AGRRA METHODOLOGY v. 4.0, June 2005

(Revision by Philip Kramer, Judith Lang, Kenneth Marks, Rodrigo Garza-Pérez & Robert Ginsburg**)**

EQUIPMENT

The following equipment is required for each diver in addition to basic snorkeling gear and SCUBA gear (including depth gauge):

*Note: If you normally use prescription lenses to correct your vision, it is **very important** to have a diving mask with the correct prescription lenses. Otherwise you may not be able to distinguish some important details while doing the surveys.*

Stony corals, Algae, and *Diadema*:

- Underwater datasheets.
  Attach the datasheets onto a clipboard, underwater slate or writing cylinder (see below). The Appendix has an example of the AGRRA benthos datasheet template. You can photocopy the data template onto both sides of white underwater Duracopy paper (boxes of 100 sheets, contact J.L. Darling Corporation, phone: (253) 922-5000, fax: (253) 922-5300; address: 2614 Pacific Hwy East, Tacoma, WA 98424-1017). The paper is expensive (about $55.00 U.S./100 sheets), but data are more likely to be entered correctly since the template is reproduced on every data sheet. Use rubber bands and/or clips to fasten the datasheets to a letter-size clipboard. Also you will find in the Appendix an enlarged version of the datasheet for people with vision problems and/or writing difficulties.

- A 10-m long transect line.
  A 10-m polypropylene line marked at 1 m intervals (with cables-ties, electrical tape or permanent ink) to which a small dive weight has been attached at each end. Or, whenever available, use a lead-core (Duraflex) weighted line. Please ask your local fishing supplies store/company; if they have it, they should know what it is.

- A 1-m long measuring pole.
  A 1-m long PVC pipe (~ ½ ” diameter) marked in 10-cm intervals.

- A 25 x 25 cm quadrat (25 cm inner diameter)
  Construct quadrats by gluing together ¼’ or ½" PVC water pipe and elbows and drill two holes on each side to let the air out.

- A small plastic ruler tied to the clipboard, slate or writing cylinder or attached to your wrist with a series of interconnected rubber bands. Trim the ruler to have a narrow, tapered point, but still be legible, at the basal 5 cm.

  For convenience, wrap the transect line tightly around the quadrat; insert the meter pole and datasheet down the center between the line. Please consult the **Appendix** for the pictures of the gear.

Fish

- Underwater datasheets.
  Attach the datasheet onto a clipboard, underwater slate or writing cylinder (see below). The Appendix has an example of the AGRRA fish datasheet template. Datasheets for REEF rover diver surveys are available for $0.60/page by ordering from REEF at (305) 451-0312.

- Transect tape and weight.
  A 30-m fiberglass transect tape with a 2-3 lb weight attached at one end of the line. Commercially available PVC surveying tapes are suitable for the transect line. A clip can be attached to the reel and suspended from the diver’s belt, which allows for the tape to deploy freely as the diver swims.

- A graduated T-bar or other measuring device (for fish density counts).
  Construct a T-bar using ½" diameter PVC pipe and a T connector (available at hardware stores). It has a 60 cm long handle and two equal-length arms providing a total width across the top of 1 m. Paint a scale along the arms showing 10-cm increments. The slate can be mounted on the T-bar to facilitate carrying the equipment. (See Apendix for details).

Writing cylinders

A writing cylinder is a "thick walled" (1/4" thick) PVC pipe that is 4" in internal diameter by ~18 cm long, with 3 holes drilled near one end through which surgical tubing is strung to fit over your wrist. The advantage is that it keeps hands free to hold other surveying equipment and to hold on in strong surge or waves. A datasheet is attached to the outside of the cylinder with tape.

SELECTION OF REEFS AND SITES

For the purposes of AGRRA, a **REGION** is defined as the coarsest scale category (~100-1000 km scale); followed by an **AREA** (~10-100 km scale); a **REEF** (~1-10 km scale); and a **SITE** (0.2 km scale). We recognize that reefs vary greatly in size, complexity, depth, profile, and coverage per km of coastline throughout the region. What follows are our recommended procedures for selecting survey sites, however we fully understand that it may be necessary to modify these procedures to accommodate the special conditions of each large-scale assessment. It is vital for the success of AGRRA that these procedures must be followed as closely as possible, and that all modifications to them be carefully noted when the data are compiled.

Reef Selection

The method for selection of REEFS to assess will be influenced in part by their abundance and distribution in your area and the amount of sampling effort to be undertaken. For most AGRRA surveys, the goal is to characterize the REEFS within a particular AREA (e.g., the sampling domain). Therefore, it is suggested that the limits of the AREA be delineated using either pre-defined biogeographic divisions (seascapes) or natural geography (island, atoll, bank, etc.). If the extent and/or number of REEFS (e.g., fringing, patch, barrier) within your AREA is so limited that they can all be assessed in a reasonable time frame there is no problem. However, if the extent, number and/or habitat complexity of REEFS are large, then they should be subdivided or "stratified" and representative examples randomly selected from each subdivision (e.g., the apples, oranges and bananas approach).

The most obvious stratifiers are geomorphic characteristics of reef habitats that are influenced by cross-shelf position, orientation, depth, slope, etc. When choosing reef habitats to survey, try to avoid hard-grounds, pavements and other habitats that lack a framework constructed of reef-building corals. Two of the most ubiquitous and important zones within typical fringing or bank-margin Caribbean reefs are the 1-5 m depth interval (shallow *Acropora palmata* zone of the seaward reef crest) and in the 8-15 m depth interval (shallow fore-reef of maximum coral growth). Beyond these general zones and depth intervals, it is up to the assessors to determine if additional reef types such as lagoonal patch reefs should be included in the survey. The Millenium Coral Reef Mapping Project (http://imars.usf.edu/corals/) has recently completed geomorphic reef classification of most areas around the western Atlantic based on the analysis of Lansat-7 images. The Millenium maps provide a first-order delineation of the extent of different reef types and generally identify constructional reef crests and reef slopes. For each REEF type that is chosen, you should try to survey one SITE within each chosen depth interval, whenever both habitats are present–even if most of the *A, palmata* in the reef crest are dead and/or their colony borders are unclear-in which case substitute point counts for individual-coral assessment as described below.

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Site Selection

A SITE is defined as an area of habitat that is more or less homogeneous and accessible from a boat anchored or moored in one place. Spatially, a SITE is roughly a 200m x 200m square unit. Once reefs are stratified, the idea is to either select representative SITES based on local knowledge (strategic) or to select SITES randomly (unbiased). For the latter method, give each reef within a subdivision a number and use a random method to select the ones to assess. If there are no clear bases for making subdivisions (e.g., in a continuous bank-barrier or fringing reef several kilometers long), then SITES should be located using a

grid superimposed over the sampling AREA following the generalized random tessellation sampling (GRTS) approach. Sampling units (generally hexagons or squares) can be generated using a variety of ESRI Arc-View GIS extensions. An ESRI extension called SPOT originally created for MARXAN conservation planning is well suited for this type of hexagon generation. The size and number of units should be adjusted in size to the number of SITES that will be surveyed (effort) for each reef type (stratum). Random SITES can be determined within each sampling unit using Arc-View extension Random Point Generator available from www.esri.com. It is suggested that 2 alternative SITES also be generated within each sampling unit in case the primary SITE is determined unsuitable (for example, the bottom type is misclassified or the SITE is too dangerous to survey).

