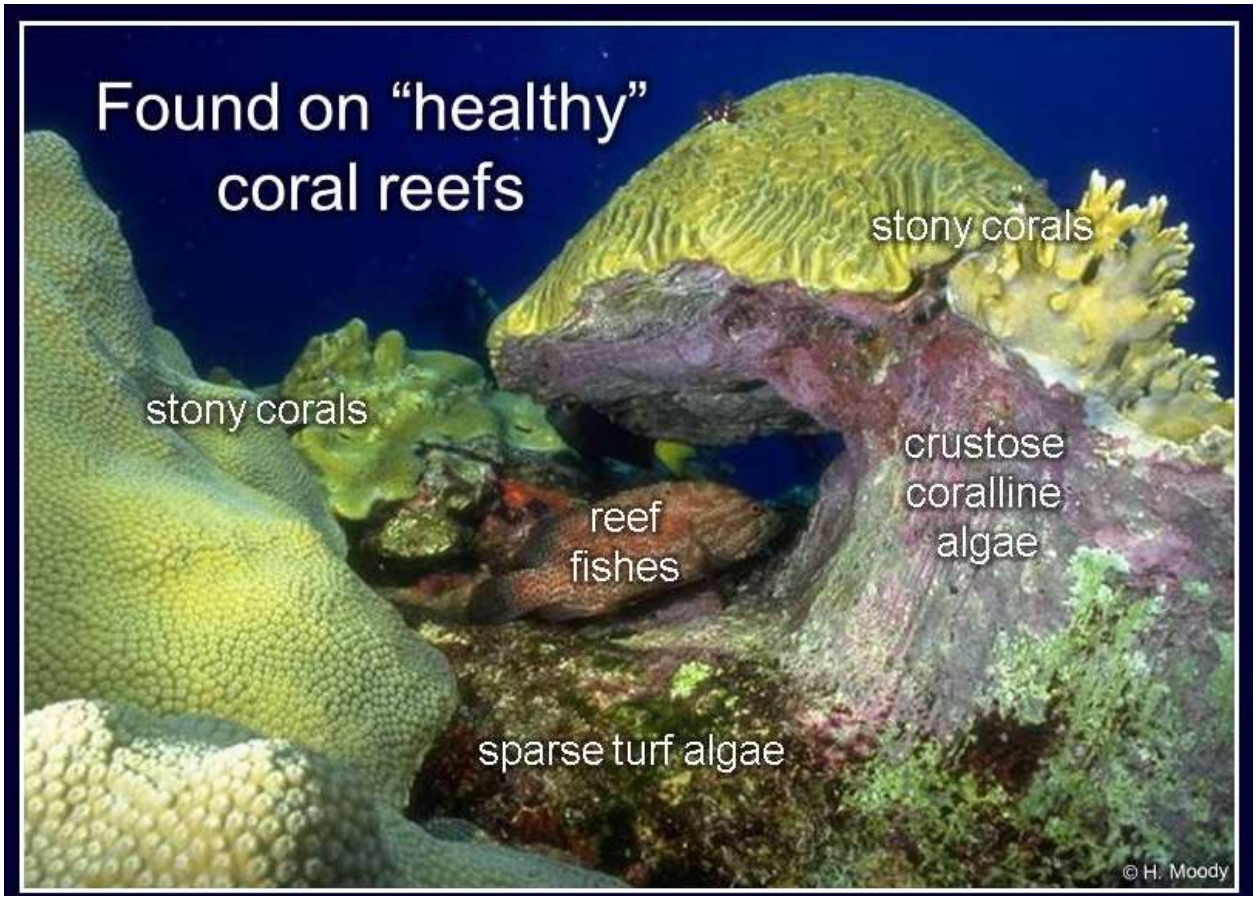
Atlantic & Gulf Rapid Reef Assessment (AGRRA)



A Guide to Methods & Training Materials 2015

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AGRRA

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AGRRA PROTOCOLS VERSION 5.4

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INTRODUCTION

The goals of the Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program are to assess important structural and functional attributes of tropical Western Atlantic coral reefs and to provide fisheries-independent estimates of fishing intensity. Data from AGRRA-sponsored surveys, or which have been collected independently and submitted to the program, are processed, archived, and posted online at regular intervals (see: www.agrra.org).

AGRRA sites are surveyed in a probabilistic fashion to yield information representative of large areas, such as shelves, islands, countries or ecoregions, *i.e.,* at the scales over which many reef structuring processes and impacts occur. Rapid sampling of numerous sites across a stratified-random seascape with a small number of non-fixed, transect-based, visual surveys has been shown to provide a more accurate and spatially representative estimate of large reef areas than is given by detailed sampling of many transects at only one or several sites (Murdock and Aronson, 1999; Kramer, 2003; S. Smith *et al*., mss.; see also T. Smith *et al.,* 2008).

Since the program was first introduced in 1998, we have learned more about sampling design, the spatial distribution of Caribbean-area reefs, and the spatial and temporal scales of processes affecting these reefs. As a result the AGRRA protocols are continuing to adaptively change while enhancing comparability between our indicators and those of many other coral reef survey programs *(e.g.,* Hill and Wilkinson, 2004; Miller, 2005; Miller *et al.,* 2008; Brandt, 2009; Obura and Grimsditch, 2009; Florida Reef Resilience Program, 2009a).

In a major change, the original AGRRA benthos protocol now is partitioned into two components, simplifying the tasks required of surveyors and increasing the efficiency of underwater data collection. The additional information that is gained outweighs the loss of direct equivalence with some indicators measured in earlier versions of the protocol.

Groups are now encouraged to set their own level of survey effort anywhere between ***basic*** (for novices and some management needs) and ***detailed*** (some research needs). When deciding which level to adopt within each survey method, groups should consider their own goals and objectives, the time or funding available for the surveys and subsequent analyses, logistical support constraints, as well as the scuba and taxonomic skills of the participants.

The number of trained divers that are needed to complete an assessment in one dive will depend on the desired level of survey effort, on the depth and geomorphology of the habitat, and on the abundance, size, and diversity of its corals, algae and fishes. We recommend a minimum of six divers, *i.e.,* two for the fish censuses, and two for each of the new benthic and coral surveys. Larger numbers are appropriate for training purposes and with student groups. Whenever possible, we urge the inclusion of a supplementary diver to make a video and/or photographic record of each transect and of additional interesting features at the survey site.

Shallow (< 4 - 5 m) AGRRA surveys were initially conducted by snorkeling. SCUBA is now recommended for all assessments, unless the water is less than about 1.5 m deep or the shallow habitat is very depauperate *(i.e.,* currently not a constructional coral reef). The additional expense is more than repaid because the divers are less fatigued and consequently more alert when transcribing their data later in the day.

Given the small spatial extent of many reefs in the tropical Western Atlantic, and to minimize incidental coverage of non-reefal *(e.g.,* sand, seagrass) habitats, transect lengths remain at 10 m for the benthic and coral protocols and at 30 m for the fish protocol. Lead-core rope is retained for the coral and benthic transects to reduce swaying and to maintain comparability with earlier AGRRA surveys. Visual census transects remain the core of the fish protocol; roving diver surveys have been moved to the expanded **OPTIONAL COMPONENTS**. The transect numbers given for each protocol are the minimum considered necessary for statistical analyses. When the number of divers is larger than the minimum, the transect number may be correspondingly increased.

SELECTING SURVEY SITES

An AGRRA **site** is situated in a geomorphic **zone** of a **reef** on an insular or continental **shelf** (as defined by Sullivan and Bustamanate, 1999) within one of the 12 marine shelf **ecoregions** of the Tropical Northwestern **province** of the Tropical Atlantic biogeographic **realm** delineated by Spalding *et al.* (2007).

A **site** is defined as a more or less homogeneous habitat, roughly 200 m × 200 m in spatial extent, and accessible from a boat or by swimming from shore. The method for selecting sites will be influenced by the size, abundance, distribution and habitat complexity of the reefs in the study location. What follows are our recommended procedures, but we fully understand that modifications may be necessary to accommodate the special conditions of a given assessment. All such changes should be carefully noted on the UW (underwater) datasheets and DataEntry spreadsheets.

If the spatial extent, habitat complexity, and/or number of reefs in the study location (shelf, island or country) are so limited that all prominent habitats can be surveyed within a reasonable time frame, there is no problem. More commonly, however, the reefs will need to be subdivided or ***stratified*** and representative examples randomly selected from among one or several strata. The most obvious stratifiers are geomorphic characteristics that are influenced by cross-shelf position *(e.g.,* shelf-edge barrier or bank reefs, lagoonal or mid-shelf patch or linear reefs, nearshore fringing reefs), orientation *(e.g.,* windward or leeward exposure), depth, slope, etc.

Zones of maximum reef development that are highly recommended for AGRRA surveys include shallow (< ~5 m) reef crests, many of which were previously constructed by *Acropora palmata,* and intermediate-depth (~5 - 15 m) linear or patch reefs that are dominated by large massive corals like the *Montastraea annularis* species complex. (Information on *A. palmata* is particularly relevant nowadays, even when most of the corals are dead and/or their borders are unclear and point counts substitute for individual colony assessments.) If these habitats are locally absent, rare, or physically inaccessible, try to select others with an abundance of reef-building corals. Wherever possible avoid hardgrounds, pavements or bedrock that lack constructional reef frameworks, and depths below about 20 m.

Sites are ***randomly*** chosen for survey after the reefs in a location have been stratified by habitat. One method is to number each distinct reef and use a random method to select the ones to survey. For continuous bank-barrier or fringing reefs that are several km or more long, **sites** can be located by randomly choosing among a grid of 200 × 200 m squares superimposed over the reef in a map, remote image or GIS product (Fig. 1).

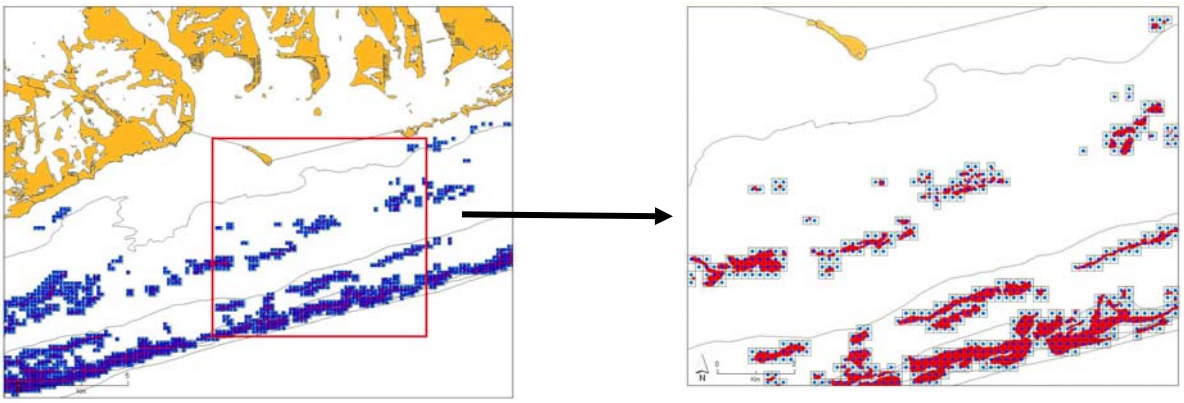

Figure 1. 200 m × 200 m grid over reef habitats (From Florida Reef Resilience Program, 2009b).

If accurate coral reef habitat maps are available in digital GIS format, more sophisticated sampling designs can be developed that are spatially balanced and fully representative using the generalized random tessellation sampling (GRTS) approach (Stevens & Olson, 2004) or 2-stage stratified random sampling (Cochran, 1977).

For those with access to ESRI's ArcGIS 9.2 or higher, in addition to providing stratified random sampling, the NOAA Biogeography Branch Sampling Design Tool can also generate sampling points after previously collected data are analyzed to compute sample size requirements or efficiently allocate samples among strata (see: http://ccma.nos.noaa.gov/products/biogeography/sampling/welcome.html).

Load the randomly chosen sites onto at least one GPS unit (two units safeguard against unexpected battery failures in the field), and use them to navigate to the locations. Unless you are sure that the habitat to be surveyed occurs within a radius of about 100 m of each randomly selected site, we recommend having alternate, randomly chosen, "backup" sites available in case some sites in the initial selection are found to be unsuitable *(i.e.,* the habitat was misclassified) or it proves too dangerous to survey due to inclement weather (Fig. 2).

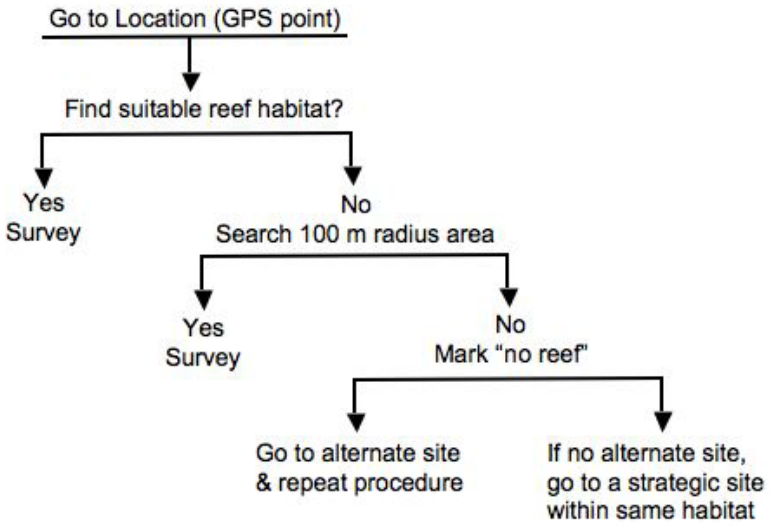

Figure 2. Site-selection decision tree. (Adapted from Florida Reef Resilience Program, 2009b).

Alternatively, it may be necessary to survey sites that are chosen ***strategically*** for some special purpose: because they are considered degraded, threatened, or in particularly good condition; to compare an MPA or fishery reserve with an unmanaged "control" or fishing area; to be located off every headland or village, or at some predetermined distance (such as every 30 km) along a coastline or bank margin. Although this has not always been possible in the past, strategic sites should be analyzed separately from randomly chosen sites.

The minimum number of randomly chosen sites to survey in each habitat increases as its spatial area in the study location increases, *i.e.,* S. Cuba > N. Jamaica > Bonaire *(e.g.,* Miller *et al.,* 2008). On the assumption that surveys are conducted in two zones/shelf (equivalent to the reef crest and deeper) that are usually of unequal spatial area, Table 1 approximates the minimum sample size (= number of survey sites) for selected Caribbean-area shelf units. Estimates of reef areas were provided by The Nature Conservancy and are based on the Millennium Coral Reef Mapping Project's geomorphic reef classification (see http://imars.usf.edu/corals/). For areas in which the reefs are not visible in the Millennium Maps (mostly narrow, inshore fringing reefs) or otherwise not given in Table 1, a minimum of five sites should be sampled within each chosen habitat stratum.

It is critical to record the exact location of the actual site with a GPS. Whenever a survey takes place immediately below a stationary boat, simply record its position once the boat has stabilized. If the survey will occur some distance from a boat (typically the case when surveying a reef crest) or from shore (when swimming from land), note the distance and direction from the recorded GPS location so that a more accurate position can be approximated later.

Table 1. Minimum number of survey sites/shelf in the tropical northwestern Atlantic, assuming two zones that are usually of unequal area/shelf (adapted from Ault and Smith, 2007).

Shelf Unit	Target # of sites	Shelf Unit	Target # of sites	Shelf Unit	Target # of sites	Shelf Unit	Target # of sites
Grand Bahama	58	NW Cuba	78	Anguilla	14	Central Panamá	10
Abaco	82	SW Cuba	15	Saba	16	West Panamá	10
Berry Islands	18	Isle of Youth	87	Antigua	13	Gulf of Mosquito	59
Bimini	12	South Central Cuba	10	Montserrat	10	South Costa Rica	10
Cay Sal Bank	39	SE Cuba	301	Guadeloupe	28	Nicaragua	132
Andros	43	Little Cayman	10	Dominica	10	Corn Islands South	18
New Providence	18	Grand Cayman	12	Martinique	19	Corn Islands North	21
Exumas Eleuthera	155	North Jamaica	37	St. Lucia	12	San Andres West	20
Long Island	27	South Jamaica	44	Barbados	11	Nicaragua Rise	113
Southern Great Bahama	35	Pedro Bank	33	St. Vincent	10	Swan Islands	10
East Bahama	13	East Jamaica	35	Grenada	21	North Honduras	10
East Acklins	10	Morant Cays	10	Trinidad Tobago	11	Bay Islands	30
Acklins Crooked	18	South Haiti	30	Blanquilla	10	Guatemala	33
East Crooked	10	West Haiti	40	Isla La Tortuga	10	Belize	68
Little Inagua	16	North Hispaniola	47	Los Roques East	10	Offshore Belize	67
North Inagua	10	NE Dominican Republic	26	Los Roques Central	46	South Yucatan	49
Great Inagua	22	East Dominican Republic	21	Los Roques West	12	Chinchorro	41
Grand Turk	41	South Hispaniola	14	West Venezuela	10	Cozumel	28
East Caicos	10	North Puerto Rico	26	Curaçao	10	North Yucatan	49
East Cuba	69	South Puerto Rico	27	Bonaire	10	Central México	10
NE Cuba	56	USVI BVI	43	Aruba	12	Dry Tortugas	34
North Cuba	19	St Croix	13	East Panamá	68	Ocean Florida Keys	14

EQUIPMENT

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

- a clipboard or UW slate (see size specifics below) and pencils
  Attach at least one pencil to the clipboard or your wrist with a series of interconnected rubber bands or string; always carry a spare pencil somewhere secure.
- UW datasheets (see below), with rubber bands or clips to fasten to the clipboard or slate
  *The datasheet templates can be photocopied with a laser printer onto **both** sides of underwater "DuraCopy" Copier/Laser Paper 6511. Although expensive (about US $65 from online distributors for 100, 8.5" × 11" sheets in January, 2010), this paper is highly recommended. Your data are more likely to be entered correctly because the appropriate template is present on every datasheet.*
- glasses or contact lenses if needed
  If you normally correct your vision on land, especially if you are far sighted, it is important to have a diving mask with the correct prescription lenses, or to wear your contacts when diving. Otherwise you may not be able to distinguish some important details while doing the surveys.

