Tsunami Damage to Coral Reefs

Guidelines for Rapid Assessment and Monitoring

ICRI/ISRS
International Coral Reef Initiative/International Society for Reef Studies
(Version 1 – January 2005)

This document is available on the following websites:
UNEP: http://www.unep-wcmc.org/latenews/emergency/tsunami_2004/coral_ass.htm
ICRI: http://www.icriforum.org/
ReefBase: http://www.ReefBase.org/

CONTENTS

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ICRI: http://www.icriforum.org/
ReefBase: http://www.ReefBase.org/
***Microsoft Excel datasheets in files*:** ISRS_ICRI Tsunami Datasheets V1.xls
Reef Check+Tsunami Datasheets V1.xls

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Introduction

The unprecedented tsunami of 26 December 2004 killed over 200,000 people in Asia and also damaged the coral reefs that many depend upon for their daily survival. Under the banner of the International Coral Reef Initiative, a group of coral reef scientists has responded by reviewing existing methods and choosing those that would be most useful for assessing the immediate damage and for monitoring long-term changes due to the tsunami. It is hoped that the protocol will be useful for assessing future tsunamis as well. It is important to note that this is a biophysical protocol and users should consider adding a socio-economic component such as SocMon or SocCheck. This protocol will allow comparisons of data at the local, national and regional levels. It is intended for use by people with experience in coral reef monitoring or underwater observation (e.g. scientists, experienced dive operations and volunteer divers) to contribute to disaster assessments of the tsunami and thereby contribute to responses to the disaster in the countries affected. Your involvement will contribute significantly to understanding the impacts of the tsunami and monitoring the recovery of reef communities afterwards.

This document is not intended to be a stand-alone manual. Familiarity with monitoring protocols, or referring to other coral reef monitoring methods will be needed. Each team will have to make decisions on how best to implement the protocols to match the local needs. Once started, it will be important to keep a consistent method. Please contact any of the coordinators/contacts given in this document if you have any questions or need advice.

The safety of monitoring teams is essential and all teams should ensure they have adequate training, equipment and supplies, and are fully knowledgeable about the monitoring areas and risks associated with snorkeling and diving.

Designing your monitoring programme

Describe the tsunami locally

The impacts of tsunamis may be highly variable even along adjacent parts of a coast. Gather as much information as possible on the size of the tsunami waves and local conditions along stretches of coastline in the survey. As far as possible, include information on:

- Wave height, number of waves, time of impact, duration of the waves
- How far did waters recede – distance from shore and/or vertical height, how many times, for how long.
- Tide level at time of impacts
- Weather condition at time of impacts – in particular, roughness of the sea and whether it was raining.
- Were there any secondary tsunami effects from aftershocks.
- Weather for the week following the tsunami, in particular, roughness of the sea and whether it was raining.

For each site, additional detail on the tsunami should be collected, including the distance that the wave penetrated inland at each site, geomorphology of the coastline, the degree of development or human impact (hotels on sand dunes, mangrove deforestation etc.), and patterns of damage on land.

Because of the variability in tsunami impacts, compile this information for different areas within the survey region– for example, every 50-100 km of coastline.

Background information

It is critical to know the context of the assessment sites. Ideally, background information should be used to select sites, but this may not be feasible and rapid assessments should proceed as soon as possible following guidelines below.

Prepare maps and site descriptions when possible, after or during final stages of rapid assessment, or perhaps conducted by people not involved in fieldwork, with the following information:

- Topographic maps, charts and satellite images showing the shape of coastlines, offshore bathymetry and location and structure of reefs. The coastline shape and depth of water had complex effects on the local size and damage related to the tsunami, as well as configurations of fringing or patch reefs, islands, offshore reef platforms, etc. Many satellite images are freely available on the internet now, and cover most areas affected by the tsunami.
- Primary coastal natural habitats – mangroves, coastal forests, sand dunes/vegetation, seagrass beds, estuaries, etc.
- Primary infrastructure – roads, towns, hotels and residential developments, aquaculture/agricultural development, etc.
- Intactness/condition of natural vegetation – highly or slightly degraded, or pristine.

The site datasheet includes a number of indicators that will help to describe the site in terms of coastal features and morphology, coastal development, existing impacts to the site and any protection regimes. The datasheet can be filled out on-site, while broader descriptions of the area should be compiled from multiple site sheets and background information suggested above.

Other ecosystems and tsunami damage assessments:

- Integrate with adjacent ecosystem assessments and general coastal area/terrestrial assessments – in particular, damage to coral reefs may be related to intact/degraded mangroves, coastal forests and coastal development.
- Integrate into disaster monitoring/mitigation strategies from local to national levels – engage with official damage assessment programmes to ensure the information feeds into national assessments of tsunami damage.

Who can conduct monitoring?

Rapid assessments and monitoring programmes have been successfully carried out in the countries affected by the tsunami by interested divers, marine managers and scientists. Rapid assessments can easily be done by people with no scientific background but with good observational skills and following strict guidelines on how to record data. Thus, make the most of available people to collect as much information as possible on the tsunami damage – this will help identify how much detailed monitoring should be carried out at later stages by scientific and more highly trained monitoring teams.

In addition, background information needs to be collected and can be done by non-divers or snorkelers, and they can help in coordinating rapid assessment teams.

Your team could include: students and travelers with experience in diving or snorkeling, fishermen, aid or military staff on their day off, scientists in other fields, marine park and reserve managers and rangers, and marine scientists and dive/snorkel operators to help in applying the methodology.

How to conduct the monitoring

- Use a staged approach starting with wide-scale surveys to assess overall levels of damage in an overall area (rapid assessments), followed by increasingly focused and detailed surveys at a smaller number of sites (detailed surveys).
- Visit sites previously known, or with data from before the tsunami to enable before-after assessments.
- Use existing methods where possible to allow best comparisons with existing datasets for the sites.
- Integrate with long term/existing monitoring programmes so that the information can be related to pre-tsunami conditions, and to support the long-term efforts of ongoing and locally based groups.

As a rule of thumb, start broad using the simpler 'volunteer' datasheet, and as the big picture becomes clear, experienced monitoring teams can move to smaller scale detailed assessments.

Sampling principles

Surveys should initially cover as large an area as possible, and as many sites as possible. After overall damage levels are known, scientists and managers can use the information to identify where to establish detailed monitoring sites.

- Rapid assessment – should be the priority for the first 1-3 months of surveys, depending on how often teams can enter the water, the size of the area being considered and the information being collected.

- Detailed surveys – should be built up following analysis of information from the rapid assessment. These should include sites that have previously been studied, perhaps in long term monitoring programmes.

Site selection

Use three primary criteria in selecting sites for initial surveys, following which a broader selection of sites can be considered to fill in the general picture:

1. Prioritize sites where it is likely that tsunami impacts were highest – this may be where the waves were known to be highest, where impacts on land were highest, or based on other knowledge. Fishermen or others may also have information on where reefs appear to be most damaged

2. Prioritize sites for which monitoring data are available from before the tsunami, or for which knowledge of its status before the tsunami is relatively good.

3. Also include a few "control" sites (2 or more) where damage is observed to be minimal. This will enable more powerful comparisons between damaged and undamaged sites, and provide the basis for estimated the magnitude of the damage in areas where no data from before the tsunami exist.

Initial surveys on sites satisfying the above criteria will enable quantification of the worst impacts of the tsunami. Following these, start to include sites that might have had lesser impacts, or that have not been surveyed before. Also select sites with different characteristics of coastal morphology, levels of exposure impact, spacing and representation, etc.

