Reef Check Australia

Methods Manual

empowering people to save our reefs and oceans

Reef Check Foundation Ltd

www.reefcheckaustralia.org

REEF CHECK
AUSTRALIA

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REEF CHECK METHODS

The goal of Reef Check monitoring is to determine broad-scale trends of how our reefs are changing over time on both local and global scales. Our data can be passed on and used by scientists and managers as an early warning system to supplement other monitoring programs that document changes and disturbances on the reef. Long-term reef monitoring is important to help understand the impacts of management practices, the disturbance–recovery regime of reefs, changes taking place over time in response to localised and global pressures (i.e. local factors such as sediment runoff or global pressures such as climate change).

Reef Check scientific methods have been peer reviewed by international scientists to create a consistent global protocol for community-based reef health monitoring. These methods were designed to be carried out by volunteer SCUBA divers with little to no previous scientific training. Volunteers are prepared to conduct surveys, utilise survey materials and identify Reef Check indicators during a four day Reef Check training course.

What do we measure?

A set of biological indicators was chosen for Reef Check, to serve individually as indicators of specific types of human impacts, and collectively as a proxy for ecosystem health. These indicators fall into the following categories:

- Anecdotal site description (conducted in the 'site survey')
- Coral Communities (conducted in the 'substrate survey')
- Macro-invertebrates (conducted in the 'invertebrate survey')
- Impacts (conducted in the 'impact survey')
- Fish (conducted in the 'fish survey')

THE TRANSECT LINE

Reef Check surveys are conducted along a transect line marked by a graduated tape measure that is laid along a constant depth and reef habitat. The transect length that is surveyed is 80m, divided into four 20m sections or transect replicates (Figure 1). Each 20m sections is separated by 5m or more to create independent replicates that can be compared within surveys as well as between surveys.

Reef habitats include: back reef crest, back reef slope, back reef wall, fringing reef leeward, fringing reef seaward, lagoon and reef flat.

Where the reef is not continuous, e.g. spur and groove formations or separate bommies, sections of the survey may be excluded if they are not representative.

Transect depths are grouped into Shallow (1-5m), Medium (6-9m) and Deep (10-12m).

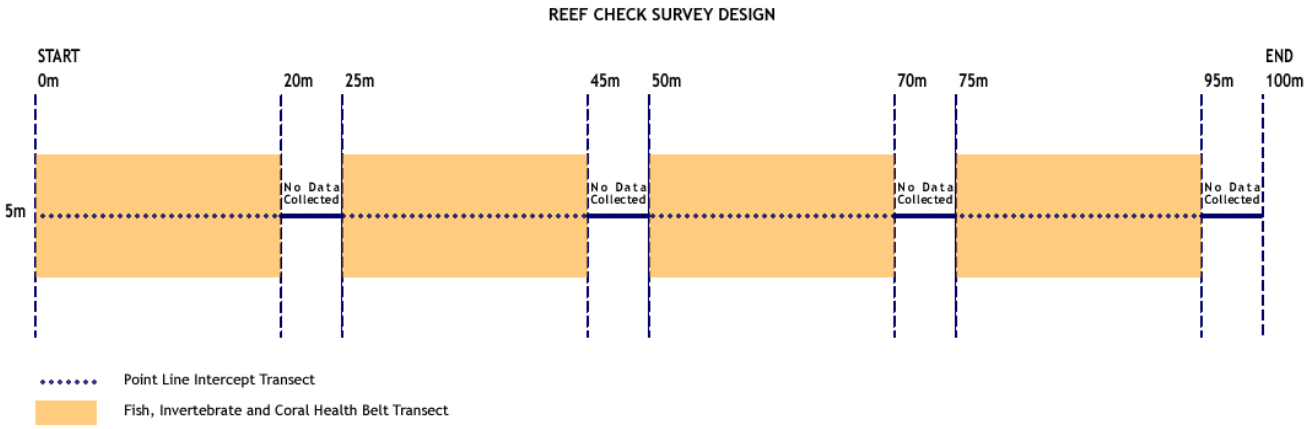


Figure 1: The Reef Check transect is made up of four 20m replicates where the substrate, invertebrate, impact and fish surveys are conducted.