Benthic Survey divers will need:

- a *letter-sized* clipboard or UW slate and pencils
- copies of the **Basic** or **Detailed** **BENTHIC-UW-V5.4** datasheet printed on UW paper
  Attach to the slate or clipboard with rubber bands, clips or bungee cord.
- ***optional*** for ***detailed-level***: a copy of the **CORAL Codes-V5.4** list printed on UW paper
  Attach to the reverse of the slate or clipboard with the rubber bands, clips or bungee cord.
- a lead-core rope (= transect line) marked with colorful (not black) cable ties at **10-cm** intervals for a distance of 10 m, and to which a tie-off loop is attached at each end
  5 mm/3/16" or 6 mm/1/4" diameter lead-core rope (e.g., Duraflex leadline) is available at commercial fishing supply stores or cooperatives. Using a metric tape or meter stick for scale, carefully add conspicuously colored cable ties at 10-cm intervals along the line. Distinguish the meter marks (be sure to include 0 and 10) with a different color from that of the cable ties marking the 10- to 90- cm marks within each meter. (If you use thick cable ties, you can number their position along the line with a Sharpie.) Remove the "tail" of each attached cable tie with a clipper (Fig. 3).

Figure 3. Lead-core rope with numbered cable ties. (J. Richardson, photo)

- a 1-m long pole marked in 10-cm intervals
  Use a narrow PVC pipe (available at hardware stores). Paint or tape a scale along the pipe at increments of 10 cm.
- a small, thin, metric plastic ruler ***(detailed-level surveys only)***
  Trim the ruler to have a tapered point but still be legible at its basal 5 cm. Drill or punch a hole at the other end of the ruler, and either tie it to the clipboard or slate, or attach it to your wrist with a series of interconnected rubber bands.

- a 25 cm × 25 cm quadrat to which a hook has been attached
  Construct the quadrat of narrow (12mm/1/2" diameter) diameter PVC pipe with 90° elbow connectors (available at hardware stores) to have an inner length of 25 cm and drill holes to let the air escape underwater (Fig. 4A).

For convenience in swimming: hook the 10-m end of the transect line to the quadrat (Fig. 4A) and wrap it tightly around the quadrat; then tie the 0-m end to one side of the quadrat. Insert the poles and clipboard through the center, as illustrated in Fig. 4B.

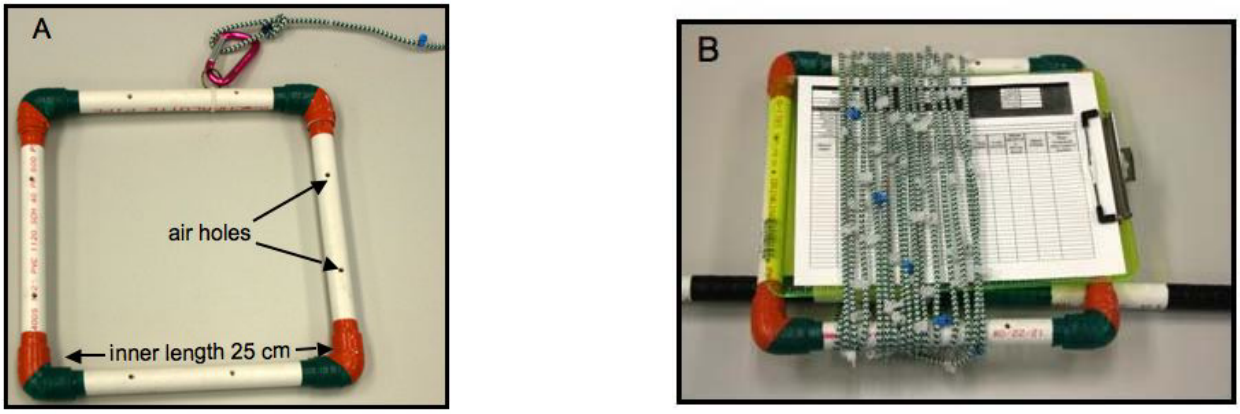

Figure 4. (A) Quadrat with hook attached to the transect line; (B) Benthic equipment "kit." (J. Richardson, photos)

Coral Survey divers will need:

- a *letter-sized* clipboard or UW slate and pencils
- copies of the **Basic** or **Detailed** **CORAL-UW-V5.4** datasheet printed on UW paper
  Attach to the slate or clipboard with rubber bands, clips or bungee cord.
- ***optional***: a copy of the **CORAL Codes-V5.4** list printed on UW paper
  Attach to the reverse of the slate or clipboard with the rubber bands, clips or bungee cord.
- a lead-core rope (= transect line) marked with colorful (not black) cable ties at **1-m** intervals for a distance of 10 m, and to which a tie-off loop is attached at each end
  5 mm/3/16" or 6 mm/1/4" diameter lead-core rope (e.g., Duraflex leadline) is available at commercial fishing supply stores or cooperatives. Using a metric tape or meter stick for scale, carefully add colorful cable ties (remove their "tails with a clipper) or electrical tape at 1-m intervals along the line.
- a 50-cm long pole marked in 10-cm intervals, with 5-cm increments at each end
- a 1-m long pole marked in 10-cm intervals
  Use narrow (12mm/1/2" diameter) PVC pipes (available at hardware stores) for both poles. Paint or tape a scale along each of the pipes.
- a small (15 cm) ruler (optional)
  Drill or punch a hole at one end of the ruler, and either tie it to the clipboard or slate, or attach it to your wrist with a series of interconnected rubber bands.
- a 25 cm × 25 cm quadrat to which a hook has been attached
  Construct the quadrat of 12 mm/1/2" diameter PVC pipe with 90° elbow connectors (available at hardware stores) to have an inner length of 25 cm and drill holes to let the air escape (Fig. 4A).

For convenience in swimming: hook the 10-m end of the transect line to the quadrat (Fig. 4A) and wrap it tightly around the quadrat; then tie the 0-m end to one side of the quadrat. Insert the poles and clipboard through the center, as illustrated in Fig. 4B (but note only the 1-m pole is shown).

Fish Survey divers will need:

- a 15 cm/6" × 23 cm/9" UW slate *(e.g.,* a REEF slate or equivalent)
  The slate should be mounted on the T-bar (see below) to facilitate carrying the equipment.
- copies of the **Basic** or **Detailed FISH-UW-V5.4** datasheet printed on UW paper
  Attach to the slate or clipboard with rubber bands, clips or bungee cord.
- **optional** for ***detailed-level:*** a copy of the **FISH List-V5.4** list printed on UW paper
  Attach to a separate slate or place under the fish datasheets on the above slate.
- a graduated T-bar with a 60-cm long handle and two, equal-length arms marked in 10-cm intervals providing a total width across the top of 1 m
  Use 18 mm/3/4" diameter PVC pipe and a T-connector (available at hardware stores). Attach the T-connector to one end of the handle pole (Fig. 5A). Paint or tape a scale in increments of 10 cm along each arm pole and on the top of the T-connector. Drill a hole on the end of each arm in order to attach them to the T-connector with a piece of bungee cord or string (Fig. 5B).
- a D-ring or clamp attached to your weight belt or BCD
- a weighted, 30 m/100 ft, fiberglass transect tape
  Attach a 1 kg/1-3 lb weight at the free end of the tape. Put a clip on the reel to attach it to a D-ring on your BCD or weight belt (Fig. 5C).

For convenience in transport and storage, disconnect the arms from the T-connector and fold them down beside the handle (Fig. 5D).

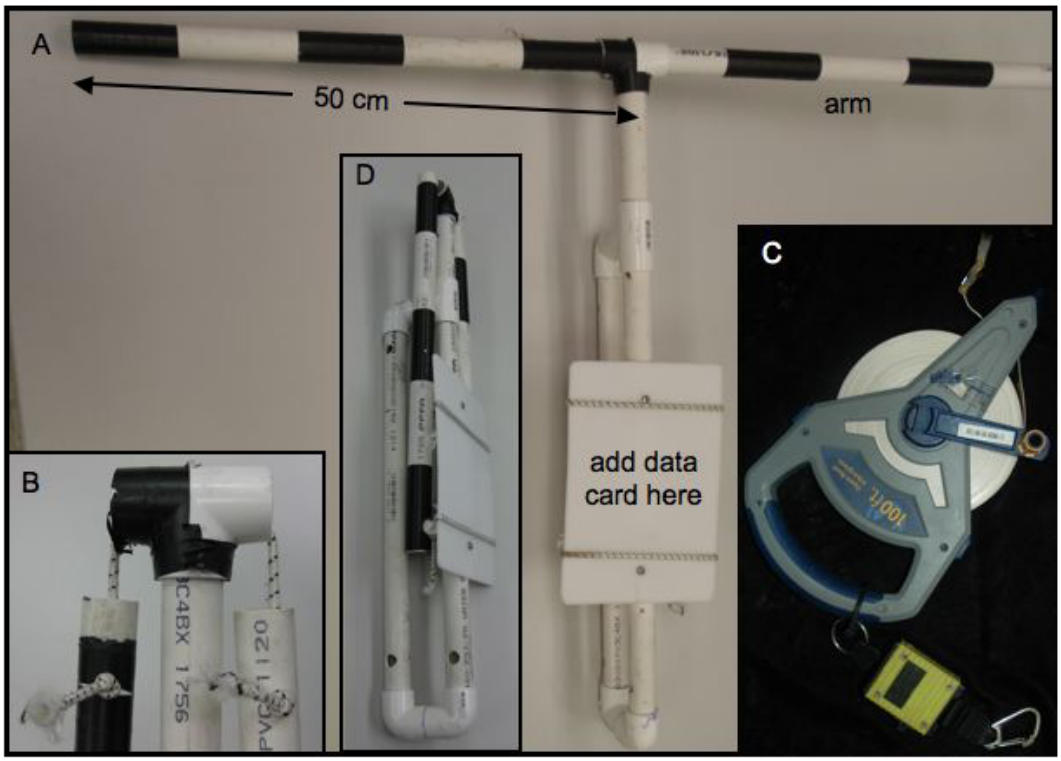

Figure 5. (A) Assembled T-bar; (B) Close-up of two arms attached with bungee cord to the T-connector; (C) a tape reel; (D) T-bar closed for transport and storage. (J. Richardson, photos A,B,D; A. Harrison, photo C)

SURVEYS

I. AGRRA Benthic Survey (minimum 2 divers)

Objectives

- Record benthic cover under points at 10-cm intervals on each of six, 10-m long transect lines.
- ***Detailed-level only***: Measure macroalgal heights to approximate their biomass (Steneck and Dethier, 1994) and ecological impact (as cover × height).
- Count all ≤ 2 cm coral "recruits," and note the substratum type in each of five, 25 cm × 25 cm quadrats placed at 2-m intervals along each transect line.
- Count all juvenile and adult long-spined urchin *(Diadema antillarum*, a key herbivore), commercially important Caribbean spiny lobster *(Panulirus argus)* and queen conch *(Strombus gigas),* invasive Indo-Pacific lionfishes *(Pterois* spp.), and identify any trash in a 1-m wide belt centered on each transect line.

New in Version 5

A. Point counts, each with a corresponding code, have been substituted for the benthos intercept length measurements used in Version 4 of the AGRRA protocols.

B. Lionfish counts, plus identification of trash and predominant algae, have been added to the belt transects.

Unchanged in Version 5

A. Small corals ("recruits") and substratum type are recorded with the quadrat.

B. As in Version 4, small *Diadema* with black-and-white banded spines are considered to be "juveniles." Larger urchins with all-black spines or with all-black spines alternating with all-white spines or, more rarely, with all-white spines, are scored as "adults."

Point-count identification effort levels

Benthic organisms chosen for AGRRA Version 5 surveys are grouped primarily by their ecological interactions with the reef-building corals and crustose coralline algae that construct reefs. Many groups (macroalgae, corals, other sessile invertebrates) can be surveyed at more than one taxonomic level to accommodate differing programmatic requirements, time available underwater, and levels of participant expertise.

Basic: primary groups of reef constructors (corals, crustose coralline algae) and major groups of organisms that kill and overgrow corals and/or prevent settlement of coral larvae (Table 2).

Table 2. Categories, codes and rationales for ***basic-level*** benthic point-count surveys.

CATEGORY	CODE	RATIONALE
Live corals (name if you can)	**LC**	Construct coral reefs; universal reef condition indicator
Bleached (live) corals	**BLC**	Indicate altered reef conditions (often thermal stress when large scale)
Newly dead corals (bright white skeleton; name if you can)	**NDC**	May indicate ongoing disease, bleaching, predation, competition, or other perturbation(s)
Crustose coralline algae	**CCA**	Construct or cement reef framework; may indicate good conditions for recruitment of coral larvae
Conspicuous ("nuisance") cyanobacteria	**CYAN**	May indicate altered reef conditions (possibly nutrients, temperature, few herbivores); may kill/overgrow corals or prevent coral larval recruitment
Turf algae[1]	**TA**	Eaten by many herbivorous fishes; when thick or tall indicate few herbivores; thick TA mats trap sediment and inhibit coral larval recruitment, plus kill/overgrow corals and crustose coralline algae (CCA)
Macroalgae	**MA**	All are eaten by some herbivorous fishes; some inhibit coral larval recruitment or kill/overgrow corals and CCA; may provide refuge for some coral predators or be a repository for some coral pathogens
Aggressive invertebrates	**AINV**	Kill/expand over corals and CCA as they grow
Other invertebrates	**OINV**	Epibenthic invertebrates that usually don't kill/expand over corals and CCA as they grow

[1] Multispecific assemblages of red, green, and brown algae and cyanobacteria, usually short (<2.5 cm tall) and often filamentous.

Detailed: live and newly dead corals by their CARICOMP-based codes (for species, the first letter of the genus name followed by the first three letters of the species name; see **CORAL Codes-V5.4** list), and other organisms to at least genus level when possible (Table 3) or to the taxonomic level specified for the survey.

Table 3. Categories, codes and rationales for ***detailed-level*** point-count benthic surveys.

CATEGORY	CODE	RATIONALE
CORALS		
Live coral by species (or genus) name	**4-letter coral code**	Construct coral reefs; universal reef condition indicator, *e.g.,* PAST = *P. astreoides;* AGAR = *Agaricia* sp.
Bleached (live) coral by species (or genus) name	**BL-coral code**	Indicate altered reef conditions (often thermal stress when large scale) *e.g.,* BL-MCOM = fully bleached *M. complanata*
Newly dead coral by species (or genus) name	**ND-coral code**	May indicate ongoing disease, bleaching, predation, competition, or other perturbation(s), *e.g.,* ND-CNAT=newly dead *C. natans*
OTHER CALCIFIERS		
Crustose coralline algae	**CCA**	Construct or cement reef framework; may indicate good conditions for recruitment of coral larvae
OR distinguish *Porolithon pachydermum*	**POR**	
Newly dead crustose coralline algae[1]	**ND-CCA**	May indicate ongoing disease; outbreaks have occurred on some reefs
Calcified worm tubes	**CWT**	Potential coral larval recruitment site
Peyssonnelid algae[2]	**PEY**	Rarely contribute to reef construction or binding; unlikely to be coral larval recruitment sites
MISCELLANEOUS		
Sediment (at least 2.5 cm/1 inch thick)	**SED**	Subtract from total as not a potential coral larval recruitment site, **ignore associated epibenthos *(e.g.,* macroalgae)**
OR distinguish as sand or mud	**SAND or MUD**	
Hard surface	**ROCK**	Potential coral larval recruitment site; often considered "barren," but probably covered with biofilms of bacteria, diatoms and/or other microalgae
OR distinguish as dead coral or pavement	**DC or PV**	
Rubble	**RB**	Subtract from total as not a potential recruitment site for most reef corals; **ignore associated epibenthos *(e.g.,* turf algae, macroalgae**)
Unknown, invisible *(e.g.,* in a hole)	**XXX**	Subtract from total as no specific information of any effects on corals or their larvae
"ALGAE"		
Conspicuous ("nuisance") cyanobacteria	**CYAN**	May indicate altered reef conditions (possibly increased nutrients, temperature, few herbivores); may prevent coral larval recruitment or kill/overgrow corals and crustose coralline algae (CCA)
Turf algae	**TA**	Eaten by many herbivorous fishes; when thick or tall indicate few herbivores
Turf algae-sediment mat	**TAS**	Thick TA mats can trap sediment, inhibit coral larval recruitment, and may kill/overgrow corals and CCA
Fleshy macroalgae	**FMA**	All are eaten by some herbivorous fishes although some are chemically defended; some inhibit coral larval recruitment or kill/overgrow corals and CCA; may provide refuge for some corallivores or be a repository for some coral pathogens
OR *Dictyota*	**DIC**	May inhibit coral larval recruitment or kill small corals and CCA
OR *Lobophora variegata*	**LOB**	Inhibit coral larval recruitment, can kill/overgrow some corals (especially small ones) and CCA, generally avoided by fishes
OR name of any other common FMA	**name** or create a **code**, *e.g.,* SAR = *Sargassum*	As for FMA

[1] Visible as orange tissues or freshly exposed white skeleton around green algae in dead skeleton.

[2] If uncertain of identity, scratch the surface with a sharp instrument: crustose coralline algae have white skeletons and the skeletons of peyssonnelids are dark.

Table 3, continued.

CATEGORY	CODE	RATIONALE
Calcareous macroalgae	**CMA**	Have calcareous (and some have chemical) defenses against herbivorous fishes; at least a few inhibit coral larval recruitment or kill/overgrow corals and CCA; may provide refuge for some corallivores or be a repository for some coral pathogens
OR *Halimeda*	**HAL**	As for CMA
OR *Halimeda* mat[3]	**HAM**	Inhibit coral larval recruitment; probably kill whatever they
OR *H. goreauii* mat	**HGM**	overgrow; avoided by some fishes; good refuge for some
OR *H. opuntia* mat	**HOM**	corallivores; may be a repository for some coral pathogens
OR name of any CMA	**name** or create a **code** (as above)	As for CMA
Mixtures of fleshy & calcareous macroalgae	**FMA-CMA** or **names** or create **codes** (as above)	Will be scored 0.5 as FMA and 0.5 as CMA
INVERTEBRATES		
Aggressive invertebrates	**AINV**	Kill/expand over corals and CCA as they grow
OR *Chondrilla caribensis*[4]	**CHON**	As for AINV
OR *Cliona*	**CLIO**	As for AINV + bioeroding activities weaken coral skeletons
OR *Cliona delitrix*	**CDEL**[5]	As for CLIO
OR zooxanthellate clionid	**CZOO**[6]	As for CLIO
OR *Briarium asbestinum*	**BRI**	As for AINV
OR *Erythropodium caribaeorum*	**ERY**	As for AINV
OR *Palythoa caribaeorum*	**PAL**	As for AINV
OR *Tridemnum solidum*	**TRI**	As for AINV
OR name any other overgrowing invertebrate	**name** or create a **code** (as above)	As for AINV
Other Invertebrates	**OINV**	Epibenthic invertebrates that usually don't kill/ expand over corals and CCA as they grow
OR Epibenthic sponge	**SPO**	As for OINV
OR Gorgonian holdfast	**GOR**	As for OINV
OR name of any other OINV	**name** or create a **code**(as above)	As for OINV

[3] *Halimeda* mat = dense clump of *Halimeda* that traps sediment
[4] formerly called *Chondrilla nucula*
[5] tissues are bright red-orange
[6] several species; tissues are brown or black

Benthic Method

See also the summary/reminder Instructions in the appropriate BENTHIC UW datasheet file.

