



INSTRUCTION MANUAL

A Guide to Reef Check Coral Reef Monitoring

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Jennifer Liebler, Craig Shuman, and Ruben Torres

2006 Edition

REEF CHECK INSTRUCTION MANUAL

A Guide to Reef Check
Coral Reef Monitoring



2006 Edition

This is the official instruction manual (2006 edition) for Reef Check monitoring procedures. If you have any questions about training procedures, please feel free to contact Reef Check at the contact numbers given below.

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**This publication should be cited as:
Hodgson, G., Hill, J., Kiene, W., Maun, L., Mihaly, J., Liebeler, J., Shuman, C. and Torres, R. Reef Check Instruction Manual: A Guide to Reef Check Coral Reef Monitoring. Reef Check Foundation, Pacific Palisades, California, USA**

ISBN 0-9723051-1-4

Front cover photo courtesy Quiksilver. Back cover photos by Badrul Huzaimi, Jennifer Liebeler, Gregor Hodgson, Reef Check's Indonesia team. Cover design by Bill Kiene. Illustrations by Sarah Lowe where acknowledged.

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Acknowledgements

Reef Check began in 1996 as a simple idea to survey the world's coral reefs using one standardized method so that survey results could be compared wherever they were carried out. Reef Check is now the thousands of individuals who have given their time and effort to conducting Reef Check surveys and to the cause of reversing the decline of the world's coral reef ecosystems. Reef Check thanks all of these dedicated volunteers for their contribution to the development, evaluation and implementation of the Reef Check protocol that has culminated in this manual. Special thanks goes to all our scientists, team leaders and national coordinators for taking the time out from their busy lives to help design the program, facilitate Reef Check surveys, education programs and management initiatives. As the number of Reef Check leaders and participants grow, they will continue to play an increasingly vital role in the evolution of Reef Check and its impact on coral reef conservation throughout the world. Reef Check has evolved from its original idea to become the Reef Check Foundation, an international marine conservation organization with headquarters in California and offices in the Philippines, Indonesia, Australia and the Dominican Republic and volunteer teams in more than 80 countries. For more information about the Reef Check Foundation, please see our website www.ReefCheck.org.

We are especially grateful to our Board of Directors and Advisors, Scott Campbell, Eric Cohen, Eddy Medora, Christeon Costanzo, Leonardo DiCaprio, Irmelin DiCaprio, Valerie Gould, Gale Anne Hurd, Gary Justice, Will Knox, Gilbert Leistner, Russ Lesser, Lenore Marusak, Eddy Medora, Jim Miller, Greg MacGillivray, Tod Mesirov, Richard Murphy, Mara New, Jerry Schubel, Craig Shuman, Shepard Smith, Andrew Wiens, David Williams.

We also thank our members, donors, major funders, and partners including, Body Glove, Conservation and Community Investment Forum, Global Coral Reef Monitoring Network, International Coral Reef Action Network, International Coral Reef Initiative, International Finance Corporation, Living Oceans Foundation, The National Fish and Wildlife Foundation, The National Oceanic and Atmospheric Administration, The National Wildlife Federation, The Packard Foundation, The John D. and Catherine T. MacArthur Foundation, The Marine Aquarium Council, The Oak Foundation, Ocean Futures Society, Quiksilver, Rockefeller Brothers Fund, The United Nations Environment Programme, United Nations Foundation, US Agency for International Development, the US Department of State, and the US Coral Reef Task Force.

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Introduction

Reef Check is the most widely used coral reef monitoring protocol. The techniques are simple to learn and the data are scientifically robust. Reef Check data (and projects) are managed by the Reef Check Foundation, which is an international marine conservation organization based in Los Angeles, California with offices in the Philippines, Indonesia, the Dominican Republic and Australia and teams in over 80 countries and territories. This Instruction Manual provides all the information necessary for Reef Check teams to carry out coral reef monitoring using the standard Reef Check protocol. In addition to this manual, there are a variety of training materials available including PowerPoint presentations and identification tests, and an instructional video/DVD that should be used during training. Those wishing to carry out a Reef Check survey are encouraged to become Certified Reef Check divers by attending a Reef Check Certification Workshop in your area. For more information, see www.reefcheck.org.

The Reef Check program brings together community groups, government departments, academia and business partners to:

- *Educate* the public about the coral reef crisis;
- *Create* a global network of volunteer teams to regularly monitor and report on reef health;
- *Scientifically investigate* coral reef ecosystem processes;
- *Facilitate* collaboration among academia, NGOs, governments and business;
- *Stimulate* local community action to protect remaining pristine reefs and rehabilitate damaged reefs worldwide using ecologically sound and economically sustainable solutions.



Figure 1. Reef Check sites in over 80 countries and territories.

Reef Check brings together coral reef stakeholders to implement conservation goals through coral reef monitoring, management and education (Figure 2).

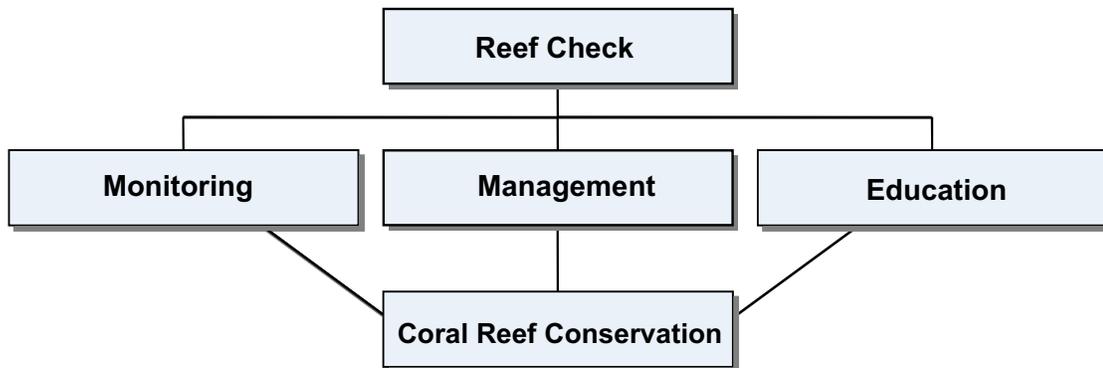


Figure 2. Reef Check's Coral Reef Conservation strategy.

History of Reef Check

Scientists have been monitoring coral reefs since the time of Darwin in the 1850s. But the introduction of scuba diving in the 1960s allowed scientists a new view of reefs that was documented and brought into the public domain by natural historians such as Jacques Cousteau. During the 1980s, many divers and scientists began to witness a decline in coral reef health at their favorite reefs, particularly at well-studied reefs such as in Jamaica. While accepting that certain reefs had been degraded, some scientists questioned the geographic extent of this issue. The 1993 Colloquium on Global Aspects of Coral Reefs (organized by Professor Robert Ginsburg of the University of Miami) was a turning point for many reef scientists who met to discuss the health of the world's reefs. Some scientists felt that most coral reefs were in serious trouble while others thought that only a few reefs were experiencing a temporary downturn in health. At the end of the meeting, it was clear that there was not enough information available to form a picture of the status of coral reefs on a global scale because there was no organized attempt to gather data.

One group of coral reef scientists felt that part of the problem lay with the ecological monitoring methods scientists have used. These detailed methods were designed to investigate community ecology and include measurements of many parameters that may not be affected when coral reef health is damaged. The scientists felt that more specific methods should be designed to investigate **human impacts** on coral reefs, because those are the impacts that are preventable.

It was recognized that another problem with the conventional approach to coral reef assessment and monitoring was that there are only a small number of reef scientists, most of whom are only able to carry out a few surveys at a few locations using different methods. Thus the data were not easily comparable. The solution was to organize a global survey effort that would take place annually using one standard survey method, which would provide a synoptic view of the health of the world's reefs. To make this survey cost-effective, the effort would depend on volunteer help from non-scientists. To help focus

attention on coral reefs, a group of coral reef scientists led by Professor Ginsburg, a coral reef geologist, declared 1997 to be the International Year of the Reef. As part of this initiative, Ginsburg asked Dr. Gregor Hodgson, a coral reef ecologist, to design a global monitoring protocol. Hodgson drafted and tested the Reef Check protocol, which was subsequently circulated on the internet and peer-reviewed by many reef scientists.

In 1997, scientists were invited to volunteer as Reef Check Trainers and the first-ever global survey of coral reef health was carried out in 31 countries in all tropical seas. The results provided scientific confirmation that coral reefs were facing a major crisis on a global scale. In the 1980s, many scientists thought that the major threats to coral reefs were primarily pollution and sedimentation. The Reef Check results demonstrated for the first time, that overfishing was a major threat to coral reefs throughout the world (Hodgson, 1999). Since then, hundreds of Reef Check teams have been monitoring reefs every year and the number of participating countries is more than 80 out of the 101 with coral reefs.

The results of the first five years of monitoring were presented in a major report, "The Global Coral Reef Crisis – Trends and Solutions" at the World Summit on Sustainable Development in Johannesburg, South Africa in September 2002. The report documented the continuing global decline in reef health but also included coral reef conservation success stories from around the world. Monitoring was carried out on over 1500 reefs in the Atlantic, Indo-Pacific and Red Sea. Following quality assurance procedures, 1107 sites were accepted for analysis. The analyses examined spatial and temporal changes in indicator abundance, as well as correlations between abundance and ratings of human impact provided by the teams. The key findings were:

- On a global scale, zero spiny lobster were recorded at 83% of shallow reefs indicating severe overfishing. There was a significant decline in lobster abundance in the Atlantic;
- The mean abundance of *Diadema* sea urchins decreased significantly in the Indo-Pacific from 1998 to 2000, approaching levels similar to those found in the Atlantic and possibly indicating ecological destabilization;
- A total of 101 triton were recorded, indicating severe overfishing for the curio market;
- Globally, there was a significant decrease in the abundance of butterflyfish from 1997 to 2001;
- There were zero grouper larger than 30 cm recorded at 48% of reefs surveyed indicating overfishing of these predators;
- Four species of fish were in critical condition: Nassau grouper were absent from 82% of shallow Caribbean reefs with only eight reefs having more than one fish observed. Barramundi cod, bumphead parrotfish and humphead wrasse were missing from 95%, 89% and 88% of Indo-pacific reefs respectively;
- Moray eels were not recorded on 81% of reefs, and in the Indo-Pacific, 55% of all reefs surveyed were devoid of parrotfish greater than 20 cm;
- Globally, the mean hard coral cover was 32%. The percent hard coral cover was significantly higher on reefs having no anthropogenic impacts than on reefs with high levels of such impacts. Only 34 reefs had greater than 70% hard coral cover and none had higher than 85% cover;
- The 1997-98 coral bleaching event reduced live coral cover by 10% globally, indicating that coral reefs are a sensitive indicator of global warming;

- Algal cover was higher on reefs rated as having high exposure to sewage pollution;
- Atlantic and Pacific reef fish populations were distinguished by the relative dominance of families Haemulidae (sweetlips) and Scaridae (parrotfishes) on Atlantic reefs and fish of the families Chaetodontidae (butterflyfishes) and Lutjanidae (snapper) on Indo-Pacific reefs;
- Marine protected areas (MPAs) in developing countries were showing some success. Five of ten fish and one of ten invertebrate indicators were significantly more abundant inside MPAs than outside.

By involving local people in community-based monitoring, Reef Check serves as the first step in attracting participation in coral reef management activities. In several cases, this has facilitated the creation of well-managed MPAs.

At the international level, Reef Check (RC) serves as the community-based component of the Global Coral Reef Monitoring Network (GCRMN) and collaborates on regular status reports. Reef Check is a member of the International Coral Reef Initiative (ICRI) and International Coral Reef Action Network (ICRAN). Reef Check provides data to and is developing interactive reef monitoring data management systems with ReefBase, the global database of coral reef information. Regional and national Reef Check training programs are offered throughout the world each year. The Reef Check monitoring program is completely volunteer, however training and management activities are often supported by private donations, grants from foundations, the United Nations and other national and international agencies including the US Agency for International Development and the National Oceanic and Atmospheric Administration.

In 2000, the non-profit 501c3 Reef Check Foundation was established in California to manage the annual survey and to create more opportunities for coral reef conservation. Reef Check has many partners, but places special attention on establishing long-term partnerships with businesses such as the tourism, diving, surfing and the marine aquarium industries. For example, Reef Check's partnership with the lifestyle company Quiksilver allowed surveys of remote reefs during the five-year long "Crossing" global surf-quest expedition.

Reef Check is also collaborating in a major conservation initiative with the Marine Aquarium Council (MAC). In 2002, Reef Check designed a detailed protocol called "MAQTRAC" to monitor the effects of the marine aquarium trade on coral reefs. The marine aquarium trade provides a valuable financial incentive to manage coral reefs. Reef Check is now working with MAC to certify the trade and establish MPAs and rehabilitate coral reefs in Indonesia, the Philippines and other countries. In 2005, Reef Check launched its first temperate reef-monitoring program in California.

In addition to collecting a wealth of valuable data from coral reefs around the world, Reef Check has received national and international environmental awards for its conservation efforts and has raised public understanding of the global coral reef crisis and the potential solutions to the problems faced by coral reefs and the people who depend on them. For more information about Reef Check activities, please refer to the Reef Check website: www.reefcheck.org.

The Reef Check Monitoring Protocol: Overview

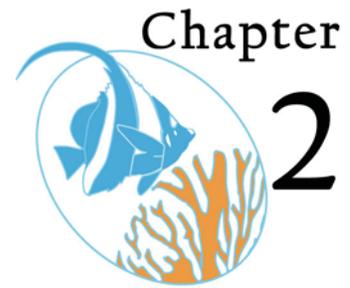
Reef Check was designed to assess the health of coral reefs and is quite different from other monitoring protocols. Since its inception, Reef Check has focused on the abundance of particular coral reef organisms that best reflect the condition of the ecosystem and that are easily recognizable to the general public. Selection of these “indicator” organisms was based on their economic and ecological value, their sensitivity to human impacts and ease of identification. Sixteen global and eight regional indicator organisms serve as specific measures of human impacts on coral reefs. These indicators include a broad spectrum of fish, invertebrates and plants that indicate human activities such as fishing, collection or pollution. Some Reef Check categories are individual species while others are families. For example, the humphead wrasse (*Cheilinus undulatus*) is the most sought after fish in the live food fish trade, whereas the banded coral shrimp (*Stenopus hispidus*) is collected for the aquarium trade. Both species are very distinctive organisms and excellent indicators of human predation. On reefs where these organisms are heavily exploited, their numbers are expected to be low compared to their abundance on unexploited reefs.

Reef Check teams collect four types of data:

- 1) A description of each reef site based on over 30 measures of environmental and socio-economic conditions and ratings of human impacts;
- 2) A measure of the percentage of the seabed covered by different substrate types, including live and dead coral, along four 20 m sections of a 100 m shallow reef transect;
- 3) Invertebrate counts over four, 20 m x 5 m belts along the transect; and
- 4) Fish counts, up to 5 m above the same belt.

Monitoring of the indicators is done along two depth contours. “Manta tows” are recommended as a habitat mapping and site selection technique in areas with sufficiently clear water (> 6 m horizontal visibility).

This easy to learn but scientifically robust sampling method is providing data on the condition of reef environments throughout the world and has been adopted as the standard monitoring protocol by marine park managers, national governments, scientific institutions as well as many volunteer teams. The methods have proven to be an effective learning tool for people wishing to gain more knowledge about coral reefs and the marine environment. They are also fun to do, attracting recreational divers wanting to experience coral reefs in a new way, as well as scientific divers wanting to improve their knowledge of taxonomy and ecology. No matter what the reasons are that have brought you to Reef Check, we are confident you will enjoy your experience!



How to Form a Reef Check Team

Eligibility

If you would like to form a Reef Check team, the first step is to contact the National Coordinator listed for your country (see: www.reefcheck.org). Your Coordinator can advise you on where to find training, on fund-raising and site selection (helping to avoid duplication of other work) as well as other aspects of setting up your team. If there is no National Coordinator listed or you have trouble contacting the Coordinator, contact Reef Check HQ directly (rcinfo@reefcheck.org). All teams must have a Team Scientist, a Team Leader and will need to be trained by a Reef Check Trainer. Beginning in 2006, a Reef Check Certification program was instituted and we encourage all former and new scientists and participants to attend a Certification Workshop to obtain their formal certification. Team Scientists should be marine biologists or highly experienced natural historians. Team Leaders should be experienced divers, preferably a divemaster or instructor and their focus is on team safety. A Reef Check Trainer is normally an experienced biologist or dive instructor. Dive instructors with no formal marine biological training but who are suitably experienced with Reef Check may become Trainers. Often a Team Scientist and Team Leader may oversee a number of Reef Check Teams and/or may also act as a National Coordinator. The organization of Reef Check is illustrated in Figure 3.

Based on experience, the most successful teams include a combination of members from academia, environmental groups, government staff and business. A biologist from a local university might be designated as the Team Scientist, while the environmental group would serve the role of community organizer. The government staff might be from the local environmental or fisheries or tourism departments. Business members might be from dive shops, clubs or other businesses that may wish to sponsor a survey or adopt a reef.

All teams must register directly with Headquarters by completing our online registration form at www.reefcheck.org or by submitting it via regular mail, fax or e-mail to rcregist@reefcheck.org. The registration form can be found in Appendix A at the end of this manual or on our website. Upon receipt of the registration form, Reef Check HQ will copy the acceptance note to the National Coordinator.

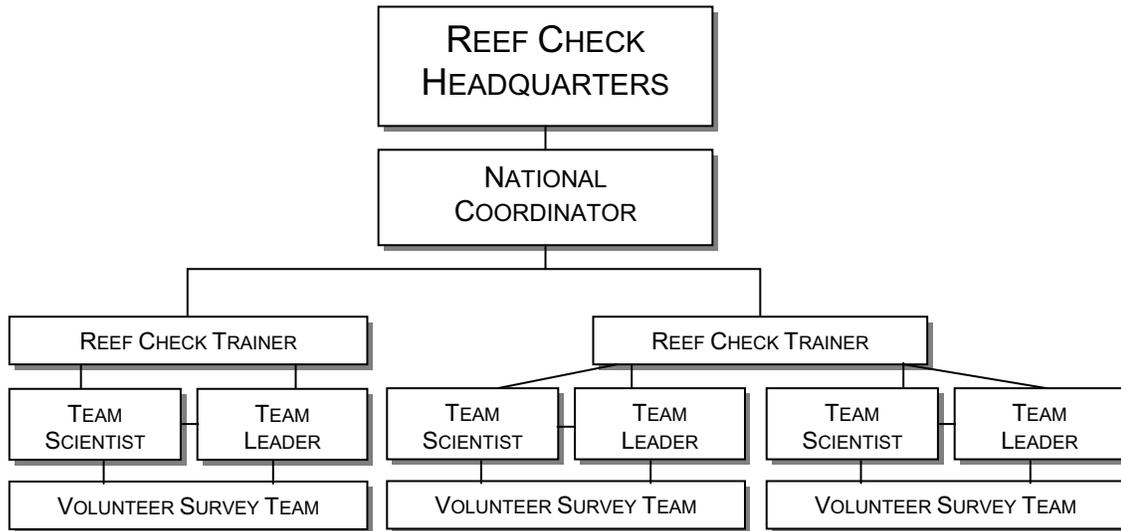


Figure 3. Organization of Reef Check teams

The Reef Check protocol has been designed to be as simple as possible so that high school students can participate. Practical team sizes are 2, 3, or 4 pairs of divers, however larger or smaller groups are possible. Divers should be sufficiently experienced (> 30 dives or equivalent experience) that they are able to perform simple activities underwater. It is the role of the Team Leader to decide if the team members are adequately qualified to undertake these activities. Reef Check surveys can be carried out by snorkelers in shallow water.

Training

An ideal Reef Check team includes six members (three buddy pairs) plus support crew, each with different specialties and experience, however teams of 2 to 12 members can easily complete Reef Check. When teams become too large, the Team Leader's job of tracking all team members in the water may become difficult. Each team should decide on the goal of the Reef Check survey. Is the goal to learn more about coral reefs and human impacts or is it to produce reliable data that can be used for local management and entered into the Reef Check global database – or both? If education is the primary goal, and no data submission is planned, then training can be relatively relaxed. If reliable data gathering and submission is the goal, then rigorous training and testing following the RC Certification system should be carried out to ensure the competency of the team members to carry out their tasks. Divers should attend a Reef Check Certification Course and after passing the test will receive an official Reef Check Certification Card (contact your National Coordinator or Reef Check HQ for a schedule of courses).

Volunteer divers should try to find a Reef Check Trainer or participate in regional and national training programs. In general, Reef Check offers several Certification Courses in each region each year. Training Centers are currently operating in the US (Los Angeles, Hawaii), Australia (Townsville), SE Asia (Bali, Manila, Cebu, Okinawa, Kuala Lumpur, Phuket) and the Caribbean (Jamaica, Cozumel, Dominican Republic, Belize, Honduras, Curacao) and Africa (Egypt, South Africa). See www.reefcheck.org for the latest contact information and training schedule.

