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Scuba search technique: Surveys of agents of coral mortality

Long-term Monitoring of the Great Barrier Reef

Standard Operational Procedure Number 8

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Cover photo:
Observer conducting scuba search survey on Reef 22-084. Photo: Long-term Monitoring Program

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1 SUMMARY

The Australian Institute of Marine Science's (AIMS) Long-term Monitoring Program (LTMP) monitors benthic and reef fish assemblages, crown-of-thorns starfish (COTS) *Acanthaster* cf. *solaris* populations and other agents of hard coral mortality (bleaching, coral diseases and *Drupella*) on a biennial basis. In alternate years when LTMP surveys are not conducted, a monitoring program assesses the effectiveness of management within the Great Barrier Reef Marine Park (GBRMP) under the Representative Areas Program (RAP). During both survey programs, reef fish and benthic communities are monitored along permanently marked transects in a standard reef slope habitat on selected reefs. This Standard Operational Procedure (SOP) is Volume 8 in a series of 10, produced by the LTMP at AIMS. It details the standard procedure used to gather information about agents of coral mortality such as COTS and coral diseases. Some information on data management is also provided.

2 INTRODUCTION

This document describes the method used by the LTMP to survey the benthic communities of coral reefs to gather information about the sources of coral mortality. These fine-scale surveys have been used by AIMS since 1989 to provide information on low-level populations of COTS, facilitate the detection of juvenile COTS and investigate other causes of coral mortality such as disease.

Historically, scuba searches have been used in conjunction with manta tow surveys to provide quantitative measures of the abundance of COTS (Endean 1974, Kenchington & Morton 1976, Roads & Ormond 1971). Scuba searches have also been employed to investigate possible biases in manta tow surveys (Fernandes 1990, Fernandes et al. 1990). More recently, scuba searches have been used by the LTMP to provide information on the sources of coral mortality, particularly diseases associated with hard corals, to assist in interpreting trends in benthic cover on permanent sites (Osborne et al. 2011). Scuba searches examine the reef in greater detail than is possible with the manta tow technique, which has many important implications for COTS surveys and detailed benthic surveys, e.g. scuba searches enable the detection of low-level populations of COTS. At low densities, COTS are cryptic and more difficult to detect with manta towing.

Scuba searches provide a method for the detection of juvenile COTS that are not easily seen by a manta tow observer because of their small size and cryptic behaviour. Scuba searches enable the diver to detect other factors that might be causing coral mortality such as the presence of *Drupella* spp., bleaching or disease (e.g. white syndrome and black band disease). Historically, there have been few reports of high-density populations of juvenile COTS on the GBR and these have involved only small areas of reef (Pearson and Endean 1969, Doherty and Davidson 1988, Fisk et al. 1988). It is only since the turn of the century, with the third series of COTS outbreaks on the central GBR, that high-density populations of COTS juveniles have been found (Engelhardt et al. 2001). The detection of juvenile COTS provides a basis for understanding recruitment events and forecasting population increases. There is also a growing body of evidence that the prevalence and effects of marine diseases have increased over the last 20 years. Thus, the objective of scuba searches in the LTMP is to detect COTS and define other sources of coral mortality, particularly disease or disease-like syndromes that may not be visible

using manta tows. Two methods of scuba searching are described, fixed and timed. The vast majority of surveys to date have been conducted using fixed transects.

3 FIXED TRANSECT SCUBA SEARCH TECHNIQUE

3.1 Sampling Design

Benthic and fish communities on 47 reefs located within six latitudinal sectors of the GBR (Cooktown/Lizard Island, Cairns, Townsville, Whitsunday, Swain and Capricorn-Bunker sectors; Figure 1) were surveyed annually up until 2005 and biennially after that. In each of these sectors (except for the Swain and Capricorn-Bunker sectors), three shelf positions (inner, mid and outer) have been sampled. Three reefs are nested within each of these shelf position/sector combinations except in the inner shelf of the Cooktown/Lizard Island sector where two reefs are surveyed and in the mid-shelf of the Cairns sector where four reefs are surveyed. In the Swain sector, only the outer shelf (two reefs) and mid-shelf (five reefs) are surveyed. In the Capricorn-Bunker sector, only the outer shelf reefs are represented, with four reefs being surveyed. The shelf position is determined by the position of a reef relative to the coast and continental slope, with inner shelf reefs closest to the coast.

Since 2006, surveys on 56 reefs, 10 of which are also surveyed as part of the LTMP, have been conducted in alternating years, as part of the RAP to assess the effectiveness of the rezoning of the GBRMP in 2004. RAP surveys are conducted in five offshore latitudinal sectors (reefs > 30 km from the coast in the Cairns, Townsville, Pompey, Swain and Capricorn-Bunker sectors) of the GBRMP and surveys No-Take Marine Reserve reefs paired with similar reefs open to fishing.

Fixed transect scuba searches are undertaken on the same fixed transects used to survey fishes and benthic organisms. On each reef, three sites are located in the first stretch of continuous reef encountered when following the perimeter from the back-reef zone towards the front reef in a clockwise direction. The sites are usually situated on the northeast flank of the reef (Figure 2). Sites are separated by at least 250 m where possible.

There are five 50 m transects within each site. Transects are permanently marked with a star picket at each end and with lengths of reinforcing rod at 10 m intervals. Transects run parallel to the reef crest at depths of approximately 6–9 m. Scuba searches are performed in a 2-metre wide belt (i.e. 1 m each side of the tape) along the full 50 m of each transect.

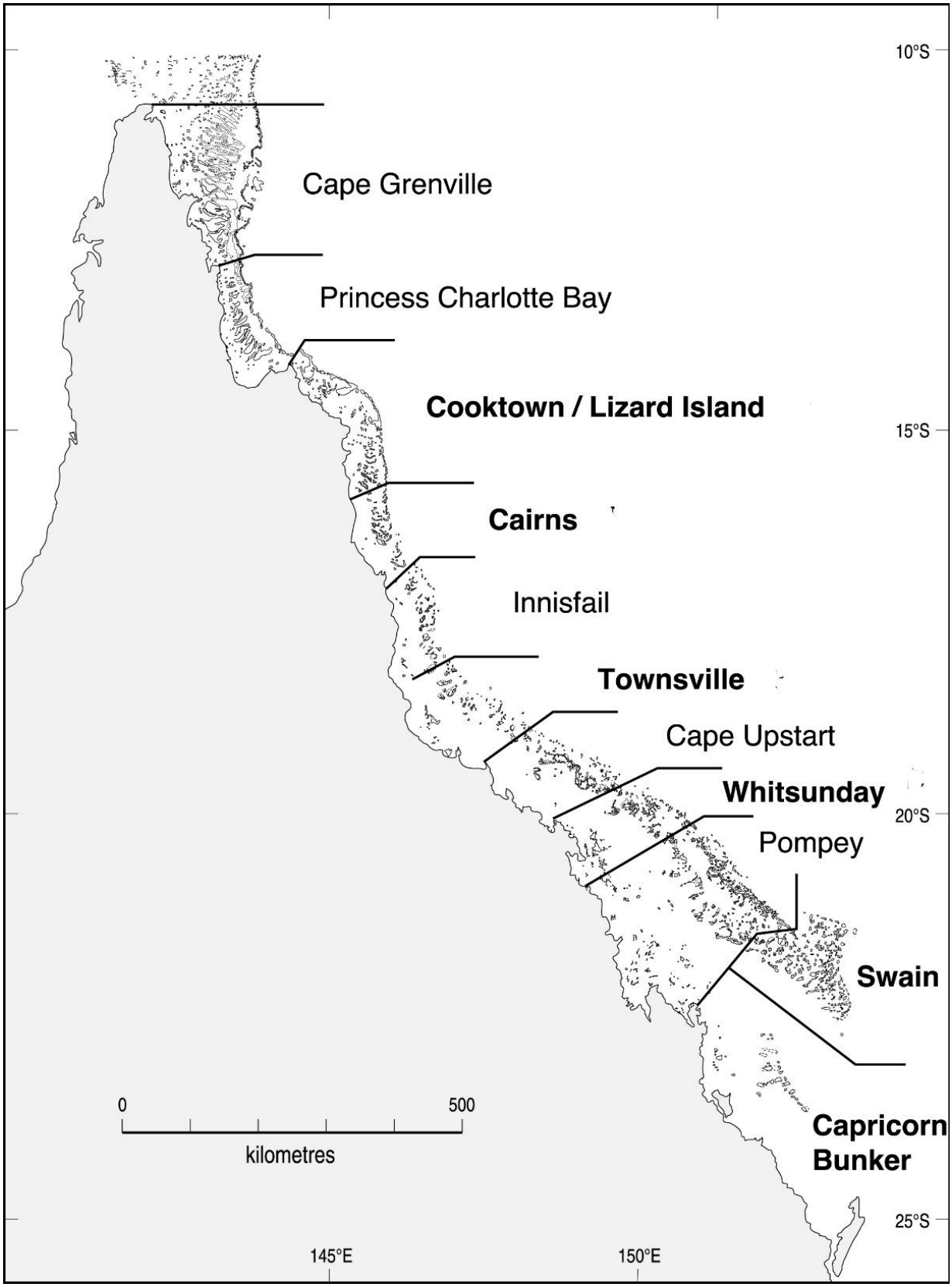

Figure 1. Sectors of the Great Barrier Reef surveyed as part of the LTMP and RAP monitoring.

