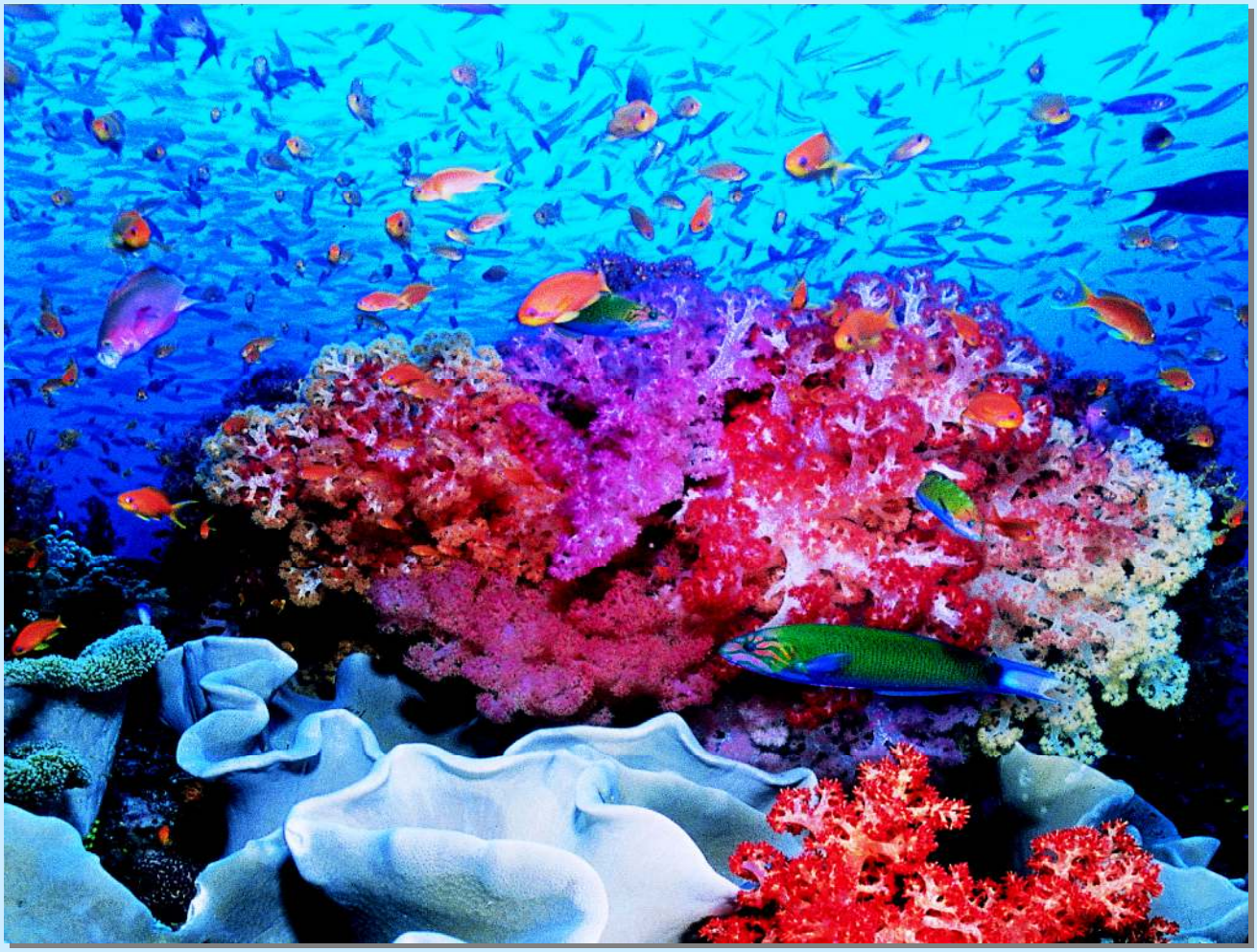

MAQTRAC

Marine Aquarium Trade Coral Reef Monitoring Protocol

Gregor Hodgson and Domingo Ochavillo

April 2006

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MAQTRAC

Marine Aquarium Trade Coral Reef Monitoring Protocol

I. Field Manual

2006

Gregor Hodgson and Domingo Ochavillo

With contributions from
Ladan Mohajerani, Jennifer Liebeler, Craig S. Shuman, and Stuart J. Green

REEF CHECK

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acknowledgements

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acronyms

CAMP	Collection Area Management Plan
CPUE	Catch-Per-Unit Effort
EFM	Ecosystem and Fisheries Management
GCRMN	Global Coral Reef Monitoring Network
GIS	Geographic Information System
GPS	Geographical Positioning System
MAC	Marine Aquarium Council
MAQTRAC	Marine Aquarium Trade Coral Reef Monitoring Protocol
MPA	Marine Protected Area
RC	Reef Check

Background .....

chapter 1

The global trade in marine ornamentals is a complex industry involving numerous countries around the world. In the early 1980s, the import value of marine fish and invertebrates for the aquarium trade was estimated to be between US$ 24 and $40 million annually (Wood 1985). Current estimates place the import value of marine ornamentals between US$200 and 300 million annually (Chapman et al. 1997; Baquero 1999; Larking and Degner 2001). The proportion of marine organisms in the ornamental trade rapidly increased in the 1980s (Andrews 1990) with marine species comprising only 1% of the world trade in 1975 compared to a current estimate of 10% of the 350 million aquarium fish traded (Forum Secretariat 1999).

Marine ornamentals are currently collected and sold worldwide. An estimated 85% of the marine organisms exported to three major destinations for marine ornamentals (North America, Europe, and Asia) are collected from reefs in the Philippines and Indonesia (Forum Secretariat 1999). The remaining 15% is obtained mainly from reefs in Pacific Island countries, Hawaii, the Caribbean, Florida, the Red Sea, Sri Lanka, Indian Ocean Island countries, and East Africa (Forum Secretariat 1999; Wood 2001).

Box 1

The Marine Aquarium Council (MAC) (www.aquariumcouncil.org) is an international, not-for-profit organization that brings marine aquarium animal collectors, exporters, importers and retailers together with aquarium keepers, public aquaria, conservation organizations and government agencies. MAC's mission is to conserve coral reefs and other marine ecosystems by creating standards and certification for those engaged in the collection and care of ornamental marine life from reef to aquarium. MAC is implementing a certification program that lays out best practices from collection by fishermen through to the retail sale of the organisms.

Although cultured organisms are a rapidly expanding market (Kaiser et al. 1997), the majority of marine ornamentals are collected from the wild, entailing the capture and removal of living reef organisms including fish, corals, macro-invertebrates, plants and live rock. The potential high income generated from rare or endemic species provides a strong incentive for overexploitation (Wood 2001). Noting the need for a sustainable trade in marine ornamentals, the Marine Aquarium Council (MAC) has devised a certification process using a set of standards to improve trade practices throughout the chain of custody, from collection in the field through to retailers shop. The MAC Ecosystem and Fishery Management standard defines collection practices that minimize ecological and environmental impacts of collection.

The principles of the Ecosystem and Fisheries Management (EFM) are that:

- Collection and fishing of target marine aquarium organisms are undertaken according to the principles of sustainable use;
- Destructive collection and fishing practices are prohibited; and
- Collection and fishing activities within the collection area support the conservation of biological diversity in the collection area;

The EFM requires that those managing the fishery shall produce and implement a Collection Area Management Plan (CAMP) consistent with the EFM management principles given above and that the CAMP shall be consistent with any pre-existing management plans that encompass the collection area and/or fishery produced by the appropriate authorities.

Box 2

The Reef Check Foundation (RC) (www.reefcheck.org) is a non-profit organization with the mission of marine conservation, especially coral reefs. Reef Check has implemented an annual global coral reef monitoring network in over 60 countries since 1997, and in 2000 launched a temperate ecosystem program in California. RC is particularly interested in market-based models for conservation such as MAC Certification. As part of the certification process, collectors must agree to set aside a sizeable percentage of their collection area as a “no-take” Marine Protected Area.