The time required to complete a Reef Check Certification Course depends on the knowledge of the participants. For teams comprised of participants with previous ecological survey experience, the training may be limited to one full day or two half-day sessions. For other teams, a minimum two-day training program will be needed. A standard schedule for such training is given in Appendix D. Training materials are available from Reef Check Headquarters, including a training video, PowerPoint presentations, identification tests and underwater field guides.

Pictures of the target organisms and substrate categories for each region that you will need to be able to identify are found in Appendix E for the Caribbean and Indo-Pacific. Photos of indicator sets for other regions can be ordered from Reef Check HQ, they are also found on the Reef Check CD, and on our website. Reef Check has also made a set of Indicator Field Guide ID cards for the Atlantic, Pacific and Hawaii that can be taken underwater. If you do not have these cards, they can be purchased from our website. Teams in developing countries may contact us for a PDF that can be printed in color and either laminated or placed inside a plastic "zip-lock" bag and then carried underwater for reference.

As part of the Certification Course, the Reef Check Trainer covers the following points:

1. An explanation of the three goals of Reef Check: education, scientific data collection, and coral reef management;
2. A review of the sampling design and rationale of the indicator organisms;
3. Field identification training for all organisms and Reef Check definitions for substrate categories and testing;
4. An introduction to the data recording format, and preparation of slates/paper;
5. An explanation of the difference between survey diving and pleasure diving and how to avoid damaging reef corals by maintaining proper buoyancy control;
6. Explanation of the post-dive data entry, checking and submission procedures.

The Team Leader is responsible for safety training and will need to assess the abilities of their team so that appropriate activity assignments can be made. The best person to serve as Team Leader is a certified and experienced scuba instructor or divemaster. In small teams, the Team Leader may be the same as the Team Scientist, but ideally these are two different people so that they can focus on their respective tasks.

Testing your skills

To ensure we are all collecting reliable data, all trainee Reef Checkers must practice their identification skills prior to participating in a survey. We recommend first doing the Reef Check photo tests which are available as a PowerPoint file from Reef Check HQ. Look at each photo and identify each organism. **The passing mark is 80%.**

When you have passed your photo test and feel confident about your skills, go into the water with a Reef Check Trainer who will ask you to identify a number of substrate types, invertebrates, reef impacts and fish. **The pass mark is 90%.**

We also recommend that Reef Checkers practice their in-water skills prior to conducting a survey. For snorkelers this will include learning the head-down "duck dive" and writing on a slate without kicking the coral reef. For divers, this will include buoyancy practice to ensure

that you can collect data without hitting the reef. To assist Trainers we have developed a buoyancy practice program for Reef Checkers which is detailed below.

Buoyancy practice (for scuba divers)

Reef Check monitoring can be carried out in shallow water without scuba. The Reef Check Foundation is not a scuba diving certification organization such as PADI or NAUI. For scuba divers already certified by one of these professional scuba training organizations, Reef Check certification will be a fun additional level of knowledge. Once the Reef Check Certification is obtained, the diver is eligible to apply to PADI or NAUI for a Specialty Course Certification.

The Reef Check protocol requires that divers can perform simple tasks underwater. These include hovering motionless near the reef, often in an upside down or horizontal position, identifying and counting target organisms and writing these observations on a slate. Multiple tasks often need extra concentration underwater and buoyancy control can easily be lost – even for experienced divers. Loss of buoyancy control can lead to broken coral, scrapes and cuts, as well as making data collection difficult. Damage to reefs can occur when divers make contact with live corals or kick up sediments from the bottom while concentrating on their survey. This contact is made most frequently from fins, but can also be from knees, gauges, regulator and hands. Good buoyancy is therefore an essential skill for collecting high quality data using scuba!

We recommend you include buoyancy practice with a certified scuba Instructor as part of your training to participate in Reef Check surveys. You may find that you are not quite as good as you thought you were! Practice will lead to good buoyancy control and will not only enhance your skill as a Reef Checker but will also enhance your recreational diving experience in the future. These buoyancy exercises are best practiced in a pool or on a calm day in shallow, clear water (3-4 m depth) over a sandy bottom in the sea.

Pre dive briefing:

1. Trainer to outline the buoyancy exercises.
2. *Weight set-up:* Weights should be positioned so that there are equal amounts on both sides of your hips. Use either a weight belt or a weight integrated Buoyancy Control Device (BCD). Avoid placing weights on the centre of your back, since that can be uncomfortable and lead to back aches. Make sure that you are not over weighted because that makes it harder to control your buoyancy.
3. *Equipment configurations:* Make sure you know how your BCD works. Where are the different dump valves located? What options are there to deflate the BCD? Where and how are the pressure gauge and octopus regulator attached?

Pre dive in the water:

4. *Buoyancy check:* Weights should be adjusted so that it is possible to float at eye level on the surface with the BCD completely deflated. Divers should be completely still and not kicking or sculling with fins or arms. Remember the tank is full, so add a kilo or two to compensate for buoyancy changes later when the tank is nearly empty. We recommend a buoyancy check also be performed at the end of the dive (50 bar/700 PSI) because optimal buoyancy control changes as air is depleted from the tank. Remember that you are more buoyant in salt water than freshwater, so more weights may be required in the sea than in a pool.

Descent:

5. Descend by exhaling and fully deflating your BCD. In shallow water, it is not necessary to kick with your fins. Just look downwards during the descent, avoid touching the bottom and control buoyancy on the way down by adding small bursts of air into the BCD.

Buoyancy control exercises:

6. *The fin pivot.* This exercise enables buoyancy control through use of the lungs. Descend to the bottom of the pool, deflate your BCD, lie with your belly facing the bottom with straight legs. Inhale slowly, if your upper body does not slowly lift off the bottom, add a little bit more air into your BCD until it does. When the upper body slowly starts to rise from the bottom, you should exhale while your fin tips still have contact with the bottom. Your upper body should now be slowly lowering. Before your chest touches the bottom of the pool, inhale again. The aim is to pivot up and down using careful breathing control, without your upper body touching the bottom.
7. *Hovering.* The aim of this exercise is to make minor depth adjustments using breath control only without touching the bottom and while you are doing an unrelated activity. Start by hovering in a vertical position about 2 m above the bottom, and when feeling comfortable, hover and without breaking the surface or touching the bottom, play scissor, paper and stone with your buddy. The winner is the first to score 10 points without touching the bottom or reaching the surface.
8. *The seahorse swim.* Practice sculling from one end of the pool to the other by using your hands as small paddles, without moving your arms.
9. *One-finger push offs.* Practice swimming slowly towards the side of the pool and then use one finger to push off from the side of the pool. The aim is to be able to gently fend off from the reef without causing any damage or disturbing any reef life.
10. *Swimming backwards.* The ability to swim backwards allows divers to back off from the reef. Together with good buoyancy, the ability to swim backwards allows divers to move independently in all three dimensions. Hovering horizontally, the hands can be used in a reverse "sea horse" swim to scull backwards. Also, a gentle frog kick can be used in a reverse manner. Fins can also be used to scull backwards. Emphasize the feeling of pushing water forward with the upper side of your fins. Swim backwards from one side of the pool to the other (10 meters).
11. *Buoyancy control while swimming.* Swim along a course above the bottom without touching it or breaking the surface. While swimming make minor depth adjustments using breath control only, concentrating on using an efficient, relaxed kicking style, preferably using the frog kick and practice gliding after each kick. Make sure equipment is always streamlined and secure so nothing damages the reef and drag is reduced.
12. *Swimming and observing.* Choose a buddy and swim around the perimeter of the pool. Carry a slate and ask and reply to each other's questions written on a slate. The purpose of this exercise is to assess your ability to control buoyancy as required to perform a successful Reef Check survey without causing any damage to the reef. Imagine that the pool is a fragile, pristine coral reef. You should not break the surface,

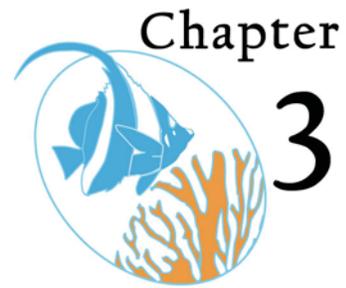
touch the bottom or the side of the pool and if you do get too close, back off or use a one-finger push off.

13. *Buoyancy control while passing weights.* The purpose of this exercise is to practice buoyancy while passing equipment to one another as you may do on a Reef Check survey. For a group, hover in a circle and pass a weight around the group while maintaining good buoyancy control.

Liability

Participants in Reef Check are considered to be fully independent individuals who have chosen to follow the Reef Check survey methodology of their own free will and are entirely responsible for their own safety. Team Leaders should carefully check what the liability requirements are in their area. All participants must sign the liability waiver (found in Appendix B) and give a copy to the Team Leader before taking part in this volunteer activity. Team Leaders should keep these on file for at least one year after the survey is completed or for the duration of time stipulated by local legislation.

Reef Check has been designed to minimize risks by limiting surveys to 12 m maximum depth, however accidents can occur anywhere. Depending on the country, individual team leaders, divemasters, dive boat operators etc. may have some liability for the safety of their team members. While each participant is responsible for their personal decision to participate, the Team Leader should provide advice to potential team members to help them determine if they are adequately experienced to carry out the Reef Check survey.



Core Methods Overview

Reef Check surveys can be carried out at any time during the year. However, for inclusion in the global database and our regular reports, data should be submitted by December 31 of any given sampling year.

All Reef Check teams should email Data Forms to rcdata@reefcheck.org as attachments or submit online at www.ReefCheck.org/datamanagement. In addition, **each group can do whatever additional sampling of any additional indicators they like**. For example, if triggerfish are considered an important indicator in your area, feel free to add them to your list. Reef Check Headquarters will include only standard RC indicators from registered teams in our analyses and annual global reef health report. At present we do not report data on local indicators.

Site Selection

Site selection is a critical factor in the success of Reef Check and should be done by the Team Scientist. One goal of Reef Check is to determine the widespread extent of human impacts on coral reefs. For this reason, Reef Check teams that can only survey one site should survey the "best" site they have access to (i.e. sites least likely to have been affected by human impacts, fishing, pollution etc). Such a site should have high living hard coral cover, and dense fish and mobile invertebrate populations.

In addition, we would also like information on the geographic distribution of human impacts on all reefs. For groups willing and able to survey multiple sites, we would suggest choosing two or more additional sites that are representative of moderate and heavy human impacted reefs. By doing so, it will be possible to construct a more complete picture of the extent and distribution of human threats, and why some reefs are more vulnerable to these threats than others.

If you are trying to locate appropriate sites for Reef Check monitoring and the underwater horizontal visibility is 10 m or more, a "manta tow" can be used to survey large sections of reef quickly. This procedure involves slowly towing an observer, using a mask and snorkel, on a rope behind a small boat. A specially designed "manta board" with handholds and a writing slate attached can be constructed for this purpose. See English et al. (1997) or Hill and Wilkinson (2004) for details or contact Reef Check HQ.

When selecting sites it is helpful to first map the reef area you are interested in. This will help you to identify the different reef zones or habitats (e.g. reef flat, reef crest, reef slope

etc. see Figure 4). The next step is to decide where you want to survey. If you compare one survey with another in a subsequent year it is important that both surveys were conducted in the same reef zone. That is, you should not compare data from a survey of the outer reef crest with those from a lagoon.

For teams capable of long-term monitoring of multiple sites, another useful approach is to use a sampling design that includes sites inside and outside of a Marine Protected Area (MPA). With sufficient surveys (3 to 5 outside and 3 to 5 inside), it will be possible to show how effective the protected area is and to distinguish if reef health improves over time. If improvement in reef health can be shown, this may serve as a valuable case study of a successful MPA and help coral reef managers replicate this effort elsewhere.

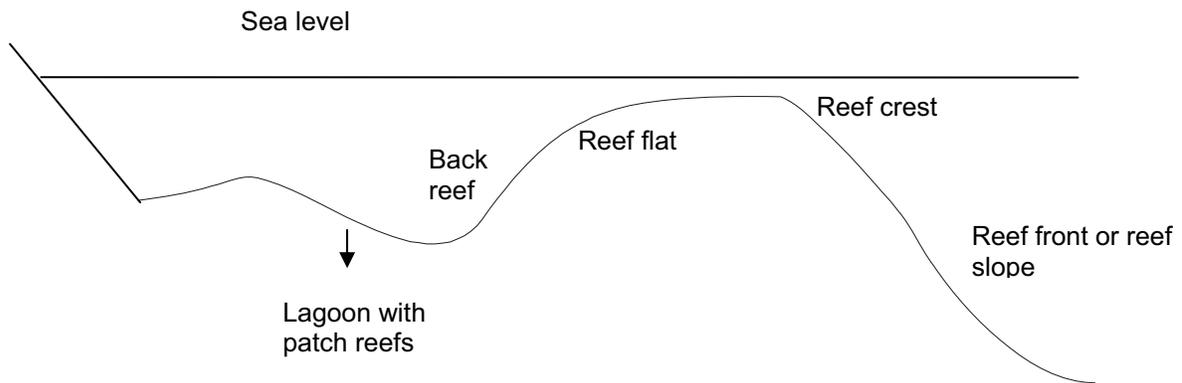


Figure 4. Diagram of reef zones. Reef Check volunteers selecting their sites should keep all transects in the same reef zone or habitat if results from these surveys are to be compared with one another or collated.

With all site selection, however, it is important to remember that a survey is only a sample of the coral reef environment. The site selected for the Reef Check should be representative of the reef area. If you are interested in the health of an entire reef, you will need to set up a number of Reef Check survey sites at a number of locations. Please see Chapter 6 on using Reef Check for long-term monitoring for a more detailed discussion of this topic.

To standardize Reef Check, we will not accept surveys of steep wall reefs (drop-offs), reefs predominantly located in caves or beneath overhangs. The survey transects should be placed seaward of the reef crest on the outer slope, parallel to shore. In lagoons, the transects may be placed on the inner reef slope (back reef). It is very important to describe the physical setting of the site and its position in relation to obvious human influences on the Site Description Form. This assures that data comparisons will be made between similar reef settings.

Marking Reef Check Sites

If you are going to monitor your Reef Check site regularly, it is a good idea to either map or permanently mark the transect or transect area to ensure your team is able to return to the same place in subsequent years. *If it is only possible to do one site we recommend using a*

permanent transect. If it is possible to do multiple sites at various locations of interest on your reef, a number of randomly-placed sites within your target depth zones are sufficient. It will be easier to find permanently marked transects. Future teams will be able to locate them and repeat the surveys without the need for the site selection process each year.

The decision to use permanent or random transects, and the number of sites you survey will depend upon your goals and the precision you need for the data. In addition to helping to build up the global picture of coral reef status, it is also important to consider how your data could be used for local decision making. To detect more detailed changes in the status of your reef you will need more precise data and so you will need to conduct more surveys at more sites. To detect only broad changes in reef health, you need not invest so much effort and can conduct fewer surveys. Below is a brief description of the advantages and disadvantages of permanent and random transects. Your Team Scientist can answer questions about these techniques.

Permanent transects

Fixed markings along the transect length are called permanent transects. They help you to lay the transect tape in more or less the same position each year. The main advantage of permanent transects is that each year the survey results will be directly comparable to surveys conducted in previous years. In addition, permanent transects provide more precise data per survey because you don't have to account for spatial variability. Another significant advantage is that the site selection process only has to be done once by a scientist. One disadvantage is that the one site may not be representative of the whole reef so you will need to take care in how you interpret your results unless you are able to monitor a number of sites on a reef area. Three sites per 1km area is a useful benchmark, however see Chapter 6 on using Reef Check for long-term monitoring for more information. Another disadvantage is that they are time consuming and can be expensive to set up – and if not marked properly they are no better than random transects.

Permanent transects can be marked with eye-bolts cemented into holes drilled into rocks or rebar steel stakes hammered into dead coral. The idea is to be able to wrap your tape-measure around the markers to ensure you are surveying the same stretch of reef each time. Ensure you obtain permission from the relevant reef management agency or stakeholder group before you do this. We recommend using a marker every 10 m along the transect. For future surveys ensure you draw a map with the compass bearing to follow to find the next marker! If the transect start point is marked with small *sub*-surface marker-buoys, it should be easier to find during the next survey. Be aware that surface marker buoys will rarely stay in place unless they are maintained. See Hill and Wilkinson (2004) for a more detailed discussion.

Random transects

Random transect placement is the technical method of placing a number of transects throughout the reef zone. The choice of each site is based on random numbers e.g. chosen from a hat or from a random numbers table and assigning distances from the boat. For example, if the boat (or diver) is in the middle of the zone of interest, a random number can be picked (say 1 through 50) to determine how far away the transect should start, with each kick of the swimmer being the number chosen at random.

This type of survey is called stratified random sampling because you are choosing the zone where the random sample is taken. The disadvantage of using random transects is that the site selection process (i.e. finding suitable reef area in your target zone) must be done each year, whereas permanent transects only need to be set up once by a scientist. Another disadvantage is that the random process could put your transect location in a large patch of sand – outside the target zone.

An advantage of random sampling is that the data from a number of randomly placed transects may provide a more representative picture of the whole reef area than data from a few permanent transects and it avoids bias of the person choosing a site. But this only works when sufficient replicate transects are conducted to account for spatial variation on the reef such that these can be differentiated from the temporal differences that you are primarily interested in. Again, three sites per 1 km area is a useful goal, however you may need more sites for random surveys than permanent on a spatially variable (heterogeneous) coral reef. See Chapter 6 on using Reef Check for long-term monitoring for more information.

Basic Design

The goal is to survey two depth contours, 3 m and 10 m below chart datum (*lowest low tide*). However, on many reefs, the highest coral cover will not be found at these exact depths. Therefore, choose the depth contour with the highest coral cover within the following ranges: **Shallow (2 - 6 m depth)**, **Mid-reef (>6 - 12 m depth)**. The transect should be laid at a constant depth within these ranges. If you select 2 m depth for your shallow transect, the whole transect should be at 2 m depth. Note that the tide should be taken into account, particularly for the shallow transect.

Along each depth contour, four 20 m long segments are surveyed to make up one transect. The segments should follow the designated depth contour one after the other. However, segment start and end points **must** be separated by a minimum of a 5 m gap. The distance between the start of the first segment and end of the last segment is $20 + 5 + 20 + 5 + 20 + 5 + 20 = 95$ m. The 5 m gaps are necessary to ensure independence between samples, which is important for statistical analyses (Figure 5).

For your transect line, we recommend using single 100 m or two 50 m fiberglass measuring tapes available from hardware and survey equipment supply stores or from Reef Check Foundation. The depth contours were chosen for practical reasons of time and safety. Reefs in many areas are not suitable for a survey at both depths. In this case, just survey one depth contour. At some reefs, it may be necessary to deploy the transects perpendicular to the reef edge or crest, i.e. following spurs or ridges. In such areas, teams may prefer to survey individual 20 m transect segments located within the specified depth contours. Since fiberglass tapes can break, it may be useful to have a second tape available as a back up.

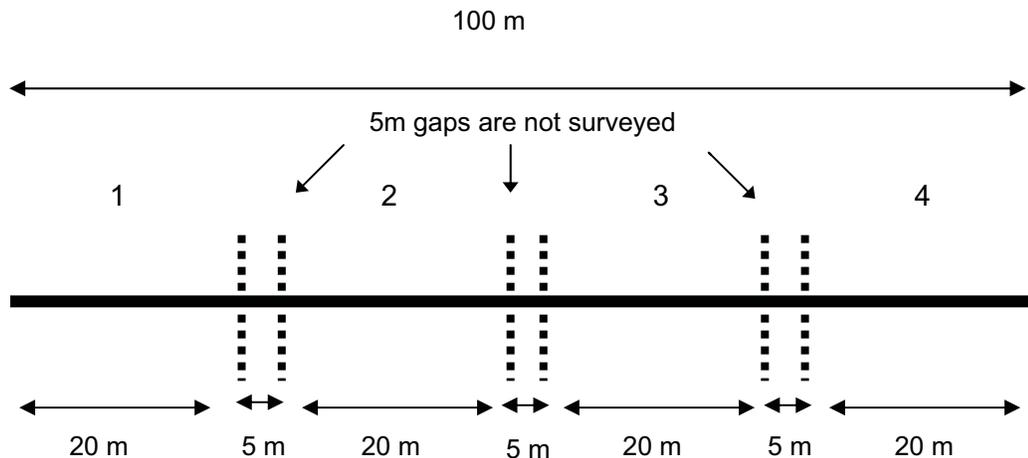


Figure 5. Diagram of a transect line. This 100 m line is divided into four 20 m segments with a 5 m gap in between them to ensure sample independence.

Four types of data are recorded and are later transferred to standard Reef Check Data Forms (Appendix F). Please make sure that you have the latest spreadsheet forms (Excel files) from Reef Check HQ as some changes are made each year. The three transect surveys are made along the same transect line.