Begin by choosing the appropriate level ***(basic*** or ***detailed)*** of effort for <u>each</u> section of the protocol. Before starting to survey, conduct **consistency-training exercises** with other benthic team members or an instructor to gain practice in setting and retrieving the lead-core transect line, in locating points on the substratum, assigning them to the AGRRA point-count categories that were chosen for inclusion in your surveys, and learning their corresponding codes. For ***detailed-level surveys:*** practice measuring macroalgal heights (plus algal turf and cyanobacterial heights if required for the particular surveys).

Retraining on a weekly basis during expeditions is strongly encouraged.

1A. At each **<u>site</u>**, record the following information on your **<u>Basic</u>** or **<u>Detailed</u> BENTHIC-UW-V5.4** datasheet before the dive:
Surveyor: 4-letter code with first two letters of your first and last names
Date: Day with two digits/abbreviation of month name/year with two digits *(e.g.,* 14 Aug 07)
Site Name: Local survey site name (if known) or description of area *(e.g.,* off Windy Hill Pt.)
Day #: sequential by day during an expedition (1, 2, 3, etc.)
Site #: sequential within each day (1, 2, 3, etc.)
AGRRA Code: sequential site code, as 3 letters + 2-3 digits *(e.g.,* BAH01, BAH02, BAH03 = first three Bahamian surveys) during an expedition

Latitude & Longitude: as determined by DGPS (or best available instrument) at the site, **to be corrected if necessary from a boat or other fixed position** (see Selecting Survey Sites)
Reef Type: *(e.g.,* bank, barrier, mid-shelf, fringing, patch)
If different from expected, please describe the reef type surveyed.
Reef Zone: *(e.g.,* back = lagoon-ward or landward of a crest; crest; fore = seaward of a crest or shore)
If different from expected, please describe the reef zone surveyed.
Subzone/Habitat: *(e.g.,* reef flat/*complanata,* inner terrace/brain corals)
If different from expected, please describe the habitat surveyed.
Selection Method: *(e.g.,* stratified random, stratified strategic)
Site Comments: space to describe how latitude and longitude were calculated *(e.g.,* on site or approximated from some fixed position), or other notes about the site**–to be completed by the end of the dive.**

1B. Attach a copy of the **CORAL Codes-V5.4** list printed on UW paper to the underside of your clipboard if needed for reference.

2. At the survey site, use a haphazard method to choose a starting point for your first transect, *i.e.,* by spinning several times with your eyes closed, or gently dropping your meter pole while descending–the latter to be avoided if a current is present or you are near deeper water.

3. Record when you begin to set the first transect in **Start Time** and, if you can, the **Bottom Temperature** at the depth of the survey habitat. Write #1 in the first Transect # box. Loop the free end of the line to a dead piece of coral or other secure object that wouldn't easily be damaged. Note the **Start Depth** at the initial (=0 m/0 cm) mark and the depth scale (specify as feet or meters). Without biasing your choice of direction by looking down, unwind the line from the quadrat as you swim away from this starting point.
Be careful not to cross benthic transects that are being set by other divers. Unless directed to survey there by your team leader, avoid the edges of the reef or unusual reef features, and areas with abrupt changes in slope, deep grooves, large patches of sand, or unconsolidated coral rubble.
As soon as the entire transect line has unreeled, pull tightly to ensure that it is taut, and secure to the bottom by wrapping the quadrat around or over some sturdy object. Note the **End Depth** at the 10-m mark.

4. As you return towards the starting point, you may need to straighten the line by repositioning one of its ends, by pulling it off the bottom in high-relief reefs, or by disentangling it from upright gorgonians, sponges, etc.
In some locations you will need to keep a lookout for lionfishes (Pterois *spp.). Should any be present and remain in the immediate vicinity, pay attention to their specific locations during your survey!*

Benthic Cover-Point Counts

5A. Starting at the initial mark, swim back above the line, recording what you see on the substratum immediately below each of the 10-cm marks, ending at the 9m/90 cm point. If the line sways due to strong surge or bottom current, note its position in the middle of its swing when locating the 10-cm points.
By entering the category codes in the vertical rows matching the 0-90 marks in each meter, you can easily retrace your route to locate any missing points at the end of each meter–and then enter the appropriate code(s) in the remaining blank box(es).

If the reef has high relief, and you are unable to locate the position of the point(s) to count on the substratum by simple visual inspection:

In a **narrow** space, hold the pole vertically below its position on the line and record what is beneath the pole.

Above a **wider** expanse of sand or pavement, note on your UW datasheet which intervals are involved. If sand, record as such and move on. If pavement, place your measuring pole on the substratum under the line. Record what is immediately adjacent to each 10-cm mark on one side of the pole across the predetermined interval *(e.g.,* if from 4.5 - 5.3 m, for a total of 9 points).

Basic-level: use the **BASIC** codes listed at the base of your UW datasheet and any additional codes considered necessary for the survey site.

Detailed-level: use the CARICOMP-based codes for corals, the **DETAILED** codes (as required) for other organisms and any additional codes required for the survey site.

If you need to create additional codes for locally abundant organisms, be sure to write an explanation in the Transect comments box *(e.g.,* MIC = *Microdictyon;* BAR or XES = the barrel sponge, *Xestospongia muta*).

Benthic Cover-Algal Heights

5B. ***Detailed-level only***: In the first transect of each surveyor, for a total of 2 transects per site, use the tapered ruler to measure the height of all macroalgae (or group of mixed macroalgae) under the 10-cm points to the nearest 1 cm if > 1 cm tall or to the nearest 0.5 cm if < 1 cm tall. For encrusting macroalgae *(i.e.,* decumbent forms of *Lobophora* and *Padina)*, measure the thickness of the blade(s) to the nearest 0.1 cm (each blade being about .1 cm thick) rather than their length along the substratum. Record as name/height *(e.g.,* DIC/.5 = 0.5 cm tall *Dictyota;* FMA-CMA/4 = 4 cm tall, mixed fleshy and calcareous algae).

Optional: *Similarly measure the heights of any cyanobacteria (as done for macroalgae) and algal turfs (to the nearest 0.1 cm) beneath the points.*

Recruits and Substratum

6A. When the point counts are finished, unhook the 25 cm × 25 cm quadrat and, if necessary to maintain its position, attach the transect line by its tie-off loop to an object that isn't easily damaged. Swim back along the transect line, temporarily centering the quadrat on the substratum at intervals of two meters *(i.e.,* under the 10-, 8-, 6-, 4-, and 2-, or the 9-, 7-, 5-, 3-, and 1- meter positions).

Within each quadrat, use your hands to brush loosely attached algae and sediment off the substratum, and then look for small, up to **2 cm** maximum diameter, coral **recruits** (all scleractinians and *Millepora)*. Note that practice and good eyesight (or corrective lenses) are needed to be successful in finding coral recruits due to their small size and inconspicuous appearance.

If the quadrat lands in an area of high topographical complexity, search everything that you can see within the frame, regardless of its orientation relative to the reef's planar surface (Slingsby, 2003).

Basic-level: tally (= count and record) the total number of small corals in each quadrat; write NONE if you see no recruits.

Detailed-level: in each quadrat, tally as many of the recruits as you can to the genus or species level using their respective coral codes; code unknowns as UK. Write NONE if you see no recruits.

6B. Record the predominant **substratum** type within each quadrat as one of the following:

LC = live coral
DC = dead coral
PV = pavement
RB = rubble
SAND = sand
Other = none of the above, or identify by name or by species code

If two substratum types are of approximately equal abundance, record both with a slash between the two codes *(e.g.,* LC/PV will be scored as a 0.5 each for live coral and pavement).

Motile Invertebrates, Lionfish and Trash

7A. Using the 1-m pole perpendicular to the line transect for horizontal scale, swim a 0.5-m wide belt transect along one side of the line. Ignoring other motile invertebrates, tally every "juvenile" and "adult" long-spined urchin *(Diadema antillarum),* plus all Caribbean spiny lobster *(Panulirus argus),* **live** queen conch *(Strombus gigas)*, lionfish *(Pterois* spp.–try to estimate the size as total length) and items of trash that you see between the initial (= 0 cm) and end (= 10 m) marks. If the line sways due to strong surge or bottom current, note its position in the middle of its swing when positioning the pole.

Inspect all shelter-providing spaces (e.g., *crevices, bases of large corals) within the belt. If you turn over* Strombus *shells that are upside-down to look for the living animal, be sure to replace the shell in its original, upright position.*

7B. Return to the starting position by swimming a second, 0.5-m wide belt transect along the other side of the transect line. Continue to tally all juvenile and adult *Diadema*, Caribbean spiny lobster, queen conch, lionfish and trash. Put a 0 in the box corresponding to any animal for which none are seen.

Predominant Algae, Other Benthic Organisms and Transect Comments

8. Note, for the belt as a whole, the predominant algal type if crustose corallines or algal turfs. If macroalgae dominate, try to identify to genus *(e.g.,* LOB for *Lobophora)* or species *(e.g.,* HGOR for *Halimeda goreauii)*.

   If any other group of benthic organisms within the belt transect is conspicuously perturbed by bleaching, disease, predators, etc., record in the transect comments box:
   its name or AGRRA code
   its approximate abundance by cover or number
   the approximate percent or number affected by the perturbation
   (e.g., 10% MALC/90% BL = *M. alcicornis* covers 10% of the substratum and 90% of the colonies are bleached; seafan, 7/20 CYANS = 7/20 *Gorgonia* colonies are being overgrown by cyanobacteria.)

   Record any other interesting observations in the Transect Comments box.

9. Take the quadrat to the 10-m end of the transect and hook it to the end of the line, then wrap the line around the quadrat as you swim to the 0-cm end and release its tie-off loop.

10. Repeat steps 2-9 until a total of six transects has been completed at the survey site *(e.g.,* three transects each if two divers). Try to stay at least 5 m away from all other benthic and coral transect lines.
    Routine measurements of macroalgal heights should be limited to two transects. However, at sites in which macroalgae are scarce or very patchy in distribution (i.e., *less than about 10 % cover), should time permit, surveyors are encouraged to measure their heights on all six transects.*

    After completing the last transect, tie the loop at the 0-m end of the wrapped transect line to one side of the quadrat.

    Record the number, and approximate size (as total length), of any lionfishes outside the area of your belt transect in the Site Comments box.

11. After diving, enter all your data and comments on a daily basis into a copy of the appropriate **Basic** or **Detailed BENTHIC-DataEntry-V5.4** spreadsheet. (The Day # and Site # information can help order the UW datasheets.) Be sure to explain any codes of your own invention used in the point counts or comments.

    Use a **separate** copy of the spreadsheet for **every site (not every day or every expedition)**, and **check your transcribed data to verify its accuracy**. Back up your own data regularly and store it in a safe place.

12. Once the team leader has signed off on all your spreadsheets, and safely stored all the original UW datasheets, the data are ready to be emailed to data@agrra.org for processing, archiving, and possible posting online at the AGRRA web site.

II. AGRRA Coral Surveys (minimum 2 divers)

Objectives

- Assess the size and overall condition of the ≥ 4 cm corals (all Scleractinia and *Millepora* except *Millepora alcicornis)* in two, 10 × 1 m^2 belt transects.
- ***Detailed-level only:*** estimate percent partial colony mortality and bleaching condition on the outward-facing surfaces of these corals.

New in Version 5

A. Corals should be consistently identified by their CARICOMP-based codes which, for species, is the first letter of the genus name followed by the first three letters of the species name *(e.g., Diploria strigosa* = DSTR).

B. Small corals were underrepresented in earlier AGRRA surveys because narrow line transects are biased towards sessile organisms with large diameters (Fig. 6; see also Zvuloni *et al.,* 2008), and because the minimum size for individual assessments was either 25 cm (routine in Version 2) or 10 cm (standard in Versions 3 and 4). Substituting 1-m wide belts, and counting **all** corals that are ≥ 4 cm in maximum length in each of two, 10 × 1 m^2 belts allows calculations of their population density, size structure and size-specific condition.

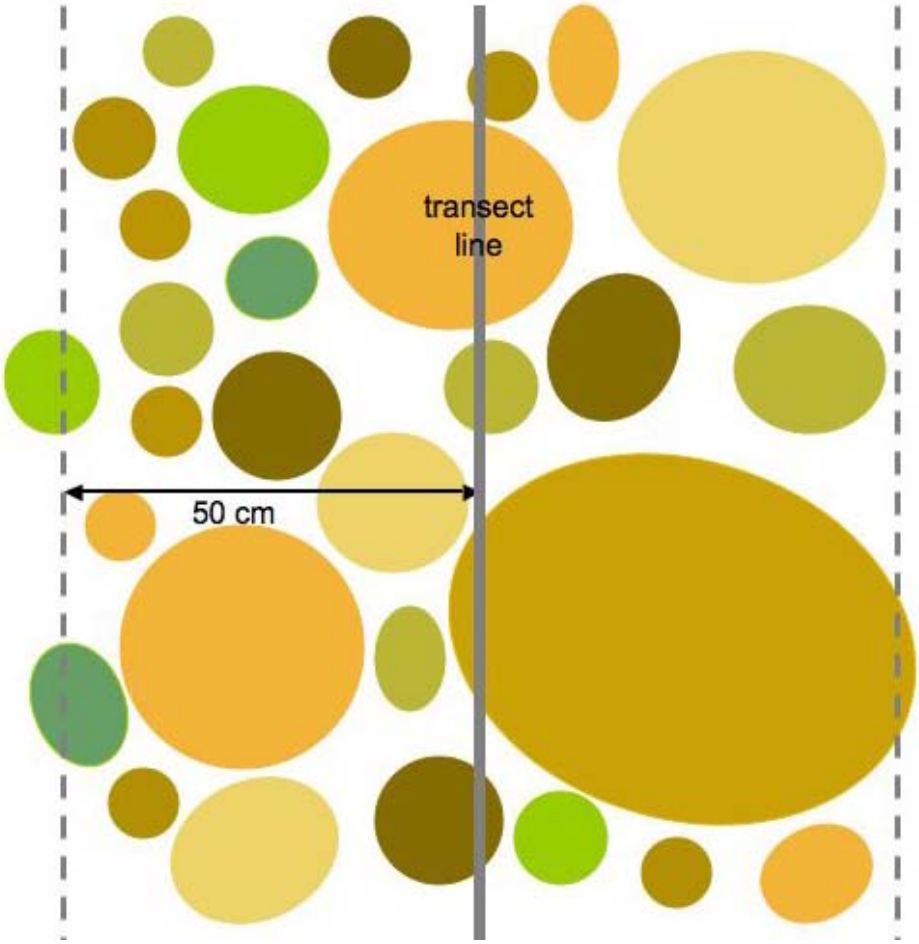

Figure 6. Conceptual diagram of how small size corals are undersampled in line transects relative to 1-m wide belt transects due to their low probability of being located beneath a transect line (After Ault and Smith, 2007).

C. The number of isolated patches of soft tissue (Florida Reef Resilience Program, 2009a) resulting from external perturbations rather than from natural growth processes (Fig. 7) is a new category for AGRRA that reflects on-going or prior disturbance processes (R. van Woesik, pers. comm.). Isolate number is likely to increase after major, partial-colony mortality events like outbreaks of disease or severe mass bleaching.

Figure 7. Large colony of *Diploria strigosa* with three soft tissue isolates resulting from partial-colony mortality. (K. Marks, photo)

D. Recent mortality as originally defined in the AGRRA benthos protocol is now partitioned as:

New mortality (NM)–non-living part(s) of the coral in which the corallite (= surficial skeletal) structures are still intact, unless they have just been bitten by a fish or abraded, and the freshly exposed, white surface is free of any sediment, microbial/diatom biofilms, other microalgae, etc. The coral's soft tissues would have died within the previous minutes-several days at most and, in some cases, may not have completely sloughed off the skeleton.

New mortality gives important temporal information during prolonged disturbances like the outbreaks of disease that can follow mass bleaching events (Kramer, 2003).

Transitional mortality (TM)–any non-living parts of the coral in which the corallite structures are slightly eroded at most, unless they have just been bitten by a fish or abraded, and its surface is covered by a thin layer of sediment, or by biofilms of bacteria (including photosynthetic cyanobacteria) and possibly diatoms or other microalgae, or by tiny turf algae. The coral's soft tissues are presumed to have died within the previous day(s)-months.

Old mortality (OM) is still defined as any non-living parts of the coral in which the corallite structures are: (a) covered over by organisms that are not easily removed *(e.g.,* thick turf algae, dense macroalgae, attached invertebrates, possibly including other corals); or (b) the overgrowing organisms (and perhaps the outer corallite structures) have been removed by a scraping herbivore *(e.g.,* the stoplight parrotfish *Sparisoma viride)*, or abraded by a storm, exposing the underlying skeleton. The coral's soft tissues are presumed to have died within the previous months-years or decades.

Standing dead (SD) is used to describe a coral that, for any combination of mortalities (NM, TM and/or OM), is completely (100%) dead over its ***entire surface*** *(i.e.,* not just on the outward-facing surface).

E. The prevalence of corals exhibiting partial mortality on any surface is recorded to enhance comparability of the AGRRA dataset with other programs. Partial mortality estimates as a percentage of the outward-facing coral surfaces are now restricted to ***detailed-level surveys.***

F. Similarly the percent of the outward-facing surface of the coral that is **pale** or **bleached** (as defined below) is now restricted to ***detailed-level surveys***. Bleaching prevalence on any surface is noted in all surveys.