For each location surveyed, record the GPS location from the drop-in point (by boat or from land) and the pick-up point, and fill in all the information on the Site datasheet. To facilitate comparisons among survey programmes and countries, it is essential to estimate the length of coastline surveyed for a site, and to be rigorous about sampling along depth contours.

Tsunami damage has already been reported as being highest in shallow waters. We recommend the following depth ranges for surveys:

1) Reef crest, reef flat and backreefs, **< 1 m depth**
2) Shallow fore reef, at **3 m**
3) Fore reef, at **10 m**
4) Deeper reefs at >15 m if time and resources allow, and it is clear that impacts have extended deeper than the above depth contours.

Rapid assessment

- The initial effort should be aimed at obtaining samples of the entire area of interest to be able to estimate damage. Initially select a broad distribution of sites across the whole area of interest, and ones that can be reached most easily. Once these are completed, identify additional/less accessible sites to fill in large gaps and complete the picture.

- The greatest distance can be covered by manta tow surveys, however these must only be done by people and boat drivers with experience – revise the manta tow methods to adapt your data collection sheets to the tsunami indicators presented here.

- Timed or distance-measured swims can be used to cover large areas – in general, try to cover long areas of coastline for distances of 300-1,000 m. There are already reports that areas with high tsunami damage are adjacent to areas with little damage – it is important to sample both types of areas.

- Much larger areas, and more time in the water, can be covered snorkeling rather than diving. Also, most impacts may be in the top 5 m of the reefs. Therefore, in first surveys, choose snorkeling over diving as it is also logistically easier. For example, start with 1 hour of snorkeling, followed by a 45-minute dive, then another hour of snorkeling. Once shallow areas are well described, you could return to the areas later, to conduct deeper diving surveys.

- It is important to use fixed categories for data collection during all surveys. Initially, if effort and experience are limited, use only the minimum set of categories, and include the more detailed ones once time and experience permit.

- Cover large areas in long transects (300-1000 m) parallel to shore/depth contours.

- Search for variability among impact levels to quantify the full range of what happened.

Long term monitoring

The basic tsunami damage methods can be adapted to suit different long term monitoring programmes. Experienced scientists should generally be involved in all survey teams, or in advisory capacity to several survey teams, and they should be consulted. If not available locally, then contact scientists from the contacts given at the end of this document to help plan the monitoring programme. In general, to adapt these methods to long term monitoring:

- Prioritize prior monitoring sites and select rapid assessment sites representative of the major classes of impact and current state (both low and high impact).

- follow previously established survey designs that have satisfied both local requirements and international recommendations.

- Use this as opportunity to add to existing long term monitoring programmes by increasing overall standards, adding new sites and documenting both tsunami and non-tsunami-related data.

This document specifies methods for conducting new rapid assessments, and recommends ways to incorporate tsunami damage indicators into long term monitoring programmes. We have endeavoured to provide indicative datasheets to facilitate this, though it may be necessary for individual survey groups to refine their own datasheets by adding tsunami damage indicators recommended here. As far as possible, follow the guidelines given here and maintain the units of sampling for tsunami damage. The list of contacts at the back of the document should be used if in any doubt.

Data collection

Sample method and unit

The key feature of this survey method is its sample unit of $10m^2$ to be spread over a study site.

Early reports after the tsunami indicated very patchy damage, necessitating coverage of large areas to describe fully the impacts and somewhat lower overall damage than originally feared. Also, some damage indicators, such as the presence of massive boulders thrown up by the waves, require a sample unit that is large, as opposed to a small one (say, of $1 m^2$, or of points along a transect line).

For these reasons, this protocol has settled on a sample unit of $10 m^2$. How these sample units are arranged in space can vary from one survey programme to another.

Three classes of methods are suggested here, from which your team can select one appropriate to its needs and history, experience levels, existing monitoring programmes and equipment available.

They are presented in decreasing order of the area of reef that can be viewed:

1. Manta tow/long swims – these cover the greatest distance, however high levels of experience are needed, and data subjectivity is higher than the other methods.
2. 'Virtual transect' – observers sample at estimated fixed distances along the bottom, but because of time or logistical constraints cannot lay a transect line. This provides better data reliability due to the fixed-area sample unit, but less distance is covered. However, sample placement is subject to observer bias and

there can be large variations in how this is done between observers and survey programmes.

3. Transect-based – placement of sample units is determined by fixed transect-based rules. Provides the most reliable data, especially for observers with low experience, but covers the least distance. This technique provides the best compatibility of data with past data from long term monitoring efforts.

Table 1. Comparison of three recommended survey types

1) Manta tow/timed swim	2) 'Virtual' transect	3) Transect based
Use recommended manta tow methods from English et al. 1997. The **tow or swim should be along a reef contour, and last a fixed time of 2 minutes**. At the end of this time, stop and record features observed on the datasheet. Unless very experienced, the volunteer datasheet should be used or a subset of variables off the detailed datasheet.	Based on an imagined transect line, 10 m^2 samples can be taken at fixed separation distances. We recommend collecting clusters of 5 samples separated by larger distances in between clusters. To minimize observer bias, estimate distances by numbers of fin-kick cycles – **10 kicks/10 seconds between samples within a cluster followed by 50 kick cycles/1 minute to the next cluster.** To minimize bias in the selection of the first sample, drop a marker or visible stone behind your back and start where it lands.	Survey teams use their normal long term monitoring transect method, and organized the 10 m^2 sampling units around these. Here, we give an example for **Reef Check transects of 100 m, with sets of two 10m^2 samples placed along each 20 m segment**. Programmes that use 10 or 20 m **Line Intercept Transects (LIT) could place a 10 m^2 sample unit at opposite ends of each transect line**, with one in the middle for 20m or longer lines.
Pros		
• Cover largest distance • Provides most general description of impacts.	Covers a moderate distance. • Area-based sampling gives good standardization among observers and survey programmes. • Highly flexible to allow for other work between samples and unpredictable events. • Flexible add-on to long term monitoring programmes	• Most rigorous layout of sample units, independent of observer. • Compatible with long term monitoring programmes
Cons		
• Time-based sampling can have high variability between observers, • Accuracy of recording indicators decreases with larger set of indicators. • Greatly influenced by distractions that reduce observer focus during each sampling interval	• Spatial layout of samples can be strongly observer-biased. • Less comparability among survey programmes	• Covers smallest distance. • Additional time spent laying transects (not a factor when these are being done already for LT monitoring)
Compatible programmes		
Rapid assessments and long term monitoring: Any programmes including manta tows and broad exploration of survey sites for recording data.	*Rapid assessments and long term monitoring:* Any programmes including broad exploration of survey sites for recording data. Monitoring programmes based on random sampling of transects or quadrats.	*Long term monitoring*: Reef Check, LIT and other transect-based permanent monitoring programmes.

There are two critical rules to follow while sampling:

1. ALWAYS use the same methodology, so that data can be compared.
2. DO NOT PRE-SELECT AREAS TO SAMPLE – for example selecting only areas with maximum damage, or only areas with the best coral growth. It is important to have an UN-BIASED estimate of the state of the reef. If there is a particularly important observation about something missed the sampling plan, describe it separately in the observation field.

Data units

Quantifying each variable must be done at a level that is suitable to the skills, knowledge and experience of data collectors in the monitoring programme. Guidelines are provided here for three estimation scales (Table 2):

1) presence or absence – where data is collected only on the basis of whether a feature is present or not.

2) 3-point scale of none, low and high – the easiest scale that gives an indication of quantity, but can be highly subjective and vary between people and programmes.

3) 6-point scale for estimation of area and greater discrimination of abundance levels. This has been used and tested over 20 years by scientists and managers on the Great Barrier Reef, and can be reliably used by observers after some training and regular verification. The first rapid assessments in Thailand used a modification of this method, combining the ‘high’ and ‘extreme’ values (see Appendix).