In early 2000, MAC contacted the Global Coral Reef Monitoring Network (GCRMN) requesting for the design of a monitoring program for the aquarium trade. GCRMN requested its partner Reef Check to carry out this task. Since then, the Marine Aquarium Trade Coral Reef Monitoring Protocol (MAQTRAC) has been tried and tested by Reef Check in partnership with a variety of individuals and organizations. Under the EFM, MAQTRAC results and recommendations are required inputs to the Collection Area Management Plan under MAC standards. MAQTRAC has been designed to be carried out by coral reef biologists and/or highly experienced individuals who have high taxonomic identification skills for ornamental fishes, corals and other invertebrates.

Specifically, MAQTRAC has been designed to:

1. Describe, in a snapshot, the stocks of aquarium trade organisms in a collection area;
2. Provide a scientific basis for recommending sustainable levels of collection;
3. Recommend the locations for 'no-take' and rehabilitation zones;
4. Determine the impact of the aquarium trade;
5. Measure over-all coral reef health.

This MAQTRAC Field Operations Manual describes how to conduct surveys, from preparation through to the actual fieldwork, including organism and site selection. A second manual describes how the data collected are analyzed and interpreted. A summary of the steps involved in a MAQTRAC survey is given below:

Box **3**

The Step-by-step MAQTRAC

Step 1.	Select the area through scoping and apply for permits.
Step 2.	Collect socioeconomic and biological data through interviews, participatory workshops and field visits with ornamental fish collectors.
Step 3.	Create species list based on data of local trade.
Step 4.	Delineate boundaries of the collection area.
Step 5.	Select survey team, assign tasks and prepare equipment and boats.
Step 6.	Select the survey sites.
Step 7.	Design and carry out the manta tow survey.
Step 8.	Create a habitat map.
Step 9.	Carry out underwater surveys (timed swims and belt transects).
Step 10.	Finalize total species list.
Step 11.	Analyze data and prepare Fisheries Management Report.

Area Selection & Scoping (Steps 1 to 4) .....

chapter 2

Before an area can begin the process towards certification, a comprehensive analysis is undertaken to ensure that the area meets a set of selection criteria. The full MAQTRAC survey is only undertaken after a desktop analysis and a separate scoping activity. The desktop analysis is mainly based on interviews of key persons such as exporters, ornamental collectors and local government personnel. An area is normally selected if it has the following:

(1) the presence of an aquarium trade (local resident collectors);
(2) a good species mix (commercially viable) and volume in order to make the trade feasible;
(3) 'buy-in' of local government unit and collectors; and
(4) the potential of fishers to adopt a certifiable way (use of non-destructive methods such as barrier net collection) of tropical fish collection;

Other relevant information that fall under the last criterion include:

(a) synergies with pre-existing projects/programs;
(b) operational issues and market linkages;
(c) stakeholders and other resource users; and
(d) legal issues;

In many countries, it is necessary to secure research permits prior to surveys. The MAC/RC Team should apply in writing and secure necessary permits from the appropriate level of government prior to carrying out fieldwork. Formal letters sent in advance help build good

relationships with local collectors and government officials. When first visiting an area, the MAQTRAC team should present themselves formally to local officials and the Collection Area Management Committee (or equivalent) if already organized. Failure to obtain written permission from the authorities could derail the entire survey process.

Secondary data and the subsequent field scoping activities (and community workshops when deemed necessary) should provide information on:

(1) the area's fisheries (fishing practices/methods, target species and species groups, fishing sites, seasons)
(2) locations of habitats;
(3) the characteristics of the local ornamental collection (number of collectors, collection techniques, target species, and history of ornamental collection), etc.

The scoping and the community workshops will be important in:

(1) drafting the initial species list for the survey; and
(2) the spatial design of the initial survey (the initial decision of the manta tow track).

Information can be collected in a variety of ways: interviews with key informants, focus group discussions and actual field observations. Working with the local collectors will help begin to build trust and to increase the level of knowledge about collection practices, species collected, collection sites and the resource management perspective of the collectors and perceived needs. Collection practices vary a great deal among sites. The aquarium trade is only one (usually small) aspect of the total fishery. Data analysis and interpretation must be done carefully and in the context of the overall fisheries in the area. The output from MAQTRAC surveys will form the basis for the local Area Profile and Ornamental Fisheries Management Report to be submitted to the CAMP Committee (Appendix 1).

Preparations for the Survey (Steps 5) .....

chapter 3

3.1 Survey Team Selection, Organization and Basic Qualifications of team members

Planning and preparation in advance of field activities is important prior to MAQTRAC surveys. This is not only true for site selection but also for team member assignments and equipment preparations. To perform a MAQTRAC survey, it is important that qualified marine biologists, who have been trained and passed regular examinations with Reef Check Foundation, are selected to carry out the survey and individual task of each scientist has been identified. Each biologist must have species level taxonomic skills and be able to identify all the key species at a given site. Typically, one scientist within a team will specialize in corals and other invertebrates and the other with fish. The ideal number of members in a team is a minimum of two or three. Multiple teams may be needed to complete surveys covering large areas.

3.2 Species Identification and Field Standardization Exercises

Prior to conducting a MAQTRAC survey, team members should undergo species identification standardization exercises to ensure that all team members have common identifications of survey organisms. For the fish specialist, underwater size estimation exercises should be conducted to help identify and correct any size estimate bias. In these exercises, fish and invertebrate models should be randomly deployed in a shallow reef area where survey scientists subsequently swim about and estimate sizes. The size of these models should cover a range of sizes (small, medium, and large depending on the species). There should be a minimum of three size estimation field exercises and skills should at the minimum approximate to within 90% of the actual size. If the skill

does not approximate the level suggested, any size bias (whether tending to downsize or outsize) should be considered in the data analysis.

Trial underwater timed swims (at least three trials to cover 100 meters in linear distance) should be done to determine the "normal" time to conduct a survey. This exercise is detailed below:

Box **4**

Determining Pre-set Timed-Swim Periods

Step 1. Lay out a 100-meter transect line over the coral reef bottom.

Step 2. Time yourself as you swim over the transect line at 'normal' pace without recording any data. Repeat at least three times.

Step 3. Take the average time in the trials conducted. This is your timed-swim period.

Based on our experience, it takes 6 minutes to swim over a 100-meter transect line. Your time should not vary greatly from this estimate.

A team leader will be designated who will be responsible for the overall planning and management of the surveys. The team leader should make sure that members sign the liability forms, have specific tasks during equipment preparation and taxonomic assignments during the data collection, make sure dive safety procedures are followed during the underwater surveys and collate the data after the survey.

Box **5**

Dive Safety Considerations:

- Surveys should be non-decompression dives with an absolute maximum of 25 m depth.
- Timed swims should be conducted not below 25 meters and belt transects not below 15 meters.
- Safety stops should always be used (5 minutes stay at 3 meters).
- Surveys should not be done in places where entrance/exit is restricted (caves, etc).
- Underwater surveys should not be done in extremely fast water currents or if weather and during storms (typhoon signal number 1 and/or other similar deemed hazardous situations).
- The team should should set every 5th day as a non-diving day and for rest.

Besides the dive equipment, the team should prepare underwater slates, stopwatch (for timed swims), plumb lines (for substrate survey), first aid kit, communication equipment (radio or cellphone) and underwater still or video cameras. Pictures and videos give a "snapshot" picture of the reef and will be useful for future comparisons. At least three still photos and a 5-minute video should be taken for a general visual overview of each site. The goal is to obtain a selection of visual representation of the average coral reef condition of the collection area. These visual tools are also important in tracking the temporal changes of the area's coral reef condition. The photos and underwater videos are also very effective for showing the state of resources during post-survey presentations for the local community.