G. Diseases. The list of "common field names" for coral diseases and syndromes in our region has expanded considerably (Weil and Hooten, 2008; Bruckner, 2009; E.C. Peters, pers. comm., 2009; see also Bruckner, 2002; Raymundo et al., 2008; www.coris.noaa.gov/about/diseases). Moreover, nomenclatural changes necessitate the recoding of a white acroporid disease (see below):

Conspicuous Tissue Loss–
CBD = Colored Band Diseases, **or distinguish as:**
BB = Black Band
RB = Red Band
CCI = Caribbean Ciliate Infection
WDS = White Diseases or Syndromes, **or distinguish as:**
Non-acroporids:
WP = White Plague
CWS = Caribbean White Syndromes *(i.e.,* not white plague, not on *Acropora)*
***Acropora* only:**
AWDS = Acroporid White Diseases or Syndromes, **or distinguish as:**
WB = White Band
WPD = White Patch Disease (formerly coded as WS)
RTL = Rapid Tissue Loss *(i.e.,* diffuse, irregular patterns that differ from WB and WPD)
Conspicuous Tissue Discoloration–
DS = Dark Spots Syndrome
YB = Caribbean Yellow Band (= yellow blotch)
Conspicuous Tissue Anomalies
GA = Growth Anomaly *(i.e.* depression or bulging mass with no polyps, or with unusual, chaotic polyps)
GI = Gigantism *(i.e.,* unusually large polyps)

Unchanged in Version 5

A. In AGRRA surveys, a **colony** has distinct margins and is considered to represent one genetic individual. Colonial corals have "an autonomous mass of skeleton covered with living tissues" (Nugues and Roberts, 2003), even if the soft tissues naturally subdivide into separate units *(e.g.,* the lobes of *Montastraea annularis)*. A **clump** (thicket or cluster) is a large group of similar appearing, conspecific corals that are usually branching *(e.g., Acropora, Porites, Madracis)* or lobate *(e.g., M. annularis),* and for which individual colony borders cannot be distinguished by visual inspection underwater. **Fragment** refers to a detached, possibly broken, and easily moved coral that is unlikely to remain for long in its current position on the reef. **Solitary** corals of the genus *Scolymia* that are large enough for inclusion in AGRRA surveys are rare in most shallow-intermediate depth habitats and should be assessed with the colonies.

B. As in Version 4 of the AGRRA benthos protocol, the width of a colony or clump is defined as its maximum distance orthogonal to the maximum length (maximum length being equal to the maximum diameter of Versions 1-3).

C. Bleaching is characterized by approximate severity of discoloration as:
P = Pale relative to what is considered "normal" for the species, geographic location, depth, habitat and season.
BL = Bleached (tissue is fully bleached, no zooxanthallae are visible).
Remember that many severely bleached corals are transparent, but you can still see the polyp tissues above the skeleton. Some fully bleached corals are pale purple, blue, or pink, in addition to being transparent.
Bleached tissues are alive and do not represent new mortality.

D. Percent partial mortality estimates are restricted to the outward-facing coral surfaces for reasons of greater simplicity, speed and estimation accuracy (J. Lang, pers. obs.). Estimates of percent partial mortality that include the entire coral are not *directly* comparable with the AGRRA data.

Coral proficiency effort levels

Basic: CARICOMP-based coral codes, tissue isolates number, size measurements, mortality prevalence (if any), and any conspicuous signs of disease or bleaching.

Detailed: as above for ***basic-level***, plus percent of any partial mortality or bleaching of the outward-facing surface (if a colony) or under points (if a clump), field names for all locally common coral diseases and, optionally, names of predators, competitors or other common sources of mortality.

Coral Method

See also the summary/reminder Instructions in the appropriate CORAL UW datasheet files.

Begin by choosing the appropriate level ***(basic*** or ***detailed)*** of effort for each section of the coral protocol. Before starting to survey, you should conduct **consistency-training exercises** with other coral team members or an instructor to gain practice in setting and retrieving the lead-core transect line, identifying corals underwater, in determining coral boundaries, measuring their sizes, counting any tissue isolates, and in recognizing mortality categories, signs of disease, bleaching, or other conspicuous local perturbations. For ***detailed-level surveys:*** also practice estimating percent partial mortality and bleaching of the outward-facing coral surfaces, and identifying coral diseases, signs of predation and competition.

Retraining on a weekly basis during expeditions is strongly encouraged.

1A. At each **site**, record the following information on your **Basic** or **Detailed** **CORAL-UW-V5.4** datasheet before the dive:
Surveyor: 4-letter code with first two letters of your first and last names
Date: Day with two digits/abbreviation of month name/year with two digits *(e.g.,* 14 Aug 07)
Site Name: Local survey site name (if known) or description of area *(e.g.,* off Windy Hill Pt.)
Day #: sequential by day during an expedition (1, 2, 3, etc.)
Site #: sequential within each day (1, 2, 3, etc.)
AGRRA Code: sequential site code, as 3 letters + 2-3 digits *(e.g.,* BAH01, BAH02, BAH03 = first three Bahamian surveys) during an expedition
Latitude & Longitude: as determined by DGPS (or best available instrument) at the site**, to be corrected if necessary from a boat or other fixed position** (see Selecting Survey Sites)
Reef Type: *(e.g.,* bank, barrier, mid-shelf, fringing, patch)
If different from expected, please describe the reef type surveyed.
Reef Zone: *(e.g.,* back = lagoon-ward or landward of a crest; crest; fore = seaward of a crest or shore)
If different from expected, please describe the reef zone surveyed.
Reef Subzone/Habitat: *(e.g.,* reef flat/*complanata,* inner terrace/brain corals)
If different from expected, please describe the habitat surveyed.
Selection Method: *(e.g.,* stratified random, stratified strategic)
Site Comments: space to describe how latitude and longitude were calculated *(e.g.,* on site or approximated from some fixed position), or other notes about the site**–to be completed by the end of the dive.**

1B. Attach a copy of the **CORAL Codes-V5.4** list printed on UW paper on the back of your clipboard if needed for reference.

2. At the survey site, use a haphazard method to choose a starting point for your transect, *i.e.,* by spinning several times with your eyes closed, or gently dropping your meter pole while descending–the latter to be avoided if a current is present or you are near deeper water.

3. Record when you begin to set the first transect in **Start Time** and, if you can, the **Bottom Temperature** at the depth of the survey habitat. Loop the free end of the line to a dead piece of coral or other secure object that wouldn't easily be damaged. Note the **Start Depth** at the initial meter mark and the depth scale (specify as feet or meters). Without biasing your choice of direction by looking down, unwind the line from the quadrat as you swim away from this starting point.
Be careful not to cross benthic transects that are being set by other divers. Unless directed to survey there by your team leader, avoid the edges of the reef or unusual reef features and areas with abrupt changes in slope, deep grooves, large patches of sand, or unconsolidated coral rubble.

As soon as the entire transect line has unreeled, pull tightly to ensure that it is taut, and secure to the bottom by wrapping the quadrat around or over some sturdy object. Note the **End Depth** at the final meter mark.

4. As you return towards the starting point, you may need to straighten the line by repositioning one of its ends, by pulling it off the bottom in high-relief reefs, or by disentangling it from upright gorgonians, sponges, etc.
   In some locations you will need to keep a lookout for lionfishes (Pterois spp.)*. Should any be present and remain in the immediate vicinity, be sure pay attention to their specific locations during your survey!*
   By the end of your dive, note the number and approximate size (as total length) of any lionfishes in the Site Comments box (if outside the area of your belt transect) and/or the Transect Comments box (if within your belt transect).

5. Using the 1-m pole perpendicular to the transect line for horizontal scale, swim a 0.5-m wide belt transect along one side of the line. Examine all scleractinians and *Millepora* (**except *M. alcicornis)*** that are ≥ 4 cm in maximum length and for which any part the coral, **no matter how small,** is located **inside the belt** (as recommended by Zvuloni *et al.,* 2008), including all those which underlie the transect line.
   Remember to ignore all corals that are < 4 cm in maximum length.

   All ≥ 4 cm Corals

   Species. Identify each colony, clump or fragment using its 4-letter coral code. Include all entirely dead corals that can be identified at least to genus and are still mostly intact. Ignore dead branching corals that have lost most of their branches as their sizes would be grossly underestimated.

   Isolates. For each **colony**, record the total number of isolated patches of soft tissue resulting from external perturbations. Put 1 if no such disruptions, and zero if standing dead. If > 10 isolates, estimate to the nearest 5 as 15, 20… *etc.* Do **not** include isolates that form naturally in some lobate corals like *Montastraea annularis*, in phaceloid corals like *Mussa angulosa* and *Eusmilia fastigiata*, or in branching corals like *Porites porites* and *Madracis auretenra* (formerly *M. mirabilis).*

   For each **clump** or **fragment**, write CLUMP or FRAG, respectively. Don't count their isolate numbers.

   ***All Colonies and Clumps* (ignore fragments)**

   Size. For each colony or clump, measure the **maximum length** and the **maximum width** of the outward-facing surface (both are perpendicular to its axis of growth) as seen from above in planar view, and its **maximum height** (parallel to the axis of growth) as seen from the side. Use the 50-cm pole or a ruler for small corals, and the 1-m pole for large corals and clumps. Try to record these measurements to the nearest 1 cm up to 10 cm, to the nearest 5 cm up to 50 cm, and to the nearest 10 cm when > 50 cm.

   Colony margins can be difficult to recognize when parts of a coral have died and are overgrown by other organisms–particularly other corals of the same species. Look for connected live tissues, basal skeletal connections, and at the size and color of the separated tissues.

   How to assess colonies or clumps that are detached from the substratum:

   If loose, and large enough to remain in place during all but severe storms, the size measurements and condition assessment should be made as if still attached (Fig. 8A). You can write LOOSE in the corresponding Comments box.

   If loose but wedged *(i.e.,* likely to remain in this position for an extended period), measure as if attached in its "new" position (Fig. 8B); you can write WEDGE in the corresponding Comments box.

   If fallen and reoriented to grow upward in a new position, measure the "new" size dimensions (Fig. 8C), and use the "new" outward-facing surface for estimating % mortality or bleached.

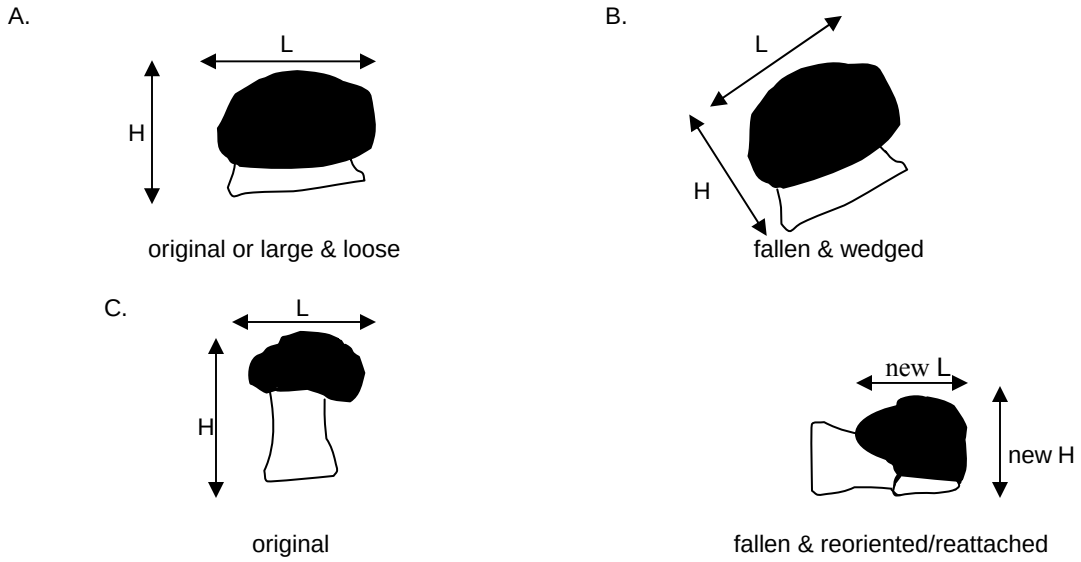

Figure 8. Assessing detached corals. L = length; H = height.

Outward-Facing Surfaces of All Colonies **(ignore clumps and fragments)**

Detailed-level only: examine the outward-facing surface of each colony in planar view as done above for measuring size. Estimate each of the following to the nearest 5%, unless very small or very large, in which case try to round to the nearest whole number *(e.g.,* 1%, 97%). Can leave blank if 0%:

Bleaching as percent of total (not just live) surface affected. Approximate severity of discoloration as:

% P (pale) and/or **% BL** (bleached) *(i.e.,* 30P, 10BL = 30% pale + 10% bleached).

Alternatively, some groups may prefer to qualitatively approximate the severity of any discoloration as:

P (pale) and/or **PB** (partly bleached = patches of fully bleached tissues). or as **BL (**all tissues are fully bleached).

Partial Mortality as **% new, % trans (= transitional)**, and/or **% old**. Although most large colonies have some dead areas, ignore any that are restricted to the sides or bases, and thus not visible when their outward-facing surface is viewed from above.

When corals are partially or completely overgrown by a brown or black, zooxanthellate clionid sponge, the live coral polyps are replaced by sponge tissues with their characteristic ostia and oscules (openings). Even though you may be able to see the coral skeleton beneath the sponge, include the affected area in your estimate of old mortality, and note CZOO OG (=zooxanthellate clionid overgrowth) in the Comments box.

Outward-Facing Surfaces of All Clumps **(ignore colonies and fragments)**

Detailed-level only: using the 50-cm or 1-m pole for scale, record the condition of the points at 10-cm intervals across the maximum length of each clump as:

L = # live tissues of "normal" pigmentation
P = # pale (live) tissues
BL = # fully bleached (live) tissues
NM = # new mortality
TM = # transitional mortality
OM = # old mortality (includes organisms overgrowing dead parts of the clump)
XX = # points that are not over a part of the clump

(e.g., 9 L, 7 P, 4 TM, 6 OM, 3 XX= 9 live, 7 pale, 4 transitional mortality, and 6 old mortality, for a total of 26 points across the clump and 3 that are not on the clump.)

Entire Surfaces of All Colonies or Clumps **(ignore fragments)**

Examine the entire colony or clump and note any of the following:

Diseases. If new mortality is common on corals or clumps that are not bleached or broken, and if common corallivores (coral predators) or other known sources of mortality are absent–

Basic-level: put X in the Disease box; identify by disease code if instructed to do so by the team leader.

Detailed-level: identify all common coral diseases and syndromes present in the survey area. Put **UK** (Unknown) when unsure.

Optional*: If unknown, try to get a photograph or describe as follows in the margin of your datasheet*: *by location (basal, mid, top); presence of one or more foci (= area of active infection); appearance of the interface between remaining live tissues and exposed skeleton (smooth, jagged); if mucus or disintegrating tissues are present; and whether or not adjoining tissues are bleached. Try to match your observations with one of the characterized diseases after the dive.*

Bleaching. Record the presence (**not** percentage) of any conspicuous bleaching as **P** (pale) and/or **PB** (partly bleached), or as **BL** (fully bleached), respectively, as follows–

Basic-level: present **anywhere** on the colony or clump.

Detailed-level: note only if not previously recorded in the *Outward-facing Surfaces of Colonies* or the *Outward-facing Surfaces of Clumps*.

Mortality. Record the presence (**not** percentage) of any new, transitional or old mortality as **NM, TM** and/or **OM**, respectively, as follows–

Basic-level: present **anywhere** on the colony or clump.

Detailed-level: note only if not previously recorded in the *Outward-facing Surfaces of Colonies* or the *Outward-facing Surfaces of Clumps*.

If the colony or clump is entirely dead over its entire surface, record as **SD** (standing dead) providing you can identify it to species *(e.g., Acropora palmata* by gross morphology or *Montastraea cavernosa* by polyp size and shape), or species complex *(e.g., Montastaea annularis* complex or digitate *Porites*), or genus *(e.g., Diploria* by size of meandering ridges and valleys).

Predators. Detailed-level only: if possible note their presence, or clear evidence of activity, as:

PFB = Parrotfish Bites
DFB = Damselfish Bites or **DFG** = Damselfish Algal Gardens (including any DFB)
CABB = coral-feeding snail, *Corallophilia abbreviata*
HCAR = bristle worm, *Hermodice carunculata*

Major Competitors. Detailed-level only: note only those organisms that have unambiguously killed and/or are overgrowing the live parts of the coral. If you need to create additional codes for locally abundant organisms, write an explanation in the transect comments, *e.g.,* AKA = *Aka coralliphaga* (formerly called *Siphonodictyon coralliphagum).*

Unhealthy Looking Tissues. ***Detailed-level only:*** if conspicuous, code as **CHC** = Compromised Health in Hard Corals.

6. Periodically check your bottom time and air supply:
If remaining time and available air both permit, after completing the belt on one side of the line, return along the second side, assessing all ≥ 4 cm corals that are at least partially within a 0.5-m wide belt.
Be careful not to resurvey any coral beneath the line that was examined during the first transect.

If at any time during the dive you don't have enough time and/or air left to complete the survey, use any blank spaces remaining on your datasheet to tally (= count and record) by **coral codes** all remaining colonies, clumps or fragments *(e.g.,* COL: AAGA 𝍸 𝍸 ||, DSTR 𝍸 |; CLUMP: PFUR |; FRAG PDIV ||| = 12 colonies of *A. agaricites*, 6 colonies of *D. strigosa*, 1 clump of *P. furcata* and 3 fragments of *P. divaricata*).

This information is important for standardized coral density estimates. ***Always try to leave enough time to tally all colonies, clumps and fragments present in the belt transect by their species codes.***

In high-relief reefs it may be easier to survey both sides of the line at the same time. However, you should still try to spread your assessment along the line in reefs containing too many corals to complete the entire 10 m^2 survey within one dive.

Optional: *Before the dive, you can randomly write the numbers between 0 and 9 on your datasheet to determine the order of surveying the meters along the line.*

7. Record the number of m^2 in which the corals were surveyed and the number of m^2, if any, in which the corals were tallied by their coral codes.

Other Benthic Organisms

8. If any other group of benthic organisms within your belt transect is conspicuously perturbed by bleaching, disease, predators, etc., record in the transect comments box:
   its name or AGRRA code
   its approximate abundance by cover or number
   the approximate percent or number affected by the perturbation
   (e.g., 10% MALC/90% BL = *M. alcicornis* covers 10% of the substratum, 90% of the colonies are bleached; seafan, 7/20 CYANS = 7/20 *Gorgonia* colonies are being overgrown by cyanobacteria.)

   Record any other interesting observations in the Transect Comments box.

9. Free the quadrat end of the line. Wrap the line around the quadrat as you swim towards the other end of the line, then release the loop at the end and tie it to one side of the quadrat.
   Check to be sure that you have entered both the area in which all corals were completely surveyed and, if applicable, the area in which they were only tallied by coral codes.

   Put the number, and approximate size (as total length), of any lionfishes outside the area of your belt transect in the Site Comments box.