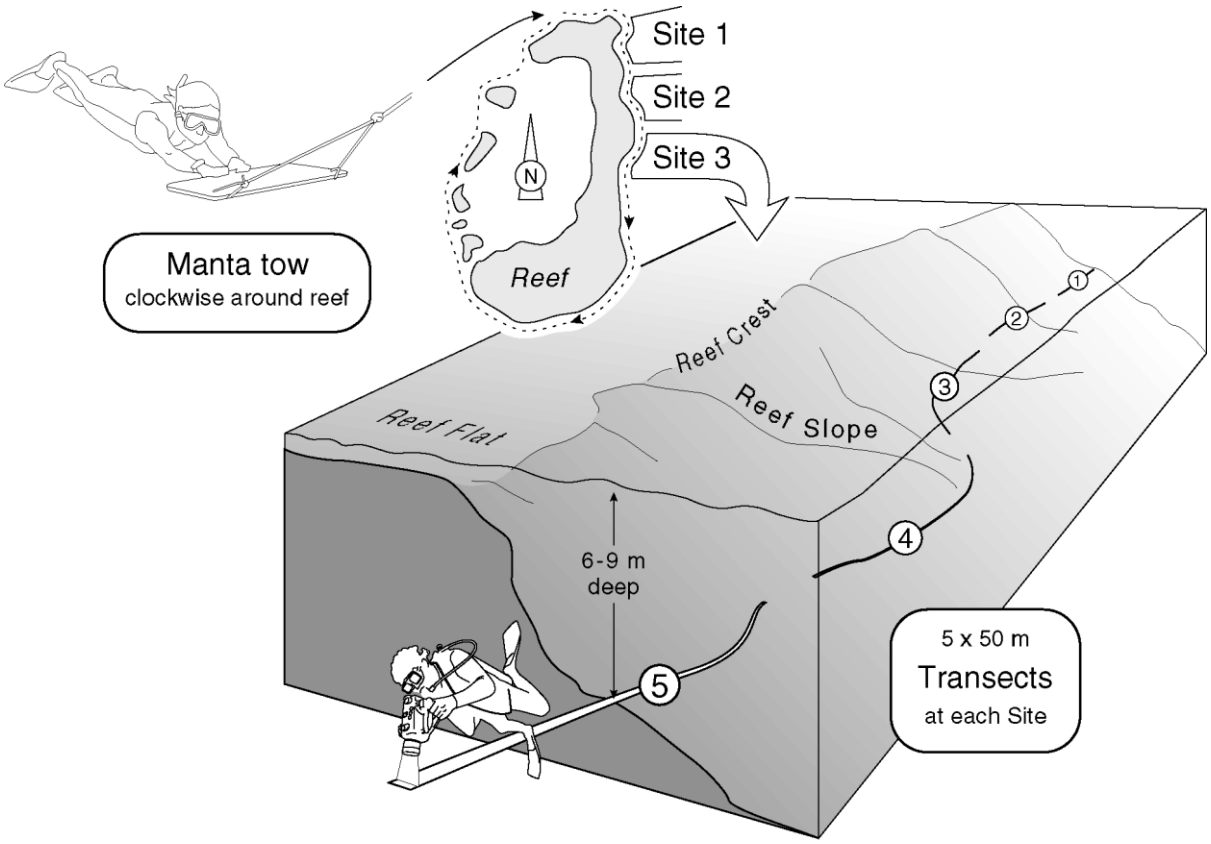

Figure 2. Schematic arrangement of sampling effort on a core survey reef.

3.2 Field Sampling Procedure

Often logistical considerations such as the number and experience of the divers and their allotted tasks determine the details on the most efficient way of performing the survey. During all surveys, due consideration should be given to diver safety. For a detailed description of other surveys conducted on these transects, see Emslie and Cheal (2018) and Jonker et al. (2019). Briefly, the following field sampling procedure is performed:

1. Scuba search surveys are conducted along each 50 m tape that has been laid down previously for other aspects of the LTMP fixed transect surveys.

2. A buddy pair consisting of a scuba search observer and, usually, a benthic observer completing photograph transects, move along the pre-laid tape. During this time, a fixed transect search is conducted by searching a 2 m belt along each transect (i.e. 1 m either side of the tape). The scuba search observer looks for areas of recent mortality of corals and crustose coralline algae and investigates these areas by closer inspection. Observations are recorded on the data sheet (Appendix 1: Scuba Survey Data Sheet).

4 TIMED TRANSECT SCUBA SEARCH TECHNIQUE

4.1 Sampling Design

Timed scuba searches are a plotless method designed to determine fine-scale patterns of COTS distribution on reefs where this information is required. This method is not part of regular LTMP surveys. Timed swims can provide counts of COTS recruits or densities of standing COTS populations. In conjunction with benthic surveys, timed scuba searches can be used to determine benthic cover and factors affecting coral mortality.

4.2 Field Sampling Procedure

1. Each reef is initially manta towed to select sites by the presence of feeding scars, COTS or signs of disease. These sites are noted during the manta tow survey and, where possible, a buoy is placed to mark the site. Upon returning to the site, the position is recorded using a GPS. Divers should search three to six sites on a reef.
2. At each site, three divers each swim parallel to the reef crest along three different depth contours (4 m, 8 m and 12 m). Where the slope is less than 12 m, divers swim parallel to each other (at least 4 m apart, depending on visibility) and cover the maximum practical depth range between the crest and base of the reef slope.
3. Each diver swims for 20 minutes and scans approximately 1 m either side of the swim path looking for evidence of coral mortality. Areas of recently dead coral are examined to determine the cause of mortality, with observations recorded on the data sheet (Appendix 1: Scuba Survey Data Sheet).

5 DATA RECORDING FOR TRANSECT SEARCHES

5.1 Data Sheet

The data sheet (Appendix 1: Scuba Survey Data Sheet) is a table consisting of five pairs of columns (one for each transect). The first column is used to record the type of scar (based on the key given at the bottom of the data sheet) and the second column is used to record the life form (and genus where possible). Each column pair is used to record information from one transect or one timed swim. The following information is recorded:

5.1.1 Transects

The number of surveyed transects for a fixed transect or the depth contour surveyed for a timed swim search is recorded (GPS position for the site is recorded under ‘site’ at the top of the data sheet for the timed swim searches).

5.1.2 COTS

COTS numbers are recorded as J, A, B or C based on the size criteria listed in Table 1. Categories of COTS size. Each individual COTS observed is recorded based on its size in the appropriate cell at the bottom of the column.

Table 1. Categories of COTS size.

Category	Size (cm)	Age Estimate
J (Early juvenile)	<= 5	Up to 1 year
A (Juvenile)	6–15	1–2 years
B (Sub-adult)	16–25	2–3 years
C (Adult)	>25	3+ years

5.1.3 COTS Scars

Each individual colony with scar(s) that are attributable to COTS feeding activity is marked as COTS and recorded in the scar column and the affected coral life form and genus is recorded in the corresponding cell.

5.1.4 *Drupella*

A review of previously recorded data suggests that it is almost impossible to identify a *Drupella* spp. scar without the associated *Drupella* spp. Thus, in this category, the number of individuals associated with each scarred coral colony is recorded in the scar column as Drup(#) and the affected coral life form and genus is recorded in the corresponding cell.

5.1.5 Unknown Scars

Any colony with scars that have no obvious cause is recorded as UN in the scar column and the affected coral life form and genus is recorded in the corresponding cell.

5.1.6 White Syndrome Disease

White syndrome disease is commonly seen either as a patch of recently dead white coral skeleton within part of the living colony or as a white band of recently dead white coral skeleton between fouled old dead coral and the still living part of the colony (Figure 3). Scars attributed to an unknown disease can be recorded as white syndrome. There is often a gradation in turf algal cover from the recently white dead parts of the colony to the darkened old dead parts of the colony. Often the necrotic tissue can be seen sloughing off the edge of the scar. Each individual colony with scar(s) attributable to white syndrome disease is recorded as WS in the scar column and the associated coral life form and genus is written in the corresponding cell. Care must be taken when identifying the disease as the ‘sign’ can easily be confused with those caused by predators such as COTS or *Drupella*.

5.1.7 Skeletal Eroding Band Disease

This disease is a 'white' disease of hard corals. It can be distinguished from other 'white' diseases by a black zone or black speckling on the coral followed by a white speckled dead coral skeleton. A line of white skeleton might precede the dark area on the colony (Figure 4).

Skeletal eroding band disease is caused by the sessile protozoan ciliate *Halofolliculina corallasia* that resides in a secreted black sac-like test called a lorica attached to the coral skeleton. Clusters of ciliates in the lorica can sometimes form a line between the live and dead coral, giving it a strong superficial resemblance to black band disease. However, the empty lorica on the white coral skeleton behind the dark band gives a dotted appearance to the dead zone that can be used to visually distinguish skeletal eroding band disease from black band disease (Antonius 1999). The disease progresses when the protozoan produces motile larvae asexually. The larvae move ahead of the band to the living coral tissue, locate a site suitable to take-up residence and proceed to secrete a lorica of their own. Damage to the coral's skeleton and tissue death are caused by a combination of chemicals associated with the production of the new lorica and the physical drilling of the lorica into the coral skeleton (Antonius & Lipscomb 2001). Each individual colony with scar(s) attributable to skeletal eroding band disease is recorded as SEB in the scar column and the affected coral life form (and genus where possible) is recorded in the corresponding cell.