Because we cannot survey every square centimetre of a coral reef, we sample small sections. We carefully select these sections to be representative of the part of the reef and the scale that we are interested in. For 1 Reef Check survey our scale is very small and we interpret our data at the scale of a dive site or <1km of reef. Where we are able to survey up to 3 Reef Check sites per location we are able to increase our confidence with interpretation to 1 km of reef.

We currently complete one standard Reef Check survey at most of our survey dive sites. One Reef Check transect site (single depth) can be surveyed in a single dive by our Reef Check team. However, In order to improve the precision of our data, we aim to do up to 3 Reef Check transects at some sites e.g. those that are most accessible and have sufficient reef (Figure 2).

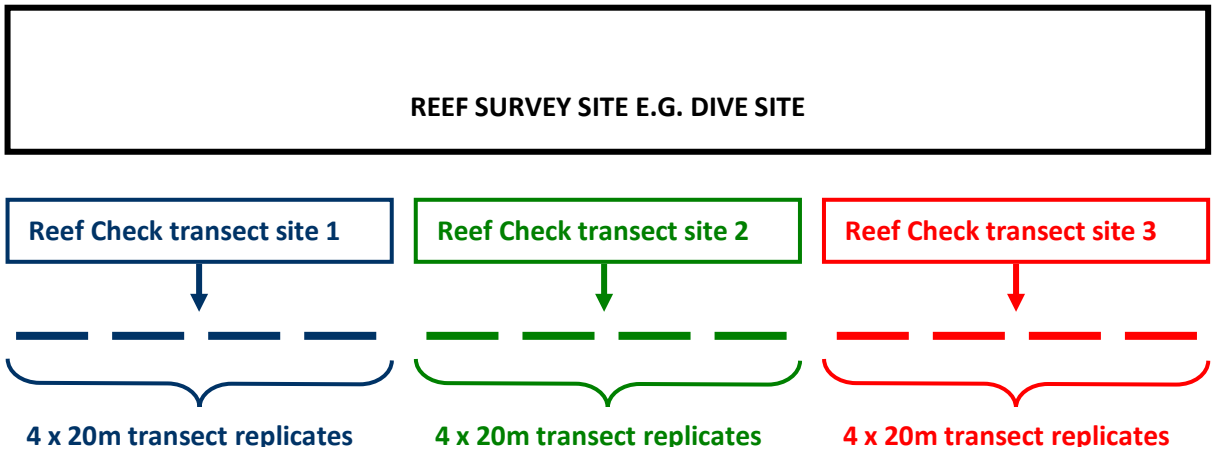


Figure 2: Illustration of how multiple Reef Check sites are set up in one survey location.

Substrate Survey

The substrate survey collects information about the percentage cover of bottom-dwelling (benthic) organisms and substrate on the reef. Each of these reef health indicator groups has a functional role on the coral reef. Reef Check Australia has 25 substrate category groups that have been expanded from the basic Reef Check International substrate categories. These expanded categories collapse to fit into the broader Reef Check International categories, allowing data cohesion while capturing additional levels of substrate detail.

The 10 Reef Check International substrate categories include: hard coral (HC), soft coral (SC), recently killed coral (RKC), nutrient indicator algae (NIA), sponge (SP), rock (RC), rubble (RB), sand (SD), silt/clay (SI) and other (OT).

A “point sampling” method is used for this survey. The team records the substrate type that is directly below the tape measure every 0.5m along each of the four 20m sections interval. These points allow us to calculate percent cover for each substrate type within the survey area. To determine which part of the reef is directly below the line at each 0.5m interval, a weighted line (called a plumb line) is dropped at each interval and the substrate the weight lands on is recorded. This removes bias, which ensures the data represent the real abundance of each substrate category on the reef.