Depending on the methods and resources available for your use, REEFS that are selected will generally fall into one of three categories:

1. Unbiased- chosen based on a random sampling strategy;
2. Strategic- chosen with local knowledge because they are threatened, suspected to be degraded, or in particularly good condition.

It is critical that the exact location of the actual survey be recorded using a GPS. In cases where the survey takes place immediately below an anchored boat, simply record the position of the boat once its position has stabilized. If the survey will occur some distance from the boat (typically the case when surveying a reef crest), note the distance and direction from the recorded GPS position so that the position can be corrected later.

CORALS, ALGAE AND *DIADEMA*

1. At each SITE, record the following information on your UW datasheet **before** each dive. (We strongly suggest that **each** team member fills in every category.)
    - Name of recorder as a four letter code (use the first two letters each of your first and last names);
    - Date as day with two digits/abbreviation of month/year with two digits;
    - Site Name (= local site name);
    - Day Number (if during an expedition);
    - Site Number for that day;
    - Latitude;
    - Longitude;
    - AGRRA location code as a three letter + three digit code (Use three letters from the name of the reef/expedition and number consecutively from 001 up to as many sites as are evaluated at that reef/during that expedition, e.g., sites at Little Island could be called LIS001, LIS002, LIS003, and so on);
    - Reef Type (e.g., fringing, bank, atoll, patch)**;**
    - How selected? (e.g., stratified random, stratified strategic);
    - Reef Zone/Habitat (e.g., reef crest, reef front, spur and groove, bommies, platform, etc.).

2. In Time Start, record the time at which you start the first transect.
   Haphazardly lay the 10-m transect line just above the reef surface. Make sure the line is taut. (*Remember to complete the **Site Description** as described above)***.***

   Note: Be sure to avoid and don't cross any other transects that are being set by your companions. Stay away from the edges of the reef. Also try to avoid areas with abrupt changes in slope, deep grooves, large patches of sand or unconsolidated coral rubble. You want to place the transect in areas where corals are likely to grow, but once you are in an appropriate spot, don't bias your selection: instead swim without looking down at the bottom as you unreel the line. Unusual reef features should only be included to the extent appropriate to their relative abundance at the site.

The benthos survey can be made in three "passes" of the transect line as follows:

First pass:

3. Using the 1-m measuring pole for scale, swim a belt transect along the 10-m line. As you go, straighten any conspicuous kinks in the transect line. Count every "juvenile" and "adult" *Diadema* (juvenile and adult) that you can see within 1/2 m of each side of the transect line. Consider as *juvenile* all those *Diadema* that still show the black and white banded pattern on the spines. (Ignore all other species of sea urchins.) Count also any spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*) and note their numbers in General Comments. (For the latter you may need to temporarily turn over shells that are upside-down to look for a living animal.) Because *Diadema* and *Panulirus* are cryptic, you must inspect all shelter-providing spaces along the line, so be prepared to poke your head under the bases of large corals or into crevices.

Second pass:

4. As you swim from one end of the transect line to the other, assess the cover, size and condition of each stony coral that is 10 cm in length or greater and for which any live or dead part of its skeleton underlies the transect line:
    a. Identify the species (scleractinians, *Millepora complanata*, *M. squarrosa*, colonies of *M. alcicornis* that are encrusting other stony corals or the substratum + bases only of colonies that are encrusting gorgonians). Include all entirely dead colonies that can be identified at least to genus.

    b. Measure the live tissue cover of the colony under the line (cm) as if seen in a photograph, from above in planar view. Record to the nearest cm for smaller corals (up to 50-100 cm) and to the nearest 5 cm for larger (>100 cm) corals.

    c. Measure the x, y, z dimensions of the colony with the 1m pole: *i.e.* the **maximum length (x)** and the **maximum width (y)** of the outward-facing colony surface (both perpendicular to the axis of growth) as seen from above in planar view, and the **maximum height (z)** (parallel to the axis of growth) as seen from the side of the colony. Record these measurements to the nearest cm for smaller corals (up to 25 cm) and to the nearest 5 cm for larger corals. (Exact size measurements are less critical here since the colonies are later grouped into size classes for comparative analyses).

    Note: Colony boundaries can be difficult to recognize when parts of the coral have died and are overgrown by other organisms–particularly other colonies of the same species. Look for connected live tissues, connected skeletal deposits above a common base, and at the size and color of separated polyps.

    Colonies derived from new recruits:
    1) *Live tissue, generally concentric with clear edge boundaries. Often have a raised "lip" at edges approximately 1-2 mm above underlying substrate/old dead coral.*
    2) *Upward growth, branching evident.*
    3) *Underlying substrate is very old dead.*

    Colonies derived from resheeting:
    1) *Live, often with preferred growth in one direction, edges on at least one side often "merge" with underlying substrate/dead coral.*
    2) *Live tissue rarely displays upwards growth (branching) except at tips.*

    d. Estimate the partial mortality (old and recent) of the colony surface from a planar view perpendicular to the axis of growth. Try to round your percentage to the nearest 5% unless it is very small or very large, in which case try to round to the nearest whole number (e.g., 1%,

97%). Although most colonies have some dead areas, 0% is recorded whenever these are restricted to the sides or bases and not visible when the outward-facing colony surface is viewed from above.

"Old dead" is defined as any non-living parts of the coral in which the corallite structures are either gone or covered over by organisms that are not easily removed (certain algae and invertebrates). If it is entirely "old dead", indicate this on your data sheet as 100% "old death", as long as you can identify it to either to the species (e.g., *Acropora palmata* by gross morphology*; Montastraea cavernosa* by polyp size and shape) or to the genus (e.g., *Diploria* by size of meandering ridges and valleys).

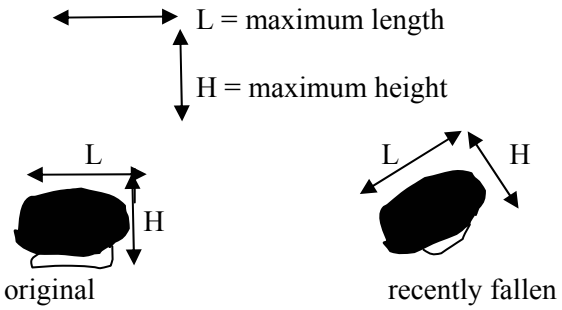
Note: In some cases, a coral may be partially or completely overgrown by one of the species of brown, zooxanthellate clionid sponges. If you look closely you will observe the in/ex- current holes of the sponge and sponge tissue instead of live coral polyps. If you can see the coral skeleton beneath the sponge, and are able to identify it to genus or even species, include the affected area in your estimate of "old death" and note "Cliona overgrowth" in the corresponding Comments box.