Table 1. List of essential survey equipment.	
Transect Line	Recommend 100 m marked in 1 cm intervals; fiberglass tape reel with handle that can be purchased or a plastic rope marked at 0.5 m intervals
Plumb line	1.5 m woven nylon or cotton string with 5 mm nut tied on
Underwater slates	3 mm thick white plastic board can be cut into A4 sheets and roughened with sand paper. A pencil can be attached by drilling a hole in a corner and tied on with string. Mark slate edges with 1 cm rule for measuring corals and other invertebrates and estimating fish size.
Manta Tow Board	Marine plywood ¾" x 1 m x 0.5 m; Attach underwater slate to the board with screws, hand hold and include cover estimates as per English et al. 1987.
Stop Watch	Any digital watch wherein a set time can be programmed during stop-and-start timed swim surveys.
Geographical Positioning System (GPS)	Any type
Navigational Map or Geographic Information System map	Map that indicates depth readings and habitat distribution especially for coral reefs.
Still and video camera	To record state of coral reef (optional).
First aid kit	Bandage strips, tornique, bandages, alcohol, spirit of ammonia, iodine solution, burn and anti-bacterial ointments, cotton, anti-diarrhea medicines, oral rehydration tablets, scissors, aspirin, antacid, anti-histamine, painkillers, eye drops, etc.
First aid handbook	Any type that is available from dive shops
Dive computer	Any type

Selection of Sites .....

chapter 4

The distribution of organisms on a reef is influenced by habitat and ecological factors at several spatial scales. These factors may include habitat distribution, wave action or exposure, light and water depth. Both windward and leeward sides at reefs with lagoons or offshore reefs should be surveyed as well as embayments and exposed areas, taking account of annual weather patterns such as monsoon winds and wave action. It is critical that the surveys include a representative sample of all habitats where fish and invertebrates are collected as well as control sites – ideally a 'no-take' MPA. Ideally, these sites should also include those identified by collectors as collection sites. It is recommended that one survey site for every km of reef front is established.

4.1 Selecting Control Sites

It is important to choose both "impact" sites where aquarium collection is taking place and "control" sites where no fishing occurs. Data collected from control sites during subsequent surveys are used to determine whether changes observed at the fishing sites were caused by fishing or some other factor that affected the whole area. Control sites are areas free from aquarium fishing activities, ideally no-fishing sites. If true control sites are not available, then the lowest impact sites can be chosen to serve as reference sites. Sites should be selected such that collection and non-collection sites are in relatively close proximity (minimum of 500 m from the edge of the core zone but not more than 5 km) to reduce the effects of spatial variability between these sites, and far enough apart such that the exchange of organisms is uncommon. In addition, collection and non-collection sites should have the same direction of exposure to wind and waves and a similar submarine topography. When choosing control sites, it is important to determine the actual level of fisheries management/enforcement because

many MPAs may be “paper parks” and lack enforcement. Ideally, 3 years strict enforcement of no-take zones should be a criterion for site selection.

4.2 Sub-sampling Strategy

The length of the MAQTRAC underwater survey period is primarily determined by funding and the size of the area. In any case, underwater surveys conducted for around 2 weeks cover around 30 km reef front and/or coastline in a fringing reef type. For longer distances and if funding does not permit an extended period, it is advisable to employ sub-sampling techniques to survey the reef fronts.

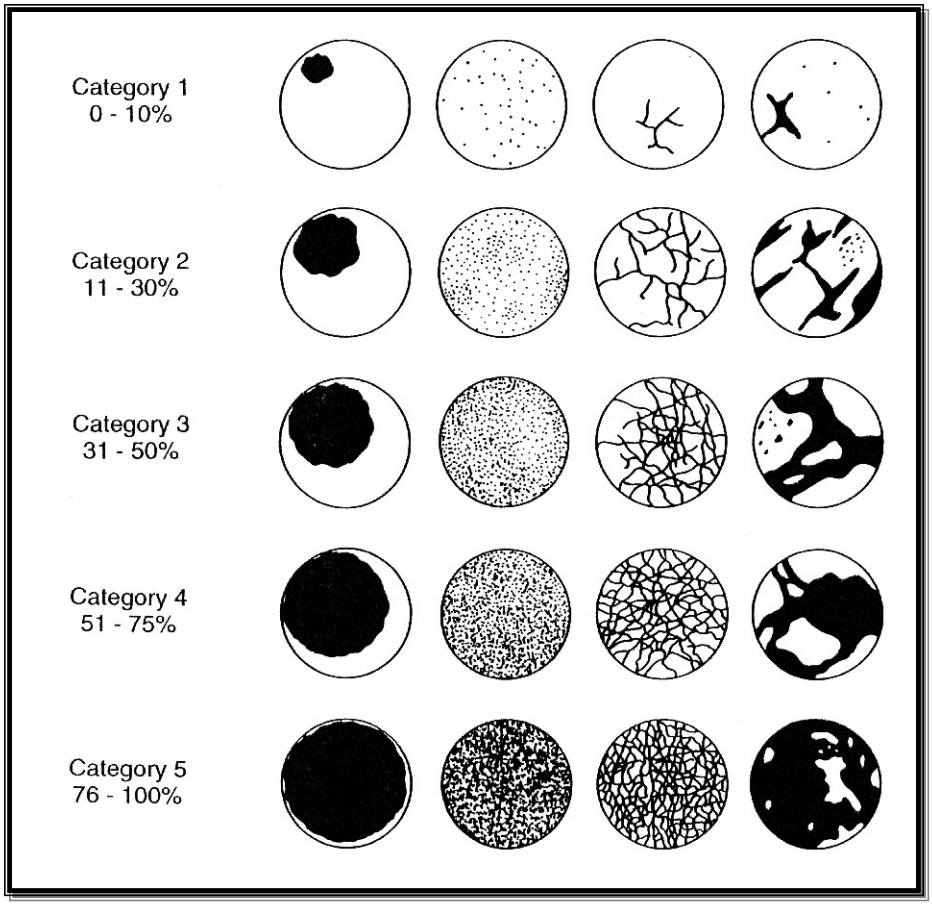


Figure 1 Sub-sampling routine for survey sites (for manta tow, timed swims and belt transect site selection).

Before doing the actual underwater survey, the survey team should estimate the linear distance of reef front or coastline. This will dictate whether a sub-sampling routine is necessary. The reef front linear extent can be estimated using a Geographic Information System (GIS) maps or roughly from the scales indicated in a navigational map using a string or ruler. For barrier reefs and atolls, the reef front distance of both the windward side and the leeward side should be separately estimated. For wider reefs, surveys should be conducted for every 100 meter reef width increment.

In longer linear distances (> 30 km and when funding does not permit surveys longer than 2 weeks), it is advisable to identify and count the total number of area representative sites (of 1 km each in linear distance) based on exposure (sheltered versus exposed sites) and types of reefs. Narrow the number to 30 sites. It is important that the numbers of sites representing different habitats are proportionately represented in the manta tow and underwater surveys. For instance, given a total of 100 sites with 60 exposed and 40 sheltered. Sixty-percent (18 of the 30 sites to be sub-sampled) should be exposed sites. Forty-percent (12 of 30) should be sheltered sites.

Figure 2 shows the identification and selection of sites during a sub-sampling routine. In this example, the total length of the reef front is 122 km. Therefore a sub-sampling strategy was necessary. Each site pointed by an arrow is potentially a different habitat based on the degree of exposure and the type of reef. Each site should be surveyed for manta tow, timed-swim and belt transect surveys as described below.

The Manta Tow Survey

chapter 5

(Steps 6 to 7) .....

Manta tows (English et at. 1997) are used to obtain a rough estimate of the distribution of habitat types and condition in large reef areas over a relatively short period. The technique is useful in identifying and selecting sites that are representative of different habitat types such as seagrass, sand, muddy bottom, and coral reef.

A manta tow involves a diver holding onto a flat “manta” board that is attached by a rope to a boat and towed at low speed. By tilting the tow-board, the diver can stay at the surface or dive below the surface. Periodically, the diver can signal the boat to stop so that notes can be recorded in a standard format. Each tow should be 3 minutes in duration and boat speed should be approximately 3 km per hour (use the GPS TRACK routine to standardize).