5.1.8 Brown Band Disease

To date, brown band disease has only been recorded from three families (Acroporidae, Pocilloporidae and Faviidae) on the GBR (Bourne et al. 2008). The disease appears as a brown band of soft jelly-like substance ahead of the recently dead white coral skeleton and moves across colonies rapidly, leaving extensive areas of white dead coral behind the lesion (Figure 5). The causative agent remains unknown and the pathology unresolved, although it has been associated with the brown ciliate *Porpostoma guamense*, which produces brown jelly-like symptoms in infected corals (Katz et al. 2014). The appearance of a white bleached zone, often observed between the healthy coral tissue and an advancing mass of ciliates, indicates that the ciliate might invade secondarily after coral health is compromised, although the ciliate subsequently becomes responsible for macroscopic field signs of brown band disease (Bourne et al. 2008). Each individual colony with scar(s) attributable to brown band disease is recorded as BrB in the scar column and the affected life form (and genus where possible) is recorded in the corresponding cell.

5.1.9 Black Band Disease

Black band disease appears as a discrete band of soft black material ahead of recently dead white coral and behind the still living tissue (Figure 6). The disease is caused by the cyanobacterium *Phormidium corallyticum* and a consortium of microscopic organisms including cyanobacteria, spirulina, sulfate oxidising and reducing bacteria, heterotrophic bacteria and others. The consortium is believed to kill the coral through anoxia and the production of hydrogen sulfide. Each individual colony with scar(s) attributable to black band disease is recorded as BBD in the scar column and the affected life form (and genus where possible) is recorded in the corresponding cell.

5.1.10 Atramentous Necrosis Disease

Atramentous necrosis disease is a putative term to describe a disease found on the GBR (Jones et al. 2004). The disease presents itself as blackened lesions that spread within days across the surface of

an infected colony (Figure 7). The disease appears superficially similar to BBD; however, instead of forming a band, atramentous necrosis disease forms a distinctive mat. Each individual colony with scar(s) attributable to atramentous necrosis disease is recorded as AN in the scar column and the affected life form (and genus where possible) is recorded in the corresponding cell.

5.1.11 *Porites* Pinking

The typical sign of *Porites* pinking is an area of pink discolouration or a bright pink line of scar tissue surrounding an area of the colony that is dead (Figure 8, cause of the pinking is unknown). It is difficult to tell whether the pink discolouration observed around dead and scarred tissue on *Porites* spp. Hard coral colonies are the symptom of a disease or simply a response of the coral to a variety of competitive, invasive or parasitic interactions. From our observations on the GBR, the observed discolouration ranges from pink through to white and appears as scar tissue that forms in a common response to stress, often mechanical, imparted by a wide variety of factors (e.g. parasites, predators, commensals, competition for space, fish bite marks, margins of damselfish gardens, persistent rubbing by other benthic organisms or margins around turf alga patches on the colony from unspecific causes). Each individual colony with scar(s) attributable to *Porites* pinking is recorded as PP in the scar column and the affected life form is recorded in the corresponding cell.

5.1.12 Hyperplasia

Hyperplasia is identified as abnormal growths or tumours on corals (Figure 9). Tumours on hard corals form as a result of abnormal proliferation of cells that are also associated with abnormal skeletal growth. These fall into two main categories: hyperplasia and neoplasia. Hyperplasia is caused by an increase in the number of cells in a tissue or organ, thereby increasing the bulk of the tissue or the organ. These cells typically remain differentiated (i.e. have a clear polyp structure, although this may be abnormal in shape and size) and maintain the colouration of healthy coral. Each individual colony with abnormal growth attributable to hyperplasia is recorded as HYP in the scar column and the affected life form (and genus where possible) is recorded in the corresponding cell.

5.1.13 Neoplasia

Neoplasia usually appears as white, globular masses of coral skeleton raised above the surface of the colony (Figure 10) and has few discernible polyp structures. Neoplasia is characterised by undifferentiated cell growth, giving the affected part of the colony a white globular or smooth appearance, whereas in hyperplasia, the macroscopic polyp structure remains visible and the tissues are pigmented. Each individual colony with abnormal growth attributable to neoplasia is recorded as NEO in the scar column and the affected life form (and genus where possible) is recorded in the corresponding cell.

5.1.14 Coralline Algae Orange Disease

Coralline algae orange disease is characterised by a ‘band’ of bright orange colour that spreads across the algal surface, leaving behind the bare skeletal carbonate remains of the coralline algae (Figure 11). Little is known about the pathology of this disease. Each individual scar on coralline algae attributable to coralline algae orange disease is recorded as CLOD in the scar column.

5.1.15 Coralline Algae Pink Disease/Coralline White Band Syndrome

Coralline algae pink disease is a putative disease that is similar to coralline algae orange disease except in this case a narrow pink band marks the line of mortality (Figure 12). The disease often appears less virulent than coralline algae orange disease and is difficult to observe as it is commonly found on coralline algae under ledges and in nooks and crannies. It is also synonymous with coralline white band syndrome. Each individual scar on coralline algae attributable to coralline algae pink disease for each transect is recorded as CLAP in the scar column.

5.1.16 Physical Damage

Physical damage occurs when an external mechanical force is applied to a coral, causing either dislodgement or breakage of the coral colony (Figure 13). Factors that cause physical damage are many and varied; however, in LTMP surveys, biotic factors such as damage caused by fish bites and lesions attributable to rubbing from other organisms are not included. The LTMP delimitates records of physical damage to clear mechanical breakage that can generally be attributable to abiotic factors such as storm damage from cyclones and anchor damage from boats. Each colony with evidence of physical damage for each transect is recorded as PHYS in the scar column.

5.1.17 Sediment

Hard corals have evolved mechanisms to clear sediment that is deposited from the water column. However, periodically the rain of sediment coming out of suspension can overcome these defences and choke the coral polyps, resulting in mortality to part of or the entire colony. This can be recognised by recent mortality (dead white coral skeleton) underneath the patch of sediment (Figure 14). Each individual colony with scar(s) attributable to sediment is recorded as SED in the scar column and the affected life form is recorded in the corresponding cell.

5.1.18 Algal Overgrowth

In certain situations, algae will overgrow and out-compete live hard corals and overgrow live hard coral tissue and cause subsequent coral mortality. In other cases, algae can interact physically and chemically with corals and induce mortality (Figure 15). Each individual colony with a scar(s) attributable to algal overgrowth is recorded as ALG and where possible the alga is identified and recorded in the scar column and the affected coral life form (and genus where possible) is recorded in the corresponding cell.

5.1.19 Ascidian Overgrowth

Colonial ascidians, similar to algae, can also successfully compete with corals for space and, in some situations, will overgrow hard corals (Figure 16). Each individual colony with spreading ascidian growth over live coral tissue is recorded as ASC in the scar column and the affected coral life form (and genus where possible) is recorded in the corresponding cell.

5.1.20 Sponge Overgrowth

Sponges play an important role in the benthic community and often aggressively compete for space with hard corals. If the sponge is overgrowing live hard coral tissue or penetrating and eroding the skeletons (Figure 17, the bio-eroding sponge *Cliona* sp. Is distinctive), SPO is recorded in the scar

column and the affected coral life form (and genus where possible) is recorded in the corresponding cell.

5.1.21 Bleaching

Bleaching is recorded as an overall category on each transect (as per Table 2) and for individual colonies. Corals may be recorded as bleached when the majority or whole colony is white but not dead. During transitional phases of bleaching and recovery, colonies may be highly coloured, patchy or pale. These can also be recorded as bleached. During major bleaching events, it may not be possible to count and record bleaching on individual colonies if coral cover is high. If it is not feasible to count colonies, then the percentage of colonies bleached as a proportion of the total is recorded as BL using the bleaching categories.

Table 2. Coral bleaching categories.

Category	Range of values (%)
0	No bleaching
0+	0–1 i.e. individual colonies
1-	1–5
1+	6–10
2-	11–20
2+	21–30
3-	31–40
3+	41–50
4-	51–62
4+	63–75
5-	76–82
5+	83–100

5.1.22 Focal Bleaching

Focal bleaching is recorded when a discrete patch of a colony is bleached or pale, but the majority of the colony appears unaffected and healthy. Typically, the underlying cause is unknown. Each individual colony is recorded as FB in the scar column and the affected coral genus and life form is recorded in the corresponding cell.

5.1.23 Comments

Pertinent notes of particular interest that might help with data interpretation are recorded in the space between each table.

