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M. Jonker, K. Johns and K. Osborne

LONG-TERM MONITORING OF THE GREAT BARRIER REEF

Standard Operational Procedure • Number 10/ 2008

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PREFACE

The Australian Institute of Marine Science's Long-term Monitoring Program annually monitors the cover of benthic organisms, reef fish abundance and crown-of-thorns starfish populations on various reefs of the Great Barrier Reef. Both reef fish and assemblages of benthic organisms are monitored using permanently marked transects. This is Standard Operational Procedure number ten, produced by the Long-term Monitoring Program at the Australian Institute of Marine Science. This volume details the procedures for the use of digital photography to sample reef benthos along permanent transects and for analysis of images from photographed transects in the laboratory using Reefmon, a software system developed at the Institute. Further details of the Long-term Monitoring Program are described in Sweatman et al. (2008) available online at http://www.aims.gov.au/docs/research/monitoring/reef/reef-monitoring.html

INTRODUCTION

Photography technique

The major objective of the benthic component of the Long-term Monitoring Program (LTMP) is to monitor the status of benthic coral reef communities, and to detect and quantify major spatial and temporal changes in the percent cover of a variety of benthos types. This is achieved using an underwater photography technique developed at the Australian Institute of Marine Science (AIMS).

Digital still photography is an alternative method of acquiring images for identifying benthic organisms that is comparable with images extracted from video photography. Both the video photography and the digital still photography sampling methods require less diving time than the line intercept method and provide a permanent record of the survey which can be revisited (Marsh *et al,* 1984; Loya, 1978). The digital still photography survey technique can be used in most diving conditions, even when visibility is limited, and is an easy method for a competent diver to learn.

The underwater photography survey technique described in this document has been developed to take advantage of the greater resolution of images that can be captured using digital still cameras compared with video photography. An unpublished pilot study conducted by the LTMP (Burgess, unpublished), found that estimates of benthic cover at group level, benthos level and family level were similar for the two methods (video and photo) and since 2007 all benthic sampling has been undertaken with digital still cameras.

The acquisition of the images differs between the underwater video technique and the underwater photography technique. Previously a belt transect was filmed along the 50m transect with a video camera, then forty regularly spaced frames were then sub-sampled from the record for each transect and written to DVD, as outlined in the Standard Operating Procedure 2 revision 3 (Abdo et al 2004). In contrast, the photography technique involves taking photos at 1 metre intervals along the 50m transect then 40 images are randomly selected from this sample. Both techniques use image analysis software developed at AIMS, where the benthic organisms lying under 5 fixed points per image are identified to give a total of 200 samples per transect.

Juvenile coral counting technique

Patterns of density of juvenile corals across space and time are the net result of processes of larval supply, settlement and post-settlement survivorship.
Juvenile corals (those that settle and survive post-settlement) can have a major influence of the population dynamics at a reef (Bak and Engel 1979; Harrison and Wallace 1990; Caley et al. 1996; Miller et al. 2000) and may indicate a reef's capacity to recover following disturbances (Connell et al. 1997; Hughes and Tanner 2000). Monitoring juvenile densities across large spatial scales should therefore be a high priority in monitoring studies (Pearson 1981; Wells 1995), especially as coral reef around the world are being subject to increasing stress (Wilkinson 2004).

The purpose of this Standard Operational Procedure document is to give an explicit account of the methods presently used by the LTMP at AIMS. As a consequence, some aspects of the manual are specific to the equipment used in this program. This Standard Operational Procedure is also intended to act as a guide for other users who wish to use photography to monitor the benthic communities of coral reefs while continuing with the standard protocol of the AIMS LTMP.

SAMPLING DESIGN

Benthic coral reef communities are surveyed annually by the AIMS LTMP. The Australian Institute of Marine Science set up a long-term monitoring program for the Great Barrier Reef (GBR) in 1992. The program is based on some previous monitoring initiatives on smaller scales and represents the first concerted attempt to assess a range of ecological variables across most of the GBR. In 1993 the Long-term Monitoring Program (LTMP) became a task in the Cooperative Research Centre for Ecologically Sustainable Use of the Great Barrier Reef and subsequently the Cooperative Research Centre for the GBR World Heritage Area. In 2006 the program was further modified, so that the LTMP core reefs were to be surveyed in alternate years, alternating with surveys of a different set of reefs chosen to investigate the effects of rezoning the GBR Marine Park in 2004. The program is funded in part by the Marine and Tropical Sciences Research Facility (MTSRF).

The LTMP surveys 48 reefs within six sectors of the Great Barrier Reef (Cooktown/ Lizard Island, Cairns, Townsville, Whitsunday, Swain and Capricorn Bunker sectors), which are defined according to latitude. Within each of these sectors, reefs are classified according to their position across the continental shelf (shelf position). With the exception of the Capricorn Bunker and the Swains sectors, three shelf positions (inshore, mid-shelf and outer shelf) have been identified. Shelf position is determined by the position of the reef relative to the coast and continental slope, with inner shelf reefs closest to the coast. Three reefs are nested within each of these shelf position/sector combinations. In the Capricorn Bunker sector, only outer shelf reefs are represented, with four reefs being surveyed. In the Swains sector there are no inshore reefs represented, however five mid-shelf reefs and two outer-shelf reefs are represented.

The RAP surveys are conducted by AIMS on reefs in the Cairns, Townsville, Mackay Swains and Capricorn Bunker reef regions. Within each region 6 pairs of reefs are surveyed (4 pairs in the Capricorn Bunkers). Pairs of reefs that were selected were open to fishing prior to 2004. In each pair, one reef remains open to fishing (blue zone) while the other reef was rezoned as a no-take area (green zone) in 2004. The pairs of reefs have a similar geomorphology on the area that is surveyed and reefs in each pair are located close to one another in the same Representative Areas Program bioregion.

On each reef a single habitat is surveyed, usually the northeast flank of the reef. This habitat is defined as the first stretch of continuous reef with a slope less than vertical, when moving in a clockwise direction from the back reef zone towards the reef front. The selection of a common habitat allows comparisons to be made between reefs, both within and between sectors and shelf positions. Within the northeast flank habitat, three sites were originally selected at each reef, and five permanently marked, 50 m long transects were set-up. Transects are located along the reef slope, lying roughly parallel to the reef crest at a depth between 6 and 9 m's. Each transect is marked at the beginning and at the end with a metal star-picket. On the LTMP survey reefs transects are also marked at 10 m intervals with steel reinforcing rods (10 mm diameter). A tape stretched between the star-pickets and rods marks the centre line of each transect. Each star-picket is labelled with an aluminium tag (identifying transects as belonging to AIMS project 221). The GPS position of the star-picket at the beginning of the first transect for each site is recorded in a database. This star-picket is also marked with a subsurface buoy to aid in locating the site. Further details of this sampling design can be found in Sweatman *et al* (2008) or from links at
http://www.aims.gov.au/docs/research/monitoring/reef/reef-monitoring.html

Benthic surveys are conducted on the upper slope side of the transect line, approximately 50 cm from tape. The still camera is held at a consistent distance from the substrate (approximately 50 cm). The resulting image on the belt transect to be analysed is approximately 25 cm by 34 cm.

PART 1 - USING UNDERWATER PHOTOGRAPHY TO SURVEY REEF BENTHOS

The following procedures are used by the AIMS LTMP as a standard survey method for sessile benthic communities using underwater still photography. They are specific to the objectives of the program but may be easily modified to satisfy other research objectives. The photography technique has several components; Personnel, Equipment, Preparation of Equipment, Equipment Maintenance, Field Sampling procedure and the Laboratory Sampling of photographed images.

Personnel

A minimum of three people are required for the collection of sessile benthic data using this survey technique. One person is required to lay a tape measure along the centre line of each transect and a second person to follow capturing images along the transect. The third person is required to remain in the boat as a divers' attendant and surface support.

However, benthic surveys are normally conducted by the AIMS LTMP concurrently with visual census surveys of reef fish, and SCUBA search surveys of the abundance of juvenile corals (see part 2), coral mortality, coral disease, the presence of Crown-of-thorns starfish (COTS) and *Drupella* spp. along the same transects.

In these circumstances, three additional people are required with the one person conducting the visual fish surveys, accompanied by a tape layer and the third conducting SCUBA searches for juvenile corals, coral disease, COTS and *Drupella*. The procedures for visual fish surveys and SCUBA searches are detailed in the Standard Operational Procedure No. 3 (Halford and Thompson 1994) and the Standard Operational Procedure No. 8 (Miller 2003) found at http://www.aims.gov.au/docs/research/monitoring/reef/technical-reports.html

Equipment

The following list of equipment is required for the collection of benthic data using underwater photography.

Field equipment

- Hand held Geographical Positioning System (GPS) (WGS-84 datum)
- Surface marker buoy attached to a 30m rope and drop weight
- Complete sets of SCUBA diving equipment and safety sausages.
- Surface float and dive flag attached to 30m rope with clip at other end
- Underwater slate, pencil and data sheets
- 5 × 60 m fibreglass measuring tapes (preferably in centimetre markings on both sides of the tape)
- Small waterproof carry case (for transporting camera and housing to field sites) lined with neoprene layer to protect camera from bumps.
- Large waterproof carry case for camera and housing containing:
  - Underwater housing with wrist strap attached
  - Flash diffuser
  - Housing manual
  - Silicone grease
  - Digital still camera (Currently using Canon Powershot G10)
  - Memory card (at least 4GB)
  - Camera manual
  - 2 x NB-7L Lithium Ion batteries
  - Battery charger and power cord
  - USB download cable
  - Photograph data sheets (Appendix I)
  - Lens cleaning tissue
  - Lens cleaning fluid
  - Lens cleaning cloth

- Personal computer with DVD writable drive, ACDSee software and Canon Powershot download software and approximately 30GB of storage space
  - Reefmon data entry software system
  - DVD +R discs (one per survey reef)
  - Note of trip number, cruise code and the next DVD label number, so that the DVDs are labelled correctly and in sequence with previous DVDS.

Laboratory equipment

- Personal computer with connection to internal network, at least 1.5GB RAM and preferably a large display screen
- Reefmon data entry software system

Preparation of equipment

Instructions to prepare the housing and digital camera are given below, however, for a more comprehensive coverage of housing and digital camera features refer to the relevant manufacturer's instruction manual and operation procedures. The AIMS LTMP is currently using Canon Powershot G10 cameras and some of the camera settings described below are specific to this model. A summary of housing and camera set up and maintenance procedures (Quick Set-up and Maintenance Procedures) is provided at the end of this section as a check list for those familiar with the preparing and setting up the camera equipment.

Recharging the digital still camera battery packs

Prior to the use of still cameras, battery packs should be completely recharged. Lithium (Canon Powershot S80 or Canon Powershot G10) or NiMH (Canon Powershot A570IS) batteries are used. These do not require discharging prior to recharging. Batteries should be charged after surveying two sites and after the day's water activities are completed.

Charging the batteries

Only use the NB-7L battery in the battery charger. Keep battery charger away from moisture.

1. Batteries should be recharged on a flat surface without vibration.
2. Plug the AC adaptor into the battery charger, and then plug this into the power outlet and place the battery in the charger.
   Note: A red light means the battery is charging, green light means the charging is complete and a red flashing light means the battery is faulty. If the battery is faulty label as such as stow away for proper disposal.
3. Remove batteries once they are fully charged as this will prolong life of batteries. Store charged batteries in the battery case within the cracked waterproof carry case. The battery charger should also be unplugged when it is not in use.

Camera preparation

Slide the battery cover open and carefully insert the fully charged battery into the camera. Turn the camera on by pressing the power button on the top of the camera. Check that the lens is free of dust or smudges and clean with Kimwipes lens cleaning fluid and a soft cloth if required.

Camera settings for photo transects

1. Check all the icons in Figure 1 are displayed on the LCD screen on the back of the camera.

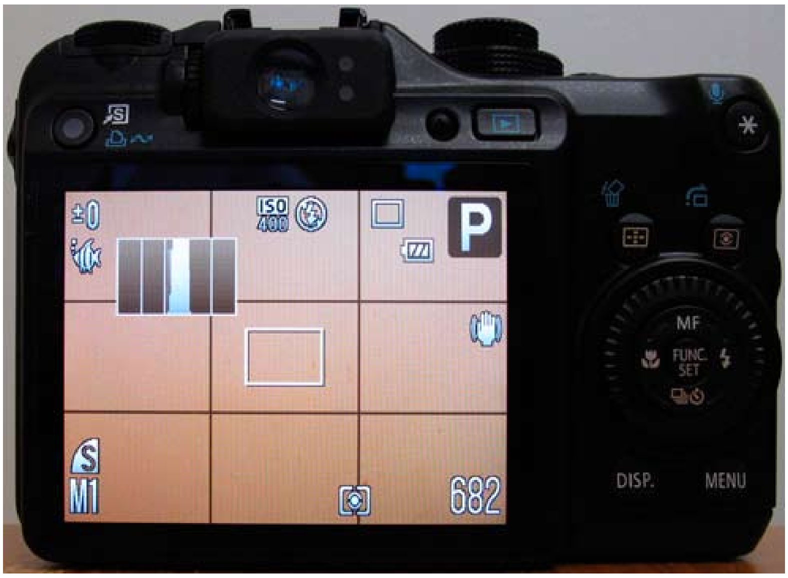

Figure 1. Canon Powershot G10 LCD monitor.

   a. In the top right of the screen a “P” (for Program) should be displayed. To set the camera to “P” turn the mode dial knob on the top right of the camera until a “P” appears on the LCD monitor.
   b. If the icons for the settings below are not displayed on the LCD monitor shown in Figure 1, press the FUNC.SET button when the camera is in shooting mode and use the multi control wheel to scroll up, down, left and right to select the following settings.
      i. A fish icon should be displayed on the top left of the LCD screen. This indicates the underwater shooting mode is activated.
      ii. The resolution of the images should be set to “3456 x 2592” pixels. The letter “M1” (for medium image size) should be displayed in the on the bottom left of the LCD screen.

iii. The quality of the images should be set to "superfine". On the bottom left of the LCD screen a quarter circle with the letter "S" should displayed above the "M1".

iv. The metering mode should be set to "evaluative". This can only be changed when the camera is not in the housing, as it requires the function of the wheel. A square with a circle in the middle should be displayed on the bottom middle of the LCD screen.

v. Ensure the "My Colours" setting is turned off. A paint brush icon will be displayed on the LCD screen with the "OFF" through it. Alternately use the "vivid" setting.

vi. Ensure Image stabilisation is turned on to assist to produce crisper images. From IS mode menu, select "continuous". A hand will be displayed on the right hand side of the camera with curved brackets on either side.
Note: If a red camera icon appears, the lighting level is insufficient for the slow shutter speed that has been selected. This might be fixed by turning the flash setting to "ON" or reducing the ISO setting to 200 or 100.

c. Select the desired ISO according to the day's conditions. ISO 400 is ideal for most lighting conditions however in high light conditions it may be necessary to set the ISO to 200 or even 100 to ensure the shutter speed is in the range of *1/ 120 to 1/500*. To check the ISO speed, depress the shutter button halfway. Then green square should appear on the LCD screen. The f-stop value is displayed below the green square. If an orange square appears the camera is most likely to be too close to the subject matter.

d. Ensure that the flash is off. Press the flash icon on the multi control wheel to activate or turn the flash off.

2. Check that the Auto-rotate function is OFF. Press Menu in either the shooting mode or playback mode. Select the Set up menu, the scroll down to "Auto Rotate" and select "OFF".

3. The review setting or drive mode on the camera can be altered depending on the preference of the benthic observer. Press Menu > my camera menu > review > scroll up or down. It is recommended that the playback of the image is either turned off (especially if the battery level is low) or set to playback for 2 seconds.

Camera settings for video panoramas

1. Turn the camera to movie mode and check the settings on this screen
    a. Standard (this is selected by turning the multi function wheel)
    b. Evaluative metering mode (Press FUNC.SET to access)
    c. Resolution should be set to 640 x 480 pixels (The icon is a rectangle with 640 in middle). If using a camera with the option of a higher resolution it would be better to use it.
    d. Frame rate 30 frames per second (30fps). This icon is a double lined rectangle with 30 in centre.

Ensure that all users have downloaded photographs and movies from camera before removing images from the memory card. To erase all images press the playback button (rectangle with triangle in the middle). Then scroll down to "erase" using the multi control dial and choose "select by range" and choose the photo range you want to erase.

Underwater housing preparation

1. Ensure both sides of the housing window for the lens are clean. Use a lens cleaning tissue (eg. Kimwipes) or the lens cleaning fluid with the soft lens cleaning cloth.

2. Remove the silicone O-rings from the underwater housing and closely examine it for nicks, scratches or other damage. If any damage is detected the O-ring should be replaced, otherwise clean the silicone O-ring and the O-ring groove with a lens cleaning tissue (eg. Kimwipes).

3. Apply a little silicone grease between thumb and forefinger and then run the entire loop of the O-ring between fingers several times to coat the entire surface with a film of lubricant. Carefully place the O-ring back into the groove without twisting it and taking care not to place grease on the lens.

4. Place the camera into the underwater housing. Mate the housing halves, ensuring that nothing is caught in between. Close the latch on the side of the housing.

5. Take a test photo to ensure the camera has been correctly installed in the housing.

6. Place the housing in a closed cracked camera case in a non air-conditioned environment to acclimatise for a short period of time before the camera case is sealed. This ensures condensation on the lens is kept to a minimum. The camera case should be sealed before moving it to the tender boat.

Pre-filming checks

After entering the water, but before descending on each dive, ensure that the equipment is functioning properly.

1. Check the housing for leaks. A habit should be made of occasionally looking inside the housing to check for leaks or condensation, particularly if the housing encounters any knocks or impacts.

2. Check the camera function buttons (i.e. On/Off, Mode dial and Zoom controls).

3. Check that there is no condensation in the front lens port or the viewfinder. If condensation is present, delay filming until it disappears. If there is a leak, abort the dive.