Table 1 provides the key of codes used for the different types of substrate. These codes are used by Reef Check volunteer researchers to quickly record the substrate categories they see underwater. They are also used on the graphs we produce of our survey results.

Table 1: Substrate categories and codes utilised for Reef Check surveys.

Reef Check Basic Categories	Reef Check Australia Categories
HARD CORALS **Growth Forms**	**HCBR**: Branching Hard Coral **HCF**: Foliose Hard Coral **HCM**: Massive Hard Coral **HCE:** Encrusting Hard Coral **HCP:** Plate Hard Coral **HC:** gathers all other growth forms (digitate, columnar, etc.) **HCB**: Bleached Hard Coral
SOFT CORALS	**SCL:** Leathery Soft Coral **SCZ:** Zoanthids **SC:** Other Soft Coral (tree or flower shaped) **SCB:** Bleached Soft Coral
RECENTLY KILLED CORAL	**RKCTA**: Recently killed coral covered with Turf Algae **RKCNIA:** Recently Killed Coral covered with Nutrient Indicator Algae **RKC:** Recently killed coral (non covered with algae)
SPONGES	**SPE:** Encrusting sponge **SP:** All other sponges
OTHER	**OT: All non-target life forms (ascidians, corallimorphs etc)**
MACROALGAE	**MA: *Padina, Sargassum, Turbinaria*** **(and *Asparagopsis* in SEQ)**
NUTRIENT INDICATOR ALGAE	**NIA: All other algae forms**
ROCK	**RCTA: Rock covered with Turf Algae** **RCCA: Rock covered with Coralline Algae** **RC: Rock (not covered with algae)**
SAND	**SD: Coarse grain particulate matter**
SILT	**SI: Fine particulate matter**
RUBBLE	**RB: Un-consolidated substrate**

Why is the substrate survey important?

The substrate survey is important because it provides the percentage cover of key functional groups making up the reef structure. One of our main categories of interest is hard corals, as they are sensitive to environmental change and are the main reef-builders. Percentage cover of hard coral is the most commonly used proxy for coral reef health by coral reef managers around the world.

When hard coral cover declines and doesn't recover well over the following 5-10 years, this may indicate a decline in coral reef health.

Hard coral cover may decline for a variety of reasons. Reef Check surveys are mainly interested in human reef impacts that can be address through management actions. We monitor a wide range of reef health impacts, such as bleaching, disease and scars which can provide additional information about how hard coral has declined. Around the world, issues such as overfishing, habitat destruction, poor water quality and thermal stress are significant causes of hard coral decline.

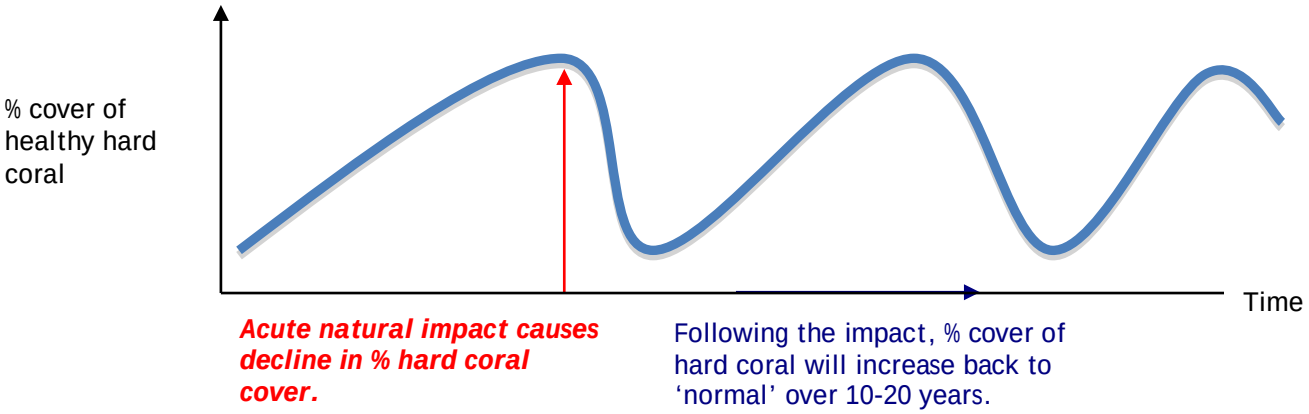
Reefs are naturally subject to acute (sudden and short-lived) environmental disturbances such as cyclones. Reefs that are damaged by these physical disturbances generally recover over a 10 to 20 year period. As reef rubble consolidates, new corals settle and grow. This in turn attracts other organisms. This cycle of physical disturbance–decline–recovery is natural for coral reefs. These natural disturbances play an important role in shaping the ecosystem structure that we see.

