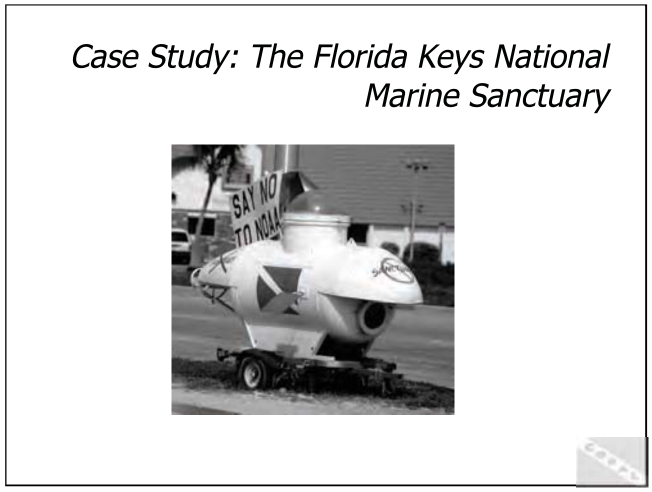
WHAT'S THE ISSUE?

• Cooperative efforts between local operators, when marketed effectively, help distinguish a destination from its competition.

NEED TO KNOW:

• There's no better example of the cooperation between resource managers and dive operators than Bunaken.

• In 2000, operators formed the North Sulawesi Watersports Association, and promote their membership heavily. (They were also responsible for initiating the current user fee system.) Here are some examples of how one Bunaken operator—Eco Divers—promotes the membership on their web site. We'll discuss the NSWA more in the presentation on "Sustainable Attitudes & Practices."



WANT’S THE ISSUE?

• People don’t often embrace change without resistance, so anticipate opposition until the benefits start to be realized.

NEED TO KNOW:

• Marketing environmental sustainability is not always easy. When the Florida Keys National Marine Sanctuary (FKNMS) was first proposed in the early-1990s, most of the local population was anything but supportive, as this”Say No to NOAA” photo attested.

• This attitude was so strong that in a county-wide referendum, 60% of the residents voted against the FKNMS. Fortunately, the vote was non-binding, and a management plan was developed cooperatively by the Florida state and federal governments.

Case Study: The Florida Keys National Marine Sanctuary

WHAT'S THE ISSUE?

• Some efforts to market environmental commitment have been too successful not to recognize and try to emulate.

NEED TO KNOW:

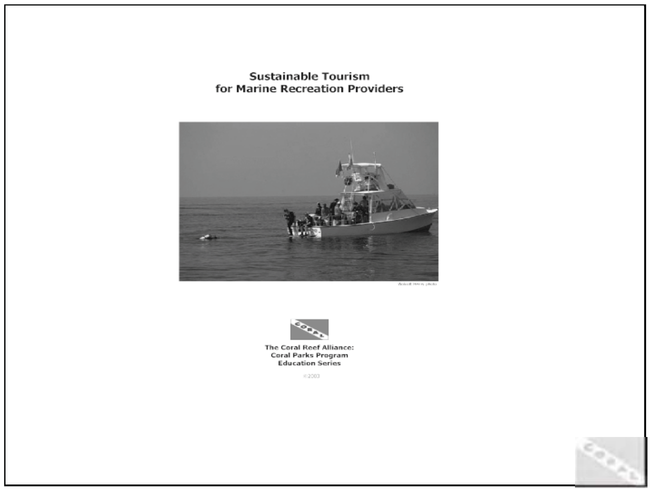
Our New Sanctuary Preservation Areas:
A Cure for the Common Dive: It took a strong dose of protection to create some of the best dive sites in the world. Take the Florida Keys' new Sanctuary Preservation Areas. While regular dive sites allow anchoring, fishing, spearfishing, shell collecting and the removal of any marine life, that's all prohibited here. Which means you'll see more species of fish, more spectacular corals and a greater variety of sea life than ever before. For more information call 1-800-FLA-KEYS. And you'll feel even better about diving in the Keys.

• This is perhaps the best example ever of how good business and good environmental management go hand-in-hand.

• The ad appeared one year after the primary dive sites in the FKNMS were declared "no-take reserves." They were so successful at recovering fish population that these "SPAs" (Sanctuary Preservation Areas) were featured in this national ad sponsored by the Florida Keys and Key West Tourism Bureau.

• Interestingly, the SPAs comprise only 6% of the Sanctuary but capture 85% of the scuba diving activity (except during the opening lobster season).

• This transformation of attitude doesn't happen without a lot of work and evidence of how improved management is of concrete benefit.



WHAT'S THE ISSUE?

• CORAL provides a number of tools to assist in your efforts to understand and market environmental good practice.

NEED TO KNOW:

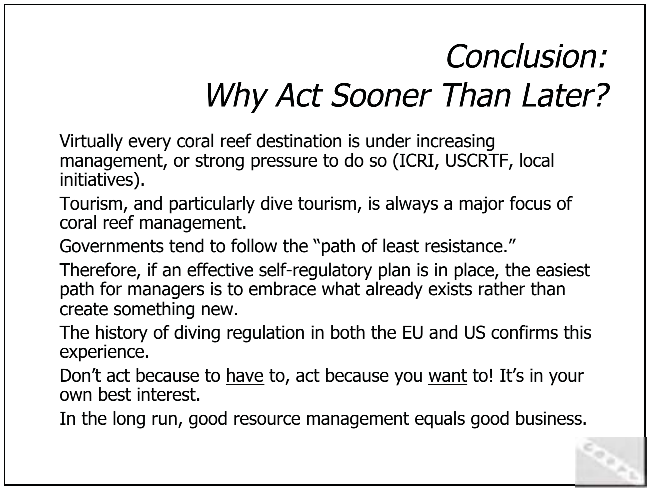
• It's impossible to explore the realm of sustainable tourism thoroughly in this brief discussion, so we are providing you with some more in-depth materials. One is a handbook that we produce. You'll find a copy on your CD.

WHAT'S THE ISSUE?

• CORAL provides a number of tools to assist in your efforts to understand and market environmental good practice.

NEED TO KNOW:

• This is another tool that CORAL helped develop along with CELB and the Tour Operators Imitative. We'll be reviewing it more thoroughly in our segment on Sustainable Practices. You have a copy of this on your CD, too.



WHAT'S THE ISSUE?

• Success most often comes to those who are proactive rather than reactive, and those who act the quickest.

NEED TO KNOW:

There are many good reasons to start acting now to make your businesses more sustainable, and to promote that you're doing so. Here are just a few:

• Because you are a major constituent with significant economic interests and influence, tourism operators are in a better position to influence coral reef resource management than many other segments of business or society. But to be effective, it must be approached in the right way—in an informed way. In short, you have to be well-versed in the issues.

• Engage and participate in the decision-making process in a positive manner. You accomplish more by subtly influencing from within; don't "shout from without."

• Most importantly, stay ahead of the curve; be proactive not reactive.

• Recognize that everyone, regardless of their interests and constituency, has the same ultimate goal: the long-term health and survival of the resource.

• Recognize that democratic outcomes are always a compromise. No one ever gets exactly what he wants.

[As an example, relate how dive operators have driven the process of marine zoning and user fees in Palau.]


Sustainable tourism is good for the environment, good for people and good for business!
MUSTARD '00

Group Exercise:
Creative Marketing of the Environment

1. What product or service might you develop (or already offer) that could be (or is) based on marketing your efforts to protect the reef?
2. What obstacles would/did you face in making this happen (i.e., management or staff resistance, time, ineffective communication)?
3. How would/did you overcome these obstacles?
4. What tools or conditions would (or did) help to make this product or service more successful?

DIRECTIONS FOR EXERISE:

• This workshop is an opportunity to put what participants have learned into practice. Divide the audience into small groups with a leader and recorder (use flip chart paper). Recognize that some of the participants may already have in place programs or services that are based on marketing a healthy marine environment. Others will not. Encourage participants to generate anything they think would work, regardless of the obstacles or tools that they might require.

• Caution groups not to spend all their time brainstorming ideas. Also consider the obstacles and tools/conditions needed to make the ideas happen.

• Allow group leaders to report their group's findings, and list them at the front of the room. For programs and services already being offered, have the participant who offered it discuss how the program evolved, what problems it faced and how they were overcome.

• Once the final list is compiled, determine if there are any commonalities in terms of programs/services, obstacles and tools or conditions necessary to make them a reality.

• Encourage the group to think beyond the ideas related in the case studies.

Taking Action—Promoting Sustainable Attitudes and Practices

Like all conservation efforts, protecting coral reefs requires changing peoples' behavior. In some cases the behavior change is aimed at a global scale, such as the reduction of greenhouse gases. But a big part of the coral reef problem relates to how people view and act toward these ecosystems on a direct and personal level. As such, tourists are a major reef user-group, and in some cases can be a major cause of reef degradation. However, if well-educated, tourists can also represent a large and influential voice for conservation.

Exactly how tourists affect coral reefs isn't always obvious. Indeed, some damage is done by ignorant snorkelers and boats, or by unskilled, clumsy divers. But a far bigger problem is the damage that comes from building and sustaining the infrastructure required to support tourism. As one coral reef advocate has put it, "a tourist is likely to do far more damage by the simple act of flushing the toilet in his hotel room than he'll ever do as a diver, boater or snorkeler."

Furthermore, there's the issue of perspective. The damage to coral reefs caused by tourism pales in comparison to other stresses such as eutrophication, climate change, destructive fishing practices or unbridled coastal development. Yet, while it may rank low on the list of reef impacts globally, tourism can be a significant problem in areas where it's highly developed. Therefore, tourists who visit coral reefs need to understand how to interact with them in ways that are responsible and non-damaging. It's also helpful to inform tourists of how they may harm reefs inadvertently through the choices they make as consumers. Many simply don't know that buying curios such as shells, or carvings made from tropical hardwoods, can contribute to the demise of coral reefs.

The good news about tourism-related damage is it's often the most easily fixed stress to reefs because the solution mainly involves education. This is where those in the tourism community can be of greatest help. By getting an accurate and focused message out to their clients, tourism operators can become a vital link in the chain of coral reef protection.

NOTES TO THE PRESENTER:

• Initially, tourism operators are sometimes skeptical or defensive about this presentation because they may see it as unfairly pointing to tourism as a primary cause for the demise of local coral reefs. (This is particularly true for those who haven't attended all or most of the previous workshop presentations.)

• Be sure to place the issue of tourism damage in perspective with other other stresses causing reef degradation. The best way to balance the discussion may be to emphasize that damage from tourism, while very low on the list as a global threat, can be a significant problem in areas where tourism is highly developed. Moreover, direct damage from tourism is often the most easily fixed stress to reefs because the solution mainly involves education.

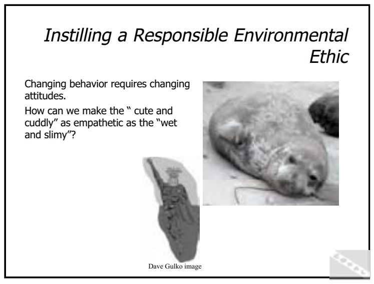
NEED TO KNOW:

• The diver depicted here is the ideal underwater tourist. She has all her gear streamlined, is maintaining a "head down/fins up" body position and is keeping a respectable distance from the reef.

• If every diver behaved this way, there'd be little need for this workshop, or at least, this presentation.

• Our goal here to is to learn how to make this role-model, rather than the exception, exemplary of all reef users.

• To do that we must address both practice and attitude because without the right attitude, good practice will never happen.



WHAT'S THE ISSUE?

• Attitude change must precede behavioral change.

NEED TO KNOW:

• Before people change their behavior, they must first change their attitude. But changing attitudes requires much more than simply informing someone of the need to change their behavior.

• Conservation has been embraced for many years in the terrestrial realm—what some have called the "land ethic"—but conserving marine environments is not as widely embraced because far fewer people have been exposed to the sea than to the land.

• What's needed is what Dr. Carl Sefina calls a new "sea ethic"—to care as much for the ocean as we do for the land. As you have direct contact with tourists, helping to develop this awareness and sensitivity is where operators can be instrumental in changing attitude and behavior.

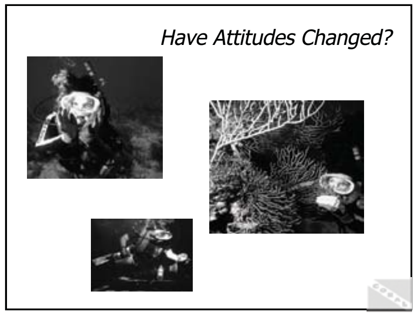
• People often buy into many wildlife conservation efforts because the "feature creature" is lovable, making it easy to empathize ("charismatic megafuana").

• We must try to build the same empathy for coral reefs as with other more empathetic species by trying to humanize them ("Captain Polyp" here is an example).

• Making the "wet and the slimy" as empathetic as the "cute and the cuddly" is a challenge, but one that we can achieve through creativity and commitment.

NICE TO KNOW:

• Two decades of research has shown that for change to occur, people must be convinced that: 1) change is possible; 2) that the problem is within their control; 3) be shown how to behave appropriately, and 4) see some evidence that their actions can make a difference.



WHAT'S THE ISSUE?

• What's considered "appropriate" behavior changes over time.

NEED TO KNOW:

• It's perhaps no surprise that these photos were taken more than 25 years old. Back then, little thought was given to the consequence of touching or handling marine life (note the "protective" gloves).

• Because they were so prolific, and considered a "nuance," even breaking up sea urchins to feed fish was a common practice.

• But have attitudes changed?

NICE TO KNOW:

• Tourists can approach an experience on the reefs as either a special and intimate opportunity to experience an environment that relatively few people see, or a trip to Disneyland. It's mostly your attitude and demeanor that will determine this.

WHAT'S THE ISSUE?

• In achieving behavior change, hope and the simple passage of time are insufficient.

NEED TO KNOW:

• These photos appeared in diving publications recently, so it seems clear that it takes more than the mere passage of time for attitudes to change.

• One way we might change attitudes is by trying to change the mindset of tourists from that of being "customers" to becoming "guests."

• Research shows that one of the most vital ingredients in changing attitudes is he need for a respected role-model (Divemaster) to demonstrate the desired behavior. This means that you and your staff has to practice what you preach. Never under estimate how important leaders are in the development of and commitment to attitudes. (Later we'll see more about how important role-models and role-model behavior can be in changing tourist behavior.)

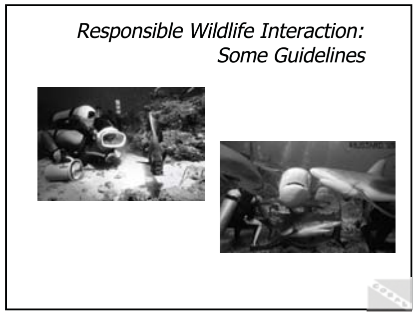
NICE TO KNOW:

<u>The Guest versus Customer Mentality</u>

• Responsible tourists are interested in seeing a destination in as real and authentic a state as possible. They interact with the local environment and culture with both awe and respect. And they never forget one vital fact: They are *guests*. Thus, they appreciate their host's gracious generosity for allowing them to visit. "Customers," on the other hand, feel that they're owed a good time because they paid for it. They rarely bother to look at the local environment beyond its entertainment value.

• Similarly, for some tourists, an experience on a coral reef is an unparalleled opportunity to see nature at its best. They respect the inhabitants and revere the chance to see incredible an ecosystem in all its unaltered glory. Then there are the those who expect, if not demand, that the environment and its inhabitants be manipulated for their enjoyment, as if they were attending a circus.

• The role of the tourism professional is turning customers into guests.



WHAT'S THE ISSUE?

• Responsible tourism includes consideration in dealing with wildlife.

NEED TO KNOW:

• Acting like a guest means interacting passively with the environment. But passivity has its rewards, as it causes the least change in the natural behavior of animals.

• Inappropriate behaviors aren't just an ethical issue. All animals must operate within an "energy budget." Although an organism may show no obvious signs of stress, divers are rarely around to see the longer-term consequences of their actions. Wasted energy or contact from a needless human interaction can put animals at higher risk of disease, or put them at a disadvantage to competitors or predators.

• Avoid touching wildlife, and back off if animal shows any signs of stress or avoidance.

• Discourage fish feeding. This can affect the animals' health, introduce disease or disrupt the local ecological community structure. It may even lead to injury of divers!

NICE TO KNOW:

• Fish feeding is a controversial and not entirely one-sided issue. Some destinations allow and even encourage it. There are also guidelines to do this properly. A good source of information is the technical report written by Huge Sweatman, *Impact of tourist pontoons on fish assemblages on the Great Barrier Reef.* (The full citation is contain in the Resource List).

WHAT'S THE ISSUE?

• Responsible tourism includes consideration in dealing with wildlife.

NEED TO KNOW:

• Avoid touching wildlife. Marine organisms often have a mucus coating which is essential to osmoregulation and prevention of disease.

• Back off if animals shows any signs of stress.

• Never illicit "defensive reactions" such as cornering or restraining an animal, or causing it to change color.

• Don't take photos of divers engaging in inappropriate or stressful behaviors toward wildlife.This gives tacit approval to the practice, and encourages others to do the same.

NICE TO KNOW:

• Some believe that any direct interaction with wildlife is wrong, while others view animals as play-toys. Most fall somewhere in the middle of the continuum.

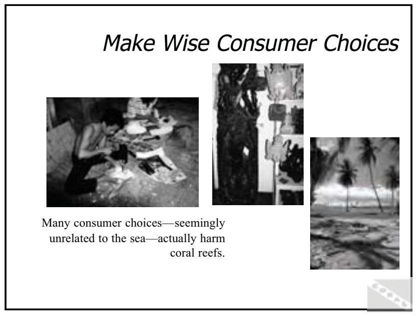
• Here are some simple criteria for determining appropriate interaction.

1. When the interaction is a free choice of the animal.

2. When natural behaviors are not altered.

3. When the experience is for more than pure entertainment.

• Interactive wildlife experiences should always have some educational objective and component. Such experiences should never be just a form of entertainment, like a trip to Disneyland.



WHT'S THE ISSUE?

• Wise consumer choices require understanding how coral reefs

function.

NEED TO KNOW:

• Everything that contributes to reef degradation doesn't necessarily happen in the sea.

• It's important to understand coral reef ecosystems enough to know when certain practices—especially those that don't directly involve the ocean—may be detrimental.

• Demand for products made from tropical hardwoods perpetuate deforestation. The absence of trees, in turn, results in high sediment loads entering coastal waters and spilling on to local reefs.

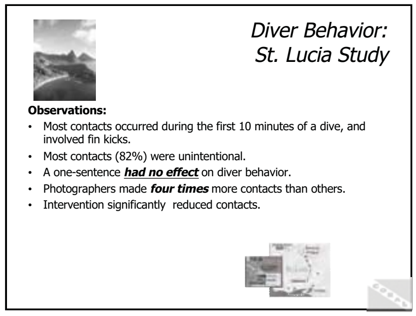
• Golf courses—and in some location even lush landscaping—require high levels of nutrients that, through run-off, contribute to eutrophication of reefs.

• Depicted at right is a golf course on the island of Tobago that's directly on the beach, and has no buffer between it and the sea. Not a good idea in a coral reef environment.

• Encourage your customers to patronize businesses that recognize the environmental responsibility, and act accordingly.

NICE TO KNOW:

• Craft aren't necessarily bad for the environment. In fact, many provide environmentally-friendly and sustainable income. However, it depends upon the materials used and harvest methods. The woods depicted (center) are all endangered tropical species—ebony, sandalwood and mahogany.



WHAT'S THE ISSUE?

• Studies have confirmed much about the nature of diver impact on reefs.

NEED TO KNOW:

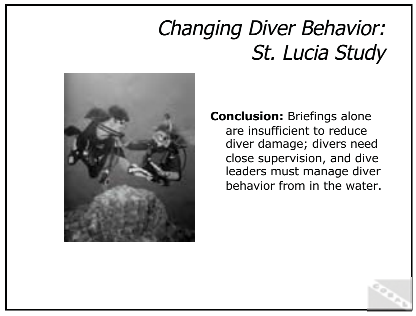
• One very recent and comprehensive one was conducted on the Caribbean island of St. Lucia in 2004 by Barker & Roberts (the full citation on the the Resource List). They spent six months observing 353 divers and found the following:

1. Most contacts with the reef occurred during the first 10 minutes of a dive, and involved fin kicks.
2. Most contacts (82%) appeared unintentional, caused by poor swimming technique, incorrect weighting and ignorance.
3. Night dives had more than double the contact rate of day dives.
4. A one-sentence reminder in the dive briefing stressing no contact with the reef had no effect on diver behavior.
5. Photographers contacted the reef four times more frequently than non-camera users (no significant difference between non-specialist or specialists).
6. The only factor that reduced diver damage was dive-leader intervention underwater (mostly, this way appreciated by divers).
7. Intervention reduced average contacts from 11.6 to 2.4 per 40-min dive (shore dive), and from 7.5 to 2.4 contacts (boat dives).