Equipment maintenance

After every use

1. Place the housing into the small waterproof camera carry case immediately after leaving the water.

2. Wash salt water from the housing with freshwater, paying particular attention to controls and recesses around the O-ring seals. This is best done by submerging the sealed housing in a container such as a large plastic container (eg. Nally ™ bin) filled with freshwater for as long as possible. Some camera weights may be necessary to ensure all buttons remain submerged in freshwater. If the housing is not opened between dives there is no need to remove the housing from the fresh water until the camera is required.

3. Remove the housing from the water and dry with a clean towel. Leave the housing in a safe, clean, airy, salt-free environment to dry completely.
   Note*: It is* ***important*** *to keep wet and dry areas separate in the vessels' laboratory. This ensures that any electronic equipment does not become damaged.*

4. Before opening the housing, carefully wipe around the O-ring seals, so that no water falls onto the camera upon opening. Open the housing by releasing the latch on the side of the housing. Carefully wipe any water on the mating surfaces of the two housing halves and leave to dry in a safe, clean, salt free environment. ***Note*: *Do not* open the housing where salt spray is present.**

5. Remove the battery and place it on the charger as outlined previously. Return the camera to a dry cracked waterproof carry case for storage. Always store the camera and housing to the carry case when not in use.

Regular maintenance

Housing

1. All O-rings should all be replaced after 2 years regardless of the amount of use.

2. If scratches appear on the housing lens, discontinue use of the housing as it may affect the quality of the photographs.

Equipment storage

Camera

When not in the housing, store camera in a protective camera pouch in the closed but cracked waterproof carry case, in an air-conditioned environment. Carry cases should be closed to protect the camera, but cracked to allow air circulation.

Housing

While the camera is in the underwater housing and it is being transported to the survey site, it should be stored in a closed waterproof camera carry case. Between dives and when batteries do not require recharging or memory card on the camera is not full, the housing is best weighted down and kept in a large fresh water-filled plastic container (eg. Nally ™ bin). By ensuring the housing is immersed in fresh water the build up of salt or corrosion within the button shafts should not occur. When the camera is not in the housing, the housing should be stored slightly open in a cracked waterproof carry case, preferably away from the salt air and in air conditioning. However if there is no air conditioning, it is better to use dry silica gel to remove any moisture and keep the housing closed.

Quick setup procedures

This section in designed for people who are experienced in the set up of their housing and cameras. The summary may be used as a reminder for those who have not conducted benthic surveys for a while and do not feel confident in the set up of their equipment. In addition, this summary may be printed out separately, stored with the camera and housing and used as a checklist to ensure no steps in the preparation of the equipment are forgotten.

Camera set-up

The camera should be set-up and placed in housing in a clean, salt free and air conditioned environment and placed in waterproof case for transport to site.

1. Place the **fully charged batteries** within the camera.

2. Place camera on clean flat surface and clean lens.

3. Switch camera on and ensure the **scene selection** is on **"P"** with the **flash turned off**, the **underwater scene** selected and the **ISO** setting is not on Auto.

4. Ensure photos and videos have been **erased** from the memory card.

Housing set-up

1. Open the housing. Check for any moisture, if any is present wipe the inside of the housing and include a sachet of dry silica gel.

2. Check **o-ring** is clean and not damaged.

3. Gently place camera into front half of housing, mate housing halves and **check that nothing is caught in between the two halves** then close latch.

4. Push the control levers in and check controls work. If these do not work, open housing, align controls and try again.

5. Place the housing into a waterproof case.

Before entering water and descending

1. Check that the controls work.

2. Check the **ISO** is still set at required level (Auto for photograph of site, 400 for images

Field sampling procedure

The following section outlines the procedure for undertaking sessile benthic surveys of a permanent monitoring site. This procedure assumes that fish surveys and SCUBA searches are being conducted concurrently as outlined in the Standard Operational Procedure No. 3 (Halford and Thompson 1996) and Standard Operational Procedure No. 8 (Miller 2003) and outlined below. If fish surveys and SCUBA searches are not conducted concurrently then the procedure can be followed without the fish observer, as mentioned in the Personnel section.

1. The site is located from the surface using a handheld GPS and/or past knowledge of the surrounding reef topography. On reaching the general area a surface marker buoy attached to a 30m rope and drop weight is deployed. A snorkel diver then locates the beginning of the first transect, marked with a star-picket and sub-surface marker buoy. If the surface buoy is not close to the beginning of the first transect, it is redeployed with the aid of the snorkel diver. The boat is then anchored slightly away from the site so that the anchor does not damage the first transect and, if conducting fish censuses, divers entering the water do not swim across transects and disturb fish before the census begins.

2. Four divers enter the water and the diver's attendant remains in the boat. The first diver (fish observer) is equipped with a slate, pencil, data sheets and one fibreglass tape. The second diver (tape layer) carries five, 60 m tapes. The third diver (benthic observer) is equipped with the camera, slate with pencil and data sheet (Appendix I). The forth diver (SCUBA searcher) is equipped with a slate, pencil and data sheet.

3. Beginning at the first star-picket of transect one, the fish observer conducts the 50 m by 5 m fish surveys by swimming along the centre line of the transects using the star-pickets and reinforcing rods as guides. The observer counts all non-Pomacentrid fish within the area 2.5 m either side of the centre line.

4. The tape layer follows the fish observer, laying a tape measure along the centre line of the transect. The tape is attached to the star-picket at the beginning of the transect, then wrapped once around each reinforcing rod and attached to, or as close as possible to, the star-picket at the end of the transect.

5. The benthic observer then follows behind the tape layer to photograph the five 50 m transects. The recording of the transect data is outlined in the next section.

6. The SCUBA searcher swims with the benthic observer, recording the genus and number of juvenile corals with a diameter less than 5cm occurring within a 34 cm belt on the left side of the transect tape for a distance of 5 m. A visual estimate of percentage cover of hard coral, soft coral, macroalgae and sand is also recorded for the 34 cm by 5 m belt, along with an estimate of the reef slope, the slope for the 5m juvenile transect and the complexity of the substrate. The SCUBA searcher then records the presence of COTS, *Drupella* and coral diseases as outlined in Standard Operational Procedure Number 8 (Miller, 2003) for the transect.

7. Each pair of divers operate as a buddy pair, therefore buddy pairs may become separated, but divers of a buddy pair remain within constant visual contact. This distance will depend on water clarity and may have to be adjusted throughout a dive depending on diving conditions.

8. Upon completion of the five, 50 m by 5 m transects by the fish observer and the tape layer this buddy pair ascend together, surface together and signal the divers' attendant.

9. The divers' attendant then collects the fish observer and the tape layer. The third buddy pair consisting of the second fish observer and the tape collector then enters the water.

10. Upon completion of the 5th transect by the SCUBA searcher and benthic observer this buddy pair returns to the surface together.

11. The second fish observer and tape collector swim along the same transects (which are now marked with a tape along the centre line) undertaking a census of the Pomacentrid fish. The tape collector follows the fish observer rolling up the tapes. Following completion of the work this buddy pair leaves the beginning of transect

one, ascending and surfacing together. The divers' attendant assists the divers into the boat.

Recording photograph data for each transect

The benthic observer should write the reef name, date, site number, and observer initials on the waterproof photograph data sheet (Appendix I) before entering the water. Before commencing filming or photography of each transect, the benthic observer should circle the transect number on the data sheet and cross off the previous transect number. If transects are not filmed in order, are filmed backwards or there is an interruption to filming, such as switching to another camera the details MUST be recorded on the data sheet, as this will assist others that may need to access these images at a later date. Abnormal conditions such as high current, strong surging waves and low light should also be recorded on the data sheet.

1. **The panoramic video**
   a. A video of the site should be filmed on the first and third transect at each site.
   b. To record the panoramic video, turn the mode control dial to video (a symbol of a video camera). Start the panoramic video by filming the data sheet so the site and transect can be identified. This shot needs to include the star-picket and tape measure, so the person videoing may need to wait for the person laying the tape to move a distance from the star-picket before commencing filming. Video a panoramic shot along the transect (showing the tape and star-picket) and then the reef surrounding the start of the transect, recording the video in a clockwise direction.
   c. The emphasis should be on recording the general structure of the reef, following the reef substrate at all times. This should take approximately 30 seconds. Move slowly, holding the camera as steady as possible for the best result. ***Note**: **Avoid** recording open water or a small area of the reef (<5 m radius) beneath you, as this may not represent the reef area. Also **avoid** sudden changes in the distances from camera to subject that will cause the image to be blurred, due to the time lag for the automatic focus to adjust.*

2. **The transect**

   To photograph a 50 m transect it should take $4^{1/2}$ to 6 minutes. The length of time required will vary depending on the topographic complexity of the reef and the water conditions, such as surge or current. It is important to pause while focusing, before taking each photograph as a sudden movement may cause the captured image to be blurred. When taking photographs ensure that you half depress the shutter to focus on the substrate, before you take the photograph by fully depressing the button. Failure to do this will result in blurred or unfocused images.

a. Turn the mode control dial to C or P and ensure the underwater scene selection is selected. Take a photograph of the data sheet on the macro setting. On the second, fourth and fifth transects, take a photograph of the reef slope in the direction of the transect. It is best to take this photograph with the ISO set on "Auto". This image of the reef slope should be taken before any photographs are taken along the transect.
b. Ensure the mode control dial is set to "P". Check that the white balance is on the underwater setting and the ISO is set to 400 or 200 for high light conditions.
c. Ensure that the camera is held approximately 50 cm to the right of the star-picket and continue along the transect staying 50 cm to the right of the measuring tape. Make certain not to photograph the tape measure, as the reflective nature of the tape can adversely affect the exposure of the digital still camera. The camera lens should be kept parallel to the reef substrate at the same distance for each photograph. The most accurate way to gauge the correct distance is by placing the slate on the benthos and moving away from the benthos, so the slate fills the entire LCD screen before capturing this image. By noting the distance, from this initial picture, the subsequent images should be captured at the correct distance. Try to check your distance from the substrate at the beginning of several transects.
d. Follow the tape along the transect, taking photos at 1m intervals, using the tape as a guide, but also count the number of photographs as you move along the transect.
e. If any extra photographs are taken between transects or at the end of a site, this should also be recorded on the data sheet. Any mistakes made during the transect should also be noted on the photograph data sheet.

3. Timing

On the Great Barrier Reef it is recommended that photography takes place between the hours of 08:00 and 15:30 for best lighting conditions. These times can be extended during summer months.

4. **Problems**
   The measuring tape that marks the centre of the transect does not always follow the contours of the reef, especially when there is a crevice or gap in the structure of the reef. If the tape does not follow the substrate, a decision must be made which determines the path to take with the camera. The path chosen should be the one that requires least deviation from the tape path (not more than 3 m below) while maintaining a constant distance m from the substrate. With broad or deep crevices it is not always possible to stay within 3 m of the tape and still have the camera at the standard distance from the substrate. In this situation remain at the same depth contour and cross the crevice at the narrowest point within 3 m of the tape. *(Do not photograph substrates that are more than 1m from the lens)*.To maintain data accuracy and confidence in both image interpretation and observer precision it is necessary to undertake quality control practices within the AIMS LTMP. Quality control is undertaken by a new observer before analysis of video transects and by all benthic observers on an annual basis.

Initial training

To ensure data integrity is maintained when a new observer begins analysis, a new observer is required to complete three observer comparison transects and obtain 90% agreement at family level with existing observers before they begin analysing transects (Ninio et al, 2003). Fifteen transects are haphazardly selected from the photographs recorded during one year of the monitoring program to be used in an observer comparison study. From these transects, three transects representing reefs within each cross shelf position are chosen. Transects are chosen from the three shelf positions to ensure an observer is competent at identifying the benthos present on reefs at each shelf position.

The images analysed by the original observer, are retrieved from the Microsoft Access© database. These transects are then analysed as described above. Observers are able to analyse the same points on photographs as identified by previous observers.

Once the new observer has completed the three chosen transects, the Reefmon system is used to calculate the number and the percentage of points wrongly analysed at each classification level, i.e. benthic group, benthic life form, family, genus and species. At the level of family, if 90% or greater agreement between the original and new observer is obtained (excluding point errors where the discrepancy is due to the point falling on the border of two organisms) then analysis by the new observer may begin. If less than 90% agreement is achieved at this level then the new and an experienced observer examine each point and the discrepancies discussed. An assessment is then made as to whether the new observer is required to undertake more training before analysis of photograph transects may begin.

Annual training

To ensure data integrity each observer completes three observer comparison transects annually. This is conducted in the same manner as the initial observer comparison for a new observer. In addition, observers complete identifications of various still images of reef benthos. The images are a selection of common and unique benthos regularly encountered during the AIMS LTMP surveys within the Great Barrier Reef.

DATA MANAGEMENT

Before going on a field trip check that the most recent version of the Reefmon data entry program has been loaded onto the field computer and it is functional. This program is available on AIMSCAPE-> Systems-> Reef Monitoring.

Input of data from photograph data sheet

Before images from surveys are downloaded from the camera to the computer, the Reefmon program should be populated with information from the photograph data sheet (Appendix I). Data should be entered by the recorder of the data to ensure the information is not entered incorrectly due to difficulties in reading unfamiliar handwriting.

Ensure that the database location is set to “LOCAL” and the appropriate Oracle Lite username has been entered (if unsure ask the database manager). Enter the two letter cruise code and check that the fields: p_code (RM or RAP), year code and visit numbers and photo transect defaults are correct.

In the “form” view enter the data from the photograph transect datasheet.

1. Firstly enter the reef, site, project and year. The sample ID is automatically assigned to the reef and site. The date doesn’t need to be entered as the program default is for the date the information is entered. The date can be changed in the “Form” view. In situations where non-standard filming occurred (e.g. repeated or incomplete transects, transects filmed backwards, transects out of order or transects with false starts) record these events in the *COMMENTS* field. As sites are assigned a unique sample identification, sites should be entered in order, even if non-standard filming occurs.

2. To enter information for each site click on “data for one sample” and then click on “photo transects”.

3. Enter your initials in the “observer” column and any comments for each transect, and then hit the “ENTER” key.

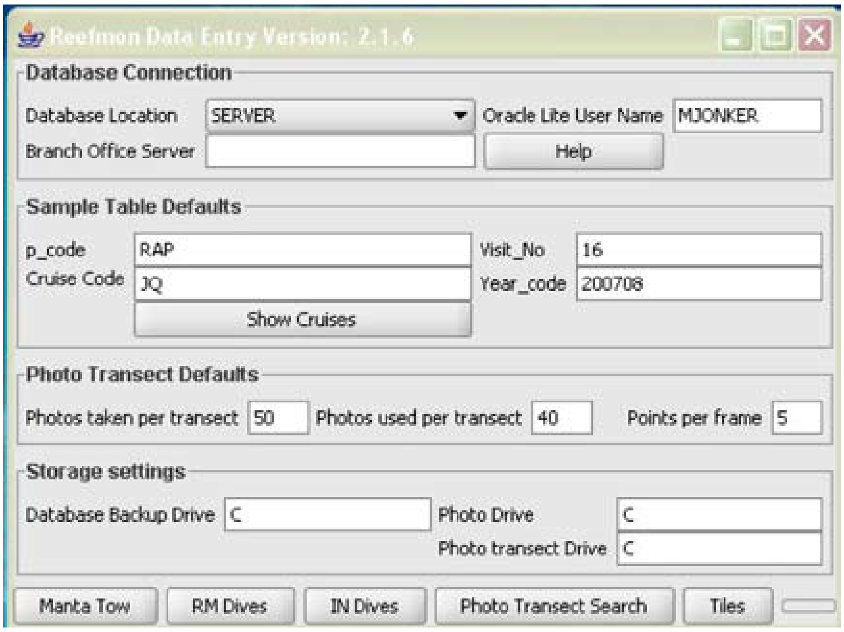

Figure 2. First screen of ReefMon data entry interface.

4. On the lower left of the screen click on "Make Directories". Check that the directory structure follows the standard format; ***project code (RM or RAP)/year code/cruise code/reef name***, as in this example: RM/200607/JO/CHICKEN REEF

Downloading photographs and video pans from the camera to field computer

Once all the information from the data sheet is entered into Reefmon, images can be downloaded from the camera and placed in the appropriate directories made by Reefmon on the field computer.

1. Attach the USB cable to the computer and the camera. Use the Microsoft Scanner and Image Wizard to download the photos.

2. Using the download wizard name the files according to reef name and site eg. GannetCays1s2. Ensure there are no spaces in between the reef name and site numbers. Download the photos to a temporary directory eg. JRTEMP

3. Once all images and videos are downloaded, safely remove the camera from the cable.

4. Once the data for the sites have been entered in Reefmon, a number of folders will appear, named by both site and transect. An example of a folder within the reef is Site1Tran1. Sort the photos for each transect into the appropriate folder. The video pans should be renamed to incorporate the site and transect and placed in the route directory for that reef.

5. Erase the images from the camera by pressing the playback button (rectangle with triangle in the middle). Then scroll down to "erase all" using the multi control dial and press "FUNC.SET". ***(Do not erase images until the photos have been sorted into folders labelled by site and transect).***

Writing images and video pans to a DVD disc using a personal computer

After each reef has been surveyed the images and videos should be backed up on DVD to ensure data is not lost or deleted from the computer. All the images from one reef will fit onto a single DVD disc. The DVD discs containing the still images are stored in a safe within an air-conditioned room at AIMS.

1. Click on the "Start" menu located on the bottom left hand corner of screen). On the drop down menu select "All Programs". In this menu choose "Roxio".

2. In the Roxio program window click on the "New Data DVD" button. Then type in a name using the reef name and visit number and DVD number (e.g.GannetCayV15_P0045).

3. Click on the "Add" button. Then browse to the appropriate cruise code directory and reef name directory (eg. "C:/JKphotos"). Choose the appropriate reef from the sub-directories within this tree (eg. "C:/JKphotos/GannetCay").
   Note*: To select multiple files use the shift button.*

4. Having chosen files to add to the DVD disc, the program takes you back to main screen.

5. Select the "Record" button. The DVD drive will then open. Insert a blank DVD disc and close the DVD drive. Wait to respond to prompt to continue, and then choose the "OK" button.