A Geographical Positioning System (GPS) reading (in Decimal Degrees or DD format) should be taken before and after each tow. After each tow, the observer will record an estimate of live coral cover according to the following schematic representations of percent cover (see Figure 1 as adapted from Dahl 1981) and the average slope angle of the reef covered by the tow.

For safety reasons, manta tows should not be used when visibility is less than 6 m. This method is primarily for shallow water surveys above 10 m depth. It should not be used in deeper waters due to safety considerations (e.g. danger of the diver going up and down in the water column).

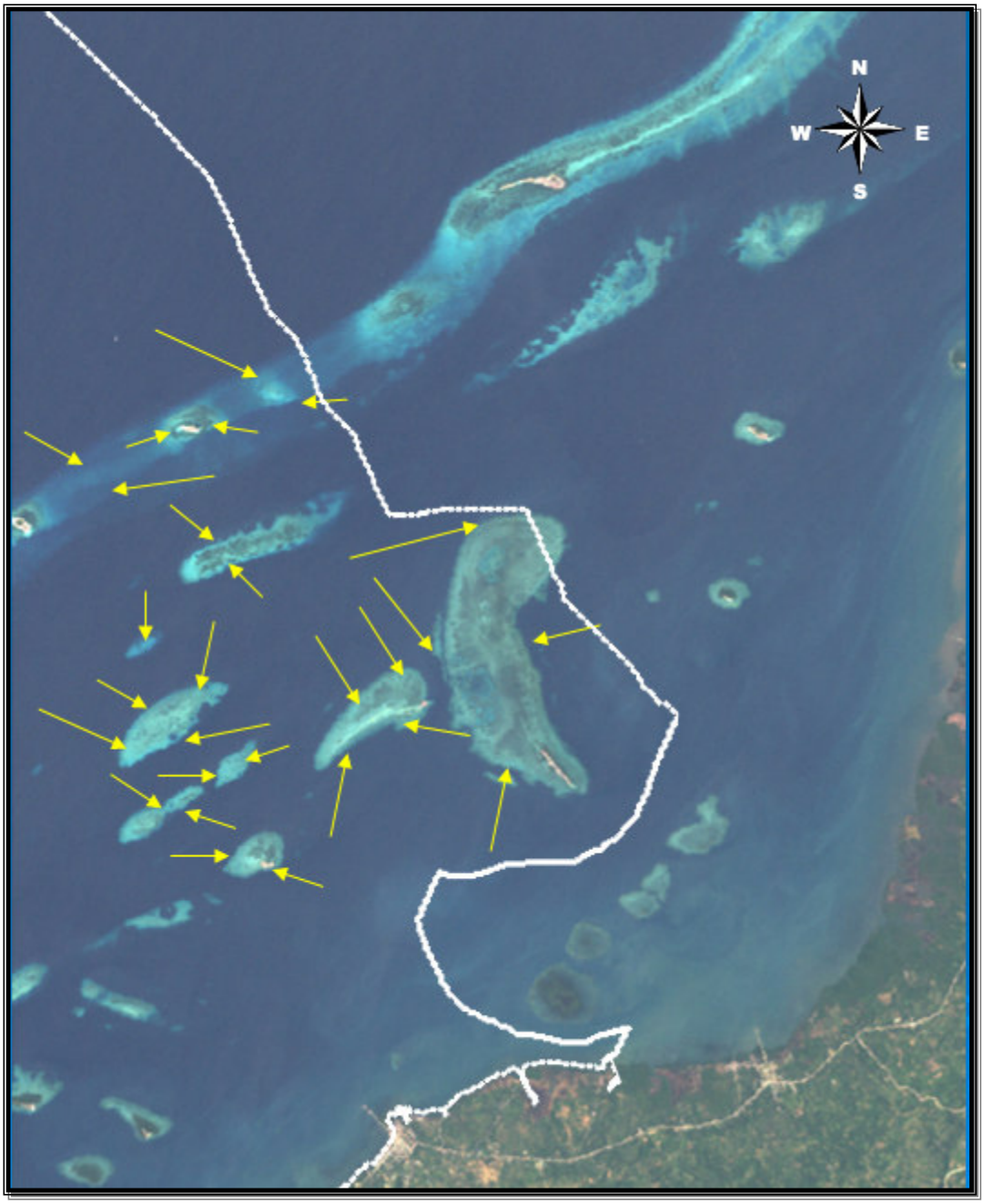


Figure 2 Schematic representations of percent cover for the estimation of live coral during the manta tow surveys.

5.1 Groundtruthing of Habitats and Estimating Areas of No-Take Zones

During the manta tow, the depth range and the position of the specific habitats (especially seagrass, algal beds and coral reefs) should be recorded at the start and the end of each tow. These ground-truthing exercises will be critical in developing a more comprehensive GIS map for the area through the merging of a nautical base map that normally has depth sounding data and a satellite map that has habitat distribution data. The consolidated map will be a more accurate estimation of the coverage of major habitats in a collection area.

As part of the ground-truthing activities, the areas of the existing and planned MPAs should be estimated. The GPS readings of the corner points of rectangular or square MPAs should be taken. In case of circular and other irregularly-shaped MPAs, the points of the perimeter can be recorded through a continuous GPS reading routine (i.e. using TRACK option) .

The production of a habitat map showing the collection area is an important visual tool to work with local stakeholders and form the core of the fisheries management report (see Figure 3). The locations of proposed no-take zones, boundaries of collection area and stock distribution can be easily be shown using this map.

Box **6**

The Collection Area Map(s) Should Include:

from Steps 1 to 4
- boundaries of collection area
- locations of fishing communities
- major fishing grounds
- ornamental collection sites

from Steps 6 to 7
- manta tow path and coral cover data
- locations and extent of the major habitats

from Steps 8 to 10
- locations of timed swims and belt survey sites
- ornamental fish, invertebrate and coral cover distribution data
- distribution of low, medium and high impact sites from site description data