10. After diving, enter all your data and comments on a daily basis into a copy of the appropriate **Basic** or **Detailed CORAL DataEntry-V5.4** spreadsheet. (The Day # and Site # information can help order the UW datasheets.) Be sure to explain any codes of your own invention.

    Use a **separate** copy of the spreadsheet for **every site (not every day or every expedition)**, and **check your transcribed data to verify its accuracy**. Back up your own data regularly and store it in a safe place.

11. Once the team leader has signed off on all your spreadsheets, and safely stored the all original UW datasheets, the data are ready to be emailed to data@agrra.org for processing, archiving, and possible posting online at the AGRRA web site.

III AGRRA Fish Surveys (minimum 2 divers)

The visual census of fishes should be located in the same habitat as the benthic and coral transects. Since many fishes are wary of humans, fish transects should be spaced further apart than 5 m whenever possible, and they may need to range into slightly deeper or shallower water. Ideally, fishes should be surveyed between 1000 and 1400 hours when visibility underwater is at a maximum due to overhead sunlight; in reality this is impossible when many sites are sampled throughout the day.

Objectives

- Count and record the size of the AGRRA fishes in the water column above a total of 10, 30-m long × 2-m wide belt transects.
- ***Detailed-level only:*** measure maximum reef relief at six, regularly spaced intervals along each transect.

New in Version 5

A. Juvenile scarids (parrotfishes) and haemulids (grunts) are difficult to identify to species without close examination and were omitted from most of the previous AGRRA surveys. Since identification at the family level is more readily learned, they are now included as undifferentiated species groups of < 5 cm parrotfishes and < 5 cm grunts, respectively.

B. New species in the Version 5 fish list are: (a) potentially significant predators of corallivores (animals that prey on corals) and/or of the key herbivore *Diadema antillarum* (species were chosen on the basis of food items or diet data in FishBase, www.fishbase.org; see also Harborne *et al*., 2009); (b) moray eels as they can eat ecologically important herbivores (Mumby *et al.,* 2006); and (c) lionfishes *(Pterois* spp.)–invasive Indo-Pacific carnivores that are spreading rapidly throughout the wider Caribbean (Albins and Hixon, 2008; Freshwater *et al.,* 2009; Schofield, 2009).

C. Maximum reef relief, a proxy for rugosity, is an important component of habitat quality for reef fishes *(e.g.,* McCormick, 1994). It was estimated in the benthic transects during earlier AGRRA surveys, but is more appropriately measured along the fish transects as these cover a much wider area and potentially more variable reef topography.

   The amount of time required for the maximum relief measurements will vary according to the rugosity of the substratum and the experience levels of the divers. Three divers may be needed to complete a total of 10 fish transects per dive in very high relief sites.

Unchanged in Version 5

A. To minimize disturbing the fishes, counts are still made at the same time as the tape is unreeled rather than over a tape after it has been placed on the substratum.

B. The width of the transect belt remains at 2 m.

Fish data derived from surveys in which the list of species counted, and/or the transect width, length or sampling protocol differ from those employed in the AGRRA project, are not *directly* comparable with the AGRRA data.

Fish identification effort levels

Fish species chosen for AGRRA Version 5 surveys include ecologically important carnivores (many are also commercially significant as food items) and herbivores (which are also eaten in some areas), and fishes that are commercially collected for marine aquaria. A standardized fish list provides divers with a relatively consistent search image that facilitates accurate species identifications and minimizes "observer overload" (K. Marks, pers. obs.). Moreover, line-of-sight issues, which are especially acute in high-rugosity habitats, and errors beyond a diver's focal range in estimating fish sizes or the location of the belt boundary, are minimized by constraining both the number of assessed species and the transect width (Sale and Sharp, 1983; Floeter *et al.,* 2005; K. Marks, pers. obs.). An inherent limitation of narrow transects, however, is their bias against large schooling, or highly mobile, fishes (Nemeth *et al.,* 2003; Floeter *et al.,* 2005).

Basic: all AGRRA fishes by either the family or species names given in Table 4.

Table 4. Fish families or species and rationale for inclusion in ***basic-level*** fish surveys.

TAXON	PRIMARY DIET	RATIONALE
BY FAMILY NAME (regardless of species name):		
Acanthuridae (surgeonfishes)	Herbivores[1]	Eat benthic algae
Balistidae (triggerfishes)	Primarily Invertivores	Eat *Diadema antillarum* + Some are Commercially Significant[2]
Chaetodontidae (butterflyfishes)	Primarily Invertivores	Some are Commercially Significant (for aquaria)
Haemulidae (grunts)	Invertivores	Some are Commercially Significant
Kyphosidae (chubs)	Primarily Herbivores	Eat benthic algae
Lutjanidae (snappers)	Piscivores/Invertivores	Commercially Significant + Eat herbivorous fishes
Muraenidae (morays)	Piscivores/Invertivores	Eat herbivorous fishes
Pomacanthidae (angelfishes)	Invertivores/Herbivores	Some are Commercially Significant (for aquaria)
Scaridae (parrotfishes)	Herbivores	Eat benthic algae + Some may eat live corals and either scrape or erode coral skeletons
Serranidae (sea basses) Only Subfamily Epinephelinae (groupers + graysby, red hind, rock hind, coney)	Piscivores/Invertivores	Commercially Significant + Eat herbivorous fishes
BY SPECIES NAME (regardless of family name):		
In Carangidae (jacks), only: *Carangoides ruber* (bar jack) *Trachinotus falcatus* (permit)	Invertivores/Piscivores	Commercially Significant + permit may eat *Coralliophila* spp.
In Diodontidae (porcupinefishes), only: *Diodon holocanthus* (balloonfish) *D. hystrix* (porcupinefish)	Invertivores	Eat *Diadema*; may eat *Coralliophila* spp.
In Labridae (wrasses), only: *Bodianus rufus* (Spanish hogfish) *Lachnolaimus maximus* (hogfish) *Halichoeres bivittatus* (slippery dick) *H. garnoti* (yellowhead wrasse) *H. radiatus* (puddingwife)	Primarily Invertivores	Commercially Significant + May eat *Coralliophila* spp. & *Diadema*
In Monacanthidae (filefishes), only: *Aluterus scriptus* (scrawled filefish) *Cantherhines macrocerus* (whitespotted filefish) *C. pullus* (orangespotted filefish)	Herbivores/Invertivores	Commercially Significant
In Sparidae (porgies), only: *Calamus bajonado* (jolthead porgy) *C. calamus* (saucereye porgy) *C. penna* (sheepshead porgy) *C. pennatula* (pluma)	Invertivores	Some may eat *Diadema* or *Coralliophila* spp.
In other families: *Lactophrys bicaudalis* (spotted trunkfish)	Invertivore	Eat *Diadema*
Microspathodon chrysurus (yellowtail damselfish)	Herbivore	Eats benthic algae + Commercially Significant (for aquaria)
Sphoeroides spengleri (bandtail pufferfish)	Invertivore	Eat *Diadema*
Sphyraena barracuda (great barracuda)	Piscivore	Commercially Significant + Eats herbivorous fishes
Pterois spp. (lionfishes)	Piscivore/Invertivore	Invasive, venomous alien predators + Can be eaten safely after cooking

[1] Herbivores feed mainly or only on plants; Invertivores feed mainly or only on invertebrates; Piscivores feed mainly or only on fishes.

[2] "Commercially Significant" defined as species in FishBase in 2005 with a Fishery Importance of "Commercial" or "Highly Commercial."

Detailed: all species in Table 5 and in the **FISH List-V5.4**.

Table 5. Wider Caribbean (WC) species, their diet, and rationale for inclusion in ***detailed-level*** fish surveys.

TAXON	DIET, TROPHIC LEVEL[2]	RATIONALE
ALL WC SPECIES[1]:		
Acanthuridae (surgeonfishes)	Herbivores, 2.0	Eat benthic algae
Balistidae (triggerfishes)	Primarily Invertivores, 3.1-3.5; Herbivore/Invertivore*:* *Melichthys niger* (black durgon), 2.4	Eat *Diadema antillarum:* + Commercially Significant*:* *Balistes vetula* (queen triggerfish) *Canthidermis sufflamen* (ocean triggerfish)
Chaetodontidae (butterflyfishes)	Primarily Invertivores, 2.8-3.3	Some Commercially Significant (for aquaria) + Eats coral polyps: *Chaetodon striatus*
Haemulidae (grunts) score all < 5 cm long by family name only	Invertivores, 3.2-3.5	Commercially Significant*:* *Anisotremus surinamensis* (black margate) *Haemulon album* (white margate) *H. flavolineatum* (French grunt) + Eats *Diadema* & may eat *Coralliophila* spp.: *Anisotremus surinamensis*
Lutjanidae (snappers)	Piscivores/Invertivores, 3.4-4.5	Commercially Significant + Eat herbivorous fishes
Muraenidae (morays)	Piscivores/Invertivores, 3.9-4.5	Eat herbivorous fishes
Pomacanthidae (angelfishes)	Invertivores/Herbivores, 2.6-3.0	Some Commercially Significant (for aquaria)
Scaridae (parrotfishes) score all < 5 cm long by family name only	Herbivores, 2.0	All eat benthic algae + May eat live corals and either scrape or erode coral skeletons: *Scarus guacamaia* (rainbow parrotfish) *S. vetula* (queen parrotfish) *Sparisoma viride* (stoplight parrotfish)
LISTED SPECIES ONLY:		
In Diodontidae (porcupinefishes), *Diodon holocanthus* (balloonfish) *D. hystrix* (porcupinefish)	Invertivores, 3.2-3.4	Eat *Diadema*; may eat *Coralliophila* spp.
In Labridae (wrasses), *Bodianus rufus* (Spanish hogfish) *Lachnolaimus maximus* (hogfish) *Halichoeres bivittatus* (slippery dick) *H. garnoti* (yellowhead wrasse) *H. radiatus* (puddingwife)	Primarily Invertivores, 3.3-3.9	Commercially Significant + May eat *Coralliophila* spp. & *Diadema*
In Monacanthidae (filefishes), *Aluterus scriptus* (scrawled filefish) *Cantherhines macrocerus* (whitespotted filefish) *C. pullus* (orangespotted filefish)	Herbivores/Invertivores, 2.6-3.0	Commercially Significant

[1] See **Fish List-V5.4** for a complete list of AGRRA fishes.

[2] Number = Trophic level given in FishBase (www.fishbase.org) for tropical western Atlantic sites in April 2008. Level 1 = photosynthetic organisms *(e.g.,* algae); level 2 = herbivores (primary consumers, *e.g.,* surgeonfish); level 3 = carnivores (secondary consumers, *e.g.,* grunts); level 4 = top carnivores (tertiary consumers, *e.g.,* sharks).
These data are used in the Fish Summary Products to estimate the biomass of AGRRA herbivores, AGRRA invertivores and AGRRA piscivores, respectively.

Table 5, continued.

TAXON	DIET, TROPHIC LEVEL	RATIONALE
LISTED SPECIES ONLY:		
In Serranidae (sea basses), All WC species of *Epinephelus, Cephalopholis, Mycteroperca*	Piscivores/Invertivores, 3.5-4.5	Commercially Significant + Eat herbivorous fishes
In Sparidae (porgies), *Calamus bajonado* (jolthead porgy) *C. calamus* (saucereye porgy) *C. penna* (sheepshead porgy) *C. pennatula* (pluma)	Invertivores, 3.2-3.4	Eat *Diadema;* may eat *Coralliophila* spp.: *C. bajonado, C. calamus, C. penna* May eat *Coralliophila*: *C. pennatula*
In other families, *Caranx ruber* (bar jack)	Invertivore/Piscivore, 3.5-4.5	Commercially Significant
Kyphosus spectator and/or *K. incisor* (Bermuda & yellow chub)	Herbivores/Invertivores, 2.1	Eat benthic algae
Lactophrys bicaudalis (spotted trunkfish)	Invertivore, 3.0	Eat *Diadema*
Microspathodon chrysurus (yellowtail damselfish)	Herbivore, 2.1	Eats benthic algae + Commercially Significant (for aquaria)
Sphoeroides spengleri (bandtail pufferfish)	Invertivore, 3.2	Eat *Diadema*
Sphyraena barracuda (great barracuda)	Invertivore/Piscivore, 3.2	Commercially Significant + Eats herbivorous fishes
Trachinotus falcatus (permit)	Piscivore/Invertivore, 3.7	May eat *Coralliophila* spp. + Commercially Significant
Pterois spp. (lionfishes)	Piscivore/Invertivore, 4.5	Invasive, venomous alien predators + Can be eaten safely after cooking

Fish Method

See also the summary/reminder Instructions in the appropriate FISH UW datasheet file.

Begin by choosing the appropriate level (***basic*** or ***detailed)*** of effort for each section of the fish protocol. Before starting to survey, you should conduct **consistency-training exercises** with other fish team members or an instructor to gain practice in setting and retrieving the tape reel, identifying the species of fish that you will survey, and estimating fish sizes underwater. Regardless of the density of fishes at a given site, swim at a speed that will allow you to complete one 30-m transect in about 6 minutes. Don't artificially inflate your abundance estimates by slowing down and waiting for some AGRRA fishes to appear ahead of you on the transect line, by changing your direction of swimming to include any as might be off to one side, or by expanding the width of your transect more than 1 m on each side of the T-bar. ***Detailed-level surveys:*** also practice measuring maximum relief as you reel in the tape.

Retraining on a weekly basis during expeditions is strongly encouraged.

1A. At each **site**, record the following information on your **Basic** or **Detailed** **FISH-UW-V5.4** datasheet before the dive:
Surveyor: 4-letter code with first two letters of your first and last names
Date: Day with two digits/abbreviation of month name/year with two digits *(e.g.,* 14 Aug 07)
Site Name: Local survey site name (if known) or description of area *(e.g.,* off Windy Hill Pt.)
Day #: sequential by day during an expedition (1, 2, 3, etc.)
Site #: sequential within each day (1, 2, 3, etc.)
AGRRA Code: sequential site code, as 3 letters + 2-3 digits *(e.g.,* BAH01, BAH02, BAH03 = first three Bahamian surveys) during an expedition
Latitude & Longitude: as determined by DGPS (or best available instrument) at the site, **to be corrected if necessary from a boat or other fixed position** (see Selecting Survey Sites)

Site Comments: space to describe how latitude and longitude were calculated *(e.g.,* on site or approximated from some fixed position), or other notes about the site**–to be completed by the end of the dive.**

1B. Attach a copy of the **FISH List-V5.4** list printed on UW paper to the back of your clipboard if needed for reference.

2. At the survey site, haphazardly choose a starting point for your first transect by swimming around looking for a small crevice in which you can place the weighted end of the tape so it won't drag when the reel stops. Then clip the reel to the D-ring or clamp on your weight belt or BCD to allow the tape to be easily released without having to hold the reel in your hands.

Fishes

3. Write 1 in the **Transect #** box. Record when you start the transect in **Start Time,** plus the **Start Depth** (specify as feet or meters) and, if you can, the **Bottom Temperature** at the depth of the survey habitat. Periodically fixing your eyes on an object in the distance to help you maintain a straight line, release the 30-m tape from the reel while holding the 1-m wide T-bar in front of you. Swim at a steady pace, looking consistently about 2 m ahead of your current position, and giving uniform attention to each successive 2-m segment of the transect.

   Estimating the width of the belt with the T-bar, count all AGRRA fishes at the specified ***(basic*** or ***detailed)*** level which are located within a belt that is 2-m wide and extends above into the overlying water column. Estimate the total length of each AGRRA fish with the 10-cm increments on the 1-m T-bar, and assign it to one of the following size categories: 0-5 cm; 6-10 cm; 11-20 cm; 21-30 cm; 31-40 cm; > 40 cm. Assess fish schools by mentally partitioning each taxon (species or family) into one or more size categories and approximating the number of individuals in each size class to the nearest 10 if fewer than about 100 fishes, or to the nearest 100 if more than about 100 fishes. Count only those members of a school that happen to be within the 2-m long segment that is immediately in front of you at any given time. Use hash marks when counting small numbers of fishes and whole numbers, separated by commas or with some other delimiting mark (like circling the number), for schools *(e.g.,* 𝍸 ||||, 10, 50 = 69).

   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 about 6 minutes should be attempted, however, high densities of AGRRA fishes could slow this pace.

   Briefly describe and sketch any unknown/unfamiliar fish in the margin of the UW datasheet. Body shape and behavior *(e.g.,* swimming with pectoral fins, lying on bottom) may help later to identify its family. Colors and notable markings (spots, lines, etc.) can be essential in determining the species.

   Basic-level: AGRRA family and species groups are listed by common English names on the **Basic FISH-UW-V5.4** datasheet.

   Detailed-level: frequently encountered species and families are listed by common English names on the **Detailed FISH-UW-V5.4** datasheet. Fill in the name of any unlisted AGRRA species present at the site in the appropriate blank space associated with its family, or in any other blank space on the datasheet.

   Stop the fish census when you reach the end of the tape, and start to rewind the tape reel. A method that has worked well while rewinding the transect tape is to unhook the tape reel from the D-ring or clip on your weight belt or BCD and to hold it in front of you while rewinding. As this operation requires both hands, you may find it convenient to rest the horizontal crosspiece of the T-bar in the crooks of your elbows.

Maximum (Max.) Relief

4. ***Detailed-level only:*** pause at predetermined points (see below) and use your T-bar as a graduated meter stick to delineate a **1-m radius** from the point. Then use your T-bar to measure the vertical height of the tallest coral or reef rock above the lowest point in the underlying substratum. Try to measure Max. Relief to the nearest 5 cm if < 50 cm, and to the nearest 10 cm if > 50 cm high. Do **not** use your depth gauge to estimate Max Relief!

   If your tape is marked in meters, make your first measurement at the 30-m mark. As you reel in the tape, pause to measure and record Max. Relief at the 25, 20, 15, 10 and 5-m marks.

   If your tape is marked in feet, make your first measurement at the 90 ft mark. As you reel in the tape, pause to measure and record Max. Relief at the 75, 60, 45, 30 and 15-ft marks.

5. After rewinding the tape, record any other interesting observations in the Transect Comments box.

6. Repeat steps 2-5 while trying to stay **at least** 5 m laterally away from your previous position and the other divers, until a total of 10 transects has been completed at the survey site. Be sure to write the **Surveyor, Date**, **Site Name** and **AGRRA Code at least once on each side of every datasheet.** Put the **Transect #**, **Start Time** and **Start Depth on all subsequent transects**. Unless you encounter a water mass of a different temperature from that experienced at the first transect, it isn't necessary to continue to record the bottom temperature.
   To economize on the use of UW datasheets, one surveyor can be responsible for 4 transects (which requires using both sides of one UW datasheet) and the second can make 6 transects (which requires 1.5 UW datasheets).