Table 2. Classes used for estimation of benthic cover and the incidence/ abundance of tsunami damage indicators. Based on Australian Institute of Marine Science long term monitoring programme and English et al. 1997.

A – Presence/absence		**B – 3 point. Low/High**		**C – 6 point. Area estimates**		
Class	*Desc*	*Class*	*Desc*	*Class*	*Range (%)*	*Desc*
0	ABSENT	**0**	ABSENT	**0**	0	None
1	Present	**1**	Present/limited extent/severity	**1**	1-10	Low
				2	11-30	Medium
		2	Common/ extensive/ severe	**3**	31-50	Common
				4	51-75	High
				5	76-100	Extreme

These estimation scales correspond to one another. It is important to note which scale is being used during data collection, and feature is included on the datasheets to enable this. Survey teams should not use the 6-point scale unless it has been practiced and verified through a training exercise using real examples and the illustration (figure 1).

In addition, different scales may be needed for indicators, and the survey team must decide which one is being used, note this for each indicator on the datasheet and be consistent throughout the monitoring programme. For example, a scientific monitoring team with experience in the 6-point scale might use this for estimating the area of live coral, intensity of rubble piling and other variables, but use only the 3-point scale or just presence/absence for the presence of huge boulders rolled over the reef. Examples for how to show this in the datasheets are presented later.

Figure 1. AIMS benthic cover figures (from English et al. 1997) showing area estimation categories in Table 2).

Reef health and tsunami damage indicators

Indicators are provided in two areas, comprising the following:

1. Standard reef health indicators – from monitoring and rapid assessment protocols. For existing monitoring programmes, the standard indicators should be used, modified or added to enable these measures to be assessed.

2. Damage indicators relevant to the tsunami, which can broadly be classified according to whether they are do to:
    a. Wave damage – physical damage from the breaking waves, or

    b. Backwash damage – physical damage and physiological stress from materials and debris carried back over the reefs by the receding backwash off the land.

In the datasheets, tsunami damage is further distinguished by damage to coral heads, and damage to the substrate. The list of indicators is given below as follows:

Category, title and code for each indicator – replicated on the datasheets.
Explanation of the indicator to facilitate recognition underwater. An experienced coral reef biologist or monitoring team leader is necessary to ensure that the explanations are understood by all team members.
Volunteer – these columns indicate which indicators are included on the volunteer-based survey datasheets, and the recommended level of quantification to be used.

Experienced – these columns indicate which indicators are included on the experienced-observer survey datasheets, and the recommended level of quantification to be used. If highly experienced volunteer teams have been monitoring a site for years, such as using Reef Check or LIT methods, they may decide to use the experienced datasheets and incorporate these into the methods they are currently using. Again, a coral reef biologist should be involved in making this decision, and the people listed on the back page of this document can be consulted for advice.

Table 3. List of reef status and tsunami damage indicators

Indicator	code	Explanation	Volunteer		Experienced	
1) Benthic						
Live hard coral	LCC	Live coral that survived the tsunami. Estimate area as proportion of bottom.	y	6pt/3pt	y	6pt/3pt
Recently killed coral/dead coral	RKC	Hard coral that has clearly died recently. The skeleton will appear a dirty white, with sediment and/or algal filaments. Estimate as proportion of LIVE CORAL identified in previous indicator			y	6pt/3pt
Coral life forms, alive	CLF	Write the main coral lifeform types from the standard list below (table 3). A - *Acropora*; TS - Table/staghorn *Acropora*; B - Branching; E - Encrusting; M - Massive/submassive; F - Foliose/plate/laminar; S - Soft coral; WF - Sea whip/sea fan.			y	text
Filamentous algae	FAG	Filamentous algae (e.g. *Enteromorpha*) - very fine filanents, grow within 3-4 weeks due to high nutrients. This may not be observable any more from tsunami, but may occur due to latent nutrients in silt.	y	3pt/p.a	y	6pt/3pt
Thick turf/fleshy algae	TAG	Thick algal turf and fleshy algae, maybe developing from filamentous algal bloom after tsunami. May be prevalent where nutrients are increased and/or fish populations are depleted.			y	6pt/3pt
Rock/bare surface	RC	Rock framework of the reef, including with a thin algal turf.			y	6pt/3pt
Rubble	RB	Old coral rock and pebbles in natural position with covering of algal turf and coralline algae	y	6pt/3pt	y	6pt/3pt
2) Damage-corals						
Overall damage to corals	CDAM	Estimate the proportion of the coral community affected/damaged by the tsunami. Include dead coral in this estimate.			y	6pt/3pt
Up-turned coral	UPC	Live corals, but broken and overturned or lying on the bottom	y	6pt/3pt	y	6pt/3pt
Broken coral	BCC	Live corals in growth position, but physically fragmented, cracked or broken	y	6pt/3pt	y	6pt/3pt
Recently killed coral - standing	RKC-S	Recently dead coral tissue, in growth position.	y	6pt/3pt	y	6pt/3pt
Recently killed coral - upturned	RKC-U	Recently killed corals, upturned and toppled			y	6pt/3pt
Coral life forms - damaged	CLF-D	List coral life forms most damaged, in all of the damage categories listed below (table 3). A - *Acropora*; TS - Table/staghorn *Acropora*; B - Branching; E - Encrusting; M - Massive/submassive; F - Foliose/plate/laminar; S - Soft coral; WF - Sea whip/sea fan			y	text
Damage-Waves						
Overall damage to substrate	SDAM	Estimate the proportion of the substrate affected/damaged by the tsunami.			y	6pt/3pt
slope erosion.	CRE	Erosion of reef slopes caused by slumping of rubble from reef zones above.	y	6pt/3pt	y	6pt/3pt
Rubble piling/movement by strong waves	RBP/M	Movement of old and new rubble by waves, distinguished by piles and drifts of rubble.	y	6pt/3pt	y	6pt/3pt
Loose rocks <50	R<50	Loose rocks (framework, or dead corals) of a small size (approximately 50 cm diameter and			y	6pt/3pt

		less)				
Loose rocks >50	R>50	Loose rocks (framework, or dead corals) of a medium size (between approximately 50 cm and 1 m diameter)			y	6pt/3pt
Boulders > 1m	BLD	Large boulders (framework, or dead corals) moved over the reef surface, of approximately 1 m diameter and larger)	y	p.a	y	6pt/3pt
Scars/exfoliation	SCR	Scars in the reef framework and exfoliation of surface organisms caused by movement of rocks and debris.			y	6pt/3pt
Scar depth cm	SCRcm	Maximum depth of scars observed in the sample unit			y	cm
Cracks	CRCK	Cracks in the reef framework caused by wave forces/battering with rocks			y	6pt/3pt
Damage-Backwash						
Silt smothering live coral surface	SILC	Silt smothering live coral surfaces. May become chronic due to silt stored in reef sediments.			y	6pt/3pt
Silt on reef surface/ sand pockets	SIT	Silt smothering reef surfaces and/or collected in sand pockets and drifts.	y	3pt/p.a	y	6pt/3pt
Debris-stone/ solid	DBS	Loose debris from land - stone, metal and solid items, e.g. from buildings, appliances, vehicles, etc.	y	3pt/p.a	y	6pt/3pt
Debris-vegetation/ seagrass	DBV	Loose debris - vegetation; from trees, mangroves, seagrass, etc.	y	3pt/p.a	y	6pt/3pt
Debris-litter (plastics/text)	DBL	Loose debris from land - litter and rubbish, plastics, textiles, etc.	y	3pt/p.a	y	6pt/3pt
Coral disease	CD	Coral diseases, potentially enhanced by microbial fauna in terrestrial silt.			y	3pt/text
Other						
Coral reef fish	CRF	Coral reef fish. Brief notes - space is included on Reef Check datasheets for notes on key species. For detailed monitoring, Underwater fish surveys should be conducted.	y	text	y	text
Seagrass reduction	SGD	Uprooting or defoliation of in situ seagrasses in sample units.	y	3pt/p.a	y	3pt/p.a
Mangrove debris	BMG	mangrove debris transported to sample areas.	y	3pt/p.a	y	3pt/p.a

Table 4 Coral life forms
A - *Acropora*
TS - Table/staghorn *Acropora*
B - Branching
E - Encrusting
M - Massive/submassive
F - Foliose/plate/laminar
S - Soft coral
WF - Sea whip/sea fan

Some variables are amenable to counting or direct quantification, e.g. mean depth of rock scars, number of framework cracks, number of boulders larger than 1m. Note these details in the comments field and the top line for documenting the quantification scale used.