6. Label the DVD with the DVD number, reef name (eg. YONGE), cruise code (eg. JK) and visit number (eg. V15 for 2006/2007 sampling period) using a permanent marker. If any additional data is recorded ensure this is included on the label.

LABORATORY SAMPLING

Transferring photographs and data on Reefmon to server

After the field trip, transfer the transect photos stored on the field computer to the network drive “pearl/phototran/PhotoTransects”. The directory structure should be identical to that on the field computer; i.e. pearl/phototran/PhotoTransects/RM/200607/JK/. Use “*msync*” to transfer data that was entered into Reefmon on the field computer to the server.

Set-up of computer equipment

Analysis is performed using a desktop computer (PC). The computer should have the Reefmon software installed, access to the network (to allow uploading and downloading to the database) and a large sharp screen.

Analysis of the photograph transect

The photograph transects are systematically sampled by identifying the benthos occurring at fixed points along the transect to the highest taxonomic level possible. Five fixed points are sampled from 40 images randomly selected by Reefmon from the 50 captured per transect, so that along each transect the benthos lying under 200 data points are identified. The Reefmon software is used to analyse the photograph transects. Reefmon retrieves images from each transect and enables a video code to be entered/assigned to each of the five points per image in a data table. During analysis the data are saved automatically into a Microsoft Access© database. In order to eliminate confounding in data analyses due to observer biases, transects from each reef are analysed by four observers. Each observer analyses the same numbered transects at each reef.

To analyse a photograph transect

1. **The sample table**
    a. Enter the Reefmon program. Check the database location reads “SERVER” and enter the cruise code, p-code, year, visit number to be analysed. Click “RM Dives” (Figure 2).
    b. To select a transect to analyse, click on the “Table View” tab in the Reefmon Sample Table window. Scroll through the list, selecting the desired transect,

then click on "data for one sample" and click on "photo transects" (Figure 3). Then enter your initials in the "Analysed By" field and tab across to automatically fill in the date in the "Analysis Date" field and click "Enter Data"

c. Select the directory containing the photos to be analysed and press "select photos". ***Note****: It is* ***important*** *to check that you have the correct directory selected in order to analyse the chosen transect. A warning message will appear if the folder name and the transect number do not match.*

2. The data entry window

a. For each photograph the benthos occurring under each point needs to be identified in the same order each time, starting at the top left hand point. The next point identified is the top right, then the centre, the bottom left and finally the bottom right point (So if the points were joined together, the letter "Z" would be formed). The function keys F1 to F5 are assigned to points 1 to 5 respectively and can be used to zoom in and out of each point.

b. For each point on the screen, identify the benthos occurring underneath it on

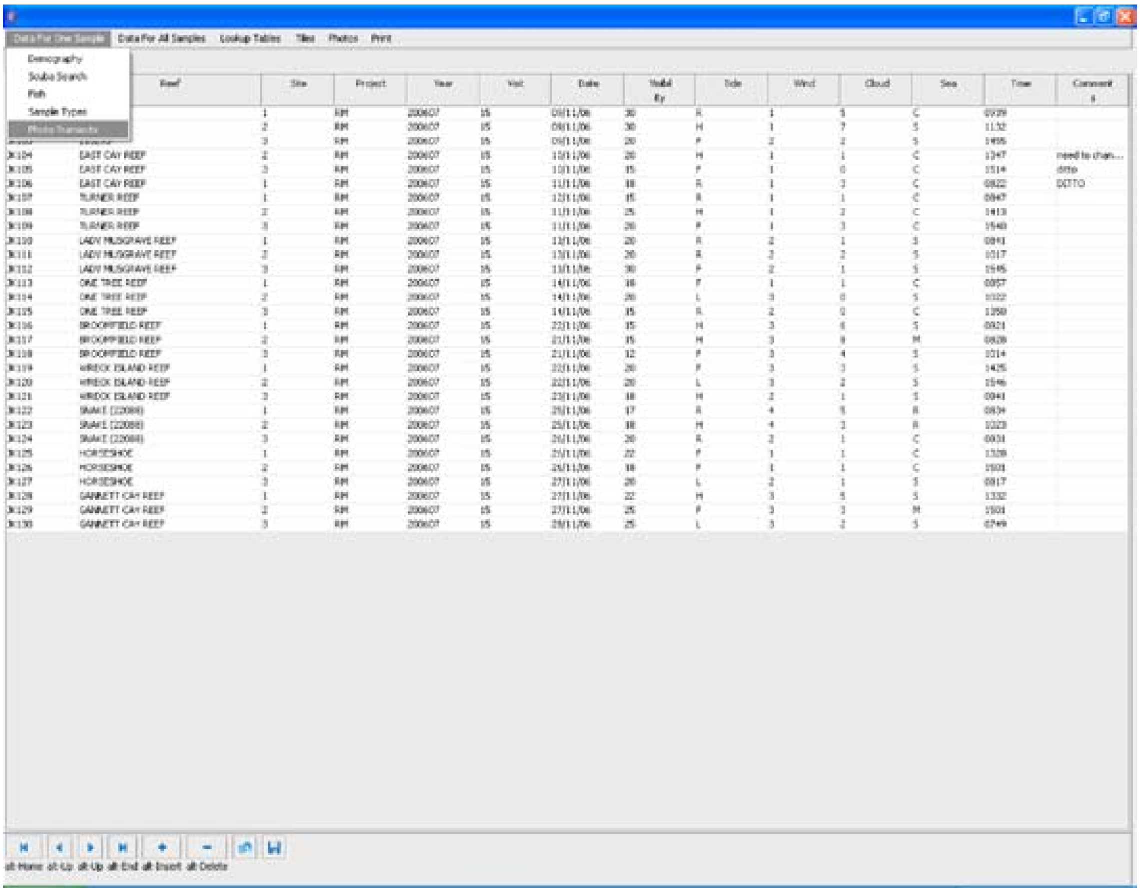

Figure 3. Sample table screen of ReefMon.

the monitor and enter the numeric video code directly into the "Video Code" column or use the drop down list on the right hand side of the data entry window (Figure 4). A single point on the image can be tagged by pressing F7, which may assist observers to find these images easily later on.

c. If there is more than one type of benthos underneath the point choose the benthos that covers most of the point. If two benthos types occupy an equal amount then choose the benthos under the top-left part of the point.
d. If the image is blurred and it is not possible to identify the benthos under the points, then click on the "Bad Photo" image. A new image to analyse will appear underneath the photograph of the slate at the top.
e. A description of the benthos that each video code represents is in the reference table (Appendix III).
f. Continue this procedure until the final frame is reached and the photograph transect analysis is complete, and then close the data entry window.

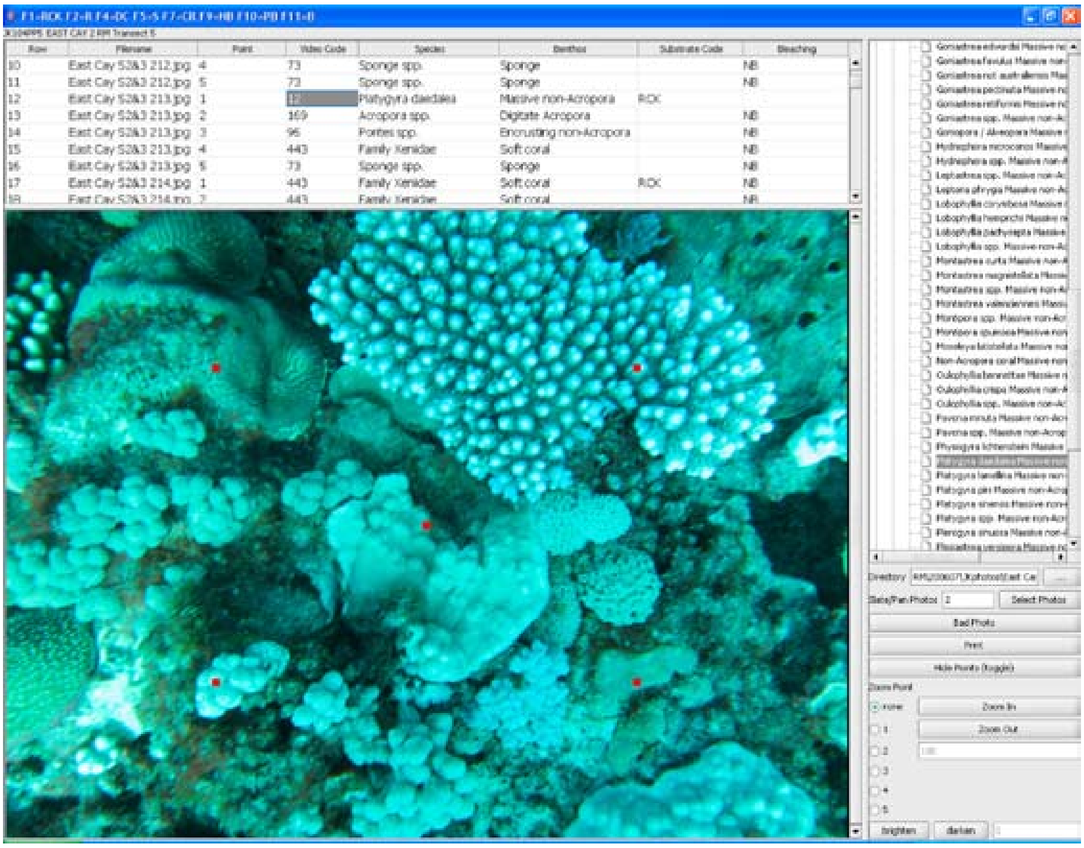

Figure 4. Data entry window in ReefMon.

3. **The species/benthos code reference table**
   There are several thousand species of hard corals, soft corals, sponges and algae on reefs of the Great Barrier Reef. However, many cannot be identified accurately to species using only a photograph.
   Benthic organisms are identified to the highest taxonomic level possible and are assigned a unique code describing both its life form and family, genera or species combination. To simplify data entry each family, genera or species code and life form combination are assigned a numeric video code. The codes used in Reefmon are listed in the reference table (Appendix III). The reference table is structured in a hierarchy so that once the data are entered they can be retrieved from the database at six classification levels; benthic group, benthic life form, family, genus and species.

Codes used in photograph analysis

The benthic group is the most often level used in monitoring reporting. It is divided into a further nine groups, which can be subdivided into benthic life forms. The benthic group and life forms are based on the ASEAN codes for the Line Intercept Transect technique (English et al. 1994) with a few changes. The nine benthic groups and life forms within these groups are shown (Table 1) and described below. The identification of benthos is facilitated by the use of a dichotomous key of life forms found below as well as A Coral Reef Handbook (Mather and Bennett 1993) and Corals of Australia and the Indo-Pacific (Veron 1993).

Table 1. Structure of benthic group codes and their component benthic life forms.

BENTHIC GROUP								
Abiotic (AB)	Hard coral (HC)	Soft coral (SC)	Coralline algae (CA)	Macro algae (MA)	Turf algae (TA)	Sponge (SP)	Other (OT)	Indeterminate (IN)
DC	ACX	SC	CA	HA	TA	SP	OT	IN
RCK	ACB			MA			UNID	W
R	ACD			AO				
S	ACE							
	ACS							
	ACT							
	CB							
	CE							
	CF							
	CM							
	CS							
	CMR							
	CL							

1. **Abiotic (AB)**

This benthos group is used when there is no biotic life form present on the substratum. These benthic codes are not generally used very often as most reef surfaces are covered in a benthic form of some sort. The substrate that the benthos is on or attached to is recorded in the database in a separate substrate category. This category provides a more detailed morphological picture of each transect.

Dead coral (DC) Recently dead coral that has a white or off-white colour and not yet colonised by turfing algae.

Reefal substrate (RCK) Substrate not colonised by visible benthic organisms. Rarely seen except where the reef has recently undergone exfoliation e.g. due to a cyclone, or where terrestrial rocks have not been colonised.

Rubble (R) Fragments of dead hard coral >0.5 cm but <15 cm in diameter which are not consolidated into a hard or stable substrate and are not colonised by turf algae.

Sand (S) Ranging from fine silt to calcareous sediment to *Halimeda* spp. fragments, <0.5 cm in diameter.

2. **Scleractinian Coral (Hard Coral, HC)**

Benthic codes

All hard corals are assigned a benthic life form category. These are defined below (adapted from (Wallace 1999;Veron 1993)).

***Acropora* corals** Growing parts of the colony characterised by an obvious axial apical corallite surrounded by radial corallites

Bottlebrush (ACX) Colonies have small branchlets with both primary and secondary branching arising from main arborescent branches e.g. *A. echinata*.

Branching (ACB) Colonies have both primary and secondary open branching, where branches are generally narrower than they are long e.g. *A. grandis*.

Digitate (ACD) Short, protruding, vertically orientated digit like branches arising from an encrusting base e.g. *A. humilis*, or a coral recruit of this genus.

Tabulate (ACT) Horizontal plates with a small area of basal attachment, where the colony is at least twice as wide as they are high e.g. *A. hyacinthus*.

Encrusting (ACE) Colonies adhere and encrust the substrate and have very little vertical growth e.g. *Isopora palifera*. * Note that the subgenus *Acropora* (*Isopora)* was elevated to genus *Isopora* (Wallace et al 2007). The benthic code remains as ACE as there is also a species code, for encrusting *Acropora* spp. which is used when an *Acropora* spp. coral does not have a distinct life form or only part of the colony can be seen on the image and it is encrusting the substrate.

Submassive (ACS) Colony surface forms columns and/or ridges and may have encrusting edges e.g. *Isopora cuneata* (This category is being kept for historical reasons).

Non-*Acropora* corals Growing parts of the colony not characterised by an obvious axial apical corallite surrounded by radial corallites

Branching (CB) Arborescent corals with open primary and secondary branching where branches are generally narrower than they are wide e.g. *Seriatopora hystrix*.

Encrusting (CE) Colonies that adhere and encrust the substrate e.g. *Pavona varians*, *Porites* spp.

Foliaceous (CF) Colony leaf-like in appearance or composed of flattened sheets which may be fused or convoluted to form whorls e.g. *Echinopora lamellosa*.

Massive (CM) Colony is of generally solid construction and the same shape in all directions (hemispherical in shape) e.g. *Platygyra daedalea*, *Porites* spp.

Submassive (CS) Colony has knobs, protrusions or columnar structures or rounded and more than 50% of the colony is raised indiscreetly from the underlying substratum e.g. *Scapophyllia cylindrica*, *Stylophora pistillata*, *Pocillopora damicornis*.

Mushroom (CMR) Unattached easily moved solitary Fungiid coral.

Solitary (CL) Attached or unattached solitary non-Fungiid coral e.g. *Cynarina lacrymalis or Scolymia vitiensis or Scolymia australis*.

Species codes

Hard corals should be identified to genus level where possible. Some species are readily identified in the photograph, such as *Diploastrea heliopora* and *Coeloseris mayeri*, and are therefore assigned a seven letter species codes, e.g. DIPHELI and COEMAYE respectively. The first three letters in the species code are derived from the genera and the last four letters from the species name, a system developed for the ASEAN-Australia Living Coastal Resources project (English et al. 1994). Other corals may only be identifiable to genera and are therefore assigned a generic species code, eg. ACRSPP (*Acropora* species). Other corals may only be identifiable to family level and a code describing this family is therefore used e.g. Faviids (FVDSPP). It is often difficult to differentiate these families into genera from the photograph. If a hard coral cannot be identified to family level it is assigned the species code CORSPP (coral species) and consequently this is not included when retrieving data at the family, genera or species level.

3. **Soft Coral (SC)**

Benthic codes

All soft corals are assigned the soft coral (SC) benthic code, this group includes gorgonians unlike the ASEAN life forms (English et al. 1994).

Species codes

The soft corals (SC) are identified to family where possible. Some soft corals can be identified to genus level consistently. Each family, genera and species group have a unique code. Where a soft coral cannot be identified to family or genus level it is assigned the generic soft coral species code (SOFSPP) species code.

4. **Algae**

Algae are divided into three benthic groups, coralline algae, macroalgae and turf algae. Both the coralline algae and turf algae groups contain only one code each (CA and TA respectively), while the macroalgae group contains three codes (see below). Algae are not identified to genera or species level, but are place in the above benthic groups, which correspond to functional groups.

Coralline Algae (CA)
This category includes all substrate and rubble covered with coralline algae (CA).

Macroalgae (MA)
Macroalgae are identified as having distinguishable structures such as fronds, stalks and holdfasts. The macroalgae are identified to genera if possible. At the benthic life form level there are three categories:

Halimeda spp. (HA) Macroalgae of the genus *Halimeda*.

Macroalgae (MA) Includes all macroalgae (brown, green and red macroalgae) with structural features >5 cm in size, e.g. *Sargassum*, *Caulerpa* and *Chlorodesmis*.

Algal Other (AO) Algae with some structural features which are <5 cm in size. This group also includes cyanobacteria and golden noodle algae that are often used as indicators of water quality, red encrusting algae and algae that cannot be identified in more detail as well as assemblages of a couple to several types of algae, but are not turfing algae.

Turf Algae (TA)
Turf algae encrust the substrate and have no distinguishable structural features (TA).

5. **Sponge (SP)**
Includes all sponges (SP). They are not identified to a higher taxonomic level.

6. **Other (OT)**
Benthic codes
All identifiable organisms not placed in any of the above categories are given the benthic code Other (OT). Any unknown benthic organisms are given the unidentified benthic code (UNID).

Species codes
All organisms given the other benthic code are either given a more detailed species code, e.g. anemones are given the species code OTHANEM and

zoanthids, OTHZOA. If the organism identified does not have its own species code it is given the generic species code (OTH).

7. **Indeterminate (IN)**
   This benthic group is divided into two codes that are used when nothing can be confidently identified under a point.