"Recently dead" is defined as any non-living parts of the coral in which the corallite structures are either white and still intact or slightly eroded but identifiable to species. Recently dead skeletons may be covered by sediment or a thin layer of turf algae.

Note: In some cases circular or oblong lesions or excavations caused by fish biting may result in destruction of the corallites. If fish bites are identifiable and constitute part of the mortality, include the affected area in your estimate of "recent death."

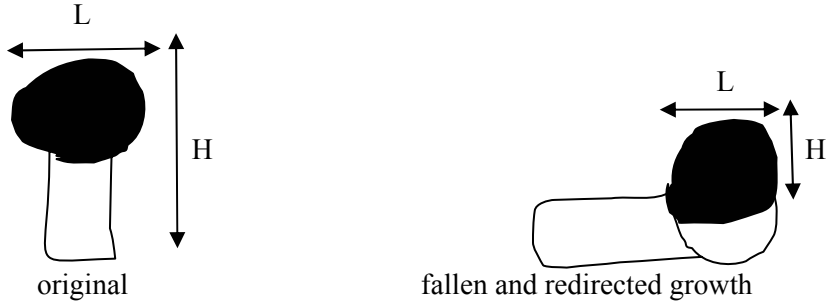
Note: How to assess corals that are detached from the substratum:

*i. If it has **recently fallen**, the length, height and % mortality should be measured as if it were still upright; write "fallen" in comments box.*



*ii. **A detached but wedged coral** should be marked as "wedged" in the comments section (as it is likely to remain in this position for an extended period).*

*iii. If it has been fallen for long enough to have **reoriented to grow upward** in its new position, the "new" maximum length and maximum width should be measured, and the new outward-facing surface used for calculating % mortality.*



e. Scan over the surviving portions of the ENTIRE coral colony for any DISEASES and/or BLEACHED tissues present.

Characterize any DISEASES by the following color categories:

BB = Black band
WB = White band *(Acropora* only)
WS = White patches/white pox/patchy necrosis *(Acropora* only)
WP = White plague
YB = Yellow-band/yellow-blotch
RB = Red band
UK = Unknown

For more information about coral diseases see:
Bruckner (2002) Appendix II Coral Health and Mortality. Recognizing the signs of coral diseases and predators. Pp. 240-278 in P. Humann, ed., Reef Coral Identification. New World Publications, Inc.);
or one of the following web sites:
http://www.unep-wcmc.org/marine/coraldis/cd/index.htm
http://www.coral.noaa.gov/coral_disease/

Characterize any BLEACHED tissues as approximate severity of discoloration:

P = Pale (discoloration of coral tissue)
PB = Partly Bleached (patches of fully bleached or white tissue)
BL = Bleached (tissue is totally white, no zooxanthallae visible)

Many severely bleached corals are translucent, but you can still see the polyp tissues above the skeleton. Bleached tissues should not be included with the "recently dead" estimates.

Note: It is important to be able to differentiate between tissues that are alive but look white because they are bleached and white, recently dead skeletons.

f. If present, record in the appropriate column the presence of any damselfish algal gardens and the number of territorial gardening damselfish [*Stegastes diencaeus* (longfin), *S. fuscus* (dusky), *S. planifrons* (threespot), or *S. variabilis* (cocoa)] associated with the coral. (You may have to wait a couple of seconds to let the fish come back or pop-up from hiding after assessing the coral.) Ignore any herbivorous *Microspathodon chrysurus* (yellowtail), which are surveyed during the fish transects, and the planktivorous *Stegastes partitus* (bicolor).

g. Record any other sources of recent mortality that can still be unambiguously identified. Possibilities include sediments, storm damage, parrotfish bites, predation on the soft tissues by snails like *Corallophilia abbreviata* or the bristle worm *Hermodice carunculata*, various effects of adjacent benthic macroalgae or sediment-bound algal turfs, and any other spatial competitors (e.g., zoanthids like *Palythoa caribeorum* and *Zoanthus* spp., encrusting gorgonians as *Briareum asbestinum* and *Erythropodium caribaeorum*, tunicates like *Trididemnum solidum* and *Didemnum vanderhorsti,* or other stony corals).

How to assess large clusters or thickets in which colony boundaries are not distinguishable:
Write "Point Counts" in the Comments box. Measure the total live coral intercept length, maximum length, maximum width and maximum height for the clump as a whole. Using the 1-m pole for scale, in the Comments box, record the condition of the points at 10 cm intervals along the transect line as # live (L), # recently dead (RD), and # old dead (OD) (i.e., 9L, 1RD, 3OD = nine points that were alive, one that was recently dead and three that were old dead). Record any signs of disease, bleaching overgrowth, etc., for the clump as a whole.

5. As you advance along the transect measure, and write down, the cover under the line of each of the following:

   Sand (only loose and deep enough to prevent coral larvae from settling);
   Live Coral (for colonies that are < 10 cm in length);
   Crustose Coralline Algae;
   Fleshy Macroalgae;
   Calcareous Macroalgae;
   Other Sessile Benthic Animals *(i.e.,* any gorgonians, sponges, zoanthids, tunicates, etc.).

   There is space on the datasheet for separate measurements as each is encountered; the totals for each category can be calculated after the dive. Do **not** measure the cover of algal turfs or "barren" areas of dead corals, rubble, hardbottoms or pavements.

Third pass:

6. Re-swim the line with the 25 X 25 cm quadrat and the 1-m pole. Starting at the 1-m mark, place the quadrat every two meters directly below the meter mark on the transect line.

   a. For each quadrat, record each of the following:

      Substratum–as pavement (pv), live coral (lc), dead coral (dc), rubble (rb) or sand (sn);

      Fleshy Macroalgal Height–approximate their average canopy height with the plastic ruler;

      Calcareous Macroalgal Height–approximate their average canopy height with the plastic ruler;

      "Recruits"–the number of all small (up to 2 cm maximum diameter) stony corals (scleractinians and *Millepora*) in the quadrat. Identify any as you can to the genus or species level.

   If there are no fleshy and/or calcareous macroalgae within the quadrat (as may occur when the 1-, 3-, 5-, 7- or 9- m mark is in the middle of a large, live coral or a sand patch), measure their average canopy heights at the closest point under the line in which they occur as you continue along the transect.

   b. Maximum Reef Relief within a 1m radius of the 1-, 3-, 5-, 7-, and 9- m marks along the transect line, measure the height of the tallest coral or reef rock above the lowest point in the underlying substratum.

   c. If you can identify the most common macroalgae in the quadrats, write their names in General Comments.

7. After you complete a transect, collect the line and haphazardly reset the next transect line, **at least** 2 m laterally away from its previous position. Remember to avoid other lines, and whenever possible, abrupt changes in slope, large areas of sand and rubble, and any other unusual reef features. Try to ensure that the transect lines are distributed around the SITE, and not concentrated close together.