It is important that we understand how reefs change naturally so that we can determine how human impacts may affect them.

A healthy coral reef will naturally decline and recover in cycles through time. The health of a coral reef can be explained in terms of its *resilience* to impacts, such as its ability to recover after disturbance. We can measure this health by monitoring how coral reefs change over time. A single survey will not tell us if a reef is healthy or not, because we would not know at what stage of decline or recovery the reef is at in terms of its dynamic balance (Figure 3).

a.

A model view of how a healthy coral reef will recover following an acute natural impact, such as a cyclone.



b.

A model view of how an unhealthy coral reef will fail to recover fully through repeated impact events.

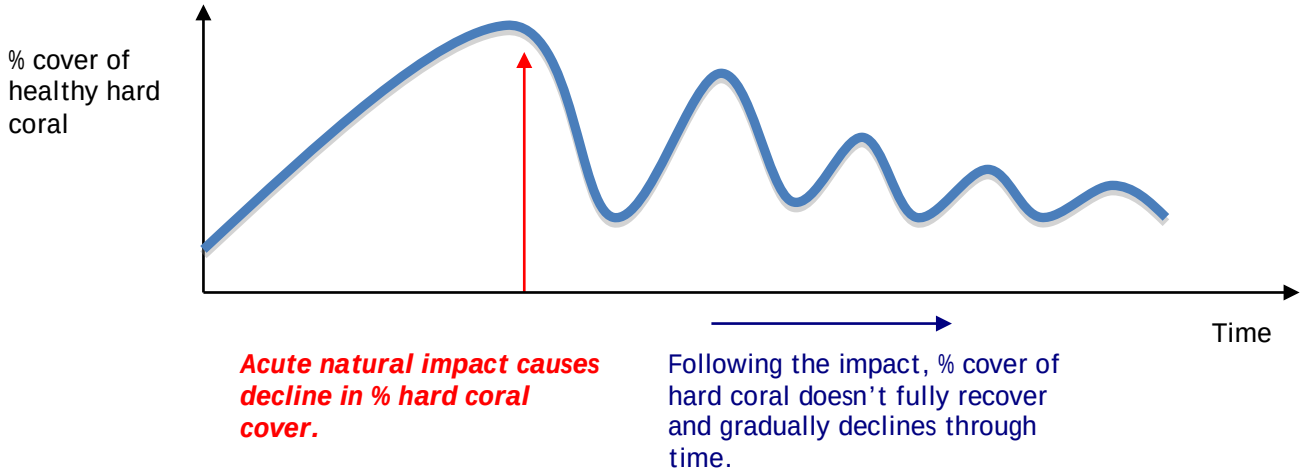


Figure 3 a & b: dynamic balance of a healthy (resilient) coral reef; b: gradual decline of an unhealthy (non-resilient) coral reef.

As the disturbance–recovery regime of a coral reef is complex, the longer the time-period for which we have monitoring data, the more disturbance-recovery patterns we can see. This will lead to a better understanding of how coral reefs can change over time.

Monitoring is, therefore, important to help managers to understand which management practices (e.g. levels of fishing pressure or fertiliser run-off that are allowed) are sustainable or which ones are unsustainable and cause a decline in coral reef health. Monitoring is an essential component to reef management.