   Water (W) Where the substrate is more than 1m from the camera and therefore the benthos cannot be identified.

   Indeterminate (IN) This code is used in a number of circumstances.
   a. Basal substrate is undefined (indeterminate)
   b. Poor image quality - data point obscure.
   c. If the benthos is obscured by a diver's hand or measuring tape

8. **Bleaching**
   This category is divided into three codes and is used to record the bleaching status of the benthos identified under a point.

   No Bleaching (NB) This is the default code for this category, and indicates the colony identified has no signs of bleaching.

   Partial Bleaching (PB) Organisms are fluorescent in colour or not completely white. Soft tissue is still present in bleached colonies but may not be obvious on the image.

   Bleaching (B) Organisms are completely white or almost completely white, as pigments produced by the coral may be present. Soft tissue is still present in bleached colonies but may not be obvious on the images.

Dichotomous key for the identification of benthic life forms used in the photograph transect method

1. a. There is no object directly below and within 1m of a point ... W
   b. There is an object directly below and within 1m of a point ... go to 2

2. a. The image is clear and the benthos can be identified ... go to 3
   b. The image is not clear and can therefore not be identified ...
   Click on the “Bad Photo” button or choose “IN”, if it is not more than one point.

3. a. It is not known what the benthos is laying under a point ... UNID
   b. The benthos lying under a point can be identified ... go to 4

4. a. The life form under the point is alive or is a living organism ... go to 5
   b. The life form under the point is not alive or a living organism ... go to 28

5. a. The life form is a coral (includes both soft and hard colonial and non-colonial life forms, consisting of polyps each with radial symmetry and a mouth surrounded by tentacles) ... go to 6
   b. The life form is not a coral ... go to 21

6. a. The coral has a calcium carbonate (limestone) skeleton (i.e. is it a hard coral) ... go to 7
   b. The coral has a soft body or an architecture not of calcium carbonate ... SC

7. a. Growing parts of the coral colony are characterised by obvious axial apical polyps ... go to 8
   b. There is no obvious axial polyp on the growing edge of the coral colony ... go to 15

8. a. The point of colony attachment is visible ... go to 9
   b. The point of colony attachment is not visible ... go to 13

9. a. The point of attachment is narrower than the main body of the colony ... go to 13
   b. The colony has an encrusting base ... go to 10

10. a. The colony is an Isoporid with one or multiple axial polyps per branch ... go to 11
    b. The colony is not an Isoporid and always has one axial polyp per branch ... go to 12

11. a. The colony encrusts the substrate and < 50% of the colony is raised above the general profile of the substratum ... ACE
    b. The colony encrusts the substrate but > 50% of the colony consists of mounds, ridges or columns or the colony consists of robust rudimentary branches with short branchlets growing off the main branch... ACS

12. a. The colony has short digit like vertically oriented branches growing from an encrusting base ... ACD
    b. The colony does not consist of digit like vertically oriented branches growing from an encrusting base ... go to 13

13. a. The colony is plate like and at least twice as wide as it is high. Branches are densely packed or anatomised ... ACT
    b. The colony is not plate like and twice as wide as it is high with densely packed or anastomosed branches ... go to 14

14. a. The colony is characterised by open secondary branching, where branches are generally narrower than they are long ... ACB
    b. The colony consist of main branches from which small branchlets are given off and is "bushy" or "bottlebrush" in appearance ... ACX

15. a. The colony consists of one polyp attached to the substratum or an unattached polyp with a pointed base ... CL
    b. The colony does not consist of a single polyp attached to the substratum or an unattached polyp with a pointed base ... go to 16

16. a. The colony is discretely raised from the substratum with the point of attachment narrower than the main body of the colony ... go to 17
    b. The colony is not discretely raised from the substratum with the point of attachment generally as wide or wider than the bulk of the colony ... go to 19

17. a. The colony is characterised by open secondary branching with branches generally being narrower than they are long ... CB
    b. The colony is characterised by either ill defined or no secondary branching or the colony consists of leaf like or flattened sheets ... go to 18

18. a. The colony is leaf-like in appearance or composed of flattened sheets that may be fused or convoluted to form whorls ... CF
    b. The colony consists of robust rudimentary branches with short branchlets growing off the main branch ... CS

19. a. The coral is not attached to the substratum and is easily moved ... CMR
    b. The coral is attached to the substratum ... go to 20

20. a. The colony is generally prostrate, in intimate contact with the substrate and less than 50% of the colony raised above the general profile of the substratum ... CE
    b. The colony has more than 50% of its structure raised above the substratum ... go to 21

21. a. Colony is of generally solid construction and the same shape in all directions (hemispherical in shape) ... CM
    b. Colony has knobs, protrusions or columnar structures or rounded and more than 50% of the colony is raised above the general profile of the underlying substratum ... CS

22. a. The life form an algae ... go to 24
    b. The life form is not an algae ... go to 23

23. a. The life form is a simple attached organism with no polyps and a soft flexible or sponge like skeleton consisting of small spicules with small openings (ostia) ... SP
    b. The life form is not the above ... OT

24. a. The algae consist of fine hair like filaments with no defined structure encrusting the substratum ... TA
    b. Algae does not consist of fine hair like filaments but is either encrusting or has some defined structure ... go to 25

25. a. The algae is green in colour calcified with the thallus being composed of disclike segments ... HA
    b. The algae may or may not be calcified but is not composed of disclike segments ... go to 26

26. a. The algae is strongly calcified with no clear structure to the thallus, usually pink to grey in colour, typically encrusting, sometimes forming small ridges and small branching structures ... CA.
    b. The algae are not strongly calcified, pink or grey in colour and typically forming small ridges and small branching structures ... go to 27

27. a. The algae is erect, has clearly defined macroscopic structures > 5m in size (eg. frond, stalk and holdfast) ... MA
    b. The algae has no clearly defined macroscopic structures or has defined macroscopic structures < 5m in size ... AO

28. a. The substratum is unconsolidated or consisting of fragments < 15cm in diameter ... go to 29
    b. The substratum is consolidated or consisting of fragments >15cm in diameter ... go to 30

29. a. The substratum consists of coral or rock fragments <15cm in size ... R
    b. The substratum consists of coral or rock fragments < 0.5cm ... S

30. a. The substratum consists of bare rock, with no cover of turf algae, coralline algae, or other macroscopic fouling organisms ... RCK
    b. The substratum is composed of white coral skeleton with little visible algal growth ... go to 31

31. a. The substratum is composed of a white coral skeleton or is part of a colony with a sharp edge or boundary between the white area and the surrounding living area of the colony ... DC
    b. The substratum is composed of a white coral skeleton. The colony is bleached but still alive as evidenced by a graduation of colour or pigmentation around the border of the white area ... B and goes to 6

TRAINING OTHERS IN THE USE OF UNDERWATER PHOTOGRAPHY

Training personnel in the use of underwater photography to survey reef benthos can be achieved by supervising trainees as they follow the instructions in this manual. Competency with underwater photography techniques requires familiarity with the still camera and housing, and proficiency in SCUBA diving (especially buoyancy control). Skill and consistency in taking photographs at a constant height and speed along the transect line is achieved through familiarity with using the equipment underwater, confidence and experience.

Extensive training is required for consistent analysis of still images. Analysis requires an understanding of Reefmon software and proficiency in the identification of sessile reef benthos. Discussing and scrutinising video images of benthic organisms in the laboratory with the trainee will facilitate accuracy.

Training should cover the following components:

1. **Preparation of the camera equipment**
    a. Care and maintenance of camera equipment before, during and after field work.
    b. Operation of digital still camera and housing.

2. **Sampling reef benthos using underwater photography technique**
    a. Learning the correct sampling protocol.
    b. Practice to attain constant swim speed and camera position.
    c. Practice to choose best filming path along the transect line.

3. **Data entry**
    a. Use of the Reefmon database.
    b. Use of training software to standardise identification of benthos.
    c. Practice in the identification of common benthic organisms of particular habitats before transect analysis.

Most of these objectives can be met by supervision of trainees in the field and the laboratory.

QUALITY CONTROL

To maintain data accuracy and confidence in both image interpretation and observer precision it is necessary to undertake quality control practices within the AIMS LTMP. Quality control is undertaken by a new observer before analysis of video transects and by all benthic observers on an annual basis.

Initial training

To ensure data integrity is maintained when a new observer begins analysis, a new observer is required to complete three observer comparison transects and obtain 90% agreement at family level with existing observers before they begin analysing transects (Ninio et al, 2003). Fifteen transects are haphazardly selected from the photographs recorded during one year of the monitoring program to be used in an observer comparison study. From these transects, three transects representing reefs within each cross shelf position are chosen. Transects are chosen from the three shelf positions to ensure an observer is competent at identifying the benthos present on reefs at each shelf position.

The images analysed by the original observer, are retrieved from the Microsoft Access© database. These transects are then analysed as described above. Observers are able to analyse the same points on photographs as identified by previous observers.

Once the new observer has completed the three chosen transects, the Reefmon system is used to calculate the number and the percentage of points wrongly analysed at each classification level, i.e. benthic group, benthic life form, family, genus and species. At the level of family, if 90% or greater agreement between the original and new observer is obtained (excluding point errors where the discrepancy is due to the point falling on the border of two organisms) then analysis by the new observer may begin. If less than 90% agreement is achieved at this level then the new and an experienced observer examine each point and the discrepancies discussed. An assessment is then made as to whether the new observer is required to undertake more training before analysis of photograph transects may begin.

Annual training

To ensure data integrity each observer completes three observer comparison transects annually. This is conducted in the same manner as the initial observer comparison for a new observer. In addition, observers complete identifications of various still images of reef benthos. The images are a selection of common and unique benthos regularly encountered during the AIMS LTMP surveys within the Great Barrier Reef.

PART 2: JUVENILE CORAL SURVEYS

AIMS commenced monitoring juvenile coral densities and distributions on inshore reefs in 2004, as part of the Marine monitoring program under reef plan while the LTMP started juvenile surveys in 2007 and most recently AIMS WA commenced juvenile surveys in 2008.

The following survey method is used by the AIMS LTMP, inshore monitoring and AIMS WA to collect information on the distribution, density and the composition of genera of juvenile coral assemblages in shallow reef environments. The field procedure for the LTMP and AIMS WA was modified from the inshore monitoring procedure. The juvenile coral surveys have several components, although some such as camera equipment and set up are covered in Part 1 of this document. The components covered below are; Personnel, Equipment, Field procedure, Data entry and Training.

Personnel

Juvenile coral surveys are only done when benthic surveys are conducted concurrently with visual fish surveys as outlined in the previous section. Once the tape measure has been laid along the centre line of the transect, juvenile coral surveys are done by the benthic observer or by the SCUBA search observer, provided the observer has experience identifying hard and soft corals in the field.

The procedures for visual fish surveys and SCUBA searches are detailed in the Standard Operational Procedure No. 3 (Halford and Thompson 1994) and the Standard Operational Procedure No. 8 (Miller 2003) found at *http://www.aims.gov.au/docs/research/monitoring/reef/technical-reports.html*

Equipment

Field equipment

- Dive slate with rubber bands and sharp pencil.
  With a piece of fibreglass measuring tape 5cm long attached to the slate by some string.
- Blank waterproof paper, the SCUBA search data sheet, the juvenile datasheet (appendix V) or the inshore teams' juvenile demography sheet

- Juvenile identification aid sheet (appendix IV)
- Camera equipment outlined in Part 1.

Laboratory equipment

- Personal computer with connection to internal network, at least 1.5GB RAM and preferably a large display screen
- Reefmon data entry software system

Field procedure

This section outlines the procedure and alternative procedures for undertaking juvenile coral surveys. Logistical considerations such as the number and experience of the divers and their allotted tasks will often determine details on the most efficient way of carrying out the survey, while ensuring diver safety has been given due consideration.

1. Ensure the reef name, date, site and observer are recorded on the data sheet. The observer should use the juvenile datasheet included at the end of this document (hard corals only) or the demography sheet to record juvenile coral counts on inshore reefs (hard corals, soft corals and several size classes).

2. Once the tape measure has been laid along the centre line of the transect, juvenile coral surveys are done by the SCUBA search observer or by the benthic observer.

3. Estimate the slope of the reef where the 50m transect tape lies. The categories and angles are on the bottom of the juvenile coral datasheet (Appendix V) at the end of this document. The broken category for slope refers to where sand, gullies and bommies occur in the transect. A flat slope (0-14°), moderate (15-74°), steep (75-89°), vertical (90°+) are self explanatory. Record the reef slope on the data sheet. Repeat this for the slope where the 5m juvenile transect occurs.

4. Categorise the complexity of the substrate within the 34cm x 5m juvenile transect into low, medium or high complexity. Low complexity applies to smooth, uniform substrate with a few crevices and raised areas. It also applies to reef structures with extremely high hard coral cover. Medium complexity refers to many small lumps and crevices, so that if the slate was used as a reference the angle of the slate would be changing slightly, but often. High complexity is only used when

the length of the juvenile transect is much more than the 5m, due to the three dimensional matrix of the reef.

5. Searches for juvenile corals only occur within a small belt transect that is 5m (transect tape) by 34cm (length of the dive slate). Surveys are conducted on the left hand side of the transect tape for the first 5 metres of the belt transect, (i.e. not just to the 5m mark, as the tape has been tied around a picket and the tape may also be broken). Even if transects are surveyed in reverse order, from transect 5 to transect 1, the area surveyed is still the same, so in this case it would be on the last 5m of the transect, on the right hand side of the tape.
****The transect length for the inshore program is 20m.****

6. All juvenile corals up to 5cm in diameter are identified within the belt transect.
    a. Use the tape that is attached to the dive slate to ensure corals are less than 5cm diameter.
    b. Use a waterproofed sheet of juvenile coral photo examples to assist with the identification of the coral genera. If the juvenile cannot be identified confidently to genus or family, use the unknown code. A photograph of the juvenile would also be useful to identify the coral later on.
    c. Record the three letter code for the genus (also on the sheet of juvenile coral photos) on the SCUBA search datasheet or waterproof paper and tally the number of each genera found along each transect.
    **** The inshore monitoring team divides the juvenile counts into three categories, less than 2cm diameter and 2-5cm diameter and 5-10cm.****
    **** The inshore team count soft coral recruits, whilst the long-term monitoring team do not.****
    NOTE: It may not be possible to identify juveniles from Family Pectinidae depending on the size of the juvenile coral colony in question and its characteristics. In these cases record the family name on the datasheet instead.
    ***NOT**E: DO NOT include dead juvenile corals (as in Figure 6) in the counts. Exclude remnants of corals from the counts, although If it is unclear whether or not a small coral is a remnant or a juvenile, <u>include it in the count</u>. It can be quite difficult to tell the difference, so use the guidelines and images below.*

7. Estimate the benthic cover (BCOV) of the 5m x 34cm transect belt that coral larvae cannot settle on, i.e. include soft coral, hard coral, macroalgae, loose rubble and sand in the estimate.
    **** The inshore reef monitoring team do not estimate benthic cover as it is the same length as the transect (20m) ****

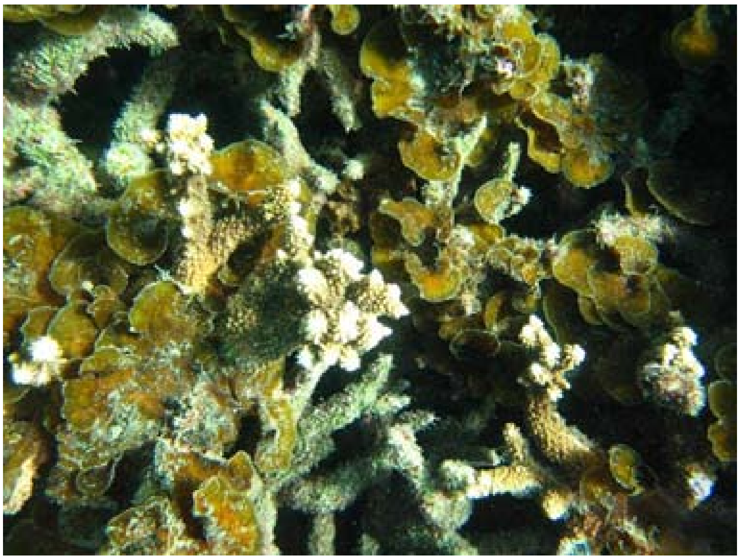

Figure 5. Remnant *Acropora* spp. colony, where partial mortality of the colony has occurred, leaving the framework intact.

Guidelines for discerning juvenile corals from remnant corals

- Partial mortality of the coral can be a sign of a remnant colony growing (particularly damage around the colony periphery) hence injured juvenile coral colonies should be excluded. Fission and partial mortality generate small colonies that are not juveniles, but remnant adult colonies (Hughes 1980).
- Look at the substrate surrounding the juvenile in question. If the small coral has recently died, as in Figure 6 do not include it in the count.
- If the juvenile has similar morphological characteristics to the surrounding substrate as seen in Figure 7, it is quite likely a remnant, so do not count it.
- Search the area surrounding the coral in question, looking for additional remnant colonies.
- Also check the area of attachment. If it has the same or very similar skeletal make up but is covered in algae it is most likely a remnant.
- A similar skeletal structure attached to the coral but covered in turf algae, as in Figure 7, is also indicative of a remnant colony.
- If the surrounding substrate has similar morphological characteristics but shows strong signs of erosion it is more likely to be a juvenile. For example, encrusting juvenile colonies of *Porites* spp., are quite round (with smooth edges) and are often near other adult colonies of *Porites* spp. (Figure 9).