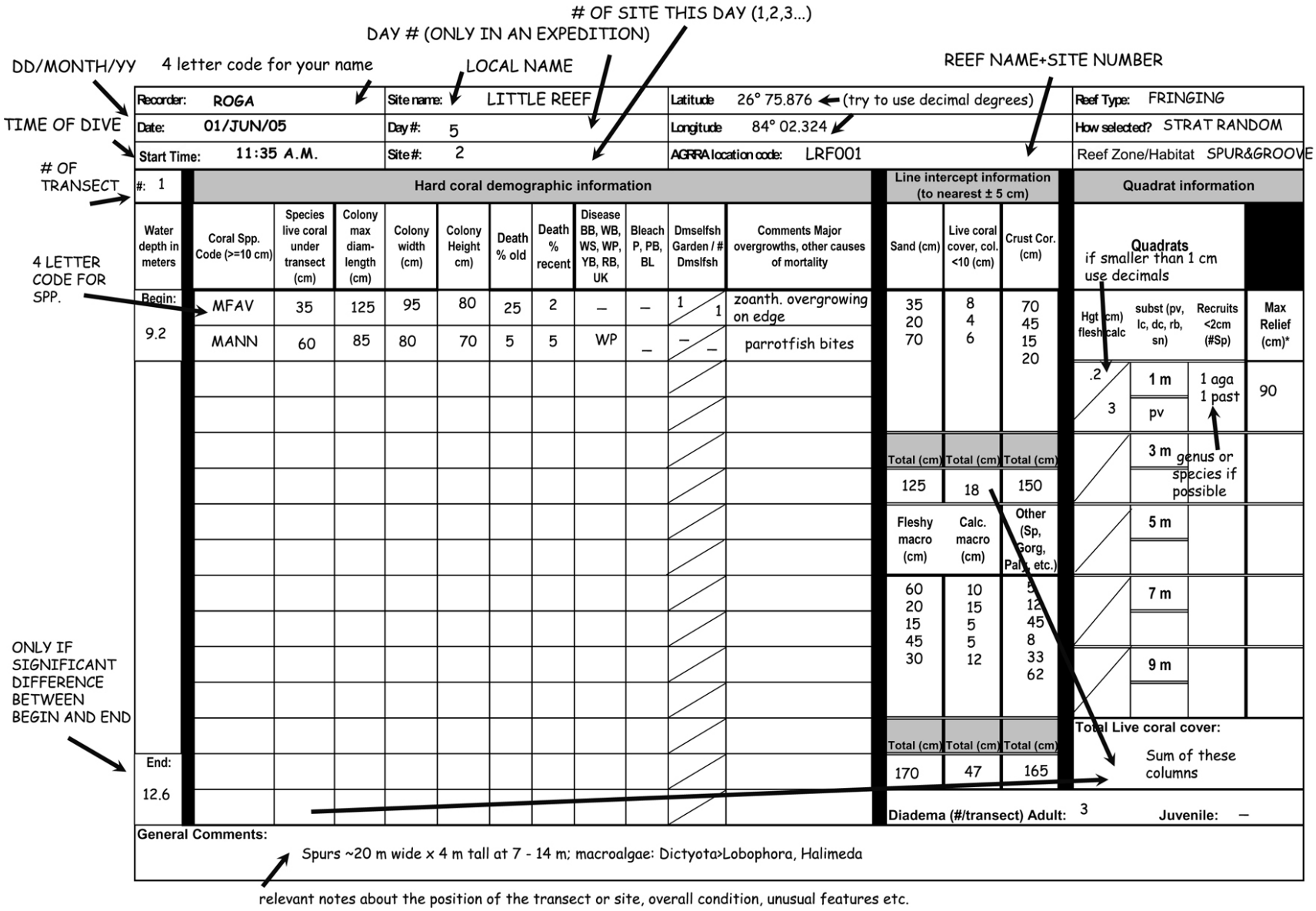
8. Repeat the above steps for each transect.

9. Continue to reset transects in new positions until there are a minimum of 6 transects per SITE. Although appropriate sample sizes will depend on the variance in the local habitats, hence we cannot prescribe "a one size fits all protocol," a minimum of 30 quadrats and 50 corals that are ≥10 cm should be assessed at each SITE

   Note: If coral density is unusually low, be sure that you are working on a reef rather than in a scattered assemblage of corals on a pavement or hardbottom.

10. After surveying, enter your data into a copy of the provided AGRRA spreadsheet in Microsoft Excel. (Be sure to use a separate copy of the spreadsheet for every SITE.) Please check your data to verify its accuracy, then submit an electronic copy to the AGRRA database. Back up your own data regularly and store it in a safe place.

Note: Please examine carefully the example of the datasheet below, and make sure you understand the instructions on how to fill in all the cells in the form.


OF SITE THIS DAY (1,2,3...)
DAY # (ONLY IN AN EXPEDITION)
DD/MONTH/YY
4 letter code for your name
LOCAL NAME
REEF NAME+SITE NUMBER
TIME OF DIVE
OF TRANSECT
4 LETTER CODE FOR SPP.
ONLY IF SIGNIFICANT DIFFERENCE BETWEEN BEGIN AND END
Recorder: ROGA
Site name: LITTLE REEF
Latitude 26° 75.876 (try to use decimal degrees)
Reef Type: FRINGING
Date: 01/JUN/05
Day #: 5
Longitude 84° 02.324
How selected? STRAT RANDOM
Start Time: 11:35 A.M.
Site #: 2
AGRRA location code: LRF001
Reef Zone/Habitat SPUR&GROOVE
#: 1
Hard coral demographic information
Line intercept information (to nearest ± 5 cm)
Quadrat information
Water depth in meters
Coral Spp. Code (>=10 cm)
Species live coral under transect (cm)
Colony max diam-length (cm)
Colony width (cm)
Colony Height cm)
Death % old
Death % recent
Disease BB, WB, WS, WP, YB, RB, UK
Bleach P, PB, BL
Dmselfsh Garden / # Dmslfsh
Comments Major overgrowths, other causes of mortality
Sand (cm)
Live coral cover, col. <10 (cm)
Crust Cor. (cm)
Quadrats if smaller than 1 cm use decimals
Hgt (cm) flesh/calc
subst (pv, lc, dc, rb, sn)
Recruits <2cm (#Sp)
Max Relief (cm)*
Begin:
9.2
MFAV 35 125 95 80 25 2 – – 1/1 zoanth. overgrowing on edge
35 20 70
8 4 6
70 45 15 20
.2/3
1 m
pv
1 aga 1 past
90
MANN 60 85 80 70 5 5 WP – –/– parrotfish bites
3 m
genus or species if possible
Total (cm) Total (cm) Total (cm)
125 18 150
5 m
Fleshy macro (cm)
Calc. macro (cm)
Other (Sp, Gorg, Palyt, etc.)
60 20 15 45 30
10 15 5 5 12
5 12 45 8 33 62
7 m
9 m
Total (cm) Total (cm) Total (cm)
End:
12.6
170 47 165
Total Live coral cover:
Sum of these columns
Diadema (#/transect) Adult: 3 Juvenile: –
General Comments:
Spurs ~20 m wide x 4 m tall at 7 - 14 m; macroalgae: Dictyota>Lobophora, Halimeda
relevant notes about the position of the transect or site, overall condition, unusual features etc.