Some components of tsunami damage may not be quantifiable using the indicators given. It is important to collect detailed comments for new features. Label these using the Sample Number and a keyword entered in the comments field, and write out a description on additional papers carried for this purpose. If a common feature is found, contact us to develop a survey protocol to include it.

Photo and video documentation of tsunami damage

For a permanent record, digital images should be used alongside the methods proposed here, both for rapid assessments and permanent monitoring sites. This will allow more detailed data collection from the images at a later date, as well as fact checking and to show the impacts of the tsunami to the public.

To collect high quality images:

- use an artificial light source/flash if possible

- use a red filter on the lens if using natural light below 5 m.
- note the photo numbers/video time units that correspond to your data samples
- afterwards, label photos/video with the name of the site, date (including year), and successive number, and record this information in the main data files and the datasheet. If collecting still images, store all photos from one site in one folder clearly labeled by that site and date.
- Vertical photographs are best for later data analysis. Hold the camera 60-75 cm (2-3 feet) above the bottom, pointing straight at the bottom, and hold still while taking the picture. If using video, hold the camera vertically while swimming slowly forward. Take 20-30 still photographs or 5-10 minutes of video like this.
- Also photograph general views showing the overall appearance of different parts of the reef, and special features such as scar marks, damaged coral or reef, debris, diseases, etc, and make notes on your datasheet to transcribe later.

As for data collected from surveys, ReefBase can archive all images collected by survey teams. Submit materials to ReefBase with the following information:

1) DATE and TIME,
2) DETAILS OF LOCATION,
3) RESOLUTION,
4) PHOTOGRAPHER,
5) USAGE RIGHTS (if the owner of the footage or image will allow usage with credits or will they require written permission),
6) GENERAL COMMENTS and OBSERVATIONS.

Datasheets

Datasheets are presented along with this document. They can be photocopied or printed onto underwater paper. Alternatively divide up an underwater slate drawing the tables in fine tip permanent marker. In either case, transcribe the data the same night (for the latter) and file them (for the former) so that you check all spelling, words and comments, and make additional notes while your memory is fresh. If possible, type the data directly into a computer the same night.

Two sets of datasheets are provided:

1) site, simple and detailed datasheets summarizing the main aspects of this methodology - ***ISRS_ICRI Tsunami data sheets V1.xls***
2) Reef Check and AIMS LIT datasheets adapted to include the main aspects of this methodology - ***Reef Check+Tsunami Datasheets V1.xls***.

The datasheets are included in the Appendices to this document from pages 21 – 29 for printing, or can be obtained as Microsoft Excel datasheets from the websites listed on the first page.

Survey teams are advised to study the first set, and if using Reef Check/LIT methods, adopt the second set of datasheets. Also, these can be used as a guide on how to adapt your own datasheets to include tsunami impact variables.

Data management and archiving

Data transfer from field sheets should be simplified as much as possible. Excel spreadsheets matching the datasheets should be developed for initial storage. It is likely that individual survey groups can analyze adequately from excel spreadsheets, and communication/coordination should occur on efficient analysis modules/macros that can be share.

ReefBase has agreed to act as a repository for all data collected on the impacts of the Tsunami and will present maps and summaries of the data on the web for general access. ***All data sheets or summary data should be emailed to Karenne Tun (K.Tun@cgiar>org) or Marco Noordeloos (M.Noordeloos@cgiar.org). Any queries on data formats and sharing protocols can be directed to them.***

Coordination and key contacts

To adequately document impacts of the tsunami, monitoring may be carried out in any affected country including Indonesia, Thailand, Sri Lanka, Malaysia, India (including the Andaman and Nicobar islands, and Lakshadweep), Seychelles and the Chagos archipelago. Due to the magnitude of the humanitarian disaster, coral reef monitoring has not been a priority in Indonesia, but it has been started in all the other areas.

To maximize coordination among groups conducting monitoring in the different countries and regions, and backup support by various agencies, the following represent primary contact points. People interested in starting monitoring initiatives should contact the country or regional contact point. For questions on methodology and other issues, see the specialists listed at the bottom of the table.

Region	Country	Contacts
Southeast Asia	Malaysia	Reef Check; Badrul Huzaimi Tajuddin Badrul_h@hotmail.com
	Indonesia	COREMAP; Sapta Putra sapta@cbn.net.id
		Reef Check; Naneng Setiasih nsetiasih@wallacea.wwf.or.id
	Thailand	Reef Check; Niphon Phongsuan PMBC Niphonp@hotmail.com
South Asia		CORDIO/IUCN/GCRMN, Jerker Tamelander, jet@iucnsl.org
	India	JK Patterson Edward, jkpatty@hotmail.com
		K. Venkataraman, dugong@md2.vsnl.net.in
		Rohan Arthur, rohanart@bom3.vsnl.net.in
	Sri Lanka	Arjan Rajasuriya; arjan@nara.ac.lk
		M.F.M. Fairoz fairoz@fish.ruh.ac.lk
	Maldives	Hussein Zahir, marine@fishagri.gov.mv
Islands	Seychelles	Rolph Payet; rolph@seychelles.sc
		Jude Bijoux; jbijoux2000@yahoo.co.uk
	Chagos archipelago	Charles Sheppard; csheppard@bio.warwick.ac.uk
Coordination	Methods	CORDIO; David Obura; dobura@cordio.info
	Data/archiving/web access	ReefBase; Karenne Tun; k.tun@cgiar.org
		ReefBase; Marco Noordeloos; M.Noordeloos@cgiar.org
	ISRS	Annadel Cabanban; annadelc@ums.edu.my
		Michel Pichon; pichon@univ-perp.fr
	ICRI	Secretariat ; secretariat@icriforum.org
	GCRMN/Reef Check	Clive Wilkinson; c.wilkinson@aims.gov.au
		Jamie Oliver; J.Oliver@cgiar.org
		Gregor Hodgson; gregorh@reefcheck.org
Additional areas	Coral Diseases	Drew Harvell; cdh5@cornell.edu
		Garriet Smith; smithres@aiken.sc.edu
		Bette Willis; Bette.Willis@jcu.edu.au

Sediments	Iuri Herzfeld; herzfeld@soest.hawaii.edu

Partnerships

Conducting an efficient monitoring programme is a complex activity, and requires partners with different specialties. To maximize efficiency, consider the following points and make sure you are in contact with a relevant person from the contact list above.

- identify partner institutions and a lead coordinator within each, that will cover different locations within a country, or can distribute sites amongst each other
- verify common methods, and if there are differences, agree on why and the different objectives of the partners. Have a common set of variables and methods that also meet national/regional analysis needs.
- Establish a contact list including all details for the coordinators and a backup person – institution, mail, courier, telephone, fax, email and web.