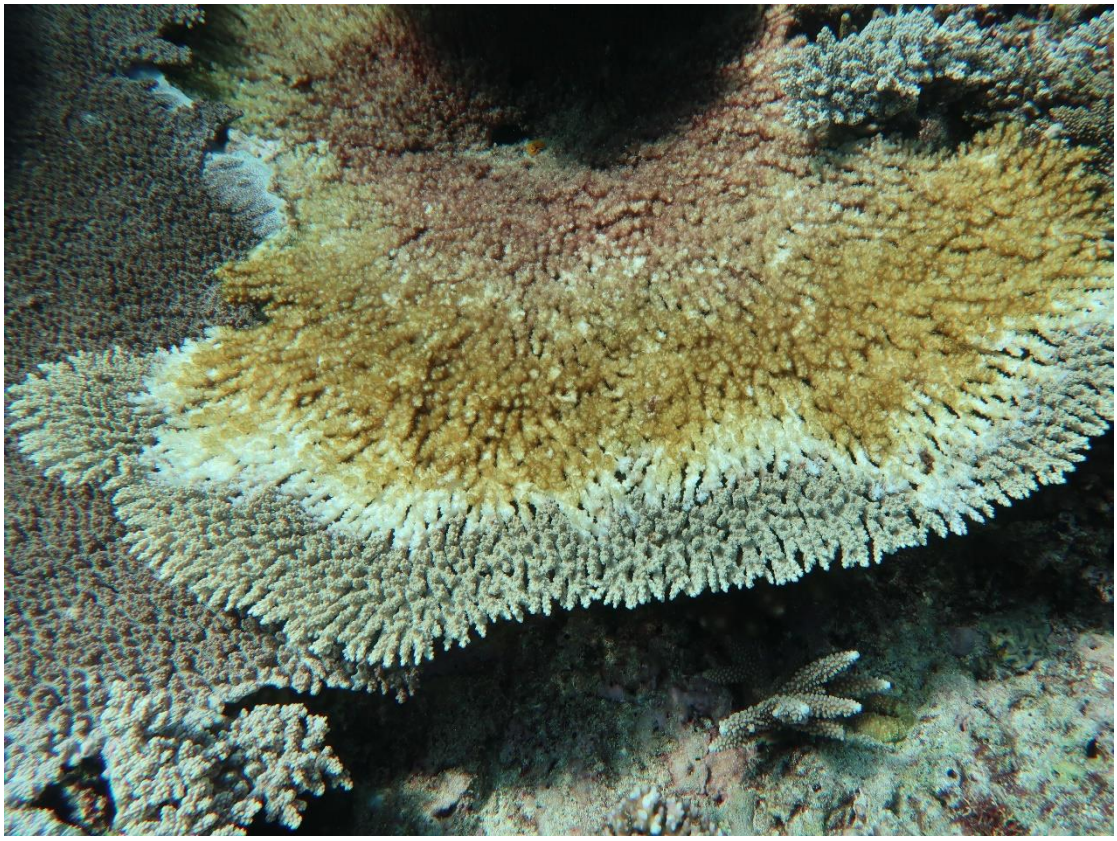

Figure 3. Tabulate *Acropora* sp. coral infected with white syndrome disease.

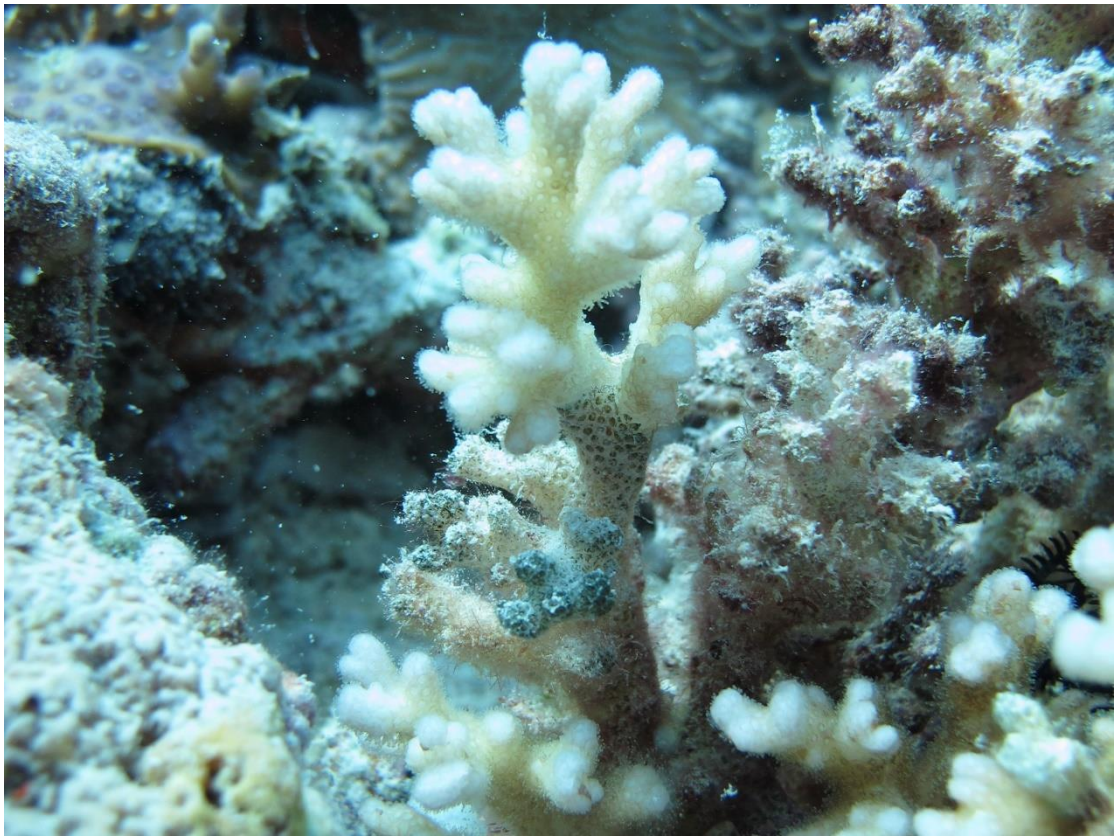

Figure 4. Close-up view of a skeletal eroding band disease on *Pocillopora acuta*.

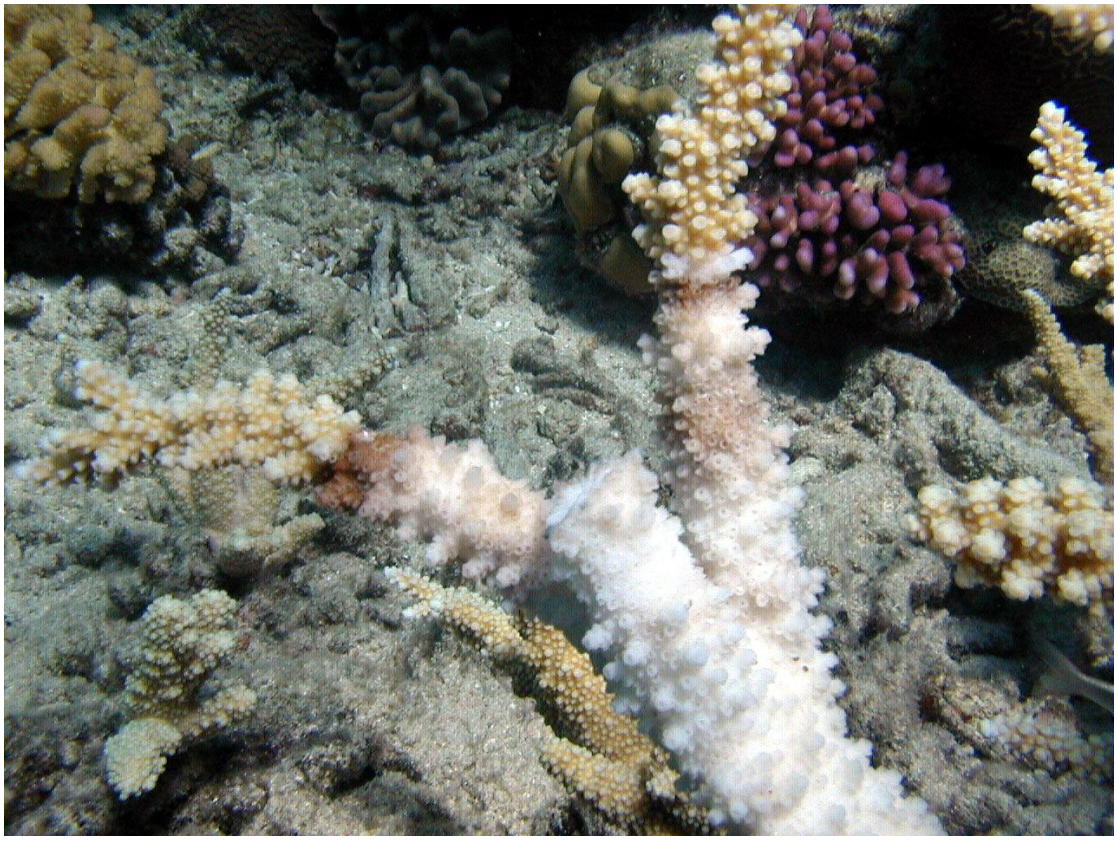

Figure 5. Branching *Acropora* sp. hard coral showing signs of brown band disease.

Figure 6. *Goniopora* sp. massive hard coral colony showing signs of black band disease.