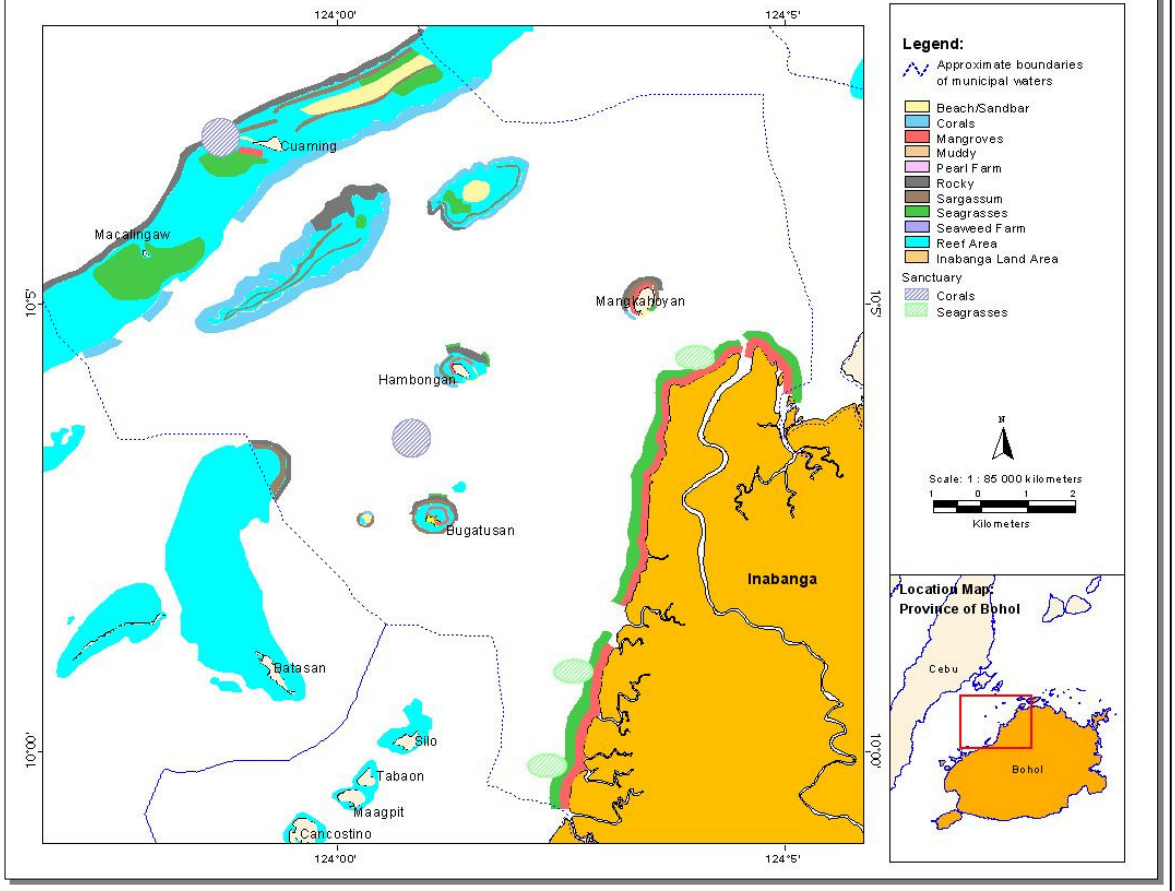


Figure 3 An example of a GIS map showing the locations of the major habitats.

The Timed-Swims Surveys .....

chapter 6

Fishes and invertebrates have seasonal reproductive patterns. It is important to recognize that some fluctuations in the populations of some organisms may be caused by this seasonality. Ideally, MAQTRAC underwater surveys should be conducted during recruitment periods although this may be difficult when these periods differ among target organisms.

Timed-swim surveys in Collection Sites

The timed swim is a standard part of a MAQTRAC underwater survey. The purpose of the timed swim is to gain more information on the abundance of ornamental stocks in a larger area than can be accomplished using the relatively short belt transects. The timed swim is also used to record all fish and coral ornamental target species; standard Reef Check fish indicators plus family level identification and size classification of siganids (rabbitfish), acanthurids (surgeonfish) and caesionids (fusiliers); and an estimate of coral cover (using the same categories as in the manta tow survey). Both the numbers and the sizes of ornamental targets are recorded. Information on size distribution is critical to track population growth and mortality rates. These data, in turn, can provide insights into the sustainable level of collection appropriate for a species or species group.

In each site, three timed swims of approximately 100 meters by 5 meters should be conducted each on the lower reef slope, the reef crest and the reef flat whether the reefs are classified as fringing, barrier or atolls (Figure 4a and 4b). In areas with no pronounced reef crest, only 2 zones (shallow and deep) should be covered. In a much wider (> 100 m) reefs, we recommend three timed swims per coral reef zone for every 100 m reef width increment.

In addition, three timed swims should be conducted in each of the key habitats used by collectors: seagrass and algal beds (or other habitats identified by fishers as important for the collection of ornamentals). In much wider (>100 m) seagrass or algal beds, we recommend three additional timed swims for every 100 meter width increment of these habitats. The three timed swims in each coral reef zone and other habitats should be conducted immediately one after the other.

Timed-swims in Non-collection Sites

For no-take zone sites, we recommend three timed-swims per coral reef zone and other habitats for every 500 meter reef front. We recommend a smaller scale survey since most non-collection sites or no-take zones in the Philippines have small areas. For much larger no-take zones and marine parks such as those in Indonesia, the one site and the corresponding timed swims per zone for every kilometer of coastline should be maintained.

Timed-swim surveys should be conducted between two hours after sunrise and two hours before sunset. This timing avoids the dawn and dusk periods when mobile nocturnal and diurnal species are changing.

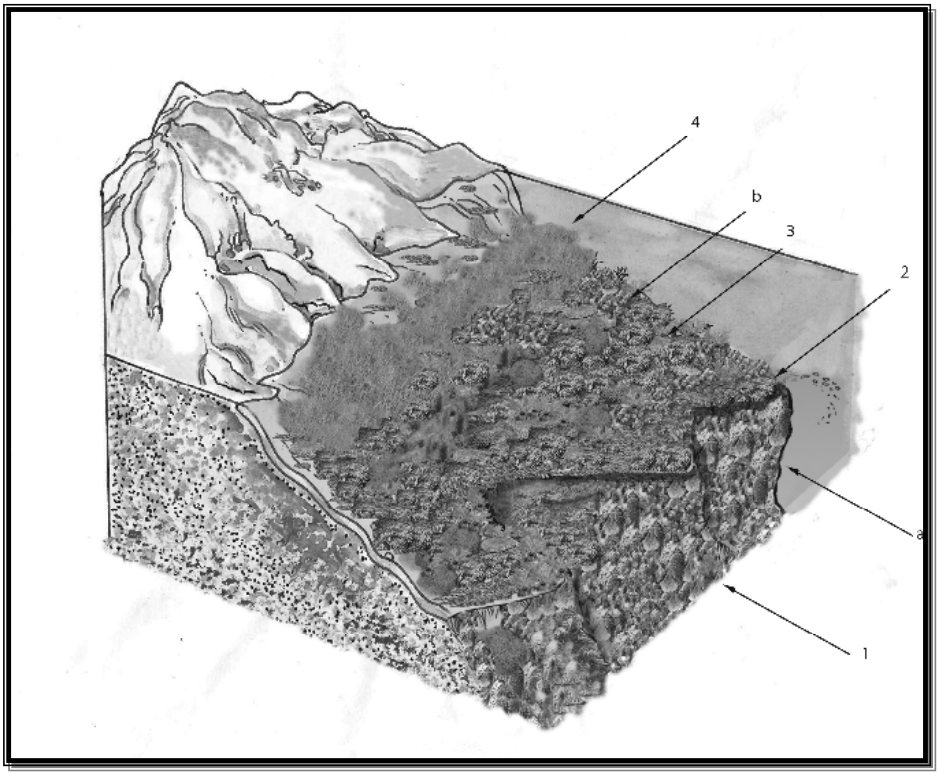
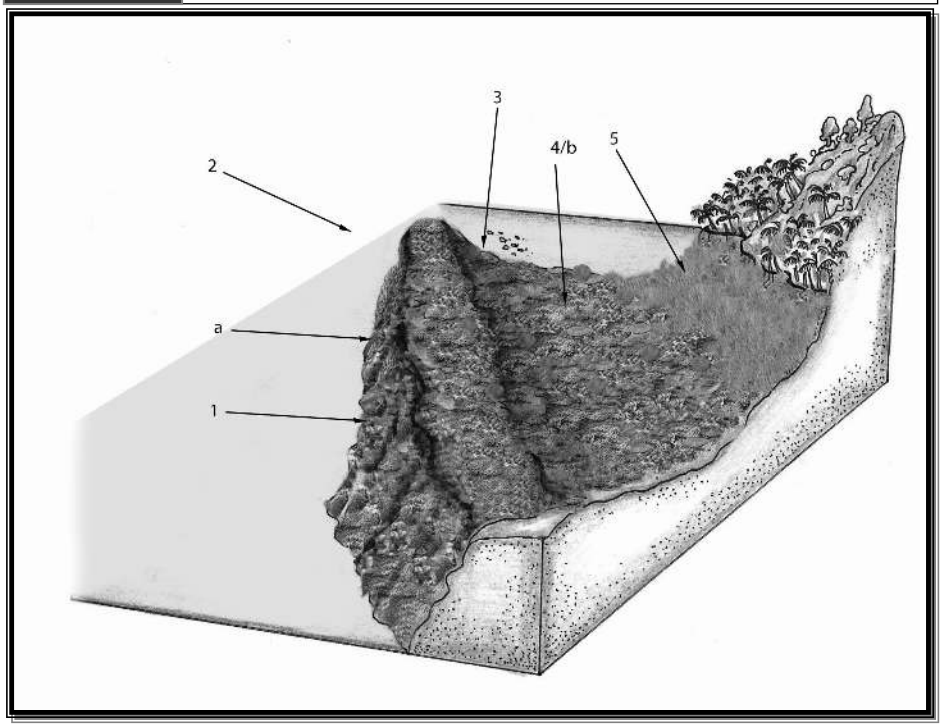


Figure 4 Site selection based on general reef types: reef with lagoon (a), reef without lagoon and offshore patch reefs (b). (Timed swims should be conducted in sites with indicated numbers while belt transects should be conducted in sites with letters.)