CORAL REEF FISHES

The AGRRA protocol for fishes includes two distinct methods that should both be applied at each site. All transects used for fish assessment should be located within the same habitats and depth intervals used for the benthic assessment (see Site Selection). Transects for fish will tend to be further apart, and may range deeper and shallower, than transects for benthic organisms. The integration of fish and benthic sampling, while beneficial, will require close coordination among team members for the two parts. It is recommended that the fish observations be conducted between 1000 and 1400 hours if at all possible, when visibility underwater is at a maximum due to overhead sunlight. Many fishes are wary of humans, hence it is necessary to try to keep away from other people while making these observations.

Method I: Belt transect counts for defined species list.

1. For each transect, record the following information in the same fashion as explained in the coral section: your name (four letter code), date, time of start of transect, site name, site number, latitude and longitude, transect # on the UW datasheet.

2. Swim a 30-m transect line by first placing the weighted end of the line on the bottom (fix to some crevice or rock, so it won't drag when the reel stops), and then swimming in a straight line while releasing it from the reel as you count the fish. This minimizes the disturbance to the fishes prior to their being counted. Periodically fixing on an object in the distance as you swim will help you swim in a straight line. (You can clip the transect tape to your weight belt to allow for easy release of the tape).

3. As you swim out the full 30 m transect line, count and record fish found within a visually estimated belt transect that is 2-m wide and extends up to the water surface. Use a 1-m wide T-bar to ensure accurate monitoring of the 2-m wide belt. Hold the T-bar ahead of you angled downward at about 45 degrees, and try to focus your gaze on the several meters of the transect ahead of the T-bar. Count only the species listed below and do not count juvenile parrotfishes or grunts that are less than 5 cm in total length. This list of species has been chosen to provide coverage of a number of the species most likely to be affected by human impacts, while preserving a relatively consistent search image to enhance the precision of transect data.

   AGRRA Fishes–unless otherwise noted below, include **every species** within each of the following families:

   Acanthuridae (Surgeonfish) **ALL** (e.g., *Acanthurus bahianus, A. chirurgus, A. coeruleus*);
   Balistidae (Triggerfish) **ONLY** *Balistes vetula* (queen triggerfish), *B. capriscus* (gray triggerfish), *Melichthys niger* (black durgon), *Aluterus scriptus* (scrawled filefish), *Cantherhines pullus* (orangespotted filefish), *C. macrocerus* (whitespotted filefish);
   Chaetodontidae (Butterflyfish) **ALL** (e.g., *Chaetodon capistratus*);
   Haemulidae (Grunt) **ALL ≥ 5 cm** (e.g., *Haemulon flavolineatum, H. chrysargyreum, H. sciurus, H. plumieri);*
   Lutjanidae (Snapper) **ALL** (e.g., *Lutjanus griseus*, *L. apodus*, *L. mahogoni*, *Ocyurus chrysurus*);
   Pomacanthidae (Angelfish) (e.g., *Pomacanthus paru, P. arcuatus, Holocanthus tricolor*);
   Scaridae (Parrotfish) **ALL ≥ 5 cm** (e.g., *Sparisoma viride, S. aurofrenatum, Scarus taeniopterus, S. vetula*);
   Serranidae (Groupers), **ONLY** *Epinephelus* spp. and *Mycteroperca* spp. (e.g., *Epinephelus guttatus, E. fulvus, E. striatus, Mycteroperca bonaci*).

Also count each of the following five species:

Bodianus rufus (Spanish hogfish)
Caranx rubber (Bar jack)
Lachnolaimus maximus (Hogfish)
Microspathodon chrysurus (Yellowtail damselfish)
Sphyraena barracuda (Barracuda)

4. Estimate the size of each fish with the 5-cm increments on the 1 m T-bar, and assign them to the following size categories: <5 cm (excepting acanthurids and scarids); 5-10 cm; 10-20 cm; 20-30 cm; 30-40 cm; >40 cm. Large groups of individuals of a species will be classified by attempting to put them into one or more size categories as necessary. By remembering to keep effort equivalent on all segments of the transect, you can limit the tendency to count all members of a school crossing the transect, instead of just those members which happen to be within the transect as counting of that segment takes place.

   Note: Sample the transect belt giving uniform attention to each successive 2-m segment. This requires swimming at a more or less constant rate, while looking consistently about 2 m ahead of your current position. You may pause while recording data, and then start swimming again. It is important to swim in a uniform manner. A speed that covers each 30-m transect in 6-8 minutes should be attempted. High densities of counted species will slow this rate in some cases. Fish observers should be trained to estimate fish lengths by using consistency training methods both on land and underwater.

5. When you reach the end of the transect line, stop the survey and recoil the transect tape.

6. Continue conducting haphazardly-positioned 30 m transects at least 5 m laterally away from the previous position. Repeat the above steps for each transect.

7. Conduct a minimum of ten (10) transects at each site.

Modifications: Some workers may want to census other species of fish. This is encouraged, provided that these other species are counted on a **separate** pass in the same area, after the AGRRA run. Otherwise the census method is substantially changed, and your data may not be directly cross-comparable with other AGRRA assessments.

Method II. Rover Diver census

After finishing the belt transects (or concurrently depending on the number of surveyors), conduct a roving diver census of **all species** of fishes following the methodology of Reef Environmental Education Foundation (REEF) (http://www.reef.org/) and briefly explained below.

1. The Rover diver census is conducted in the same general area as the belt transects are set.

2. Swim around the reef site for approximately 30 minutes (preferably 45-60 min) and record ALL fish species observed. Use all knowledge you have of fish habits, and search under overhangs, in caves, and so on. The objective is to find the maximum number of species that you can in during your search time.

3. Estimate the density of each species by using logarithmic categories: Single (1fish), Few (2-10 fishes), Many (11-100 fishes), or Abundant (>100 fishes).

4. Record your observations on the standardized REEF data entry sheet.

5. Submit data to REEF database.

OPTIONAL COMPONENTS

Several other useful assessments may be easily integrated into the core portion of the protocol given above. These optional components, while not part of the core methods, can yield additional information that may lead to a better understanding of the condition of a reef. These optional components include coral recruitment (additional sampling effort) and fish bites.

Coral Recruitment: Coral recruitment is an important indicator of a reef's regeneration potential and is now incorporated into the standard AGGRA protocol. If you would like to increase your sample size of coral recruits, we suggest the following:

Method:

1. After you have completed your 6 standard benthic transects (you may plan an extra dive at the same location for this procedure), lay a set of 10 haphazard transects, placing the 25 x 25 cm quadrat on the substratum right below each of the odd meter marks (1,3,5,7,9). The objective is to assess 50 extra quadrats for a minimum sample size of 80 quadrats (30 from the first 6 transects + 50 from the extra 10 transects), which equals an area of 5 sq. meters.
2. Count all small (maximum diameter 2 cm), stony corals (scleractinians and *Millepora*) that you can see within the 25 X 25 cm quadrats.
3. Whenever possible, record their scientific names at least to the level of genus.
4. Try to repeat for a total of at least 80 quadrats (an overall sample of 5 square meters of reef surface).