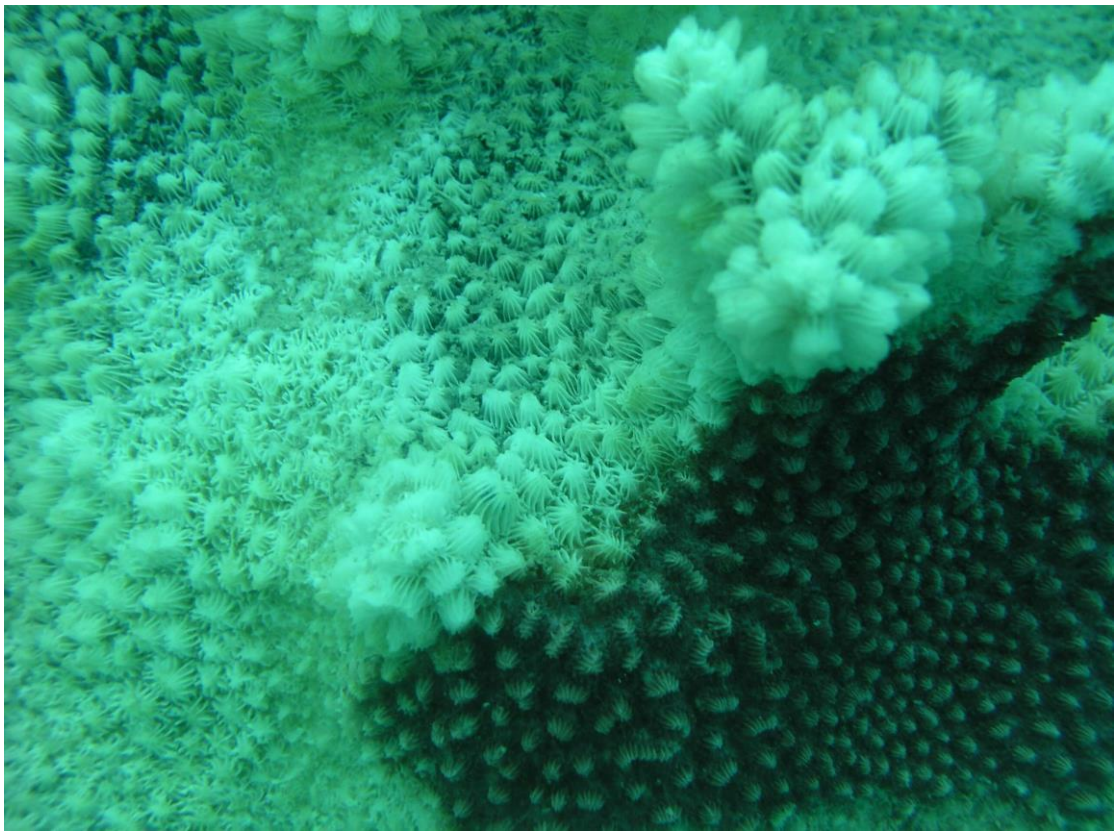

Figure 7. Submassive *Hydnophora* sp. hard coral showing signs of atramentous necrosis disease.

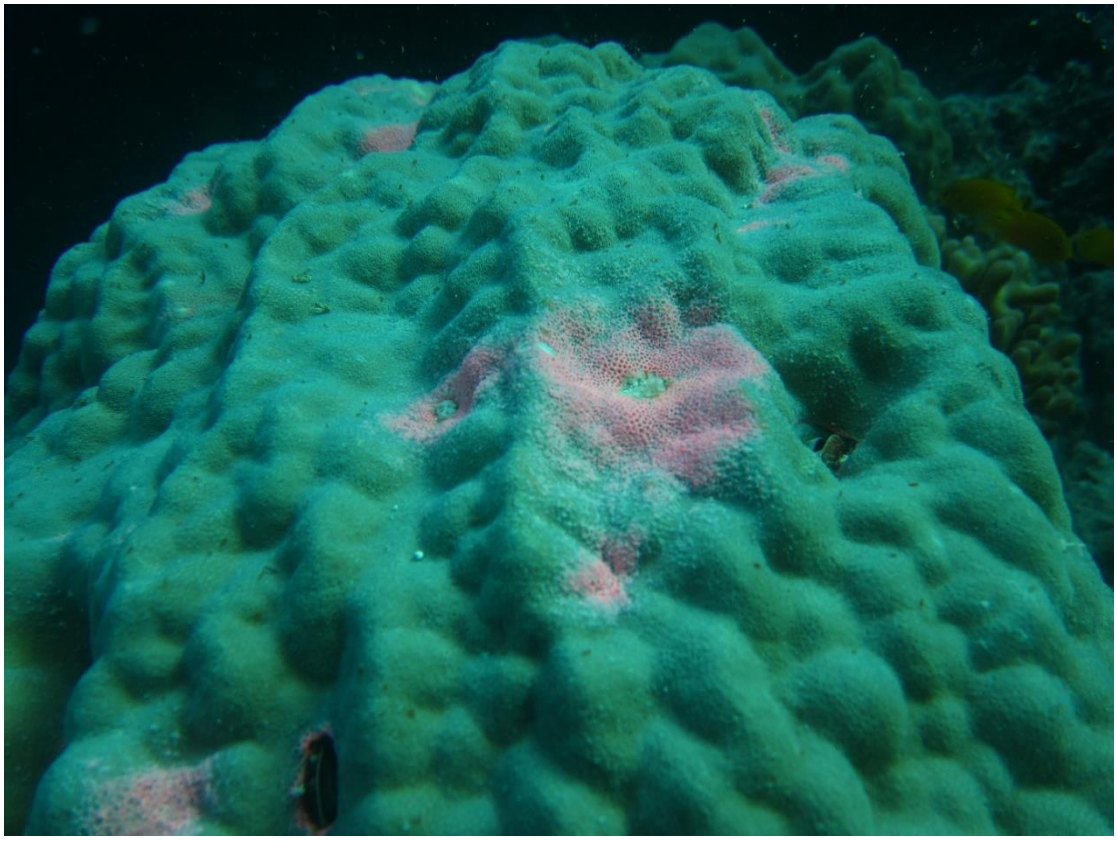

Figure 8. Photograph of *Porites* pinking.

Figure 9. Hyperplasia in the background growing on a tabulate *Acropora* sp. hard coral contrasts with the neoplasia growth in the foreground.

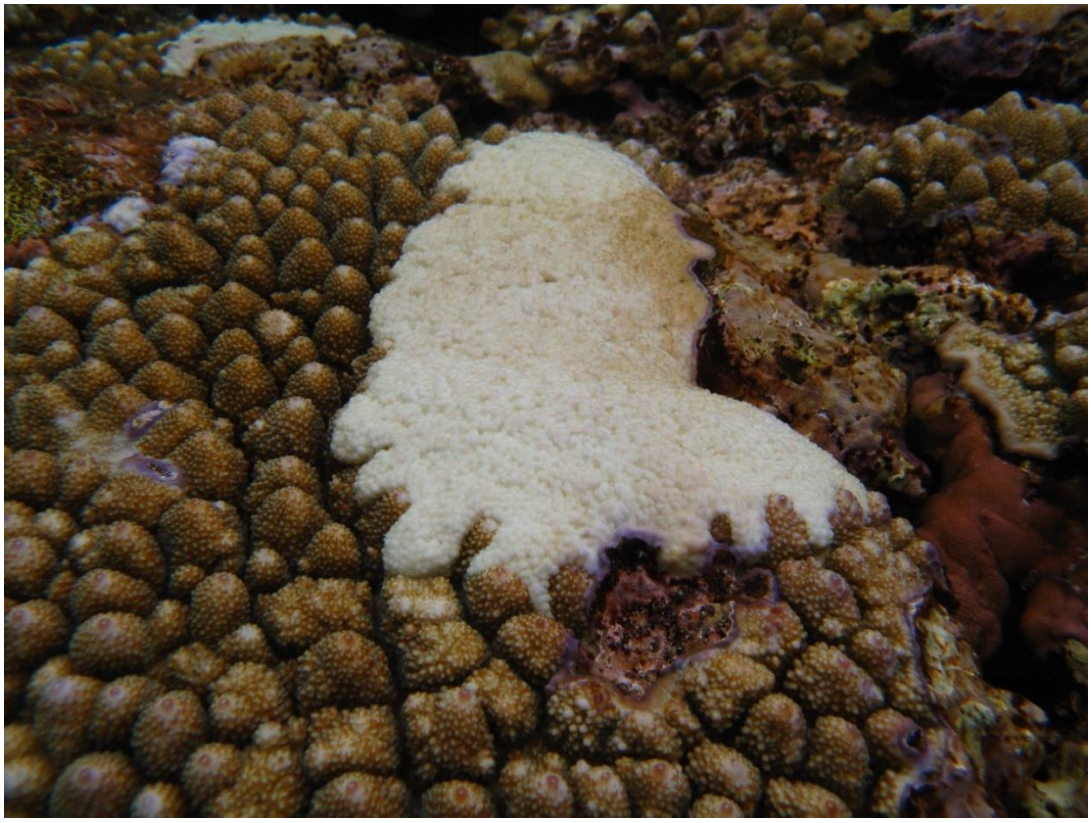

Figure 10. Photograph of neoplasia on a digitate *Acropora* sp. hard coral.