7. After diving, enter all your data and comments on a daily basis into a copy of the appropriate **Basic** or **Detailed FISH-DataEntry-V5.4** spreadsheet. (The Day # and Site # information can help order the UW datasheets.) Include any species that was identified after the dive on the basis of its UW sketch or description.

   Use a **separate** copy of the spreadsheet for **every site (not every day or every expedition)**, and **check your transcribed data to verify its accuracy**. Back up your own data regularly and store it in a safe place.

8. Once the team leader has signed off on all your spreadsheets, and safely stored all the original UW datasheets, the data are ready to be emailed to data@agrra.org for processing, archiving, and possible posting online at the AGRRA web site.

OPTIONAL COMPONENTS

Several other useful assessments may be integrated into the core protocols if additional information is required locally for certain survey sites. You will need to construct appropriate UW datasheets for some of the methods.

Stony Coral Species Richness
Conduct a roving diver census around the entire habitat and tally all coral species that you can find. (Can be combined with photography or videography of the site and transects.)

Targeted Coral Size and Condition
Additional size, density and condition measurements can be made for any given coral species, or any given coral size class, of interest by increasing the number of haphazardly set, 1 × 10 m belt transects at the survey site.

Targeted Coral Disease(s)
A more reliable estimate of the prevalence of coral diseases can be obtained by increasing the number of haphazardly set, 1 × 10 m belt transects at the survey site.

Targeted Coral Recruitment
A more reliable estimate of coral recruitment can be obtained by increasing the number of haphazardly set, 10-m line transects at the survey site (see Benthic Method, 6A, p. 12).

Reef Fish Species Richness
A roving diver census can be conducted in the same general area as the fish belt transects following the Reef Environmental Education Foundation (REEF) method as briefly explained below. REEF membership is free and any surveyors planning on conducting roving diver censuses should sign-up at www.reef.org.

1. Swim around the reef site for at least 45-60 minutes and record **every fish species** observed on a copy of the REEF UW paper or comparable checklist. Use all your knowledge of fish habits, and be sure to search under overhangs, in any caves, etc.

2. Estimate the **density** of each species by using the following logarithmic categories:
   Single = 1 fish
   Few = 2-10 fishes
   Many = 11-100 fishes
   Abundant = >100 fishes

3. Record your observations on a REEF data-entry bubble sheet and mail to REEF or enter the data online using the web-based entry form at www.reef.org.

Herbivory
The effect of herbivorous fishes on macroalgal composition can be approximated with Steneck's (1985) Fish Bite Method. Different guilds of herbivorous fishes are categorized as:

Excavators (**Eroders and Scrapers** that can remove macroalgal holdfasts while feeding) = parrotfish (scarids);

Denuders (Grazers that eat macroalgal tissues without removing their holdfasts) = surgeonfish (acanthurids), *Microspathodon chrysurus* (yellowtail damselfish);

Non-denuders (Browsers that take bites of macroalgae) = other damselfish (pomacentrids) but not bicolor damselfish *(Stegastes partitus)* which feeds on plankton.

You must be able to distinguish:

Juvenile parrotfishes from juvenile surgeonfishes (acanthurids) and other juvenile fishes with similar stripes, such as wrasses (labrids) or grunts (haemulids) which only look as though they are biting algae as they search for small invertebrates;

Yellowtail damselfish from non-denuding species of damselfish.

1. Use a 1-m pole 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 × 1 m and representative of the benthic cover on the reef substratum.
   Do not use a meter quadrat to mark your observation area, as some herbivorous fishes commonly bite novel objects that are 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. Score large (> 20 cm total length) parrotfishes separately from smaller (≤ 20 cm) parrotfishes as they are more effective herbivores. Identify as many of the fishes to species as best as you can.

3. Repeat for a total of at least 5 squares (and 25 minutes observation).

4. Average your counts by guilds or by species; then multiply by 12 to calculate grazing rate/m^2/hour.

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Appendix 1. Benthic Training

Benthic Method Summary Instructions
Underwater Data Sheet
Training Card

AGRRA Detailed BENTHIC Protocol V5
Summary Instructions, March 2015

The **AGRRA Benthic UW V5** datacard is formatted to be printed on 8.5x11" underwater paper ("DuraCopy" Copier/Laser Paper 6511). To reduce expenses, print this form on both sides of each sheet.

Each benthic surveyor should have a complete set of benthic survey equipment. Be sure to take enough **Benthic V5 UW** datascards when making more than one survey during any given field outing. Attach a copy of the **AGRRA Benthic Codes** list printed on UW paper to the underside of your clipboard or slate if needed for reference.

Complete before the dive. Site Information

Surveyor: Name of the person making the survey or his/her 4-letter name code *(e.g.,* Anna Reyes = ANRE).
(Surveyor) Level: Basic or Detailed
Site Name: Name of dive site or description of area *(e.g.,* between Boston Beach & Splash Hotel).
AGRRA Code: Sequential site code *(e.g.,* MEX007 = seventh Mexican site).
Date: Enter date as: day, month name, year *(e.g.,* 19 Oct 09).

Once on site at the start of the dive.

Lay First Transect Line. Chose starting point **haphazardly.** Loop the free end of the line to a dead piece of coral or other secure object that won't easily be damaged. Unwind the transect line from the quadrat while avoiding the transect lines of other divers and–unless instructed otherwise by the team leader–avoid reef edges, unusual reef features, abrupt slope changes, deep grooves and large patches of sand or rubble. When the entire transect line is unwound, pull tightly to ensure that it is taut, and secure to the bottom by wrapping the quadrat around or over some sturdy object.

As you return towards the starting point, straighten the line if necessary by repositioning one of its ends, by pulling it off the bottom in high-relief reefs or by disentangling it from upright gorgonians, sponges, *etc.*

If the line sways a little due to strong surge or bottom current during the survey, note its position in the middle of its swing when locating the 10-cm points, or the center of the quadrats, or the midline of the belt.

If lionfishes (Pterois *spp.) are present, pay close attention to any that remain in the immediate vicinity of the transect line!*

Complete at the start of the first transect only (unless encountering water of a different temperature).

Start Time: Time at the start of the transect.
Bottom Temperature: If you can: numerical value at the depth of the survey habitat; circle the appropriate unit (^{o}C or ^{o}F).

Complete at the start of each transect. Transect Information

Transect #: Sequential number for the transect.
Start & End Depths: Depth of the transect line at the 0-m and 10-m marks; circle the appropriate unit (ft or m).

Complete during each transect. Point Count Information

Points. Record what is growing on the substratum immediately under the line at each of the marked 10-cm point intervals between the initial mark at 0 m/0 cm and the 9 m/90 cm mark.
Cover: Use the CARICOMP-based codes for corals + the codes listed on the **AGRRA Benthic UW Codes** sheet. Alternatively, you can use your own personal codes UW, providing the data are recoded with the AGRRA codes during the data entry process.

If several organisms co-occur under a point, record only the two most common, separated by a dash *(e.g.,* **TA-CCA, CYAN-FMA, FMA-CMA**).

Record a newly fragmented coral as live (**LC**) or newly dead (**ND** = bright white skeleton), depending on its condition under the point.

Record whatever is growing ***on* the surface of** coral rubble or dead corals (do **not** put RUB or DC, respectively).

For gorgonians, upright *Briarium* or ropy sponges, only record points that are directly above the area of attachment to the substratum.

If a point falls on drift algae, the upright areas of gorgonians, upright *Briarium* or ropy sponges, or a motile animal, record whatever is growing on the underlying substratum.

Code any sand-dwelling algae or seagrasses in sand as sand.

If additional codes are considered necessary at the transect site, be sure to write an explanation in the Transect Comments cell.

On high relief reefs, if you can't locate the position of the point(s) to count by simple visual inspection:

Above a narrow space, hold the 1-m pole vertically below its position on the line and record what is beneath the pole.

Above a wide space, note on your UW datasheet which intervals are involved. If sand or mud, record as such and move on. If not, place your 1-m pole under the line and record what is growing on the substratum immediately adjacent to each 10-cm mark on one side of the pole in the above-noted intervals on the UW datasheet *(e.g.,* if from 4.5 - 5.3 m, for a total of 9 points).

For each meter, write 10 benthic codes in the vertical rows matching its 0-90 mark. If necessary, retrace your route to locate any missing points at the end of every meter and add the appropriate code(s) in the remaining blank box(es*).*

Macroalgal Heights: ***For a total of 2 transects,*** record the heights of macroalgae under the points to the: nearest 1 cm if >1 cm *(e.g.,* CMA/2 = 2 cm tall calcareous macroalga or SAR/4 = 4 cm tall *Sargassum)*, nearest .5 cm if <1 cm tall, or nearest .1 cm for encrusting macroalgae like *Lobophora.*

If several algae co-occur under a point, measure only the height of the total assemblage.
If macroalgae are scarce *(i.e.*, cover < ~10 % of the substratum), try to measure their heights on all six transects.

Quadrat Information

Recruits, SC (Small Corals) and Substratum. Unhook the quadrat and sequentially center it at 2-m intervals on the substratum beneath 5 of the meter marks while swimming back along the transect line. Brush loosely attached algae and sediment off the substratum and from any partially buried recruits or small corals. Search all surfaces in planar view in areas of high topographic complexity. Ignoring any < 4 cm remnants of formerly larger colonies, record:

≤ 2 cm Recruits: Total number for each species or genus (by code) or as UK if identity is unknown *(e.g.,* 2SSID, 1UK = *2 S. siderea* and 1 unknown). Write NONE if no recruits are seen.

>2 - < 4 cm SC: Total number for each species or genus (by code) or as UK if identity is unknown. Write NONE if no small corals are seen.

Record the predominant substratum type in each quadrat:

Substratum Type: Code as **LC** for live coral, **DC** for any dead coral, **RUB** for rubble (<30 cm, loose), **DCB** for dead coral (>30 cm, loose), **PAVE** for carbonate pavement, **ROCK** for large, terrestrial boulders, **SAND** for sand (at least 5 cm thick), **MUD** for Mud (at least 5 cm thick).

Remember that only **LC, Sand** and **Mud** occur in both the Point Counts and Substratum.

If several substratum types are common, record only the two most common, separated by a dash *(e.g.,* **DC-PAVE**).

Hook the quadrat to the near end of the transect line when finished.

Belt Information

Motile Invertebrates, Lionfish and Trash. Using the 1-m pole for scale, sequentially search a 50-cm wide belt on each side of the transect line between the 0 m/0 cm and the 10 m marks. Record any of the following:

Juv. *Diadema*: Number of "juvenile" *Diadema* (small, with black-and-white banded spines). Put a 0 if none are seen.

Adult *Diadema*: Number of "adult" *Diadema* (larger, all-black spines, or all-black spines alternating with all-white spines, more rarely with all-white spines). Put a 0 if none are seen.

Other Urchins Number of any non-*Diadema* urchins on the reef or rubble; ignore all urchins in sand or mud. Put a 0 if none are seen.

Spiny Lobsters: Number of Caribbean spiny lobster *(Panulirus argus).* Put a 0 if none are seen.

Q. Conch: Number of **live** queen conch *(Strombus gigas).).* Be sure to return to their original positions any shells that are moved to see if they are alive. Put a 0 if none are seen.

Lionfish: Number of lionfish *(Pterois* spp.) Put a 0 if none are seen.

Trash: Number and kind of any trash items *(e.g.,* fishing line, beer cans, engine block). Put a 0 if none are seen. Please collect any trash that can be safely and easily removed from the reef.

Summarize for the belt transect as a whole:

Transect Comments: Define any unique codes used *(e.g.,* VALO = *Valoniopsis).*
Add any other important observations about the transect *(e.g.,* 2 spotted spiny lobster or 2 *P. guttatus).*
If any group of benthic organisms in the belt is ***conspicuously*** perturbed, record: its name or AGRRA code; its approximate abundance by % cover or by number; and the approximate % cover or number affected by the perturbation *(e.g.,* 35% PAL/ 50% BL = *Palythoa* covers 35% & 50% are bleached; 1/2 XES or 1/2BAR die = 1 of 2 *Xestospongia muta* or barrel sponges are dying).

When finished, rewind the transect line on the quadrat and continue to the next transect.

Benthic teams should survey a total of 6 transects/site; more are acceptable.

Complete by the end of the dive.

Site Comments: Add any other notes about the site, including number of any lionfishes, turtles, sharks, or other large vertebrates not in the belt transects, or any conspicuously diseased organisms.

Complete after the dive. **Data Entry & Backup**

Enter all your data, including any comments, on a daily basis ***online*** or in a copy of the **Benthic Data Entry V5 *spreadsheet*. (<u>If the latter, use a separate copy of the spreadsheet for each site.)</u> Always back up your own data on a daily basis and store your files in a safe place.**

If you have invented any additional benthic codes: first check the complete list of Benthic Codes found in the **AGRRA Benthic Codes-V5.6** file and, if found, substitute for your code(s). If there is no pre-existing code, use your code(s) and be sure to include an explanation for each in the relevant transect or site comments cell.

Surveyor: | **Level:** | **Site Name:** | **Agrra Code:** | **Date:** | **Start Time:**

Bottom Temp.: °C or °F? | **Site Comments** *(e.g.,* **major organisms):**

Detailed Level: ***Record macroalgal heights for a total of 2 transects/site. If macroalgae are scarce (<10% cover), try to measure in all 6 transects/site.***

Depth–Start: End: ft or m? | ***Diadema*–Juv:** Adult: | **Other Urchins:** | **Lobster:** | **Q. Conch:** | **Lionfish:** | **Quadrats**

Transect #:	0 m	1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	#	≤ 2 cm Recruits >2 - <4 cm SC	Substratum
0 cm											1	# R:	
10 cm												# SC:	
20 cm											2	# R:	
30 cm												# SC:	
40 cm											3	# R:	
50 cm												# SC:	
60 cm											4	# R:	
70 cm												# SC:	
80 cm											5	# R:	
90 cm												# SC:	

Trash (# of each kind): | **Transect Comments:**

Depth–Start: End: ft or m? | ***Diadema*–Juv:** Adult: | **Other Urchins:** | **Lobster:** | **Q. Conch:** | **Lionfish:** | **Quadrats**

Transect #:	0 m	1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	#	≤ 2 cm Recruits >2 - <4 cm SC	Substratum
0 cm											1	# R:	
10 cm												# SC:	
20 cm											2	# R:	
30 cm												# SC:	
40 cm											3	# R:	
50 cm												# SC:	
60 cm											4	# R:	
70 cm												# SC:	
80 cm											5	# R:	
90 cm												# SC:	

Trash (# of each kind): | **Transect Comments:**

Depth–Start: End: ft or m? | ***Diadema*–Juv:** Adult: | **Other Urchins:** | **Lobster:** | **Q. Conch:** | **Lionfish:** | **Quadrats**

Transect #:	0 m	1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	#	≤ 2 cm Recruits >2 - <4 cm SC	Substratum
0 cm											1	# R:	
10 cm												# SC:	
20 cm											2	# R:	
30 cm												# SC:	
40 cm											3	# R:	
50 cm												# SC:	
60 cm											4	# R:	
70 cm												# SC:	
80 cm											5	# R:	
90 cm												# SC:	

Trash (# of each kind): | **Transect Comments:**

AGRRA Benthos Training Card

Practice Show-and-Tell: *check when seen or point at when asked*

Point Count Codes	**X**		**X**		**X**
LC: Live Coral (don't touch) often shades of yellow-brown		**CYAN**: Cyanobacteria - many shapes and shades		**AINV**: Aggressive Invertebrate – often encrusting, sponge, cnidarian or tunicate	
BLC: Bleached *(Live)* Coral - often white; can see skeleton through tissues		**TA**: Turf Algae - tiny; usually filaments; many shades		**OINV**: Other Invertebrate - grow primarily off substratum; diverse shapes and shades	
NDC: Newly Dead Coral- bright white; intact skeletal surfaces		**TAS**: Turf Algae + Sediment - forming a thick mat		**Hole:** - can't see any organisms	
CCA: Crustose Coralline Alga - solid; pink or red; green if not photosynthetic; white skeleton		**FMA**: Fleshy Macroalga – flexible, green, red or brown		**Sand:** at least 5 cm thick	
PEY: fleshy or calcareous peyssonnelid, thin crusts; dark skeleton		**CMA**: Calcareous Macroalga - brittle; usually green or red		**Mud:** at least 5 cm thick	

Recruit and Small Coral Codes	**X**		**X**
R: ≤ 2 cm Recruits		**SC:** > 2 - ≤ 4 cm Small Corals	

Substratum Codes	**X**		**X**		**X**		**X**
LC: Live Coral		**RUB**: Rubble - loose, < 30 cm		**PAVE**: Pavement (carbonate hardbottom)		**SAND:** Sand – at least 5 cm thick	
DC: Dead Coral		**DCB:** Dead Coral Boulder - loose, > 30 cm		**ROCK**: Non-carbonates		**MUD:** Mud – at least 5 cm thick	

Motile Animals	**X**		**X**		**X**
Juvenile *Diadema* - black and white banded spines		**Other Urchins:** all other reef-dwelling echinoids		**Queen Conch** (*Strombus gigas*) - tally live animals only	
Adult *Diadema* - all black, all black + all white, or all white (rare) spines		**(Caribbean Spiny) Lobster** (*Panulirus argus)*		**Lionfish** (*Pterois* spp.)	

Practice a Partial Transect: Haphazardly chose a starting point to lay part of the transect line. Avoid other transect lines and reef edges, unusual reef features, abrupt slope changes, deep grooves, and large patches of sand or rubble. Pull line taut, and straighten or disentangle as needed.

Record: Start Time; Bottom Temp. (if you can, as ^{o}C or ^{o}F); Start and End Depths (as feet or meters).

Start Time:	**Bottom Temp. ^{o}C/ ^{o}F**
Depth–Start: End: ft or m?	

Practice Point Counts: Use the Point Count codes to record the appropriate benthic code for each 10-cm point under the line between 0 cm and 90 cm at the 0 m (or at some other m if working in pairs on the same line)**.** Remember that up to 2 codes can be recorded for each point when live organisms are on top of other live organisms. ***Optional:*** measure the height of any of the fleshy or calcareous macroalgae.

Transect #	**0 m**
0 cm	
10 cm	
20 cm	
30 cm	
40 cm	
50 cm	
60 cm	
70 cm	
80 cm	
90 cm	

Practice Quadrats: Unclip the quadrat and center it on the substratum beneath 2 of the m marks at 2-m intervals along the line. Brush away loosely attached algae and sediment and then count the total number of Recruits and Small Corals. Use the Substratum codes to record the Predominant Substratum Type.