NICE TO KNOW:

• In the study "non-specialist" photographers were those with non-adjustable, "point and shoot" cameras. Specialists where those with more sophisticated, adjustable cameras.

• Citations for many more diver impact studies are contained on the Resource List. Most of what we see here is mirrored in this earlier work.



WHAT'S THE ISSUE?

• Simple considerations and technique can contribute to far less diver contact.

NEED TO KNOW:

• Conclusion: Briefings alone are insufficient to reduce diver damage; divers need close supervision, and dive leaders must manage diver behavior from in the water.

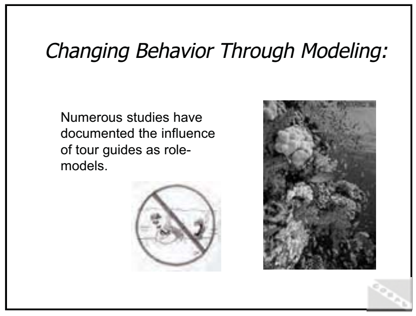
• Recommendations for Divemasters:

1. Active in-water management is needed to reduce diver damage; Divemaster must intervene when they see divers contacting the reef.

2. Lead by example—keep your own fins and other equipment clear of the reef.

3. Be extra vigilant toward photographers, on night dives and at the beginning of dives.

4. Keep dive groups small enough to maintain close supervision.



WHAT’S THE ISSUE?

• Never underestimate your influence as a role model.

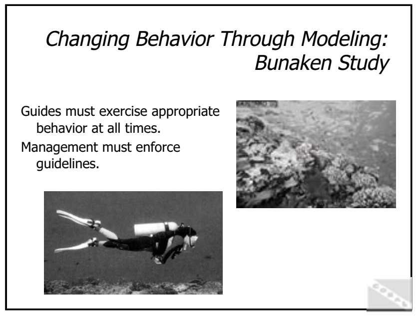
NEED TO KNOW:

• Never underestimate the affect that your own attitudes and behavior have on your clients. Here are quotes from several studies (full citations are on the Resource List).

NICE TO KNOW:

Howard/Vanuatu, 1999: *“The amount of contact by divers varied with the behavior of the instructor leading the tour. In one case, where an instructor encouraged contact and searching .., a contact rate of 24 times per minute was recorded for two people. However, if the instructor remained a good distance above the reef, contact was low by the group as they followed.”*

Townsend/BVI, 2000: *“Another important qualitative observation made by the researcher was the importance of the guide as a behavioral role model when underwater. The extent to which all divers, even those with significant experience, would mirror the guides’ behavior, was surprising. When a guide stayed at least one meter above the reef, the divers generally stayed above it as well. The important implication of this observation for guides is that even though their own behavior may not be damaging, when copied by a diver it may become so.”*



WHAT'S THE ISSUE:

• Guides must act appropriately and be supported my management in their attempts to enforce responsible behavior.

NEED TO KNOW:

• Bear in mind that not only can our own appropriate behavior have a positive effect, if we behave inappropriately, the consequences can be equally negative.

• In a study from 2004 conducted by de Vantier & Turak, done in Sulawesi's Bunaken Marine Park, they found that guides can be part of the problem. (Full citation is on the Resource List.)

Quote: *"Some dive guides were among the worst offenders in terms of harassment, actively seeking out and manipulating organisms such as pygmy seahorses and other 'critters' for their clients. This practice is encouraged by some dive operations, as the dive clients have paid to see and photograph these particular animals, and the operators and their guides feel obliged to deliver." (P.76)*

• It's very important than a dive operation staff not be rewarded if they engage in inappropriate behavior even if it was for the benefit of customers (or at their request). In fact, there should be a strong management policy to sanction staff who engage in such practices.

• Make sure, as well, that customers understand that guides will not engage is inappropriate behavior, and that staff will not tolerate it from customers. (More on how to do this later.)

NICE TO KNOW:

WHAT'S THE ISSUE?

• A few simple steps before a dive can make al the difference.

NEED TO KNOW:

• Proper behavior begins before a diver even enters the water. Taking a moment to streamline equipment can prevent lots of unintended damage.

• Sometimes divers do not have a way to easily secure their equipment. A quick and easy technique to overcome this problem is have available a supply of large rubber bands that can be used as makeshift lanyards or tethers (see lower photo).

• Properly secured equipment is also safer than dangling equipment because gauges or octopus regulators are always readily available and easily seen.

NICE TO KNOW:

• Sometimes dive guides do not notice dangling equipment until the dive has commenced. If that's the case, never hesitate to correct the situation.

• Again, this problem can be easily solved by keeping a few rubber bands in a BC pocket.

WHAT'S THE ISSUE?

• No need to re-invent the wheel, as there are already programs in existence designed to encourage responsible behavior.

NEED TO KNOW:

The Florida Keys National Marine Sanctuary's Sea Smart/Dive Smart Program developed the concept of *"Responsible Diving From Head To Toe."* (The image at right is a laminated slate developed by the FKNMS)

• Use your head: Take the time to learn about where you're going to dive. Become familiar with the representative flora and fauna. Remember that, to a large extent, the site you visit will be damaged or preserved, based on your behavior.

• Use your eyes: Look before leaping. Before swimming off haphazardly, take a moment to notice what's going on. How are the creatures interacting with each other? What's their reaction to you?

• Use your body: Be constantly aware of body position, and maintain proper dive posture—fins slightly elevated above the level of your head. Maintain proper buoyancy control and secure all equipment close to your body.

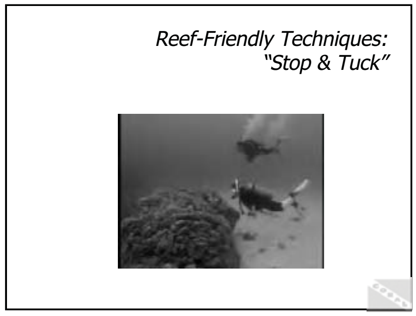
• Use your hands: Learn to do fine maneuvering by sculling with your hands—avoid fin kicking when in confined spaces. This is for your protection as well as the reef. The best way to sensitize yourself to hands-off behavior is by not wearing gloves.

• Use your feet: But carefully! Most reef damage is a result of unintentional fin contact. Remember that when you're wearing fins, you're about a foot taller than normal. Learn and use the "Stop & Tuck" technique (reviewed next).

NICE TO KNOW:

• Many problem with equipment configuration can be spotted by the divemaster by watching divers as they prepare their equipment for a dive.

• A discrete and friendly word can prevent a minor oversight from becoming either a safety hazard or an environmental nightmare.



WHAT'S THE ISSUE?

• It's important to develop "fin awareness," as inadvertent fins kicks are the primary form of diver damage.

NEED TO KNOW:

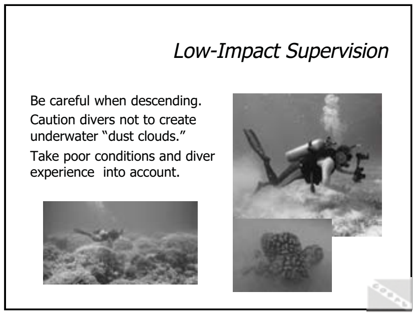
• Even after they realize they've accidentally kicked the reef, diver sometimes continue to more unintentional damage as they try to move away.

• The idea is simple: If you ever feel something come in contact with your fins, STOP kicking immediately, then TUCK your knees toward your chest, and swimming away using your hands, not your fins.

NICE TO KNOW:

• Fin impacts are often a result on poor buoyancy control, as much as lack of awareness.

• Properly weighted divers are much less likely to swim in the dangerous "feet down/head up" position.



WHAT'S THE ISSUE?

• Proper supervision can prevent most diver damage.

NEED TO KNOW:

• Divemasters can help prevent destructive behavior on the part of divers by the techniques they use in directing and supervising them.

• Use sand to your advantage. Encourage divers to descend over sand patches rather than directly over the reef.

• Remind students to pay attention to their descent rate, and be especially careful to avoid contact as they approach the bottom. (Some encourage a "head-down" swimming descent to prevent contact with the bottom.)

• When guiding inexperienced divers on reef tours, remain over sandy areas rather than swimming directly over the reef.

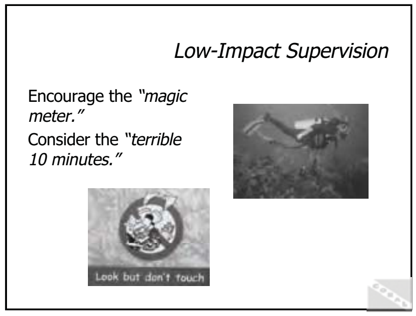
• Caution divers to be careful around sand, too. Poor swimming technique or buoyancy control can cause underwater "dust clouds" which can be as harmful as a poison gas attack to sessile (unmoving) reef residents. Coral, especially, can be highly stressed and uses considerable energy reserve in dealing with sedimentation.

• Avoid diving on delicate or highly pristine sites with inexperienced divers, or when surface weather creates extremely low visibility or abnormally strong surge conditions.

NICE TO KNOW:

• Be very caution when supervising a group of divers for the first time. For initial trips, take guests to environments that are less fragile and, therefore, less prone to damage from a rusty or unskilled diver.

• Take only experienced divers who have demonstrated competence at buoyancy control to especially fragile dive sites.



WHAT'S THE ISSUE?

• Proper supervision can prevent most diver damage.

NEED TO KNOW:

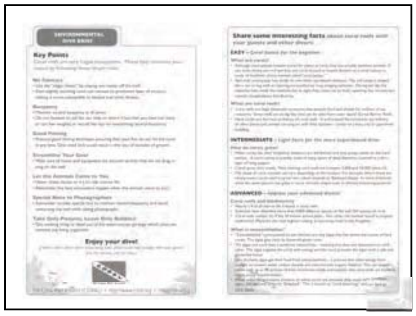
• Encourage divers to keep a "magic meter" between themselves and the reef. Remain at least one meter (or an arm's length) away from the bottom at all times, but especially when swimming over the reef.

• Divers are at their clumsiest during the first "terrible10 minutes" of a dive. So, select your sites and mooring placements in consideration that damage is often caused by divers who arrive on the bottom and need a few minutes to get acclimated or make necessary adjustments to their equipment.

• Make a standing offer to assist divers with weight adjustments and buoyancy control skills.

NICE TO KNOW:

• To stimulate interest and awareness in buoyancy control, introduce some competition. Hold a contest to see which diver can remove the most weight from his/her weight belt over the course of their stay with you. Give a prize for "getting the most lead out."



WHAT'S THE ISSUE?

• Dive briefings should be detailed and well-planned, not haphazard and cursory.

NEED TO KNOW:

• As we saw in the discussion of the Baker & Roberts study from St. Lucia, a sentence or two before divers enter the water probably isn't going to be effective in changing diver behavior. Yet, it's difficult to remember everything that's important to include in a proper briefing.

• A good tool is a plastic-laminated version of CORAL's "Environmental Dive Brief."

• One side contains a handy reminder of what to included in the briefing, while the other side has some useful and interesting facts about coral reefs.

INTERACTIVE ACTIVITY:

<u>Conduct role-model dive briefings</u>

• Using the CORAL "Environmental Dive Brief" slate depicted here, have participants practice their own briefings with a buddy.

• Provide a role-model examine for the group.

• Ask a few volunteers to demonstrate their briefing before the group.

WHAT'S THE ISSUE?

• Effective management sometimes require adapting to local conditions and compromises.

NEED TO KNOW:

• Some dive destinations have developed special techniques to make diving easier, safer, AND also to reduce environmental impact. "Drift lines" are one example.

• These allow divers to "hook in" to a stationary position, eliminating the need to hold on to the reefs to remain in place during a drift dive.

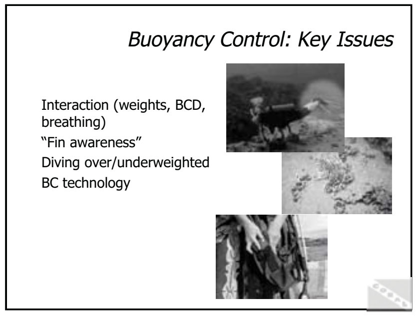
• Some contend that this techniques is very destructive to the portion of reef where lines are used. Indeed, this may be the case, but if the practice is restricted to a small area, it may be a necessary a compromise.

• Much like building a parking lot or camp ground in an otherwise pristine park, it's an intentional sacrifice of a very small part of the resource to avoid more widespread and extensive damage.

NICE TO KNOW:

• Drift diving is another good example of a technique based on adaptation. In many locations, anchor just isn't possible because of consistent currents.

• Although it wasn't the original intention, drift diving is also an environmentally friendly technique as it precludes the need for anchoring or even installing moorings. (Plus, dives appreciate being picked up at the end of their rather rather than having to swim back to the boat.)



WHAT'S THE ISSUE?

• Mastering good buoyancy control skills is the key to environmentally-responsible diving.

NEED TO KNOW:

• Good buoyancy control is an essential skill to prevent damage to the reef. However, it's equally important for diver safety. Many diving accidents occur because of panic, exhaustion or running out of air—problems which are easily prevented or overcome by good buoyancy control.

• Good buoyancy control is possible only when divers understand, and master, the interaction of three critical factors: the BC (for gross positive buoyancy), weights (for gross negative buoyancy) and breath control (for fine tuning body position in the water column).

• The primary form of damage caused to coral reefs by divers is from fin kicks. To avoid this, divers must become aware that their body length increase 12in/30cm or more when wearing fins.

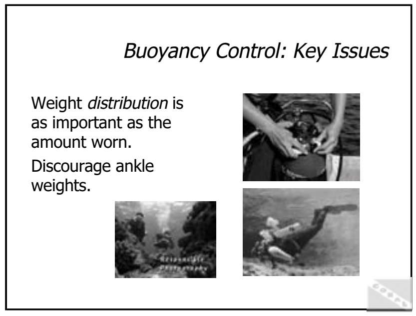
• Over weighted divers take on a "head up/feet down" position, making them very likely to kick the bottom. Underweighted divers often grab on to the substrate to help them remain on bottom. Both can result in damage to the reef, so the goal is neutral buoyancy.

• Like all technology, BCs are constantly evolving. Many now have integrated weight systems, and other features such as pockets that allow the distribution of weights. Some weight systems are even affixed to the tank, rather than the BC. Make sure that you stay up to date with the advances in design so you can assist anyone who experiences problems or poor technique.

NICE TO KNOW:

• In teaching diving, never overweight students to make it easier on you, the instructor. Students often assume that the amount of weight they trained in is correct for them, and if they're use to diving over weighted, problems will result.

• Train students to wear only the amount of weight they need, no more and no less.



WHAT'S THE ISSUE?

• Mastering good buoyancy control skills is the key to environmentally-responsible diving.

NEED TO KNOW:

• The amount of weight worn is only one factor in mastering buoyancy control. How the weight is distributed is equally important. Consider taking a small amount (less than what's needed to establish positive buoyancy) off the belt and placing it elsewhere on the BC or tank.

• One redistribution idea is to secure an ankle weight around the tank valve. This shifts the diver's center of buoyancy forward, making it easier to maintain the desired "head down/feet up" position.

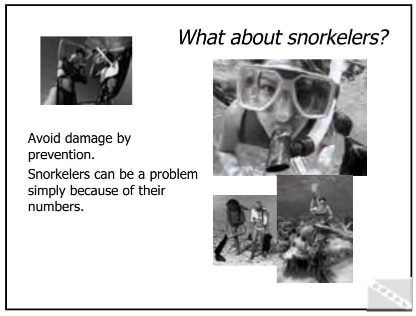
• Divers from cold water destinations who wear dry suit often wear ankle weights. Discourage this practice when reef diving, as it places the feet closer to the bottom, making damage from kicking more likely.

NICE TO KNOW:

• Divers who want to master buoyancy control to an expert level are advised to take a cavern diving specialty course.

• Mastering buoyancy control and always diving in the position show at bottom is critical to avoid a deadly "silt-out."

• The original concept and technology for buoyancy control came out of the cave diving community in the 1970s.



WHAT'S THE ISSUE?

Snorkelers far surpass the number of scuba divers and, combined with their inexperience, can be far more damaging that scuba divers.

NEED TO KNOW:

• The environmental effects of snorkeling have been less well studied than scuba diving. However, because there are so many more snorkelers than divers, it's logical to assume that the problems created by snorkelers could be more significant than that of divers. However, the data is thus far inconclusive. Some studies have shown snorkeler damage to be significant, while others have not.

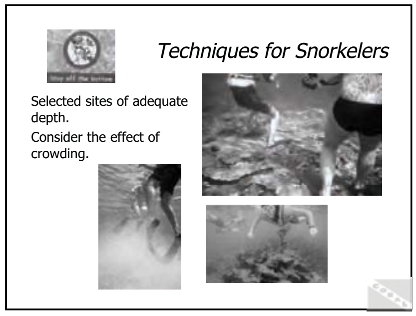
• Most problems created by snorkelers can be prevented with a little common sense and forethought on the part of the tour operator.

NICE TO KNOW: (See the Resource List for full citations.)

• Nelson and Mapstone (1998) reported that no statistically significant changes in coral cover in a study of seven snorkeling sites. At five of the seven snorkel sites, coral cover increased during the study (3% to 13% cover per year). Only one of four sites analyzed demonstrated a significant difference between control and impact sites in the amount of damaged corals.

• Allison (1996) reported that most damage in the Maldives occurred when snorkelers kicked or stood on coral colonies.

• Plathong *et al* (2000) examined the effects of snorkel trails and found that even at low levels of use (15 snorkellers per week), a difference could be detected in the number of broken corals between the trails and control sites. Within a month of the opening of the trail to snorkellers, the amount of damage stabilized. The question is whether it's best to concentrate snorkeller damage to a small area, using trails, or spread the impacts over a wider area.



WHAT'S THE ISSUE?

• Much of the damage caused by snorkelers can be prevented by proper planning.

NEED TO KNOW:

• When snorkeling most people stay on the surface of the water, so they're unlikely to contact on the reef—unless they can stand up. And if they can stand up, they probably will.

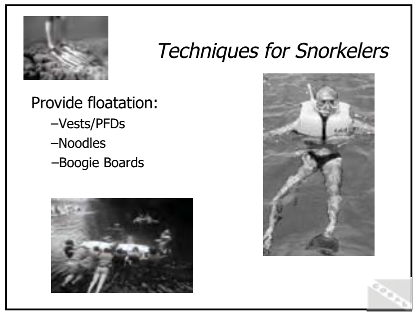
• So, select snorkeling sites that are too deep for so people to stand up, even on their fin tips.

• When snorkeling in a large group, those with lots of prior snorkeling experience may be put off by the feeling of being crowded. Survey customers periodically to gather feedback on the quality of experience.

NICE TO KNOW: (See Resource List for citations.)

• Snorkeling is one of the few areas of tourist behavior where social impacts have been examined. Shafer et al (1998, 2000) reported that most people surveyed on day trips to the reef were not negatively affected by the number of others in the water with them. They suggested that visitors with little prior experience had few expectations, and no basis for comparison, so were not disturbed by the presence of others. More experienced snorkellers were able to swim further from the boat and large groups.

• Inglis *et al* (1999) analyzed perceptions of crowding by snorkelers, and found that more experienced participants preferred a less crowded setting. Most people surveyed preferred sites with fewer than six other snorkellers.



WHAT’S THE ISSUE?

• Many damaging impact from snorkelers can be prevented by proper equipment selection.

NEED TO KNOW:

• The most important consideration in controlling snorkelers is providing them with adequate surface support. This will preclude any need for them to stand up to rest, adjust their equipment or clear their mask.

• Snorkeling vests or PFDs are the most commonly used devices, but many people find them awkward and uncomfortable because they tend to ride up and push the swimmer on to his/her back.

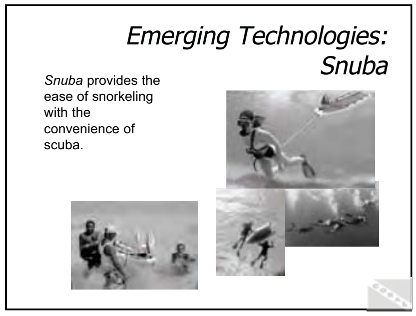
• Many operators have found that “noodles” (Styrofoam® tubes) are more effective than vests because the user can place the tube comfortably under their arms, and still maintain a comfortable face-down position.