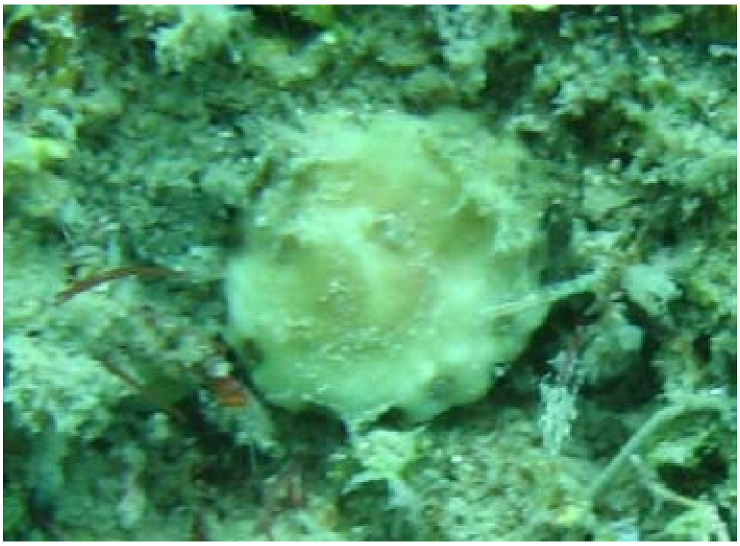

Figure 6. Dead juvenile coral (*Turbinaria* spp.). Note the mucus covering the coral.

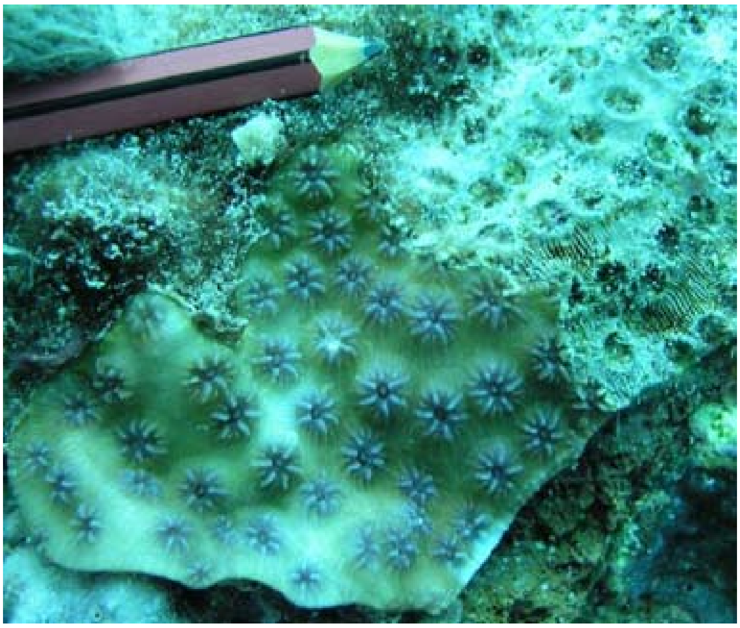

Figure 7. Remnant *Echinopora* spp. colony. On the upper right part of the image shows the detailed coral skeleton from partial mortality of the colony.

Figure 8. Remnant *Porites* spp. colony at the top centre of the image. This is easy to tell as the colony does not show the typical round appearance of an encrusting juvenile coral.

Figure 9. Numerous *Porites* spp. juveniles among larger reproductive *Porites* spp. colonies.

Figure 10. Juvenile coral. The difference between the substrate and the juvenile hard coral is distinct in this image, as the smooth edge of the coral does not blend in with the substrate.

Additional things you can look for to help identify juvenile corals:

- Small corallites on the periphery (eg. Faviids)
- Encrusting forms of colonies or encrusting colony periphery for species that typically do not have encrusting growth forms as adults eg. *Pocillopora damicornis*, *Seriatopora* spp., *Acropora* spp..
- Short branches compared to adult proportions (also useful for fragmenting species like *Acropora nana* and *Acropora latistella*)
- Check if the juvenile is attached to the substrate by gently nudging it.

Reefmon data entry program for juvenile corals

1. Ensure the latest version of Reefmon is on the computer. This can be downloaded from AIMSCAPE-> Systems->Reef Monitoring-> Reef Monitoring Data Entry Program and choose the version that will work within the limits of your computer's RAM.

2. Check the information for the trip is correct on the first page then click on "RM dives".

3. The information for the reef and site number should be entered. Please refer to the Part 1 of this document for more details.

4. Select the sample ID of the relevant reef and site in Reefmon. Click on the menu title "Data for one sample" and select "Juvenile Corals BCover". Enter the observer's initials and the benthic cover estimate that coral cannot settle on for each transect within the site. Also enter the information for slope and complexity. Close the frame.

5. Click on the menu title "Data for one sample" and select "Juvenile Corals". Enter the transect number, coral genera and the number of juveniles for each transect. If no juveniles are recorded on the transect do not include this transect number. Close the frame and repeat step 3 and 4 for each site.

6. Photos of juvenile corals can be added to the database for each site on a reef. Go to the top bar and click on the "Photos" button. Then drag the photograph across to the "Other photos" bar at the bottom of the screen. Enter a caption and Keywords that will help identify the image when searching the database.

Checking data

In the laboratory check the data with two personnel. The first person will read out the genera and tallies from the original data sheet and the second person will check these against a print out of the data from Reefmon. Any errors are recorded on the print out and changes are entered into Reefmon. The original data sheets and printouts are then filed. The same procedure also needs to be completed for the benthic cover estimates.

TRAINING OTHERS IN THE IDENTIFICATION OF JUVENILE CORALS

Before training personnel to identify juvenile corals, it is essential that the trainee can identify all the relevant hard coral genera (and possibly soft coral genera) for the area in which they will do field work, as the distributions of several genera do not occur on both the Great Barrier Reef and reefs in Western Australia.

The trainee should also be competent with underwater photography techniques, particularly with using the macro function, so that juvenile corals that can not be identified in the field can be photographed and further examined in the laboratory.

Training should cover juvenile coral identification the laboratory and in the field. Firstly the trainee should read through and understand the correct sampling protocol outlined in Part 2 of this document. To assist the trainee to recognise and correctly identify juvenile hard or soft corals, use images that have been identified from a photo collection. These images should be scrutinised by the new observer and their identifications should be recorded and then discussed with the trained observer. Once the experienced observer is confident with the trainees' identifications, training in the field can begin.

In the field the new observer should first observe how an experienced observer conducts the searches for juvenile corals. Then the new observer can do the juvenile counts under the guidance and supervision of the experienced observer. The new observer can use the piece of tape attached to the slate to check the size of the juveniles. Initially, the new observer should conduct the juvenile search on one site per reef under the supervision of the experienced observer. Once the experienced observer is confident the new observer has picked up the technique, the new observer can progress to conducting juvenile searches on two sites per reef on alternate reefs. It is strongly advised that the observer carry a camera and photograph any juvenile corals that they have trouble identifying. The unknown code (UNK) should be used in such cases. Observers should take a camera when they are in a complex of reefs new to them (i.e. both sector and shelf position on the Great Barrier Reef). The macro setting on the camera is best for photographing juvenile corals. The new observer can then try to identify the coral from the image later and the experienced observer can validate this identification.

QUALITY CONTROL

To maintain data accuracy and confidence in observer identification and observer precision it is necessary to implement quality control practices within the AIMS LTMP. Quality control is undertaken by a new observer before participating in juvenile coral searches and by all juvenile coral observers on an annual basis.

Initial training

To ensure data integrity is maintained when a new observer begins juvenile coral searches, the new observer will need to complete transects under supervision as outlined in the previous section.

Annual training

To ensure data integrity observer comparisons are conducted in the field on the annual training trip. The juvenile observers conduct a series of transects and quadrats along a 50 m tape. All observers mark the location of juvenile corals within a quadrat (35cm x 35cm) on water proof paper. Observers also complete short transects (34cm x 5m) individually and compare their counts for each transect.

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ACKNOWLEDGEMENTS

The video technique detailed above was initially devised at AIMS by Dr Terry Done. This survey method has been established as a standard monitoring method by the AIMS Long-term Monitoring Program and has been modified using the experience gained from the application of the technique. We would like to thank Scott Burgess, Abbi McDonald, Cathie Page, Rachelle Ninio, Debbie Bass, Caroline Christie, Stephen Neale and Will Oxley for their input into both the development of this technique and the previous versions of this document.

APPENDIX 1

Photo data sheet- one reef per table

AIMS LTMP- Photograph Data Sheet Reef: Date:			
Site	Transect	Observer	Comments:
1	1 2 3 4 5		
2	1 2 3 4 5		
3	1 2 3 4 5		
Check:	✓ ISO 400 ✓ T1 &T3->Panorama video ✓ T2, T4 & T5->Landscape photo		

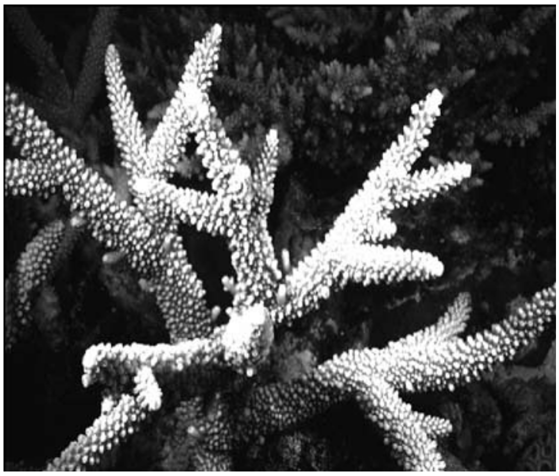
Photo data sheet- one site per table

AIMS Long-term Monitoring Program - Video Data Sheet

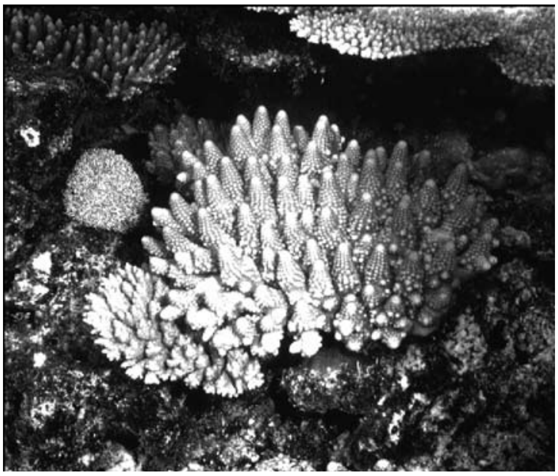
Cruise Code	Transect	Comments
Date:		
Reef:		
Site: 1 2 3		
Transect: 1 2 3 4 5		
Filmed by:		

APPENDIX II

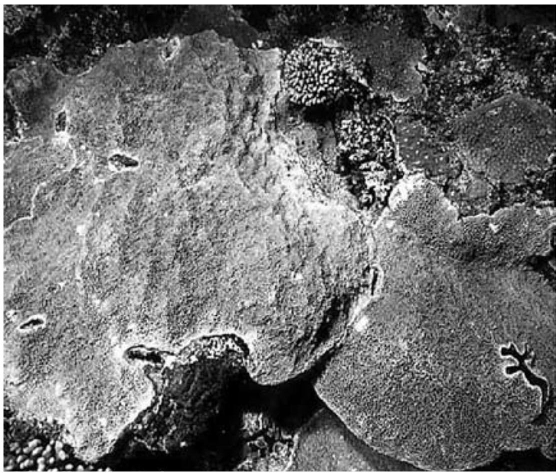
Bottlebrush *Acropora* (ACX)



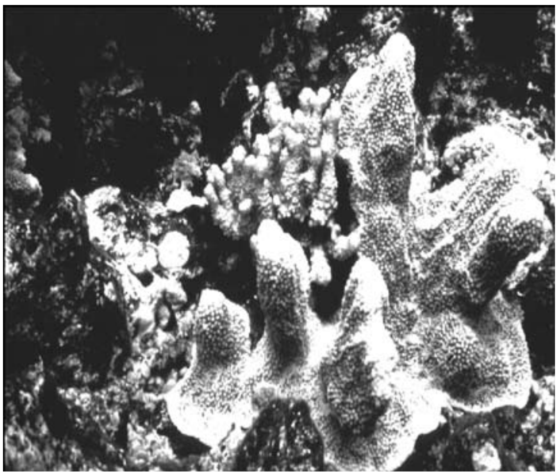
Branching *Acropora* (ACB)



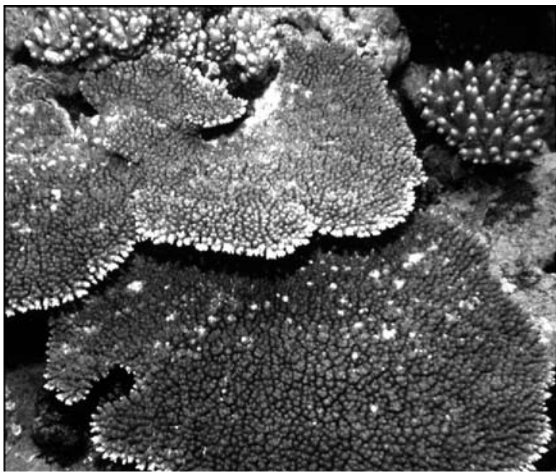
Digitate *Acropora* (ACD)



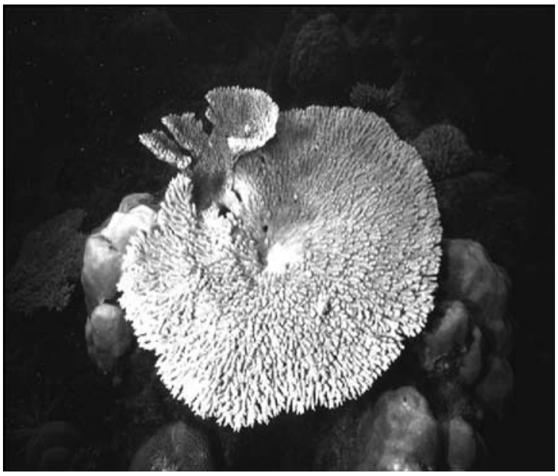
Encrusting *Acropora*/*Isopora* (ACE)



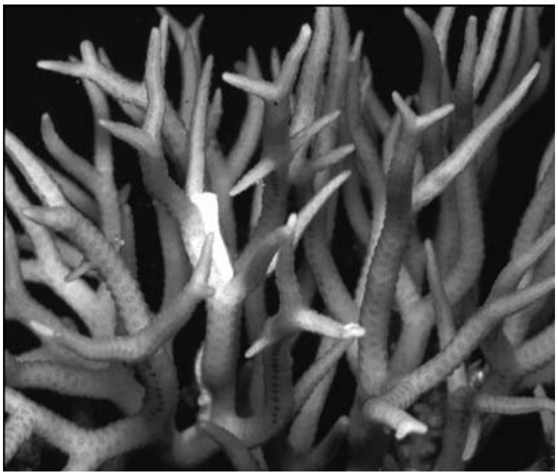
Submassive *Acropora* (ACS)



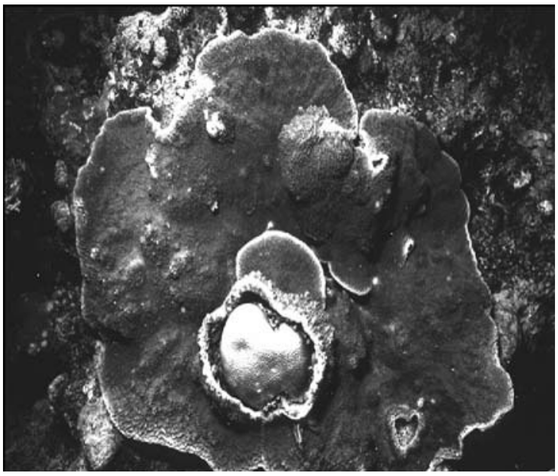
Tabulate *Acropora* (ACT)



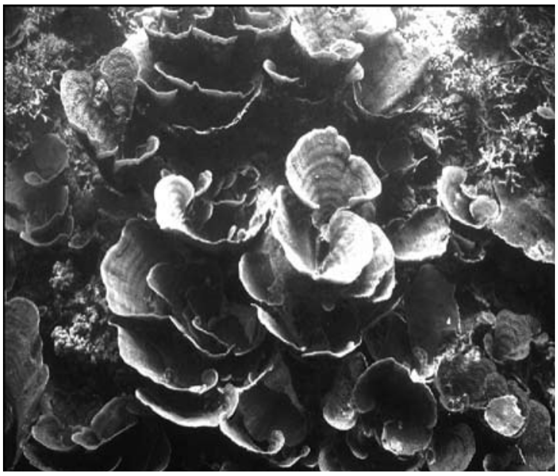
Tabulate *Acropora* (ACT)



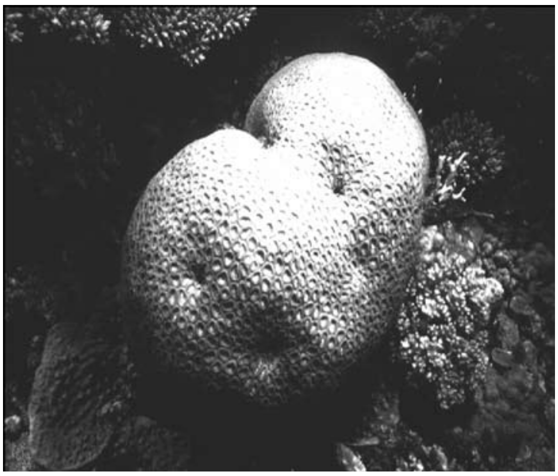
Branching non-Acropora (CB)



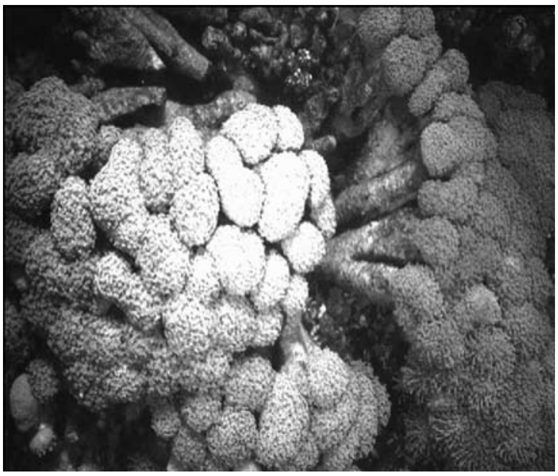
Encrusting non-*Acropora* (CE)