#	**< 2 cm Recruits >2 - <4 cm SC**	**Substratum**
1	# R:	
	#SC:	
2	# R:	
	#SC:	

Practice Belt: Using the 1-m pole for scale, sequentially search a 50-cm wide belt on each side of the transect line between the 0m/0 cm and the 10-cm marks. Total each of the following; specify kind of any trash:

Diadema*–Juv*: **Adult**	**Other Urchins:**	**Lobster:**	**Q. Conch:**	**Lionfish:**
Trash (# of each kind):				

Appendix 2. Coral Training

Coral Method Summary Instructions
Underwater Data Sheet
Coral Training Card 1
Coral Training Card 2

AGRRA Detailed CORAL Protocol
Summary Instructions, March 2015

The **Coral UW V5** datacard is formatted to be printed on 8.5x11" underwater paper ("DuraCopy" Copier/Laser Paper 6511). To reduce expenses, print this form on both sides of each sheet.

Each coral surveyor should have a complete set of coral survey equipment. Be sure to take enough **Coral UW** datacards when making more than one survey during any given field outing. Attach a copy of the **Coral Codes** list printed on UW paper to the underside of your clipboard or slate if needed for reference.

Complete before the dive. Site Information

Surveyor: Name of the person making the survey or his/her corresponding 4-letter code *(e.g.,* Anna Reyes = ANRE).
(Surveyor) Level: Basic or Detailed
Site Name: Name of dive site or description of area *(e.g.,* between Boston Beach & Splash Hotel).
AGRRA Code: Sequential site code *(e.g.,* MEX007 = seventh Mexican site).
Date: Enter date as: day, month name, year *(e.g.,* 19 Oct 09).

Once on site at the start of the dive.

Lay Transect Line. Chose starting point **haphazardly.** Loop the free end of the line to a dead piece of coral or other secure object that won't easily be damaged. Unwind the transect line from the quadrat while avoiding the transect lines of other divers and–unless instructed otherwise by the team leader–avoid reef edges, unusual reef features, abrupt slope changes, deep grooves and large patches of sand or rubble. When the entire transect line is unwound, pull tightly to ensure that it is taut, and secure to the bottom by wrapping the quadrat around or over some sturdy object.

As you return towards the starting point, straighten the line if necessary by repositioning one of its ends, by pulling it off the bottom in high-relief reefs or by disentangling it from gorgonians, sponges, *etc.*

If the line sways a little due to strong surge or bottom current during the survey, locate the midline of the belt by noting its position in the middle of its swing.

If lionfishes (Pterois *spp.) are present, pay close attention to any that remain in the immediate vicinity of the transect line!*

Complete at the start of the transect. Transect Information

Start Time: Time at the start of the transect.
Bottom Temperature: If you can: numerical value at the depth of the survey habitat; circle the appropriate unit (^{o}C or ^{o}F).
Start & End Depths: Depths at the 0-m and 10-m marks; circle appropriate unit (ft or m).

Complete during the transect.

Starting on one side of the line, survey all ≥ 4 cm stony corals, except for *Millepora alcicornis*, for which any part, no matter how small, is located inside a 50-cm-wide belt between the 0-m and the 10-m marks. Ignore dead corals that can no longer be identified at least to genus and dead branching corals in which most of the branches are missing. Then continue in a 50-cm-wide belt on the 2nd side of the transect line, being careful not to resurvey corals that are under the line.

In high-relief reefs it may be easier to survey both sides of the line at the same time. However, you should still try to spread your assessment along the line in reefs containing too many corals to complete the entire 10 m^2 survey within one dive. ***Optional:*** *Before the dive, you can randomly write the numbers between 0 and 9 on your datasheet to determine the order of surveying the meters along the line.*

If survey cannot be completed during one dive *(e.g.,* due to a large number of corals), tally by species all remaining ≥ 4 cm corals as colonies, clumps or fragments.

Coral Terms. **Colony**: one genetic individual, even if the soft tissues naturally divide into separate units. Put any **solitary** *Scolymia* here.

Clump *(i.e.,* thicket or cluster): a group of similar appearing corals of the same species for which individual colony borders are indistinct, *e.g.,* branching species and large groups of lobate corals like *Orbicella* (ex-*Montastraea) annularis.*

Fragment: detached coral, often broken and easily moved; unlikely to remain in its current location for long.

Identify Each Surveyed ≥ 4 cm Coral

Species Code: Record its 4-letter coral code *(e.g.,* CNAT = *Colpophyllia natans).*
Use genus code if unsure of species *(e.g.,* ORBI for the *O. annularis* complex).
Sketch and briefly describe any unfamiliar corals and try to identify them after the dive. Include any standing dead corals that can be identified at least to genus and for which the original size can still be estimated.

 # Isolates, or put CLUMP or FRAG: If a **colony** or **solitary coral,** put the total number of soft tissue isolates resulting from prior or ongoing perturbations. Put 0 if entire colony is standing dead, *i.e.,* skeleton is intact but has no live tissues. Put 1 if the soft tissues lack externally produced sub-divisions. If >10, estimate to the nearest 5 as 15, 20, *etc.* Ignore the isolates that form naturally in some species *(e.g., O. annularis, P. porites, E. fastigiata).*
If a **fragment** or **clump**, do not count isolate number but write FRAG or CLUMP, respectively.
Colony margins (needed for # isolates and max. sizes) can be difficult to recognize when parts of a coral have died and are overgrown by other organisms–particularly other corals of the same species. Whenever possible, look for connected live tissues, basal skeletal connections, and at the size and color of the separated tissues.

Size of each ≥ 4 cm Colony, Solitary Coral and Clump (Ignore Fragments)

Max. Size (cm). As appropriate for the corals' size, use the ruler, 50-cm pole or 1-m pole to measure its maximum dimensions, as seen in planar view, to the nearest 1 cm up to 10 cm, to the nearest 5 cm up to 50 cm, to the nearest 10 cm up to 200 cm, to the nearest 20 cm up to 500 cm, and the nearest 50 cm if > 5 m (some large clumps). Record:

Length: Maximum length perpendicular to the axis of growth in cm.
Width: Maximum width at right angles to the maximum length in cm.
Height: Maximum height parallel to the axis of growth in cm.

Measure the maximum sizes of large colonies and clumps even when they extend outside the belt transect.

How to assess colonies, solitary corals or clumps that are detached from the substratum:
***If loose*,** and large enough to remain in place during all but severe storms, measure size as if still attached.

If loose but wedged *(i.e.,* likely to remain in this position for an extended period), measure size as if attached in the "new" position.

If fallen and reoriented to grow upward in a new position, measure the "new" size dimensions.

Condition of Outward-Facing Surfaces:
Each Colony and Solitary Coral (ignore Clumps and Fragments)

Examine the ***outward-facing surface*** of each colony or solitary coral and note any of the following to the nearest 5% *(e.g.,* 35%) unless very small or very large–in which case try to round to the nearest whole number *(e.g.,* 3%, 99%). Leave blank if 0%.

% Bleach: [alt. P, PB, BL] The percent of the entire planar surface **(and not just the proportion of live tissues)** that is **P** (pale) and/or **BL** (fully bleached) *(i.e.,* 30P, 10BL = 30% pale + 10% bleached).
[Alternatively, some groups have qualitatively approximated the severity of any discoloration as **P** (pale), and/or **PB** (partly bleached, *i.e.,* some polyps are fully bleached) and/or **BL** (all polypтs are fully bleached).]
Remember that some bleached corals have fluorescent purple, pink or blue colors**.**

% Partial Mortality: The percent of the entire planar surface that is:

New **New** for any new mortality, *i.e.,* skeletal structures are intact unless live tissues have just been
Trans bitten by a fish or abraded and have no sediment, bacterial/microalgal biofilms, turf algae, *etc.*,
Old on their bright white surfaces; and/or
Trans for any transitional mortality, *i.e.,* skeletal structures are slightly eroded at most and covered with fine layer of sediment, microbial/microalgal biofilms, or tiny turf algae–unless they have just been bitten by a fish or abraded, thereby exposing the underlying bright white skeleton; and/or
Old for any old mortality, *i.e.,* skeletal structures are completely covered over by organisms that are not easily removed, *e.g.,* thick algal turfs, many macroalgae and invertebrates–unless they have just been bitten by a fish or abraded, thereby exposing the underlying, bright white skeleton.

Although most large colonies have some dead areas, ignore any that are restricted to the sides or bases, and thus not visible when their outward-facing surface is viewed from above.

When corals are partially or completely overgrown by a brown or black zooxanthellate clionid sponge, the live coral polyps are replaced by sponge tissues with their characteristic ostia and oscules (openings). Even though the coral skeleton may be visible beneath the sponge, include the affected area in your estimate of old mortality.

Each Clump (Ignore Colonies, Solitary Corals and Fragments)

In the Comments cell, tally the condition of points at regular intervals across the maximum length (Max L) of each clump with the 50-cm or 1-m pole for scale, using the following codes:

Point Counts for CLUMPS: **L** for number of points over live tissues with "normal" pigmentation; **P** for number of points over pale live tissues; **BL** for number of points over fully bleached live tissues; **NM** for number of points over new mortality; **TM** for number of points over transitional mortality; **OM** for number of points over old mortality (includes other organisms overgrowing dead parts of the clump); **OTHER** for number of points over anything that is not part of the clump *(e.g.,* 15 L, 3 P, 4 TM, 8 OM, 5 OTHER = 15 live, 3 pale, 4 transitional mortality and 8 old mortality points on the clump; 5 points not on the clump).

Suggested interval lengths: 5-cm up to 1 m max L; 10-cm from 1 - 2 m Max L; 20-cm from 2 - 5 m Max L; 50-cm from 5 - 10 m Max L; 1-m for > 10 m Max L. ***Note the interval length used.***

Signs of Disease in Each Colony, Solitary Coral and Clump (ignore Fragments)

Examine the ***entire surface*** of each colony, solitary coral and clump. Record the presence (but not %) of any signs of disease (new mortality with no evidence of bleaching, breakage or predators, *etc.)*. Leave blank if none seen. Code as:

Disease:

CBD (Colored Band Disease with conspicuous tissue loss), or distinguish as **BB** (Black Band), **RB** (Red Band), or **CCI** (Caribbean Ciliate Infection).

WDS (White Disease or Syndrome with conspicuous tissue loss):

If not *Acropora*, try to distinguish as **WP** (White Plague) or **CWS** (Caribbean White Syndrones = not WP);

If *Acropora* as **AWDS** (Acroporid White Disease/Syndrome), or try to distinguish as **WB** (White Band), **WPD** (White Patch Disease, formerly coded as WS), or **RTL** (Rapid Tissue Loss).

Any conspicuous tissue discoloration as **DS** (Dark Spots Syndrone) or **YB** (Caribbean Yellow Band).

Any conspicuous tissue anomalies as **GA** (Growth Anomaly), or **GI** (Gigantism).

Put **UK** when an unknown disease or as instructed by the team leader. Can photograph or describe unknowns.

Condition of Colony, Solitary Coral and Clump (ignore Fragments) Sides

Examine the ***sides*** of each coral and note the presence (but not %) of any bleaching or mortality only if not already recorded on the outward-facing surface of colonies and solitary corals or under the counted points of clumps.

Any "Extra" P, BL, NM, TM, OM SD:

Any "extra" bleaching as **P** for pale and/or as **BL** for fully bleached.

Any "extra" mortality as **NM** for new mortality, and/or **TM** for transitional mortality, and/or **OM** for old mortality.

Put **SD** only if the **entire coral** is standing dead (= complete, 100% mortality) and you can identify it to species, species complex, or genus by gross morphology and/or by polyp size, shape and arrangement.

Comments +

Point counts, and point-count intervals, of any clumps are entered here.

Space is also available here for any other relevant observations about the coral.
Only if ***conspicuous,*** note the effects of any predators, *e.g.,* **PFB** for Parrotfish Bites, **DFB** for Damselfish Bites, **DFG** for Damselfish Algal Gardens**, CABB** for short coral snail, *Coralliophila abbreviata*, **CAR** for bristle worm, *Hermodice carunculata,* or any major overgrowing competitors by name or AGRRA code.If appropriate, note any unhealthy looking tissues as **CHC** for compromised coral health.

If coral is photographed, note image number here.

After completing the belt on one side of the line, return along the second side. If remaining time and available air both permit, assess all ≥ 4 cm corals that are at least partially within a 0.5-m wide belt. ***Be careful not to resurvey any coral beneath the line that was examined during the first transect.***

Area Surveyed (m^2): When finished surveying, record the total number of square meters with completed surveys of all ≥ 4 cm stony corals.

Remember that the area between each 1-m mark on one side of the transect line = 0.5 m^2.

Identify Each Tallied ≥ 4 cm Coral

If at any time during the dive you don't have enough time and/or air left to complete the survey, use any blank spaces remaining on your datacard to tally the numbers per species of any remaining ≥ 4 cm colonies, clumps and fragments in the belt transect using their 4-letter coral codes *(e.g.,* COL: OFAV 𝍸 II, CNAT IIII; CLUMP: PPOR II; FRAG APAL I = 7 colonies of *O. faveolata*, 4 colonies of *C. natans*, 2 *P. porites* clumps and 1 *A. palmata* fragment).

Area Tallied (m^2): When finished tallying, record the total number of square meters in which all ≥ 4 cm stony corals were tallied by species and as colonies, clumps or fragments.

Coral teams should survey a total of 2 transects; more are acceptable.

Complete by the end of the dive: Comments

Transect Comments: Define any unique codes used.
Add any other important observations about the transect, including number of any lionfishes.
If any other group of benthic organisms in the belt is *conspicuously perturbed*, note: its name or AGRRA code; its approximate abundance by % cover or number; and the approximate % or number affected by the perturbation *(e.g.,* 35% PAL/ 50% BL = *Palythoa* cover is 35% & 50% are bleached; 1/2 XES or BAR die = 1 of 2 *Xestospongia muta* or barrel sponges are dying).

Site Comments: Add any other notes about the site, including number of any lionfishes, turtles, sharks, or other large vertebrates not in the belt transects, or any conspicuously diseased organisms.

Complete after the dive: Data Entry & Backup

Enter all your data, including any comments, on a daily basis ***online*** or in a copy of the **CORAL-Data Entry V5 *spreadsheet*. (If the latter, use a separate copy of the spreadsheet for each site.) Always back up your own data on a daily basis and store your files in a safe place.**

If you have invented any additional benthic codes: first check the complete list of Benthic Codes found in the **AGRRA Benthic Codes** file and, if found, substitute for your code(s). If there is no pre-existing code, use your code(s) and be sure to include an explanation for each in the relevant transect or site comments.

Surveyor:	Level:	Site Name:	AGRRA Code:	Date:	Start Time:
Depth–Start: End: ft or m?		Site Comments *(e.g.,* major organisms, bottom temp.):			
Area–Surveyed (m^2): Tallied (m^2):		Transect Comments:			

All ≥ 4 cm Corals		All Colonies, Solitary Corals and Clumps									
Species Code	# Isolates, or put CLUMP or FRAG	Max. Size (cm)			Outward-facing Surface (Colonies)				Disease: X or code	Any "Extra" P, PB, BL: NM, TM, OM; SD	Point Counts for CLUMPS + Comments
		Length	Width	Height	% Bleach (or P, PB, BL)	% (or x) Partial Mortality					
						New	Trans	Old			

AGRRA Coral Training Card-Codes

Practice Show-and-Tell: *check when seen or point at when asked*

Common AGRRA Corals

Mound and Boulder	**X**	**Meandroid**	**X**	**Plates**	**X**
DSTO ***Dichocoenia stokesi***		**CNAT** ***Colpophyllia natans***		**ALAM** ***Agaricia lamarcki***	
MCAV ***Montastraea cavernosa***		**DCYL** ***Dendrogyra cylindrus***		**HCUC** ***Helioseris cucullata***	
ORBI *Orbicella (formerly Montastraea) annularis* complex		**DLAB** ***Diploria labyrinthiformis***		UNDA *Undaria* (formerly *Agaricia*)	
OANN ***Orbicella annularis***		MEAN *Meandrina*		**UAGA** ***Undaria agaricites***	
OFAV ***Orbicella faveolata***		**MJAC** ***Meandrina jacksoni***		**Branching**	
OFRA ***Orbicella franksi***		**MMEA** ***Meandrina meandrites***		MADR *Madracis*	
PAST ***Porites astreoides***		*MYCE Mycetophyllia*		**MAUR** ***Madracis auretenra*** (formerly *mirabilis)*	
SIDE *Siderastrea*		MALI *Mycetophyllia aliciae*		**MDEC** ***Madracis decactis***	
SSID ***Siderastrea siderea***		MFER *Mycetophyllia ferox*		PDIG "digitate" *Porites*	
SINT ***Stephanocoenia intersepta***		**MLAM** ***Mycetophyllia lamarckiana***		**PFUR** ***Porites furcata***	
		PSEU *Pseudodiploria*		**PPOR** ***Porites porites***	
		PCLI ***Pseudodiploria clivosa***			
		PSTR ***Pseudodiploria strigosa***		**Fire**	
		"Flower"		MILL *Millepora*	
		EFAS ***Eusmilia fastigiata***		**MCOM** ***Millepora complanata***	

Major Coral Condition Indicators

Bleaching	**X**	**Mortality**	**X**	**Common Diseases**	**X**
P Pale		**New/NM New Mortality**		**BB Black Band**	
PB Partly Bleached		**Trans/TM Transitional Mortality**		**CCI Caribbean Ciliate Infection**	
BL (fully) Bleached		**Old/OM Old Mortality**		**WP White Plague**	
		SD Standing Dead		**DS Dark Spot**	
				YB Yellow Band	

Major Predators and Effects

Invertebrates	**X**	**Fish**	**X**	**Fish**	**X**
CABB coral snail		**DFB Damselfish Bite**		**PFB Parrotfish Bite**	
HCAR fireworm		**DFG Damselfish Algal Garden**		**FB (unknown) Fish Bite**	

Practice Coral Assessments: Haphazardly chose a starting point to lay part of the transect line. Avoid other transect lines and reef edges, unusual reef features, abrupt slope changes, deep grooves, and large patches of sand or rubble. Pull line taut, and straighten or disentangle as needed. Examine five ≥ 4 cm corals within .5 m on one side of the line.