By monitoring our reefs each year, we'll be helping scientists understand how human activities affect reefs into the future.

BELT TRANSECT: INVERTEBRATE, IMPACT AND FISH SURVEYS

Fish, invertebrate and impact abundance surveys are conducted using the same transect as the substrate survey, using a 5m wide belt transect area using a u-shaped search pattern to search for target indicators.

The presence or absence of these indicators does not necessarily mean there is a problem on a reef-by-reef scale. However, providing an overview of where indicators occur and changes in abundances can help us to understand changes to reefs over time and analyse the potential cause of threats to reef health.

Invertebrate survey

Selected invertebrate indicators represent organisms that have an economically or ecologically important role. See Table 3 for a list of these indicators and why they have been selected.

Economically important species are generally harvested for food, decoration or the aquarium trade. An example of economically important species in Australia includes banded coral shrimp, which are collected for the aquarium trade.

Ecological indicators are important for the health and functioning of the reef system. Examples of ecological indicators are *Diadema* sp. urchins, which are important algae grazers. The absence of algae grazers can cause prolific algae growth and may change a coral reef from a coral-dominated state to an algae-dominated state.

Table 3: Reef Check Australia invertebrate indicator categories and the reef health impacts they may help indicate.

Indicators	Overfishing	Dynamite Fishing	Cyanide Fishing	Curio Collection	Aquarium Fish Collecting	Pollution e.g. fertilizer, sewage	Coral damage
Invertebrates							
Banded coral shrimp (*Stenopus hispidus*)					X		
Crown-of-thorns starfish (*Acanthaster planci*)						X?*	X
Spiny lobster & Slipper Lobster (*Panulirus* spp.)	X						
Long-spined black sea urchins (*Diadema and Echinothrix spp.*)							
Giant clams (*Tridacna* spp.)	X			X			
Pencil urchin (*All species)*				X			
Sea cucumbers (*Thelenota ananas, Stichopus chloronotus, Holothoria edulis*)	X						
Triton (*Charonia tritonis*)	X			X			
Drupella spp. snails							X
Collector urchins *(Tripneustes* spp.)	X					X	
Trochus (*Trochus niloticus)*	X			X			
Anemone (All species)					X		

*Scientists think there may be a link between crown-of-thorns starfish outbreaks and nutrient pollution (Brodie et al, 2005).

Fish Survey

Fish abundance data is recorded using the same transect line area, counting fish within a 5m wide belt and 5m tall tunnel from the benthos to the water column. Humphead wrasse and Bumphead parrotfish are also recorded when not on the transect area. RCA fish indicators represent economically or ecologically important fish species, such as those important for fisheries or maintaining reef system health. See Table 4 for a list of the 11 RCA indicator fish categories. Additional fish categories are being reviewed for inclusion in South East Queensland surveys.

Table 4: Reef Check Australia fish indicator categories and the reef health impacts they may help indicate.

Indicators		Overfishing	Dynamite Fishing	Cyanide Fishing	Curio Collection	Aquarium Fish Collecting	Pollution e.g. fertilizer, sewage	Coral damage
Fish								
Barramundi cod (*Cromileptes altivelis*)		X	X	X		X		
Butterfly fish *(Chaetodontidae)*		X		X		X		
Grouper	Common Coral Trout* *(Plectropomus leopardus)*	X	X	X				
	Queensland Grouper* *(Epinephelus lanceolatus)*	X	X	X				
	Grouper* *(Serranidae)*	X	X	X				
Humphead wrasse** (*Cheilinus undulates*)		X	X	X		X		
Moray eel *(Muraenidae)*		X				X		
Parrotfish	Bumphead parrotfish** (*Bolbometopon muricatum*)	X	X	X		X		
	Parrotfish >20cm *(Scaridae)*	X	X	X		X		
Snapper *(Lutjanidae)*		X	X					
Sweetlips *(Haemulidae)*		X	X	X		X		

*Note that all grouper > 30 cm and sized to the nearest 10 cm are counted.