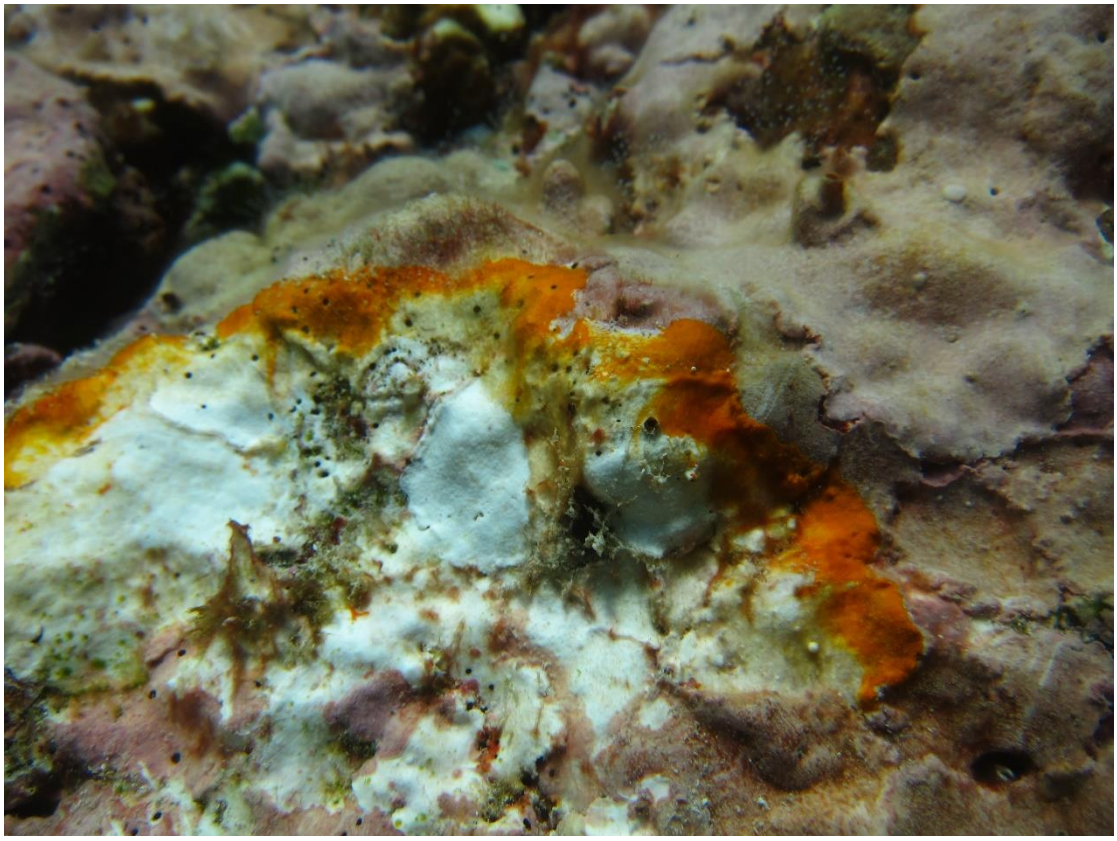

Figure 11. Photograph of coralline algal orange disease growing on a crustose coralline alga.

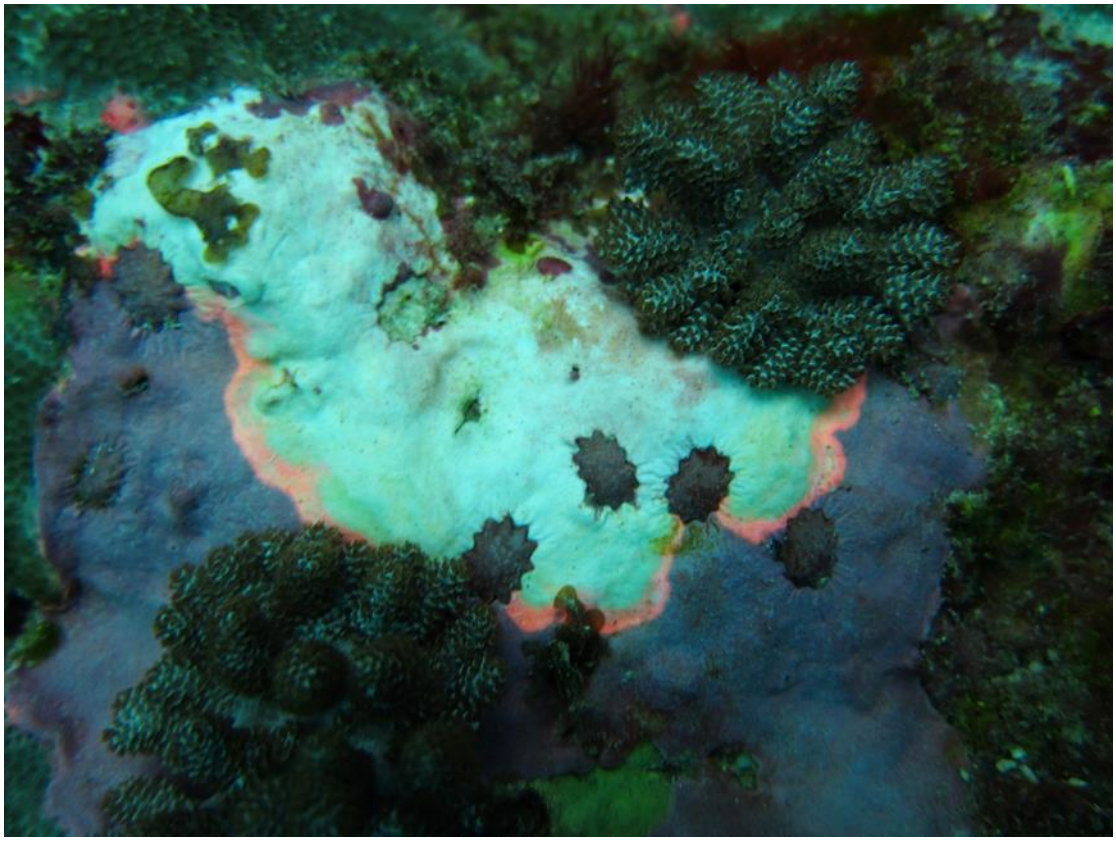

Figure 12. Photograph of coralline algal pink disease growing on a crustose coralline alga.

Figure 13. Signs of physical damage on a large submassive *Pocillopora* sp. coral that has had several branches snapped off due to the effects of Cyclone Yasi.

Figure 14. Partial mortality to a *Favites* sp. hard coral because of sediment deposition.

Figure 15. *Seriatopora hystrix* hard coral colony showing clear signs of mortality, likely from the action of an unidentified filamentous red alga.

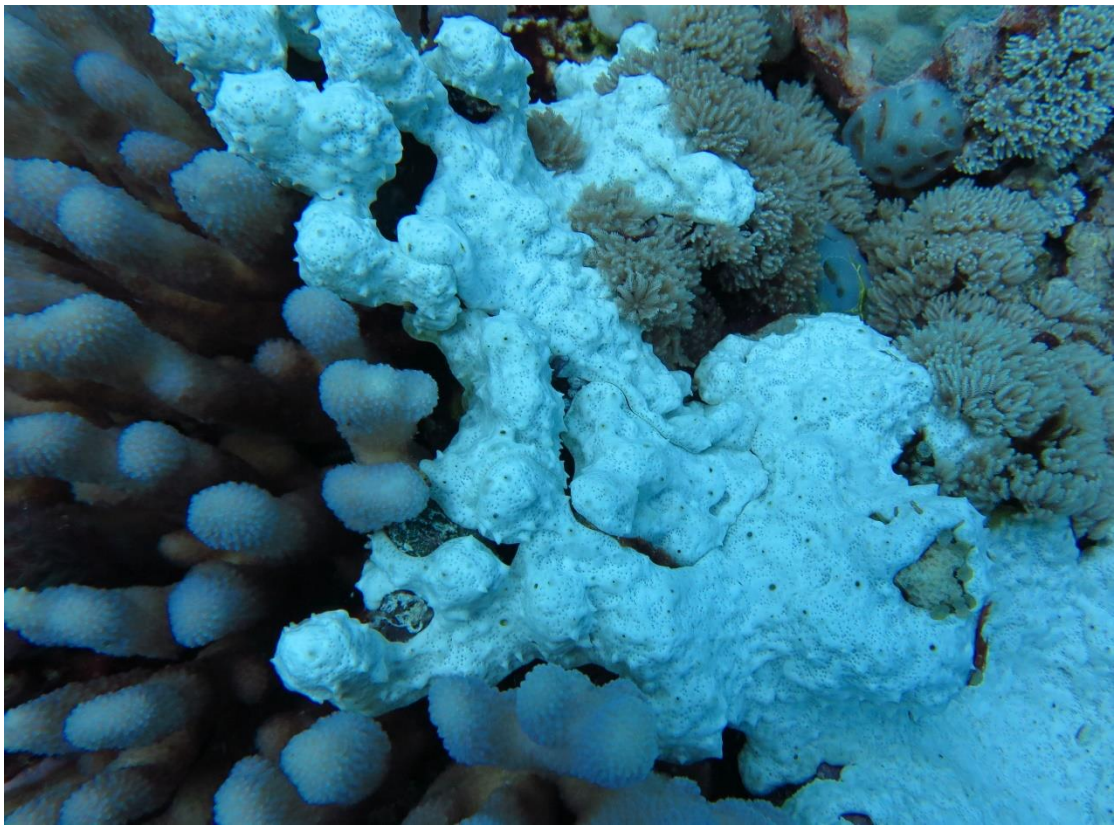

Figure 16. Colonial ascidian (white mass) overgrowing a submassive *Stylophora* sp. hard coral.