Key documents

English, S, Wilkinson, C, Baker, V (1998) Survey Manual for Tropical Marine Resources. Australian Institute of Marine Science, Townsville.

Hodgson, G., Kiene, W., Mihaly, J., Liebeler, J., Shuman, C., and Maun, L. Reef Check Instruction Manual: A Guide to Reef Check Coral Reef Monitoring. Published by Reef Check, Institute of the Environment, University of California at Los Angeles. February 2004. ISBN 0-9723051-1-4 (free download http://www.Reef Check.org/infocenter/publications.asp)

OECS (2003) - Environment & Sustainable Development Unit. Technical Manual For Post-Disaster Rapid Environmental Assessment. VOLUME 1 and 2. April 2003.

Oliver, J, Marshall, P, Setiasih, N, Hansen, L (2004) A global protocol for assessment and monitoring of coral bleaching. WWF.

APPENDICES

***Reef Check* +Plus *and LIT* +Plus**

Modification of existing Reef Check (Indo-Pacific) and the AIMS LIT survey methods to include indicators for post-tsunami assessment and monitoring

In addition to the new tsunami assessment protocol, various groups, especially those in Southeast Asia, have requested that the existing protocols of Reef Check and AIMS LIT be modified to include indicators for post-tsunami assessments as they have been using these methods extensively in the past few years and would to adopt the methods for post-tsunami assessments as add-ons to their existing programmes.

This appendix gives guidelines on modification of the existing Reef Check and LIT methods to include the Tsunami-related variables. The modified methods are referred to as Reef Check +*Plus* and LIT +*Plus*. Datasheets for these methods are included as Appendices in the companion Excel file.

Reef Check +*Plus* (RC+)

RC+ essentially comprises the existing RC method with additional entry fields for several of the datasheets for tsunami-related indicators. The details are described below are included in the RC+ datasheets for the Indo-Pacific.

RC+ Site Description
The RC+ Site Description datasheet retains all the original site description parameters but includes 2 additional sections for tsunami impact assessment – "Coastal Features and Morphology" and "Data Types Collected" and are described in section 'Site selection'.

- The *Coastal Features and Morphology* section is aimed at obtaining site features that might affect, or be affected, by tsunami waves.

- The *Data Types Collected* section is aimed at obtaining information on various types of data collected, which may include other surveys or observations in addition to Reef Check (indicated in red shading in the table below).

RC+ General Reef Condition
The RC+ Genera Reef Condition survey retains all the original reef condition parameters, but includes several additional sections on tsunami impact assessment – "Benthic Cover Indicators", "Indicators of Impacts from Breaking Tsunami on Coral Reefs", "Indicators of Impacts from Backwash on Coral Reefs" and "Indicators of Impacts on Seagrasses and Mangroves". The aims of the various categories are described in the protocol document (Table 3).

RC+ Fish and Invertebrate Belt Transect
The RC+ Fish and Invertebrate Belt Transect datasheets retain all the original target fish and invertebrate indicators and has no additional inclusion.

RC+ Substrate Line Transect
The RC+ Substrate Line Transect datasheet retains all the original substrate indicators, but includes an additional "Status" field of entry for each substrate recorded.

The status codes are similar to the codes for "Benthic Cover Indicators" in the RC+ General Reef Condition survey, but are restricted to the individual substrate types recorded at each point of the substrate line transect survey.

LIT *+Plus*

Modifications to the LIT+ survey method are similar to modifications to the RC Substrate Line Transect survey. Essentially, the method remains unchanged, with the recommendation that following each benthos type recorded, an addition field called "Status" be included. The status field reflects the status of the benthos being recorded, and is assigned the same status codes as the RC+ Substrate Line Transect survey.

Collecting sediments

Prepared by:
Iuri Herzfeld
Department of Oceanography, University of Hawaii, 1000 Pope Road, Honolulu, HI 96822. Email: Herzfeld@soest.hawaii.edu. Tel: 808-734-5439 (office)

For survey teams interested in sediment analyses, this section is included to assist in the standardization of collection. For analysis details, contact Mr Herzfeld directly.

Prepared by:
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For survey teams interested in sediment analyses, this section is included to assist in the standardization of collection. For analysis details, contact Mr Herzfeld directly.

Rationale

Tsunami waves most likely mobilized large amounts of soil from land depositing it on the reef environment, potentially severely damaging the resources. In the strictly physical sense, quantification of the amount and type (sand/silt/clay) of deposited sediments may be of interest. Understanding the temporal loss (physical transport away) of these sediments from the reef environment would only be possible from this initial quantification.

Although physical smothering of sediments may be the most obvious effect of tsunami waves on the reef, chemical effects of this sediment load may also be of great importance to understand possible long term patterns in nutrient cycling and ecosystem structure change. Because most of the land affected by the tsunami waves was in the tropics, and because soils of tropical land are moderately to highly weathered parent material composed of iron and alumino-silicate clays, it is likely that reefs are experiencing a higher level of iron (Fe) input. Increased levels of iron (aluminum) oxides (above natural thresholds levels) can potentially interfere with the biogeochemical cycling of important nutrients, especially phosphorus (P) through adsorption/desorption kinetics. Increased levels of P in the sediments could lead to shifts in the sediment's role as a source or sink of dissolved P to the water column.

As an initial assessment of the Tsunami impacts, the extent of sediment deposition on the reef, and the physico-chemical characteristics of such sediment must be performed. The methods described here should help with the initial physico-chemical characterization and perhaps aide as a protocol to follow for subsequent ecosystem monitoring efforts.

Methods

Two methods could be utilized to readily assess the sediment physico-chemical characteristics. The first method is simpler to apply and appropriate where resources are low and analysis will be simple. The second method is more intensive, requires greater resources and supplies more information.

1) Hand-grab samples (sediment only, no interstitial water)

Equipment (per sample)
-fine mesh canvas bag or self-sealing plastic bag (e.g. zip-loc).

Method:
Sediment extraction is performed simply by placing your hand in an inverted (plastic or fine mesh canvas) bag, grabbing sediment off the surface, then reverting the bag immediately and sealing it.

Although there are accounts of minimal sediment smothering on the reefs, survey teams may still choose to perform this simple survey by collecting grab samples. Grab samples provide the survey teams with an easy method to work with while under either snorkel or SCUBA. Samples should be set to air dry until analysis.

2) Syringe coring (both sediment and interstitial water)

Equipment (per sample):
-1 (pre-weighed) plastic coring syringe (reusable)
-1 sample plastic syringe
-1 three-way stopcock (reusable)
-1 scintillation vial
-1 filter (0.45micon)
-1 small self-sealing plastic bag

Method
A small 20-60cc plastic syringe (with its winged end cut-off) of known weight (to the nearest 0.1g), and equipped with a 3-way plastic stopcock is weighted (with any non-metal negatively buoyant object) and carefully inserted into the sediment (with stopcock in “open” position) taking care not to cause much sediment disturbance. Syringe is carefully retrieved in upright position and syringe plunger inserted to cap the core. With the stopcock still in the “open” position and core in upright position free-diver/SCUBA diver proceeds to discard overlaying water being careful not to “squeeze” water out of the sediment portion of the core. Close the core to the atmosphere (“closed” position of the stopcock). Cores are ready for extraction of their interstitial water.

Either in the laboratory/hotel/boat/or any other fairly clean area…, Weigh the syringe with sediment core (at least to the nearest 0.1g), and note the length (depth into sediment) of sediment collected. Following, connect a second (clean) syringe to the core syringe via the 3-way stopcock. Set the stopcock to open circuit between the core and the new syringe. Apply a vacuum to the core using the second syringe (pull second syringe’s plunger) until interstitial water has been extracted from the core (Note: you may only get a few milliliters of sample). Liquid samples should be filtered through 0.45micon filters into 20mL scintillation vials and stored frozen until ready for liquid phase analysis.