Box **7**

Timed Swim Data Should Include:

- Ornamental fish being traded
- Ornamental corals (for relevant countries)
- Reef Check Fish Indicators plus family level identification and size estimation of siganids, acanthurids and caesionids
- Estimate of hard live coral cover using manta tow categories

Box **8**

Coral reef health fish indicators (for timed swims)

Common Name	**Scientific Name**
Grouper/coral trout (>30 cm)	*Serranidae*
Barramundi cod	*Cromileptes altiveles*
Butterflyfish (any species)	*Chaetodontidae*
Humphead (Napoleon wrasse)	*Cheilinus undulatus*
Bumphead parrotfish	*Bolbometopon muricatum*
Grunts/Sweetlips/Margates	*Haemulidae*
Parrotfish (>20 cm)	*Scaridae*
Snapper	*Lutjanidae*
Moral eel (any species)	*Muraenidae*
Surgeonfishes	*Acanthuridae*
Fusiliers	*Caesionidae*
Rabbitfishes	*Siganidae*

Guidelines for Timed-Swims

- Each timed swim should be 100 m in length by 5 m wide of reef area.
- Maintain a constant swim speed.
- Stop the timer when recording data and start timer when swimming until the next target fish or invertebrate comes long.
- Each ornamental fish and coral should be identified to species when possible or trade category, and its individual size and their numbers estimated.
- Count Reef Check Fish Indicators but include size estimates for surgeonfishes, fusiliers and rabbitfishes.

- The total period of the stop-and-start timed swim should be approximately 6 minutes depending on the field trial exercises.

Guidelines for Estimating the Numbers of Fish and Corals

- Visually group the fishes and corals by size classes (see recommended classes below) and count the number of individuals per size class.
- When a school of fish exceeds 50 individuals, practice visually superimposing an imaginary quadrat over the school. Take a third or quarter of this imaginary quadrat. Count the abundance of fish in that section and then scale up the count accordingly; (Figure 5)
- Use the imaginary quadrat method for clumped corals such as Goniopora, Diaceris, Polyphyllia, and Fungia; (Use body length as a tool to visually superimpose imaginary quadrats with a maximum size of 2.5 by 2.5 meters depending on the area coverage.) Count and size normally when they are not clumped.

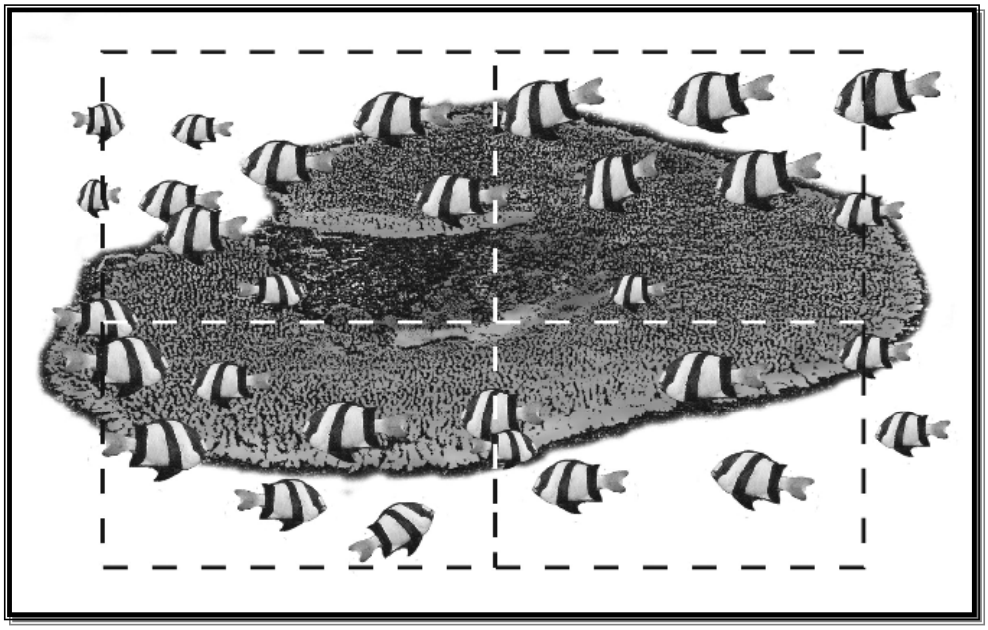


Figure 5 Using an imaginary quadrat when counting numerous individuals of a species during a survey.

Guidelines for Estimating the Size of Fish and Corals

- For fish, estimate size from the tip of the caudal fin (tail) to the tip of the snout (total length) to the nearest centimeter.
- Estimate fish size from the end of the longest fin in fishes with caudal fins of unequal sizes.
- Fish less than one centimeter should be recorded as being half a centimeter (0.5 cm).
- For hard corals, measure length along the longest aspect. (Figure 6)
- For corals, record abundance in the size classes: ≤ 5 cm, 5 to 15 cm, 15 to 25 cm, 26 to 50 cm., and more than 50 cm. (These are the size categories used in the trade.)
- Use the ruler on one side of the slate to estimate fish and coral sizes and standardize for parallax errors.

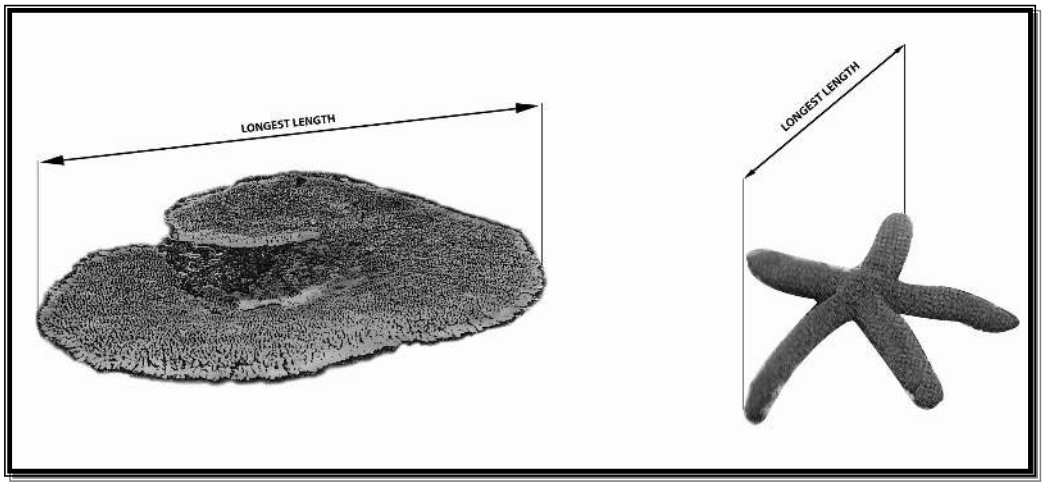


Figure 6 Measuring the length of corals and other similarly-shaped invertebrates and a starfish.

The Belt Transect Surveys .....

chapter 7

Belt transects are used to survey other ornamental invertebrates, and Reef Check invertebrate indicators. A belt transect survey covers 100 meters long, 5 meters wide (2.5 meters on each side) and 5 meters above the line.