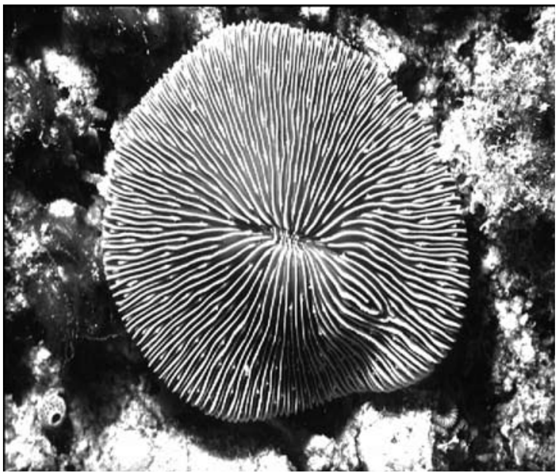
Foliaceous non-*Acropora* (CF)



Massive non-*Acropora* (CM)



Submassive non-*Acropora* (CS)


Mushroom Coral (CMR)


Solitary Coral (CL)

APPENDIX III

Species/benthos codes reference table

Species code	Species description	Video Code	Benthos code	Benthos description	Group code	Group description
AB	Abiotic	445	AB	Abiotic	AB	Abiotic
ABIDC	Dead standing coral (white)	149	DC	Dead coral (recent)	AB	Abiotic
ABIROCK	Reefal substrate	3	RCK	Reefal substrate	AB	Abiotic
ABIRUBB	Rubble	2	R	Rubble	AB	Abiotic
ABISAND	Sand	1	S	Sand	AB	Abiotic
ABISILT	Silt	132	SI	Silt	AB	Abiotic
ABWATER	Water	76	UNK	Unknown	IN	Indeterminate
ACAECHI	*Acanthastrea echinata*	75	CM	Massive non-*Acropora*	HC	Hard Coral
ACASPP	*Acanthastrea* spp.	245	CM	Massive non-*Acropora*	HC	Hard Coral
ACRARAB	*Acropora arabensis*	706	ACD	Digitate *Acropora*	HC	Hard Coral
ACRAUST	*Acropora austera*	284	ACB	Branching *Acropora*	HC	Hard Coral
ACRBRUE	*Acropora brueggemanni*	60	ACB	Branching *Acropora*	HC	Hard Coral
ACRCARD	*Acropora carduus*	56	ACB	Branching *Acropora*	HC	Hard Coral
ACRCLAT	*Acropora clathrata*	161	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRCYTH	*Acropora cytherea*	55	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRECHI	*Acropora echinata*	273	ACX	Bottlebrush *Acropora*	HC	Hard Coral
ACRELSE	*Acropora elseyi*	205	ACX	Bottlebrush *Acropora*	HC	Hard Coral
ACRFLOR	*Acropora florida*	92	ACB	Branching *Acropora*	HC	Hard Coral
ACRFORM	*Acropora muricata/formosa*	307	ACB	Branching *Acropora*	HC	Hard Coral
ACRGEMM	*Acropora gemmifera*	87	ACD	Digitate *Acropora*	HC	Hard Coral
ACRGLAU	*Acropora glauca*	242	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRGRAN	*Acropora granulosa*	629	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRHGRP	*Acropora horrida* (group)	99	ACB	Branching *Acropora*	HC	Hard Coral
ACRHUMI	*Acropora humilis*	59	ACD	Digitate *Acropora*	HC	Hard Coral
ACRHYAC	*Acropora hyacinthus*	10	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRLIST	*Acropora listeri*	628	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRLONG	*Acropora longicyathus*	97	ACX	Bottlebrush *Acropora*	HC	Hard Coral
ACRLORI	*Acropora loripes*	627	ACX	Bottlebrush *Acropora*	HC	Hard Coral
ACRLORI	*Acropora loripes*	141	ACO	Corymbose *Acropora*	HC	Hard Coral
ACRLOVE	*Acropora lovelli*	610	ACB	Branching *Acropora*	HC	Hard Coral
ACRLUTK	*Acropora lutkeni*	289	ACO	Corymbose *Acropora*	HC	Hard Coral
ACRMICR	*Acropora microphthalma*	306	ACB	Branching *Acropora*	HC	Hard Coral
ACRMILL	*Acropora millepora*	98	ACO	Corymbose *Acropora*	HC	Hard Coral
ACRMONT	*Acropora monticulosa*	247	ACD	Digitate *Acropora*	HC	Hard Coral
ACRNASU	*Acropora nasuta*	310	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRNOBI	*Acropora intermedia/nobilis*	301	ACB	Branching *Acropora*	HC	Hard Coral
ACRPACU	*Acropora palifera/cuneata*	186	ACE	Encrusting *Acropora*	HC	Hard Coral

ACRPACU	*Acropora palifera/cuneata*	85	ACS	Submassive *Acropora*	HC	Hard Coral
ACRREC	*Acropora* spp. recruit	279	ACD	Digitate *Acropora*	HC	Hard Coral
ACRROBU	*Acropora robusta*	198	ACB	Branching *Acropora*	HC	Hard Coral
ACRSARM	*Acropora sarmentosa*	217	ACO	Corymbose *Acropora*	HC	Hard Coral
ACRSECA	*Acropora secale*	666	ACO	Corymbose *Acropora*	HC	Hard Coral
ACRSELA	*Acropora selago*	626	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRSPIC	*Acropora spicifera*	238	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRSPP	*Acropora* spp.	287	ACH	Staghorn *Acropora*	HC	Hard Coral
ACRSPP	*Acropora* spp.	288	ACS	Submassive *Acropora*	HC	Hard Coral
ACRSPP	*Acropora* spp.	169	ACD	Digitate *Acropora*	HC	Hard Coral
ACRSPP	*Acropora* spp.	117	ACE	Encrusting *Acropora*	HC	Hard Coral
ACRSPP	*Acropora* spp.	17	ACO	Corymbose *Acropora*	HC	Hard Coral
ACRSPP	*Acropora* spp.	101	ACT	Tabulate *Acropora*	HC	Hard Coral
ACRSPP	*Acropora* spp.	140	ACB	Branching *Acropora*	HC	Hard Coral
ACRSPP	*Acropora* spp.	249	ACX	Bottlebrush *Acropora*	HC	Hard Coral
ACRSPP	*Acropora* spp.	396	ACC	Caespitose *Acropora*	HC	Hard Coral
ACRTENU	*Acropora tenuis*	235	ACO	Corymbose *Acropora*	HC	Hard Coral
ACRVALI	*Acropora valida*	620	ACO	Corymbose *Acropora*	HC	Hard Coral
ACRVERW	*Acropora verweyi*	100	ACO	Corymbose *Acropora*	HC	Hard Coral
ACRWA	*Acropora* WA	240	ACO	Corymbose *Acropora*	HC	Hard Coral
ALGASP	Asparagopsis	633	AO	Algae Other	A	Algae
ALGASSE	Algal spp. (Algal Assemblage)	311	AA	Algal assemblage	A	Algae
ALGBRWN	Brown Algae Family	623	MA	Macroalgae	A	Algae
ALGCALC	*Calcareous algae*	112	MA	Macroalgae	A	Algae
ALGCACU	*Caulerpa cupressoides*	194	MA	Macroalgae	A	Algae
ALGCARA	*Caulerpa racemosa*	173	MA	Macroalgae	A	Algae
ALGCASE	*Caulerpa serrulata*	177	MA	Macroalgae	A	Algae
ALGCASP	*Caulerpa* spp.	638	MA	Macroalgae	A	Algae
ALGCATA	Coralline algae/turf	262	CA	Coralline algae	A	Algae
ALGCERA	*Ceratodictyon spongiosum*	202	MA	Macroalgae	A	Algae
ALGCHLO	*Chlorodesmis fastigiata*	46	MA	Macroalgae	A	Algae
ALGCORA	Coralline algae	14	CA	Coralline algae	A	Algae
ALGCYA	Cyanobacteria	632	AO	Algae Other	A	Algae
ALGDICT	*Dictyota bartayresii*	139	MA	Macroalgae	A	Algae
ALGENC	Encrusting red algae	241	MA	Macroalgae	A	Algae
ALGFILA	Filamentous algae	7	TA	Turf algae	A	Algae
ALGGNOO	Golden Noodle	635	AO	Algae Other	A	Algae
ALGGRN	Green Algae Family	625	MA	Macroalgae	A	Algae
ALGHALI	*Halimeda* spp.	111	HA	Halimeda	A	Algae
ALGHYDR	*Hydroclathrus* spp.	265	MA	Macroalgae	A	Algae
ALGHYPN	*Hypnea* spp.	637	MA	Macroalgae	A	Algae
ALGLOBO	*Lobophora* spp.	403	MA	Macroalgae	A	Algae
ALGMAFL	Fleshy Macro Algae	412	MA	Macroalgae	A	Algae
ALGPADI	*Padina australis*	110	MA	Macroalgae	A	Algae
ALGPEYS	*Peyssonnelia* spp.	183	MA	Macroalgae	A	Algae
ALGRED	Red Algae Family	624	MA	Macroalgae	A	Algae

ALGSACR	*Sargassum crassifolium*	228	MA	Macroalgae	A	Algae
ALGSARG	*Sargassum* spp.	387	MA	Macroalgae	A	Algae
ALGSPP	Algae Other	442	AO	Algae Other	A	Algae
ALGTAHA	Turf Algae on *Halimeda* spp.	634	TA	Turf algae	A	Algae
ALGTURB	*Turbinaria ornata*	48	MA	Macroalgae	A	Algae
ALVCATA	*Alveopora catalai*	113	CB	Branching non-*Acropora*	HC	Hard Coral
ALVSPON	*Alveopora spongiosa*	208	CT	Tabulate non-*Acropora*	HC	Hard Coral
ALVSPP	*Alveopora* spp.	90	CM	Massive non-*Acropora*	HC	Hard Coral
ASTMYRI	*Astreopora myriophthalma*	188	CM	Massive non-*Acropora*	HC	Hard Coral
ASTSPP	*Astreopora* spp.	54	CM	Massive non-*Acropora*	HC	Hard Coral
ASTSPP	*Astreopora* spp.	266	CE	Encrusting non-*Acropora*	HC	Hard Coral
AUMROWL	*Australomussa rowleyensis*	317	CM	Massive non-*Acropora*	HC	Hard Coral
AUSZELL	*Australogyra zelli*	216	CB	Branching non-*Acropora*	HC	Hard Coral
CARFAM	Fam Caryophyllidae	430	CM	Massive non-*Acropora*	HC	Hard Coral
CATJARD	*Catalaphyllia jardinei*	221	CM	Massive non-*Acropora*	HC	Hard Coral
CAUSPP	*Caulastrea* spp.	159	CS	Submassive non-*Acropora*	HC	Hard Coral
CAUTUMI	*Caulastrea tumida*	395	CS	Submassive non-*Acropora*	HC	Hard Coral
CIRRHIP	Cirrhipathes	335	OT	Other organisms	OT	Other
CLASPP	*Cladiella* spp.	615	SC	Soft coral	SC	Soft Coral
COEMAYE	*Coeloseris mayeri*	44	CM	Massive non-*Acropora*	HC	Hard Coral
COLSPP	*Colpomenia* spp.	705	MA	Macroalgae	A	Algae
CORREC	Coral spp. recruit	285	CE	Encrusting non-*Acropora*	HC	Hard Coral
CORSPP	Non-*Acropora* coral	43	CB	Branching non-*Acropora*	HC	Hard Coral
CORSPP	Non-*Acropora* coral	152	CS	Submassive non-*Acropora*	HC	Hard Coral
CORSPP	Non-*Acropora* coral	80	CM	Massive non-*Acropora*	HC	Hard Coral
CORSPP	Non-*Acropora* coral	36	CE	Encrusting non-*Acropora*	HC	Hard Coral
CORSPP	Non-*Acropora* coral	190	CF	Foliose non-*Acropora*	HC	Hard Coral
COSCOLU	*Coscinaraea columna*	175	CM	Massive non-*Acropora*	HC	Hard Coral
COSEXES	*Coscinaraea exesa*	147	CS	Submassive non-*Acropora*	HC	Hard Coral
COSSPP	*Coscinaraea* spp.	704	CM	Massive non-*Acropora*	HC	Hard Coral
CTECRA	*Ctenactis crassa*	601	CMR	Mushroom coral	HC	Hard Coral
CYNLACR	*Cynarina lacrymalis*	244	CL	Solitary coral	HC	Hard Coral
CYPJAPO	*Cyphastrea japonica*	223	CB	Branching non-*Acropora*	HC	Hard Coral
CYPSERA	*Cyphastrea serailia*	146	CM	Massive non-*Acropora*	HC	Hard Coral
CYPSPP	*Cyphastrea* spp.	702	CS	Submassive non-*Acropora*	HC	Hard Coral
CYPSPP	*Cyphastrea* spp.	21	CM	Massive non-*Acropora*	HC	Hard Coral
CYPSPP	*Cyphastrea* spp.	261	CE	Encrusting non-*Acropora*	HC	Hard Coral
CYPSPP	*Cyphastrea* spp.	460	CB	Branching non-*Acropora*	HC	Hard Coral
DICTYOT	*Dictyota* Species unknown	608	MA	Macroalgae	A	Algae
DIPHELI	*Diploastrea* heliopora	26	CM	Massive non-*Acropora*	HC	Hard Coral
DISSPP	*Distichopora* spp.	197	CST	Distichopora	OT	Other
ECHHORR	*Echinopora horrida*	323	CB	Branching non-*Acropora*	HC	Hard Coral
ECHHORR	*Echinopora horrida*	104	CS	Submassive non-*Acropora*	HC	Hard Coral
ECHLAGE	*Echinopora lamellosa/gemmacea*	256	CS	Submassive non-*Acropora*	HC	Hard Coral

ECHLAGE	*Echinopora lamellosa/gemmacea*	11	CF	Foliose non-*Acropora*	HC	Hard Coral
ECHMAMM	*Echinopora mammiformis*	226	CS	Submassive non-*Acropora*	HC	Hard Coral
ECHMAMM	*Echinopora mammiformis*	191	CF	Foliose non-*Acropora*	HC	Hard Coral
ECHSPP	*Echinopora* spp.	399	CS	Submassive non-*Acropora*	HC	Hard Coral
ECHSPP	*Echinopora* spp.	157	CE	Encrusting non-*Acropora*	HC	Hard Coral
ECHSPP	*Echinopora* spp.	320	CF	Foliose non-*Acropora*	HC	Hard Coral
ECHSPP	*Echinopora* spp.	315	CB	Branching non-*Acropora*	HC	Hard Coral
ECLASPE	*Echinophyllia aspera*	102	CE	Encrusting non-*Acropora*	HC	Hard Coral
ECLORPH	*Echinophyllia orpheensis*	236	CE	Encrusting non-*Acropora*	HC	Hard Coral
ECLSPP	*Echinophyllia* spp. (and *Oxypora* spp.)	454	CF	Foliose non-*Acropora*	HC	Hard Coral
ECLSPP	*Echinophyllia* spp. (and *Oxypora* spp.)	137	CE	Encrusting non-*Acropora*	HC	Hard Coral
EUPANCO	*Euphyllia ancora*	131	CM	Massive non-*Acropora*	HC	Hard Coral
EUPDIVI	*Euphyllia divisa*	234	CM	Massive non-*Acropora*	HC	Hard Coral
FAVFAVU	*Favia favus*	20	CM	Massive non-*Acropora*	HC	Hard Coral
FAVLAXA	*Favia laxa*	182	CM	Massive non-*Acropora*	HC	Hard Coral
FAVLIZA	*Favia lizardensis*	29	CM	Massive non-*Acropora*	HC	Hard Coral
FAVMARI	*Favia maritima*	105	CM	Massive non-*Acropora*	HC	Hard Coral
FAVMATT	*Favia matthaii*	19	CM	Massive non-*Acropora*	HC	Hard Coral
FAVMAXI	*Favia maxima*	600	CM	Massive non-*Acropora*	HC	Hard Coral
FAVPALL	*Favia pallida*	13	CM	Massive non-*Acropora*	HC	Hard Coral
FAVROTD	*Favia rotundata*	38	CM	Massive non-*Acropora*	HC	Hard Coral
FAVROTU	*Favia rotumana*	603	CM	Massive non-*Acropora*	HC	Hard Coral
FAVSPEC	*Favia speciosa*	160	CM	Massive non-*Acropora*	HC	Hard Coral
FAVSPP	*Favia* spp.	453	CS	Submassive non-*Acropora*	HC	Hard Coral
FAVSPP	*Favia* spp.	78	CM	Massive non-*Acropora*	HC	Hard Coral
FAVSPP	*Favia* spp.	452	CE	Encrusting non-*Acropora*	HC	Hard Coral
FAVSTEL	*Favia stelligera*	8	CM	Massive non-*Acropora*	HC	Hard Coral
FUNFAM	FUNGIIDAE Family	440	CMR	Mushroom coral	HC	Hard Coral
FUNSPP	*Fungia* spp.	89	CMR	Mushroom coral	HC	Hard Coral
FVDSPP	Favid spp.	590	CS	Submassive non-*Acropora*	HC	Hard Coral
FVDSPP	Favid spp.	174	CE	Encrusting non-*Acropora*	HC	Hard Coral
FVDSPP	Favid spp.	166	CM	Massive non-*Acropora*	HC	Hard Coral
FVSABDI	*Favites abdita*	39	CM	Massive non-*Acropora*	HC	Hard Coral
FVSCHIN	*Favites chinensis*	180	CM	Massive non-*Acropora*	HC	Hard Coral
FVSCOMP	*Favites complanata*	66	CM	Massive non-*Acropora*	HC	Hard Coral
FVSFLEX	*Favites flexuosa*	25	CM	Massive non-*Acropora*	HC	Hard Coral
FVSHALI	*Favites halicora*	239	CM	Massive non-*Acropora*	HC	Hard Coral
FVSPENT	*Favites pentagona*	142	CM	Massive non-*Acropora*	HC	Hard Coral
FVSRUSS	*Favites russelli*	604	CM	Massive non-*Acropora*	HC	Hard Coral
FVSSPP	*Favites* spp.	257	CS	Submassive non-*Acropora*	HC	Hard Coral
FVSSPP	*Favites* spp.	203	CE	Encrusting non-*Acropora*	HC	Hard Coral
FVSSPP	*Favites* spp.	9	CM	Massive non-*Acropora*	HC	Hard Coral
GALASTR	*Galaxea astreata*	107	CS	Submassive non-*Acropora*	HC	Hard Coral
GALFASC	*Galaxea fascicularis*	35	CE	Encrusting non-*Acropora*	HC	Hard Coral