• Boogie boards are also used by many operators. As they can accommodate numerous snorkelers, they’re also good for control. Note that in the picture (bottom) snorkelers are not wearing fins. This technique requires that they hold on to the board, offering great control by the in-water tour guide.

NICE TO KNOW:

• If operators take time to insure that rental equipment fits and is comfortable, snorkeler will be less like to try and make “adjustments”—and therefore attempt to stand—on the reef.

• Quality, properly fitted equipment also equals happier customers, so don’t scrimp when outfitting your operation.



WHAT'S THE ISSUE?

• Savvy operators must remain up-to-date and be able to accommodate changing technology.

NEED TO KNOW:

• SNUBA is a technology that makes reef encounters accessible to others who, in the past, would have never considered it.

• The upside is increase business, but the downside is having to supervise a novice with very little competence and familiarity with the reef. This requires the utmost supervision, and careful consideration of what makes an "acceptable" dive site.

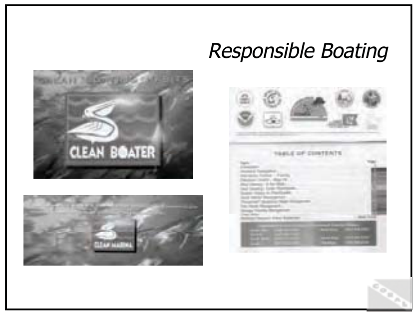
• Pristine sites, especially those with delicate formations, are not a good choice for this group.

NICE TO KNOW:

• Many uninitiated reef tourists will acquire seeing lots of fish with a quality experience, and not expect as healthy a reefs as an experienced diver/snorkeler.

• Therefore, some believe that less-than-spectacular sites can be augmented by activities such as fish feeding.

• The quality of a tourist's experience often has as much to do with the attitude of the staff, and they way they treat their customers, as it does with the quality of the site they visit. Good customer service can make up for some compromise in the quality of the environment.


Responsible Boating
CLEAN BOATER
CLEAN MARINA
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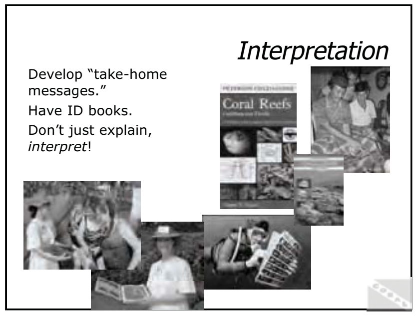
Help Using Moorings

Marty Snyderman photo



WHAT'S THE ISSUE?

• Don't squander the opportunity to influence peoples lives and conservation attitudes.

NEED TO KNOW:

• Develop several "canned" presentations on important aspects—"take-home messages"—of reef ecology, such as the roles of zoox, why herbivores are vital, how eutrophication affects the reef or how the loss of biodiversity can compromise reef health. (See the reverse side of the CORAL Environmental Dive Brief for more ideas.) This way you'll always be prepared to give a good extemporaneous reef interpretation.

• Take a lead from the birding community. Always have field guides available, and encourage customers to use them.

• On the reef, most peoples' initial interests is in the fish, not the corals, because they're so beautiful and obvious. So, use fish as a hook! Explain how the fishes lifestyles, behavior, and even their physical attributes are determined by their role in the ecosystem. This can be a good segue into explaining broader and more fundamental aspects of reef ecology.

NICE TO KNOW:

• Merely dispensing information is not sufficient; you must <u>interpret</u> the experience. Interpretation is the art of relating information to the personalities and experiences of the current audience to reveal a larger meaning that lies behind a simple statement of fact. The chief aim of interpretation is not instruction, but provocation. People should go home from the experience wanting to know more. The key is making them understand how what they're experiencing relates to them, personally.

WHAT'S THE ISSUE?

• The affect change we need to do more than simply "no harm;" we have to contribute.

NEED TO KNOW:

• Tourists can become more than "low-impact" reef users; they can become "positive-impact" users by taking a few simple steps and donating their time.

• One easy way to getting more involved is to remove trash from the reef when you see it (but learn how to do it without damaging the reef while you remove it). Many divers carry a litter bag in the BC pocket just for this purpose.

• Getting society to embrace reef conservation is a political process. And in politics, it's "the squeaky wheel that get the grease," so be active and express your opinion as a conservationist. Don't keep your enthusiasm for the reef to yourself; become a vocal reef advocate and support reef conservation.

• Tourism operators have an incredible opportunity to influence the behavior, opinion and attitudes of thousands of people. Use this very powerful position to help conserve reefs.

NICE TO KNOW:

• Over time, some refuse can become habitat, so make sure that you're not doing more harm by removing trash (removing habitat) than good by leaving it alone.

• Reef refuse will often become encrusted, and sometime even incorporated into the reef. Remove such trash only if you know how. Use shears, not knives, to cut trash free of the reef.

WHAT'S THE ISSUE?

• Several organization have programs using volunteers to monitor and survey coral reefs.

NEED TO KNOW:

• REEF Base

• The Ocean Conservancy's RECON Program

• ReefCheck

• REEF (Reef Environmental Education Foundation)/Great American Fish Count

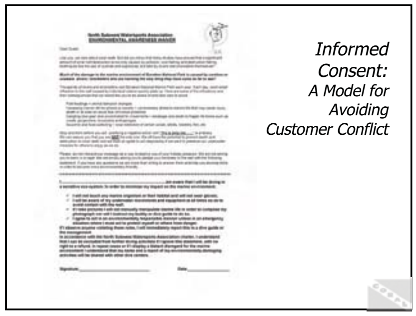
NICE TO KNOW:

• ReefBase is an online information system on coral reefs, and provides information services to coral reef professionals involved in management, research, monitoring, conservation and education.

• RECON is a coral reef monitoring program that trains recreational divers to observe and record valuable information about current conditions at selected coral reefs. Our volunteers gather information about the state of our reefs in Florida, the Bahamas, Colombia (San Andres & Old Province), Puerto Rico, and the US Virgin Islands.

• Reef Check is an international program that works with communities, governments and businesses to scientifically monitor, restore and maintain coral reef health. Reef Check objectives are to: educate the public about the coral reef crisis and create a global network of volunteer teams trained in scientific methods.

• REEF is dedicated to educating and enlisting a corps of volunteer divers and snorkelers to conduct marine life surveys too provide the resource management and conservation communities with a reliable, geographically broad and continuing source of marine biodiversity data for practical application in habitat conservation and resource management. They also promote the diving community as an active partner in the long-term conservation of coral reefs and other marine habitats.



WHAT’S THE ISSUE?

• Being sure that customers clearly understand what behavior is expected of them will help avoid confusion and conflict.

NEED TO KNOW:

• Maintaining good customer relations is a very important, and sometimes challenging, task. And it’s most difficult when dealing with customers who are behaving inappropriately.

• One way to help solve this problem is by taking a lead from the legal community, and their concept of “informed consent.” What we have here in not a liability waiver but an we have an “environmental wavier.” It’s based on the liability waiver than many or most of you already use.

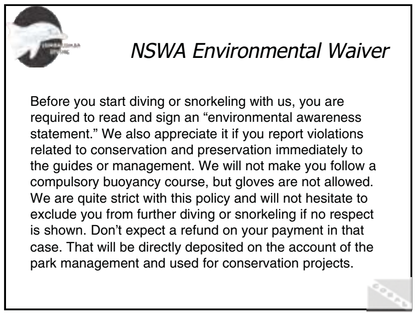
• Having customers sign this document before the dive—or even before the they arrive—is an excellent way to put them on notice that certain behaviors will not be tolerated. It also demonstrates how serious that you are about protecting the resources on which your business is dependent.

• The difficulty in dealing with a problem customer can be eased considerably when this or a similar waiver is used. It allows you to reference what they’ve already agreed to do, rather than having to tell them “you did something wrong.” It also eliminates any ambiguity or misunderstanding about policy.

• A copy of this form is on your CD.

NICE TO KNOW:

• Consider making some form of this document part of your pre-trip customer information package, or putting it on your web site.



WHAT’S THE ISSUE?

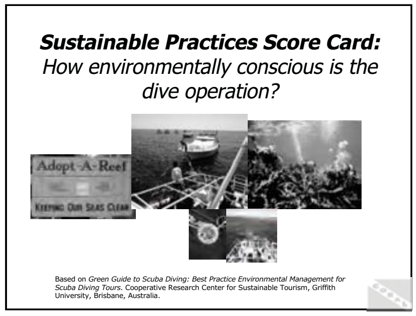
• An operator’s environmental policy can be used in marketing to help brand them as a responsible business.

NEED TO KNOW:

• Members of the North Sulawesi Watesports Association, who developed the environmental wavier, are very committed to it, as this except from one of the member’s web site attests.

• There’s little question that this is an operator who is serious about their desire to protect local coral reef resources.

• Note that the balance of any unreturned funds are not kept by the operator, but donated to the park authority.



WHAT'S THE ISSUE?

• Quantifying a tour operator's commitment to sustainable dive practice.

INTERACTIVE ACTIVITITY:

• Distribute the *"Sustainable Practices Score Card"*

• Explain that this is an exercise to help attendees gain personal insight into the current state of practice. No one will be asked to divulge their score, so participants should be totally honest when completing the checklist.

• For those in the audience who are not dive operators, ask them to try and amend the criteria to make it fit their operation, and determine if it helps them in any way quantify their status.

• Emphasize that sustainability isn't a black and white issue. It can be viewed on a continuum from making absolutely no attempt to consider the environmental/social consequences of one's actions, to giving prime important to this in every business decision that you make. Few operations are ever on the ends of that scale.

• Ask the group to describe if and how this exercise helped identifying practices that they're not employing, and if it will now encourage them to change. If not, what would motivate them to operate in a more sustainable way?

DRAFT
Sustainable Tourism for Marine Recreation Providers

Wolcott Henry photo

The Coral Reef Alliance:
Coral Parks Program
Education Series

Introduction

In this era of the global economy, tourism has become a primary source of revenue for many regions of the world, generating nearly $500 billion in worldwide revenues in 2001, and continuing to grow (WTO, 2001). The United Nations Environment Program recently facilitated a study which points out that the tourism industry now represents more than 10% of the world's gross domestic product (UNEP, 2002).

While tourism brings significant benefits for both local and global economies, its rapid growth and development in recent decades has caused widespread social and environmental change across the globe, particularly in popular coastal resort destinations. In contrast, the concept of sustainable tourism is now seen as a way to promote socio-economic development in a given region while simultaneously protecting local culture and the natural environment.

In order to address these issues and how they impact coral reefs, the Coral Reef Alliance (CORAL) has compiled this *Sustainable Tourism for Marine Recreation Providers* handbook. In an effort to promote sustainable tourism, the information contained in this handbook is meant to highlight some of the current environmental problems associated with tourism growth and development, and to promote practical solutions for marine recreation providers to adopt good environmental practices. We encourage any readers to provide us with feedback as to how we can improve this publication. Comments, questions and general suggestions can be addressed to:

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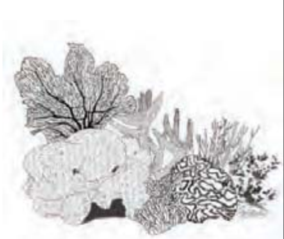

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Rich Wilson

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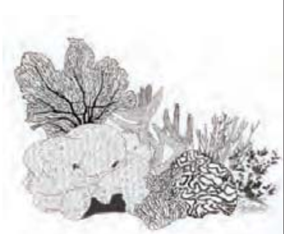

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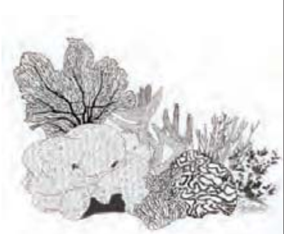
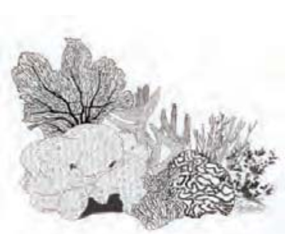


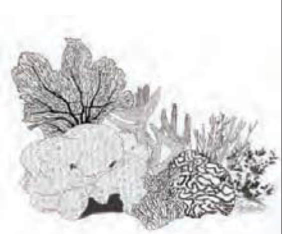
Part I: Tourism and the Value of Coral Reefs



Tourism and the Value of Coral Reefs

Key facts about tourism and reefs:

- Coral reefs are worth millions of dollars to numerous states and nations.
- Millions of divers visit reefs every year.



Every year, millions of tourists travel to tropical resort destinations to experience the beauty and vibrancy of coral reef ecosystems. Snorkeling, scuba diving, recreational boating and a variety of other water sports activities make up a significant portion of the tourism market in several regions of the world. The economies of many island nations in particular are heavily dependent on this type of coastal tourism-generated revenue. As the following examples illustrate, the value of coral reefs for marine-related tourism is extremely high in areas that regularly receive high numbers of visitors:

- Coral reefs have been estimated to provide the world with US $375 billion in goods and services (Status of Coral Reefs of the World, 2002).
- In Hawaii, it is estimated that coral reefs generate US $360 million annually in state revenues (NOAA, 2002).
- Tourism in the Caribbean generated approximately US $34 billion in 2002, and is projected to increase to US $74.1 in 2012 (WTTC, 2002).
- The World Resources Institute estimates that coral reefs in Southeast Asia are worth US $700 to $111,000 per square kilometer of reef for tourism. (Reefs at Risk in Southeast Asia, 2002).
- Worldwide there are more than 15 million certified recreational divers. Many of these divers regularly seek out coral reef ecosystems (World Atlas of Coral Reefs, 2001).
- By 2005, it is projected that the scuba diving industry alone will generate $1.2 billion in worldwide revenues. (The Ocean Conservancy, 2003)

Vibrant Coral Reef — Burt Jones and Maurine Shimlock photo

How Rapid Tourism Growth Affects Local Businesses and Communities

Socioeconomic impacts of rapid tourism growth:

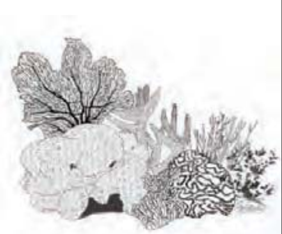
- Loss of traditional lifestyle.
- Immigration.
- Higher costs of living.
- Resource conflicts.

While growth and development can bring significant economic benefits and opportunities to a region, uncontrolled tourism can also create problematic social and environmental impacts for local communities. These include:

- **Shifts to a service economy**, resulting in an abandonment or loss of traditional lifestyles, culture, and values.
- **An increase in immigration**, leading to greater competition for jobs and additional pressure on natural resources.
- **Higher costs of housing and living** that affect both local residents and visiting tourists.
- **Economic development and activities** that limit local access to previously available natural areas and resources.
- **Conflicts over resources**, particularly between local fishers and marine recreation providers.

Wolcott Henry photo

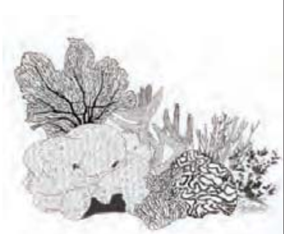
Construction of modern airstrips, such as this one in Roatan, Honduras, commonly opens up previously remote locations to rapid growth and development.



How Rapid Tourism Growth Affects Local Businesses and Communities

Combined effects of rapid tourism growth and irresponsible marine recreation:

- Loss of tourism revenue.
- Higher unemployment.
- Fewer available food resources.
- Less coastal protection.



Land-based pollution, especially sewage and solid waste, and intensive coastal development as a result of rapid economic growth, causes the most significant impacts to coral reefs in popular tourism destinations. Yet on a smaller but still significant scale — particularly in areas that are popular for marine-related tourism — irresponsible or uninformed marine recreation also undermines the health and attractiveness of near shore coral reef ecosystems.

The combined effects of this growth and activity can lead to negative socio-economic and environmental impacts on both businesses and communities that depend on a healthy tourism industry. These include:

- **Loss of tourism revenue:** Revenues from marine-related tourism will fall as popular snorkeling, diving and glass bottom viewing reefs decline as a result of poorly conducted marine tourism. Heavily damaged areas may see significant decreases in visitation from tourists.

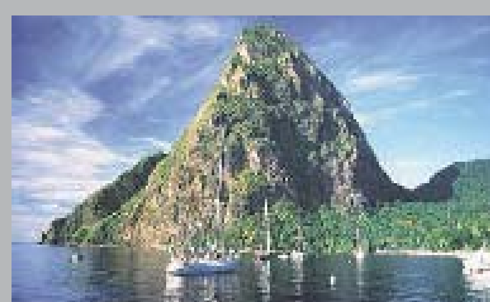
- **Higher unemployment:** Reduced levels of tourism can lead to higher unemployment in industry related jobs such as hotels, restaurants and boating.

- **Fewer available food resources:** Unmanaged marine recreation activities and the harvesting of species for souvenir and food consumption by tourists can directly deplete marine resources. These negative impacts threaten the supply of locally caught seafood, and can be felt by the commercial and recreational fishing industries, as well as fishers who depend on local resources as part of their food supply.

- **Less coastal protection:** As reefs degrade and lose their physical structure, coastal areas will have increased exposure to damage from storms and waves.

Case Study: Creation of the Soufriere Marine Management Area

Soufriere is a small, rural town on the southwest coast of St. Lucia, in the Eastern Caribbean. The rapid growth of tourism in this area in recent years led to many changes and conflicts within the local population. Intensive shoreline development to support tourism created serious environmental problems, including: increased pollution and sedimentation in near shore reef ecosystems, discharge of sewage, depletion of coastal fisheries, degradation of beaches and poor resource management. All of these problem sparked conflicts between different user groups over management of these areas. In particular, local fishers and the dive industry challenged each other over who was damaging reefs. This conflict eventually led to the establishment of the Soufriere Marine Management Area (now known as the Soufriere Marine Management Association). Stakeholders worked together on conflict resolution and established the SMMA in 1994. The region has since been divided up into five management zones that attempt to address the interests of all stakeholders. These include: Marine Reserves; Fishing Priority Areas; Recreational Areas; Multiple Use Areas; and Mooring Areas. One already documented upshot of the establishment of a marine reserve within the boundaries of the management plan has been improved fish stocks in the areas surrounding the reserve.



Photos courtesy of Kai Wulf, SMMA

The creation of the Soufriere Marine Management Area has brought divergent user groups together in a common effort to protect the waters around the small town of Soufriere, St. Lucia. In the photo left, fishermen and toursits gather at a local beach.

Sustainable Tourism and Marine Recreation

This handbook will promote sustainable tourism by:

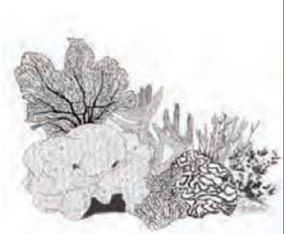
- Highlighting the economic value of coral reefs.
- Exploring relevant environmental threats.
- Developing practical responses.
- Providing examples of sustainable tourism.

This handbook, developed by the Coral Reef Alliance (CORAL), is designed to assist marine recreation providers and water sports enthusiasts in supporting behavioral and operational changes, and adopting good environmental practices that actively promote sustainable tourism. In part two, the handbook will define the concept of sustainable tourism by:

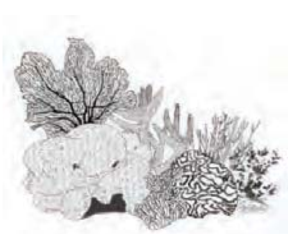
- Providing an overview of sustainable tourism and related concepts.
- Explaining the problems of rapid growth and development associated with unsustainable tourism and how it impacts the natural environment.

Marine recreation, as a well established and growing sector of the wider tourism industry, is in a unique position to establish and promote sustainable practices. Part three of the handbook will develop practical solutions for marine recreation providers by:

- Exploring relevant environmental issues and threats from different sectors of the marine recreation industry.
- Developing practical responses that will promote good environmental practices and voluntary codes of conduct across a wide spectrum of marine recreation activities.
- Providing examples of how sustainable practices can be leveraged into support and enhancement of marine protected areas.



Part II: Sustainable Tourism: Key Concepts



Key concepts:

- Sustainable tourism.
- Unsustainable tourism.
- Greenwashing.