Note: Proper training and good eyesight (or corrective lenses) are essential to accurately detect the presence of small corals due to their inconspicuous size and nature.

Herbivory

The objective of the Fish Bite Method (Steneck 1985) is to gauge the effect of herbivorous fishes on algal composition by quantifying their level of herbivory. Fish herbivory is assessed by counting the observed number of bites per square meter of different guilds of herbivorous fishes, which are categorized as:

Scrapers = Scaridae (parrotfish)
Browsers = Acanthuridae (surgeonfish), *Microspathodon chrysurus* (yellowtail damselfish)
Non-denuders = other Pomacentridae (damselfish) but not *Stegastes partitus* (bicolor damselfish).

Method:

1. Use the 1 m stick in conjunction with natural landmarks on the reef surface (e.g., a small coral or gorgonian) to haphazardly delineate an area that is approximately 1 m square and representative of the benthic cover on the reef substratum. (Please do not place a meter quadrat to mark your observation area, as some fish are particularly prone to biting novel objects placed within their feeding territories).
2. Back off as far as you can while still seeing the meter square area. Watch for 5 minutes. Record the depth, time of day, and number of bites from all species of fishes in the three guilds listed above (identify them to species as best as you can). Repeat for a total of 5 squares (and ~25 minutes of observation).

Note: You must be able to distinguish (a) juvenile scarids from other fishes with similar stripes, such as acanthurids and labrids (wrasses- which only look as though they are biting algae as they search for amphipods to eat) and (b) yellowtail damselfish (which are browsers) from other species of damselfish (that cultivate algal gardens). Be sure to remember to record the time of day since fish activity varies temporally.

Appendix

How to paint the 1 m sticks:
Cut ½" PVC water pipe into a few 1m long segments.
To build a painting template (Figure 1):

Cut a ¾" PVC water pipe into a 1 m segment, and then cut it in half longitudinally.
Cut ¾" PVC pipe into five 10 cm segments and glue them to the 1 m half pipe segment, spaced exactly 10 cm from each other.

Slide in one of the 1 m ½" segments through the template, matching both ends, one must be covered and the other uncovered.
Apply spray paint to the ½" pipe rotating inside of the template to cover the whole circumference of the pipe.
Let it dry a bit and start again from #3.

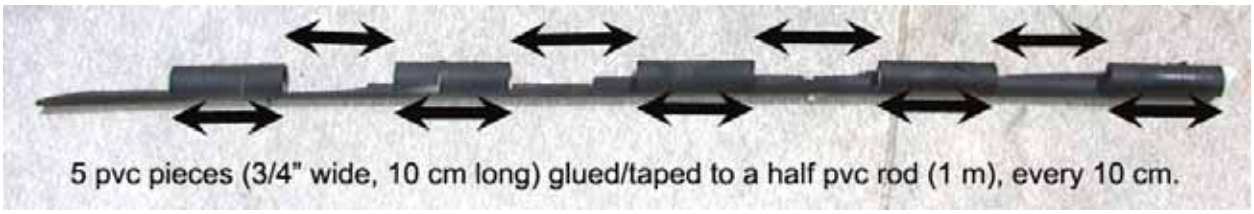


Figure 1. Template for painting 1 m sticks

AGRRA kit for Benthic Survey

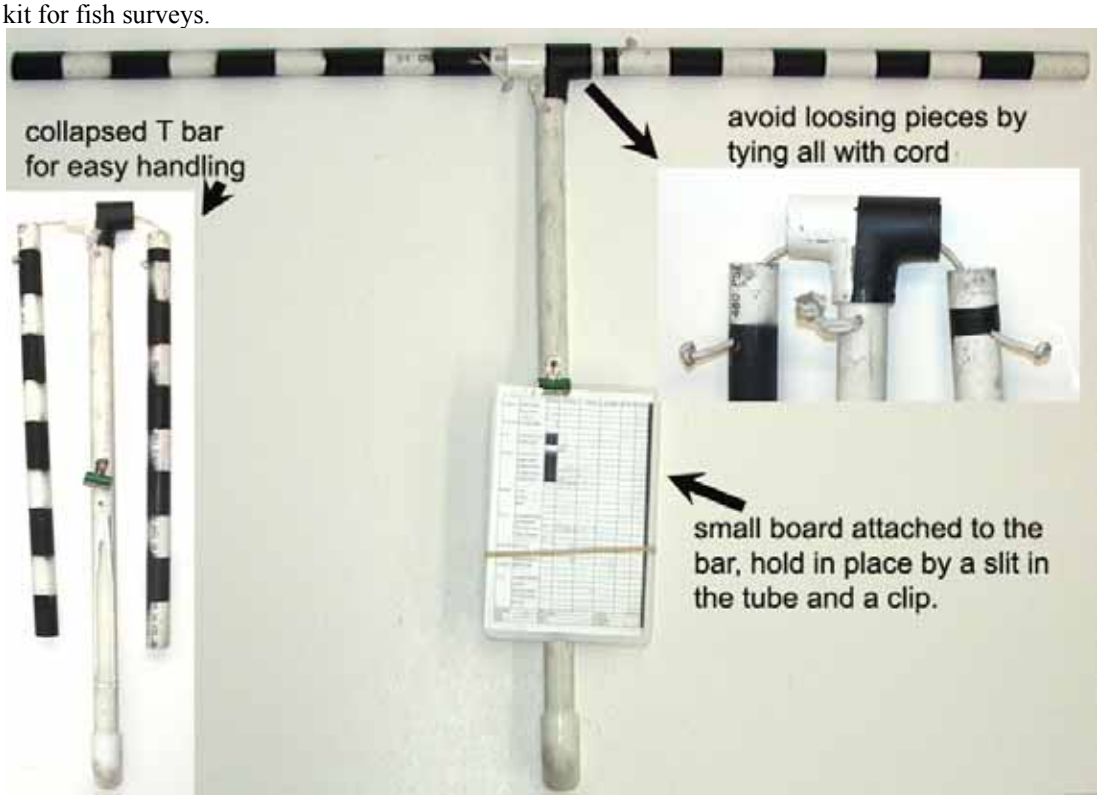
Views of the transect line wrapped tightly around the quadrat, holding the 1 m stick and the clipboard (with rubber bands for securing the benthic datasheets to the clipboard).


(a) front view

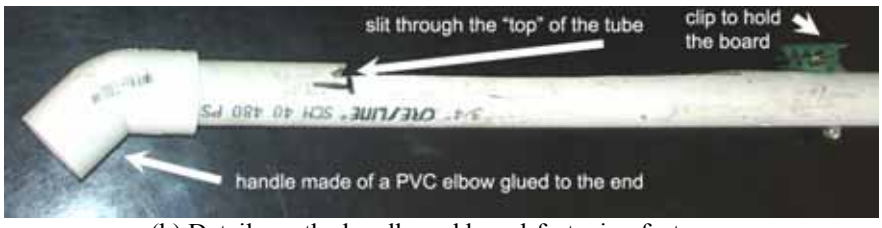

(b) back view

(c) Details of the quadrat: note the holes on the corners to let the air and water out, example of the rubber band leash for rulers and pencils (If available, we recommend PaperMate ® Sharpwriter mechanical pencils).