- 1) **Site Description.** Anecdotal, observational, historical, location and other socioeconomic data should be recorded on the Site Description Form. These data are extremely important when we interpret global correlations.
- 2) **Fish belt transect.** Four 5 m wide (centered on the transect line) by 20 m long segments are sampled for fish species typically targeted by fishermen, aquarium collectors and others. Fish seen up to 5 m above the line are included. This is the first survey to be performed.
- 3) **Invertebrate belt transect.** The same four 5 m wide by 20 m long segments as used for the fish belt transect are sampled for invertebrate species typically targeted as food species or collected as curios. Reef impacts are also counted along this line.
- 4) **Substrate line transect.** The same transect line as the fish and invertebrate belt transects is used, but this time, points are sampled at each 0.5 m interval along the tape to determine the substrate types on the reef.

Reef Check surveys may be replicated, as needed depending on the purpose of the monitoring. Three to five surveys on one reef will provide results useful for management. For more details on long-term monitoring, please refer to Chapter 6.

Before You Jump in the Water

- 1) Assign team members to survey tasks.
- 2) Prepare datasheets (record the names of the Team Leader, Team Scientist and Team Members, as well as the date, site name and depth on all data sheets and

start to complete the Site Description Form to include recording the Global Positioning System (GPS) coordinates of your survey site. See Chapter 4 for more information on using GPS).

- 3) Prepare all necessary equipment.

1. Assign team members to survey tasks

There are many acceptable ways to divide up the survey tasks depending on the skills of the team members and team size. Some team members will feel more comfortable recording fish or invertebrates, and others will just want to watch and serve as buddies. Because each team will be different, the data collection strategy should be adjusted to match the ability and experience of the team. The best quality data will be obtained by allowing an experienced Team Leader or Team Scientist to assign tasks appropriate for each team member. The Team Leader/Team Scientist must ensure that every team member understands their assignment and is capable of carrying it out properly. We recommend pairing up experienced Reef Checkers with those with less experience.

Please note where there is some question about the reliability of data from a site, we will not include the site in our global database or reports.

2. Prepare data sheets

Prepare the data sheets and ensure that you have sufficient slates or underwater paper for all team members. The number of slates and sheets will depend on the number of people in your team. Every member should have a data sheet to complete his or her portion of the survey. Remember, for each site, you will need **two** complete sets of the Belt Transect and Line Transect sheets because there is one transect at the shallow (2-5 m) and a second transect at medium (6-12 m) depths. Only one Site Description Form is needed.

3. Prepare all necessary equipment

Prepare and distribute all equipment used during a Reef Check survey as follows:

1. Underwater Indicator organism ID cards if required.
2. GPS or nautical chart to mark position of survey.
3. Transect Lines: We recommend using a 100 m fiberglass measuring tape with a hand crank, however you can use one or two 50 m or one or more 20 m tapes. Alternatively, you can easily make a transect line by placing meter marks on plastic rope using colored wire or tags.
4. Slates/Underwater Paper: Teams may use underwater paper, a flat plastic writing slate or a tube shaped arm-slate. These may be pre-printed with the required template using a permanent felt pen (slates) or laser printer (underwater paper). If you use the flat slates, the team scientist should keep a photocopy of each full slate for your records.
5. Pencils: To record data on slates or underwater paper (short golf or plastic pencils work best)
6. Waterproof, permanent markers for labeling slates.
7. Buoys: To mark start and beginning of transect line (can be made from empty plastic bottles).

8. Plumb Line: String (1.5-2 m) with a small weight (e.g. fishing sinker) for the Substrate Survey. Note that a standard builder's plumb "bob" (weight) is larger and heavier than needed.
9. Safety Gear: Dive flag, sunscreen, a First Aid kit, and plenty of water.

The materials needed for an RC Survey can be ordered from the RC website.

Deploying the Transect

Once the Team Scientist is satisfied there is at least 100 m of coral reef of the same habitat (e.g. outer reef slope) for either a continuous 100 m of line (of four 20 m segments separated by 5 m gaps) or four separate 20 m segments, then you are ready to lay the line. The transect line should be deployed by an experienced Reef Checker or the Team Scientist. Once the depth contour is chosen, the start point should be located such that the transect goes through areas of high coral cover (known-bias survey). Once you have decided your target depth (i.e. between 2-6 m at lowest tide height for the shallow transect or >6-12 m at lowest tide height for the deep transect) you should aim to stick to that depth for the whole 100 m. For example, if your target depth is 3 m, then the whole of your transect should be laid as near to 3 m depth as possible, however, a range of 1 m above or below (e.g. between 2-4 m in this example) is acceptable. This is because coral reef habitats change with depth and we want each Reef Check transect to stay in the same habitat.

After deployment, the entire length of the transect should be examined to ensure it is not snagged or floating more than 1 m off the bottom (this can be done by the buddy of whoever is laying the line by following behind). Small temporary surface floats can be attached to transect start and end points so that it is easy to locate by the rest of the team and the surface watch. Remember to watch the tide on the shallow transect.

What to do when there is a gully on your transect

Coral reef topography can be highly irregular and it can be difficult to remain at a constant depth for the whole of your transect. For example, some reefs may have deep gullies/cracks/fissures along the reef slope or others have spur and groove formations.

If there are gullies in the reef that are deeper than 1 m then try to lay the transect around them if possible because we want to collect data from a constant depth of reef. If this is not possible and there is a deep (> 1 m) gully in the middle of a 20 m segment, then stop surveying until after the gap and **add the distance you missed to the end of your 20 m segment** (so that we **do not** miss recording any data points) then start your next 5 m gap.

It is particularly important for the substrate survey **to not miss recording any data points**. At the end of the survey 40 data points must be recorded per 20 m segment for a complete survey. This survey method will be explained fully in the section on the line transect later in this chapter. Please note that a space between e.g. a staghorn coral colony and the adjacent sandy bottom is not a gully – this is just natural variation in topography caused by the colony (Figure 7).

This is not a gully/fissure but a gap between coral colonies. Do collect data points here.

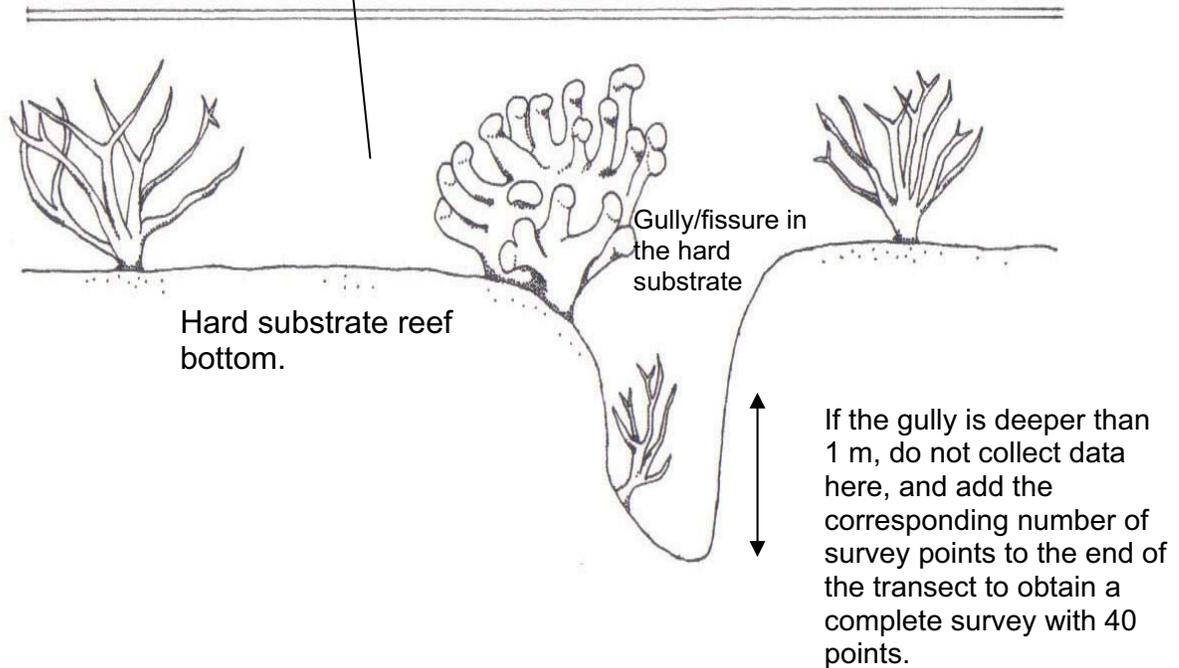


Figure 7. What is a gully and when is it variable topography? (*Illustration by Sarah Lowe*).

See site selection in Chapter 3 and how to use Reef Check for long-term monitoring in Chapter 6 for more information on site selection and marking permanent transects.

A NOTE ON SAFETY!

Safety of divers is the number one priority. No Reef Check surveys should be undertaken when weather or sea conditions are unsafe or if a diver does not feel well. In particular, teams should plan surveys to avoid decompression dives during Reef Check. Any diver who is not comfortable diving for any reason should **NOT** participate in the diving aspects of the survey.



Conducting the Surveys and Data Collection

Site Description Instructions

The Site Description helps us put the other survey data into context – it is therefore essential in helping us interpret what we see underwater. The Site Description Form (Appendix F) can be completed before or during the survey with only one completed per site. It is helpful if one team member is given the responsibility of completing the form with the help of other team members.

Please use the information below (also found on the Site Description Field Guide on the Reef Check CD) to complete this form as it helps to keep our data standardized. Please also mark one response for each question. **Blanks will be interpreted as missing data or unknown.**

Basic Information

COUNTRY, STATE/PROVINCE, CITY/TOWN:

Please be as descriptive as necessary and if you are located on an island, please record appropriately. (Example: Country: **Australia** State/Province: **Queensland** City/Town: **Cairns**)

LATITUDE/LONGITUDE:

Record the coordinates in degrees, minutes, seconds. If you record the coordinates in a format other than degrees, minutes, and seconds (e.g. degrees, minutes; degrees), please indicate this on the Site Description Form. Make sure to note the units required for specific fields (i.e. distance from shore in **meters**; distance from nearest river in **km**; population size **x1000**, i.e. write in 15 for 15,000). Please record the compass direction of the transect line in relation to these fixed coordinates. For more details on the use of GPS and maps, see the end of this chapter.

IMPACTS

Indicate if the site is sheltered or exposed and if there have been recent coral damaging storms. It is important to provide the date of the storm if known. Please estimate the overall anthropogenic impact at your site and indicate if siltation is a problem.

The following definitions should be used to fill out the Site Description Form.

BLAST FISHING

None ---

Low — Known blast fishing in area, but no evidence seen or heard during survey

Med — Blast crater observed anywhere on reef, no blasts heard during survey

High — One or more blasts heard during survey and/or blast crater on transect

POISON FISHING

None ---

Low — Less than one incident per month

Med — More than one incident per month, but less than one per week

High — One incident a week or more

NET AQUARIUM FISHING

None ---

Low — Less than one fisherman/collector trip per month

Med — More than once per month, but less than once per week

High — Once a week or more

COLLECT INVERTEBRATES FOR FOOD

None ---

Low — One fisher collects less than once per week

Med — Multiple fishers collect more than once per week, but less than daily

High — Daily collection by multiple fishers

COLLECT INVERTEBRATES FOR CURIO* SALES

None ---

Low — One fisher collects less than once per week

Med — Multiple fishers collect more than once per week, but less than daily

High — Daily harvest by multiple fishers

* *A curio is something that is collected to be admired as an object but not eaten.*

TOURIST/VISITOR DIVING/SNORKELING (PEAK SEASON AVERAGE PER DAY)

None ---

Low — 1-5 individuals per day

Med — 6-20 individuals per day

High — More than 20 individuals per day

SEWAGE POLLUTION (OUTFALL OR BOAT)

None ---

Low — Sewage, irregular or rare discharge and > 500 m away

Med — Source of discharge > 100 m but < 500 m from transect

High — Source of discharge < 100 m from any point on transect

INDUSTRIAL POLLUTION

None ---

Low — Source greater than a 500 m distance

Med — Source between a 100 and 500 m distance

High — Source less than a 100 m distance

COMMERCIAL FISHING (FISH CAUGHT FOR FOOD TO SELL, NOT INCLUDING LIVE FISH RESTAURANT TRADE)

None ---

Low — Less than once per month

Med — Less than once a week and more than once a month

High — Once a week or less

FISHING FOR THE LIVE FOOD FISH RESTAURANT TRADE

None ---

Low — Less than one fishing trip per month

Med — Less than one fishing trip per week and more than once per month

High — One fishing trip per week or less

ARTISANAL/RECREATIONAL FISHING (MAINLY FOR LOCAL CONSUMPTION)

None ---

Low — Less than one fishing trip per week

Med — More than one fishing trip per week, but less than daily

High — Daily fishing trips

LIST THE NUMBER OF YACHTS/MOTORBOATS TYPICALLY PRESENT WITHIN 1 KM OF THE REEF

None ---

Few — 1-5 per day

Med — 6-10 per day

Many — More than 10 per day

PROTECTION

Indicate if the area has any sort of protection from human usage (legal or otherwise), the level of protection and if this protection is enforced. Please check the listed activities that are banned at your site.

TEAM MEMBERS

IMPORTANT: Please record the name of the Team Scientist your team works with, even if they do not participate in this survey. In addition to the name of the person recording the data and the team leader, please list the names and nationalities of all team members

Belt Transect Instructions

The Reef Check CD includes this Instruction Manual as well as data sheets for each region; Caribbean, Pacific, Hawaii, Red Sea, Arabian Gulf). **IMPORTANT:** There two sets of sheets. There are field sheets for printing out and use during the survey and data sheets for inputting data and submitting to RC HQ. The only difference is that the computer data sheets include three extra columns. The extra columns have automatic “macros” in each cell that calculate mean, total and standard deviation of each row. It is important to choose the correct data sheets for your region. **Use the field sheet to print out your datasheets onto underwater paper or you can copy the design by hand using a permanent marking pen onto an underwater slate.**

Fish Belt Transect

The fish belt transect is the first survey completed because fish can easily be disturbed by divers. If you are doing repeated fish surveys, try to do them at a standard time e.g. between 9 and 10 am. In any case, it is important to note the time you conducted the survey on the datasheet. After the transect has been deployed, the divers should wait 15 minutes in a location away from the transect before starting the survey. This waiting period is necessary to allow fish to resume normal behavior after being disturbed by the divers deploying the transect. The maximum height above the transect to record fish is restricted to 5 m in the water column. This can be estimated as two body lengths including outstretched arms and fins.

Each diver assigned to count fish swims slowly along the transect counting the indicator fish. The diver then stops every 5 m, and then waits one minute* for indicator fish to come out of hiding before proceeding to the next 5 m stop point. The fish are counted while swimming and while stopped along the entire length of each 20 m transect. This is a combined timed and area restricted survey: four segments x 20 m long x 5 m wide = 400 m². As with each of the surveys, there are four 5 m gaps where no data are collected. At each depth contour, there are sixteen "stop-and-count" points, and the goal is to complete the entire 400 m² belt transect in one hour (see Figure 5).

Remember, a note should be made of any sightings of what are now becoming rare animals such as manta rays, sharks and turtles, but if these are off-transect records, they should be recorded at the bottom of the data sheet under "Comments." For teams in the Indo-Pacific, remember to include off transect records of humphead (Napoleon) wrasse and bumphead parrotfish as these species roam near reefs rather than being strictly resident species.

**Note the change in protocol: prior to 2006, fish counters waited for 3 minutes.*

Indicator fish

The indicator fish have been selected because they are typically shot out of reefs by spearfishing, removed as targets of cyanide fishing, and caught using hand-lines. Size minimums have been placed on two families of food fish (**> 30 cm for Grouper, > 20 cm for Parrotfish**). **Grouper and parrotfish smaller than these limits are not counted.** Given these limits and the magnifying effect of the water, divers should practice estimating sizes before attempting the fish surveys. When practicing, a measured 2.5 m colored wire or 2 cm diameter PVC pipe can be used to help estimate the 5 m belt transect width, however these tools can be difficult to carry in a current, and may scare some fish. Another method is to lay a 5 m wide line perpendicular to the start of each 20 m segment to help you to continuously re-adjust your estimates of width. A final method is to measure yourselves from your fin tips to you finger tips and use your body length lying horizontal in the water to help judge the width.

To practice estimating fish lengths, first make color copies of each fish picture of the correct size on large transparencies (used for overhead projectors) and tether these in the water column. A small fishing weight can be tied on to a hole made in the bottom edge of the transparency and a float can be attached to the top of the transparency so that it will float upright. A series of these photos can be set out along a test transect. A more basic method

is to make 20 and 30 cm sticks, 1 cm in diameter and set them out on the reef in a similar manner with a weight and float. If your slate is marked with a rule, this also can help you to estimate the 20 and 30 cm distances. **For each Grouper counted, a size estimate should be given in the specified section of the datasheet. Record size classes as 30-40 cm, 41 – 50 cm, 51-60 cm etc.**

We recommend that one diver records fish on each side of the transect at the same time, that is the buddy pair work together, both counting, one on each side handling a 2.5 m wide belt. Alternatively, one diver may conduct the survey for the whole 5 m belt. It is imperative that divers communicate with each other to avoid double counting fish that may swim across the transect line. Tally the fish on the slate using a vertical tick mark for each fish observed and after each four fish, draw a horizontal line through the four, thus creating easily counted groups of five next to the correct name and under the appropriate column (Figure 8). It is crucial to remember to keep the counts for each of the four segments of the transect separate and to avoid double counting by communicating with your buddy.

	0-20 m	25-45 m	50-70 m	75-95 m

Figure 8. Example of data recording for belt transects.

All of the fish to be counted within these fish belt transects are listed below. Photographs for the Caribbean, Indo-Pacific and Hawai'i regions are included in Appendix E. Other regions (Arabian Gulf and Red Sea) are available separately from Reef Check HQ.

Indo-Pacific

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Grouper/coral trout (>30 cm)	Serranidae	Parrotfish (>20 cm)	Scaridae
Barramundi cod	<i>Cromileptes altivelis</i>	Snapper	Lutjanidae
Butterflyfish (any species)	Chaetodontidae	Moray eel (any species)	Muraenidae
Humphead (Napoleon) wrasse	<i>Cheilinus undulatus</i>		
Bumphead parrotfish	<i>Bolbometopon muricatum</i>		
Grunts/Sweetlips/Margates	Haemulidae (e.g. <i>Plectorhincus spp.</i>)		

(Note: off-transect records of the two distinctive species of humphead wrasse and the bumphead parrotfish should be recorded as these species roam near reefs rather than being resident species).

Hawai'i

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Bluestripe snapper (Ta'ape)	<i>Lutjanus kasmira</i>	Jacks (Ulu)	Carangidae
Peacock grouper (Roi)	<i>Cephalopholis arus</i>	Parrotfish >20cm (Uhu)	Scaridae
Butterflyfish	Chaetodontidae	Snapper	Lutjanidae
Orangespine Unicornfish (Umauma-lei)	<i>Naso lituratus</i>	Moray eel (Puhi)	Muraenidae
Yellow tang (Lau'ipala)	<i>Zebрасoma flavescens</i>		
Yellow(fin) goatfish (Weke-ula)	<i>Mullodichthys vanicolensis</i>		

Atlantic

Common Name

Nassau Grouper (>30 cm)
 Other grouper (>30 cm)
 Grunts/Sweetlips/Margates
 Moray eel (any species)

Scientific Name

Epinephelus striatus
 Serranidae
 Haemulidae
 Muraenidae

Common Name

Butterflyfish (any species)
 Snapper
 Parrotfish (>20 cm)

Scientific Name

Chaetodontidae
 Lutjanidae
 Scaridae

Arabian Gulf

Common Name

Barramundi Cod
 Orange-spotted Grouper (>30cm)
 Other Grouper (>30cm)
 Grey Grunt (Yanam)
 Black Spotted Grunt (mutawa'a)
 Spotted Grunt (firsh)
 Dark Butterflyfish (egr'aisee)
 Arabian Butterflyfish (misht el-aroos)
 Longfin Butterflyfish (Anfooz)
 Humphead Wrasse

Scientific Name

Cromileptes altivelis
Epinephelus coioides
 Serranidae
Plectorhinchus sordidus
Plectorhinchus gaterinus
Plectorhinchus pictus
Chaetodon nigropunctatus
Chaetodon melapterus
Heniochus acuminatus
Cheilinus undulates

Common Name

Grunts/Sweetlips/Margates
 Butterflyfish
 Parrotfish (>20 cm)
 Snapper
 Moray eel

Scientific Name

Haemulidae
 Chaetodontidae
 Scaridae
 Lutjanidae
 Muraenidae

Red Sea

Common Name

Grouper (>30cm)
 Grunts/Sweetlips/Margates
 Broomtail wrasse
 Humphead wrasse
 Bumphead parrot

Scientific Name

Serranidae
 Haemulidae
Cheilinus lunulatus
Cheilinus undulates
Bolbometopon muricatum

Common Name

Butterflyfish
 Parrotfish (>20 cm)
 Snapper
 Moray eel (any species)

Scientific Name

Chaetodontidae
 Scaridae
 Lutjanidae
 Muraenidae

Invertebrate Belt Transect

When the fish belt transect is complete, the invertebrate team can then carry out the belt transect survey for invertebrates using the same belt transect that was used for the fish survey. Each belt transect is 5 m wide (2.5 m on either side of the transect line). The total survey area is 20 m x 5 m = 100 m² for each segment and 400 m² for one complete transect of 4 segments for each depth contour, (800 m² per complete survey including the two depths). The invertebrate survey is similar to the fish survey, however, the diver does **not** need to stop every 5 m but each diver should swim slowly along the transect counting the indicator invertebrates (Figure 9).