Sustainable Tourism: Key Concepts

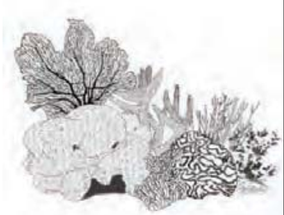
Sustainable tourism often means different things to different people. In the context of this handbook, tourism — and its associated growth in development and activities — is considered sustainable when it simultaneously promotes economic development and protects the natural and cultural heritage of a region.

It is important, however, for tourists and bulk purchasers of marine recreation activities to be wary of a false sense of sustainable practices that is often promoted throughout the industry. For example, many resorts and marine recreation providers will offer trips and label them as sustainable tourism or "ecotourism" simply because they take place in an outdoor setting or superficially promote the protection of nature. Key concepts for understanding this issue include:

- **Sustainable Tourism:** Tourism that provides economic benefits to local communities, respects cultural values, and minimizes environmental degradation for the long-term benefit of present and future generations.

- **Unsustainable Tourism:** Tourism that provides limited economic benefits to communities, disrespects cultural values, and degrades and destoys the natural resources that support the economy of a region.

- **Greenwashing:** A false sense of companies or organizations promoting sustainble tourism or "ecotourism" when in reality little is being done to minimize operational impacts to the natural environment.



The Problem of Unsustainable Tourism

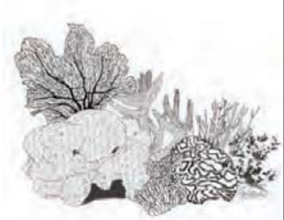
When not planned properly, the rapid growth of tourism can create serious environmental problems for coastal communities. In many places, the explosion of visitors and development associated with tourism has led to the decline of natural ecosystems such as mangroves, wetlands, beaches and coral reefs. The problem of unsustainable tourism in coastal areas is generally linked to the following:

- **Tourism Infrastructure and Development**
- **Hotel, Lodging and Restaurant Operations**
- **Marine Recreation**

Poorly planned tourism growth negatively impacts the environment through:

- Tourism infrastructure and development.
- Hotel, lodging and restaurant operations.
- Marine recreation.

In many locations, the rapid growth and resulting negative impacts of tourism have motivated communities to become more involved in the decision making process of community development.



Examples of Sustainable Versus Unsustainable Tourism

Tourism Activity	Sustainable Practice	Unsustainable Practice
Coastal development	Building away from the beach and coast, and disposing of wastes properly.	Building on the beach causing erosion and increasing sediments in the water column and dumping wastes in the water.
Hotels and lodging	Using phosphate free detergents and treating sewage.	Dumping laundry waste and untreated sewage in near shore and coral reef environments.
Boating	Using moorings to avoid anchor damage.	Anchoring on the reef; dumping oily waste in water.
Restaurants	Selling abundant, non-threatened fish.	Selling rare, threatened or endangered local fish.
Snorkeling and diving	Not touching the coral reef and related organisms.	Touching, feeding and harrassing the coral reef and related organisms.

Case Study: The Development of Cancun, Mexico

In the early 1970's, the small town of Cancun, in the northeastern coastal area of the Mexican state of Quintana Roo, was rapidly developed and became a premiere Caribbean tourist destination. Just twenty-five years later, the area is home to some 300,000 residents and supports more than two million visitors each year. This rapid growth in tourism development and infrastructure, however, also led to severe environmental impacts, including deforestation, increased sedimentation and sewage effluent in coastal marine ecosystems, as well as pressure on coral reefs from consumer demands and marine recreation. In recent years, environmental organizations and government agencies have sought to improve coastal development regulations and mitigate impacts from future development that is likely to come in the Costa Maya region south of Cancun. In 1998, voluntary guidelines were published supporting low-impact tourism and environmentally conscious development practices throughout the state of Quintana Roo. Supporters of these guidelines are continuing to build relationships with government agencies and private developers to promote the Quintana Roo area as a leading example of sustainable development and tourism.

Coastal development in Cancun, Mexico — Wolcott Henry photo

Tourism Infrastructure Development

Tourism infastructure development can impact coral reefs by causing:

• Physical damage.

• Sedimentation.

As larger numbers of tourists travel to a region, a common result is the rapid development of infrastructure to support these foreign visitors. In many respects, this brings clear benefits to a local community in the form of jobs and increased economic activity. However, if construction of supporting infrastructure in coastal regions is done in a poorly planned manner, there can be serious negative environmental consequences.

How does this impact coral reef ecosystems?

Coastal development projects — such as airport runways, resort hotels, restaurants, piers and marinas — can kill coral directly by causing severe **physical damage** to the reef structure. Additionally, the long-term effects of increased levels of **sedimentation** generated by this type of coastal development negatively impact the health of coral reef ecosystems.

Specific impacts on coral reefs from tourism infrastructure development include:

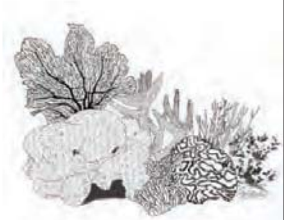
Physical Damage to Reefs:
- Blasting and dredging for projects destroys the foundation and structure of coral reefs, causing a reduction in biological diversity.

- Destruction of reef structure prohibits recruitment and settling of new corals and therefore inhibits recovery in areas that have been severely damaged.

Because corals and the symbiotic algae in their tissues need sunlight to produce food, sedimentation in the water column blocks out sunlight, and kills corals.

Sedimentation:
- Coastal construction increases sedimentation. Many studies have shown that sediment suspended for extended lengths of time in a reef environment causes significant decline and death of living corals.

- The reduction of coral cover due to sedimentation contributes to overall ecosystem decline and a loss of diversity and stability.



Hotel, Lodging and Restaurant Operations

Hotel, lodging and restaurant operations create direct impacts on coral reefs through:

• Pollution.

• Over-consumption.

In many ways, the environmental impacts of coastal development are directly related to the consumption habits of tourists. In response to consumer demand, developers commonly build hotels, restaurants, golf courses and other tourist accommodations directly on coastal waterfront property.

How does this impact coral reef ecosystems?

The operation of tourist facilities such as hotels and lodges creates solid and liquid wastes from landscaping and golf courses, human waste, laundry and other guest services. Additionally, restaurants that serve locally threatened or endangered fish contribute to the decline of local fisheries. This type of development generates increased levels of **pollution** and **over-consumption** of marine resources in near shore environments.

Impacts on coral reefs from hotel, lodging and restaurant operations include:

Pollution:

- Sewage, nutrient or chemical run-off stimulates algae blooms that smother and inhibit coral growth and reduce species diversity on the reef.

- Pathogens, bacteria and viruses associated with microorganisms contained in human waste can cause disease in several species of corals.

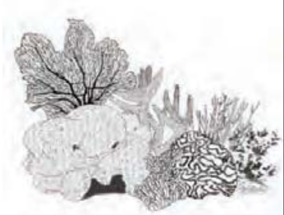
- The build-up of chemical pollutants in an ecosystem, such as herbicides and pesticides, can contribute to disease and poor health in fish and other species and make them unfit for human consumption.

Hotels in coastal areas are able to significantly reduce their impact on the marine environment by implementing energy conservation and recycling programs.

Over-consumption:

- Excessive consumption of food resources — particularly threatened and endangered fish species that are served as seafood cuisine in restaurants — can lead to the collapse of local fisheries as well as the decline of diversity and stability in near shore reef ecosystems.

- The sale of corals, shells and other reef dwelling species as ornamentals at hotel gift shops and local markets reduces diversity and stability in near shore reefs. Many popular "curio" items are key components of reef ecosystems, and their removal leads to negative cascading effects in the environment.



Marine Recreation

Marine recreation can directly impact coral reefs through:

- Physical damage.
- Harassment of marine life.
- Pollution.

Coastal tourism, particularly in tropical regions, has given rise to a booming marine recreation industry throughout the world. Snorkeling, diving, recreational fishing and a variety of other water sports activities now represent a significant part of the economy in many regions that support coral reefs.

How does this impact coral reef ecosystems?

Poorly conducted boat operations, as well as irresponsible snorkeling and diving, can cause **physical damage** to reefs from improper anchoring, propeller wash and sedimentation, **harassment of marine life**, and unnecessary **pollution** of the environment.

Physical Damage:

- Anchors and chains crush living corals and break-up reef structure.
- Snorkelers and divers damage coral and other organisms in a reef by touching with hands, fins or dangling equipment.
- Operating boats in shallow reef environments causes sedimentation, decreasing available sunlight for living corals.

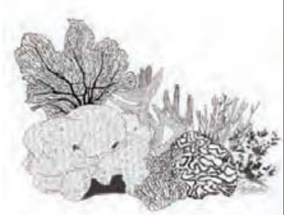
Harassment of Marine Life:

- Handling and feeding marine wildlife causes undue stress and behavioral changes to animals and can lead to abandonment of primary feeding and reproductive grounds.
- Chasing marine wildlife with boats — particularly turtles and marine mammals such as whale and dolphins — causes stress and can separate cow/calf pairs.

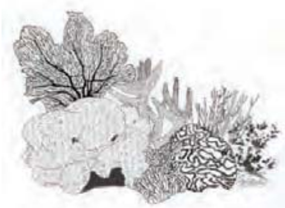
By operating with inefficient two-stroke engines, personal watercraft such as jet skis and wave runners dump nearly 30% of their fuel unburned into the marine environment.

Pollution:

- Fuels, oils and other toxins released from inadequately maintained vessels can stress and kill corals and other organisms in the marine environment.
- Distribution of toxins in the food chain can impact fish populations and negatively affect available resources for consumers, including humans.
- Release of raw sewage from vessels can scar and cause disease in several species of corals.

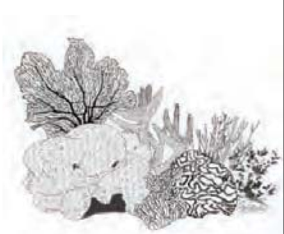


Part III: Establishing Good Environmental Practices and Voluntary Codes of Conduct



Key concepts for marine recreation providers:

- Establishing good environmental practices.
- Voluntary codes of conduct.



Establishing Good Environmental Practices and Voluntary Codes of Conduct

The rapid growth of marine recreation in tropical areas around the world has contributed to decline of coral reef ecosystems in many locations. Through simple behavioral and operational changes in business practices, however, marine recreation providers can simultaneously work to promote industry and protect the underwater environment.

This section of the training handbook will highlight the concept of good environmental practices and establishment of voluntary codes of conduct for marine recreation providers. For each topic covered, the potential environmental problems will be addressed, followed by a list of recommended solutions.

The topics will include:

- **Anchoring**
- **Boat Operations and Maintenance**
- **Sewage and Garbage Disposal**
- **Snorkeler and Diver Impacts**
- **Marine Wildlife Viewing**
- **Suncare Products**
- **Seafood Consumption**
- **Collection and Sale of Marine Ornamentals**
- **Recreational Fishing**

Anchoring

Achoring damages corals in a number of ways:

- Crushing and breaking corals.
- Chafing coral tissue.
- Break up reef structure.
- Stirring up of sediment.

Every year, the use of anchors for mooring commercial and recreational boats causes millions of dollars in damage to coral reefs around the world. Ironically, the impacts caused by anchoring are slowly destroying the economic value that is inherent in healthy, undamaged reefs. Protecting against anchor damage, therefore, not only preserves the biodiversity of an ecosystem, but also sustains the economic base of the marine recreation industry.

Anchors cause damage to reefs in a number of ways:

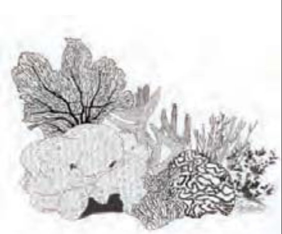
- Anchors, and the long chains associated with them, damage coral reefs by **crushing and killing corals** and other organisms on which they fall.
- Anchor chains **strip the live tissues off corals**, causing widespread scarring, and leaving the injured corals open to infection and disease.
- Repeated anchor drops or large anchors will **break up the reef structure** and can prevent new corals from developing.
- Anchoring causes other harmful effects, such as **clouding the water with disturbed sediment**, which chokes corals and reduces the amount of sunlight that symbiotic algae require for photosynthesis.

Given the slow rate growth for most coral species, it can take years for a reef to recover from damage caused by one improperly set anchor!

Mark Micklefield photo

John W. McManus photo

Even anchors from small boats can cause extensive damage to coral reefs!



Good Environmental Practices: Anchoring

Simple ways that boaters can reduce impacts to coral reefs:

- Use mooring buoys.
- Change boating practices.

Minimizing anchor damage is crucial to protecting near shore marine and coral reef ecosystems and the livelihoods that depend on them. Fortunately, anchor damage can be easily prevented through the installation of mooring buoys, simple changes in boating habits, and education.

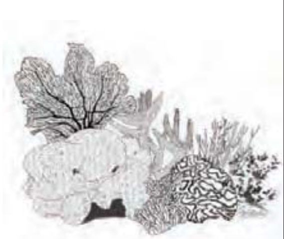
Use Mooring Buoys. Mooring systems provide permanent lines that allow boaters to fix their position without dropping anchor. An effective mooring program includes:

- The installation of moorings that are suitable for coral reef areas.
- Use of moorings by all recreational and commercial boats.
- Regular maintenance and correct use of moorings.
- Outreach and education with the boating community and the general public on how to properly use and maintain moorings.

Change Boating Practices. By simply making small adjustments to their practices, boat operators can help protect and conserve coral reefs. Here are some examples:

Remember that the attached anchor chain and line can cause as much damage to the reefs as the anchor itself!

- Correctly use mooring buoys whenever possible. Proper scope is a key element to reducing the load that boats place on moorings. Additionally, allow yourself room to maneuver by passing a mooring line at least half the length or more of your boat through the eye or "hook-up" point on the buoy, and then secure both ends to a cleat on the deck.
- When anchoring is absolutely necessary, boaters should make sure they are in designated areas away from important marine ecosystems and where they will not be dragged near these areas and cause damage.
- If no moorings are present, dive boat operators may consider drift dives instead or boat crews can manually swim anchors down and place them in locations where they will not damage or destroy reefs.
- Always avoid anchoring near coral reefs in heavy weather conditions such as high winds or swells unless it is necessary for the safety of the crew, passengers and vessel.



Simple ways that boaters can reduce impacts to coral reefs:

Educate boat users:

- Explain mooring buoys and the threats of anchoring.
- Provide infomation on anchoring practices.

Good Environmental Practices: Anchoring (continued)

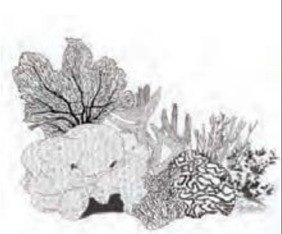
Educate Customers and Tourists Who Rent Boats. Many tourists who rent boats, sailboats, kayaks or canoes have little understanding of how harmful anchors can be to near shore marine environments and reefs. Rental operators can help protect coral reefs by educating their customers. Here are some ideas of what rental operators should do for their customers:

- Explain what mooring buoys are and encourage renters to use them whenever possible.
- Explain the proper way to anchor before guests set out.
- Provide waterproof information on proper anchoring practices on all rental vessels.
- Explain the potential negative impacts of poor anchor use.

See CORAL's *Mooring Buoy Installation and Maintenance* handbook.

Florida Keys National Marine Sanctuary photo

Many communities have realized that proper use and maintenance of moorings in popular areas plays a key role in protecting coral reefs from anchor damage.

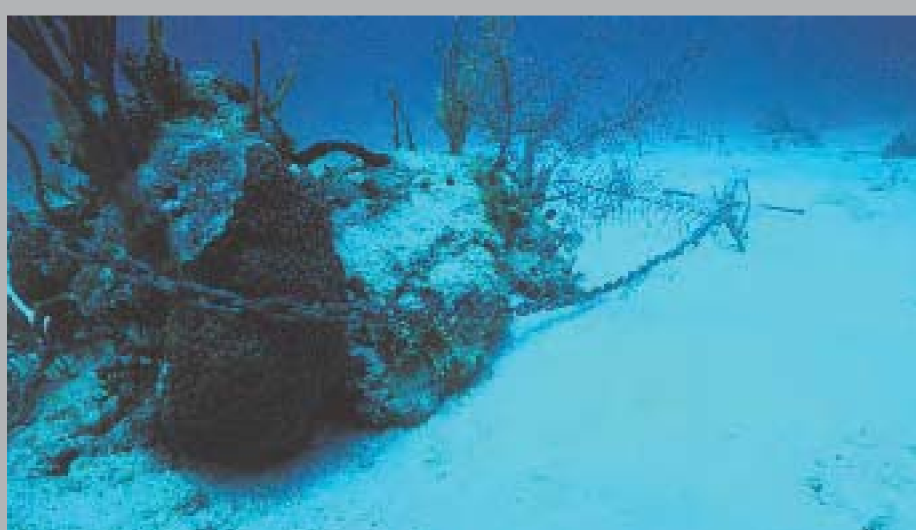


Case Study: Day-Use Moorings in the Hawaiian Islands

The Day-Use Mooring Program in the Hawaiian Islands was initiated in the late 1980's in response to increasing anchor damage to coral reefs from commercial and recreational boaters across the state. Both Halas eyebolt pins and Manta Ray systems have significantly reduced anchor damage at several popular snorkel and dive sites.

Mooring projects are planned and completed largely by volunteers working in partnership with the Hawaii Department of Land and Natural Resources, the Malama Kai Foundation, environmental organizations and members of the local dive industry. Partnerships, coalition building, appropriate use of the media, outreach to the public and development of consensus decisions have all proven valuable at integrating and involving many players.

Ultimately, the program still depends on the interest and energy of volunteers to make projects happen. In 2002, however, funding was secured from a grant through U.S. Fish and Wildlife Foundation and a half-time Day-Use Mooring Program Coordinator was hired for the state.



FKNMS photo

Anchor chains often cause more damage to corals than anchors!

Boat Operations

Boat operations can damage coral reefs through:

- Vessel groundings.
- Anchor damage.
- Pollution and increases in sedimentation.

Recreational and commercial boating is an immensely popular and important economic activity that involves millions of people across the globe. In tropical areas, boaters often have relatively easy access to coastal or near shore coral reef ecosystems that serve as a source of food, resources, recreation and tourism. As a result, it has become increasingly important for boaters of all backgrounds to engage in operations in an environmentally responsible manner.

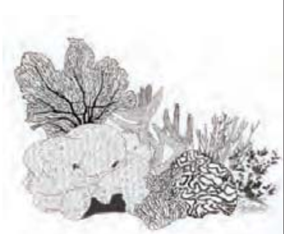
While recreational boating experiences often lead to a conservation ethic among marine enthusiasts, there can be negative environmental impacts associated with poorly conducted or irresponsible boat operations and accidents. Vessel groundings and anchor damage have the most immediate and destructive impact on coral reefs. An increase in pollution, sewage, solid waste, and sedimentation from shallow water operations, however, can also negatively affect coral reefs and other nearshore marine ecosystems.

Poorly conducted boat operations can cause damage to coral reefs in a number of ways:

- When a boat collides with a reef, it **crushes and kills large areas of corals** and other reef dwelling organisms. Additionally, a boat that sinks as a result of a collision can **introduce significant amounts of toxic fuel and oil into the marine environment**.

Many communities offer classes in basic boating, which teach skills that help prevent ecreational boating accidents.

- Large commercial ships are known to cause **massive damage when running aground on reefs**, however, smaller private or commercial boats can also severely impact a reef ecosystem.
- Careless operation of small boats in shallow water can generate propeller wash, wave creation and excess sedimentation, which can **smother reef dwelling organisms** and inhibit the photosynthetic process of symbiotic algae that live within coral tissues.
- Operation of older boats and jet skis that have two-stroke engines — which are very inefficient on fuel consumption — contributes to **serious levels of pollution** in the environment.



Good Environmental Practices: Boat Operations

Principles of boat operations that minimize negative environmental impacts:

- Know the "rules of the road."
- Keep boats in operating prime condition.

There are many established boating principles that conscientious operators can follow in order to avoid accidents and unintentional damage to coral reefs.

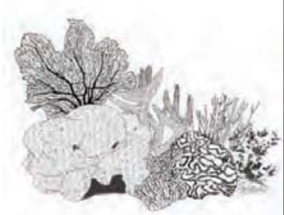
Follow Established Navigation Principles and Mooring Techniques.

- Stay within designated channel markers, and when in reef areas, stay beyond the furthest visible reef patch at unknown or unmarked sites.
- Obey all speed signs to avoid marine mammal strikes (propeller hits).
- Identify dark water areas as a possible important underwater ecosystem, for example a shallow reef.
- Know how to properly read and interpret a navigational chart.
- In coral reef areas, use mooring buoys where available. If anchoring, always drop anchors in sand or rubble channels well away from living reefs and allow sufficient bowline scope to avoid dragging along the bottom.