Once interstitial water has been extracted from sample core, solid phase sample remaining in syringe should be oven dried (inside syringe) at temperatures ranging from 70-105 ˚C for 3 days (or until stable dry weight), and the weight of dry syringe and sediment sample should be noted (data needed for bulk density calculation). Dry samples could be stored in plastic scintillation vials (or self-sealing plastic bags) until ready for solid phase analysis.

Although it may sound a bit complicated, this sample collection technique has proven to be quite easy with some practice. I have been able to collect about 3-4 cores in a period of 40 minutes under 10m of water. A team of three divers dedicating a 40 minute dive at 10m or less could easily collect 9 samples along a predetermined transect.

Coral diseases

Microbial activity associated with terrigenous sediment has been implicated in greater incidence of coral diseases in the Caribbean. Increased terrigenous sediment on coral reefs due to the tsunami may result in higher disease rates, so take particular note of coral diseases, and use the following procedure to note if it may be a known disease or an unknown condition, and quantify impacts for all diseases together in the data table.

1) Is the coral/soft coral showing an unusual colouration/disfigurement?
2) Is there mortality associated with it? **Yes/no**
3) Is it a known disease/condition? If yes, name it. If no, go to 4.
4) If answer to 3 is no, describe the colour, area/shape of the condition, and mortality associate with it.
5) if possible take a photograph that can be clearly labelled with your observations.
6) How many corals in the sample area are affected? Enter your estimate in the table. If possible, also estimate the proportion of all coral colonies affect. (that is, number of corals with disease divided by total number of corals in the sample area)

If mortality from a distinctive syndrome is extensive and appears to be spreading, contact disease experts to try and identify the responsible microorganism (see contacts list).

Sample Rapid assessment of coral reef damage in Thailand

An extract from a field report from Thailand is reproduced here to illustrate how rapid assessment indicators of coral reef damage can be compiled to provide a clear assessment of damage levels. We would like to acknowledge Dr. Niphon Phyongsuwan and colleagues for providing this study.

Summary on Impact Assessment of the Tsunami on Marine Resources

Coordinated by Niphon Phongsuwan, Phuket Marine Biological Station

About 100 research officers from Department of Marine and Coastal Resources and many organizations, namely: Chulalongkorn University, Kasetsart University, Burapha University, Ramkhamhaeng University, Prince of Songkhla University, Walailak University, Mahidol University, Trang Rachamangala Institute, and Department of National Park Wildlife and Plant, with the cooperation of more than 120 volunteer divers, participated in assessment of the impact of tsunami on marine resources. The working period was between 30 Dec 2004 and 15 January 2005.

The assessments were done in 10 marine parks and one wildlife reserved area, which were:

1. Laem Son Marine National Park, Ranong province
2. Surin Islands Marine National Park, Phangnga province
3. Similan Islands Marine National Park, Phangnga province
4. Sirinart (Nai Yang beach) Marine National Park, Phuket province
5. Nopparat Thara Beach and Phi Phi Islands Marine National Park, Krabi province
6. Tharn Boke Koranee Marine National Park, Krabi province
7. Lanta Islands Marine National Park, Krabi province
8. Chao Mai Marine National Park, Trang province
9. Phae Tra Marine National Park, Satun province
10. Tarutao Marine National Park, Satun province
11. Talibong Wildlife Reserve Area, Trang province

Method

The survey recorded diver observations on overall and lifeform cover of hard corals on shallow and deeper areas, as well as estimates of damage in the categories listed below. Observations were accumulated over a whole dive:

Coral damage categores:

- turned over,
- broken,
- collapsed on sliding sand slope,
- smothered by sand and sediment, and
- debris or garbage in reef.

Degree of damage was assessed using a 5 points scale of

0	0%	No impact
1	1-10%	Very low impact
2	11-30%	Low impact
3	31-50%	Medium impact
4	>50%	High impact

Sample Result
Here, one aspect of the data is reported: degree of damage of corals depended on geography of the islands, location and morphology of coral reefs, as well as water depth, which promoted or protected reefs in certain areas from the effects of tsunami.

Table: results from 324 spot-checking sites or 174 validated representative sites (percent).

Province	No impact (0%)	Very low impact (1-10%)	Low Impact (11-30%)	Medium impact (31-50%)	Heavy impact (>50%)	Total sites
Ranong	0%	17%	17%	8%	58%	12
Phangnga	29%	17%	22%	14%	18%	72
Phuket	57%	24%	14%	5%	0%	21
Krabi	40%	27%	13%	13%	7%	30
Trang	25%	50%	25%	0%	0%	8
Satun	71%	16%	10%	0%	3%	31
Total	69 (40%)	36 (21%)	30 (17%)	16 (9%)	23 (13%)	174

The most affected areas were in Ranong province, Surin islands, Similan islands and Phi-phi islands while Satun, Phuket, Krabi, Trang and Phangnga Bay were almost untouched by the tsunami.

DATASHEETS

Site sheet

Datasheet – simple

Datasheet – detailed

These datasheets are available in Microsoft Excel format from the webpages listed below. They are contained in the file:

ISRS_ICRI Tsunami Datasheets V1.xls

UNEP:	http://www.unep-wcmc.org/latenews/emergency/tsunami_2004/
ICRI:	http://www.icriforum.org/
ReefBase:	http://www.ReefBase.org/

Site name: **Sheet code:**

BASIC INFORMATION

Country: State/Province: Town:
Date: Time: Start of survey: End:
Latitude (deg. min. sec): Longitude (deg. min. sec):
From chart or by GPS? (If GPS, indicate units): chart___ GPS_____ GPS units:
Orientation of transects: N-S_____ E-W___ NE-SW_____ SE-NW_____
Temperature (in degrees C): air: ______C surface: ______C at 3m: ______C at 10m: _______C
Distance om shore (m): from nearest river (km):
River mouth width: <10 m 11-50 m 51-100 m 101-500 m
Visibility (m) : Weather sunny cloudy raining

COASTAL FEATURES AND MORPHOLOGY

Site features that might affect tsunami waves. Select yes/no and describe important features.
Inside embayment - Yes ___ No ___ Shallow gently-shelving slope Yes ___ No ___
Along a headland - Yes ___ No ___ Outer protective reef/bank? Yes ___ No ___
Against rocky cliffs - Yes ___ No ___ Against sandy beach? Yes ___ No ___
Is this site: Always sheltered: Sometimes: Exposed:
Major coral damaging storms Yes: No If yes, When was last storm:
Why is this site selected: Is this best reef in the area Yes: No :
Any other comments:

Mangrove forests present? Yes ___ No ___ Disturbe Yes ___ No ___
Nipah forests present? Yes ___ No ___ Disturbe Yes ___ No ___
Seagrass beds present? Yes ___ No ___ Disturbe Yes ___ No ___

ANTHROPOGENIC IMPACTS TO SITE

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:
Tourist diving/snorkeling: None: Low: Med: High:
Sewage pollution (land or boat) None: Low: Med: High:
Industrial pollution None: Low: Med: High:
Commercial fishing (for sale) None: Low: Med: High:
Live food fish trade None: Low: Med: High:
Artisanal/recreational (personal) None: Low: Med: High:
How many yachts typically? None: Few (1-2): Med (3-5): Many (>5):
Other impacts:

COASTAL DEVELOPMENT

Distance from population center *km* *Is any damage visible at the site from each type of coastal development?*
Size of population center (x1000) --> Yes No
Distance from airports *km* --> Yes No
Distance from mines *km* --> Yes No
Distance from tourist resorts *km* --> Yes No
Distance from dive centers *km* --> Yes No