**Maori wrasse and bumphead parrotfish that are off the transect area recorded because the transect length is insufficient to capture true populations of these large fish which have a large range.

Reef Impact survey

Reef impact surveys are conducted using the same 5m belt transect, searching for visual evidence of reef health impacts. See Table 5 for a list of the 12 reef health impacts that are recorded. Photographs are taken of reef impacts for further documentation.

Impact surveys are conducted to record reef health impacts observed on a transect. Examples of impacts include hard coral bleaching and disease, but also fishing line and trash. The presence of extensive areas of bleaching may be an indicator of a larger more serious problem and this information can be passed on to scientists who can then investigate further. The presence of trash and fishing line can also be reported to the relevant authorities who can organize a clean up or look to try to reduce the problem.

Table 5: Reef Check Australia impact categories.

REEF IMPACT INDICATORS	Coral damage: boat/anchor, dynamite, other Trash: Fishing line, fishing nets, general Bleaching: percent of coral population and each impacted colony Disease: Incidents of coral disease Coral Scars: *Drupella* sp. scars, Crown-Of-Thorns scars, other scars

QUALITY ASSURANCE

Quality assurance procedures are essential for maintaining high-quality data that can be utilised for science and management applications. These guidelines have been implemented to help ensure the quality of data and include comprehensive training requirements, data collection instructions and data entry processes.

Training

All Reef Check Australia volunteers are required to successfully complete the RCA Training course under the direct supervision of a certified RCA Instructor to be eligible join survey teams. Participants receive a PADI Reef Health Surveyor Distinctive Specialty certificate and an EcoDiver certification, allowing them access to the global Reef Check network (additional regional training may be required).

We maintain a high standard of identification accuracy by volunteers as well as reducing variability between volunteers by rigorously training our volunteer researchers. The RCA training course requirements include:

1. Completed reading Reef Check Australia Training Manual and Knowledge Reviews (6 hours)
2. Attendance and participation at classroom sessions (8 hours)
3. Attendance and participation at field sessions, including buoyancy practice (5-6 dives)
4. Successfully pass the written exam (85% passing score)
5. Successfully pass the in-water identification exams (95% passing score)

Please see website for our current Dive Policy and current training participant requirements.

Data Collection

RCA data collection methods have been designed to ensure the safety of the surveyor as the primary goal, followed by the accuracy and precision of all data collected.

To increase survey precision and reduce error, our survey protocol requires:

1. A Team Scientist/Team Leader to supervise each survey team to ensure transect deployment, review data, monitor volunteers and answer questions.
2. Standardized site selection and transect deployment procedures
3. Standardized time requirements for survey completion to ensure consistent survey effort
4. Minimised redeployment error for the transect tape placement by using a detailed map of the survey area, mean low tide times and GPS coordinates.
5. Grouping of species with similar morphological traits to reduce the likelihood of misidentification
6. Use of size categories for fish surveys
7. Use of standardized data notation procedures on the underwater data sheets

Field Data Verification

Immediately following each dive, each team member must review their data sheet for completeness and legibility. The Team Leader reviews data sheets (and photographs) with volunteers to ensure the data sheets have been fully completed and are accurate before leaving the site.

Data Entry

In 2009, Reef Check Australia launched the Reef Health Database as a transparent and accessible system that shares the data collected by survey teams. All Reef Check Australia data is also provided to Reef Check International for global data comparisons.

Data entry procedures

1. Team Leader or RCA Staff takes completed datasheet set from survey site, rinses and dries sheets. Original sheets are scanned and saved.
2. Quantitative data collected on datasheets is compared with digital photos to ensure accuracy.
3. Data is entered on-line through Reef Health Database in the following categories:
    a. Site information
    b. Line transect data (160 substrate data points)
    c. Belt transect data (including fish, invertebrates and reef impacts)
    d. Photographs (with category identification)
4. Raw data and automated graphs are reviewed by Regional Coordinator and Team Leader is contacted regarding any queries.