The transect line is divided into four segments that are used as statistical replicates. The replicates extend over the following lengths of the transect: 0 - 20 m, 25 – 45 m, 50 – 70 m, and 75 – 95 m. Organisms are counted and/or sized within these dimensions of the survey. For relatively new trainees, it is not advisable to bring rods to estimate the width of the belt transect since they can scare away the fishes. Instead, team members are advised to estimate the width using their extended arm lengths from the transect line during field exercises.

Each survey site in a kilometer of reef front should have two belt transect surveys: one in <5 m depth (shallow) and another in 10 to 15 m depth (deep). In no-take zones we recommend two belt transects (one shallow and one deep survey) for 500 m of reef front in small marine protected areas (i.e. < 0.5 km^2). For wide reefs (> 100 meters wide), we recommend two parallel belt transects for every 100 m increment of coral reef.

In some areas, invertebrates are collected in high numbers in the intertidal areas. Intertidal areas should also be sampled in a similar way using the belt transect. The latter is best done during high tide so as not to disturb the habitat by trampling.

7.1 Laying Down The Transect Line

It is usually convenient to lay the transect and record data while swimming against the current and to retrieve the transect line with the current. The transect line should be laid parallel to the shoreline and as close to the coral reef substratum as possible. It must follow the coral reef contour as much as possible at uniform depth. When the reef forms spurs-and-grooves, the transect should follow the contour as long as the path of the transect does not overlap (see Figure 7). Otherwise, it can be run down the spurs. The belt transect surveys should be done in the same vicinity as the timed swim surveys.

Figure 7 How to lay the transect line on the coral reef bottom with spurs-and-grooves.

7.2 Sequence of Tasks during the Belt Transect Surveys

For two-member teams:

After laying the transect, the team member assigned should go back to the start of the transect. The invertebrate specialist team member can immediately proceed to conduct the invertebrate survey. The team member who laid the transect should follow and conduct the substrate survey while following the invertebrate specialist. Usually, the invertebrate survey takes a longer period than the substrate survey. Therefore, we recommend that the invertebrate specialist cover only one side of the belt transect. After finishing the substrate survey, the transect line layer can then later conduct the invertebrate survey covering the other side of the belt transect. The other team member can then retrieve the transect line.

Box 9

Belt Transect Data Should Include:

- Other ornamental invertebrate being traded besides corals
- Reef Check Invertebrate Indicators
- Substrate data points sampling
- Coral reef damage and rare sightings

Box 10

Coral reef health invertebrate indicators.

Common Name	Scientific Name
Long-spined black sea urchin	*Diadema* spp. and *Echinothrix* diadema
Lobsters (all edible species)	*Panulirus* spp.
Banded coral shrimp	*Stenopus hispidus*
Sea Egg/Collector urchin	*Tripneustes* spp.
Giant clams (record size and species)	*Tridacna* spp.
Edible sea cucumbers	*Thelenota ananas*, *Stichopus chloronotus*, etc.
Triton	*Charonia tritonis*
Crown-of-thorns starfish	*Acanthaster planci*
Pencil urchin (record size of longest spine)	*Heterocentrotus mammilatus*

7.3 Guidelines for the Invertebrate Belt Transect Surveys

- For ornamental invertebrates, measure length along the longest aspect.
- For starfish, take the longest length from the tip of an arm to the opposite arm tip.
- Count only Reef Check Invertebrate Indicators but include sizes for pencil urchin and size and species for each giant clam recorded.
- Measure the longest spine of pencil urchins.
- Measure only the height for Dendronephthya spp.
- Abundance data without size measurements are sufficient for species that are difficult to size such as Xenia.
- Use the imaginary quadrat data for clumped ornamental invertebrates such as Discosoma, Sarcophyton, Xenia, brittle stars (in intertidal sites), etc. (Estimate an imaginary quadrat with a maximum size of 2.5 by 2.5 meters depending on the area coverage.) Count and size as usual when they are not clumped.

7.4 Coral Damage and Rare Sightings Data Format

It is also important to take note of the degree of coral reef damage per segment during the belt transect survey (Appendix 3). The survey scientists are recommended to consult the updated standard Reef Check instruction manual.

7.5 Substrate Indicators

The goal of the substrate survey is to determine the health of the coral reef based from the cover data. For this purpose, each transect line will be point-sampled at 0.5 m intervals. To reduce bias, it is useful to carry a five-millimeter diameter nut or other small metal object tied onto a two-meter cotton or nylon string for use as a "plumb-line."

The substrate type is recorded at 0.5 m intervals along the line, i.e. at: 0.0 m, 0.5 m, 1.0 m, 1.5 m etc. up to 19.5 m (40 data points for every 20 m transect segment). The use of the plumb line prevents parallax error of surveyors who are swimming above the

substrate. Plumb lines are useful in cases where the transect is hanging above the substratum and swinging back and forth with the surge. Dropping the plumb line at the designated mark eliminates any choice in where to measure.

Substrate category abbreviations are as follows :

Table 2. Coral reef health substratum survey categories and abbreviations.

Abbreviation	Substratum Category
HC	Hard coral
SC	Soft coral
SG	Seagrass
RKC	Recently killed coral
AL	Algae
SP	Sponge
RC	Rock
RB	Rubble
SD	Sand
SI	Silt/clay
OT	Other

7.6 Category guidelines for determining substratum types

1. **Hard coral:** Include fire coral (*Millepora*), blue coral (*Heliopora*) and organ pipe coral (*Tubipora*) all types of “reef builders”.
2. **Soft coral:** Include zoanthids, but not sea anemones (the latter go into "Other")
3. **Seagrass:** All species of seagrass, not to be confused with algae.
4. **Recently killed coral:** Record coral that has died within the past year. The coral may be standing or broken into pieces, but appears recently killed. (Coral is white, structurally intact, only partially overgrown by algal turf etc.) This will be particularly important in detecting the possible impacts of cyanide and evidence of dynamite use.
5. **Algae:** Do not include coralline or turf algae in this category.
6. **Sponge:** All sponges (but no tunicates) are included.
7. **Rock:** Any hard substratum whether it is covered in algae (turf or encrusting coralline), barnacles, oysters or other organisms are placed in this category. Rock

will also include dead coral that is more than about 1 year old, i.e. is worn down so that few coral structures are visible, and covered with a thick layer of encrusting organisms and/or algae.

8. **Rubble:** Includes rocks (often laying over sand) between 0.5 and 15 cm diameter. If it is larger than 15 cm it is rock, smaller than 0.5 cm then it should be considered as sand.
9. **Sand:** Smaller than 0.5 cm and falls quickly to the bottom after being re-suspended.
10. **Silt/Clay:** Sediment that remains in suspension if disturbed. *Note: that these are practical definitions not geotechnical.*
11. **Other:** Any other sessile organism including sea anemones (which are also included in the invertebrate belt), tunicates, gorgonians or non-living substrata.

7.7 Guidelines for substratum transect survey

- The observer should stop every 0.5 m and record the substrate at that point. (0.0m, 0.5m, 1.0m, 1.5m, etc… 19.5m);
- A point sample is taken by dropping the “plumb line” and determining the substrate that the weight at the bottom of the line lands on; (see Figure 8).

Figure 8 Point sampling using a plumb line.

Observing Collection Practices & Tracking Catch-Per-Unit Effort

chapter 8

8.1 Diving observations of collectors

It is important to directly observe aquarium collectors in the field to gain information about the specific target habitats, techniques, impacts, and collection efficiency. We recommend a minimum of two days diving observations of collectors, especially for highly in-demand species. The number of fish caught per man-hour (catch-per-unit effort or CPUE) will be calculated from the total time that encompassed travel and collection and also during collection time (time spent in the water). These values will be used to calibrate values obtained from collector records for fisheries temporal comparisons. Different collection methods will have different CPUE ranges; therefore, monitoring of collectors should be based on local collection techniques employed. It is important to note the habitat type, using the substrate categories in Section 6, targeted by the collectors during the diving observations.