Keep Boats in Prime Condition for Operations and Emergencies.

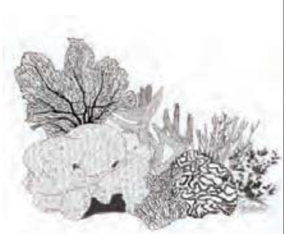
Simple behavioral and operational changes on the part of boat crews can significantly reduce damage to coral reefs.

- Have boat engines regularly serviced by a certified mechanic to optimize performance and fuel efficiency. When possible, replace older two-stroke engines with more fuel-efficient, cleaner burning four-stroke outboards. If you use a two-stroke outboard engine, opt for alkylate petrol. For larger vessels with in-board propulsion systems, consider converting to biodiesel.
- Carry a supply of basic tools that will assist engine repairs out at sea.
- Always carry both a primary and secondary anchor line so vessels can be securely moored in emergency situations.
- Keep absorbent pads on-board to deal with hazardous chemical spills.
- Non-toxic oils are available and should be used whenever possible. Wait until you get to the marina to dispose of your waste oil, and recycle if possible.
- Refuel only at a dock or in the marina. If you fill up at sea, you could spill fuel into the water. Have absorbent pads available when fueling in order to deal with any spills that occur.



Principles of boat operations that minimize negative environmental impacts:

- Educate customers and tourists who rent boats.



Good Environmental Practices: Boat Operations (continued)

Educate Customers and Tourists Who Rent Boats.

- Instruct renters in basic navigation, boat handling and safety principles.
- Explain the sensitive nature of coral reefs and the importance of avoiding shallow reef areas with motorized vessels (see Appendix — Environmental Briefing Cards).
- Provide easy-to-use waterproof navigation and reef location charts.
- Explain the threat that anchors pose to near shore ecosystems and reefs and the proper way to moor a boat without causing damage to the underwater environment.
- Provide on-board information about location and proper use of reef mooring buoys at popular snorkel and dive locations.

For more extensive information on good environmental practices for boaters and marinas, check out, *Good Mate: Recreational Boating and Marina Manual,* published by the Ocean Conservancy.

Case Study: Development of the SmartVoyager Environmental Certification Program in the Galapagos Islands, Ecuador

Launched in May, 2000, the SmartVoyager voluntary environmental quality standards certification program works to reduce negative environmental impacts on marine and terrestrial ecosystems connected to the unique Galapagos Islands. A broad set of stakeholders from the community — including government agencies, boat operators, tour associations, conservationists and local citizens, participated in the development of the program.

Coordinators of this program developed a strategy that focused on tourists and the 60 tour boats that regularly shuttle them from island to island. Voluntary standards were established which set specific and detailed conservation practices in place and further required vessels to educate their customers regarding the delicate and vulnerable nature of the islands' ecosystems.

Some examples of changes in boating operations include:

- Replacment of on-board air conditioners and refrigerators that use chlorofluorocarbons (CFC's).
- Replacement of old, two-stroke outboards with cleaner burning four-stroke models.
- Installation of noise abatement systems on propulsion and generator engines.

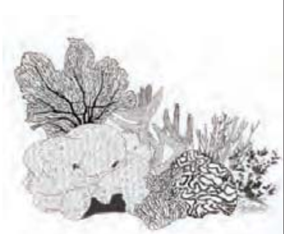
Tour operators who met these standards were officially certified by the program. Stakeholders in this project included relevant government agencies, conservationists, tour operators and members of the local community. While the initial focus targeted larger vessels, it was quickly realized that it was of equal importance to conduct outreach and provide resources that would integrate smaller scale operations into the program as well. To date, there has been widespread acceptance within industry that the SmartVoyager standards provide appropriate environmental guidelines and increase social responsibility in the Galapagos Islands.

Boat Maintenance

Environment impacts from inadequate boat maintenance can include:

- Leaks of toxic fuels and oils.
- Heavy metals in the environment from anti-fouling bottom paint.
- Discharge of raw or untreated sewage.
- Toxic substances contaminating bottom sediments.

Chronic toxic waste leaks are a common souce of pollution from small boat harbors and marinas.



While boaters can minimize impacts on the marine environment by conducting responsible operations, regular and proper maintenance is another key part of boating that can significantly reduce unintentional and unnecessary damage to near shore coral reefs. A significant source of water pollution near harbors, marinas, and popular dive and snorkel sites commonly comes from fuel, oils, solvents and cleaners used by recreational and commercial boaters.

One small fuel or sewage leak from a recreational or commercial vessel may not cause long-term damage to the marine environment. Over time, however, the combined effects of pollution from multiple boats in marinas or popular areas can lead to significant degradation of coral reefs and other marine habitats. These impacts have negative consequences for both the ecological health and economic value of an entire coastal community.

Inadequate boat maintenance can lead to damaging effects on coral reefs in the following ways:

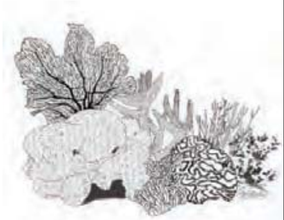
- Environmental problems associated with boat maintenance are generated by **leaks of toxic substances** such as oil or fuel, and release of heavy metals from anti-fouling bottom paints.
- The cumulative effects of poor maintenance on boats **can be as negative and severe as other boating related impacts** to coral reefs such as anchor damage, groundings, and waste disposal.
- Accidental **discharge of raw or untreated sewage** can result from improper maintenance of vessel sewage containment systems.
- Toxic substances such as fuel, oil, and other chemicals often **sink and contaminate bottom sediments**. This contamination can be spread throughout the food chain and ecosystem by fish and other animals that feed on bottom dwelling organisms.

Good Environmental Practices: Boat Maintenance

Boaters can reduce environmental impacts through:

- Regular boat maintenance.
- Using absorbent bilge sponges.
- Avoiding CFC refrigerants and fire extinguishers.
- Avoiding pumping oily bilge water into the sea and minimizing use of toxic chemicals.

Regular, quaity maintenance of small recreational or commercial boat is “win-win” for both the owner and the coral reef.



There are many practical solutions that can prevent or remedy problems associated with intentional or accidental dumping of toxic substances into sensitive marine habitats as a result of inadequate boat maintenance.

Maintenance for All Operations

- **Perform regular maintenance on engines, fuel tanks and their associated components.** Have a mechanic perform regular servicing on an engine to maximize operating capacity and minimize fuel consumption. Use clean burning four-stroke engines whenever possible, or convert engines on larger vessels to operate on biodiesel.

- **Regularly inspect areas that are susceptible to potential leaks of toxic substances.** This can include regularly checking fuel lines and tanks, filters, separators, vents and bilge pumps.

- **Keep toxic absorbent sponges in bilges.** This can significantly reduce discharge of oils and fuels. Many types of sponges are available that absorb fuel and oil but not water. Additionally, absorbent pads or pillows should be kept on-hand to clean any ptotential spiils that may ooccur while a vessel is being fueled in a marina or harbor.

- **Avoid on-board refrigeration units and fire extinguishers that use chlorofluorocarbons (CFC’s) or halons.** CFC’s and halons have been shown to cause damage to the earth’s ozone layer. This natural layer in the atmosphere filters out harmful ultraviolet radiation (UV) from the sun. As light sensitive animals, corals can be damaged by significant increases in UV exposure.

- **Avoid pumping oily bilge water into the sea**, particularly when you are near a coral reef. Unless the boat is in danger, wait until you can properly dispose of or recycle wastes at a marine facility. Additionally, avoid using detergents or emulsifiers as bilge cleaners. These chemicals disolve oils and fuel into water, thereby allowing both to be pumped overboard.

- **Avoid using toxic cleaners or other chemicals** while moored at coral reef sites. Cleaning can wait until vessels are back at the marina or a permanent, overnight mooring. Even then, boaters should minimize use of chemicals while seeking alternative, biodgradable, and non-toxic cleaners that are now available at many marine stores.

Good Environmental Practices:
Boat Maintenance, continued

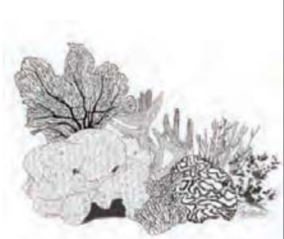
In addition to maintenance for good operations, boaters can:

In the Marina:

- Fuel carefully.
- Avoid dispersing spills with liquid detergent.
- Use non-toxic cleaners.

In Dry Dock:

- Use catchment basins when removing bottom paints or sanding.
- Use non-toxic bottom paints.
- Properly dispose of toxic paints and chemicals.



In addtition to properly maintaining boats for regular operations on the water, it is important to engage in good practices while moored in a marina or engaged in vessel restoration or repairs during drydock.

In the Marina

- **Exercise care when fueling vessels on the water**. Have oil absorbent pads ready for any potential leaks while fueling. Fill tanks only to 90% capacity in order to allow for expasion and avoid spills due to overfilling.

- **Do not use dishwashing detergent to disperse small fuel or oil spills** in the water. This causes more harm than good, as it sends toxins below the surface and contaminates bottom sediments.

- **Use non-toxic and phosphate free cleaners** on decks, bilges, and hulls. Many biodegrable cleaners are now commonly available at marine stores (See Appendix). Read labels and become familiar with "green" products.

- **When cleaning vessels, use the minimum amount of chemicals** necessary to do the job. Additionally, it is important to dispose of toxic materials properly, including rags, absorbent pads, paints, cleaners and other items used during routine vessel maintenance.

In Dry Dock

- **Seek out facilities that have catchment basins** when pressure washing and removing toxic bottom paints. If these facilities are not available, encourage your local marina to acquire them.

- **Use non-toxic anti-fouling paints on boat hulls.** International laws are beginning to ban commonly used anti-fouling paints of the past. These paints are known to contain biocides and heavy metals that can cause cancer in both humans and marine animals. Less harmful anti-fouling paints are now available on the commercial market (See Appendix).

- **When sanding hulls or decks, use a vacuum sander** and place tarps or drop cloths below the vessel in order to collect harmful bottom paint paticles, fiberglass, varnish or other toxic substances for proper disposal.

- **Properly dispose of all toxic paints and other chemicals** used during dry dock as hazardous materials, and reuse or recycle what you can.

Sewage and Garbage Disposal

Improper sewage disposal:

- Contributes to algae blooms.
- Poses a health threat.

Improper garbage disposal:

- Can be deadly to wildlife.
- Can entangle and smother coral reefs.

A growing threat to both people and the environment comes from vessels discharging raw or partially treated sewage and dumping garbage in coastal waters. Human waste contains nutrients, pathogens and viruses that can contribute to disease and detrimental algae blooms in coral reefs and also pose a serious threat to human health. Garbage in the marine environment is unsightly and dangerous, and items such as plastics, styrofoam and cigarette butts can prove fatal to many marine species.

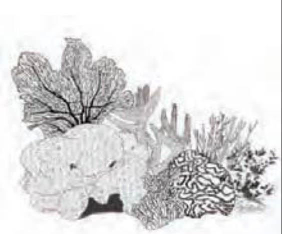
Sewage and garbage disposal in the marine environment can damage coral reefs and wildlife in many ways:

- The build-up of sewage or other organic nutrients **contributes to massive algae blooms** in near shore marine environments. This reduces available oxygen in the environment and smothers reef corals, thereby inhibiting growth and access to sunlight.
- Bacteria, viruses and diseases associated with human waste can pose **serious risks for human health** and food resources in a local community. Additionally, bacteria associated with sewage can contaminate a variety of harvestable resources such as fish and other species.
- Marine debris in the form of plastics, fishing line and nets, cigarette butts, and styrofoam are often consumed by or entangle turtles, seabirds, fish and marine mammals and **cause the death of millions of animals** every year.
- When garbage becomes entangled on coral reefs, it **smothers and kills coral colonies** and can pose a **safety hazard** to snorkelers and divers.

Sewage effluent has been linked to black band disease in living corals in the Caribbean and a parasitic worm that destroys coral tissue throughout the Pacific.

Jake Asher photo, NOAA.

Garbage in the marine environment, particularly discarded fishing gear, plastics and styrofoam, can be deadly to wildlife. This green sea turtle in the Northwestern Hawaiian Islands was freed by NOAA divers, but suffered severe damage to both its front fins.

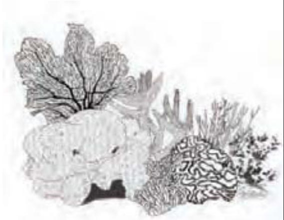


Good Environmental Practices: Sewage and Garbage Disposal

Steps to reduce the sewage and garbage in the environment:

- Pump-out facilities and land-based restrooms.
- Sewage treament and sanitation devices in prime working condition.
- "No Discharge Zones."
- Keep garbage in contained places and minimize use of plastics and styrofoam.

Plastic alone in the marine enviroment kills millions of marine animals every year!



There are simple steps that marine recreation providers and visitors can take to reduce the impacts associated with sewage and garbage disposal from a boat.

- **Use pump-out facilities where available.** Disposal of sewage from small vessels on land is the best way to protect the marine environment, as this waste generally goes to some kind of treatment plant to minimize pathogens and levels of toxicity. If these facilities are not available, encourage your local marine to acquire them.

- **Use land-based restroom facilities prior to boat excursions.** Most land-based facilities are connected to some kind of municipal waste treatment facility. Using these facilities can significantly reduce discharge of untreated sewage at sea.

- **Keep vessel marine sanitation devices in good operating condition.** Regularly inspect and maintain all hoses, fittings, and mechanisms associated with waste storage in order to prevent accidental discharge of untreated sewage. Keep Y-valves closed while operating in coastal waters.

- **Treat sewage prior to release from vessel.** If pump-out facilities are not available, there are several non-toxic, biodegradable chemicals and mechanical methods that can be used to reduce solids and pathogens in waste prior to disposal in the environment (See Appendix). Small vessels should proceed as far offshore as possible prior to discharging treated sewage. Avoid discharging toilets or sewage holding tanks in confined or crowded places, environmentally sensitive areas or marine protected areas.

- **Support the establishment of "No Discharge Zones."** The creation and enforcement of "No Discharge Zones" helps protect ecologically and economically important coastal areas in a community.

- **Keep garbage contained and minimize use of plastics/styrofoam.** Garbage bins on tour boats should be contained or kept inside to minimize the chance of debris blowing overboard. Additionally, vessels should use paper instead of plastic and styrofoam plates and cups and can provide information to tourists regarding the threat that improper garbage disposal poses to marine life.

- **Pick up damaged fishing nets or lines cut away from propellers.** Do not leave them in the sea, as they could injure or kill marine wildlife.

Snorkeler and Diver Impacts

Snorkelers and divers impact coral reefs by:

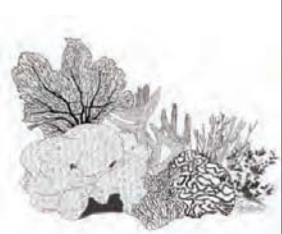
- Touching and crushing organisms.
- Stirring sediment.
- Handling and harassing wildlife.
- Providing artificial food to wildlife.

Throughout the world, coral reefs are beginning to show signs of decline as a result of impacts generated by the snorkeling and diving industry. These impacts are relatively insignificant compared to larger environmental problems associated with coastal development, pollution and over-fishing. Yet direct contact with corals, reef animals, and other wildlife by snorkelers and divers is leading to increased levels of degradation and disturbance in coral reefs.

Irresponsible snorkeling and diving practices can cause physical damage to a coral reef:

- The consistent presence of small and large groups of people in a shallow coral reef habitat **can lead to significant degradation of an ecosystem over time.**
- Irresponsible or inexperienced snorkelers and divers regularly **crush and break corals and other reef dwelling organisms** with fins, equipment and body parts.
- Snorkeler and diver impacts are **usually a result of individuals or groups** trying to gain control, get a closer look or photograph, stand or walk in a shallow area, fight a current, or handle, touch and feed wildlife.
- The **cumulative effects of snorkeler and diver impacts** can lead to a decline in living corals and other reef dwelling organisms, increases in sedimentation, and disturbance to wildlife.
- Degradation of reefs from snorkelers and divers can **significantly reduce the beauty and aesthetic qualities** that attract visitors to a reef.

Snorkeler and diver related impacts are often simply the result of tourists being unaware and uneducated about the fragile nature of coral reefs.



W. Harrigan photos, FKNMS

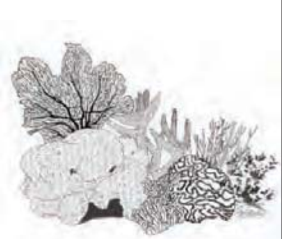
Snorkelers and divers can cause significant damage to coral reefs.

Good Environmental Practices: Snorkeler and Diver Impacts

Environmentally conscious snorkeling and diving includes:

- No-contact policies.
- Environmental briefings.
- Discourage fish feeding or harassment of wildlife.
- Support mooring buoy projects.
- Support of Marine Protected Areas.

Learning more about coral reef ecology generally makes snorkelers and divers more conscientious about impacts to the marine environment.



If done in an environmentally conscious manner, snorkeling and diving can be an economically valuable and ecologically sustainable industry. Similarly, when conducted appropriately, these marine recreational activites are very important conservation mechanisms because of their high educational value. There are many simple ways that tour operators, marine recreation providers and individual snorkelers and divers can reduce impacts to coral reefs:

- **Establish a "no contact" policy.** Marine recreation providers and companies that rent and sell snorkel and dive gear can promote a voluntary "no contact" policy for recreational snorkelers and divers. These policies can be supported by encouraging the use of flotation vests for inexperienced snorkelers and discouraging the use of gloves by divers.

- **Conduct environmental awareness briefings for tourists and other marine enthusiasts.** Studies have shown that damage to near shore marine and reef environments can be minimized when tour operators educate tourists, photographers, videographers and others about the sensitive nature of coral reef ecosystems and the potential impacts that can result from irresponsible snorkeling and diving.

- **Conduct buoyancy refreshers.** Dive operators in particular can conduct buoyancy refreshers and other basic dive skills training with inexperienced, out-of-practice, or non-regular divers.

- **Discourage feeding of sharks and reef fish and harassment of wildlife.** Wildlife disturbance caused by snorkelers and divers can be significantly reduced with a voluntary policy of "take only pictures, leave only memories" that discourages fish feeding and harassment of wildlife.

- **Support mooring buoy projects.** The establishment of permanent mooring buoys at popular snorkel and dive sites significantly reduces anchor damage to near shore marine environments, particularly coral reefs, that are often associated with the marine recreation industry.

- **Support the establishment of Marine Protected Areas (MPAs).** Designation of MPAs often results in an increase of protective measures for an area. This can include reduction or elimination of anchoring, fishing, harvesting of corals and other species and harassment of wildlife. These protections often enhance the economic and ecological value of an area and create market advantages for businesses operating in them.

Marine Wildlife Viewing

Irresposible marine wildlife viewing can result in:

- Disturbance of marine mammal cow/calf pairs.
- Abandonment of primary feeding and reproductive grounds.
- Injury or death.

In recent years, wildlife viewing has grown into a significant sector of the marine recreation industry. Many stakeholders in the industry have realized that several species of previously considered "harvestable" animals now have much greater economic value for "wildlife viewing" by visiting tourists. Destruction of habitat, direct harvesting, pollution and marine debris in the ocean remain the most important threats to marine animals. In many cases, however, intrusive or irresponsible methods of marine wildlife viewing can potentially harm and even kill popular animals such as whales, dolphins, manatees and dugongs, and marine turtles among others.

Irresponsible marine wildlife viewing can cause:

- **Disturbance of cow/calf pairs.** Marine mammals such as whales and dolphins can commonly be located in shallow, coastal tropical environments when nursing young. Intrusive viewing can create stress in mothers, separate cow/calf pairs, and decrease survival rates in new-born calves.

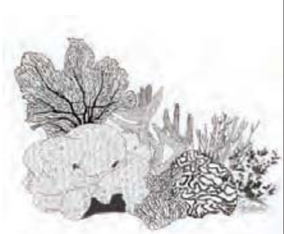
- **Abandonment of primary feeding or reproductive grounds.** Excessive handling or interaction can cause marine turtles to abandon primary feeding grounds in coastal environments. Marine mammals may leave key breeding sites if stressed from human interaction.

- **Injury or death.** Slow moving marine animals, particularly whales, manatees and marine turtles, can be injured and killed by propellers and fast moving boats. Additionally, scarring caused by propellers can make marine animals more susceptible to infection and disease.