GALHORR	*Galaxea horrescens*	214	CB	Branching non-*Acropora*	HC	Hard Coral
GALSPP	*Galaxea* spp.	431	CM	Massive non-*Acropora*	HC	Hard Coral
GALSPP	*Galaxea* spp.	414	CE	Encrusting non-*Acropora*	HC	Hard Coral
GARPLAN	*Gardineroseris planulata*	16	CM	Massive non-*Acropora*	HC	Hard Coral
GONFRUT	*Goniopora fruticosa*	178	CS	Submassive non-*Acropora*	HC	Hard Coral
GONSPP	*Goniopora* spp. / *Alveopora* spp.	69	CS	Submassive non-*Acropora*	HC	Hard Coral
GONSPP	*Goniopora* spp. / *Alveopora* spp.	192	CM	Massive non-*Acropora*	HC	Hard Coral
GOSASPE	*Goniastrea aspera*	305	CM	Massive non-*Acropora*	HC	Hard Coral
GOSAUST	*Goniastrea australensis*	274	CE	Encrusting non-*Acropora*	HC	Hard Coral
GOSAUST	*Goniastrea australensis*	71	CM	Massive non-*Acropora*	HC	Hard Coral
GOSEDWA	*Goniastrea edwardsi*	164	CM	Massive non-*Acropora*	HC	Hard Coral
GOSFAVU	*Goniastrea favulus*	165	CM	Massive non-*Acropora*	HC	Hard Coral
GOSPECT	*Goniastrea pectinata*	51	CM	Massive non-*Acropora*	HC	Hard Coral
GOSRETI	*Goniastrea retiformis*	300	CM	Massive non-*Acropora*	HC	Hard Coral
GOSSPP	*Goniastrea* spp.	456	CE	Encrusting non-*Acropora*	HC	Hard Coral
GOSSPP	*Goniastrea* spp.	47	CM	Massive non-*Acropora*	HC	Hard Coral
GOSSPP2	*Goniastrea* not australiensis	470	CE	Encrusting non-*Acropora*	HC	Hard Coral
GOSSPP2	*Goniastrea* not australiensis	469	CM	Massive non-*Acropora*	HC	Hard Coral
HALRUBB	Halimeda Rubble	251	R	Rubble	AB	Abiotic
HELACTI	*Heliofungia actiniformis*	108	CMR	Mushroom coral	HC	Hard Coral
HEPCOER	*Heliopora coerulea*	231	SM	Massive Soft Coral	SC	Soft Coral
HERLIMA	*Herpolitha limax*	133	CMR	Mushroom coral	HC	Hard Coral
HYDEXES	*Hydnophora exesa*	79	CS	Submassive non-*Acropora*	HC	Hard Coral
HYDMICR	*Hydnophora microconos*	181	CM	Massive non-*Acropora*	HC	Hard Coral
HYDPILO	*Hydnophora pilosa*	254	CE	Encrusting non-*Acropora*	HC	Hard Coral
HYDPILO	*Hydnophora pilosa*	189	CS	Submassive non-*Acropora*	HC	Hard Coral
HYDRIGI	*Hydnophora rigida*	154	CB	Branching non-*Acropora*	HC	Hard Coral
HYDSPP	*Hydnophora* spp.	455	CE	Encrusting non-*Acropora*	HC	Hard Coral
HYDSPP	*Hydnophora* spp.	86	CS	Submassive non-*Acropora*	HC	Hard Coral
HYDSPP	*Hydnophora* spp.	151	CM	Massive non-*Acropora*	HC	Hard Coral
HYDSPP	*Hydnophora* spp.	416	CB	Branching non-*Acropora*	HC	Hard Coral
ISOSPP	*Isopora* Spp.	433	ACS	Submassive *Acropora*	HC	Hard Coral
ISOSPP	*Isopora* Spp.	417	ACE	Encrusting *Acropora*	HC	Hard Coral
LEPPHRY	*Leptoria phrygia*	34	CM	Massive non-*Acropora*	HC	Hard Coral
LERINAE	*Leptastrea inaequalis*	179	CE	Encrusting non-*Acropora*	HC	Hard Coral
LERSPP	*Leptastrea* spp.	450	CM	Massive non-*Acropora*	HC	Hard Coral
LERSPP	*Leptastrea* spp.	50	CE	Encrusting non-*Acropora*	HC	Hard Coral
LESMYCE	*Leptoseris mycetoseroides*	227	CE	Encrusting non-*Acropora*	HC	Hard Coral
LESPAPY	*Leptoseris papyracea*	314	CF	Foliose non-*Acropora*	HC	Hard Coral
LESSPP	*Leptoseris* spp.	419	CF	Foliose non-*Acropora*	HC	Hard Coral
LESSPP	*Leptoseris* spp.	418	CE	Encrusting non-*Acropora*	HC	Hard Coral
LESYABE	*Leptoseris yabei*	109	CF	Foliose non-*Acropora*	HC	Hard Coral
LOBCORY	*Lobophyllia corymbosa*	209	CM	Massive non-*Acropora*	HC	Hard Coral
LOBHEMP	*Lobophyllia hemprichii*	193	CM	Massive non-*Acropora*	HC	Hard Coral
LOBPACH	*Lobophyllia pachysepta*	176	CM	Massive non-*Acropora*	HC	Hard Coral

LOBSPP	*Lobophyllia* spp.	22	CM	Massive non-*Acropora*	HC	Hard Coral
MERAMPL	*Merulina ampliata*	253	CE	Encrusting non-*Acropora*	HC	Hard Coral
MERAMPL	*Merulina ampliata*	224	CS	Submassive non-*Acropora*	HC	Hard Coral
MERAMPL	*Merulina ampliata*	40	CF	Foliose non-*Acropora*	HC	Hard Coral
MERSCAB	*Merulina scabricula*	308	CF	Foliose non-*Acropora*	HC	Hard Coral
MERSPP	*Merulina* spp.	451	CE	Encrusting non-*Acropora*	HC	Hard Coral
MERSPP	*Merulina* spp.	420	CS	Submassive non-*Acropora*	HC	Hard Coral
MERSPP	*Merulina* spp.	434	CF	Foliose non-*Acropora*	HC	Hard Coral
MILEXAE	*Millepora exaesa* (yellow mass)	32	CME	Millepora	OT	Other
MILSPP	*Millepora* spp	24	CME	Millepora	OT	Other
MONDIG	*Montipora digitata*	325	CS	Submassive non-*Acropora*	HC	Hard Coral
MONSPP	*Montipora* spp.	156	CE	Encrusting non-*Acropora*	HC	Hard Coral
MONSPP	*Montipora* spp.	218	CS	Submassive non-*Acropora*	HC	Hard Coral
MONSPP	*Montipora* spp.	187	CF	Foliose non-*Acropora*	HC	Hard Coral
MONSPP	*Montipora* spp.	4	CM	Massive non-*Acropora*	HC	Hard Coral
MONSPUM	*Montipora spumosa*	302	CM	Massive non-*Acropora*	HC	Hard Coral
MORANNU	*Montastrea annuligera*	201	CE	Encrusting non-*Acropora*	HC	Hard Coral
MORCURT	*Montastrea curta*	15	CM	Massive non-*Acropora*	HC	Hard Coral
MORMAGN	*Montastrea magnistellata*	220	CM	Massive non-*Acropora*	HC	Hard Coral
MORSPP	*Montastrea* spp.	162	CM	Massive non-*Acropora*	HC	Hard Coral
MORVALE	*Montastrea valenciennesi*	52	CM	Massive non-*Acropora*	HC	Hard Coral
MOSLATI	*Moseleya latistellata*	136	CM	Massive non-*Acropora*	HC	Hard Coral
MYCELEP	*Mycedium elephantotus*	81	CE	Encrusting non-*Acropora*	HC	Hard Coral
MYCROBO	*Mycedium robokaki*	309	CE	Encrusting non-*Acropora*	HC	Hard Coral
OTH	Other organisms	212	OT	Other organisms	OT	Other
OTHANEM	Anemone	94	OT	Other organisms	OT	Other
OTHANNE	Annelid	233	OT	Other organisms	OT	Other
OTHASCI	Ascidian	5	OT	Other organisms	OT	Other
OTHBIVA	Bivalve - mussel-like (SA)	707	OT	Other organisms	OT	Other
OTHCORA	Corallimorpharia	394	OT	Other organisms	OT	Other
OTHCOTS	*Acanthaster planci*	260	OT	Other organisms	OT	Other
OTHCRIN	Crinoid	118	OT	Other organisms	OT	Other
OTHDIAD	*Diadema* spp.	88	OT	Other organisms	OT	Other
OTHECH	*Echinometra mathii*	701	OT	Other organisms	OT	Other
OTHFILO	*Filograna implexa*	206	OT	Other organisms	OT	Other
OTHHOLO	Holothurian	114	OT	Other organisms	OT	Other
OTHHYDR	Hydroid	68	OT	Other organisms	OT	Other
OTHPEN	*Prionocidaris baculosa* (Pencil Urchin)	709	OT	Other organisms	OT	Other
OTHSEAG	Seagrass	237	OT	Other organisms	OT	Other
OTHSTAR	Starfish (not *A. planci*)	172	OT	Other organisms	OT	Other
OTHTMAX	*Tridacna maxima*	199	OT	Other organisms	OT	Other
OTHTSPP	*Tridacna* spp.	116	OT	Other organisms	OT	Other
OTHZOAN	Zoanthid	6	ZO	Zoanthid	OT	Other
OULBENN	*Oulophyllia bennettae*	184	CM	Massive non-*Acropora*	HC	Hard Coral
OULCRIS	*Oulophyllia crispa*	195	CM	Massive non-*Acropora*	HC	Hard Coral

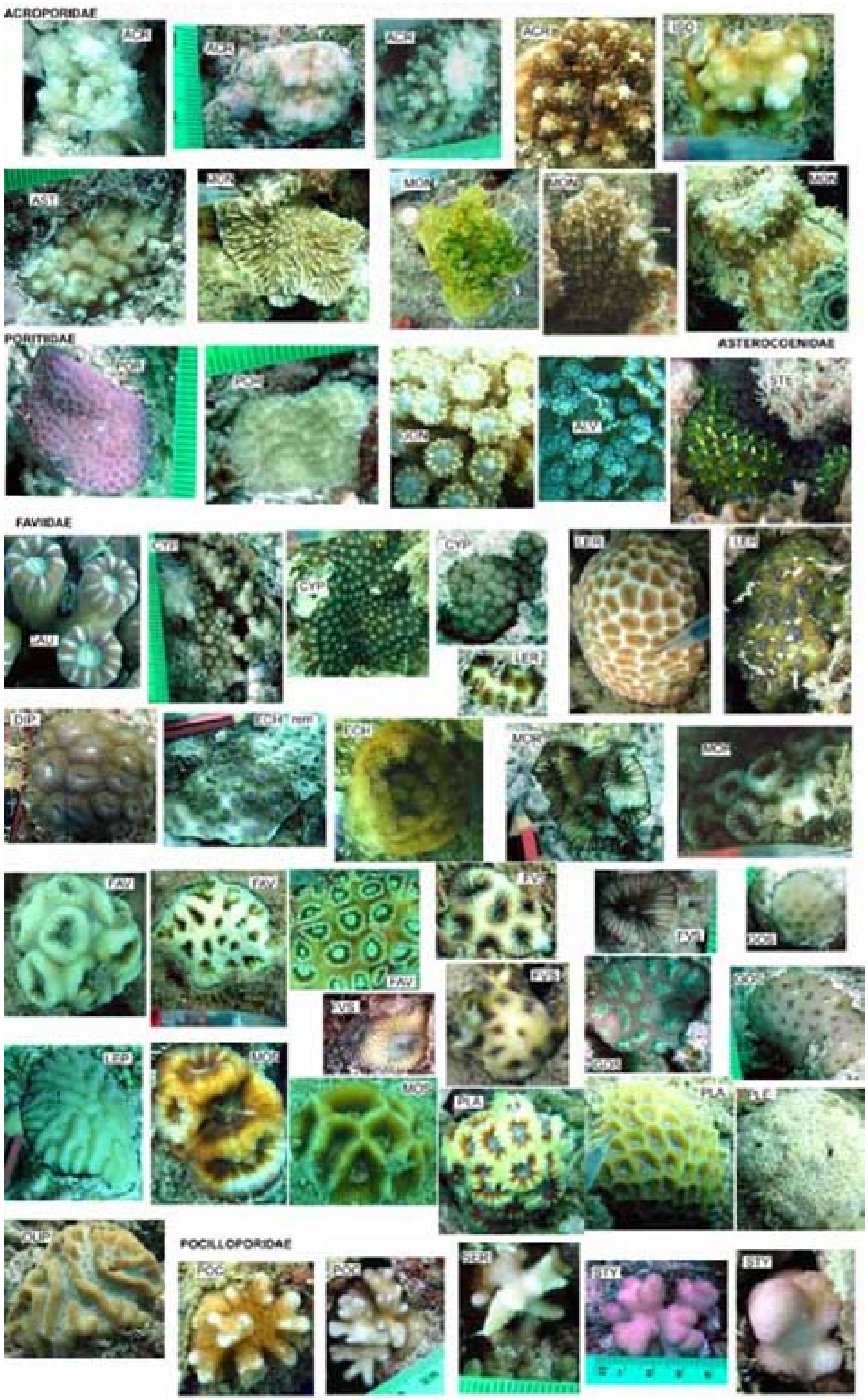
OULSPP	*Oulophyllia* spp.	421	CM	Massive non-*Acropora*	HC	Hard Coral
OXYLACE	*Oxypora lacera*	119	CF	Foliose non-*Acropora*	HC	Hard Coral
OXYSPP	*Oxypora* spp.	406	CE	Encrusting non-*Acropora*	HC	Hard Coral
OXYSPP	*Oxypora* spp.	397	CF	Foliose non-*Acropora*	HC	Hard Coral
PACRUGO	*Pachyseris rugosa*	120	CS	Submassive non-*Acropora*	HC	Hard Coral
PACSPEC	*Pachyseris speciosa*	121	CF	Foliose non-*Acropora*	HC	Hard Coral
PACSPP	*Pachyseris* spp.	422	CF	Foliose non-*Acropora*	HC	Hard Coral
PALRAMO	*Palauastrea ramosa*	213	CB	Branching non-*Acropora*	HC	Hard Coral
PARTRIA	*Paraclavarina triangularis*	589	CB	Branching non-*Acropora*	HC	Hard Coral
PAVCACT	*Pavona cactus*	122	CF	Foliose non-*Acropora*	HC	Hard Coral
PAVCLAV	*Pavona clavus*	219	CS	Submassive non-*Acropora*	HC	Hard Coral
PAVDECU	*Pavona decussata*	134	CF	Foliose non-*Acropora*	HC	Hard Coral
PAVEXPL	*Pavona explanulata*	207	CE	Encrusting non-*Acropora*	HC	Hard Coral
PAVMALD	*Pavona maldivensis*	215	CS	Submassive non-*Acropora*	HC	Hard Coral
PAVMINU	*Pavona minuta*	204	CM	Massive non-*Acropora*	HC	Hard Coral
PAVSPP	*Pavona* spp.	424	CS	Submassive non-*Acropora*	HC	Hard Coral
PAVSPP	*Pavona* spp.	423	CF	Foliose non-*Acropora*	HC	Hard Coral
PAVSPP	*Pavona* spp.	61	CM	Massive non-*Acropora*	HC	Hard Coral
PAVSPP	*Pavona* spp.	425	CE	Encrusting non-*Acropora*	HC	Hard Coral
PAVVARI	*Pavona varians*	155	CE	Encrusting non-*Acropora*	HC	Hard Coral
PECLACT	*Pectinia lactuca*	93	CE	Encrusting non-*Acropora*	HC	Hard Coral
PECLACT	*Pectinia lactuca*	321	CF	Foliose non-*Acropora*	HC	Hard Coral
PECPAEO	*Pectinia paeonia*	312	CF	Foliose non-*Acropora*	HC	Hard Coral
PECPAEO	*Pectinia paeonia*	123	CE	Encrusting non-*Acropora*	HC	Hard Coral
PECSPP	*Pectinia* spp.	426	CF	Foliose non-*Acropora*	HC	Hard Coral
PHYLICH	*Physogyra lichtensteini*	63	CM	Massive non-*Acropora*	HC	Hard Coral
PLADAED	*Platygyra daedalea*	12	CM	Massive non-*Acropora*	HC	Hard Coral
PLALAME	*Platygyra lamellina*	58	CM	Massive non-*Acropora*	HC	Hard Coral
PLALEGA	*G.australiensis/playgyra/leptoria*	468	CE	Encrusting non-*Acropora*	HC	Hard Coral
PLALEGA	*G.australiensis/playgyra/leptoria*	467	CM	Massive non-*Acropora*	HC	Hard Coral
PLAPINI	*Platygyra pini*	31	CM	Massive non-*Acropora*	HC	Hard Coral
PLASINE	*Platygyra sinensis*	84	CM	Massive non-*Acropora*	HC	Hard Coral
PLASPP	*Platygyra* spp.	49	CM	Massive non-*Acropora*	HC	Hard Coral
PLASPP	*Platygyra* spp.	248	CE	Encrusting non-*Acropora*	HC	Hard Coral
PLESINU	*Plerogyra sinuosa*	170	CM	Massive non-*Acropora*	HC	Hard Coral
PLSVERS	*Plesiastrea versipora*	243	CM	Massive non-*Acropora*	HC	Hard Coral
POCDAMI	*Pocillopora damicornis*	57	CS	Submassive non-*Acropora*	HC	Hard Coral
POCEYWD	*Pocillopora eydouxi/woodjonesi*	74	CS	Submassive non-*Acropora*	HC	Hard Coral
POCRECR	*Pocillopora* spp. recruit	286	CS	Submassive non-*Acropora*	HC	Hard Coral
POCSPP	*Pocillopora* spp.	427	CS	Submassive non-*Acropora*	HC	Hard Coral
POCVEME	*Pocillopora verrucosa/meandrina*	23	CS	Submassive non-*Acropora*	HC	Hard Coral
PODCRUS	*Podabacia crustacea*	144	CE	Encrusting non-*Acropora*	HC	Hard Coral
PODCRUS	*Podabacia crustacea*	271	CF	Foliose non-*Acropora*	HC	Hard Coral
POLTALP	*Polyphyllia talpina*	471	CMR	Mushroom coral	HC	Hard Coral