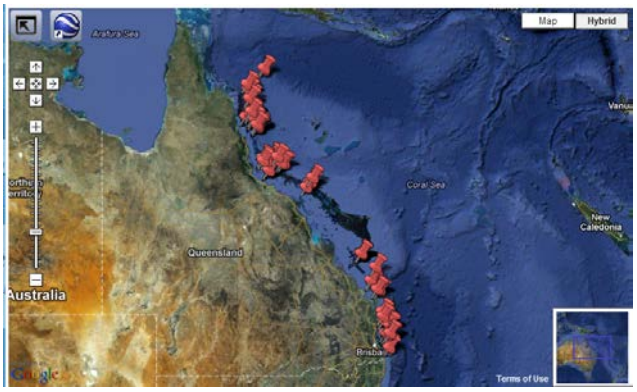
Data Interpretation

We recognise that a key question for users of community-based monitoring data is how well the data reflects real patterns and can detect temporal change.

A study to look at the observer effects of Reef Check volunteers found that differences between observers and subsequent transect deployments is low, with average deployment effect across all benthic categories of only 6.14% (Done et al 2012 in draft). In summary, the standard error of the cover estimate across all categories was of the order of 1-2%. We have confidence that observer errors are only minor contributors to the variability among pooled samples at the scales of individual reefs and across many reefs. This means with adequate training and suitable maps, volunteers can be trained to collect useful reef health monitoring information, but that small changes in substrate cover are not detectable.

We practice carefully data analysis, with recognition of strengths and limitations. Our measures of data precision show that we cannot determine differences in percent cover within a 5% range, but differences within the 10% range are likely to indicate real changes when looking at data from one year to the next.

WHAT HAPPENS TO THE DATA?



All of our data is available online through our Reef Health Database. Summary data is available to the public through our summary Google Map interface and raw data is available for Data Users through an online portal. We wanted to make it easy for any interested party (scientist, NRM manager, government official, tourism operator, volunteer or member of the public) to view summary data collected by our survey teams or access raw data for additional analysis. The Database also houses photographs collected during our surveys. The RCA Reef Health Database ensures that: our volunteers can review the data collect, that Reef Check data is in a safe and secure location for storage, interested stakeholders can access data as needed, there is additional scope for data application, there are query applications to investigate data, data review by staff & team scientists is efficient and rigorous and that data is available to other relevant online storehouses, including the Reef Check global program.

All Reef Check Australia data is shared with Reef Check International to contribute to the global reef database, for worldwide reef health comparisons. You can also find a list of scientific articles that have used Reef Check data.

In addition to contributing to the Reef Check monitoring program, Reef Check is a Partner organisation & data provider for The World Fish Centre's ReefBase; a data contributor for the Global Coral Reef Monitoring Network's Status of the Coral Reefs of the World reports; and our data is incorporated into the E-Atlas portal for Australia's tropical terrestrial and marine environments.

HOW DO YOU INTERPRET REEF CHECK RESULTS?

There are strengths and limitations to Reef Check data. Our community-based framework allows us to engage volunteer divers in monitoring their own local reefs with minimal expense compared to other professional programs. It also allows us to connect with the tourism industry to gather their valuable insights and feedback as well as sharing results of our program with our boat guests. Our program can help to fill gaps in monitoring data for improved scientific knowledge for management decisions and help to involve coastal communities in better understanding and protecting their reefs.

Our annual surveys are intended to be a snapshot of reef health and not a detailed scientific inventory. The global nature of our program requires that we maintain broad monitoring categories for large-scale comparability and consistency. Annual surveys are sufficient to collect data about substrate cover, but may not be adequate to monitor highly mobile invertebrates or fish, nor can it detect seasonal variations.

If we see a small change in percent cover of substrate, what does this mean?

It is important to take into account that slight alterations in transect placement between each survey period as well as small observer errors may account for slight differences between percentage cover of particular categories from year to year. Our measures of data precision show that we cannot determine differences in percent cover within a 5% range, but that differences within the 10% range are likely to indicate real changes when looking at data from one year to the next. Where there are long term data sets it is possible to look at the general trend to determine if a small increase or decrease from one year to the next is likely to be real or not.