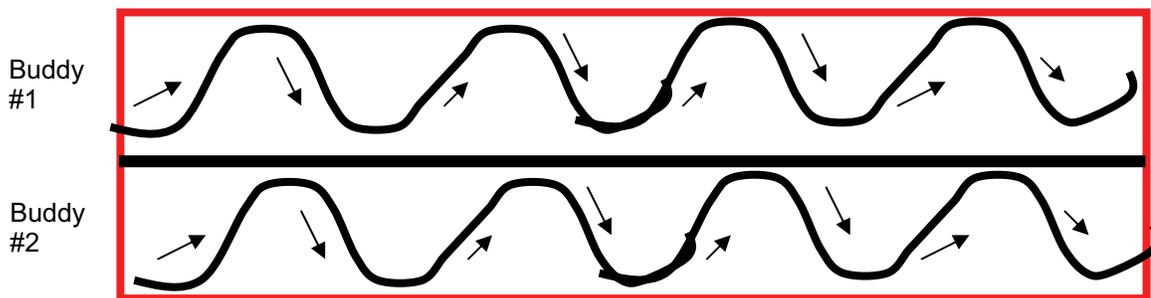


Figure 9. Divers should swim in an S-shaped pattern and search for the indicator invertebrates inside cracks or crevices on the reef.

It is best to adopt the face down, feet up position to ensure all parts of the transect are explored. It is extremely important to look in cracks and under large coral heads and overhangs to search for cryptic species such as lobster and banded coral shrimp. But do not pick up or move rocks or coral heads to look under them. We recommend that Buddy #1 records invertebrates on the left side of the transect while Buddy #2 surveys the right side. There are many other ways to perform this survey, each with its own advantages. Feel free to use the method that works best for you and your team.

All of the organisms to be counted within the invertebrate belt transects are listed below and photographs for your region are given in Appendix E. It is the responsibility of the Reef Check Trainer and Team Scientist to ensure that their team members are sufficiently prepared to identify the animals before surveys begin. See the section on Training in Chapter 2.

All Regions

Long-spined black sea urchin	<i>Diadema</i> (and <i>Echinothrix diadema</i> in Indo-Pacific)		
Banded coral shrimp	<i>Stenopus hispidus</i>		
Lobster (spiny and slipper/rock)	Malacostraca (Decapod)	Sea Egg/Collector urchin	<i>Tripneustes</i> spp.

Indo-Pacific

Giant clam (give size/species)	<i>Tridacna</i> spp.	Triton	<i>Charonia tritonis</i>
Edible sea cucumbers (3 species)		Crown of thorns starfish	<i>Acanthaster planci</i>
Prickly redfish	<i>Thelenota ananas</i>	Pencil urchin	<i>Heterocentrotus mammilatus</i>
Greenfish	<i>Stichopus chloronotus</i>		
Pinkfish	<i>Holothuria edulis</i>		

Atlantic

Pencil urchin	<i>Eucidaris</i> spp.		
Flamingo tongue	<i>Cyphoma gibbosum</i>	Triton	<i>Charonia variegata</i>
Gorgonian (sea fan, sea whip)			

Arabian Gulf

Black urchin	<i>Echinothrix diadema</i>	Cowries	Cypraeidae
Pencil urchin	<i>Heterocentrotus mammilatus</i>	Short Spine urchin	<i>E. mathaei</i>
Crown-of-thorns star	<i>Acanthaster planci</i>	Sea cucumber (edible only)	
Triton	<i>Charonia tritonis</i>		

Red Sea

Crown-of-thorns star	<i>Acanthaster planci</i>	Triton	<i>Charonia tritonis</i>
Giant clam	<i>Tridacna</i> spp.	Sea cucumber (edible only)	
Pencil urchin	<i>Heterocentrotus mammilatus</i>		

Hawai'i

Triton	<i>Charonia tritonis</i>	Cowries	Cypraeidae
Pencil urchin	<i>Heterocentrotus mammilatus</i>		
Crown-of-thorns star	<i>Acanthaster planci</i>		

Coral Disease/Bleaching, Trash and Coral Damage

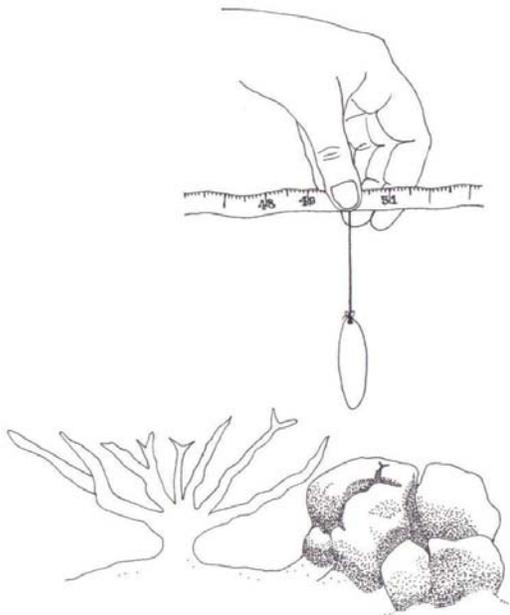
Each team records the level of bleaching and the presence of coral disease, trash and coral damage in the survey area. Corals that are still alive, but bleached should be recorded as live coral (HC) on the line transect. If bleaching is present, two estimates are made. First, teams estimate the percentage of all corals on the transect that are bleached. Second they estimate the mean percent of each individual colony that is bleached. For example, the estimate might be 30 out of 100 corals (30%) along the transect are bleached but of the

colonies bleached, the mean level of bleaching per colony is 80%. Please also indicate the date when bleaching started and maximum water temperature if known in the “Comments” section. Coral disease is noted as present or absent and the type of coral disease should be noted in the comment box (if identified). Note that many diseases are difficult to identify without a high level of training. All cases of suspected coral disease should be compared with the Reef Check ID cards and confirmed by the Team Scientist and if you have a camera – please take a photo. Indicate yes or no in the appropriate box on the data sheet and note the percentage of coral in the segment with disease. Trash is separated into general and fish nets/traps, while coral damage is separated into boat/anchor, dynamite, and other. Damage and Trash should be rated as the following: None = 0; one piece/damage per transect any type is Low = 1; two to four pieces/damage per transect is Medium = 2; and more than four pieces/damage is High = 3. **It is important to put zeros in these fields if there is no bleaching, disease, trash or coral damage noted.**

For the belt transects, team members are encouraged to look in holes and under overhangs to detect organisms, such as lobster and especially banded shrimp, that may be hiding.

Line Transect Instructions

When the invertebrate belt transect is almost completed, the next buddy pair can begin the line transect. We use a “point sampling” method for the substrate survey because it is the least ambiguous and fastest method and is easily learned by non-scientists. It involves recording the substrate type that lies directly below the tape at 0.5 m intervals i.e. at: 0.0 m, 0.5 m, 1.0 m, 1.5 m etc. up to 19.5 m (40 data points per 20 m transect segment).



To minimize bias, it is important to use a plumb line, which is a 5 mm diameter metal nut or other small metal object (e.g. a fishing weight) tied to a 1.5 m length of string. The weight is dropped at each sampling point and it lands on only one substrate type, which is recorded (Figure 10). This minimizes potential bias in what is counted, especially in cases where the tape is hanging above the substrate and swinging back and forth with the surge. Note, do not use fishing line for the plumb line as it will tangle easily. Use woven nylon or cotton string.

Figure 10. A 1.5 m plumb line is wrapped around the wrist and the plumb “bob” or weight is lowered quickly to the bottom. The diver records the type of substrate directly where the weight touches the bottom (*Illustration by Sarah Lowe*).

There is a space for each point sample result on the Field Line-Transect Sheet (Appendix F). Input the substrate category abbreviations in the appropriate space on the data sheet. **Each segment must have a total of 40 entries for the computer data sheet to automatically calculate results and charts. Therefore ensure that EVERY box is completed when you conduct your survey.**

There are many cases when the substrate type may be ambiguous. Please use the following guidelines to identify substrate types for Reef Check. **Note that these may differ from other definitions with which you are already familiar.**

Reef Check Guidelines For Categorizing Substrate Types

Hard Coral (HC): Live coral including bleached live coral. Also include fire coral (*Millepora*), and in the Indo-Pacific, blue coral (*Heliopora*) and organ pipe coral (*Tubipora*) because these are reef builders.

Soft Coral (SC): Include zoanthids, but not sea anemones (the latter go into "Other"). Sea anemones do not occupy space in the same manner as zoanthids or soft corals, which can compete with hard corals. In the Atlantic, this category is for zoanthids.

Recently Killed Coral (RKC): The aim is to record coral that has died within the past year. The coral may be standing or broken into pieces. RKC appears fresh and white *or* with corallite structures still recognizable (i.e. their structure is still complete/not yet eroded). Please write the estimated percentage of RKC that is the result of bleaching at the bottom of the data sheet.

Nutrient Indicator Algae (NIA): The aim is to record blooms of algae that may be responding to high levels of nutrient input. In 2006, the NIA definition was changed to include all algae except coralline, calcareous (such as *Halimeda*) and turf. Turf algae are defined as being shorter than 3 cm. When turf algae are present, record the substrate directly beneath the algae and note this in the Comments section.

Sponge (SP): All sponges (but no tunicates) are included. The aim is to detect sponge blooms that cover large areas of reef in response to disturbances.

Rock (RC): Any hard substrate whether it is covered in e.g. turf or encrusting coralline algae, barnacles, oysters etc. Rock also includes dead coral that is more than about 1 year old, i.e. is worn down so that few corallite structures are visible, and covered with a thick layer of encrusting organisms and/or algae.

Rubble (RB): Includes rocks between 0.5 and 15 cm diameter in the longest direction. If it is larger than 15 cm it is rock, if it is smaller than 0.5 cm it is sand.

Sand (SD): Particles smaller than 0.5 cm. In the water, sand falls quickly to the bottom after being dropped.

Silt/Clay (SI): Sediment that remains in suspension if disturbed. Note that these are practical definitions, not geotechnical. Often, silt is present on top of other indicators such as rock. In these instances, silt is recorded if the silt layer is thicker than 1 mm or covers the

underlying substrate such that you cannot observe the color of what is underneath. If the color of the underlying substrate can be discerned, then the contact will be counted as the underlying substrate NOT silt.

Other (OT): Any other sessile organism including sea anemones, tunicates, gorgonians or non-living substrate.

Additional tasks

Following the 1997-8 global coral reef bleaching event, it became clear that many very old large colonies of *Porites* were killed. If you would like to help us to track the remaining colonies, please record the longest diameter of the largest living *Porites* coral head on your survey and include this in the comments section.

Photography/video

Documenting the transect location, survey results, and findings using either still photos or videography both on land and in the water is very helpful to both teams and headquarters. We recommend taking one dozen or so above water photos in several directions showing the transect buoy locations lined up against whatever landmarks may be available for future reference.

We suggest making a video of the entire transect by swimming over it very slowly. For permanent records, we recommend taking a complete set of still photos of the transect using a camera equipped with a 28 to 35 mm lens, either mounted on a quadropod or held free. Additional video and photographs should be obtained of as many of the Reef Check parameters as possible, particularly various types of bleaching, disease or damage. All of these visuals will be important for future comparison and for presenting the results of your survey to the media. Please keep copies for your records and send a copy to Reef Check Headquarters.

We strongly encourage all teams to document their training, travel, survey, analysis and post-dive party and any PR/media events with still photos or video. A general video of the Reef Check survey and the site environment would be extremely useful to you for media presentations, and to HQ for our annual Press Conference. Please send team photos/video of your Reef Check team "in action". We will feature these in our newsletters, reports and publications in order to bring attention to the coral reef crisis and how Reef Check is part of the solution.

Recording transect location

We would like you to record the location of your transect on our Site Description Form using either of the following methods:

1. GPS
2. Maps

1. GPS

Recording the latitudinal and longitudinal coordinates of your survey sites is essential if your data are to be included in a spatial database. You can use a Global Positioning System (GPS) or a detailed chart to obtain these coordinates measured in degrees, minutes and seconds. These coordinates can also be very useful in finding the start of your transect for

future surveys. Please note that GPS have become much more accurate lately, however in the past there may still be an error of up to 15m depending on conditions and the unit used. If you record the coordinates in a format other than degrees, minutes, and seconds (e.g. degrees, minutes; degrees), please indicate this on the Site Description Form. Bearings to landmarks should also be recorded for your future reference in case the GPS was not set up properly and has given false readings. Teams without a GPS should obtain the most detailed chart of the area available and record the coordinates of the transect location in degrees, minutes and seconds. In this case, please include the map projection (e.g. WGS 84) and the type of map. **We cannot use your data unless you record the location accurately.**

Using a GPS

Check the datum that is being used by the GPS. A datum is a point on the earth's surface that is used to anchor a map. A commonly used and recommended datum is WGS-84. The datum used by your GPS will have been chosen when you originally set it up. You should be able to retrieve the datum from the GPS by going through the set-up procedures and checking the entry for datum. The latitudes and longitudes will differ based on the datum being used.

GPS units

Latitude and Longitude coordinates in the Reef Check database are in units of Degrees, Minutes, Seconds. We require all teams to submit their GPS coordinates in these units. Most GPS have an option that displays position in degrees, minutes, and decimals (10th minutes). So please ensure that the GPS is set up properly. If your coordinates are in units of Degrees, Minutes and Decimals (10th minutes), simply multiply the fraction of minutes by 60 to get seconds. For example 3 Degrees 10.25 minutes North would be 3 Degrees 10 Minutes 15 seconds North ($0.25 \times 60 = 15$ seconds).

Using Charts/Maps

Check the chart/map projection upon which the chart/map is based. A projection is a method that cartographers use to display the round globe in a flat plane. Depending upon what projection is used, it will affect where a point will appear on different maps. Map projection is usually written in small print at the bottom of the map or near the scale bar. A typical nautical map's projection is Mercator. Underneath the projection may be information such as a spheroid name (e.g. Clarke) and a datum name (e.g. WGS-84). Write down all the information listed on the map.

2. Drawing maps

For re-surveys, maps are invaluable to help you find permanent transect markers or the same habitat area (as surveyed previously) for stratified random sampling. It is useful to attach a surface marker buoy at the start and end points of the transect then note the position of these buoys in relation to landmarks. For stratified random sites it may also be useful to map underwater features and landmarks to help locate where previous transects were laid in order to make it easier for future teams to find the correct habitat for a re-survey. For example, a map that specifies the depth and a compass bearing to the start point and the transect direction from an underwater feature e.g. a mooring block or boulder coral should be sufficient as long as you can find the correct starting point from the surface.



Post Dive Tasks, Data Entry, Data Reporting and Quality Assurance

Data Entry

The Team Scientist is responsible for data checking, analysis and submission of data. Team members should assist with this activity. Data checking and quality assurance are critically important parts of Reef Check.

The first level of data checking is performed at the site immediately following the dive. The Team Scientist should examine the data and request clarifications on illegible entries and records that seem to be outliers or differ from what was observed. Checking the data at this stage is best because it is still fresh in the data collector's mind. The second level of data checking is for the Team Scientist to compare the spreadsheet entry into the computer with the hand written original data. **Both the person who inputs the data into the spreadsheet and a second person (e.g. the Team Scientist) should check them independently.** We will perform a third error check at Headquarters. The complete Quality Assurance procedures are listed in Appendix C.

It is possible to either enter your data onto Excel spreadsheets and email (or fax/post) them to Reef Check Headquarters, or enter your data online onto our WRAS database data forms. See www.reefcheck.org/datamanagement and follow instructions online.

If you are using the Excel spreadsheets, the advantage of these data forms is that we have built-in macros to calculate the mean, standard deviation, standard error and totals for parameters of interest. All you need to do is to fill in the raw data, and the calculations will be made automatically. This allows: 1) a quick check to see that the spreadsheets were filled in correctly and 2) immediate feedback so you can discuss the results with your team.

Simply fill in the spreadsheets making sure to fill in all boxes that have a black outline around them. It is **EXTREMELY IMPORTANT** to put **ZEROS** in boxes where no organisms were found. Blank boxes are treated as **MISSING DATA** in the Reef Check global database.

After all data have been entered into the Reef Check Excel spread sheets, the data need to be double checked to ensure no errors are present. Please make sure all information is filled out on the Site Description Form and that the site name and date correspond to those on the Substrate and Belt Transect Data Entry Sheets. The formulas (macros) programmed into the Substrate Data Entry Sheet will indicate if data were entered correctly. Please make sure all 4 segments have a total of 40 entries as calculated by the macros on the bottom of the Substrate Data Entry Sheet. **We will not accept data if the substrate totals do not add up to 40 for each segment.** Make sure all entries are filled out on the Belt Transect Data Entry Sheet with special emphasis on ZEROS to indicate organisms that were not seen. If you do not have access to Excel, you should request a hard copy of the data forms from Headquarters, and fax or email a copy of your results to us.

Data should be entered as soon as possible into the Reef Check Excel spreadsheets. Your Reef Check Coordinator will have these or they can be obtained from rcdata@reefcheck.org or from <http://www.reefcheck.org/methods/instructions.asp>. The Team Scientist will organize this process, however, this activity is meant to be a team effort.

The files you will be using for data entry are:

Site description: *Site description.xls*

Inverts, impacts and fish: *Belt transect (fish and inverts).xls*

Substrate: *Line transect (substrate).xls*

Each of these files contains spreadsheets in which to enter your data (go to the DATA worksheet). The spreadsheet will automatically calculate some basic statistics on your data and will automatically make some graphs (on the GRAPHS tab). They also contain field sheets for you to print out onto underwater paper (go to FIELD SHEET).

Substrate

To aid accurate data entry, the spreadsheet design includes codes for parameters such as "HC" for hard coral (Figure 11). In addition, some equations are embedded in the spreadsheets to automatically calculate results such as column totals and percent cover. Since there are a preset number of data points, it is easy to determine if an incorrect number of entries have been recorded. Double check that the Totals box at the bottom of each column equals 40 because this is the total number of points you should have counted on each 20 m transect. If the totals DO NOT equal 40 then you have made an error when entering one of the codes e.g. put RCK instead of RKC for recently killed coral.

When you have entered all your data and the survey details on the "data" worksheet, go to the "graphs" worksheet. Here you will see the percent cover of each of the substrate codes and the Standard Error (SE) values automatically calculated. There will also be a selection of graphs of your data. You can choose which ones you want to use if you want to present your results. All you need to do is put the title on the graphs (Figure 12).

Don't forget to fill in the survey details!

Site name: _____ Country/Island: _____
 Depth: _____ Date: _____
 TS/TL: _____ Data recorded by: _____
 Time: _____

Substrate Code

HC	hard coral	SC	soft coral	RKC	recently killed coral
NIA	nutrient indicator algae	SP	sponge	RC	rock
RB	rubble	SD	sand	SI	silt/clay
OT	other				

(For first segment, if start point is 0 m, last point is 19.5 m)

	SEGMENT 1 0 - 19.5 m			SEGMENT 2 25 - 44.5 m			SEGMENT 3 50 - 69.5 m			SEGMENT 4 75 - 94.5 m					
0	HC	10	RC	25	HC	35	HC	50	RC	60	HC	75	RC	85	HC
0.5	HC	10.5	RC	25.5	HC	35.5	HC	50.5	RC	60.5	HC	75.5	RC	85.5	HC
1	NIA	11	RC	26	HC	36	HC	51	RC	61	HC	76	RC	86	HC
1.5	SD	11.5	OT	26.5	SC	36.5	SC	51.5	OT	61.5	SC	76.5	NIA	86.5	SC
2	SD	12	SC	27	RC	37	RC	52	RKC	62	RKC	77	RB	87	RC
2.5	HC	12.5	SC	27.5	HC	37.5	HC	52.5	RKC	62.5	RKC	77.5	RB	87.5	HC
3	OT	13	SP	28	RKC	38	OT	53	RKC	63	RKC	78	SP	88	OT
3.5	RC	13.5	SP	28.5	RKC	38.5	RC	53.5	SP	63.5	RC	78.5	NIA	88.5	RC
4	OT	14	HC	29	RKC	39	OT	54	HC	64	OT	79	NIA	89	OT
4.5	NIA	14.5	HC	29.5	SD	39.5	OT	54.5	RC	64.5	RKC	79.5	NIA	89.5	OT
5	NIA	15	RKC	30	SD	40	SC	55	RC	65	RC	80	RKC	90	SC
5.5	NIA	15.5	RKC	30.5	SD	40.5	SC	55.5	SP	65.5	RKC	80.5	RC	90.5	NIA
6	SP	16	RKC	31	RB	41	SP	56	RC	66	SP	81	RKC	91	NIA
6.5	SP	16.5	RKC	31.5	RB	41.5	SP	56.5	RC	66.5	SP	81.5	SC	91.5	NIA
7	SI	17	RC	32	RB	42	SI	57	NIA	67	SI	82	SP	92	SI
7.5	SI	17.5	HC	32.5	RB	42.5	SI	57.5	SP	67.5	SI	82.5	SP	92.5	SI
8	SI	18	SI	33	SI	43	SI	58	SI	68	SI	83	SI	93	SI
8.5	SI	18.5	SI	33.5	SI	43.5	SI	58.5	SI	68.5	SD	83.5	SI	93.5	SI
9	SI	19	SI	34	SI	44	SI	59	SI	69	SD	84	SI	94	SI
9.5	SI	19.5	SP	34.5	SI	44.5	SI	59.5	SP	69.5	SI	84.5	SP	94.5	SI

Enter substrate codes here

DO NOT TYPE DATA BELOW THIS LINE

Total S1	Total S2	Total S3	Total S4	Grand total
HC 6	HC 8	HC 4	HC 4	HC 22
SC 2	SC 4	SC 1	SC 3	SC 10
RKC 4	RKC 3	RKC 8	RKC 2	RKC 17
NIA 4	NIA 0	NIA 1	NIA 7	NIA 12
SP 5	SP 2	SP 6	SP 4	SP 17
RC 5	RC 3	RC 9	RC 6	RC 23
RB 0	RB 4	RB 0	RB 2	RB 6
SD 2	SD 3	SD 2	SD 7	SD 14
SI 9	SI 10	SI 7	SI 9	SI 35
OT 3	OT 3	OT 2	OT 3	OT 11
# 40	# 40	# 40	# 40	160

Mean	SD
HC 5.5	HC 1.91
SC 2.5	SC 1.29
RKC 4.25	RKC 2.63
NIA 3	NIA 3.16
SP 4.25	SP 1.71
RC 5.75	RC 2.5
RB 1.5	RB 1.91
SD 1.75	SD 1.26
SI 8.75	SI 1.26
OT 2.75	OT 0.5

TOTALS MUST = 40 FOR EACH SEGMENT

Comments: _____

PLEASE TURN TO THE GRAPHS TAB

Check each segment total =

Figure 11: The data worksheet for the substrate computer Excel file.