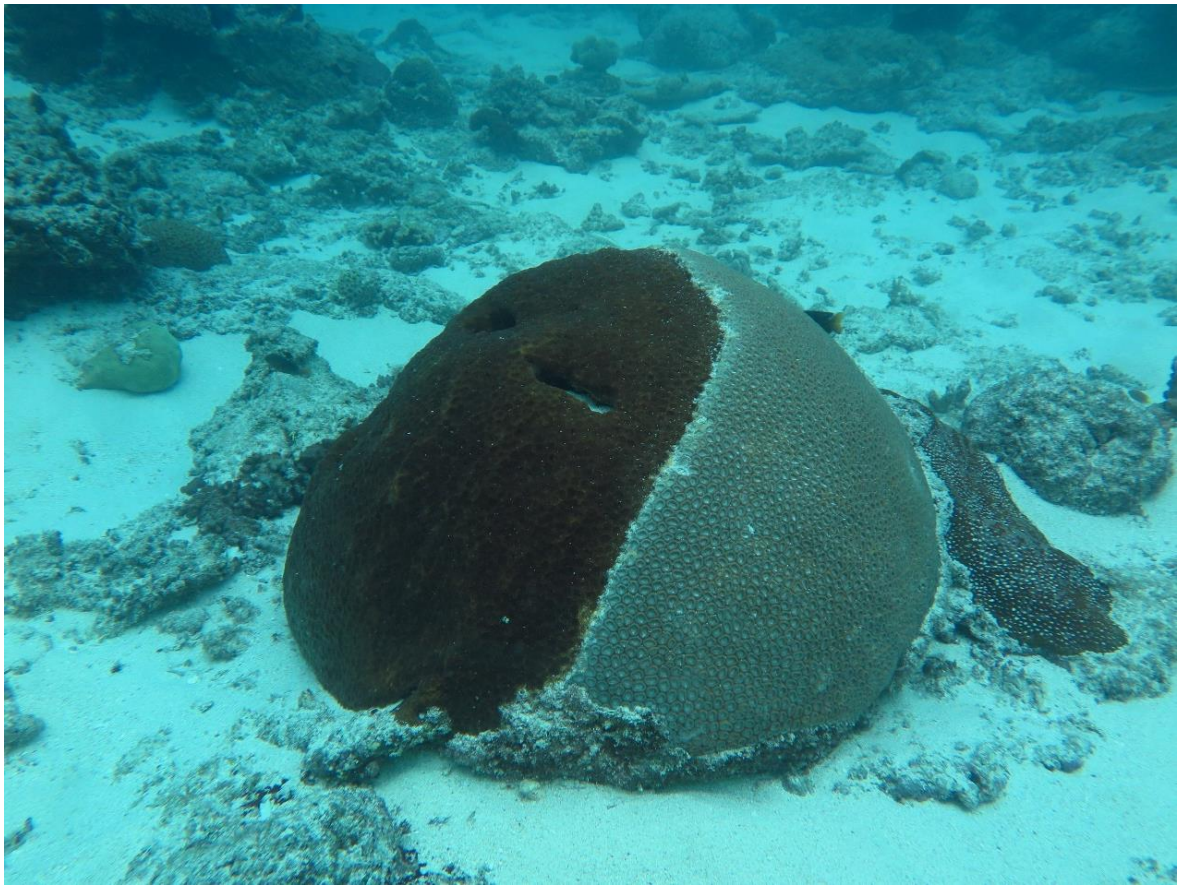

Figure 17. Massive *Favia* sp. hard coral colony being overgrown by the bio-eroding sponge *Cliona* sp.

Figure 18. Bleached *Acropora* corals.

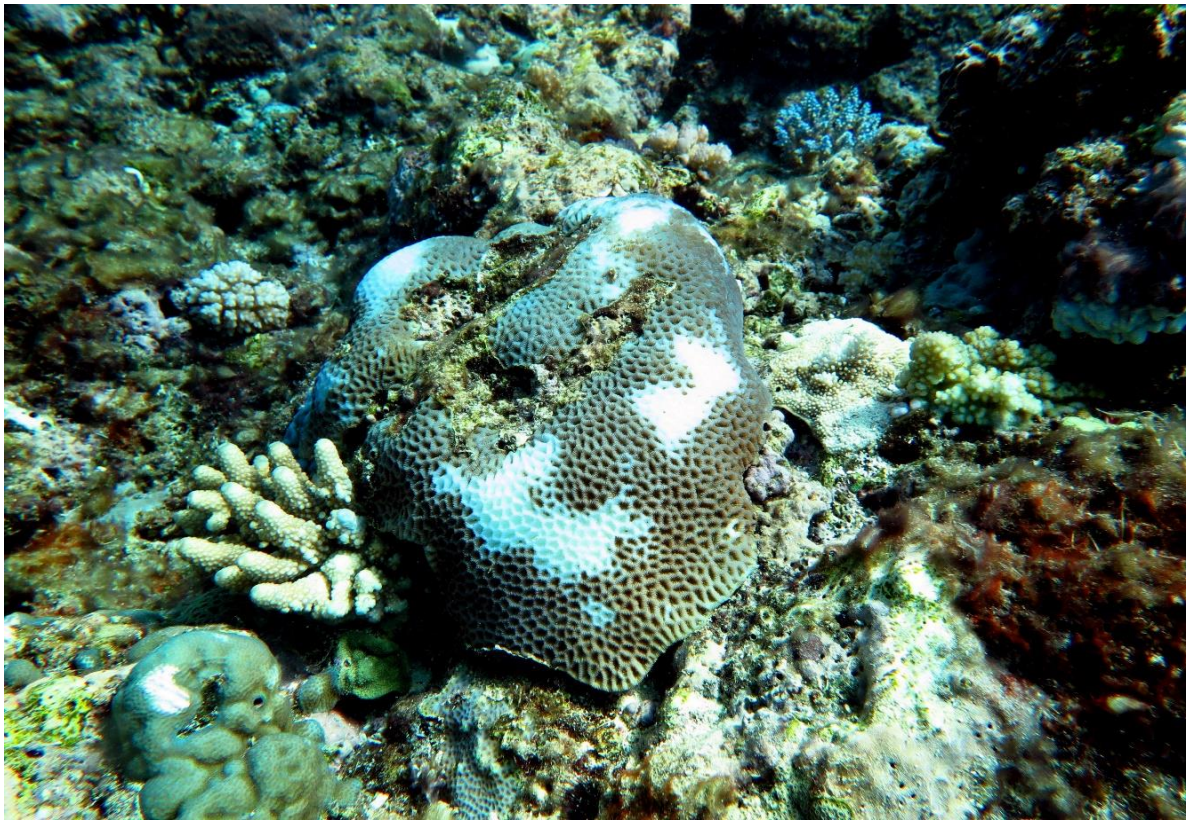

Figure 19. *Goniastrea* colony showing focal bleaching.

6 DATA MANAGEMENT

6.1 Scuba Search Data

Data must be managed using a set procedure to maintain consistency in the database. The following steps will assist in ensuring consistency in the data reaching the database.

6.1.1 Data Sheets

1. When finished recording and on return to the mother vessel, rinse underwater data sheets in fresh water and dry.
2. Label each scuba search data sheet with a unique sample identification number for each site. For scuba search surveys, a sample identification number consists of a two-letter code unique to each survey trip, followed by a three-digit number starting at 100, e.g. AB100. The numbering increments up to 199. Beyond this number, scuba search data follow on in sequence from sample identification numbers assigned to manta tow and reef description data.

6.1.2 Data Entry

Data is entered into a laptop computer in the field using software designed for the AIMS LTMP, called Reefmon. For a detailed explanation of the AIMS database structure, refer to Baker and Coleman (2000). In lieu of Reefmon, a relational database should be used for entering and storing the data. The following is a basic guide to using Reefmon.

1. Open the Reefmon program. Check the database location reads 'LOCAL' (not SERVER) and enter the cruise code, p-code, year and visit number. Click 'RM Dives' to enter scuba search data (Figure 20).

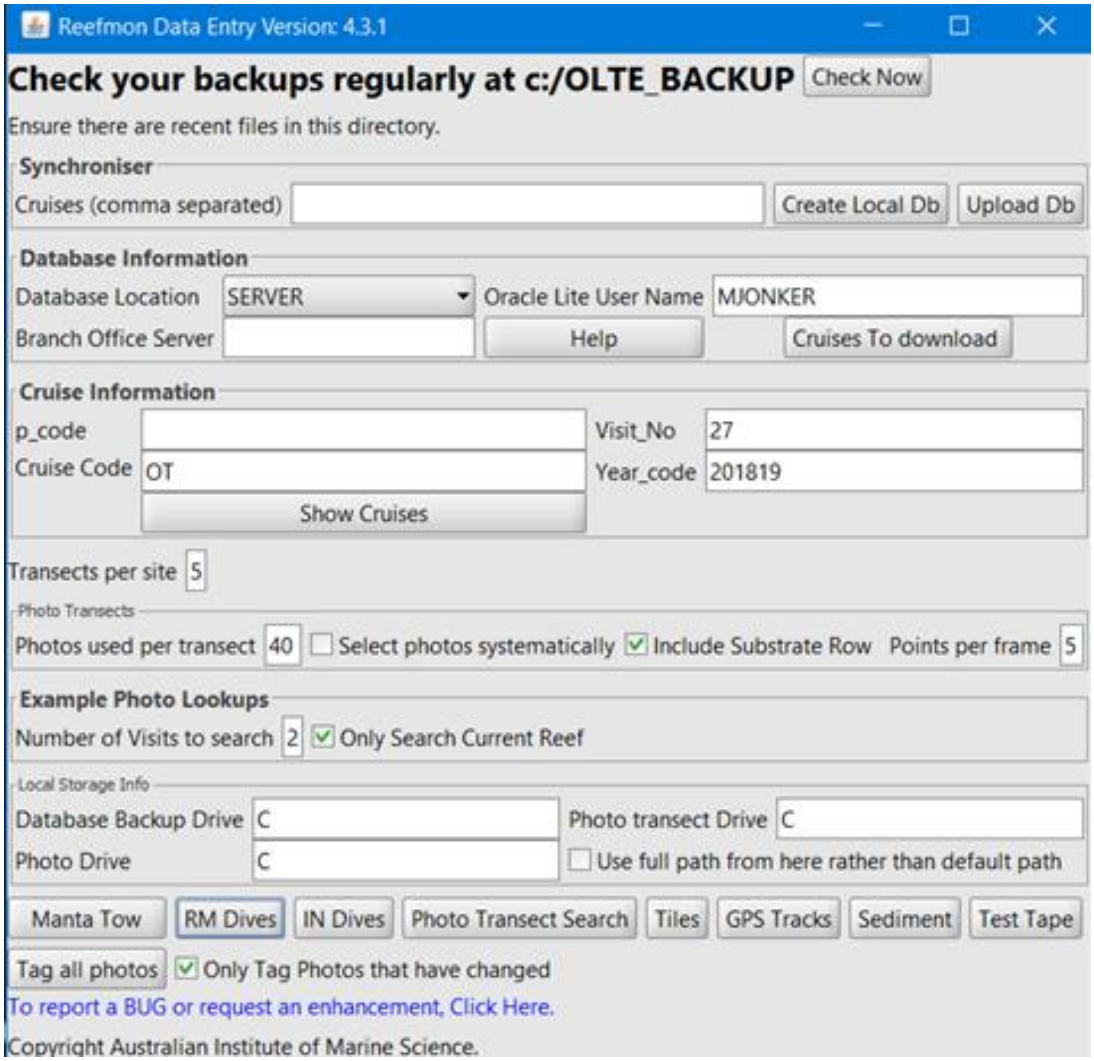

Figure 20. Reefmon data entry program.