In recent years, whale and dolphin watching has become tremendously popular in many regions of the world, generating a significant source of revenue for coastal communities.

Lori Mazucca photos



Good Environmental Practices: Marine Wildlife Viewing

In order view marine life in a responsible way, operators should:

- Avoid chasing, feeding and/or surrounding wild animals.
- Practice a policy of no-contact.
- Observe the law.
- Be litter conscious.

There are simple yet important operating methods and practices that boaters and other water sports enthusiasts can abide by in order to enjoy wildlife viewing without disturbing the animals' that are involved. As a responsible boat operator or tourist, make sure to:

- **Avoid chasing marine animals.** Whether in the water or on a boat, watersports enthusiasts and tour operators should always operate at a slow speed and never chase marine animals. If whale watching, it is best to approach animals very slowly from the side, versus head-on or from behind, and keep at a relative distance. Many environmental organizations and governments recommend staying at least one hundred yards from large whales. If animals approach the vessel, slow down or stop and put propellers in neutral. Always let the animal(s) determine its own path and behavior.

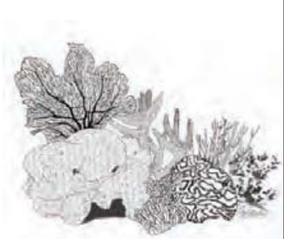
- **Practice a no-contact policy.** As an individual water sports enthusiast, or a small group, always avoid touching and handling marine animals such as turtles, whales and dolphins, and manatees.

- **Never feed wild animals.** Providing artificial food can alter an animal's behavior and impair natural feeding abilities and survival mechanisms.

- **Avoid surrounding animals.** If several tour boats are engaged in whale watching, for example, a concerted effort should be made to avoid surrounding the animals and causing unnecessary stress. This same concept applies for individual or small groups that are in the water viewing wildlife.

- **Observe the law.** In recent years, many places have passed laws banning or limiting the use of thrill craft or fast boat operations in sensitive marine habitat in order to protect slow moving or endangered marine animals such as manatees, turtles and whales. Additionally, in many places it is illegal to touch or handle marine wildlife, particularly if the animals are threatened or endangered.

- **Be litter conscious.** Marine debris is one of the greatest threats to wildlife in the oceans today. Be aware that debris as small as a cigarette butt can be very harmful to animals such as sea turtles. If engaged in boating or coastal activities, always make sure that trash goes in its proper place and does not end up in the marine environment.



Suncare Products

Suncare products are potentially a new threat to coral reefs:

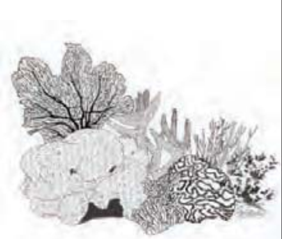
- Petroleum-based products can be harmful to livingcorals.
- Suncare products may disrupt the natural hormone systems in animals.

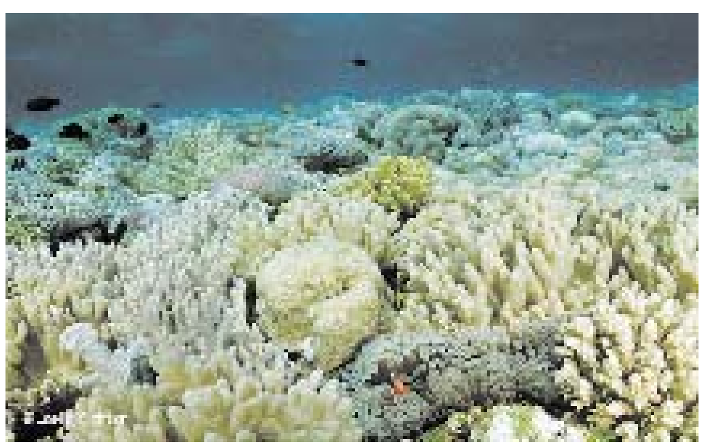
Suncare products are potentially a new and emerging threat to the health of coral reef ecosystems in tropical resort destinations. Many “sunscreens” are petroleum-based, and studies in recent years have shown that petroleum products can be detrimental to living corals and other organisms in a reef community. While scientists and others recognize the need to conduct more research into the direct impacts of suncare products on coral reefs, excessive introduction of these chemicals into the environment is a growing concern of conservationists and many stakeholders within the marine recreation industry.

Excessive use of suncare products around coral reefs may have several negative impacts on reef health:

- Several studies have shown that **petroleum products**, especially various types of oils, **can have severely damaging short and long-term effects on living corals.** While sunscreens do not have the toxicity levels of heavy industrial oils, many are petroleum-based and could be viewed as potentially lethal to corals and other reef dwelling organisms.
- The more **water-soluble a suncare product** is, the greater likelihood it will get into the water column and come into **direct contact with living organisms** in the reef community.
- Many suncare products are known to **contain chemicals that may actively disrupt natural hormone (endocrine) systems in animals.** It is therefore possible that corals are susceptible to damage from hormone disruption as a result of exposure to suncare products.

Ironically, just as we are beginning to learn of the potential threat of sunscreens, scientists are now deriving compounds to make sunscreen from living corals.





Leslie Richter photo

Coral reefs are a haven for biological diversity!

Good Environmental Practices: Suncare Products

Steps to reduce impacts to coral reefs from suncare products:

- Use UV protective clothing as a substitute for sunscreen prior to entering the water.
- Educate tourists.
- Use organic suncare products.

There are several simple steps that marine recreation providers and tourists can take to reduce the potential impact that suncare products have on coral reefs.

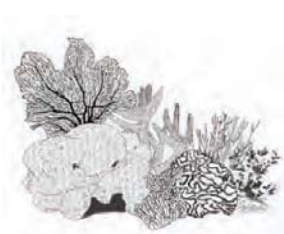
- **Use UV protective clothing as an alternative to sunscreen prior to entering the water.** Wearing rash guards, skinsuits, wetsuits and other aquatic gear can act as a substitute for sun protection and can significantly reduce introduction of potentially lethal chemicals into the marine environment.

- **Educate tourists.** Marine recreation providers can use snorkel or dive briefings as an opportunity to educate tourists about the potential damage to coral reefs from the introduction of synthetic chemicals. Retail shops that sell suncare products or rent snorkel and dive gear can also provide information to tourists regarding impacts to coral reefs.

- **Use organic suncare products.** Some manufacturers now make products that have less impact on the natural environment. For example, *Caribbean Pacific* produces a number of different biodegrable sunscreens that are organic and do not use petroleum-based ingredients. In some cases, resort destinations have adopted and actively promote these types of products in an effort to reduce human impacts at popular reef locations.

More scientific studies need to be conducted to investigate the impact that petroleum-based suncare products have on coral reefs.

The impacts to coral reef ecosystems from chemicals associated with petroleum-based and other suncare products are not yet fully understood. Environmental problems linked with similar chemicals, however, as well as extensive laboratory and field-testing on oils of various types, suggest caution in using these products in and around coral reefs. Rather than wait to see negative cumulative impacts based on a lack of consideration of the issue, it is plausible and practical to recommend minimal exposure of shallow coral reef ecosystems to suncare products.



Seafood Consumption

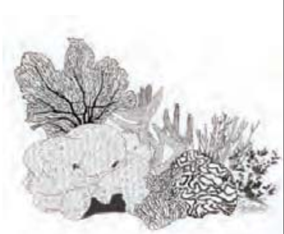
Over-harvesting of seafood poses a serious threat to coral reefs:

- Unsustainable harvests.
- Poorly informed and uneducated tourists.
- Negative effects on the marketability of natural areas.
- Unsustainable harvests for short term gain.

The over-harvesting of marine resources for seafood cuisine poses a serious threat to the health of coral reefs. In addition to existing international markets, visitors regularly consume many types of seafood harvested from the marine environment while on vacation. As a result of the demand for seafood in popular tropical destinations, many reef fish such as snappers, groupers, jewfish, jacks, as well as conch and lobster, have virtually disappeared in areas from the Caribbean to Hawaii to Asia.

As tourism has grown to become a major part of the socio-economic structure in these regions, it has become increasingly important for marine recreation providers — including sportfishers, dive and snorkel charters, and other boaters — to operate in ways that discourage excessive or uninformed consumption of marine resources, especially locally rare, threatened and endangered species.

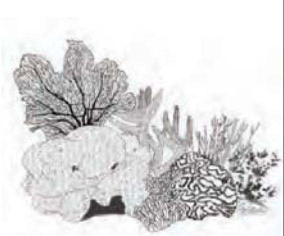
- Over-harvesting of key species in coral reefs can **disturb natural balances and lead to an overall loss of biodiveristy** in the ecosystem.
- Tourists are often **unaware of the fact** that a seemingly harmless purchase of a seafood dish can have **serious negative consequences** for the environment.
- Compounded by other existing environmental problems, this type of consumption can **negatively impact the health and marketability of the same natural areas** that attract and support foreign tourists.
- Given the potential for **short-term monetary gain** through the sale of popular seafood cuisine, many species are now **harvested from coral reefs and other marine habitats in an unsustainable manner.**



Good Environmental Practices: Seafood Consumption

Ways that environmentally conscious consumption can minimize impacts to coral reefs:

- Education.
- Avoid harvesting rare, threatened or endangered species.
- Inquire about how seafood was caught.
- Observe the law.



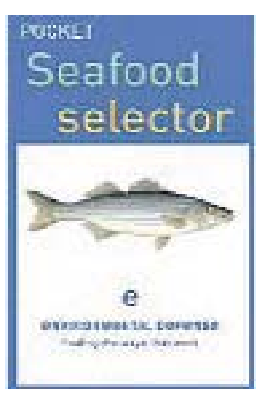
There are a number of ways that marine recreation providers can minimize the impacts of both recreational and commercial fisheries to near shore marine and coral reef ecosystems by the way they operate. In turn, travelers can become "responsible tourists" and contribute to both the economic and ecological sustainability of a particular region.

- **Educate clients and be informed consumers.** Marine recreation providers can supply information to clients about the sensitive nature of coral reef ecosystems. Operators have the opportunity to educate tourists regarding which species in a given region should not be consumed as seafood because it is rare, threatened or endangered.

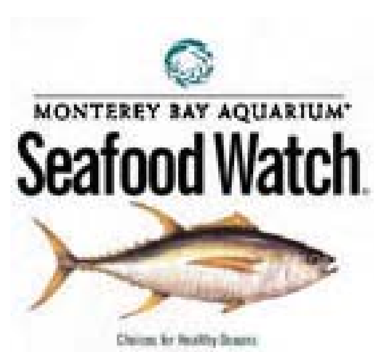
- **Support ecologically sustainable fisheries practices.** Marine recreation providers that serve seafood cuisine can help protect stocks of threatened or endangered fish by not offering these items during their operations. Instead, they should support suppliers that harvest non-threatened or non-endangered fish and other species in an ecologically sustainable manner.

- **Inquire about how seafood has been harvested** when purchasing cuisine, and whether or not the species in locally threatened or endangered.

- **Observe the Law.** Marine recreation providers and tourists should abide by all regional, national and international laws regarding harvesting of marine species for seafood cuisine.



www.chartingnature.com



www.mbayaq.org

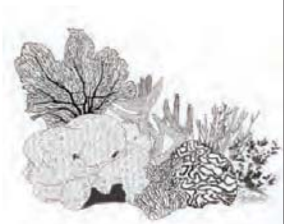
Many ocean conservation organizations now actively promote wise seafood choices for consumers through the use of educational "wallet sized" seafood cards.

Collecting and Selling Marine Ornamentals

Souvenir collecting and sales harm coral reefs by:

- Providing short-term monetary gain.
- Threatening sustainable fisheries and tour operations.
- Reducing diversity and stablilty in coral reefs.

The Marine Aquarium Council provides certification of quality and sustainablility for those involved with the collection of marine organisms.
www.aquariumcouncil.org



The collection and sale of marine organisms such as corals, shells and aquarium fish poses an incresing threat to the health and diversity of coral reefs around the world. Not only do tourists commonly purchase marine ornamentals or "curious" while on vacation, but worldwide demand for such products has created a mult-billion dollar industry that is having increasingly negative impacts on coral reef ecosystems.

Marine recreation providers have the opportunity to inform and influence the behaviour of consumers by pointing out the threats that this industry poses to coral reefs. Additionally, these same operators can minimize their own impacts by discouraging the collection and sale of marine ornamentals, as this industry damages reefs in a number of ways.

- Given the potential for **short-term monetary gain** through the sale of ornamental souvenirs such as fish, corals, shells, and other reef dwelling organisms, many species are now **harvested from coral reefs and other marine habitats in an unsustainable manner.**

- Removal of living coral, "live rock" and other marine organisms from coral reefs can **reduce the ability of these marine ecosystems to sustain local fisheries, tourism operations and coastal protection**.

- Overharvesting of key ecological components can have **unpredictable effects on the biodiversity and stability** of a coral reef. For example, excessive harvesting of urchins can lead to an overgrowth of algae, which can reduce live coral cover and overall species diversity on the reef.

Wolcott Henry photo

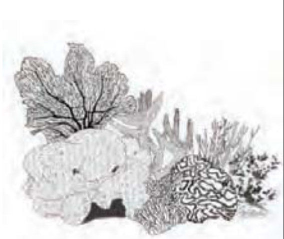
Corals for sale as ornamental souvenirs.

Good Environmental Practices: Collecting and Selling Marine Ornamentals

Limit the impacts of the sale of marine ornamentals by:

- Avoiding purchasing products.
- Supporting "no take" zones and management plans.
- Abiding by certification schemes.
- Being informed and obeying the law.

Harvesting living coral from a reef environment removes habitat for countless other species of fish and invertebrates.



There are many practical ways — ranging from a complete avoidance of ornamental souvenir purchases to support of a sustainable industry — that both marine recreation providers and tourists can minimize the impacts associated with collection and sale of marine ornamentals.

- **Avoid selling or purchasing marine ornamentals.** Marine recreation providers should avoid selling marine ornamentals and souvenirs. Tourists, on the other hand, can help prevent the removal of key components of reef ecosystems for short-term gain by avoiding the purchase of marine ornamentals.

- **Support the establishement of "no take" marine reserves** where it is illegal to collect marine organisms for sale or purchase as ornamentals and "curios." Additionally, work with local communities and government officials to ensure that proper management and enforcement takes place in these protected areas.

- **Support the establishment of local and regional management plans** that limit harvesting of marine organisms to levels which are sustainable for both industry and ecological health of coral reefs. Remember that reefs have diverse economic values beyond resources available for the marine ornamental industry.

- **Promote and support certification schemes** which give a market advantage to products harvested in a sustainable manner. If as a consumer you choose to buy marine ornamentals, make sure to purchase "certified" products in order to promote sustainable harvesting practices within the industry.

- **Be an informed business operator or consumer.** If you are a marine recreation provider, ensure that all your staff are informed about the potential negative consequences of harvesting marine ornamentals from coral reefs and that they share this information with clients. As a tourist or consumer, make the effort to be informed about why you should not purchase certain types of marine resources.

- **Observe the Law.** Marine recreation providers and tourists should abide by all regional, national and international laws regarding harvesting of marine species for as ornamental souvenirs.

Recreational Fishing

Concerns about the ecological impacts of recreational fishing:

- Declines in popular game fish.
- Need for catch-and-release fishing programs.
- Controversial nature of spear fishing.

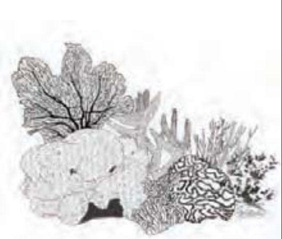
Throughout tropical resort destinations, visiting tourists regularly seek out sport fishing charters that target popular game fish such as marlin, dorado, wahoo and many others. Additionally, spear fishing and pole fishing among coral reefs has gained in popularity in recent years, both among tourists and locals in tropical communities. Though commercial fisheries likely have a bigger impact on open ocean fisheries than sport fishing charters, it has been shown that spear fishing can negatively impact populations of reef fish such as Nassau grouper, Jewfish, various types of parrotfish, and other marine species.

- Given the decline of many popular game fish throughout the world in recent years, **catch-and-release fishing is a growing practice** among sport fishing charters.
- In coastal environments, the **decline in reef fish has been linked to spear fishing** as well as over-consumption of marine resources by local populations and visiting tourists.
- Critics point out that **spear fishing is too highly effective a method of harvesting reef fish.** For example, parrotfish, due to their method of resting among a reef at night, are an easy target for spear fishers during this time.

Unsustainable fishing practices negatively affect the nutrition level in the diet of many local coastal communities.

Chuck Savall photo

Parrotfish are one of the most popular coral reef species targeted by recreational fishers throughout tropical regions of the world.



Good Environmental Practices: Recreational Fishing

Ways that fishers can reduce impacts to coral reefs and marine resources:

- Practice catch-and-release fishing.
- Avoid spear fishing.
- Prevent marine pollution from fishing gear.
- Observe the law.
- Support Marine Protected Areas.

There are many simple practices that fishers can adopt which will protect marine ecosystems and enhance recreational fishing in local and regional communities.

- **Practice catch-and-release fishing.** Sport fishing charters can make significant contributions to conservation of fish species by practicing partial or total catch-and-release programs. This can be especially effective when dealing with threatened or endangered fish species.

- **Avoid spear fishing.** Many critics believe that spear fishing is too effective a method of harvesting marine resources. Additionally, the nature of limited time available while on SCUBA contributes to excessive, rapid harvesting by many divers.

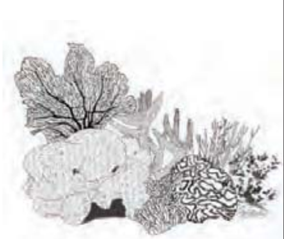
- **Prevent marine pollution from fishing gear.** Marine debris poses a serious threat to both coral reefs and open ocean species. Monofilament line, lead weight and associated fishing gear can tangle and kill corals and many other forms of marine life. Sport fishing charters and other recreational fishers can contribute to the protection of marine ecosystems by ensuring that no marine debris results from their fishing practices.

De-hooking devices are available that increase the survival game fish in catch-and-release fishing programs.

- **Observe the law.** Nearly all regions of the world have laws and regulations that govern fish catch sizes and seasons. These laws are generally established to protect fisheries and recreational fishers will benefit by following them.

- **Support the establishment of Marine Protected Areas (MPAs).** MPAs commonly strike a balance by leaving fishing open in some regions while establishing strict “no take” zones in other areas. In several areas of the world it has been shown that fish stocks rapidly improve in “no take” zones, which leads to a spillover effect and improved fishing in areas immediately adjacent to these zones.

- **Use “ecological common sense.”** In addition to observing laws and regulations, fishers should maintain an awareness to avoid spawning aggregations, reproductive seasons, and harvesting of juveniles. Additionally, when a large school of potential game fish is located, fishers can help protect the ecosystem and the fishing industry by not harvesting the entire school.



Case Study: Diver User Fees Support Bonaire National Marine Park, Netherlands Antilles.

First established in 1979, the Bonaire National Marine Park in the Netherlands Antilles is a leading example of how sustainable policies and practices can generate resources that protect coral reef ecosystems. Through a revitalization effort that began in 1991, the park has expanded its mooring system to reduce anchor damage; instituted a ban of spear fishing; engaged in research and monitoring of coral reefs that continues today; and introduced a user fee for divers that generates funds for park protection.

The US $10 annual diver fee was introduced in 1992 after a survey determined overwhelming support for the concept from visiting divers. After paying the fee, divers are given a small colored tag to attach to their buoyancy control device while diving (collection of these tags has now become a source of pride and commitment to conservation among many divers to the area). The funding generated from this program supports a small staff, operational costs of vehicles and boats, maintenance of 75 public moorings, as well as research, monitoring and education programs throughout the park. The adopted user fee has proven to be a key component that generates financial resources for the variety of conservation activities that take place in the park. Additionally, this user fee system has been adopted by other coral parks as a model for self-sufficiency in protecting coral reef ecosystems.

Divers explore a reef in Bonaire Tegan Hoffmann photo

Case Study: North Sulawesi Watersports Association Working to Protect Bunaken National Park, Indonesia

To address the impacts associated with the rapid growth of marine recreation in Bunaken National Park in recent years, the North Sulawesi Watersports Association (NWSA) has taken a lead role in promoting environmentally responsible policies and operations within the park. Following a rapid expansion of marine tourism in 1996, anchor damage quickly became identified as a serious threat to coral reef health in the area. Members of the NWSA established a no-anchoring policy in the park that has significantly reduced the problem today.