PLEASE SELECT WHICH GRAPHS YOU WANT TO USE FROM THE FOLLOWING OPTIONS AND COMPLETE THE TITLE WHERE INDICATED IN RED

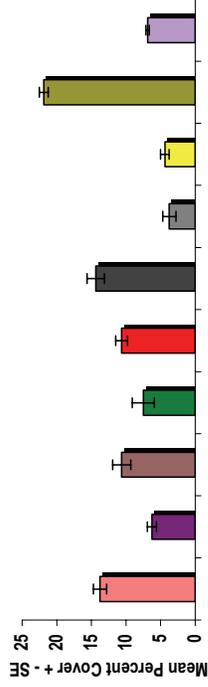
	%	SE
HC	13.75	0.9574271
SC	6.25	0.6454972
RKC	10.625	1.3149778
NIA	7.5	1.5811388
SP	10.625	0.8539126
RC	14.375	1.25
RB	3.75	0.9574271
SD	4.375	0.6291529
SI	21.875	0.6291529
OT	6.875	0.25

Check the
Total = 100

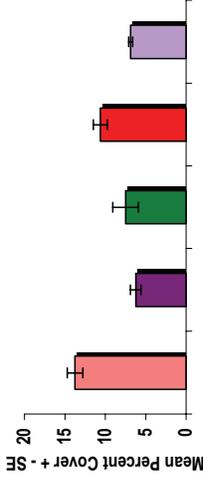
Live reef cover	%	SE
HC	13.75	0.9574271
SC	6.25	0.6454972
NIA	7.5	1.5811388
SP	10.625	0.8539126
OT	6.875	0.25

Non-living reef cover	%	SE
RKC	10.625	1.3149778
RC	14.375	1.25
RB	3.75	0.9574271
SD	4.375	0.6291529
SI	21.875	0.6291529

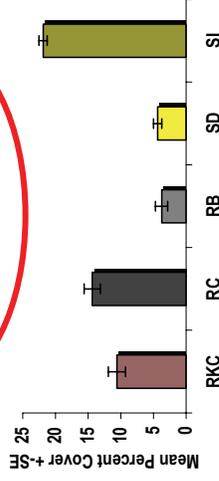
Mean Percent Cover Of Substrate For <<RC Reef name, depth and date>>



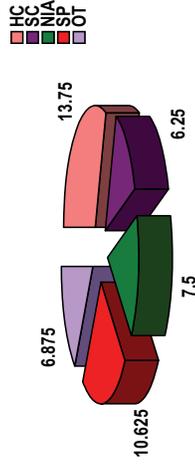
Mean Percent Living Cover For <<RC Reef name, depth and date>>



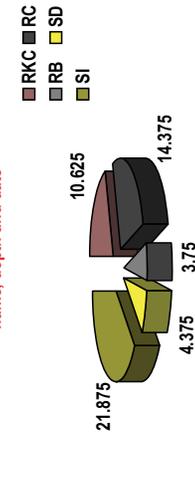
Mean Percent Non-Living Cover For <<RC Reef name, depth and date>>



Mean Percent Living Cover For <<RC Reef name, depth and date>>



Mean Percent Non-Living Cover For <<RC Reef name, depth and date>>



All you have to do is put the title information on the graphs. You can then copy and paste them into a document for presentation to your team and local stakeholders.

Figure 12. The graphs worksheet for the substrate Excel file.

Fish, Invertebrates and Impacts

As with the substrate form, totals and statistics are automatically calculated for you in the “data” worksheet (Figure 13) and graphs are automatically made for you in the “graphs” worksheet (Figure 14). Remember to put zeros in where you did not see an indicator organism or an impact. A zero is a very important data point since it is often an indication of human impacts.

Don't forget to fill in the survey details!

Site Name:					Country/Island:		
Depth:					Team Leader:		
Date:					Time:		
Fish							
<i>Data recorded by:</i>							
	0-20m	25-45m	50-70m	75-95m	Total	Mean	SD
Butterflyfish	4	14	7	5	30	7.5	4.509
Haemulidae	3	1	1	5	10	2.5	1.915
Snapper	2	0	2	5	9	2.25	2.062
Nassau grouper*	5	0	1	3	9	2.25	2.217
Grouper*	4	3	4	1	12	3	1.414
Parrotfish	5	4	1	2	12	3	1.826
Moray eel	6	5	1	1	13	3.25	2.63
<i>*give size in "grouper size" field at bottom</i>							
Invertebrates							
<i>Data recorded by:</i>							
	0-20m	25-45m	50-70m	75-95m	Total	Mean	SD
Banded coral shrimp	3	1	0	1	4	1	1.414
Diadema	2	1	0	0	3	0.75	0.957
Pencil urchin	4	1	0	0	5	1.25	1.893
Triton	3	1	6	1	11	2.75	2.363
Flamingo tongue	2	4	7	0	13	3.25	2.986
Gorgonian	2	3	1	0	6	1.5	1.291
Collector urchin (Sea egg)	2	0	1	1	4	1	0.816
Lobster	1	0	1	1	3	0.75	0.5
Coral Disease/ Bleaching//Trash/Other							
	0-20m	25-45m	50-70m	75-95m			
Coral damage: Boat/Anchor	1	0	0	1	2	0.5	0.577
Coral damage: Dynamite	2	0	2	0	4	1	1.155
Coral damage: Other	1	1	2	0	4	1	0.816
Trash: Fish nets	1	0	1	1	3	0.75	0.5
Trash: General	1	0	0	1	2	0.5	0.577
Bleaching (% of coral population)	5	20	10	5	40	10	7.071
Bleaching (% of colony)	50	10	50	50	160	40	20
	0-20m	25-45m	50-70m	75-95m			
Grouper sizes (cm) (put average size)	30	60	40	30	160	40	14.14
Coral Disease (% of coral affected if yes)	10	5	3	2	20	5	3.559
Rare animals sighted (type/#)							
Comments:							

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Figure 13. The data worksheet for the belt Excel file.

Fish	Mean	SE
Butterflyfish	7.5	2.2546249
Haemulidae	2.5	0.9574271
Snapper	2.25	1.0307764
Nassau grouper	2.25	1.1086779
Grouper	3	0.7071068
Parrotfish	3	0.9128709
Moray eel	3.25	1.3149778

Invertebrates	Mean	SE
Banded coral shrimp	1	0.7071068
Diadema	0.75	0.4787136
Pencil urchin	1.25	0.9464847
Triton	2.75	1.1814539
Flamingo tongue	3.25	1.4930394
Gorgonian	1.5	0.6454972
Collector urchin	1	0.4082483
Lobster	0.75	0.25

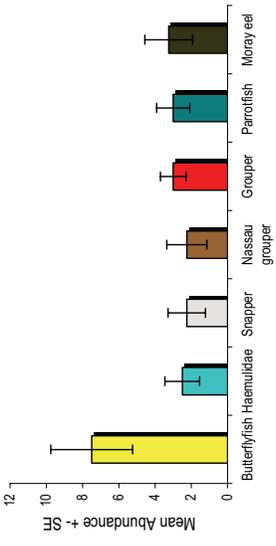
Impacts	Mean	SE
Boat/Anchor	0.5	0.2886751
Dynamite	1	0.5773503
Other coral damage	1	0.4082483
Fish nets	0.75	0.25
Trash	0.5	0.2886751

Bleaching % of population	Mean %
% Bleached	10
% Not Bleached	90

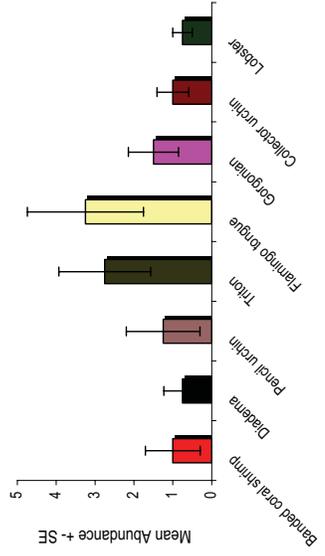
Bleaching % of colony	Mean %
% Bleached	40
% Not Bleached	60

Coral disease % of coral with disease	Mean %
% Diseased Coral	5
% Healthy Coral	95

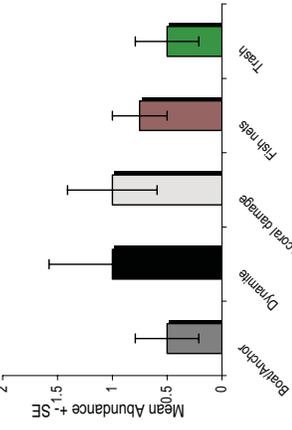
Mean Fish Abundance For <<RC Reef name, depth and date>>



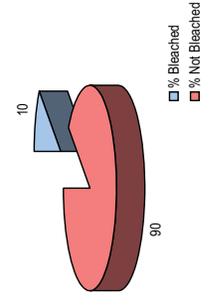
Mean Abundance Of Invertebrates For <<RC Reef name, depth and date>>



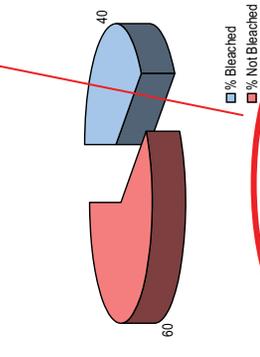
Abundance Of Impacts For <<RC Reef name, depth and date>>



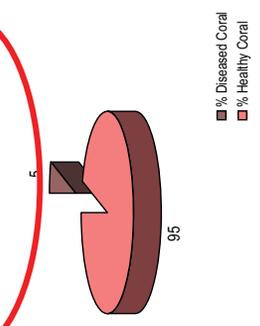
Estimated Percentage Of Coral Population Affected By Bleaching For <<RC Reef name, depth and date>>



Estimated Percentage Of Coral Colony Surface Affected By Bleaching For <<RC Reef name, depth and date>>



Estimated Percentage Of Coral Population Affected By Disease For <<RC Reef name, depth and date>>



All you have to do is put the title information on the graphs. You can then copy and paste them into a document for presentation to your team and local stakeholders.

Figure 14 The graphs worksheet for the belt Excel file.

Data analysis

The basic statistics that the spreadsheet calculates for you include the mean (average) percentage cover for the substrate survey and the mean abundance of invertebrates, impacts and fish. The Standard Deviation (SD) and Standard Error (SE) are also calculated for you. These statistics are useful when interpreting the data you have collected.

Standard Deviation

The Standard Deviation (SD) tells us how widely the distribution of observations is distributed around the mean, i.e. how variable our observations are. SD does not, however, tell us how closely the sample mean estimates the population mean.

Standard Error

Standard error (SE) tells us how accurately a sample mean estimates the population mean (the population is what is actually on the reef, the sample is the part of the reef we surveyed – in a survey our aim is to obtain a sample that represents the true population). The higher the SE, the less our sample accurately portrays the real world. We can reduce the SE by increasing the size of our sample, i.e. doing more Reef Check surveys at a site. See how to use Reef Check for long-term monitoring in Chapter 6 to find out how many surveys you should do.

The lines on the graphs are “standard error bars” and they tell us how variable our data is along our 4 transect segments. Where these SE error bars overlap with one another, the differences in species or impact abundance are not statistically significant (regardless of how different the means may be). Where these SE error bars do not overlap, the differences in species or impact abundance may be statistically significantly different. See Figure 14 as an example of a Reef Check graph with error bars.

Data Checking

The Team Scientist is responsible for gathering the slates and data together as soon as the survey is completed and reviewing them immediately with the team members. The purpose is to make a quick assessment of the data to determine if some error has been made that can be corrected while the team is still on site, and the transect is in place. Typical errors that could be corrected would be "double-counting" of fish, misidentification of organisms or mislabeling the slate. When an error is suspected, the Team Scientist should accompany the data recorder in the water to check or to correct it.

Before departing from the site, the Team Scientist is responsible for ensuring that all required data have been collected, and that the slates have been filled out properly to include the names of the team members who collected each bit of data. This will allow the Team Scientist to check with the responsible party if an error is detected later. This is a good time to consolidate data from multiple slates to avoid later confusion.

Data File Names

Due to the large number of data files received by Reef Check, we ask you to adhere to the following file-naming format to help us keep track of all submissions.

All file names should have the following format:
site name, date (dd-mm-yy), datasheet type (site, belt, or line), depth (s or m for shallow, 2 – 6 m, or medium >6 – 12 m).

Site Description Form should just have: site name date (dd-mm-yy) site

For example, if we did a survey at Paradise Reef on December 13, 2002 at 3m and 11m, we would have the following file names:

Paradise 13-12-02 site
Paradise 13-12-02 belt s
Paradise 13-12-02 belt m
Paradise 13-12-02 line s
Paradise 13-12-02 line m

Note that there are 5 files associated with a complete Reef Check survey done at two depths at one site.

Sending the Data to Reef Check

When all data have been double checked for accuracy, the Excel files should be sent to Reef Check Headquarters at rcdata@reefcheck.org within ten days of your survey.

What more can you do?

If you have finished one survey and are able to do more, we welcome surveys at additional sites. The results will help to gain a more accurate assessment of reef health. The more sites that are surveyed as part of Reef Check the more complete our picture will be of the status of the world's reefs. We do realize that some of you would like to carry out more detailed surveys. If so, we recommend you try GCRMN methods described in English et al (1997) and Hill and Wilkinson (2004).

A new Reef Check Plus protocol is also available from HQ. It involves measuring size and abundance of the top ten food fish families and abundance of coral recruits (new colonies).

For those interested in the marine aquarium trade, Reef Check has designed the MAQTRAC protocol, a highly intensive, three-tier system (Hodgson and Ochavillo, 2006).

Long-Term Monitoring Using Reef Check

Before embarking on an ecological monitoring program, it is important to define the objectives. The monitoring program can then be designed to fulfill those objectives. If the purpose of monitoring is to assist resource managers, then a number of important questions should be considered during the design process. Once these questions have been answered, a useful, cost-effective monitoring program can be set up.

The Role of Reef Check

A major goal of a coral reef monitoring program is to provide the data required for management. As more Marine Protected Areas (MPAs) are established, it is becoming increasingly important to monitor whether they are achieving their management goals. MPAs will fail without community support. Involving the community in monitoring builds public support for management initiatives. The Reef Check coral reef survey program is carried out by volunteers from the community, and is thus a useful tool in building public support for government and NGO coral reef conservation efforts. The publicity generated from the survey activities can also be particularly useful in raising public awareness and rewarding government agencies, companies and NGOs for their support.

To be useful, Reef Check should be carried out every year with sufficient replication (number of sites) to provide a comprehensive view of the reefs of interest. There are tradeoffs between investing in more replication at different geographic and temporal scales. For example, quarterly surveys at one location will provide a more accurate picture of reef health – particularly with respect to highly mobile fish. But this may limit the number of locations that can be surveyed and thus give a biased picture of the overall health in the region. Ideally, a long-term monitoring plan should be developed at the local and national level so that monitoring resources can be allocated in a logical design that best supports management goals.

Standard Reef Check alone is not sufficient to provide a complete picture of coral reef health. Ideally, a long-term monitoring plan should include both Reef Check and some more taxonomically detailed surveys such as Reef Check Plus, GCRMN or MAQTRAC that would include e.g. fish families, fish size estimates, coral genera, and coral colony sizes. Some useful techniques are presented in English et al. (1997) and are recommended by the Global Coral Reef Monitoring Network (GCRMN) and Hill and Wilkinson (2004). Unfortunately, such detailed surveys require teams of highly trained

scientists and are more time consuming and costly than Reef Check. In most countries, an initial goal of establishing a network of Reef Check sites alone is already a serious challenge. Therefore, for most areas/countries, we recommend setting up a network of Reef Check sites as a first step towards a local or national monitoring program. When this network can be successfully funded and maintained for two years, then sites where more detailed monitoring is carried out can be added as financial and scientific personnel become available. A good example of how effective this program can be is the Reef Check Hong Kong program. Their website shows all aspects of this success: www.afcd.gov.hk/conservation/english/corals_reefcheck1.htm

It is interesting to note that some scientists who have traditionally been involved in taxonomically detailed ecological monitoring programs may initially object to allocating funding for Reef Check surveys, which they may consider too broad-brush to be scientifically meaningful. In addition, despite published evidence from detailed studies (Harding et al. 2002), some scientists still do not believe that volunteers can collect reliable data. It is important to reassure these scientists that their skills are still needed, but given the usual scarcity of resources, they need to use their skills at specific sites and for specific reasons. A highly efficient use of scarce resources occurs when Reef Check is used as an “early warning system.” More detailed surveys by scientific teams can be done when a particular problem such as siltation or algal invasion are detected. Managers should recognize that academic scientists typically measure a large number of ecological parameters – many of which are not useful for management. If scientists are allowed to dominate the design of a long-term monitoring program, then resources can be wasted in overly detailed monitoring without regard to resource constraints or management goals. By including coral reef managers such as MPA staff and other stakeholders such as fishermen in the planning process for a long-term monitoring program, questions can be asked regarding the cost-benefit of various sampling designs. Managers should not be shy about challenging scientists on the value of monitoring certain parameters.

A number of issues must be considered when using the Reef Check protocol for long-term monitoring. The most important are taxonomic specificity, temporal and spatial replication. There will never be an “off-the-shelf” long-term monitoring program. Each location has specific needs and resources that will require a custom design. An “ideal” two-level monitoring program would have a few high-resolution sites using methods such as English et al. (1997) or MAQTRAC, and a larger number of lower resolution Reef Check sites. In a two-level monitoring program Reef Check has several roles. First, it is a relatively fast method that allows a team to gather a snapshot of the health of reef corals, other invertebrates and fish at up to two sites per day. As more sites are surveyed in a particular area, the resolution of the snapshot is increased. Because Reef Check is based on major inputs from volunteers, with modest government and NGO support, Reef Check teams can be mobilized to survey many more sites than is possible with more intensive methods which are much more costly in time, staff and funding. In addition, the Reef Check sites can be resurveyed more frequently than the high-resolution sites. If Reef Check surveys are repeated at quarterly intervals, they can then act as an early warning system for major anthropogenic changes such as bleaching, blast or poison fishing, overfishing, eutrophication and sedimentation.

In addition to providing timely information to reef managers, a second role of Reef Check is to build up community support for a coral reef monitoring and management program in each area. Without such support, even well-funded, government-led management efforts

will fail. By participating in Reef Check training, fundraising, and surveys, community members develop a sense of stewardship towards the reefs they are monitoring. What is particularly important about this ideological transformation is that it may involve businessmen, politicians, artists etc. These are people who may not originally have had a particularly strong interest in conservation, and who can then spread their educational experience throughout society. There also are large rewards for scientists who volunteer to help train the survey teams. By taking the time to explain to members of the public why coral reefs are important, scientists are able to show why coral reef science and ecology in general are important to society. While many scientists are already involved in some form of community education, others are not. This type of interaction generates public support for coral reef science and for scientists who carry out basic research.