AGRRA kit for fish surveys.



(a) T-bar with a clip and a slit to hold the half/letter size board, and rubber bands to secure the UW datasheets.



(b) Details on the handle and board-fastening features.

Fish Memory Cues (common AGRRA species)

Angelfishes

21 Queen Angelfish
The Queen has a crown (dark blue spot on forehead ringed with bright blue).

23 French Angelfish
This fashionable French beauty is dressed in classic black (with gold highlights).

25 Gray Angelfish
As its name implies, the Gray is gray to grayish brown.

25 Rock Beauty
This little beauty is yellow and black. The juvenile is bright yellow with a small black spot (ringed in blue). The black spreads as the fish grows covering most of the fish as an adult.

Butterflyfishes

29 Banded Butterflyfish
White with black bands (thick diagonal black markings).

29 Foureye Butterflyfish
Large false “eyespot” on tail.

31 Spotfin Butterflyfish
Small black spot on the rear of the bright yellow dorsal fin.

31 Reef Butterflyfish
Uncommon – identification by process of elimination (no good memory clue).

33 Longsnout Butterflyfish
Tiny fish with long pointy snout (as name implies). Usually found deep.

Surgeonfishes

33 Blue Tang
Blue with contrasting yellow “tang” (spine on base of tail). Juveniles change from all yellow to combination of yellow and blue to all blue as adult.

35 Ocean Surgeonfish
Clear pectoral fin – think “Clear Ocean”. Leading edge of pectoral fin clear to yellowish but never opaque.

37 Doctorfish
Dark pigmented leading edge of pectoral fin – think “Dark Doctor”.

Silvery (Miscellaneous)

45 Bar Jack
Most common jack with black and blue “crowBAR” along back and onto lower tail fin.

65 Great Barracuda
Large, silvery, toothy torpedo. Most divers (and non-divers) know this species.

Grunts

93 French Grunt
Diagonal gold markings like the gold braids worn on a French General's uniform.

93 Bluestriped Grunt
Blue horizontal stripes over yellow body. If pale in shallow water, black rear dorsal and tail fin are good ID cue.

93 Smallmouth Grunt
Small grunt – (Small Mouth). Silvery fish with horizontal yellow lines and yellow fins.

95 White Grunt
All fins white. Body checkered pattern of pearly white, blue & yellow formed by scales. Thin stripes only on head.

95 Caesar Grunt
Silvery with thin yellow lines like raw egg drizzled over a Caesar salad. Dusky rear dorsal, anal, and tail fins like the dusty feet of Caesar's army.

97 Tomtate
Whitish fish with two thin yellow lines (one midbody through eye, the other on back). Usually a black spot at base of tail. Think of a TomTom (a small drum) with the two yellow lines as drum sticks.

97 Cottonwick
Black line from the snout through the eye fades as it reaches the tail. Think of the black cotton wick of a candle. Usually have a black diagonal stripe that runs along the back and onto the tail.

99 Spanish Grunt
Large grunt with horizontal black lines and a yellow saddle on the base of the tail. Think of the fried egg in a Spanish omelette.

101 Sailors Choice
Silvery gray fish with distinctive black spots on scales covering the body; gold ring encircles the eye. Think pirates (who were sailors) with the black spots as rows of waves and the gold ring as an golden earring.

107 Porkfish
Two black diagonal bands on head (one through eye and the other just behind the gills). For pork, think of the bands as two strips of overcooked bacon.

109 Black Margate
The large black patch on the side of this fish makes the Black Margate easy to remember.

109 White Margate
About the size of a Black Margate but without the black patch. Very steep forehead with high back profile. Eye is tiny with white iris.

Snappers

111 Mutton Snapper
This species is easiest to ID if you know that its scientific name is *analis* since it is the only snapper with a pointed (not rounded) anal fin. It usually has a small black spot on the back ("the button on the Mutton") which we can use to remember its common name.

111 Cubera Snapper
This is the largest of the snappers (up to 3'), usually solitary, and often with pale bars across back.

113 Gray Snapper
Gray with no distinguishing features other than a dark diagonal band that occasionally runs from lip across eye.

115 Dog Snapper
Has “teardrop stains” below eye. For the girls we say the fish is crying because it lost its dog; for the guys we go for the more macho memory cue of “dog tags”.

115 Mahogany Snapper
Silvery white fish with “Mahogany” red margin on tail; sometimes reddish tinge on body or other fins.

117 Lane Snapper
Though sometimes faint, this fish has yellow “lane” markers (think highway) along it’s body. It may have a small black spot just below the rear dorsal.

119 Yellowtail Snapper
Bright yellow midbody stripe continues onto yellow tail. Feed in the water column high above reefs.

121 Schoolmaster
Large silvery white fish with all yellow fins.

Damselfishes

133 Yellowtail Damselfish
The only damselfish we need to know and one of the easiest to remember as it has a yellow tail. Juveniles are bright blue with brilliant blue spots. The tail is translucent on very young juveniles.

Groupers/Sea Basses

153 Nassau Grouper
The black saddle is the easiest way to ID this fish. Think “Ride the Nassau Grouper back to the Bahamas”.

157 Graysby
Most common of the smaller groupers. Grayish brown with 3-5 pale or dark spots along back along base of dorsal fin. If you want you can think of “buttons down the vest of the Great Gatsby”.

159 Red Hind
Reddish spots over a lighter background rear fins (rear dorsal, tail, and anal) edged in black. Think “RED with a black beHIND”.

159 Rock Hind
Have a black saddle (and usually additional black blotches along back under the dorsal fin). Think of these spots as “rocks”.

161 Coney
This variable species can be reddish brown, bicolor (upper dark lower pale), or a brilliant yellow so color is not a good ID cue. The body is usually covered with tiny blue spots. One constant is that it has two spots on the lower lip and two on the base of the tail.

163 Black Grouper
Blotches on back squarish. Think “Black Bricks” or “Black Blocks”.

165 Tiger Grouper
Have “tiger-strips” across back. Also have some pretty impressive canine teeth.

167 Yellowmouth Grouper
Corners of the mouth a distinctive yellow. Margins of pectoral fins pale.

169 Yellowfin Grouper
Margins of pectoral fins yellow. Blotches on back are more oval and not squarish like the Black Grouper.

Parrotfishes

195 Blue Parrotfish
Adults are blue with no markings. Juveniles have a yellow wash on the head.

195 Midnight Parrotfish
Dark navy ("midnight") blue with some lighter blue on body (especially on head).

197 Rainbow Parrotfish
"Rainbow" colored with orangish head and tail and bright green rear body.

197 Queen Parrotfish
TP: Queen has a moustache and beard (blue/green markings around mouth).
IP: Black and white like a chess board.