PROTECTION

Any protection (legal or other): Yes: No: If yes, answer questions below
Is protection enforced? Yes: No:
Any poaching in protected area? None: Low: Med: High
Check which activities below are banned:
Spearfishing Anchoring
Commercial fishing Diving
Recreational fishing Other (specify)
Invertebrate/shell collecting

DATA TYPES COLLECTED

Coral Reef Benthos Reef Check AIMS LIT Others (specify)
Coral Reef Fish Reef Check AIMS FVS Others (specify)
Coral Reef Invertebrates Reef Check Others (specify)
Coral Reef Condition Reef Check Others (specify)
Post-Disaster Assessment Post-Tsunami Protocol Others (specify)
Physico-Chemical Parameters (specify)
Othes (specify)

OTHER COMMENTS

TEAM INFORMATION

Submitted by Regional Coordinator:
Team Leader:
Team Scientist:
Team Members:

Site name: ______________________ **Sheet code:** ______________
Sitesheet name/code: ______________________ Other datasheets for this site: ______________
Country: ______________ State/Province: ______________ Town: ______________
Date: ______________ Time: Start of survey: ______________ End: ______________
Zone of Reef: Backreef/lagoon ______ Reef flat ______ Crest ______ Slope ______
Depth (m): ______________
Date recorded by: ______________

Benthic cover indicators

		Segment 1 (1-20m)		Segment 2 (25-45m)		Segment 3 (50-70m)		Segment 4 (75-95m)	
		5m	10m	25m	35m	50m	60m	75m	85m
LCC	Live hard coral								
FAG	Filamentous algae								
Additional information/notes:									

Indicators of impacts from breaking tsunami on coral reefs

		Segment 1 (1-20m)		Segment 2 (25-45m)		Segment 3 (50-70m)		Segment 4 (75-95m)	
		5m	10m	25m	35m	50m	60m	75m	85m
UPC	Up-turned coral								
BCC	Broken coral								
RKC	Recently killed coral								
CRE	slope erosion								
RB	Rubble on surface								
RBP/M	Rubble piling/moved								
LSG	Loose seagrass								
CRF	Coral Reef Fish								
Additional information/notes:									

Indicators of impacts from backwash on coral reefs

		Segment 1 (1-20m)		Segment 2 (25-45m)		Segment 3 (50-70m)		Segment 4 (75-95m)	
		5m	10m	25m	35m	50m	60m	75m	85m
SIT	Silt								
LTT	Litter								
DBS	Debris (rock, wood etc)								
Additional information/notes:									

Indicators of impacts on seagrasses and mangroves

		Segment 1 (1-20m)		Segment 2 (25-45m)		Segment 3 (50-70m)		Segment 4 (75-95m)	
		5m	10m	25m	35m	50m	60m	75m	85m
SGD	Seagrass reduction								
BMG	Mangrove debris								
Additional information/notes:									

Site name: ____________________ **Sheet code:** ____________
Sitesheet name/code: ____________________ Other datasheets for this site: ______
Country: ____________________ State/Province: Town: ____________
Date: ____________________ Time: Start of survey: ____________ End: ____________
Zone of Reef: Backreef/lagoon ______ Reef flat ______ Crest ______ Slope ______
Depth (m): ____________
Data recorded by: ____________________ Total dist. Covered ______ m

Quantitative Levels and cross-comparisons						
A) Pres/Abs.		**B) Low/high**		**C) 6pt. Area**		
0	Absent	**0**	None	**0**	0	None
1	Present	**1**	Low	**1**	1-10	Low
				2	11-30	Medium
		2	High	**3**	31-50	Common
				4	51-75	High
				5	76-100	Extreme

Sampling method
- ____ Manta Tow — 2 minute intervals
- ____ Timed swim — 2 minute intervals
- ____ Virtual' transect — 5*10+50 kicks/se m
- ____ Layed transect — local method

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
QUANTITATIVE LEVEL (A/B/C)																										
Benthic																										
Live hard coral	**LCC**																									
Recently killed coral	**RKC**																									
Coral life forms, alive	**CLF**																									
Filamentous algae	**FAG**																									
Thick turf/fleshy algae	**TAG**																									
Rock/bare surface	RC																									
Rubble	RB																									
Damage-corals																										
Overall damage	CDAM																									
Up-turned coral	**UPC**																									
Broken coral	**BCC**																									
RKC - standing	**RKC-S**																									
RKC - upturned	**RKC-U**																									
Coral life forms - damag	**CLF-D**																									
Damage to Substrate-Waves																										
Overall damage-REEF	SDAM																									
slope erosion.	**CRE**																									
Rubble piling/movement	**RBP/M**																									
Loose rocks <50	**R<50**																									
Loose rocks >50	**R>50**																									
Boulders > 1m	**BLD**																									
Scars/exfoliation	**SCR**																									
Scar depth cm	**SCRcm**																									
Cracks	**CRCK**																									
Damage to Substrate-Backwash																										
Silt smothering live coral	**SILC**																									
Silt on reef surface/sand	**SIT**																									
Debris-stone/solid	**DBS**																									
Debris-veget/seagrass	**DBV**																									
Debris-litter (plastics/text	**DBL**																									
Coral disease	**CD**																									
Other																										
Coral reef fish	**CRF**																									
Seagrass reduction	**SGD**																									
Mangrove debris	**BMG**																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

NOTES

Reef Check + datasheets

The following 5 datasheets are for Indo-Pacific Reef Check surveys adapted to include tsunami damage indicators, termed “Reef Check +”. The fish and invertebrate survey datasheets are no different from the normal Reef Check sheets.

1) Reef Check +*Plus* GENERAL REEF CONDITION Survey -
2) Reef Check +*Plus* GENERAL REEF CONDITION Survey
3) Reef Check +*Plus* FISH Belt Transect Survey *(no difference)*
4) Reef Check +*Plus* INVERTEBRATE Belt Transect Survey *(no difference)*
5) Reef Check +*Plus* SUBSTRATE Line Transect Survey

These datasheets are available in Microsoft Excel format from the webpages below. They are contained in the file:

Reef Check+Tsunami Datasheets V1.xls

UNEP: http://www.unep-wcmc.org/latenews/emergency/tsunami_2004/
ICRI: http://www.icriforum.org/
ReefBase: http://www.ReefBase.org/
Reef Check: http://www.reefcheck.org/

Reef Check +*Plus* GENERAL REEF CONDITION Survey

Site Name: ____ **Sheet Code:** ____

BASIC INFORMATION

Country:	____	State/Province:	____	Town:	____		
Date:	____	Time of Survey:	Start ____	End ____			
Latitude (deg.min.sec):	____	Longitude (deg.min.sec):	____				
From chart or by GPS?	Chart ____	GPS ____	(GPS units ____)				
Orientation of transects:	N-S ____	E-W ____	NE-SW ____	SE-NW ____			
Temperature (degC):	Air ____	Surface ____	At 3m ____	At 10m ____			
Distance from shore (m):	____	Distance from nearest river (km):	____				
River mouth width:	<10 m ____	11-50 m ____	51-100 m ____	101-500 m ____			
Visibility (m):	____	Weather:	Sunny ____	Cloudy ____	Rain/Overcast ____		

COASTAL FEATURES AND MORPHOLOGY

Site features that might affect tsunami waves. Select yes/no and describe important features.