It is important for all potential Reef Check users to recognize that **the core methods are not flexible and cannot be changed**, however, Reef Check teams can always add parameters as needed for local use. Standardization allows Reef Check data to be compared from sites anywhere in the world. Reef Check is the only globally standard coral reef monitoring program. While the methods were designed to be used by volunteers, they have been used in many parts of the world by teams of pure scientists. Some teams collect detailed data and then extract the core data and submit them to Reef Check for inclusion in the global database and annual report. As more parameters and/or specificity are added to the core Reef Check protocol, the designer must try to strike a balance between the need to obtain “useful” data, the ability of the volunteer team members, and the potential to bore or “burn them out.” If more than a few additional species level identifications are added, pre-testing should be used to ensure that the volunteers are capable of identifying all organisms accurately. The success of Reef Check depends on it remaining an enjoyable experience for volunteers. When data are submitted to HQ, only the core standard data should be included as these are the parameters that Reef Check analyzes.

If a Reef Check site is monitored once per year, this level of temporal replication is typically sufficient to characterize changes in reef corals and other sessile invertebrates. If there is sufficient manpower, this may be increased to twice per year to get a more accurate view of temporal fluctuations. For mobile invertebrates and reef fish, however, this frequency of replication is generally too low for a meaningful stock assessment at one site (but when repeated at many sites, the snapshot becomes very meaningful). It is important to recognize that the sample size used in one Reef Check survey is robust with respect to the parameters measured. What allows the survey to be carried out quickly is that there are relatively few parameters measured and no temporal replicates. To use Reef Check protocol for long-term monitoring of fish and mobile invertebrates, additional temporal replicates should be made of the fish and invertebrate belt transects. A pilot study can be carried out to determine the variability of fish and invertebrate populations at a given location. Recent studies indicate that three to five replicate (full) surveys are sufficient to achieve a stable picture of conditions at individual reefs (Myers et al., submitted).

The core methods include four spatial replicates along the transect line. There are two transects monitored per site for a total of eight replicate segments. Given the low taxonomic specificity in the methods (typically family level), these replicates are sufficient to capture variability within one site, and the overall 100 m length of the sample is robust. However, it is desirable to measure variability at several sites within “the area of

interest.” Thus for long-term monitoring within e.g. a 1 km long reef, a set of three to five sites should be used.

The core methods include two transects with the deepest located at a maximum allowable depth of 12 m. The Reef Check program generally does not accept data obtained from deeper areas for two reasons: safety considerations and the fact that reefs do not extend below this depth in many parts of the world making regional and global comparisons difficult. However, in areas where it is important to record information at greater depths, a third or fourth transect could of course be monitored and the information used locally. Although these data will not be included in the annual Reef Check report, they could be submitted directly to ReefBase (www.reefbase.org).

Designing a Monitoring Program

The design of a practical, useful monitoring plan involves art as well as science. There is no one correct design, but there are many incorrect ones. A poorly designed monitoring plan can be costly, wasteful, and may produce meaningless, misleading or incorrect results. To avoid these pitfalls, it is essential to follow a rigorous design process that includes consideration of a series of questions about the purpose and content of the project, as well as a detailed review of available data and/or a pilot study to determine key factors. While it may not be possible to answer all the questions posed, it is important to at least define what is not knowable. As part of the monitoring plan, it is often useful to consider drafting a flexible Action Plan, which lists what specific management activities may be undertaken if a particular change is detected in the ecosystem. By discussing these “What if?” scenarios, it is possible for a group of knowledgeable people to come up with a realistic Action Plan.

While there is good advice available on the many methods available for coral reef monitoring, surprisingly little has been written on the subject of how to choose a suite of methods to design a complete monitoring and audit program for reefs that will provide the information needed to manage them. A major vacuum is in the area of how to interpret various types of results and what management actions are feasible. The subject of sampling design and statistics for environmental biologists is thoroughly covered by Green (1979). The application of EIA techniques to coastal areas is reviewed by Carpenter and Maragos (1989). The results of a conference on monitoring methods include much useful information (Crosby et al. 1996). Oxley (1997) has presented a summary of important design considerations with respect to coral reefs. Short but useful guidance is given in the UNEP publication “Staff Training Materials for the Management of Marine Protected Areas,” especially Training Session 8.2 (Kenchington and Looi, 1994). Several other UN publications on monitoring include Stoddart and Johannes (1978), Dahl (1981), UNESCO (1984), UNEP/IAEA/IOC (1991), UNEP (1993), UNEP/AIMS (1993). Methods for use in the Caribbean are described by CARICOMP (1991), Rogers (1993) and Aronson et al. (1995). Those for the Great Barrier Reef are detailed in Oliver et. al, (1995). An extensive menu of marine monitoring methods for both reefs and non-reef areas in the Pacific is provided in English et al, (1997) and a global overview by Hill and Wilkinson (2004). The use of volunteers and non-professionals in monitoring programs was reviewed by Wells (1995).

There is much literature on ecological sampling design and statistical analysis. Numerous publications by A.J. Underwood and colleagues at Sydney University have

covered the statistical aspects of using complex sampling designs such as “before-after, control-impact” or BACI, that meet the assumptions of parametric statistics, particularly ANOVA (e.g. see Underwood, 1993). BACI designs tend to be very complex and can be costly, however, they are rigorous. As an alternative, R.M. Warwick and colleagues at Plymouth Marine Laboratory, UK have promoted the use of multivariate statistical designs, particularly ordination, as a basis for analysis that allows the sampling design to be relatively simple and inexpensive. Their publications and the instruction manual for their Primer statistical package contain much useful advice (Clarke and Warwick, 2001). The final choice of a sampling design for a given location will depend on the objectives defined by the government, and the resources available. To begin to consider which monitoring design will be most suitable for a given location, it is helpful to discuss the following questions:

What resources are available to support the monitoring program?

All governments have limited resources available to support a coral reef monitoring program. At most, a few sites can be monitored intensively by existing government researchers. By using volunteer labor in combination with state workers, consultants and academics, the value of government investment in monitoring and management will be increased many times. In addition, by using volunteers, particularly students or community groups, it is possible to attract cash and in-kind cost-sharing for training, surveys etc. In any given year, Reef Check teams leverage several million dollars in support globally.

What are the temporal and spatial scales of interest?

It is safe to assume that the scale of interest to most people is the condition of their favorite dive or fishing site. While it would be a mistake to only choose monitoring stations based on usage, it is not possible, nor sensible, to monitor equally everywhere. It is also impossible, and would not be sensible, to monitor all locations at the same frequency. Sites that are subject to continuous impacts from tourists and divers should be monitored at more frequent intervals – certainly once per month in some cases. Sites where impacts are not expected at frequent intervals could be surveyed once or twice per year for coral, and quarterly for fish and mobile invertebrates.

What natural variations in population parameters are expected?

For each long-term monitoring site, it will be important to carry out an assessment of all available information from the scientific literature, technical reports, and from interviews with fishermen and divers to determine what natural and anthropogenic changes are likely to occur (storm waves, runoff, impacts from fishing, boating, pollution, divers etc), and to what extent they might be expected to affect populations of ecologically or socio-economically important organisms. Even in the absence of human impacts, populations of marine animals are notoriously unstable and may vary dramatically (50-100%) over time due to natural events such as poor recruitment, storms etc. Without knowing what level of variation is typical over say, a ten-year period, it is difficult to design an Action Plan that is not overly sensitive, nor insensitive, to changes in populations. Pilot studies may be very useful to determine the short-term “noise” in population sizes of important organisms. Such studies are also very helpful for assessing methods and designs. Many grand monitoring schemes have quickly fallen apart when tested under real field conditions.

What variables can be monitored most efficiently?

Unfortunately, the origins of scientific monitoring of reefs lie in traditional community ecology that was aimed at understanding relationships among different species. A number of these methods have survived until today and are best avoided, as they are unnecessary when the goal is to provide information for managers. For example, many monitoring programs have included coral growth forms as one parameter to be measured. Coral growth forms are a very useful descriptive feature of reefs, yet it is a rare management decision that would be taken based on a change in percentage cover of a particular coral growth form. If no management decision can be made based on a shift in growth forms, there is no point in recording these data *for the purpose of a monitoring program to serve management*. Many monitoring programs differentiate between zooanthids, soft corals and sea anemones. If shifts among these three categories will not result in a management action, then there is no reason to differentiate them in the monitoring program. Many ecologists will swear that it is necessary to record taxonomy to the species level to understand a system. But given typical resource limitations, this is not practical in many cases. Much research has indicated that monitoring at the genus or even family level provides a similar answer to that produced from much more costly and time-consuming species level data (Clarke and Warwick, 1997). Taken to its extreme, Johannes (1998) has argued that many management decisions can be made with no quantitative data. It is useful to bear in mind that if problems are detected at a broad level, it is always possible to increase monitoring to a more detailed, intensive level to try to determine a cause of a change.

Obviously, the selection of methods will determine the time, effort and cost to obtain data of interest. There is a clear trend towards modifying methods to become more efficient. So-called "Rapid Assessment" protocols have been devised, but some of these (e.g. AGRRA) are in fact very time consuming when compared with Reef Check. The Reef Check program uses point sampling for substrates because this is one of the quickest methods underwater. For long-term monitoring, it is recommended that a full set of still photos and a video be obtained of the transect and surrounding area. Such photographs and video can be very useful in answering unexpected questions that crop up long after the survey is completed. It is generally not advisable to rely completely on video or photo monitoring for two reasons: 1) the ability to identify organisms in videos and photos is limited, and 2) analysis requires a great deal of time, even when aided by semi-automated procedures. These problems are compounded when one person records the images and another analyzes them.

What level of change should trigger management action?

It is useful to consider the natural range of variation of e.g. fish densities and coral cover on reefs. What is the expected range (what are the null hypotheses)? There is no point in taking management action for changes that are well within the normal range of natural variation. The normal range can be used as a basis for deciding on the level and duration of change that should trigger management action. Taken together, a list of ranges for parameters can be developed that can become the basis for an Action Plan that provides specific trigger points and actions to guide management. This approach examines one parameter at a time (univariate). On the other hand, a multivariate approach can also be used. For example, a 25% reduction in a species of butterflyfish can be examined statistically on its own (univariate) or in light of a suite of other parameters (multivariate) that could point to a cause of the decline. The manager should

not be locked into taking a costly action that will not address the problem. In management, it is very dangerous and costly mistake to adopt a “no change expected” policy (null hypothesis). As noted above, all populations change due to natural causes. Quite often, changes due to natural causes, e.g. storms, can be quite large in comparison to anthropogenic changes due to e.g. sedimentation, divers, pollution etc. Unfortunately, all these changes are additive. Generally, what is of interest is to detect anthropogenic changes that indicate that the reef is moving in an unsustainable direction.

What sampling design and analytical statistics will be used?

It is important to consider the sampling design needs with respect to detecting change, particularly if the sampling design is meant to produce results that are to be assessed using parametric statistics such as ANOVA. A statistician should be involved in the design from the beginning. Multiple control stations are required, and sufficient replication is needed across all levels of the sampling design. If the goal is to detect change at a particular reef, then replicates within that reef will be needed. A nested or hierarchical design is a useful solution (Oxley, 1997). The same concerns with space are applicable to time. If an annual comparison is required, then temporal replication is required at a smaller time interval to reveal any sub-annual variation. Random, stratified sampling is usually most appropriate for coral reefs due to clear zonation patterns. Usually, a combination of univariate and multivariate analyses is most illuminating. For example, a univariate approach may be used with a single organism such as a species of lobster, while a multivariate ordination approach may be most useful for assessing overall reef health. The Great Barrier Reef monitoring program (Oliver et al, 1995) is an excellent example of a combined approach. Numerous personal computer packages are now available at reasonable cost that can handle very complex multivariate tests with large matrices.

What level of change is ecologically significant?

It is quite possible for a change to be statistically significant without being ecologically significant. This can occur when there is a relatively small but uniform increase at many sites in a large sample. The change may be a seasonal change or due to some other natural factor that is not something that a manager should be concerned about. On the other hand, changes may occur that are clearly ecologically significant, but due to the sampling design, cannot be shown to be statistically significant. Therefore it is important to not only plan to rely on a statistical interpretation of change but also **to decide in advance** what levels of changes would be considered *ecologically* significant. For example, what decrease in the live:dead coral ratio, or what decrease in a fish population should be considered sufficient cause for alarm. By formally going through this decision-making process about what changes are considered important before changes occur, a decision matrix can be developed that gives managers a clear idea of their objectives. Many managers feel that a change of 50% or more over a period of 1 year would be required to trigger management action.

How to determine the cause of a significant change?

Although strictly speaking not part of the monitoring plan, but rather the Action Plan, it is clearly important to have a mechanism in place to try to determine the cause of a statistically and/or ecologically important change in the reef. The procedures may

include increasing the frequency or number of locations for monitoring, alerting a team of specialists (rapid response team) to investigate, and listing the methods that could be employed. Unless such a system is planned well in advance, a major change could occur and its cause be finished long before a response could be assembled.

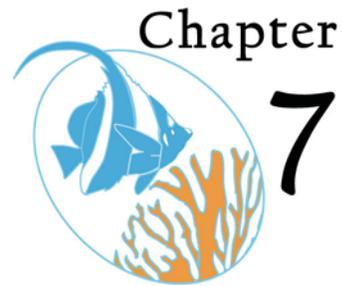
What are the management action options in response to a change?

As part of the Action Plan, once a change has been detected at a reef, and a cause has been suspected or determined, it is useful to have a prepared plan listing possible options for management decisions. For example, if a decrease in certain fish species is detected, one response might be to close the area to fishing. If partial mortality of corals has increased at a popular dive site for tourists, and it is suspected that tourists are partially to blame, then restrictions could be placed on the number of tourists visiting each day.

There are many types of changes that could be traced to “natural variation.” It is important not to invoke an inappropriate and possibly expensive management action in response to a natural change. Therefore, it is critically important to avoid locking the manager into a particular management action in response to a given change. That is, the Action Plan should be designed as a menu of possible actions that allow the manager the flexibility to make a management decision based on all available evidence.

What are the deficiencies of the design?

There is no such thing as a perfect monitoring program and it is useful to review the program and identify deficiencies on an annual basis so that contingency plans can be made to fill gaps. The monitoring program should be sufficiently flexible to allow it to be altered as needed in the future to take into account any new information or needs.



Sustainable Financing

It is a priority for governments to pay for schools, roads, hospitals and the military. Environmental needs are usually the last to be considered when the annual budget is allocated. Funding for coral reefs – one component of the environment – is never going to be a priority for most governments. Therefore, finding sustainable financing for the education, monitoring and management activities that fulfill the Reef Check mission will require some imaginative thinking. A major role of Reef Check Headquarters is locating funding sources and assisting teams to develop funding proposals and sponsors.

Over the past few years, it has become clear that the best model for Reef Check to pursue is to establish and register non-profit Reef Check organizations in each country where we operate. Aside from the legal registration, this process involves gathering a group of like-minded people to work together to achieve shared goals. There is strength in numbers, diversity of skills and an organization with a clear mission. We would encourage all national coordinators to set up a formal Reef Check NGO with a solid Board of Directors. We can help with model By-laws, Articles of Incorporation and Mission Statements that can be adapted to local needs.

Government Funding

Governments of coral reef countries should contribute funds to monitor and manage coral reefs. It is the role of Reef Check teams to convince government agencies that this is in their long-term self-interest. The best way to convince governments to fund coral reef monitoring and management is to build a constituency of coral reef supporters and to provide useful information to government agencies responsible for coral reefs. These agencies are often asked to report on the status of the reefs but typically they have no data and no idea what the status is. By providing a simple report to government staff, they can then forward it to senior government officials. Another very good way to get government interested in supporting Reef Check is to invite staff from all agencies to participate. Since Reef Check is actually a lot of fun, they will be supportive. In some cases, inviting a Minister or President to participate in a Reef Check will be a very useful strategy as it can provide excellent positive images and stories for the media.

An excellent example of a successful collaboration between a government agency and private groups is RC Hong Kong. There the government Agriculture, Fisheries and Conservation Department teams up with the local RC Coordinator, dive shops, dive clubs, NGOs and universities. Each group puts together at least one team to monitor chosen reefs and the results are published in English and Chinese on the AFCD and

other websites. The impressive collaboration has provided a regular monitoring program for Hong Kong reefs. In fact their problem is that they now have so many teams, they are running out of reefs to survey!

See: http://www.afcd.gov.hk/conservation/english/corals_reefcheck.htm

It is not always necessary for governments to provide cash to support monitoring. In some cases the provision of in-kind staff time, office space, boat usage etc., will be more valuable than the cash. If you do not ask for help with these items, you will never receive them.

Grants

Grants are available from a wide range of sources. There are dozens of private philanthropic US foundations that potentially support coral reef education, monitoring and management. In addition, each year, a US government agency (NOAA) advertises the availability of grant funds to support coral reef conservation. Each of these funding opportunities has geographic restrictions, therefore not all areas can be supported each year, but they are open to foreign applications. A major role of Reef Check HQ is to work with our teams to help find grant support to start up and maintain Reef Check programs until such time that they can be locally self-supporting. Please let us know if you would like to work with us to develop a grant or see:

<http://coralreef.noaa.gov/funding/welcome.html>

Cooperative Projects

Several organizations carry out Reef Check as part of ecotourism expeditions and are willing to help raise funds to finance these activities. Earthwatch is one such organization and runs over 100 expeditions of all types per year. Earthwatch would like to increase the number of Reef Check expeditions. Earthwatch can provide up to about \$25,000 per Reef Check expedition if a team is interested to train paying guests. The funds must be used to fully support all aspects of the expedition (travel, food, research) with a small stipend available for the team leaders. Interested Reef Check teams should carefully read the instructions on the Earthwatch website www.earthwatch.org and then discuss the proposed expedition with Reef Check HQ. Other groups that carry out Reef Check as part of their programs include Biosphere Expeditions, Coral Cay Conservation, Greenforce, Frontier and Operation Wallacea. We appreciate these groups' help in supporting monitoring and conservation. We encourage all our Coordinators to consider running an expedition. This should be planned at least one year in advance.

Corporate Sponsors

In most countries, corporate sponsorship is one of the easiest types of funding to obtain and it can build up useful relationships that will lead to future funding. All corporations need to maintain a "good" public image as well as to sell their products through advertising. Reef Check offers both of these excellent opportunities to corporations. By sponsoring a Reef Check team, the company can gain a lot of free media attention if the team invites the press to attend a fundraising or outreach event. One easy way to give

instant credit to the company is to ask them to sponsor Reef Check t-shirts that include their name so that on the day of the dive, the company also can get its name out to the public.

In general, US and European companies are very familiar with the value of this type of sponsorship while local companies may be less aware of the opportunity. A typical sponsorship might cost the company \$1000 and so would be very cheap from the company's perspective. It is worth remembering that these same companies may spend tens of thousands of dollars if not more (depending on the size of the company) for print, radio and television advertising. A single print ad in a major US newspaper or magazine can cost between \$50,000 and \$100,000. So providing banners for an event with the sponsor's company logo included has value, and so the larger the event and the more people who see it, the more value it has.

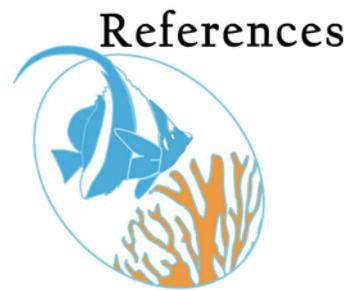
Many companies such as dive resorts and hotels may provide "in-kind" donations such as use of facilities, boats, dive equipment and staff time. These are valuable as well, and it is important to ensure that any donation, whether cash or in-kind, is properly acknowledged.

Fund-raising Events

Country coordinators and teams should consider planning and doing a fundraiser for their teams. The best way to do this would be to have the Reef Check organization registered as a local charity or non-profit first. This gives donors and sponsors the confidence that any funds raised will be handled properly. The formal status allows the group to open a specific bank account to handle Reef Check funds. As a temporary solution for teams that have not yet set up a formal Reef Check NGO, a partner organization could be asked to handle finances.

Fund raising events are a huge amount of work, but if carefully planned with sufficient time, they can raise large amounts of cash. Each country will have a different system and country coordinators should study the prevailing fund raising models in their country before attempting this. It is possible to lose money by investing in a fund raising event and then having poor attendance, donations and sponsorship.

To organize a fundraising event, the first step is to form an event committee and to write down a list of tasks and assign committee members to tasks. The event should be planned one year in advance. Reef Check has held successful fundraisers in many countries so do not think that just because it is an environmental cause that it is not possible in your country.



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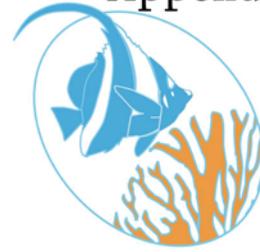
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A. Reef Check Registration Form

To participate in Reef Check, you must submit a registration form, preferably online at www.reefcheck.org or by e-mail to Reef Check Headquarters at rcregist@reefcheck.org. We will then confirm your status or ask for additional information. Note that there is one basic requirement of Reef Check. Each team should include members who are Certified Reef Check divers i.e. have attended a formal Reef Check Certification Course, and/or they must have a qualified marine scientist on board to train the team in survey methods, to help with identifications, and to help with the data analysis. Teams without a qualified marine scientist are welcome to carry out Reef Check surveys, however, we do not accept data from unregistered teams. Please let us know if you have a team but need help locating a scientist.