If we see large changes in percent cover of substrate, what does this mean?

If we see a large difference in the percent cover of a substrate we will first look at our site information and other survey data for clarification. For example, if hard coral cover is drastically reduced and we see from the invertebrate survey that crown-of-thorns starfish abundance is high, then it is possible that hard coral decreases are due to starfish predation. However, the reason for fluctuations may not always be apparent, it may be short-lived, e.g. algal blooms, and they may not be serious.

So to increase our understanding of patterns of change, it is very useful to monitor sites through the long-term. Such studies also help us to determine if any changes that we are concerned about e.g. reduced coral cover, continue to get worse, fail to recover to their previous amount or are just fluctuating in a cycle (see Figure 3 – the dynamic balance of coral reefs).

Reef Check results are meaningful on a long-term scale, rather than from a single snapshot in time.

Does low hard coral cover mean our dive site is unhealthy?

It is important to remember that some sites will naturally support more or less coral cover due to a variety of environmental factors. Therefore it is not important how much coral a reef has, but how it reacts over time to its environment. Healthy coral reefs with low coral cover can have a stunning array of fish and invertebrate life!

Cycles of decline and recovery are natural for coral reefs. We get concerned if a reef declines and does not show signs of recovery with ongoing monitoring. For example, coral cover at a site may decline due to crown-of-thorns starfish predation or cyclone damage. The hard cover percentage cover will decline with this impact, but on a healthy reef coral cover will increase again over the next 10-20 years as the site recovers. This cycle has been recorded for a number of reefs on the Great Barrier Reef that have been affected by crown-of-thorns starfish outbreaks.

Natural disturbance is important in sustaining species diversity.

Natural disturbance is important on coral reefs where corals (and other animals and plants) compete with one another for space. Cyclones and crown-of-thorns starfish will tend to wipe out delicate coral growth forms, such as branching or plate coral. These delicate corals tend to be faster growing and out-compete the more robust species for space. These impacts, therefore, give the more robust corals a chance to grow and promote species diversity (and health) of coral reefs.

If we don't record certain indicators, is there a problem?

The presence or absence of one or several indicators does not mean there is a problem. The abundance of some of the indicators, particularly invertebrates, will naturally vary from reef to reef. Each site will be unique in its ecological make-up. Therefore, long-term data for each site is important for us to determine if our reefs are changing.

In addition to variations from reef to reef, many of the target invertebrates and fish are highly mobile and their abundance in a particular part of a reef changes through the day as well as across seasons. A single Reef Check survey is not sufficient to fully characterise fish or mobile invertebrate populations at a site but rather provide a snapshot of what is there. Therefore these data must be interpreted with care. For long-term studies, however, we will become concerned when invertebrates and fish that used to be present at a local scale are no longer there.

Disclaimer

The Reef Check protocol was designed for use by volunteer divers and snorkelers to monitor basic and globally applicable indicators of reef health. Small-scale fluctuations cannot be determined from Reef Check data, which is designed to detect broad changes through the long-term.

Reef Check Foundation Ltd makes no representations or warranties in respect to the accuracy, usability or completeness of the data; or the data being free from errors. The supplier may update, change, alter or delete the data at any time without liability. Data users will only use the data for the purpose of information and research and will not use or exploit (whether for itself or for any other person) any of the Data for commercial purpose.

Data users must include the following text in the appropriate referencing section in the relevant document: "This document contains information or data belonging to, and reproduced with the permission of Reef Check Foundation Limited "Reef Check Australia"). Reef Check Australia has not evaluated the data or information contained in this document. Reef Check Australia gives no warranties and makes no representations in respect to the data. The data belonging to Reef Check Australia, shall not be copied or in other way made use of by any person without the express written consent of Reef Check Australia."

USEFUL REFERENCES

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Season Reports

Please see links to Season Summary reports on our website.

Reef Check Applications

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