All ≥ 4 cm Corals		All Colonies, Solitary Corals and Clumps									
Species Code	# Isolates, or put CLUMP or FRAG	Max. Size (cm)			Outward-facing Surface (Colonies)				Disease: X or code	Any "Extra" P, BP, BL; NM, TM, OM; SD	Point Counts for CLUMPS + Comments
					% Bleach (or P, BL)	% (or x) Partial Mortality					
		Length	Width	Height		New	Trans	Old			

Species Code: Record the 4-letter CARICOMP-based coral code. Use genus code if unsure of species.

 # Isolates: Put 0 if entire colony is standing dead. Put 1 if the soft tissues lack ***externally*** produced sub-divisions. If >10, estimate to the nearest 5. Ignore the isolates that form naturally in some species. If **Clump** or **Fragment:** do not count isolate number but write CLUMP or FRAG, respectively.

Sizes: Use the 50-cm pole or a ruler for small corals or the 1-m pole for large corals and clumps to measure the **Maximum Length, Maximum Width** and **Maximum Height** of each Colony, Solitary Coral or Clump.

Outward-facing Surfaces of Colonies (and Solitary Corals)
Bleach: Either put **P** if any polyps are **pale**, and/or **PB (=partly bleached)** if some polyps are fully bleached, and/or **BL** if all polyps are fully bleached; or you can estimate the **%** that are **P** and/or **BL.**

Mortality: Either put **X** if any **new mortality**, **X** if any **trans (= transitional) mortality**, **X** if any **old mortality**, or you can estimate the **%** of any that are affected.

Disease: Put **X** if there are any signs of **disease** (new mortality with no evidence of bleaching, breakage or predators, *etc.);* identify by disease code if you can.

"Extras:" Record by code (**not** %ages) any "extra" bleaching, mortality, or disease as occurs on the sides and bases of large colonies and wasn't already recorded on their outward-facing surfaces. Put **SD** if the **entire** colony is **standing dead**.

Comments: Space for point counts of the condition of any clumps (as **L, P, BL, NM, TM, OM, Other**, *i.e.,* another organism) or other relevant observations, like **conspicuous** predation or competition with other organisms for any coral.

Appendix 3. Fish Training

Fish Method Summary Instructions
Underwater Data Sheet
AGRRA Fish Common Names
Fish Memory Clues for AGRRA species
Size Calibration

AGRRA Detailed Fish Protocol
Instructions for Use, March 2015

The **FISH UW V5** datasheet is formatted to to be printed on 8.5x11" underwater paper ("DuraCopy" Copier/Laser Paper 6511). To reduce expenses, print this form on both sides of each sheet.

Each fish surveyor should have a complete set of fish survey equipment. Be sure to take enough **Fish** datacards when making more than one survey during any given field outing. You can attach a copy of the **Fish List** printed on UW paper to the underside of your clipboard or slate if needed for reference.

Complete before the dive. Site Information

Be sure to write your initials (or name), the date, site name and AGRRA (site) code on **EACH** datasheet used during the dive.

Surveyor: Name of the person making the survey or the corresponding 4-letter code *(e.g.,* Anna Reyes = ANRE). Put at least once on each side of every datasheet.

Level: Basic or Detailed

Site Name: Name of dive site or description of area *(e.g.,* between Boston Beach & Splash Hotel). Put at least once on each side of every datasheet.

AGRRA code: Sequential site code *(e.g.,* MEX007 = seventh Mexican site). Put at least once on each side of every datasheet.

Date: Enter date as: day, month name, year (e.g., 19 Oct '09). Put at least once on each side of every datasheet.

Site Comments: Describe how latitude and longitude were calculated if estimated from some fixed position, or other notes about the site.

Choose transect starting point. Haphazardly choose a starting point for each transect by placing the weighted end of the tape in a small crevice so it won't drag when the reel stops. As much as possible, given the shape and size of the reef at the survey site and the prevailing visibility conditions underwater, avoid the other fish surveyer(s) and the divers with transect lines on the substratum. Clip the reel to the D-ring or clamp on your weight belt or BCD to allow the tape to be easily released while swimming.

Complete at the start of the first transect only (unless encountering water of a different temperature).

Bottom Temperature: If you can: numerical value at the depth of the survey habitat; enter beside appropriate unit (^{o} C or ^{o} F).

Complete at the start of each transect. Transect Information

Transect #: Sequential number of the transect.

Start Time: Time at the start of the transect. Use to ensure that you are swimming at a steady pace of about 6 minutes/transect.

Start Depth: Depth at the start of the transect; enter beside appropriate unit (ft or m).

Complete during each transect. Fish Information

Fish counts. Swim in a straight line, at a steady pace about 2 m above the substratum, while releasing the 30-m or 100 ft tape, holding the T-bar in front for scale, and giving uniform attention to each successive, 2-m long segment of the transect. (On shallow reefs, it may be necessary to swim closer to the substratum.) Within each 2-m long segment, count all AGRRA fishes that are within a 2m-wide belt extending from the substratum into the overlying water column. Estimate the total length of each fish using the 10-cm increments on the T-bar for scale, and assign it to one of the following size classes: 0 - <5 cm; 6 - 10 cm; 11 - 20 cm; 21 - 30 cm; 31 - 40 cm; or any appropriate 10-cm increment above 40 cm– write the latter in the column for > 40 cm. If individuals within a single size class are so abundant that you need to expand into an adjacent cell or cells, be sure to draw an arc around the additions that clearly shows to which size class they belong.

Use hash marks when counting few fishes, and whole numbers separated by commas or some other delimiting mark for schools *(e.g.,* ~~IIII~~ III, 30, 20 = 58). Put large schools into one or more size classes and approximate the numbers of individuals to the nearest 10 or 100. Remember to count only those members of a school that happen to be within the 2-m long segment that is immediately in front of you at any given time. *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 about 6 minutes should be attempted, however, high densities of AGRRA fishes could slow this pace.

In addition to counting, briefly describe and sketch any unknown/unfamiliar fish in the margin of the UW datasheet. Body shape and behavior *(e.g.,* swimming with pectoral fins, lying on bottom) may help later to identify its family. Colors and

notable markings (spots, lines, *etc.)* can be essential in determining the species.

To conduct a survey you must be able to identify the AGRRA Detailed-level fishes by either their common English or their scientific names. Frequently encountered species and families are listed on the **Detailed FISH-UW-V5.6** datasheets. Fill in the name of any unlisted AGRRA species present at the site in the appropriate blank space associated with its family, or in any other blank space on the datasheet.

AGRRA Detailed-level Fishes by English Common Name:

Identify ALL Western Caribbean Species: in these families–Angelfish, Butterflyfish, Grunt (score all < 5 cm long by family name only), Parrotfish (score all < 5 cm long by family name only), Sea Bass (Grouper subfamily only), Snapper, Surgeonfish, Triggerfish, Moray.

Identify to Species: in Wrasses–hogfish, puddingwife, slippery dick, Spanish hogfish, yellowhead wrasse;
in Filefishes–orangespotted filefish, scrawled filefish, whitespotted filefish;
in Porcupinefish–balloonfish, porcupinefish;
in Porgy–jolthead porgy, pluma, saucereye porgy, sheepshead porgy;
+ bandtail pufferfish, bar jack, chubs (Bermuda & yellow), great barracuda, permit, spotted trunkfish, threespot damselfish, yellowtail damselfish, lionfish

Complete at the end of each transect. Transect Information

Stop the fish census when you reach the end of the tape. Record the following:

End Depth: Depth at the end of the transect; enter beside appropriate unit (ft or m).

Transect Comments: Add any other important or interesting observations about the transect *(e.g.,* the names of any conspicuously diseased fishes; fishes with external isopod or copepod parasites).

Complete for each transect while rewinding the tape. Maximum Relief Information

Max. Relief. Unhook the tape reel from the D-ring or clip and hold it while rewinding. As this requires the use of both hands, crook the elbows to rest the horizontal crosspiece of the T-bar. Pause to use the T-bar as a graduated meter stick to measure maximum relief as defined below at each of the following points along the tape: 30 m, 25 m, 20 m, 15 m, 10 m and 5 m **or** 90 ft, 75 ft, 60 ft, 45 ft, 30 ft and 15 ft. Be sure to put a comma or some other delimiting mark between adjacent measurements for accuracy of subsequent data entry *(e.g.,* 170, 45, 210, 70, 150, 25).

Max. Relief: Vertical height in cm (not in meters) of the tallest coral or reef rock above the lowest point in the underlying substratum within a 1-m radius of each point.

Try to measure Max. Relief to the nearest 5 cm if < 50 cm, and to the nearest 10 cm if between 50 and about 400 cm high. Although depth gauges are unreliable over small changes of depth, they may be used to approximate vertical heights greater than approximately 3 m/10 ft providing the numbers are converted to cm before subsequent data entry.

Then continue to the next transect, while trying to stay **at least** 5 m laterally away from your previous position and the other divers.

Fish teams should survey a total of 10 transects/site; more are acceptable.

To economize on the use of UW datasheets, one surveyor can be responsible for 4 transects (which requires using both sides of one UW datasheet) and is then encouraged to conduct a REEF species richness-type survey (see www.reef.org) while the second conducts 6 transect surveys (which requires 1.5 UW datasheets).

Complete by the end of the dive.

Site Comments: Add any other notes about the site *(e.g*., the maximum number of sharks of any given species seen at any one time during the dive).

Complete after the dive. Data Entry & Backup

Enter all your data, including any comments, on a daily basis ***online*** or in a copy of the **Fish Data Entry V5 *spreadsheet.*** **(If the latter, use a separate copy of the spreadsheet for each site.)** Include any species that was identified after the dive on the basis of its UW sketch or description. **Always back up your own data on a daily basis and store your files in a safe place.)**

Surveyor:		Level::	Site Name:			AGRRA Code:	
Date:	Site Comments:						
Transect #:	Start Time:	Start Depth: ft/ m		End Depth: ft/ m		Bottom Temp.: °C/ °F	
Max. Relief:		Transect Comments:					

Family	Species	0-5 cm	6-10 cm	11-20 cm	21-30 cm	31-40 cm	> 40 cm (cm interval)
Angelfish							
	Gray Angel						
	Rock Beauty						
Butterflyfish							
	Foureye Butterfly						
Grunt							
* = by famiy	French Grunt	*					
		*					
Parrotfish							
* = by famiy	Princess Parrot	*					
	Redband Parrot	*					
	Stoplight Parrot	*					
	Striped Parrot	*					
		*					
Sea Bass							
(Subfam.	Coney						
Grouper/Hind)	Graysby						
Snapper							
	Mutton Snapper						
	Schoolmaster						
	Yellowtail Snapper						
Surgeonfish	Blue Tang						
	Doctorfish						
	Ocean Surgeon						
Triggerfish							
Moray							
Wrasse							
	Spanish Hogfish						
	Yellowhead						
Filefish							
Porcupinefish							
Porgy							
	Bandtail Pufferfish						
	Bar Jack						
	Chubs						
	Great Barracuda						
Other	Permit						
	Spotted Trunkfish						
	Threespot Damsel						
	Yellowtail Damsel						
	Lionfish						

Surveyor:		Level::	Site Name:			AGRRA Code:	
Date:	Site Comments:						
Transect #:	Start Time:	Start Depth: ft/ m		End Depth: ft/ m		Bottom Temp.: °C/ °F	
Max. Relief:		Transect Comments:					

Family	Species	0-5 cm	6-10 cm	11-20 cm	21-30 cm	31-40 cm	> 40 cm (cm interval)
Angelfish							
	Gray Angel						
	Rock Beauty						
Butterflyfish							
	Foureye Butterfly						
Grunt							
* = by famiy	French Grunt	*					
		*					
Parrotfish							
* = by famiy	Princess Parrot	*					
	Redband Parrot	*					
	Stoplight Parrot	*					
	Striped Parrot	*					
		*					
Sea Bass							
(Subfam.	Coney						
Grouper/Hind)	Graysby						
Snapper							
	Mutton Snapper						
	Schoolmaster						
	Yellowtail Snapper						
Surgeonfish	Blue Tang						
	Doctorfish						
	Ocean Surgeon						
Triggerfish							
Moray							
Wrasse							
	Spanish Hogfish						
	Yellowhead						
Filefish							
Porcupinefish							
Porgy							
	Bandtail Pufferfish						
	Bar Jack						
	Chubs						
	Great Barracuda						
Other	Permit						
	Spotted Trunkfish						
	Threespot Damsel						
	Yellowtail Damsel						
	Lionfish						

ANGELFISHES

- Blue Angelfish
- French Angelfish
- Gray Angelfish
- Queen Angelfish
- Rock Beauty

BOXFISHES

- Spotted Trunkfish

BUTTERFLYFISHES

- Banded Butterflyfish
- Foureye Butterflyfish
- Longsnout Butterflyfish
- Reef Butterflyfish
- Spotfin Butterflyfish

GROUPERS/SEA BASSES

- Black Grouper
- Coney
- Graysby
- Nassau Grouper
- Red Hind
- Rock Hind
- Tiger Grouper
- Yellowfin Grouper
- Yellowmouth Grouper

GRUNTS

- Black Margate
- Bluestriped Grunt
- Caesar Grunt
- Cottonwick
- French Grunt
- Porkfish
- Sailors Choice
- Smallmouth Grunt
- Spanish Grunt
- Tomtate
- White Grunt
- White Margate

LEATHERJACKETS (TRIGGERFISHES & FILEFISHES)

- Black Durgon
- Ocean Triggerfish
- Orangespotted Filefish
- Queen Triggerfish
- Whitespotted Filefish

MORAYS

- Goldentail Moray
- Green Moray
- Spotted Moray

PARROTFISHES

- Blue Parrotfish
- Greenblotch Parrotfish
- Midnight Parrotfish
- Princess Parrotfish
- Queen Parrotfish
- Rainbow Parrotfish
- Redband Parrotfish
- Redtail Parrotfish
- Stoplight Parrotfish
- Striped Parrotfish
- Yellowtail Parrotfish

PORCUPINEFISHES

- Balloonfish
- Porcupinefish

PORGIES

- Jolthead Porgy
- Saucereye Porgy
- Sheepshead Porgy
- Pluma Porgy

PUFFERFISHES

- Bandtail Puffer

SNAPPERS

- Cubera Snapper
- Dog Snapper
- Gray Snapper
- Lane Snapper
- Mahogany Snapper
- Mutton Snapper
- Schoolmaster
- Yellowtail Snapper

SURGEONFISHES

- Blue Tang
- Doctorfish
- Ocean Surgeonfish

WRASSES (HOGFISHES)

- Hogfish
- Puddingwife
- Slippery Dick
- Spanish Hogfish
- Yellowhead Wrasse

MISCELLANEOUS

- Chub
- Bar Jack
- Great Barracuda
- Lionfish
- Permit
- Threespot Damselfish
- Yellowtail Damselfish

Fish Memory Cues (common AGRRA species)

Angelfishes

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

Blue Angelfish
The Blue looks very similar to the Queen but without a crown and with a blue tail (not yellow).

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

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

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

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

Foureye Butterflyfish
Large false “eyespots” near tail.

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

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

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

Surgeonfishes

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.

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

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

Silvery (Miscellaneous)

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

Permit
Rounded shape due to high back profile. Orange area at base of anal fin.

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

Sheepshead Porgy
Small black spot at base of pectoral fin. Upper jaw overbite.

Saucereye Porgy
Bluish saucer-shaped line below eye.

Jolthead Porgy
Large mouth with thick lips. Yellow-orange at corner of mouth.

Pluma
Blue rectangular patch behind eye. Looks like a feather or ‘pluma’ in Spanish.

Chub
There are two closely related species (Bermuda & Yellow) that are very closely related and nearly impossible to tell apart underwater. We count these football shaped fishes under the simple name Chub.

Grunts

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

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

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

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

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.

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 Tom-Tom (a small drum) with the two yellow lines as drum sticks.

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.

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 omelet.

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 a golden earring.

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.

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

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

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.

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

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

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".

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

Lane Snapper
Though sometimes faint, this fish has yellow "lane" markers (think highway) along its body. It may have a small black spot just below the rear dorsal.

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

Schoolmaster
Large silvery white fish with all yellow fins. Think of a yellow school bus when you see the yellow fins.

Damselfishes

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

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

Graysby
Most common of the smaller groupers. Grayish brown with 3-5 pale or dark spots along back along base of dorsal fin. Think of the pairs of spots along the back as bullet holes – the fish was “grazed” by gunfire.

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

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

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.

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

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

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

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

Parrotfishes

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

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

Rainbow Parrotfish
“Rainbow” colored with orangish head and tail and bright green rear body.

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

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?)

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”.

Striped Parrotfish
TP: The tail is 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).

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.

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

Yellowtail Parrotfish
This species has a yellow tail in all of its phases.

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.

Wrasses/Hogfishes

Hogfish
The spiky front dorsal fin is like the bristles on the back of a razorback hog.

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

Puddingwife
White splotches on back of common intermediate phase.

Yellowhead Wrasse
Distinctive yellow head on TP. Wavy lines behind eyes on juveniles.

Slippery Dick
Dark spot on upper part of gill cover. Dark triangular corners on tail of TP. White with black mid-body stripe on JP.

Pufferfishes

Bandtail Puffer
Two dark bands on tail and a row of spots along the mid-body.

Porcupinefishes

Balloonfish
Long spines all over body especially on head. No black spots on fins.

Porcupinefish
Black spots on all fins.

Boxfishes

Spotted Trunkfish
Black spots over white background. White area around mouth.

Leatherjackets (Triggerfishes & Filefishes)

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

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

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

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.

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

Eels

Green Moray
Largest of the eels found in the area. Distinctive light greenish color makes this species easy to identify and remember its common name.

Spotted Moray
Brown and white speckling/spotting over entire body with dark border along the dorsal fin.

Goldentail Moray
Smaller than the Spotted Moray with finer spotting. Named for the golden color on the tip of the tail (which is rarely seen as it doesn't often leave its burrow). Golden color around the eye is also distinctive and will help to recall the common name.

Exotic Invasive

Lionfish
One or more species of the Scorpionfish family commonly known as lionfish are now aggressively naturalizing in the waters of the Tropical Western Atlantic. Lionfish can be easily identified by the featherlike pectoral and dorsal fin rays. The dorsal on top as well as the paired fins below (ventral & anal) are capable of inflicting a venomous sting. Envenomations are rarely fatal. The toxin is only active in living lionfish as it degrades quickly once the fish is dead.

0-5		6-10		11-20		21-30		31-40		>40	
Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual

Calibration spreadsheet for recording size estimates in various size categories.
From a distance of approximately 2 meters, estimate the width of many stationary objects (sponges, corals, etc.) in various size classes. Use the T-bar to measure the actual size and record the estimated and actual (measured) sizes to the nearest cm.

0-5		6-10		11-20		21-30		31-40		>40	
Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual

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