Inside embayment?	Yes No ____	Shallow gently-shelving slope?	Yes No ____	
Along a headland?	Yes No ____	Outer protective reef/bank?	Yes No ____	
Against rocky cliff?	Yes No ____	Against sandy beach?	Yes No ____	
Is this site sheltered?	Always ____	Sometimes ____	Exposed ____	
Major coral damaging storms?	Yes No ____	If Yes, when was the last storm?	____	
Why is this site selected?	____			
Is this best reef in the area?	Yes No ____			
Mangrove forests present?	Yes No ____	Are they disturbed?	Yes No ____	
Nipah forests present?	Yes No ____	Are they disturbed?	Yes No ____	
Seagrass beds present?	Yes No ____	Are they disturbed?	Yes No ____	
Other comments:	____			

ANTHROPOGENIC IMPACTS TO SITE

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 ____
Tourist diving/snorkeling:	None ____	Low ____	Med ____	High ____
Sewage pollution (land or boat):	None ____	Low ____	Med ____	High ____
Industrial pollution:	None ____	Low ____	Med ____	High ____
Commercial fishing (for sale):	None ____	Low ____	Med ____	High ____
Live food fish trade:	None ____	Low ____	Med ____	High ____
Artisanal/recreational/personal fishing?	None ____	Low ____	Med ____	High ____
How many yachts typically?	None ____	Few (1-2) ____	Med (3-5) ____	Many (>5) ____
Other impacts:	____			

COASTAL DEVELOPMENT

		Is any damage visible at the site from each type of coastal development?	
Distance from population center:	____ km		
Population center size (x1000):	____	Yes ____	No ____
Distance from airports:	____ km	Yes ____	No ____
Distance from mines:	____ km	Yes ____	No ____
Distance from tourist resorts:	____ km	Yes ____	No ____
Distance from dive centers:	____ km	Yes ____	No ____

PROTECTION

Does the area have any protection (legal or other)?		Yes ____	No ____	
If yes, answer questions below:				
Is protection enforced?	Yes ____	No ____		
Does poaching occur?	None ____	Low ____	Med ____	High ____

Check which activities below are banned:

Spearfishing	____	Anchoring	____
Commercial fishing	____	Diving	____
Recreational fishing	____	Other (specify)	____
Invertebrate/shell collecting	____		____

DATA TYPES COLLECTED

Coral Reef Benthos:	RC ____	AIMS LIT ____	Others (specify) ____
Coral Reef Fish:	RC ____	AIMS FVS ____	Others (specify) ____
Coral Reef Invertebrates:	RC ____	Others (specify) ____	

Reef Check *+Plus* GENERAL REEF CONDITION Survey

Site Name: ____________ **Sheet Code:** ____________

Date: ____________ Time: ____________

Reef Zone: Lagoon ________ Reef flat ________ Crest ________ Slope ________

Depth (m): ____________

Date recorded by: ____________

Rate the following as: None=0, Low=1, Medium=2, High=3, Extreme=4

Reef Check General Reef Condition Indicators

	Segment 1	Segment 2	Segment 3	Segment 4
	1-20m	**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)				
Please fill in the following				
Grouper sizes (cm) ONLY >30cm				
Coral Disease (Yes/No and %):				
Rare animals sighted (type/#):				
Other:				
Additional information/notes:				

Benthic cover indicators

		Segment 1	Segment 2	Segment 3	Segment 4
		1-20m	**25-45m**	**50-70m**	**75-95m**
LCC	Live hard coral				
FAG	Filamentous algae				
Additional information/notes:					

Indicators of Impacts from Breaking Tsunami on Coral Reefs

		Segment 1	Segment 2	Segment 3	Segment 4
		1-20m	**25-45m**	**50-70m**	**75-95m**
UPC	Up-turned coral				
BCC	Broken coral				
RKC	Recently killed coral				
CRE	slope erosion				
RB	Rubble on surface				
RBP/M	Rubble piling/moved				
LSG	Loose seagrass				
CRF	Coral Reef Fish				
Additional information/notes:					

Indicators of Impacts from Backwash on Coral Reefs

		Segment 1	Segment 2	Segment 3	Segment 4
		1-20m	**25-45m**	**50-70m**	**75-95m**
SIT	Silt				
LTT	Litter				
DBS	Debris (rock, wood etc)				
Additional information/notes:					

Reef Check +*Plus* FISH Belt Transect Survey

Site Name: ____________ **Sheet Code:** ____________
Date: ____________ Time: ____________
Date recorded by: ____________

	0-20m	25-45m	50-70m	75-95m
Butterfly fish				
Sweetlips (Haemulidae)				
Snapper (Lutjanidae)				
Barramundi Cod				
Other Grouper >30cm*****				
Humphead wrasse				
Bumphead parrot				
Other Parrotfish (>20cm)				
Moray eel				

** give average size range in comments*

Comments

Reef Check +*Plus* INVERTEBRATE Belt Transect Survey

Site Name: ____________ **Sheet Code:** ____________
Date: ____________ Time: ____________
Date recorded by: ____________

	0-20m	25-45m	50-70m	75-95m
Banded coral shrimp				
***Diadema* urchins**				
Pencil urchin				
Sea cucumber (edible only)				
Crown-of-thorns starfish				
Giant clam				
Triton				
Collector urchin				
Lobster				

Comments

Reef Check *+Plus* SUBSTRATE Line Transect Survey

Site Name: ______________________ **Sheet Code:** ______________________

Date: ______________ Time: __________

Date recorded by: ______________________________

Substrate Codes				**Status Codes**			
HC	hard coral	**RB**	rubble	**UPC**	Up-turned coral	**LTT**	Litter
SC	soft coral	**OT**	other	**BCC**	Broken coral	**DBS**	Debris (rock, wood, etc)
RKC	recently killed coral	**RC**	rock	**RBP/M**	Rubble piling/moved		
NIA	nutrient indicator algae	**SD**	sand	**CRE**	Slope erosion		
SP	sponge	**SI**	silt/clay				

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

SEGMENT 1 (0-19.5m)
0 - 19.5 m

Point	Substrate	Status	Point	Substrate	Status
0			10		
0.5			10.5		
1			11		
1.5			11.5		
2			12		
2.5			12.5		
3			13		
3.5			13.5		
4			14		
4.5			14.5		
5			15		
5.5			15.5		
6			16		
6.5			16.5		
7			17		
7.5			17.5		
8			18		
8.5			18.5		
9			19		
9.5			19.5		

SEGMENT 2 (25-44.5m)
25 - 44.5 m

Point	Substrate	Status	Point	Substrate	Status
25			35		
25.5			35.5		
26			36		
26.5			36.5		
27			37		
27.5			37.5		
28			38		
28.5			38.5		
29			39		
29.5			39.5		
30			40		
30.5			40.5		
31			41		
31.5			41.5		
32			42		
32.5			42.5		
33			43		
33.5			43.5		
34			44		
34.5			44.5		

SEGMENT 3 (50-69.5m)
50 - 69.5 m

Point	Substrate	Status	Point	Substrate	Status
50			60		
50.5			60.5		
51			61		
51.5			61.5		
52			62		
52.5			62.5		
53			63		
53.5			63.5		
54			64		
54.5			64.5		
55			65		
55.5			65.5		
56			66		
56.5			66.5		
57			67		
57.5			67.5		
58			68		
58.5			68.5		
59			69		
59.5			69.5		

SEGMENT 4 (75-94.5m)
75 - 94.5 m

Point	Substrate	Status	Point	Substrate	Status
75			85		
75.5			85.5		
76			86		
76.5			86.5		
77			87		
77.5			87.5		
78			88		
78.5			88.5		
79			89		
79.5			89.5		
80			90		
80.5			90.5		
81			91		
81.5			91.5		
82			92		
82.5			92.5		
83			93		
83.5			93.5		
84			94		
84.5			94.5		