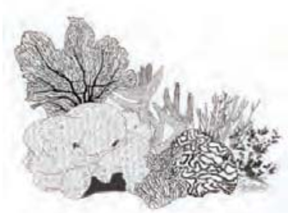
Additionally, NWSA promotes programs that create and distribute reef-friendly tourism informational brochures; develop working relationships with local restaurants to reduce the sale of threatened and endangered species on menus such as lobster, shark and grouper; support the sale of locally handcrafted items; and provide scholarships to local residents in the field of marine science.

NWSA also partners with local officials to improve better enforcement of conservation laws in the park. The organization makes regular contributions that support police and ranger patrols, and in January 2000 instituted a night patrol to reduce the problem of cyanide fishing. NWSA recently signed a memorandum of understanding with the Bunaken National Park rangers that will help formalize a regular patrol system to enforce conservation laws in the park.

In order to generate revenue to fund these and other protective measures for the park, NWSA instituted an annual US $5 fee that provides visiting divers with a small colored tag to wear on their BCD. Modeled on the program that was first established on the Caribbean island of Bonaire, 80% of the collected user fees go straight into programs that support protection of the park.

To date, the revenue generated has helped support a variety of programs that have improved the management capacity of the park, including an increase in ranger patrols, conservtion education in local villages, trash management, and rehabilitation of reefs and mangroves within the park. Overall, there is strong stakeholder support for the program from local villages and tourism industry representatives.

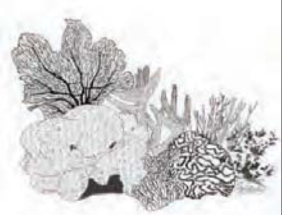
Part IV: Appendix



Environmental Briefings

The benefits of environmental briefing cards:

- Educate tourists on the diverse and fragile nature of coral reefs.
- Provide tour guides an interpretive opportunity.
- Prepare guests for their excursion.
- Cultivate an environmental ethic and sense of responsibility for coral reefs.



Environmental briefings are now commonly used throughout the dive industry. They allow dive masters or other tour guides to introduce visitors to a site, review the dive plan, and sensitize divers to the fragile nature of coral reef ecology and the importance of low-impact diving. This kind of briefing can be done in five minutes or less and serves to inform and educate visitors about the importance of sustainable practices moments before a dive is meant to take place. Studies have shown that environmental briefings largely determine the degree of physical interaction that divers and snorkelers have with coral reefs.

Although the following **sample briefing card** relates most specifically to SCUBA diving, the included information can be adapted to environmental briefings for a range of on-water activities, from snorkeling to kayaking to glass bottom reef viewing. Additionally, the specific substance of briefings will always vary based on what region of the world the marine activities are taking place.

In all cases, tour guides can treat the briefing as an interpretive opportunity, and utilize local knowledge to enhance visitor experience and make a significant contribution to promoting low-impact, sustainable tour operations.

Fijian divemasters practice environmental briefings at a CORAL workshop.

Environmental Dive Brief

Coral reefs are very fragile ecosystems. Please help protect these special places by following some simple rules:

No Contact

- Use the "magic meter" by staying one meter off the reef.
- Even slightly touching coral can remove its protective layer of mucous, making it more susceptible to disease and other threats.

Buoyancy

- Maintain neutral buoyancy at all times.
- Do not hesitate to ask for our help or advice if you have too many or too few weights, or would like tips on maintaining neutral buoyancy.

Good Finning

- Practice good finning technique, ensuring that your fins do not hit the coral at any time. One small kick could result in the loss of decades of growth.

Streamline Your Gear

- Make sure all hoses and equipment are secured so they do not drag or snag on the reef.

Let the Animals Come to You

- Never chase, harass, or try to ride marine life.
- Remember, the best encounters happen when the animals come to you!

Special Note to Photographers

- Remember to take special care to maintain neautral buoyancy, and avoid contacting the reef while taking photographs.

Take Only Pictures, Leave Only Bubbles!

- Take nothing living or dead out of the water, except garbage which has not become attached to the reef and does not contain living organisms.

Enjoy your dive!

CORAL

Environmental Dive Brief

If you have time, select one or two interesting facts to help educate your clients.

EASY – Coral basics for the beginner.

What are corals?

- Although many people mistake corals for plants or rock, they are actually **spineless animals**. If you look closely, you will see that one coral mound or branch (known as a **coral colony**) is made of hundreds of tiny animals called "coral polyps."
- Each soft **coral polyp** lives inside its own hard, cup-shaped skeleton. The soft polyp is shaped like a sac or bag with an opening surrounded by long, stinging tentacles. During the day the tentacles hide inside the skeleton, but at night they come out to feed, capturing tiny microscopic animals (zooplankton) that float by.

What are coral reefs?

- Coral reefs are huge limestone structures that provide food and shelter for millions of sea creatures. Some reefs are so big that some can be seen from outer space!
- Hard corals are the main architects of the limestone structure of coral reefs. In and around the structure are millions of plants and animals carrying on with their business - similar to a busy city or apartment building.

INTERMEDIATE – Light facts for the more experienced diver.

How do corals grow?

- When corals die, their limestone skeletons are left behind, and new polyps settle on the hard surface. A coral colony is actually made of many layers of dead skeletons covered by a thin layer of living polyps!
- Corals grow very slowly. Most existing coral reefs are between 5,000 and 10,000 years old.
- The **shape of coral** colonies can vary depending on the location. For example, where there are strong waves, corals tend to grow into robust mounds or flattened shapes. In more sheltered areas the same species may grow in more intricate shapes such as delicate branching patterns.

ADVANCED – Impress your advanced divers!

Coral reefs and biodiversity

- Nearly 1/4 of all marine life is found in coral reefs.
- Scientists have identified more than 4,000 different species of fish and 700 species of coral.
- Coral reefs contain 32 of the 34 known animal phyla – four times the number found in tropical rainforests! (Phyla are the next highest ranking in taxonomy next to Kingdom).

What is zooxanthellae?

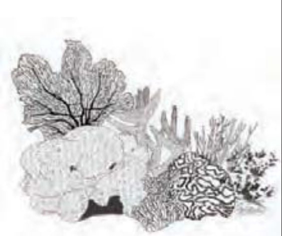
- "Zooxanthelllae" (pronounced zo-zan-thel-ee) are tiny algae that live within the tissues of hard corals. The algae give coral its brownish-green color.
- The algae and coral have a **symbiotic relationship** – meaning that they are dependent on each other. The algae supplies the coral with food, and the coral provides the algae with a safe and protected home.
- Like all plants, algae get their food from **photosynthesis** – a process that takes energy from sunlight to convert water, carbon dioxide and minerals into organic material. This can supply corals with up to 98 percent of their nutritional needs. This explains why coral reefs are found in warm, sunny, tropical waters.
- When water temperatures increase, or when corals are stressed, they expel their symbiotic algae, and become white or "bleached." This is known as "coral bleaching." and can lead to coral death.

Environmentally Conscious Boating Products

As environmental problems affecting the world's oceans have increased in recent years, many manufacturers of boating products have made a concerted effort to produce paints, chemicals, cleaners and other products that are less toxic and harmful to the marine enviroment than products of the past. Check with your local marine supply store to see what environmentally safe products are available in your area. The following list highlights recommended products for marine recreation providers in the areas of:

- Anti-fouling bottom paints
- Fuel and bilge supplies
- Boat cleaners
- Sewage teatment

Dive boat on a coral reef in Palau S. Flumerfelt photo



Environmentally Conscious Boating Products: Anti-Fouling Bottom Paints

Anti-fouling bottom paints

Many anti-fouling bottom paints of the past are slowly being phased out as a result of their toxic properties. Newer, less toxic paints use a variety of biocide alternatives to the copper or tributylin-based (TBT) paints of the past. Boaters can use these alternatives to reduce pollution and introduction of heavy metals into the marine environment.

What can your company use?

Recommended products:

Epaint

EP2000 - Water-based paint that is recommended for a smooth, hard finish; contains no organotin or copper compounds. 1 year to re-paint.

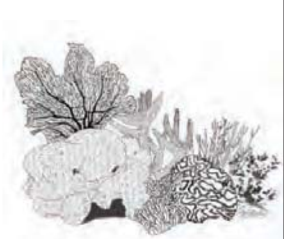
Cost: US$68 per quart/$228 per gallon

EP-ZO - High performance anti-fouling bottom paint used on commercial and recreational vessels. Recommended by e-paint as the easiest to use and apply. 1 year to re-paint.

Cost: US$47 per quart/$177 per gallon

Product information

E Paint Company
25 Research road
East Falmouth, MA 02536
USA
800-258-5998
(toll free number)
508-540-4412 telephone
508-495-3210 fax
www.epaint.org
epaint@epaint.org



Environmentally Conscious Boating Products: Fuel and Bilge Supplies

Fuel and bilge supplies
Chronic leaks of toxic substances into the marine environment are a common problem near harbors, marinas and popular boating sites. A number of inexpensive products are available that can reduce and/or eliminate pollution from small boats. Most of these products can be found at local marine hardware and supply stores.

What can my company use?

Recommended products:

Bilge Absorbent Sock - Designed to be placed in the bilge to absorb oils and fuels while repelling water in order to prevent discharge into the marine environment. Cost - US$12

Oil Absorbent Sheets - Material soaks up oil and gasoline but not water. Avaiable for a variety of uses to minimize toxic oils and fuel discharge into the marine environment. Cost - US$1.25

Engine Pan Pillow - Placed directly under the engine bock to absorb leaks of oil and fuels. Does not absorb water. Cost - US$12

Star Brite Sea Safe Bilge Cleaner - Dissolves oil, grease, gasoline, diesel and fuel. (Emulsifies oils and fuels, does not necessarily prevent them from entering the marine environment like absorbers). Cost - US$8.00 per quart.

Fuel Overfill Catchment System - Designed to hook onto fuel vent while re-fueling in order to catch overflow spills.
Cost - US$70

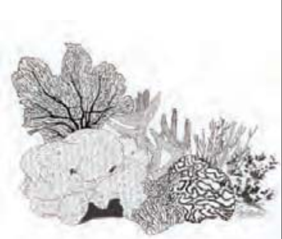
Fuel Vent Line Surge Protector - Helps minimize spills by shutting off pumps when vessel tank is full. Cost - US$23

Fuel/Air Separators - Designed to prevent the discharge of fuel overboard while re-fueling or underway. Cost - US$65

Vaccum Sander - For use in collecting hull and other debris during sanding operations. Cost - US$80 - $300

Product information

West Marine
P.O. Box 50070
Watsonville, CA 95077-5050
USA
(800)262-8464 toll free
(831)761-4421 fax
www.westmarine.com



Environmentally Conscious Boating Products: Sewage Treatment

Sewage treatment
The most environmentally conscious practice for sewage disposal is to use pump-out or other land-based facilities. Unfortunately, many harbors and marinas do not have pump out stations or other disposal options. As a result many boaters dishcarge sewage directly into the sea.

If you choose to discharge into the marine environment, it is important to stay as far offshore during the process as possible and treat sewage prior to discharge. When treating your onboard sewage avoid products with methyl alcohol, formaldehyde, glutaraldehyde, and quarternary salts, which are toxic to corals. Look for products that are biodegradable and non-toxic or have "eco-safe" labels.

What can my company use?

Recommended products:

Portable Marine Toilet - Comes in various models and allows small vessels to contain and dispose of human waste at land-based facilities versus at sea. Cost - US$75 - 125

SeaLand Marine Toilet Tissue - Biodegrable tissue that breaks down quickly and does not contain dyes or perfumes. Cost - US$3.00

SeaLand Ultra Secure Holding Tank Treatment and Cleaner - Biodegrable chemical liquid that helps break down wastes. Cost - US$8.00 per 8 oz.

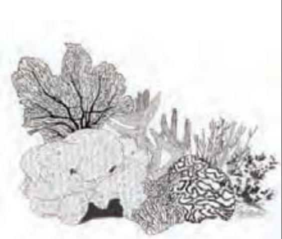
MDR Headzyme Tabs Toilet Treatment - Non-toxic, biodegradable chemical tablets that help break down waste. Cost - US$6.00

Headzyme Holding Tank Treatment - Organic liquid formula uses enzymes versus bacteria to assist in the break down of tissue and waste. Cost - US$12.50 per quart

Star Brite Sea Safe Toilet Treatment - Non-formaldehyde, biodegradable formula

Product information

West Marine
P.O. Box 50070
Watsonville, CA 95077-5050
USA
(800)262-8464 toll free
(831)761-4421 fax
www.westmarine.com



Environmentally Conscious Boating Products: Boat Cleaners

Boat cleaners. Boaters can make a significant contribution to keeping toxic pollutants out of the marine environment by using only non-toxic and biodegradable boat cleaning products. Avoid products with "toxic to humans" warnings on them (if it's toxic to humans, it will also be toxic to marine life). Become familiar with labels and avoid products containing phosphates and ammonia, which cause algal blooms that overgrow corals and choke out other marine life. Also avoid hydrochloric acid, sodium, oxalic acid, petroleum distillates, kerosene, and chlorinated solvents, which are toxic and can cause coral death on contact or changes in behavior. Substitute chemical cleaners with natural ones, such as vinegar, citric juices, borax, and baking soda.

What can my company use?

Recommended products:

Simple Green - Multi-purpose cleaning agent that is non-toxic and biodegradable. Cost - US$21.00 per gallon

Star Brite Sea Safe Boat Wash - Biodegradable formula that cleans away dirt, stains, grease, oil and salt. Cost - US$7.00 per quart

Star Brite Sea Safe Hull Cleaner - Removes stains from marine growth and rust; contains no solvents, strong acids, or harsh chemicals. Cost - US$12.00 per quart

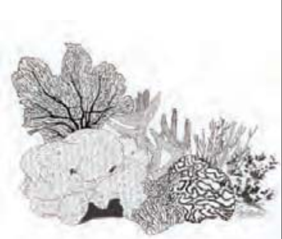
Star Brite Sea Safe Deck Cleaner - Biodegradable formula that cleans away dirt and stains. Cost - US$8.00 per quart

Citrus Cleaner and Degreaser - Natural cleaning agent that is based on citris and is low in surfactants. Cost - US$7.00 per pint

Citrus Boat Soap - Cleaning agent based on citrus, therfore low in surfactants and also does not produce high suds like detergents. Cost - US$8.00 per quart

Product information

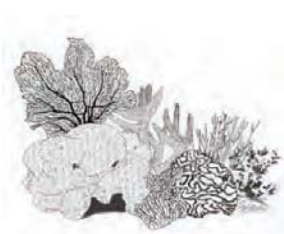
Star Brite
4041 S.W. 47th Avenue
Ft. Lauderdale, FL
33314
USA
(800)327-8583 toll free
(954)587-6280 tel.
(954)587-2813 fax
www.starbrite.com



Environmentally Conscious Boating Products
Four-stroke Outbaord Engines

Technological advancements in recent years have allowed manufacturers to design marine outboard engines that are significantly cleaner than engines of the past. The classic example of this is the switch from older two-stroke models — which deposit as much as 30% of their fuel unburned into the marine environment and also generate significant amounts of air pollution — to cleaner, more fuel efficient four-stroke models. Though the initial cost of four-stroke engines can be relatively high, in the long-term they can save businesses money by requiring less fuel and reducing pollutants in the marine environment, thereby protecting the economic value of coral reefs.

Model Description	Horse Power	2004 Price
4-stoke models		
Yamaha F30TLRC	30	US $4,750
Yamaha F40TLRC	40	US $5,144
Yamaha F50TLRC	50	US $5,827
Yamaha F60TLRC	60	US $6,338
Yamaha F75TLRC	75	US $7,200
Yamaha F90TLRC	90	US $7,688
Yamaha F115TLRC	115	US $8,594
Yamaha F150TLRC	150	US $11,383
Yamaha F200TXRC	200	US $15,387
Yamaha F225TXRC	225	US $16,894
4-stoke models		
Honda BF30D4LRGA	30	US $4,095
Honda BF40A4LRTA	40	US $4,840
Honda BF50A4LRTA	50	US $5,380
Honda BF75A4LRTA	75	US $7,226
Honda BF90A4LRTA	90	US $7,822
Honda BF115A4LA	115	US $8,493
Honda BF130A4LA	130	US $9,375
Honda BF150A4LA	150	US $11,569
Honda BF200A4LA	200	US $13,994
Honda BF225A4LA	225	US $15,058



Environmentally Conscious Boating Products: Four-stroke Outboard Engines

Model Description	Horse Power	2004 Price
4-stoke models		
Mercury 30E EFI	30	US $4,402
Mercury 40E EFI	40	US $4,823
Mercury 50ELPT	50	US $6,334
Mercury 60ELPT	60	US $6,732
Mercury 75ELPT	75	US $7,732
Mercury 90ELPT	90	US $8,380
Mercury 115 ELPT	115	US $8,594
Mercury 225 XL	225	US $16,686

Product information

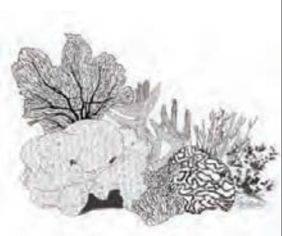
Yamaha Motor Corporation
1270 Chastain Road NW
Kennesaw, GA 30144
USA
(806)894-1626 tel.

Product information

Honda Marine Group
4900 Marconi dr.
Alpharetta, GA 30005
USA
(800)426-7701 tel.
(678)339-2670 fax

Product information

Mercury Marine
W6250 W. Pioneer rd.
P.O. Box 1939
Fond du Lac, WI 54936
(920)929-5040 tel.



About the Coral Parks Program

What is a coral park?

A coral park is a protected area that includes a coral reef in its boundaries and allows visitors. The coral parks program helps tourism and conservation to work in partnership for the benefit of coral reefs and the tourism industry.

The goal of the Coral Reef Alliance's (CORAL) Parks Program is to help coral park managers leverage sustainable tourism to build local investment in the conservation of coral reef parks. We work to achieve this goal by providing training, tools and resources to partners in local coral reef communities, including dive operators, conservation groups, and community leaders, and through our global partnership with the International Coral Reef Action Network (ICRAN). Our current geographic focus is on the Western Pacific and the Caribbean, primarily the Mesoamerican Barrier Reef.

Training and technical assistance for coral parks: CORAL provides on-site training and technical assistance to communities and businesses that depend on coral reefs, helping to ensure the success of local coral parks. Training topics include coral reef ecology, moorings as an alternative to anchoring, sustainable marine tourism, and self-financing of coral parks. CORAL works with marine recreation providers, bulk purchasers (such as cruise lines and tour operators), park managers, and other community members involved in the coral reef tourism industry. Through the development of partnerships between tourism and coral parks, CORAL builds cooperation that enhances both environmental and economic sustainability.

Financial support of park conservation programs: CORAL's microgrant program has provided much needed financial support to local conservation programs around the world. Since 1995, CORAL has provided over $350,000 in micrograms to support grass-roots conservation. Currently, CORAL provides seed money to local partners participating in CORAL's training program. Through microgrants we help coral parks pay for mooring buoys to stop anchor damage, purchase functioning boats to patrol and enforce fishing rules, and publish brochures to educate visitors of park rules. Read more about past microgrant recipients on the CORAL website.

Information and Resources: The parks program provides tools and resources, as well as education and outreach materials (see page 52), to help park managers and communities to more effectively protect their coral reefs. Visit our website at www.coral.org to find information on:

- Coral Reef Fact Sheets for the general public
- International Directory of Coral Reef Organizations
- Online Coral Reef Education Materials Library
- Coral Reef Photobank

For more information:

The Coral Reef Alliance
417 Montgomery Street, Suite 205
San Francisco, CA 94104
Tel: 415-834-0900
Fax: 415-834-0999
Email: info@coral.org
Web: www.coral.org

CORAL's Educational and Outreach Materials

CORAL's educational and outreach materials:

• Guidelines for good environmental practices.

• Issue briefs for policy makers and community leaders.

• Handbooks on:

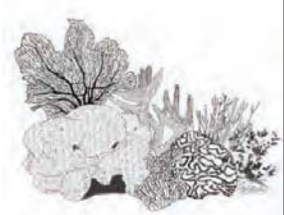
Coral Reef Ecology, Threats and Solutions.

Sustainable Tourism for Marine Recreation Providers.

Mooring Buoy Installation and Maintenance.

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."