2. Click on 'Data for One Sample' (Figure 21). If only one observer was collecting the data on the site, go to the next step. If there was more than one observer within the site, select 'Scuba Search Sample' (Figure 21). Press alt+ insert to enter in the first transect and enter in the first observer's initials. Continue this for all observers of the site. Close the window.

Figure 21. Reefmon data entry program—sample selection.

3. Open the 'Scuba Search' table. If there was only one observer enter their initials in the 'Observer' box, otherwise leave this blank (Figure 22).

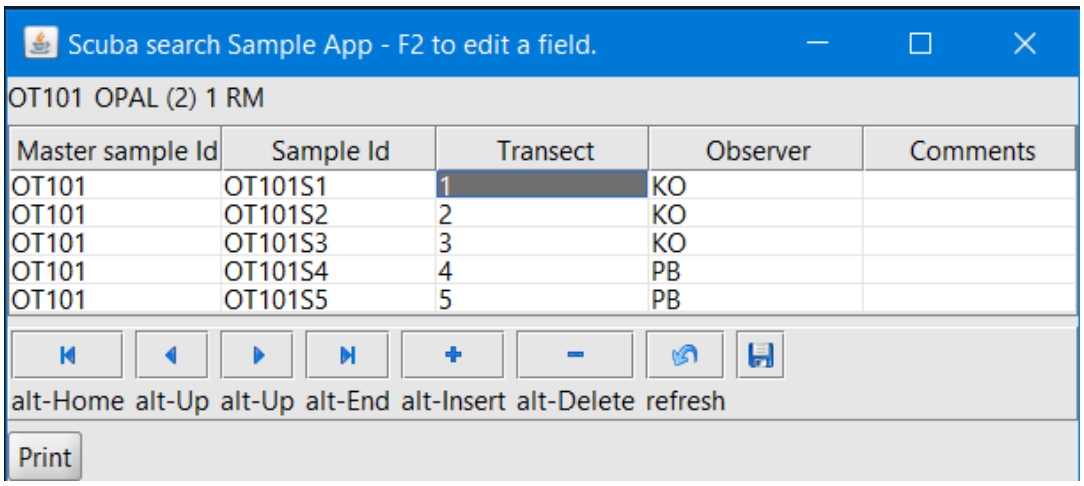

Figure 22. Reefmon data entry for individual observers.

4. Enter the data into the Scuba Search Sample file. Press alt+ insert to start entering the data. Select from the drop-down menus or type in the code in 'Damage', 'BenthosPM' and 'Genus'. Enter the abundance. If there is bleaching, enter the abundance per genus. Also enter the overall amount of bleaching observed in the column 'Category' (see bleaching categories in Appendix). For coralline algae orange disease and coralline algae pink disease, enter a full stop for 'BenthosPM' and 'Genus'. When entering the information, ensure you change the number in the 'TransectNo' column when you have entered in all the data for that transect. If there is no data for a transect, change the number in the column 'TransectNo' to the next transect that has data (Figure 23).

5. Back-up the data regularly to an external hard drive.

6. At the completion of a field trip when back in the office and in collaboration with the database manager, upload the data from Reefmon using purpose-built software (see database manager for details). Change the database location on the Reefmon program to 'SERVER'.

7. Print the data and check it against the data sheets. Two people are required, one to read out the raw figures and one to check these against the printout, to reduce the possibility of errors. Make the appropriate corrections in Reefmon.

8. Keep the checked printout on file as a record of data entry errors.

9. File the data sheets with the checked printouts.

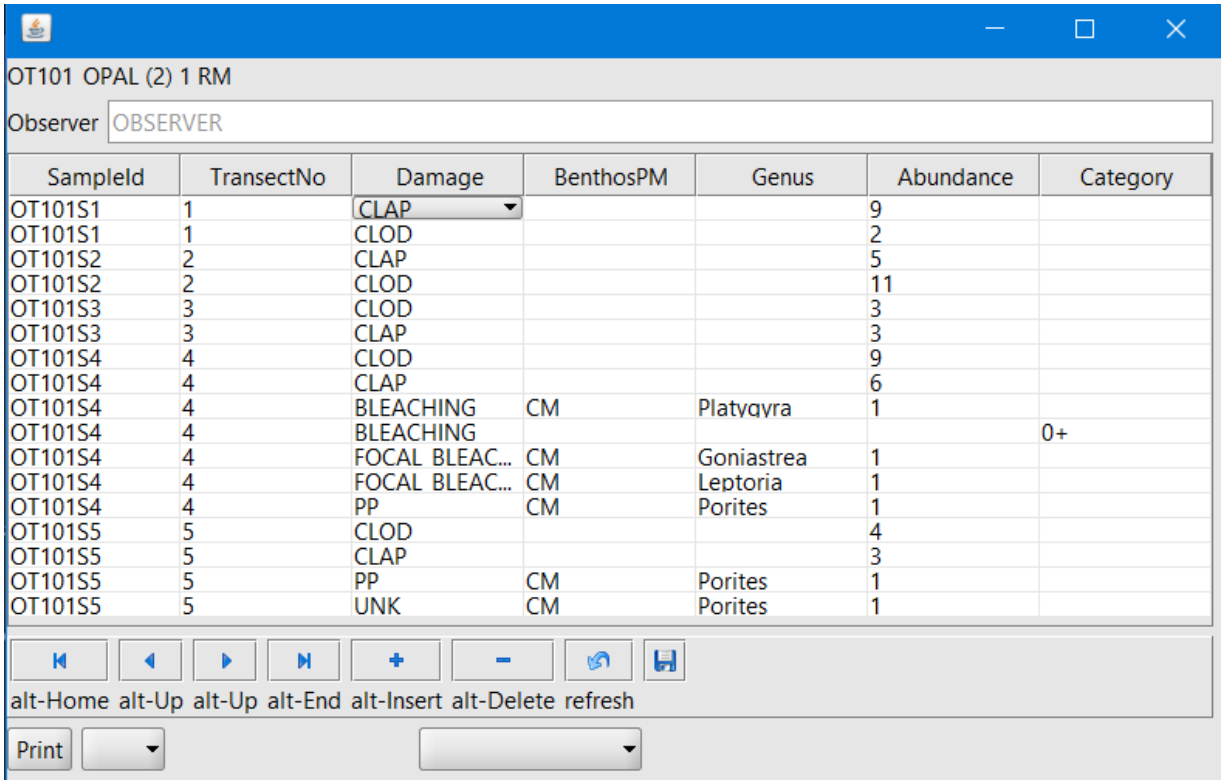

Figure 23. Reefmon data entry for scuba search scars.

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8 APPENDIX

8.1 Appendix 1: Scuba Survey Data Sheet

FIXED SCUBA SEARCH SURVEY

Long-term Monitoring Program
Australian Institute of Marine Science

Reef: **Site:** **Date:** **Time:** **Observer:**

Transect 1		Transect 2		Transect 3		Transect 4		Transect 5	
Scar	**Genus/form**	**Scar**	**Genus/form**	**Scar**	**Genus/form**	**Scar**	**Genus/form**	**Scar**	**Genus/form**
COTS J		**COTS J**		**COTS J**		**COTS J**		**COTS J**	
COTS A		**COTS A**		**COTS A**		**COTS A**		**COTS A**	
COTS B		**COTS B**		**COTS B**		**COTS B**		**COTS B**	
COTS C		**COTS C**		**COTS C**		**COTS C**		**COTS C**	
Bleaching		**Bleaching**		**Bleaching**		**Bleaching**		**Bleaching**	

Bleaching recorded as a percentage of the total hard coral cover: 0=absent, 0+ = individual colonies, -1= 1-5%, +1= 6-10%, 2=11-30%, 3=31-50%, 4 =51-75%, 5=76-100%

COTS: **J** < 5cm, **A** = 6-15cm, **B** = 15-25cm, **C** > 25cm
COTS Scar: **COTS**
Drupella: **Drup(#)**
Bleaching: see above
Unknown: **UN**
White Syndrome: **WS**
Skeletal Eroding Band: **SEB**
Brown Band: **BrB**
Black Band: **BBD**
Atrementous necrosis: **AN**
Porites Pinking: **PP**
Hyperplasia: **HYP**
Neoplasia: **NEO**
Coralline Orange: **CLOD**
Coralline Pink: **CLAP/CWBS**