Please carefully check the Teams List to determine if your desired site is already listed. To determine the exact location of another group's planned survey, you may need to contact us, or that group's Team Leader.

Who is considered a qualified marine scientist? We are looking for Masters or Ph.D.-level scientists who specialize in tropical marine ecology and who have experience carrying out underwater transect surveys. On an individual basis, we are willing to consider self-taught scientific leaders if a reef scientist known to us can vouch for their qualifications.

Reef Check Registration Form

Team Leader

- First Name:
- Last Name:
- Address:
- City:
- State (if applicable):
- Country:
- Zip/Postal Code:
- Phone/Fax:
- E-mail:
- Affiliation with dive club or other organization:
- Number of team members (excluding team leader):
- Are you local to the area where you will be conducting surveys?
 - If yes, how long have you been in the area?
 - If no, how long have you been visiting/diving in the area?

Team Scientist (please leave blank if you need us to pair you with a scientist)

- First Name:
- Last Name:
- Highest academic degree:
 - Subject of degree:
 - University:
 - Year earned:
- Institutional Affiliation:
- Phone/Fax:
- E-mail:

Other Information

- Has anyone on your team participated in an Reef Check survey before?
 - Team Leader?
 - Team Scientist?
 - Other team member?
- Do you or your TS have any underwater survey experience other than Reef Check? Please briefly describe:
- Are you and/or the TS comfortable correctly identifying fish/invertebrate species in the region?

Site Information

- Reef Name:
- Nearest Town/City:
- Country:
- Planned Survey Date:

By submitting this registration form, our team gives Reef Check permission to use any data submitted for public relations and in summary form for a published global summary report. Note: When submitting a hard copy of this form, please include a signature.

Signature

Date

Submit to: rregist@reefcheck.org

Reef Check Foundation
PO Box 1057
17575 Pacific Coast Highway
Pacific Palisades, CA 90272-1057
1-310-230-2371, 1-310-230-2360 (phone)
1-310-230-2376 (fax)
<http://www.ReefCheck.org>

B. Liability Release

All participants must sign a copy of this form before taking part in any Reef Check activities.

Reef Check Waiver of Liability

I acknowledge that Reef Check is a volunteer program. I recognize that I do not have to participate. I acknowledge that I have chosen to follow the Reef Check survey methodology because it provides one suitable way of collecting scientific information, and not because it minimizes any of the risks of scuba diving. I recognize that scuba diving is an inherently risky activity and I expressly assume all risk associated with scuba diving in any way affiliated with Reef Check. Moreover, I hereby release and hold Reef Check harmless for any and all negligent acts in any way related to Reef Check activities. I have chosen to do this volunteer work of my own free will for the purpose of contributing to science and coral reef conservation and I agree that I, and only I, shall be responsible for my safety, and any injuries I may sustain. I agree that I will not hold liable or responsible the Reef Check Foundation or any personnel associated with any of the above, whether employees, agents, independent contractors, team leaders or other volunteers. I absolve all of them from any responsibility for my safety or any injuries, which I may suffer in the process of following the Reef Check survey methodology, or any deviation from it.

Signature: _____ Date: _____

Full name (print): _____

C. Quality Assurance Procedures

Quality assurance (QA) is a system for ensuring that procedures are carried out following a defined, written plan, and that if a mistake is made, it can be promptly detected, traced to a responsible person and corrected. This document defines the procedures to ensure that data collected for a Reef Check survey are correctly logged and submitted to the global Reef Check database for analysis. One of the goals of Reef Check is to monitor and report on the health of coral reefs on a global basis. But there are many reasons to carry out a Reef Check survey other than to serve science and management: for education, public awareness raising, use as a training tool or just for fun. However, if a team would like to submit data to the global database, the team scientist must follow the QA procedures outlined below.

Dive

Site selection and transect location

The Team Scientist is responsible for choosing the survey location and for ensuring that the transect is placed in an appropriate location. For resurveys, this includes ensuring that the transect is in the same location as the previous survey. The Team Scientist is also responsible for ensuring that the Site Description Form is filled in, particularly, the location information (coordinates). The Team Scientist should use the collective knowledge of the team to complete the Site Description Form.

Volunteer assignments

The Team Scientist and Team Leader should ensure that volunteers are assigned to scientific tasks appropriate for their abilities. That is, someone who is good at fish identification should not be assigned to carry out the invertebrate survey until sufficient training has been completed.

Data collection

The Team Scientist is responsible for checking the data collection procedures followed by the volunteers. This can be done by teaming up with the volunteers or by simply looking over their shoulder as they collect data. Attention should be paid to potential problems such as: missing information (name, date, time etc), incorrect information, incorrect identifications, incorrect numbers, improper use of the plumb line or belt-transect marking rod. If problems are noted, the corrections should be made immediately and an explanation given later at the surface. Each volunteer should write on their slate or paper what task they have completed.

Post-Dive Data Checking

Boat/On shore

Once the Reef Check Team has finished each part of the survey and has returned to shore (or the boat), it is the responsibility of the Team Scientist to review the data immediately and ask for clarification of any data that does not match the scientist's observations. If necessary, and after discussing the problem with the team, the Team Scientist should correct errors and if necessary, resurvey the problem segment.

Data Input to Computer

The raw data should be input to the electronic Excel spreadsheets on the day of the survey (Site Description, Fish and Invertebrate Belt, and Substrate) or input directly to the RC website. The timing is important because if an error is detected, often there will be time to correct it. This is an important part of the QA because the electronic data sheets have been set up to help highlight certain types of errors including: incorrect substrate codes and incorrect substrate counts per transect. It is very important that the person who inputs the data to the computer asks another person to check that the data in the computer matches the data on the original data sheets. The Team Scientist is responsible for ensuring that the data are correct prior to submission to Reef Check Headquarters.

Data Submission

Once the raw data have been transferred to standard Reef Check Excel data sheets, the files should be emailed as attachments to the Reef Check Data Manager **rcdata@reefcheck.org** and confirmation should be requested. Please include a list of files that are attached (name of each file and name of each reef). It is particularly important to indicate the country, province/state and location of each attached file. Remember to follow the standard instructions for naming each file as given in the Reef Check Instruction Manual. Alternatively, the data may be input directly to the Reef Check WRAS system using webforms.

Data Checking at Reef Check Headquarters

The submitted files will be checked by Reef Check staff, usually within one week of receipt. The files will be printed and added to the master data book. The staff will examine the spreadsheets to ensure that they are compliant with Reef Check procedures, including:

- All requested information is provided
- Substrate Sheet includes only correct substrate codes
- Substrate Sheet segment totals are 40
- Outliers are checked

An outlier chart (Table 1) for the belt transect is used to check the validity of outliers found within the organism counts. The chart was generated from over six years of Reef Check data in the database. For each of four geographic regions, the chart indicates the maximum number of each indicator organism (per 20 m transect segment) that is allowable without requiring a validity check. These outlier maxima are means of the top ten counts for each organism from all 20 m transects in the database as of 3/28/2006. If a count is submitted that is higher than allowed, then a query will be sent requesting the team to check if the number is correct. If needed, a resurvey will need to be made for that indicator. If any non-compliant features are noted, staff will contact the Team Scientist to try to rectify the problem. The Reef Check HQ data checker will write their name and date in the databook on the lower right corner of each data set that they have checked. The data will then be imported into the Reef Check database.

HQ Data Storage

Data received at HQ will be copied into at least two storage locations. Every day the database is used, the data will be copied onto a backup device held at HQ. Once a week, the database and the data will be saved and stored at a location outside HQ. Reef Check data are available online as part of the WRAS system and are also submitted to ReefBase and included in their global coral reef database.

Table 1. QA Chart for Belt Transect Outlier Definitions

FISH	Indo-Pacific	Hawai'i	Atlantic	Red Sea	Arabian Gulf
Arabian butterflyfish					3
Barramundi cod	8				0
Black spotted grunt					2
Blueline snapper		3			
Broomtail wrasse				6	
Bumphead parrot	27			7	1
Butterflyfish	147	20	40	32	11
Dark butterflyfish					12
Goatfish		15			
Grey grunt					0
Grouper	20		12	9	2
Haemulidae	68		780	57	2
Humphead wrasse	26			4	1
Jacks		1			
Longfin butterflyfish					2
Moray eel	5	2	6	3	0
Nassau grouper			10		
Orange spine unicornfish		3			
Orange spotted grouper					1
Parrotfish	95	7	48	18	5
Peacock grouper		3			
Snapper	202	7	179	94	14
Spotted grunt					0
Yellow tang		15			

INVERTEBRATES	Indo-Pacific	Hawai'i	Atlantic	Red Sea	Arabian Gulf
Banded coral shrimp	23	1	28	6	0
Black urchin					24
COTS	62	0		7	0
Cowries		2			0
Diadema	962	38	354	199	50
Flamingo tongue			22		
Giant clam	467			74	0
Gorgonian			927		
Lobster	6	1	9	1	1
Pencil urchin	29	152	54	26	2
Sea cucumber	126			9	17
Short spine urchin					213
Tripneustes	33	59	117	8	0
Triton	8	0	6	2	1

Values from database as of
3/28/2006

D. Recommended Training Guidelines

Reef Check Short Course (2 half days)

- Day 1** Intro to Reef Check PowerPoint
Reef Check Video (stop as needed to explain)
Indicator Identification PowerPoint and identification tests
- Day 2** Field Snorkel practice and ID tests
Scuba survey
Data input

Reef Check Training of Trainers Course (2 – 5 full days)

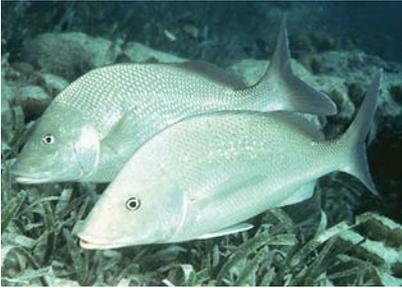
- Day 1**
Morning Introduction and goals of Workshop/Reef Check
Review Reef Check activities in Country X
Review Reef Check methods (Intro to Reef Check PowerPoint)
- Afternoon Training Video
Land-based methods practice (everybody to walk through and pretend to do a survey)
- Day 2**
Morning Snorkel Reef Check practice
Fish size estimation 20 and 30 cm
- Afternoon Discussion of Reef Check practice session and review of PowerPoint
PowerPoint identification tests plus feedback
Introduction to long-term monitoring
- Day 3**
Morning Scuba Reef Check identification tests
- Afternoon Discussion of scuba Reef Check
Data input and quality assurance
- Day 4**
Morning Manta tow practice for site selection (if visibility allows)
Scuba Reef Check
If poor visibility – then just scuba Reef Check
- Afternoon Interpretation and analysis of Reef Check data
- Day 5**
Morning Scuba Reef Check or review of scuba identification tests
- Afternoon Long-term monitoring design
Long-term financing

E. RC Indicator Organisms

ATLANTIC / CARIBBEAN INDICATORS

Fish:

Common Name	Family Name	Indicator of
Butterflyfish (all species)	Chaetodontidae	Overfishing Aquarium Collection
Grunts/Margates	Haemulidae	Overfishing
Snapper	Lutjanidae	Overfishing
Parrotfish (> 20 cm)	Scaridae	Overfishing
Moray Eel (all species)	Muraenidae	Overfishing
Grouper (any >30 cm)	Serranidae	Overfishing
Nassau Grouper	<i>Epinephalus striatus</i>	Overfishing

<p>Butterflyfish (all species) Chaetodontidae</p> <p>Indicator of overfishing & aquarium trade</p> <p>Example: Four-eye butterflyfish</p>	 <p><i>Robert A. Patzner (Salzburg, Austria)</i></p>
<p>Grunts/Margates Haemulidae</p> <p>Indicator of overfishing</p> <p>Example: White margate</p>	 <p><i>John E. Randall</i></p>
<p>Snapper Lutjanidae</p> <p>Indicator of overfishing</p> <p>Example: Schoolmaster snapper</p>	 <p><i>Robert A. Patzner (Salzburg, Austria)</i></p>

Parrotfish (any > 20cm)
Scaridae

Indicator of overfishing

Example: Princess parrotfish



Robert A. Patzner (Salzburg, Austria)

Moray Eel (all species)
Muraenidae

Indicator of overfishing

Example: Spotted moray



Robert A. Patzner (Salzburg, Austria)

Grouper (any > 30 cm)
Serranidae

Indicator of overfishing

Example: Yellowfin grouper



Robert A. Patzner (Salzburg, Austria)

Nassau Grouper
Epinephalus striatus

Indicator of overfishing



John E. Randall

Invertebrates:

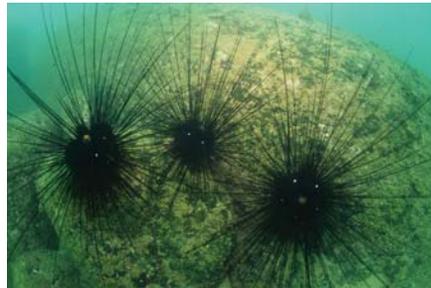
Common Name	Species/Class Name	Indicator of
Banded Coral Shrimp	<i>Stenopus hispidus</i>	Aquarium collection
Long-spined Black Sea Urchin	<i>Diadema</i> spp.	Overfishing
Pencil Urchin	<i>Eucidaris</i> spp.	Curio trade
Sea Egg/Collector Urchin	<i>Tripneustes</i> spp.	Overfishing
Triton	<i>Charonia variegata</i>	Curio trade
Flamingo Tongue	<i>Cyphoma gibbosum</i>	Aquarium collection
Gorgonian		Linked to Flamingo tongue and disease
Lobster (spiny and slipper/rock)	Malacostraca (Decapoda)	Overfishing

Banded Coral Shrimp
Stenopus hispidus
 Indicator of aquarium collection



Jeff Jeffords

Long-spined Black Sea Urchin
Diadema antillarum
 Absence or low numbers, may indicate urchin disease; high numbers are an indicator of overfishing of urchin predators



Gregor Hodgson

Pencil Urchin
Eucidaris spp.
 Indicator of collection for curio trade



Trish Baily

Collector Urchin/Sea Egg
Tripneustes spp.
 Indicator of overfishing



Trish Baily

Triton

Charonia variegata

Indicator of collection for curio trade



www.jaxsbells.org

Flamingo Tongue

Cyphoma gibbosum

Indicator of aquarium collection



Ruben Torres

Gorgonian

Indicator linked to Flamingo tongue and disease

Examples: sea fans (*left*), sea whips (*right*)



Gregor Hodgson

Lobster (spiny and slipper/rock)
Malacostraca (Decapoda)

Indicator of overfishing



Fish:

Common Name	Family Name	Indicator of
Butterflyfish (all species)	Chaetodontidae	Overfishing Aquarium Collection
Grunts/Sweetlips	Haemulidae	Overfishing
Snapper	Lutjanidae	Overfishing
Parrotfish (> 20 cm)	Scaridae	Overfishing
Moray Eel (all species)	Muraenidae	Overfishing
Grouper/Coral Trout (any >30 cm)	Serranidae	Overfishing Live fish trade
Barramundi Cod	<i>Cromileptes altivelis</i>	Overfishing Live fish trade
Bumphead Parrotfish	<i>Bolbometopon muricatum</i>	Spearfishing Overfishing
Humphead (Napolean) Wrasse	<i>Cheilinus undulatus</i>	Overfishing Live fish trade

Butterflyfish (all species)
Chaetodontidae

Indicator of overfishing & aquarium trade

Example: Vagabond butterflyfish

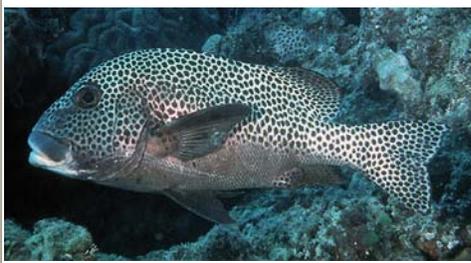


Robert A. Patzner (Salzburg, Austria)

Grunts/Sweetlips
Haemulidae

Indicator of overfishing

Example: *Plectorhincus* spp.



John E. Randall

Snapper
Lutjanidae

Indicator of overfishing

Example: Common bluestripe snapper



Robert A. Patzner (Salzburg, Austria)

Barramundi Cod

Cromileptes altivelis

Indicator of overfishing, live fish trade and spearfishing



John E. Randall

Humphead (Napolean) Wrasse

Cheilinus undulates

Indicator of overfishing and live fish trade



John E. Randall

Bumphead Parrotfish

Bolbometopon muricatum

Indicator of overfishing



John E. Randall

Parrotfish (any > 20cm)

Scaridae

Indicator of overfishing



Dee Wescott

Moray Eel (all species)

Muraenidae

Indicator of overfishing

Example: Yellow edged moray



Robert A. Patzner (Salzburg, Austria)

Grouper/Coral Trout

(any > 30 cm)

Serranidae

Indicator of overfishing and live fish trade

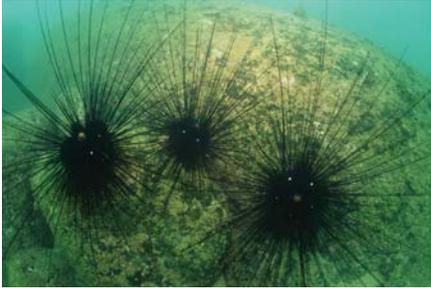
Example: Coral trout



John E. Randall

Invertebrates:

Common Name	Species/Class Name	Indicator of
Banded Coral Shrimp	<i>Stenopus hispidus</i>	Aquarium collection
Long-spined Black Sea Urchin	<i>Diadema</i> spp. and <i>Echinothrix diadema</i>	Overfishing
Pencil Urchin	<i>Heterocentrotus mammillatus</i>	Curio trade
Sea Egg/Collector Urchin	<i>Tripneustes</i> spp.	Overfishing
Crown-of-thorns Starfish	<i>Acanthaster planci</i>	Population outbreaks
Triton	<i>Charonia tritonis</i>	Curio trade
Lobster (spiny and slipper/rock)	Malacostraca (Decapoda)	Overfishing
Giant Clam (give size/species)	<i>Tridacna</i> spp.	Overharvesting
Edible Sea Cucumber (3 species)		Beche-de-mer fishing
Prickly Redfish	<i>Thelenota ananas</i>	
Greenfish	<i>Stichopus chloronotus</i>	
Pinkfish	<i>Holothuria edulis</i>	

<p>Banded Coral Shrimp <i>Stenopus hispidus</i></p> <p>Indicator of aquarium collection</p>	 <p style="text-align: right;"><i>Dee Wescott</i></p>
<p>Long-spined Black Sea Urchin <i>Diadema</i> spp., <i>Echinothrix diadema</i></p> <p>In high numbers, indicator of overfishing of urchin predators</p>	 <p style="text-align: right;"><i>Gregor Hodgson</i></p>
<p>Pencil Urchin <i>Heterocentrotus mammillatus</i></p> <p>Indicator of collection for curio trade</p>	 <p style="text-align: right;"><i>Gregor Hodgson</i></p>

Collector Urchin

Tripneustes spp.

Indicator of overfishing



Gregor Hodgson

Crown-of-thorns Starfish

Acanthaster planci

Indicator of Crown-of-thorns population outbreaks



Jeff Jeffords

Triton

Charonia tritonis

Indicator of collection for curio trade



Karenne Tun

Lobster (spiny and slipper/rock)
Malacostraca (Decapoda)

Indicator of overfishing



Mark Rosenstein

Giant Clam (give size and species)

Tridacna spp.