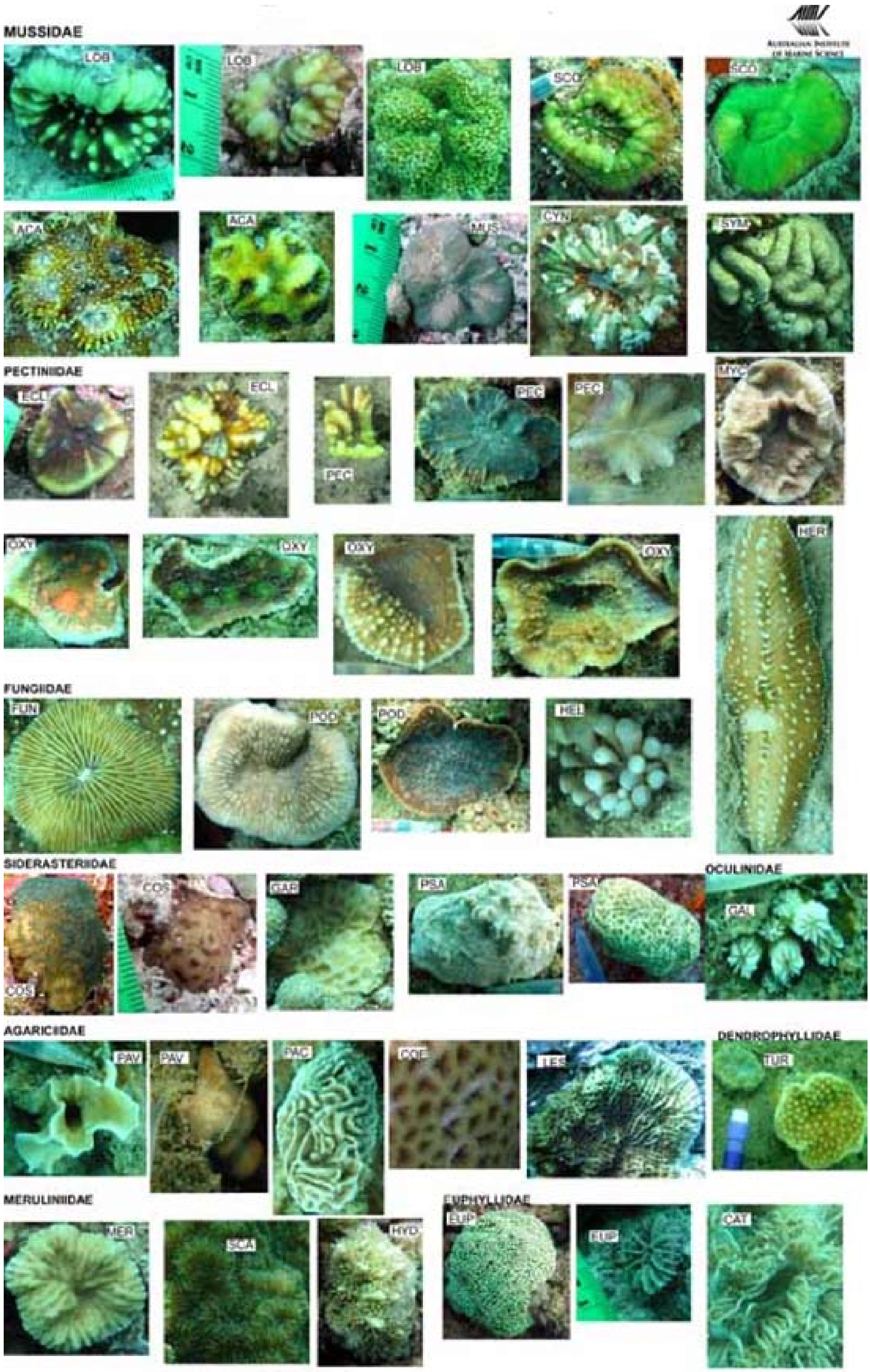
PORANNA	*Porites annae*	45	CS	Submassive non-*Acropora*	HC	Hard Coral
PORCYLI	*Porites cylindrica*	124	CB	Branching non-*Acropora*	HC	Hard Coral
PORHERO	*Porites heronensis*	246	CS	Submassive non-*Acropora*	HC	Hard Coral
PORHNC	*P. harrisoni / nodifera / compressa*	708	CS	Submassive non-*Acropora*	HC	Hard Coral
PORLICH	*Porites lichen*	232	CS	Submassive non-*Acropora*	HC	Hard Coral
PORLOBA	*Porites lobata*	28	CM	Massive non-*Acropora*	HC	Hard Coral
PORNIGR	*Porites nigrescens*	304	CB	Branching non-*Acropora*	HC	Hard Coral
PORRUS	*Porites (Synaraea) rus*	264	CS	Submassive non-*Acropora*	HC	Hard Coral
PORRUS	*Porites (Synaraea) rus*	229	CM	Massive non-*Acropora*	HC	Hard Coral
PORSPP	*Porites* spp.	463	CF	Foliose non-*Acropora*	HC	Hard Coral
PORSPP	*Porites* spp.	96	CE	Encrusting non-*Acropora*	HC	Hard Coral
PORSPP	*Porites* spp.	41	CM	Massive non-*Acropora*	HC	Hard Coral
PORSPP	*Porites* spp.	398	CB	Branching non-*Acropora*	HC	Hard Coral
PORSPP	*Porites* spp.	153	CS	Submassive non-*Acropora*	HC	Hard Coral
PSACONT	*Psammocora contigua*	163	CS	Submassive non-*Acropora*	HC	Hard Coral
PSADIGI	*Psammocora digitata*	95	CS	Submassive non-*Acropora*	HC	Hard Coral
PSASPP	*Psammocora* spp.	407	CM	Massive non-*Acropora*	HC	Hard Coral
PSASPP	*Psammocora* spp.	158	CS	Submassive non-*Acropora*	HC	Hard Coral
PSASPP	*Psammocora* spp.	259	CE	Encrusting non-*Acropora*	HC	Hard Coral
PSASUPE	*Psammocora superficialis*	200	CS	Submassive non-*Acropora*	HC	Hard Coral
PSETAYA	*Pseudosiderastrea tayami*	125	CE	Encrusting non-*Acropora*	HC	Hard Coral
REDAA	Red algal assemblage	630	MA	Macroalgae	A	Algae
REDEP	Red algae as epiphytes	631	MA	Macroalgae	A	Algae
RUMPHEL	*Rumphella* spp.	332	SC	Soft coral	SC	Soft Coral
SANROBU	*Sandalolitha robusta*	150	CMR	Mushroom coral	HC	Hard Coral
SCACYLI	*Scapophyllia cylindrica*	27	CS	Submassive non-*Acropora*	HC	Hard Coral
SCOVITI	*Scolymia vitiensis*	72	CL	Solitary coral	HC	Hard Coral
SERCALI	*Seriatopora caliendrum*	171	CB	Branching non-*Acropora*	HC	Hard Coral
SERHYST	*Seriatopora hystrix*	91	CB	Branching non-*Acropora*	HC	Hard Coral
SERSPP	*Seriatopora* spp.	429	CB	Branching non-*Acropora*	HC	Hard Coral
SIDSPP	*Siderastrea* spp	703	CM	Massive non-*Acropora*	HC	Hard Coral
SIFSPP	Family Siderasteidae	459	CS	Submassive non-*Acropora*	HC	Hard Coral
SIFSPP	Family Siderasteidae	457	CM	Massive non-*Acropora*	HC	Hard Coral
SIFSPP	Family Siderasteidae	458	CE	Encrusting non-*Acropora*	HC	Hard Coral
SOFALCL	*Alcyonium* spp. & *Cladiella* spp.	296	SA	Arborescent Soft Coral	SC	Soft Coral
SOFALF	Alcyoniidae Family	465	SC	Soft coral	SC	Soft Coral
SOFANT	Anthelia spp.	269	SCC	Capitate Soft Coral	SC	Soft Coral
SOFAST	*Asterospicularia* spp.	297	SL	Lobate Soft Coral	SC	Soft Coral
SOFBRIA	*Briareum*	70	SE	Encrusting Soft Coral	SC	Soft Coral
SOFCAP	*Capnella* spp.	295	SL	Lobate Soft Coral	SC	Soft Coral
SOFCLAV	*Clavularia* spp.	129	SER	Erect Soft Coral	SC	Soft Coral
SOFCLV	Clavulariinae Family	464	SE	Encrusting Soft Coral	SC	Soft Coral
SOFDEND	*Dendronephthya* spp.	292	SA	Arborescent Soft Coral	SC	Soft Coral

SOFEFCE	*Efflatournaria* spp. and *Cespitularia* spp.	290	SL	Lobate Soft Coral	SC	Soft Coral
SOFGORG	Gorgonia	33	SA	Arborescent Soft Coral	SC	Soft Coral
SOFIS	*Isis hippuris*	298	SB	Branching Soft Coral	SC	Soft Coral
SOFJUNC	*Junceella fragilis*	330	SC	Soft coral	SC	Soft Coral
SOFKLY	*Klyxum* spp	466	SC	Soft coral	SC	Soft Coral
SOFLEM	*Lemnalia* spp.	267	SA	Arborescent Soft Coral	SC	Soft Coral
SOFLOBO	*Lobophytum* spp.	42	SE	Encrusting Soft Coral	SC	Soft Coral
SOFNED	Family Nephtheidae	444	SA	Arborescent Soft Coral	SC	Soft Coral
SOFNEPH	*Nephthea* spp.	293	SA	Arborescent Soft Coral	SC	Soft Coral
SOFPACH	*Pachyclavularia* spp.	77	SM	Massive Soft Coral	SC	Soft Coral
SOFPARA	*Paralemnalia* spp.	294	SD	Digitate Soft Coral	SC	Soft Coral
SOFPARE	*Parerythropodium* spp	331	SC	Soft coral	SC	Soft Coral
SOFPLEX	*Plexaura flava*	329	SC	Soft coral	SC	Soft Coral
SOFRHYS	*Rhystima* spp	103	SE	Encrusting Soft Coral	SC	Soft Coral
SOFSARC	*Sarcophyton* spp.	83	SCC	Capitate Soft Coral	SC	Soft Coral
SOFSCAP	*Sinularia capitalis*	328	SC	Soft coral	SC	Soft Coral
SOFSCL	*Scleronephthya* spp.	710	SA	Arborescent Soft Coral	SC	Soft Coral
SOFSFLX	*Sinularia flexibilis*	327	SC	Soft coral	SC	Soft Coral
SOFSINU	*Sinularia* spp.	130	SAE	Arb & Enc Soft Coral	SC	Soft Coral
SOFSPP	Soft coral spp.	64	SC	Soft coral	SC	Soft Coral
SOFSPP	Soft coral spp.	413	SE	Encrusting Soft Coral	SC	Soft Coral
SOFSTE	*Steronephthya* spp.	303	SA	Arborescent Soft Coral	SC	Soft Coral
SOFSYM	*Sympodium* spp.	268	SE	Encrusting Soft Coral	SC	Soft Coral
SOFXED	Family Xeniidae	443	SC	Soft coral	SC	Soft Coral
SOFXENI	*Xenia* spp.	82	SCC	Capitate Soft Coral	SC	Soft Coral
SPOSPP	Sponge spp.	115	SPE	Sponge Encrusting	SP	Sponge
SPOSPP	Sponge spp.	73	SP	Sponge	SP	Sponge
STFSPP	Stylasteridae Family	461	OT	Other organisms	OT	Other
STYPIST	*Stylophora pistillata*	30	CS	Submassive non-*Acropora*	HC	Hard Coral
SYMSPP	*Symphyllia* spp.	53	CM	Massive non-*Acropora*	HC	Hard Coral
TUBMICR	*Tubastraea micranthra*	318	CS	Submassive non-*Acropora*	HC	Hard Coral
TUBSPP	*Tubastraea* spp.	210	CS	Submassive non-*Acropora*	HC	Hard Coral
TUPMUSI	*Tubipora musica*	65	SM	Massive Soft Coral	SC	Soft Coral
TURFRON	*Turbinaria frondens*	128	CF	Foliose non-*Acropora*	HC	Hard Coral
TURHERO	*Turbinaria heronensis*	211	CB	Branching non-*Acropora*	HC	Hard Coral
TURMESE	*Turbinaria mesenterina*	126	CF	Foliose non-*Acropora*	HC	Hard Coral
TURPELT	*Turbinaria peltata*	145	CF	Foliose non-*Acropora*	HC	Hard Coral
TURRENI	*Turbinaria reniformis*	127	CF	Foliose non-*Acropora*	HC	Hard Coral
TURSPP	*Turbinaria* spp.	168	CE	Encrusting non-*Acropora*	HC	Hard Coral
TURSPP	*Turbinaria* spp.	67	CF	Foliose non-*Acropora*	HC	Hard Coral
TURSTEL	*Turbinaria stellulata*	62	CM	Massive non-*Acropora*	HC	Hard Coral
TURSTEL	*Turbinaria stellulata*	222	CE	Encrusting non-*Acropora*	HC	Hard Coral
UNDSUB	Undefined Substrate	333	OT	Other organisms	OT	Other
UNHAND	Divers Hand	138	UNK	Unknown	IN	Indeterminate
UNID	Can't tell	18	OT	Other organisms	OT	Other
UNTAPE	Fibreglass Tape	135	UNK	Unknown	IN	Indeterminate

APPENDIX IV

Examples of juvenile corals on the Great Barrier Reef




MUSSIDAE
LOB
LOB
LOB
SCO
SCO
ACA
ACA
MUS
CYN
SYM
PECTINIIDAE
ECL
ECL
PEC
PEC
PEC
MYC
OXY
OXY
OXY
OXY
HER
FUNGIIDAE
FUN
POD
POD
HEL
SIDERASTERIIDAE
COS
COS
COS
GAR
PSA
PSA
OCULINIDAE
GAL
AGARICIIDAE
PAV
PAV
PAC
COE
LES
DENDROPHYLLIDAE
TUR
MERULINIIDAE
MER
SCA
HYD
EUPHYLLIDAE
EUP
EUP
CAT

APPENDIX V

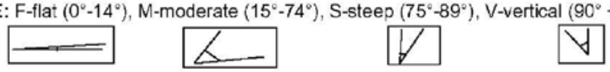
AIMS LONG TERM MONITORING PROGRAM- JUVENILE FIELD DATA SHEET

REEF		SITE		DATE		OBSERVER

	SLOPE -all/5m					
	GENERA	**T1**	**T2**	**T3**	**T4**	**T5**
ACROPORA	Benthic cover					
	Acropora					
	Montipora					
	Astreopora					
PORITIDAE	*Porites*					
	Alveopora					
	Goniopora					
POCILLOI	*Pocillopora*					
	Seriatopora					
	Stylophora					
FAVIIDAE	*Australogyra*					
	Barabattoia					
	Caulastrea					
	Cyphastrea					
	Diploastrea					
	Echinopora					
	Favia					
	Favites					
	Goniastrea					
	Platygyra					
	Leptastrea					
	Leptoria					
	Montastrea					
	Moseleya					
	Oulophyllia					
	Plesiastrea					
MUSSIDAE	*Acanthastrea*					
	Lobophyllia					
	Symphyllia					
	Cynarina					
	Scolymia					

	COMPLEXITY					
	GENERA	**T1**	**T2**	**T3**	**T4**	**T5**
PECTINIDAE	*Echinophyllia*					
	Oxypora					
	Mycedium					
	Pectina					
MERULINIDAE	*Hydnophora*					
	Merulina					
	Scapophyllia					
	Paraclavarina					
FUNGIIDAE	*Fungia*					
	Cantharellus					
	Ctenactis					
	Heliofungia					
	Herpolitha					
	Podabacia					
	Polyphillia					
	Sandalolitha					
AGARICIIDAE	*Pavona*					
	Leptoseris					
	Gardineroseris					
	Coeloseris					
	Pachyseris					
SIDERAST	*Coscinareea*					
	Psammocora					
	Pseudosid.					
EUPHYLLI	*Euphyllia*					
	Physogyra					
	Pleurogyra					
ASTRO	*Palauastrea*					
	Stylocoeniella					
	Galaxea					
	Turbinaria					
	Scleractinian					
	NOTES:					

SLOPE: F-flat (0°-14°), M-moderate (15°-74°), S-steep (75°-89°), V-vertical (90° +), B-broken



COMPLEXITY (L-low, M- medium, H- high)

Benthic cover = all things occupying the space where juveniles can't settle (sand, SC, HC, MA, AC-algal assemblages)