-Maragaret Mead



The Coral Reef Alliance (CORAL) has developed a broad selection of outreach and educational materials in order to promote the conservation and protection of coral reefs. Some of our materials include the following:

Guidelines for Good Environmental Practices - CORAL's guidelines reflect the most commonly accepted "best practices" around the world for marine recreation activities and give essential advice on how to protect coral reefs while enjoying activities in and around them. Guidelines are available in English, Spanish, Indonesian and Japanese, and address the following topics:

- Diving
- Snorkeling
- Whale and Dolphin Watching
- Turtle Watching
- Underwater Cleanup

Environmental Issue Briefs - CORAL's issue briefs discuss some of the most important issues being addressed by CORAL and the partners of the International Coral Reef Action Network (ICRAN), and are designed to assist policymakers, business leaders and other influential community members to make informed decisions on issues that affect the health of coral reefs. Issue briefs are available in English and Spanish, with topics including:

- Coral Reefs and Global Climate Change
- Coral Reefs and Sustainable Coastal Development
- Watersheds and Healthy Reefs
- Exploitive Fishing
- Effective Coral Reef Marine Protected Areas (MPAs)
- Coral Reef Mining, Harvesting and Trade

Handbooks - CORAL's handbooks provide a comprehensive look at the nature of coral reefs, threats to these marine ecosystems, and practical solutions to promote and implement conservation and sustainable business practices. Our handbook series includes the following publications:

- *Introduction to Coral Reef Ecology, Threats and Solutions*
- *Mooring Buoy Installation and Maintenance.*
- *Sustainable Tourism for Marine Recreation Providers*

For more information on available materials and resources, visit our website at www.coral.org or email us at info@coral.org

RESOURCES ON CORAL REEF SCIENCE, EDUCATION AND MANAGEMENT

Organizations

(The International Directory of Coral Reef Organizations, a database of hundreds of organizations from around the world that work on coral reef related issues, including non-governmental organizations (NGOs), research institutions, aquariums, marine protected areas (MPAs), government agencies, international programs and more can be found at: http://www.coralreefalliance.org/index.php?option=com_content&task=view&id=96&Itemid=120)

Coral Reef Alliance (CORAL)
417 Montgomery #205
San Francisco, CA 94104
415-834-0900
web:www.coral.org

- *The Coral Reef Alliance (CORAL) is a member-supported, non-profit organization, dedicated to protecting the health of coral reefs by integrating ecosystem management, sustainable tourism, and community partnerships. The organization works with communities to identify and solve conservation challenges; changes attitudes and behavior through education and training; provides resources to strengthen conservation efforts; and creates incentives for sustainable tourism.*

Reef Environmental Education Foundation (REEF)
(305) 451-0312
reef003@aol.com
www.reef.org

- *Trains recreational divers to conduct field surveys of reef fishes. Web-site data network is used by scientists and managers for many applications.*

The Ocean Conservancy
(202) 429-5609
cmc@dccmc.org
www.oceanconservacy.org

- *Initiated the International Coastal Clean-up, which now has an extensive diver-run underwater component. Also working on a coral* *reef monitoring protocol that can be easily performed by recreational divers. Recently introduced a coral reef monitoring program called RECON—Reef Ecosystem Condition.*

International Society for Reef Studies
P.O. Box 1897
Lawrence, KS 66044

- *This is the primary scientific organization devoted to coral reef research. They publish the peer-reviewed journal, "Coral Reefs," which contains articles on cutting-edge research in all aspects of coral reef science and management.*

Project AWARE Foundation
30151 Tomas St.
Rancho Santa Margarita, CA 92688-2125
800-729-7234

- *AWARE—Aquatic World Awareness, Responsibility and Education—is devoted to all aspects of aquatic conservation, with a primary constituency of recreational scuba divers. It is affiliated with the Professional Association of Diving Instructors (PADI).*

Web Pages (Non-Technical)

Acropora Coral Growth - Operated by Reefkeeper. Time lapse movie.
http://mars.reefkeepers.net/movie.html

An Internet Guide to Coral Reefs
http://greennature.com/article1062.html

Animal World Coral Reef Animals of the World
http://www.exotictropicals.com/encyclo/reef/reef.htm

Center for Ecosystem Survival: Adopt-a-Reef Program
http://www.savenature.org/adoptreef.html

Coral Reef Action Atlas
http://www.motherjones.com/coral_reef/

Coral Reef Report
http://coralreefreport.info/

Coral Reef Alliance Resource Library (images, educational materials and International Directory of Coral Reef Organizations) http://www.coralreefalliance.org/index.php?option=com_content&task=section&id=4&Itemid=15

Coral Reefs by Charles Darwin
http://pages.britishlibrary.net/charles.darwin/texts/geological_observations/coral_reefs.html

Coral Reefs: Rainforests of the Sea Oceanic Research Group
http://www.oceanicresearch.org/crrainspt.html

Coral Reefs: State University of New York—Stony Brook
http://life.bio.sunysb.edu/marinebio/coralreef.html

Ecology of coral Reefs (Dr. Alex Mustard)
http://www.soc.soton.ac.uk/GDD/hydro/atmu/ecology/menu.html

Environmental Defense: Coral Reefs Coral reef fact sheet
http://www.environmentaldefense.org/article.cfm?contentid=1155

EPA Coral Reef Homepage
www.epa.gov/owow/oceans/coral

Field Guide to Coral Diseases and Other Causes of Coral Mortality
http://www.unep-wcmc.org/marine/coraldis/cd/index.htm

International Coral Reef Initiative
http://www.icriforum.org/

Marine Protected Areas of the United States, by US Commerce and Interior departments.
http://www.mpa.gov/

NASA Millenium Coral Reef LANSAT Archive
http://oceancolor.gsfc.nasa.gov/cgi/landsat.pl

NOAA's Coral Reef Information System
http://www.coris.noaa.gov/

NOAA Photo Library
http://www.photolib.noaa.gov/reef/

NOS Education Discovery Kits—Coral Reefs
http://oceanservice.noaa.gov/education/kits/corals/welcome.html

"People Project What they Love": The Rhetoric and Politics of Coral Reef Conservation http://typhoon.wcp.muohio.edu/tropicalvideos/coralecology02/mcphail/glg515/project/default.htm

Reef Guardian
http://www.reefguardian.org

Reef Snapshots—Great Barrier Reef Marine Park Authority
http://www.gbrmpa.gov.au/corp_site/info_services/library/resources/reef_snapshots/

ReefBase
http://www.reefbase.org

Reefnet
http://www.reefnet.org

ReefVid (A resource of free coral reef video clips for educational use)
http://www.reefvid.org/index.php

Sea World education department resources
http://www.buschgardens.org/infobooks/Coral/home.html

U.S. Coral Reef Task Force
http://coralreef.gov/

World Maps of Coral & Mangroves:
www.wcmc.org.uk/marine/data/coral_mangrove/

World WildLife Fund—Coral Reefs
http://www.panda.org/about_wwf/what_we_do/marine/our_solutions/protected_areas/increasing_protection/corals_mangroves/index.cfm

Web Pages (Technical)

Benthic habitat mapping
http://biogeo.nos.noaa.gov/projects/mapping/caribbean/

Bureau of Oceans and International Environmental and Scientific Affairs: U.S. Department of State
http://www.state.gov/g/oes/

Coral Health and Monitoring Program
http://www.coral.noaa.gov

Coral ListServer
http://coral.aoml.noaa.gov

Coral Diseases
http://ourworld.compuserve.com/homepages/mccarty_and_peters/coraldis.htm

International Center for Living Aquatic Resources Management:
http://www.cgiar.org/iclarm/

Web Pages (Regional)

Australian Institute of Marine Science
http://www.aims.gov.au/

Bermuda's Coral Reefs
http://www.coexploration.org/bbsr/coral/html/introduction.html

Hawaii's Coral Reefs.
http://library.thinkquest.org/J002237/

Hawaii Coral Reef Initiative
http://www.hawaii.edu/ssri/hcri/ah/index.htm

Southeast Florida Coral Reef Initiative
http://www.dep.state.fl.us/COASTAL/programs/coral/

Radio Broadcasts

Coral Reef in the Balance—National Public Radio
http://www.npr.org/programs/re/archivesdate/2004/jun/reefs/

Video Tapes

Life on the Reef, Coral Sea Imagery & New Zealand Television. Distributed in North America by Small World Music, 117 30th St., Nashville, TN 37212. 800-757-2277.

- *Outstanding overview of reef ecology with incredible images and thorough explanation of coral reproduction and dispersion.*

Caribbean Reef Encounters, Delphin Underwater Productions, Inc., P.O. Box 2105, South Hackensack, NJ 07606.

- *Probably the best video identification guide available. Also addresses some ecological issues.*

Canary of the Ocean: America's Troubled Reef, Miranda Smith Productions. Available from The Video Project Phone: 1-800-PLANET4. www.videoproject.org.

- *Excellent review of the problem facing the Florida Keys reef tract. Good introduction to ocean resource management.*

Coral Reefs: Rainforests of the Sea, Ocean Research Group. Available from The Video Project Phone: 1-800-PLANET4. www.videoproject.org.

CD-ROMs

Films Media Group (2005). *Coral Reefs: A Comprehensive Overview.* www.films.com.

Murphy, R. (1995). *Cities Under the Sea: Coral Reefs.* Sunburst Communications: Pleasantville, NY.

- *Outstanding and highly comprehensive examination of coral reef ecology and resource issues. A must for anyone interested in coral reefs. Appropriate for all ages.*

Sumeria, Inc. (1995). *Ocean Life.* This 5-volume set covers the Western Pacific, Micronesia, Hawaii, Great Barrier Reef and the Caribbean.

- *Although primarily a guide to identification, this series also contains information on anatomy, habitat and more.*

Lesson Plans

Brown, R., Gentry-Gruber, J., Hardesty, J., Meyer, M., Thompson, J., Weir, W. (1996) *Coral Forest Teachers Guide.* Coral forest: San Francisco, CA.

- *Compilation of lesson plans for Grades K-12. Covers the full range of disciples.*

Christie, S & Halversen, C., (1998). *Coral Reefs: Vanishing Treasures.* MARE, Lawrence Hall of Science, University of California at Berkeley.

- *This is a teacher's guide for grades 6-10 of five activities developed for use in conjunction with a shortened version of The Fragile Ring of*

Life, described above. It's available from Oceanwatch. See "Organizations."

Ginsburg, R.N. (1997). *Cities Under The Sea: A Teacher's Guide to Introduce Coral Reefs to Students and Adults*. Miami, FL: Rosenstiel School of Marine and Atmospheric Science, University of Miami.

- *Excellent presentation supported by forty 35mm slides on the problems coral reefs face and what can be done to protect them using a vivid and effective analogy.*

"Our Coral Reef"—A Comprehensive Lesson Plan for Teachers
http://www.prel.org/products/ms_/pathfinder/CoralReef.htm

Walker, S.H. & Newton, R.A. (1997). *An English Compilation of Activities for Middle School Students.* Washington, DC: US Environmental Protection Agency (EPA160-B-97-900a). Can be order at www.epa.gov/nceplhm/index.html

- *Although it was designed as a middle school curriculum, the material has far more utility. Many of the activities, with only minor or no modification, are useful for adults in non-formal settings. It also contains a plethora of good information and ideas on teaching coral reef ecology and biology.*

Books (Non-Technical)

Because of the extensive number available, this bibliography does not include field identification guides. An extremely comprehensive selection is available from Sea Challenger Natural History Books. Their web site is **www.seachallengers.com**

Bryant, D., Burke, L., McManus, J. & Spalding, M. (1998). *Reefs at Risk: A Map-Based Indicator of Threats to the World's Coral Reefs.* World Resources Institute, Washington, DC.

- *Outstanding visual perspective of the plight of coral reefs.*

Davidson, O.G. (1998). *The Enchanted Braid: Coming to Terms With Nature on the Coral Reef.* John Wiley & Sons, Inc.: New York.

- *An absolute must-read for anyone interested n coral reefs. Probably the best book on the subject ever written for the layman. Reads like a novel but extremely well documented.*

Deloach, N. (1999*). Reef Fish Behavior.* Jacksonville, FL: New World Publications.

- *Excellent companion book to the outstanding fish identification series published by New World. Covers only Western Atlantic species.*

Gulko, D. (1998). *Hawaiian Coral Reef Ecology.* Mutual Publishing, Honolulu, HI.

- *Although much of the book is specific to Hawaii, it contains an outstanding overview of issues pertinent to all coral reefs. Also extremely well-illustrated and written to the layman in a fun, easy to read format. A great book.*

Kaplan, E.H. (1982). *Peterson Field Guide: Coral Reefs of the Caribbean and Florida*. Boston: Houghton Mifflin Co.

- *For many years this was the only text on reef ecology for layman. It should be in every diver's library who cares about coral reefs.*

Kaplan, E.H. (1988). *Peterson Field Guide: Southeastern and Caribbean Seashores*. Boston: Houghton Mifflin Co.

- *Excellent compendium to the above reference on coral reefs; covers reef-associated ecosystems very well.*

Kohler, A & Kohler, D. (1997). *The Underwater Explorer: The Diver's Guide to Interacting With Marine Life*. The Lyons Press: New York.

- *Great book that takes the idea of a field guide much further. Good, though a bit biased, coverage of marine resource manage issues affecting divers. Only draw back is that it's exclusively oriented to the Indo-Pacific.*

Lobban, C.S. & Schefter, M. (1997). *Tropical Pacific Island Environments.* University of Guam Press: Mangilao, Guam.

- *A must have book for anyone working or visiting the South Pacific; very easy read and well-designed.*

Mojetta, A. (2003). *The Coral Reef.* White Star: Vercelli, Italy.

Murphy, R.C. (2002). *Coral Reefs: Cities Under the Sea.* The Darwin Press, Inc.: Princeton, NJ.

Sapp, J. (1999). *What Is Natural? Coral Reef Crisis.* Oxford University Press: New York, NY.

- *An intriguing examination of the history and controversy surrounding the outbreak of the crown-of-thorns sea star and their impact on Indo-Pacific reefs.*

Spalding, M.D. (2004). *A Guide to the Coral Reefs of the Caribbean.* University of California Press: Berkeley, CA.

Spalding, M.D., Ravilious, C. & Green, E.P. (2001). World Atlas of Coral Reefs. Berkeley, CA: University of California Press.

- *Another "must-have" for anyone interested in coral reefs. Contains not only a country-by-country overview of all the world's coral reef, but also contains an excellent overview of their ecology, status and outlook.*

Strykowski, J & Bonem, R. (1993). *Palaces Under the Sea.* Dubuque, IL: Bellwether-Cross Publishing.

- *Probably the best and most comprehensive treatment of coral reef ecology for layman. Very non-technical. A must for any diver's library*

Sumich, J.L & Morrissey, J.F. (2004). *Introduction to the Biology of Marine Life*. Jones and Bartlett Publishers: New York, NY.

- *This freshman-level textbook contains an excellent, up-to-date and thorough chapter on coral reefs and coral reef fishes.*

Viders, H. (1995). *Marine Conservation for the 21st Century.* Best Publishing: Flagstaff, AZ.

- *Good overview to the big picture of marine resource management. Very diver-oriented.*

Wells, S. & Hanna, N. (1992). *The Greenpeace Book of Coral Reefs.* Sterling Publishing Co.: New York.

- *Good layman's book covering a wide range of issues from science to resource management. Excellent section on reef-based tourism.*

Whelan, T. (1991). *Nature Tourism: Managing for the Environment.* Island Press: Washington, DC.

- *Good overview of nature-based tourism and issues currently under date; includes case study of Saba Marine Park.*

Wilson, R.W & J.Q. (1992). *Watching Fishes: Behavior on Coral Reefs*. New York: Harper & Row Publishers.

- *Comprehensive treatment of fish ecology for layman. Extremely well-researched and documented for a book of this nature.*

Popular Articles

Chadwick, D.H. (1999). Coral in Peril. *National Geographic*. January, pp. 30-37.

Goreau, T.F., Goreau, N.I. & Goreau, T.J. (1979). Corals and Coral Reefs. *Scientific American*, 241(2) 124-136.

Ward, F. (1990). Florida's Coral Reefs Are Imperiled*. National Geographic*, July, pp. 115-132.

Williams, F. (1999). Coral Vision*. National Geographic Traveler*. March.

Books (Technical)

Barnes, R.S.K. & Hughes, R.N. (1995). *An Introduction to Marine Ecology.* Blackwell Science: Cambridge, MA.

- *Excellent chapter on coral reefs*

Birkeland, C. (ed.) (1996). *Life and Death of Coral Reefs,* Chapman & Hall Publishers: New York. [out of print]

- *The most up-to-date and comprehensive single text on the subject of coral reefs currently available, but be forewarned. As a graduate-level textbook, it's highly technical and definitely not for the scientifically squeamish.*

Britton, J.C. & Morton, B. (1989). *Shore Ecology of the Gulf of Mexico*. University of Texas Press: Austin, TX.

- *Excellent chapter on coral reefs.*

Myers, R.L. & Ewel, J.J. (1992). *Ecosystems of Florida.* University of Central Florida Press: Orlando, FL.

- *Excellent chapter on coral reefs.*

Orams, M. (1999). *Marine Tourism: Development, Impacts and Management.* London: Routledge Press.

- *Good general treatment of all aspects of marine tourism and how diving fits within this context.*

Sale, P.F. (ed.) (2002). *Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem*. Academic Press: New York.

- *The definitive textbook on coral reef fish ecology; a college-level text but not too incomprehensible for the motivated layman. Update of the listing below.*

Sale, P.F. (ed.) (1991). *The Ecology of Fishes of Coral Reefs.* Academic Press: New York.

Salm, R.V. & Clark, J.R. (2000). *Marine and Coastal Protected Areas: A Guide for Planners and Managers,* 3rd edition. Gland, Switzerland: World Conservation Union.

- *An update of the highly regarded "bible" on marine protected areas. Not only is it a comprehensive and easy read, the content is reinforced with extensive practical examples and case studies.*

Viles, H & Spencer, T. (1995). *Coastal Problems*. Edward Arnold: London.

- *Excellent chapter on coral reefs*

White, AT, Hale, L.Z, Renard, Y. & Cortesi, L. (1994). *Collaborative and Community-Based Management of Coral Reefs: Lessons From Experience.* Kumarian Press: West Hartford, CT.

- *Excellent overview of the issue with six supporting case studies from around the world.*

<u>Theses, Dissertations and Technical Reports</u>

Aiello, R.L. (1996). *Successes and failures of global reef management.* Reef Tourism 2005: Cairns, Australia, 167 pp.

- *An outstanding report covering issues on the value of coral reefs, global status of reefs, impacts on reefs, marine park management as well as eight case studies on well-known marine parks around the world.*

Best, B.A., Pomeroy, R.S. & Balboa, C.M. (2002). *Implications for Coral Reef Management and Policy: Relevant Findings from the 9th International Coral Reef Symposium.* U.S. Agency for International Development: Washington, DC, 113 pp.

de Vantier, J & Turak, E. (2004). *Managing Marine Tourism in Bunaken National Park and Adjacent Waters, North Sulawesi, Indonesia*. Technical Report prepared by the Natural Resources Management Program, Protected Areas and Agriculture Team. Available at: http://www.tnc-seacmpa.org/download.htm

Glick, P. (1999). *Coral Reefs and Climate Change: Last Straw for a Threatened Ecosystem.* National Wildlife Federation: Washington, DC, 8 pp.

Harriott, V.J. (2002). Marine Tourism Impacts and Their Management on the Great Barrier Reef. CRC Reef Research Centre Technical ReportNo. 46. Townsville, Australia.

Hatziolos, M.E., Hooten A.J. and M. Fodor (eds.) (1997). *Coral Reefs: Challenges and Opportunities for Sustainable Development.* The World Bank: Washington, DC.

- *Proceedings from a World Bank Conference in October 1997. Good discussion of topics not often addressed including: destructive fishing practices, illegal versus sustainable trade in coral reef resources, marine protected areas, marine education and economic valuation of coral reefs.*

Hoegh-Guldberg, O. (1999). *Climate Change, Coral Bleaching and the Future of the World's Coral Reefs.* Greenpeace, Australia, *http://www.greenpeace.org.au/info/archives/climate/index.html*

Mascia, M.B. (ed.) (2001). *Designing Effective Coral Reef Marine Protected Areas: A Synthesis Report Based on Presentations at the 9th International Coral Reef Symposium, Bali, Indonesia October 2000*. Special Report to IUCN and World Commission on Protected Areas-Marine: Gland, Switzerland. 23 pp.

Medio, D. (1996). *An investigation into the significance and control of damage by visitors to coral reefs in the Ras Mohammed National Park Egyptian Red Sea.* Unpublished doctoral dissertation. University of York, United Kingdom. 332p.

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