199 Stoplight Parrotfish
JP & IP: Bright red belly (like a stoplight).
TP: Small yellow spot at top of gill cover. (Like the yellow light in a middle of a traffic light?)

199 Princess Parrotfish
TP: Tail bordered with pink. Think "Pink Princess".
JP: Looks like the Striped Parrotfish juvenile but doesn't have a gold nose. Think "The Princess has no gold".

201 Striped Parrotfish
TP: The tail is not bordered in blue (not pink like the "Pink Princess").
JP: The Princess Parrotfish may be royalty but it is the Striped that has the gold (on its nose).

203 Redband Parrotfish
Exceedingly variable parrotfish. Only the TP have the namesake "redband" across the cheek. In all of the other JP/IP color variations, look for the white spot (saddle) on the base of the tail.

205 Redtail Parrotfish
TP: Red crescent in the middle of the tail.
IP: Red tail (and body) – mostly reddish gray can be pale.

205 Redfin Parrotfish
Also known as Yellowtail Parrotfish. Name comes from small reddish spot at base of pectoral fin but yellow tail is usually more visible. I always remember this fish by both of its names when I see it and think "yellowtail => redfin".

209 Greenblotch Parrotfish
Tiny parrotfish named Greenblotch for the green blotch on the side of the TP. The JP/IP are usually red to yellowish red. All phases have a bright yellow-gold to red iris.

Hogfishes

213 Hogfish
The spiky front dorsal finare like the bristles on the back of a razorback hog.

213 Spanish Hogfish
Think of the purple area across the top of the body as stain from a bottle of Spanish wine.

Leatherjackets (Triggerfishes & Filefishes)

395 Queen Triggerfish
The Queen is long eyelashes (the black lines radiating from the eyes) but like the Queen Parrotfish, she has a blue moustache.

397 Ocean Triggerfish
Uniformly gray and usually swimming high in the water column. Has a black spot at base of pectoral fin.

399 Black Durgon
Usually black overall (with pale bluish white lines along base of dorsal and anal fins. Can have a bluish or greenish cast.

401 Whitespotted Filefish
Large orange, brown and gray colored fish often with large white spots. Commonly seen in pairs with one fish showing spots, the other without. Pair of orange spines at tail base.

403 Orangespotted Filefish
Dusky brownish color with small orange spots (more intense on back and toward tail). Small white saddle on tail is distinctive.

Recorder:	Site name:	Latitude	Reef Type:
Date:	Day #:	Longitude	How selected?
Start Time:	Site #:	AGRRA location code:	Other:

#:	Hard coral demographic information											Line intercept information (to nearest ± 5 cm)			Quadrat information			
Water depth in meters	Coral Spp. Code (>=10 cm)	Species live coral under transect (cm)	Colony max diam-length (cm)	Colony width (cm)	Colony Height cm)	Death % old	Death % recent	Disease BB, WB, WS, WP, YB, RB, UK	Bleach P, PB, BL	Dmselfsh Garden / # Dmslfsh	Comments Major overgrowths, other causes of mortality	Sand (cm)	Live coral cover, col. <10 (cm)	Crust Cor. (cm)	Quadrats			
Begin:															Hgt (cm) flesh/calc	subst (pv, lc, dc, rb, sn)	Recruits <2cm (#Sp)	Max Relief (cm)*
																1 m		
												Total (cm)	Total (cm)	Total (cm)		3 m		
												Fleshy macro (cm)	Calc. macro (cm)	Other (Sp, Gorg, Paly, etc.)		5 m		
																7 m		
																9 m		
												Total (cm)	Total (cm)	Total (cm)	Total Live coral cover:			
End:																		
												Diadema (#/transect) Adult:			Juvenile:			

General Comments:

Recorder:	Site name:	Latitude	Reef Type:
Date:	Day #:	Longitude	How selected?
Start Time:	Site #:	AGRRA location code:	Other:

#:	Hard coral demographic information											Line intercept information (to nearest ± 5 cm)			Quadrat information			
Water depth (units)	Coral Spp. Code (>=10 cm)	Species live coral under transect (cm)	Colony max diam-length (cm)	Colony width (cm)	Colony Height cm)	% old	% recent	Disease BB, WB, RB, YB, UK	Bleach P, PB, BL	Dmselfsh # / Garden	Comments Major overgrowths, other causes of mortality	Sand (cm)	Live coral cover, col. <10 (cm)	Crust Cor. (cm)	Quadrats			
Begin:															Hgt (cm) flesh/calc	subst (pv, lc, dc, rb, sn)	Recruits <2cm (#Sp)	Max Relief (cm)*
																1 m		
												Total (cm)	Total (cm)	Total (cm)		3 m		
												Fleshy macro (cm)	Calc. macro (cm)	Other (Sp, Gorg, Paly, etc.)		5 m		
																7 m		
																9 m		
												Total (cm)	Total (cm)	Total (cm)	Total Live coral cover:			
End:																		
												Diadema (#/transect) Adult:			Juvenile:			

General Comments:

		0-5 cm	6-10cm	11-20cm	21-30cm	31-40 cm	>40 cm
Angelfish	French Angel.						
	Rock Beauty						
Butterflyfish	Foureye Butter.						
Grunt	Bluestriped Grunt						
	French Grunt						
Parrotfish	Princess Parrot.						
	Queen Parrot.						
	Redband Parrot.						
	Stoplight Parrot.						
	Striped Parrot.						
Seabass	Coney						
	Graysby						
	Black						
Snapper	Mahogany Snapp.						
	Schoolmaster						
	Yellowtail Snapp.						
	Mutton Snapper						
Surgeonfish	Blue Tang						
	Doctorfish						
	Ocean Surgeon.						
Triggerfish	Black Durgon						
others	Yellowtail Damsel.						
	Hogfish						
	Spanish Hogfish						
	Great Barracuda						
	Bar Jack						

Recorder:	Site name:	Latitude:
Date:	Day #:	Longitude:
Time:	Site #:	Transect # _____ of _____

		0-5 cm	6-10cm	11-20cm	21-30cm	31-40 cm	>40 cm
Angelfish	French Angel.						
	Rock Beauty						
Butterflyfish	Foureye Butter.						
Grunt	Bluestriped Grunt						
	French Grunt						
Parrotfish	Princess Parrot.						
	Queen Parrot.						
	Redband Parrot.						
	Stoplight Parrot.						
	Striped Parrot.						
Seabass	Coney						
	Graysby						
	Black						
Snapper	Mahogany Snapp.						
	Schoolmaster						
	Yellowtail Snapp.						
	Mutton Snapper						
Surgeonfish	Blue Tang						
	Doctorfish						
	Ocean Surgeon.						
Triggerfish	Black Durgon						
others	Yellowtail Damsel.						
	Hogfish						
	Spanish Hogfish						
	Great Barracuda						
	Bar Jack						

Recorder:	Site name:	Latitude:
Date:	Day #:	Longitude:
Time:	Site #:	Transect # _____ of _____