Indicator of overharvesting



Chuck Savall

Edible Sea Cucumbers

(3 species)

Indicator of overfishing

Examples:

Prickly Redfish *Theleota ananas*

Indicator of beche-de-mer fishing



Karenne Tun



Karenne Tun

Greenfish *Stichopus chloronotus*

Indicator of beche-de-mer fishing

Pinkfish *Holothuria edulis*

Indicator of beche-de-mer fishing



Gregor Hodgson

Fish:

Common Name	Family/Species Name	Indicator of
Bluestripe Snapper (Ta'ape)	<i>Lutjanus kasmira</i>	Overfishing
Jacks (Ulu)	Carangidae	Overfishing
Peacock Grouper (Roi)	<i>Cephalopholis arus</i>	Overfishing
Parrotfish (>20cm) (Uhu)	Scaridae	Overfishing
Butterflyfish (all species)	Chaetodontidae	Overfishing
Snapper	Lutjanidae	Aquarium collection
Orangespine Unicornfish (Umauma-lei)	<i>Naso lituratus</i>	Overfishing
Moray Eel (Puhi)	Muraenidae	Overfishing
Yellow Tang (Lau'ipala)	<i>Zebbrasoma flavescens</i>	Spearfishing
Yellow(fin) Goatfish (Weke-ula)	<i>Mulloidichthys vanicolensis</i>	Aquarium trade
		Overfishing

Butterflyfish
Chaetodontidae

Indicator of overfishing & aquarium trade



Dee Wescott

Blueline Snapper (Ta'ape)
Lutjanus kasmira

Indicator of overfishing



John E. Randall

Jacks (Ulu)
Carangidae

Indicator of overfishing

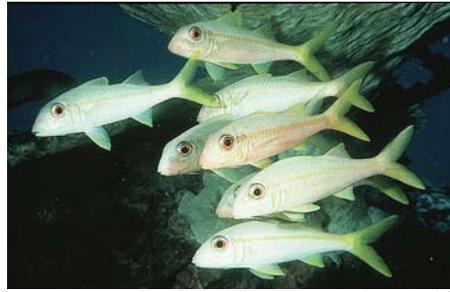


John E. Randall

Yellow(fin) Goatfish (Weke-
ula)

Mulloidichthys vanicolensis

Indicator of overfishing



John E. Randall

Parrotfish (Uhu)

(> 20 cm)

Scaridae

Indicator of overfishing



Dee Wescott

Yellow Tang (Lau'ipala)

Zebrasoma flavescens

Indicator of aquarium trade



John E. Randall

Snapper

Lutjanidae

Indicator of overfishing



John E. Randall

Moray Eel

Muraenidae

Indicator of overfishing and spearfishing

Example: Spotted eel



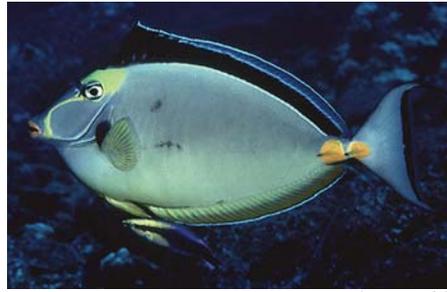
John E. Randall

Orangespine Unicornfish

(Umauma-lei)

Naso lituratus

Indicator of overfishing and aquarium trade



John E. Randall

Peacock Grouper (Roi)

Cephalopholis arus

Indicator of overfishing



Dee Wescott

Invertebrates:

Common Name	Species/Class Name	Indicator of
Banded Coral Shrimp	<i>Stenopus hispidus</i>	Aquarium Collection
Long-spined Black Sea Urchin	<i>Diadema</i> spp. and <i>Echinothrix diadema</i>	Overfishing
Pencil Urchin	<i>Heterocentrotus mammilatus</i>	Collection
Collector Urchin	<i>Tripneustes</i> spp.	Overfishing
Lobster (spiny and slipper/rock)	Malacostraca (Decapoda)	Overfishing
Cowries	Cypraeidae	Curio trade
Triton	<i>Charonia tritonis</i>	Overharvesting
Crown-of-thorns Starfish	<i>Acanthaster planci</i>	Population outbreaks

Banded Coral Shrimp

Stenopus hispidus

Indicator of aquarium collection

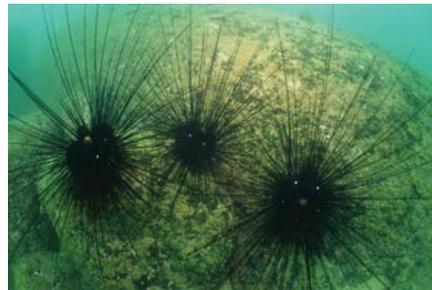


Dee Wescott

Long-spined Black Sea Urchin

Diadema spp., *Echinothrix diadema*

In high numbers, indicator of overfishing of urchin predators



Gregor Hodgson

Pencil Urchin

Heterocentrotus mammilatus

Indicator of collection



Gregor Hodgson

Collector Urchin

Tripneustes spp.

Indicator of overfishing



Gregor Hodgson

Lobster (spiny and slipper/rock)
Malacostraca (Decapoda)

Indicator of overfishing



Mark Rosenstein

Cowries
Cypraeidae

Indicator of curio trade



Dr. James P. McVey, NOAA Sea Grant Program

Triton
Charonia tritonis

Indicator of overharvesting



Karenne Tun

Crown-of-thorns Starfish
Acanthaster planci

Indicator of Crown-of-thorns population outbreaks



Jeff Jeffords

F. Field Data Sheets

Site Description Form

BASIC INFORMATION					
Country:	_____	State/Province:	_____	City/town:	_____
Date:	_____	Time:	Start of survey: _____	End of survey:	_____
Latitude (deg. min. sec):	_____	Longitude (deg. min. sec):	_____		
From chart or by GPS? (if GPS, indicate units):	_____	Chart:	_____	GPS:	_____
				GPS units:	_____
Orientation of transect:	N-S: _____	E-W: _____	NE-SW: _____	SE-NW: _____	
Temperature (°C):	Air: _____	surface: _____	at 3m: _____	at 10m: _____	
Distance	from shore (m): _____		from nearest river (km): _____		
River mouth width:	<10 m _____	11-50 m _____	51-100 m _____	101-500 m _____	
Distance to nearest population center (km):	_____		Population size (x1000):	_____	
Weather:	sunny: _____	cloudy: _____	raining: _____		
Visibility (m) :	_____				
Why was this site selected:	_____	Is this best reef in the area?	Yes: _____	No: _____	
IMPACTS:					
Is this site sheltered?:	Always: _____	Sometimes: _____	Exposed: _____		
Major coral damaging storms	Yes: _____	No: _____	If yes, when was last storm: _____		
Overall anthropogenic impact	None: _____	Low: _____	Med: _____	High: _____	
Is siltation a problem	Never: _____	Occasionally: _____	Often: _____	Always: _____	
Blast fishing	None: _____	Low: _____	Med: _____	High: _____	
Poison fishing	None: _____	Low: _____	Med: _____	High: _____	
Aquarium fishing	None: _____	Low: _____	Med: _____	High: _____	
Harvest inverts for food	None: _____	Low: _____	Med: _____	High: _____	
Harvest inverts for curio sales	None: _____	Low: _____	Med: _____	High: _____	
Tourist diving/snorkeling:	None: _____	Low: _____	Med: _____	High: _____	
Sewage pollution (outfall or boat)	None: _____	Low: _____	Med: _____	High: _____	
Industrial pollution	None: _____	Low: _____	Med: _____	High: _____	
Commercial fishing (fish caught to sell for food)	None: _____	Low: _____	Med: _____	High: _____	
Live food fish trade	None: _____	Low: _____	Med: _____	High: _____	
Artisinal/recreational (personal consumption)	None: _____	Low: _____	Med: _____	High: _____	
How many yachts are typically present within 1km of this site	None: _____	Few (1-2): _____	Med (3-5): _____	Many (>5): _____	
Other impacts:	_____				
PROTECTION:					
Any protection (legal or other) at this site?	Yes: _____	No: _____	If yes, answer questions below		
Is protection enforced	Yes: _____	No: _____			
What is the level of poaching in protected area?	None: _____	Low: _____	Med: _____	High: _____	
Check which activities are banned:	Spearfishing _____	Commercial fishing _____	Recreational fishing _____	Invertebrate or shell collecting _____	
	Anchoring _____	Diving _____	Other (please specify) _____		
Other comments	_____				
TEAM INFORMATION					
Submitted by	_____	Regional Coordinator:	_____		
		Team Leader:	_____		
		Team Scientist:	_____		
		Team Members:	_____		

Substrate Form

Site name _____
 Depth: _____
 TS/TL: _____
 Time: _____

Country/Island: _____
 Date: _____
 Data recorded by: _____

Substrate Code

HC hard coral SC soft coral RKC recently killed coral
 NIA nutrient indicator algae SP sponge RC rock
 RB rubble SD sand SI silt/clay
 OT other

(For first segment, if start point is 0 m, last point is 19.5 m)

SEGMENT 1				SEGMENT 2				SEGMENT 3				SEGMENT 4			
0 - 19.5 m				25 - 44.5 m				50 - 69.5 m				75 - 94.5 m			
0		10		25		35		50		60		75		85	
0.5		10.5		25.5		35.5		50.5		60.5		75.5		85.5	
1		11		26		36		51		61		76		86	
1.5		11.5		26.5		36.5		51.5		61.5		76.5		86.5	
2		12		27		37		52		62		77		87	
2.5		12.5		27.5		37.5		52.5		62.5		77.5		87.5	
3		13		28		38		53		63		78		88	
3.5		13.5		28.5		38.5		53.5		63.5		78.5		88.5	
4		14		29		39		54		64		79		89	
4.5		14.5		29.5		39.5		54.5		64.5		79.5		89.5	
5		15		30		40		55		65		80		90	
5.5		15.5		30.5		40.5		55.5		65.5		80.5		90.5	
6		16		31		41		56		66		81		91	
6.5		16.5		31.5		41.5		56.5		66.5		81.5		91.5	
7		17		32		42		57		67		82		92	
7.5		17.5		32.5		42.5		57.5		67.5		82.5		92.5	
8		18		33		43		58		68		83		93	
8.5		18.5		33.5		43.5		58.5		68.5		83.5		93.5	
9		19		34		44		59		69		84		94	
9.5		19.5		34.5		44.5		59.5		69.5		84.5		94.5	

What percentage of recorded RKC is a result of bleaching?

Comments:

Belt Transect Form (Atlantic/Caribbean)

Site Name: _____	Country/Island: _____			
Depth: _____	Team Leader: _____			
Date: _____	Time: _____			
Data recorded by: _____				
<u>Invertebrates</u>	0-20m	25-45m	50-70m	75-95m
Banded coral shrimp (<i>Stenopus hispidus</i>)				
<i>Diadema</i> urchins				
Pencil urchin (<i>Eucidaris</i> spp.)				
Collector urchin/sea egg (<i>Tripneustes</i> sp.)				
Triton (<i>Charonia variegata</i>)				
Flamingo tongue (<i>Cyphoma gibbosum</i>)				
Gorgonian (sea fan, sea whip)				
Lobster (Palinuridae)				
<u>Impacts: Coral Disease/ Bleaching/Trash/Other</u>	<i>0 = none, 1 = low, 2 = medium and 3 = high</i>			
	0-20m	25-45m	50-70m	75-95m
Coral damage: Boat/Anchor				
Coral damage: Dynamite				
Coral damage: Other				
Trash: Fish nets				
Trash: General				
Bleaching (% of coral population)				
Bleaching (% of colony)				
Coral Disease (% of coral affected if yes)				
Rare animals sighted (type/#)				
Comments:				

Site Name: _____	Country/Island: _____			
Depth: _____	Team Leader: _____			
Date: _____	Time: _____			
<h2><u>Fish</u></h2>				
<i>Data recorded by:</i>				
	0-20m	25-45m	50-70m	75-95m
Butterflyfish (Chaetodontidae)				
Grunts/Margates (Haemulidae)				
Snapper (Lutjanidae)				
Parrotfish (Scaridae) (only >20 cm)				
Moray Eel				
Nassau grouper (<i>Epinephalus striatus</i>) sizes (cm):	0-20m	25-45m	50-70m	75-95m
30-40 cm				
40-50 cm				
50-60 cm				
>60 cm				
Total # grouper				
Other Grouper (Serranidae) sizes (cm) (only >30 cm):	0-20m	25-45m	50-70m	75-95m
30-40 cm				
40-50 cm				
50-60 cm				
>60 cm				
Total # grouper				
Rare animals sighted (type/#)				
Comments:				

Belt transect Form (Indo-Pacific)

Site Name: _____	Country/Island: _____			
Depth: _____	Team Leader: _____			
Date: _____	Time: _____			
<i>Data recorded by:</i>				
<u>Invertebrates</u>	0-20m	25-45m	50-70m	75-95m
Banded coral shrimp (<i>Stenopus hispidus</i>)				
<i>Diadema</i> urchins (including <i>Echinothrix</i> spp.)				
Pencil urchin (<i>H. mammilatus</i>)				
Collector urchin (<i>Tripneustes</i> spp.)				
Sea cucumber (Holothuridae)				
Crown of thorns (<i>Acanthaster plancii</i>)				
Triton (<i>Charonia tritonis</i>)				
Lobster (Palinuridae)				
Giant clam (<i>Tridacna</i> sp.) sizes	0-20m	25-45m	50-70m	75-95m
<10 cm				
10-20 cm				
20-30 cm				
30-40 cm				
40-50 cm				
>50 cm				
Total # giant clams observed				
<u>Impacts: Coral Disease/ Bleaching/Trash/Other</u>	<i>0 = none, 1 = low, 2 = medium and 3 = high</i>			
	0-20m	25-45m	50-70m	75-95m
Coral damage: Boat/Anchor				
Coral damage: Dynamite				
Coral damage: Other				
Trash: Fish nets				
Trash: General				
Bleaching (% of coral population)				
Bleaching (% of colony)				
Coral Disease (% of coral affected if yes)				
Rare animals sighted (type/#)				
Comments:				

Site Name: _____	Country/Island: _____
Depth: _____	Team Leader: _____
Date: _____	Time: _____

Fish

Data recorded by: _____

	0-20m	25-45m	50-70m	75-95m
Butterflyfish (Chaetodontidae)				
Sweetlips (Haemulidae)				
Snapper (Lutjanidae)				
Barramundi cod (<i>Cromileptes altivelis</i>)				
Humphead wrasse (<i>Cheilinus undulatus</i>)				
Bumphead parrotfish (<i>Bolbometopon muricatum</i>)				
Other parrotfish (Scaridae) only >20 cm				
Moray eel (Muraenidae)				

Grouper (Serranidae) sizes (cm) (count ONLY >30cm):	0-20m	25-45m	50-70m	75-95m
30-40 cm				
40-50 cm				
50-60 cm				
>60 cm				
Total # grouper				

Rare animals sighted (type/#)				
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Comments: _____

Belt transect Form (Hawai'i)

Site Name: _____	Country/Island: _____			
Depth: _____	Team Leader: _____			
Date: _____	Time: _____			
<i>Data recorded by:</i>				
<u>Invertebrates</u>	0-20m	25-45m	50-70m	75-95m
Banded coral shrimp (<i>Stenopus hispidus</i>)				
<i>Diadema</i> urchins (including <i>Echinothrix</i> sp.)				
Pencil urchin (<i>H. mammilatus</i>)				
Collector urchin (<i>Tripneustes</i> spp.)				
Lobster (Palinuridae)				
Cowries (Cypraeidae)				
Triton (<i>Charonia tritonis</i>)				
Crown-of-thorns starfish (<i>Acanthaster planci</i>)				
<u>Impacts: Coral Disease/ Bleaching/Trash/Other</u>	<i>0 = none, 1 = low, 2 = medium and 3 = high</i>			
	0-20m	25-45m	50-70m	75-95m
Coral damage: Boat/Anchor				
Coral damage: Dynamite				
Coral damage: Other				
Trash: Fish nets				
Trash: General				
Bleaching (% of coral population)				
Bleaching (% of colony)				
Coral Disease (% of coral affected if yes)				
Rare animals sighted (type/#)				
Comments:				

Site Name: _____	Country/Island: _____
Depth: _____	Team Leader: _____
Date: _____	Time: _____

Fish

Data recorded by: _____

	0-20m	25-45m	50-70m	75-95m
Butterflyfish (Chaetodontidae)				
Ta'ape /Blueline snapper (<i>Lutjanus kasmira</i>)				
Ulua / Jacks (Carangidae)				
Goatfish (Mullidae)				
Uhu / Parrotfish (Scaridae) only > 20 cm				
Lau'ipala /Yellow tang (<i>Zebrasoma flavescens</i>)				
Snapper (Lutjanidae)				
Puhi / Moray eel (Muraenidae)				
Umaumalei / Orange spine unicornfish (<i>Naso lituratus</i>)				
Roi /Peacock grouper (<i>Cephalopholis arus</i>) sizes (cm)	0-20m	25-45m	50-70m	75-95m
30-40 cm				
40-50 cm				
50-60 cm				
>60 cm				
Total # grouper				
Rare animals sighted (type/#)				
Comments:				

Belt Transect Form (Arabian Gulf)

Site Name: _____	Country/Island: _____			
Depth: _____	Team Leader: _____			
Date: _____	Time: _____			
<i>Data recorded by:</i>				
<u>Invertebrates</u>	0-20m	25-45m	50-70m	75-95m
Banded coral shrimp (<i>Stenopus hispidus</i>)				
<i>Diadema</i> urchins				
Black urchin (<i>Echinothrix diadema</i>)				
Short spine urchin				
Pencil urchin (<i>H. mammilatus</i>)				
Collector urchin (<i>Tripneustes</i> spp.)				
Sea cucumber (Holothuridae)				
Crown of thorns (<i>Acanthaster planci</i>)				
Cowries (Cypraeidae)				
Triton (<i>Charonia tritonis</i>)				
Lobster (Palinuridae)				
Giant clam (<i>Tridacna</i> sp.) sizes	0-20m	25-45m	50-70m	75-95m
<10 cm				
10-20 cm				
20-30 cm				
30-40 cm				
40-50 cm				
>50 cm				
Total # giant clams observed				
<u>Impacts: Coral Disease/ Bleaching/Trash/Other</u>	<i>0 = none, 1 = low, 2 = medium and 3 = high</i>			
	0-20m	25-45m	50-70m	75-95m
Coral damage: Boat/Anchor				
Coral damage: Dynamite				
Coral damage: Other				
Trash: Fish nets				
Trash: General				
Bleaching (% of coral population)				
Bleaching (% of colony)				
Coral Disease (% of coral affected if yes)				
Rare animals sighted (type/#)				
Comments:				

Site Name: _____	Country/Island: _____
Depth: _____	Team Leader: _____
Date: _____	Time: _____

Fish

Data recorded by: _____

	0-20m	25-45m	50-70m	75-95m
Dark butterflyfish (egr'aisee)				
Arabian butterflyfish (misht el-aross)				
Longfin butterflyfish (Znfooz)				
Butterflyfish (Chaetodontidae)				
Barramundi cod (Cromileptes)				
Humphead wrasse (<i>Chelinus undulatus</i>)				
Grey grunt (Yanam)				
Black spotted grunt (mutawa'a)				
Spotted grunt (firsh)				
Sweetlips (Haemulidae)				
Bumphead parrot (<i>Bolbometopon</i> spp.)				
Parrotfish (Scaridae) (ONLY >20cm)				
Snapper (Lutjanidae)				
Moray eel (Muraenidae)				

Grouper sizes (cm) (count ONLY >30cm):	0-20m	25-45m	50-70m	75-95m
30-40 cm				
40-50 cm				
50-60 cm				
>60 cm				
Total # grouper				

Orange spotted grouper (hamour) sizes (cm) (count ONLY >30cm):	0-20m	25-45m	50-70m	75-95m
30-40 cm				
40-50 cm				
50-60 cm				
>60 cm				
Total # grouper				

Rare animals sighted (type/#)				
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Comments: _____

Belt Transect Form (Red Sea)

Site Name: _____	Country/Island: _____			
Depth: _____	Team Leader: _____			
Date: _____	Time: _____			
<i>Data recorded by:</i>				
<u>Invertebrates</u>	0-20m	25-45m	50-70m	75-95m
Banded coral shrimp (<i>Stenopus hispidus</i>)				
<i>Diadema</i> urchins (including <i>Echinothrix</i> spp.)				
Pencil urchin (<i>H. mammilatus</i>)				
Collector urchin (<i>Tripneustes</i> spp.)				
Sea cucumber (Holothuridae)				
Crown of thorns (<i>Acanthaster plancii</i>)				
Triton (<i>Charonia tritonis</i>)				
Lobster (Palinuridae)				
Giant clam (<i>Tridacna</i> sp.) sizes	0-20m	25-45m	50-70m	75-95m
<10 cm				
10-20 cm				
20-30 cm				
30-40 cm				
40-50 cm				
>50 cm				
Total # giant clams observed				
<u>Impacts: Coral Disease/ Bleaching/Trash/Other</u>	<i>0 = none, 1 = low, 2 = medium and 3 = high</i>			
	0-20m	25-45m	50-70m	75-95m
Coral damage: Boat/Anchor				
Coral damage: Dynamite				
Coral damage: Other				
Trash: Fish nets				
Trash: General				
Bleaching (% of coral population)				
Bleaching (% of colony)				
Coral Disease (% of coral affected if yes)				
Rare animals sighted (type/#)				
Comments:				

Site Name: _____ Depth: _____ Date: _____	Country/Island: _____ Team Leader: _____ Time: _____			
<h2 style="margin: 0;"><u>Fish</u></h2>				
Data recorded by: _____				
	0-20m	25-45m	50-70m	75-95m
Butterflyfish (Chaetodontidae)				
Sweetlips (Haemulidae)				
Broomtail wrasse (<i>Cheilinus lunulatus</i>)				
Humphead wrasse (<i>Cheilinus undulatus</i>)				
Bumphead parrotfish (<i>Bolbometopon muricatum</i>)				
Other parrotfish (Scaridae) only >20 cm				
Snapper (Lutjanidae)				
Moray eel (Muraenidae)				
Grouper (Serranidae) sizes (cm) (count ONLY >30cm):	0-20m	25-45m	50-70m	75-95m
30-40 cm				
40-50 cm				
50-60 cm				
>60 cm				
Total # grouper				
Rare animals sighted (type/#)				
Comments: _____				



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ISBN 0-9723051-1-4



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