8.2 Fisheries Dependent Surveys (Catch-Per-Unit Effort Data)

Besides the field surveys, it is equally important to track trends in catch-per-unit-effort of target organisms among collectors in an area. Catch-per-unit-effort is a useful tool to infer changes in target abundance especially for those species not always observed during the surveys. Surveys can miss species that are either cryptic, found in specific

reef habitats or highly mobile. Catch-per-unit effort data are only meaningful for those organisms that are always in demand (middle to high-end species). Data based on orders of organisms from buyers is not useful in assessing stock size; because catch is dependent on what is currently in demand. Fishes that have traditionally been in demand in SE Asia include the anemonefishes (especially *Amphiprion ocellaris* and *Premnas biaculeatus*), some butterflyfishes, angelfishes (*Pomacanthus imperator*, *P. navarchus*, *P. xanthometopon*, *Pygoplites diacanthus*), surgeonfishes (e.g. *Paracanthurus hepatus*), balistids (e.g. *Balistoides conspicillum*) and the mandarinfish *Synchiropus splendidus*. Catch-per-unit effort data, expressed as number of target organisms per collector and period of collection (usually per hour), can be obtained from the logbooks of collectors. Ideally the data should also include the location where fish were collected.

MAQTRAC Data Storage, Management & Other Concerns

chapter 9

MAQTRAC teams collect a large amount of data during their field assessments. It is important that data are quickly transcribed into a computer and backed up. To make assessment and data consolidation simpler, standardized forms are available from Reef Check. All data should be entered into a database or spreadsheet format.

9.1 The Ornamental Survey Data Storage Format

The data format should include information on the area, site name, GPS reading (Decimal Degrees or DD format), observer, date of survey, collection (yes or no) (on the site description worksheet); species, size estimate, count, and special remarks (on the data input worksheet). The fish and invertebrate data on over-all coral reef health should be recorded and associated with the same GPS coordinates as the ornamental data. We have included in this manual the database formats for the ornamental data as a guide (Appendix 2).

9.2 The Substrate Data Storage Format

The substrate data format should show the categories every 0.5 meter of each replicate (Appendix 3).

9.3 Coral Damage and Rare Sightings Data Format

It is important to take note of degree of coral damage and rare sightings per survey site (Appendix 4).

9.4 The Site Description Data

The site description is to record the condition of a specific survey site. More importantly, it aims to give a general picture of human impacts on the coral reef site (Appendix 5).

9.5 Data Ownership and Confidentiality of the Data and Results

Data collected are owned by the sponsoring company or agency that paid for the MAQTRAC surveys. In case of public funded projects, the data should be in public domain. Some of the data may contain business and/or ecologically sensitive information that should be confidential unless permission is given to release them. Summary reports of the outputs and management recommendations will be available to the public and the relevant local management authority .

Researchers may use the data for publication in scientific journals with prior written authorization from the sponsoring company or agency that paid for the surveys.

For instructions on data analysis and interpretation, please see the MAQTRAC Data Analysis Manual.

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appendices

Appendix 1. The Reef Check Fisheries Management Report Format

REEF CHECK FISHERIES MANAGEMENT REPORT
Report Area "XXXXXX" – 2005

1 **LOCATION: AREA NAME, PROVINCE, GEOGRAPHIC LOCATION**

Table of Contents ***Page Number***

I. Collection Area and Description

II. Status of coral reefs and surrounding ecosystems in the collection area
Characterization of the reef health and human impacts
Current management initiatives in place / proposed
Key habitats and their locations in the collection area

III. Fisheries (all)
Types of fisheries
Number of boats / people
Roving collectors / illegal fishing
Fishing gear inventory
All fish and invertebrates collected in the area
Types of fishing gear used to collect ornamental fish

IV. MAQTRAC results
Fish
Invertebrates
Precautionary species
Species unsuitable for collection
The density based approach to management
Total Allowable Catches of species

V. Proposed management planning activities

Appendix 2. The Ornamental Data Format (on an Excel file named ExcelMAC1.xls)

Appendix 3. Coral Damage and Rare Sightings Data Format

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

Description	0-20m	25-45m	50-70m	75-95m
Coral damage: Boat/Anchor				
Coral damage: Dynamite				
Coral damage: Other				
Trash: Fish nets				
Trash: General				
Please fill in the following	**0-20m**	**25-45m**	**50-70m**	**75-95m**
Grouper sizes (cm):				
Bleaching (% of coral population):				
Bleaching (% colony):				
Coral Disease (Yes/No and %):				
Rare animals sighted (type/#):				
Other:				

Appendix 4. The Substrate Data Format

Site				**Date**			
Observer				**Visibility**			
Point (A)	**Substrate**	**Point (B)**	**Substrate**	**Point (C)**	**Substrate**	**Point (D)**	**Substrate**
0	*HC*	25.0	*HC*	50.0	*HC*	75.0	*HC*
0.5	*SC*	25.5	*SC*	50.5	*SC*	75.5	*SC*
1.0	*RK*	26.0	*RK*	51.0	*RK*	76.0	*RK*
1.5	*Etc*	26.5	*Etc*	51.5	*Etc*	76.5	*Etc*
2.0		27.0		52.0		77.0	
2.5		27.5		52.5		77.5	
3.0		28.0		53.0		78.0	
3.5		28.5		53.5		78.5	
4.0		29.0		54.0		79.0	
4.5		29.5		54.5		79.5	
5.0		30.0		55.0		80.0	
5.5		30.5		55.5		80.5	
6.0		31.0		56.0		81.0	
6.5		31.5		56.5		81.5	
7.0		32.0		57.0		82.0	
7.5		32.5		57.5		82.5	
8.0		33.0		58.0		83.0	
8.5		33.5		58.5		83.5	
9.0		34.0		59.0		84.0	
9.5		34.5		59.5		84.5	
10.0		35.0		60.0		85.0	
10.5		35.5		60.5		85.5	
11.0		36.0		61.0		86.0	
11.5		36.5		61.5		86.5	
12.0		37.0		62.0		87.0	
12.5		37.5		62.5		87.5	
13.0		38.0		63.0		88.0	
13.5		38.5		63.5		88.5	
14.0		39.0		64.0		89.0	
14.5		39.5		64.5		89.5	
15.0		40.0		65.0		90.0	
15.5		40.5		65.5		90.5	
16.0		41.0		66.0		91.0	
16.5		41.5		66.5		91.5	
17.0		42.0		67.0		92.0	
17.5		42.5		67.5		92.5	
18.0		43.0		68.0		93.0	
18.5		43.5		68.5		93.5	
19.0		44.0		69.0		94.0	
19.5		44.5		69.5		94.5	
20.0		45.0		70.0		100	

Appendix 5. The Site Description Form

Site name:				
Date:				
Surveyor names:				
Time of day that work started:				
Time of day that work ended:				
Latitude of transect start & end point:	*Start:*		*End:*	
Longitude of transect start & end point:	*Start:*		*End:*	
Orientation of transect:	*N-S___ NE-SW____ E-W____ SE-NW____*			
Distance from shore:	_____ *m*			
Weather:	*sunny_____*	*cloudy____ _*	*raining___*	
Distance to nearest population centre:	_____ *km*			
Approximate population size (x1000):	_____			
Horizontal visibility in water:	_____ *m*			
Why was this site selected?				
Any major coral damaging storms in past years?	*yes_____*	*no_____*	*unknown__*	
How do you rate this site overall in terms of anthropogenic impact?	*none____*	*low____*	*moderate__*	*heavy_ __*
What types of impacts do you believe occur?				
What is the level of food fishing at this site?	*none____*	*low____*	*moderate__*	*heavy_ __*
What is the level of ornamental fishing at this site?	*none____*	*low____*	*moderate__*	*heavy_ _*
What species are targeted as both ornamentals and food fish?				
Is there any form of protection (statutory or other) at this site?	*yes_____*	*no_____*		
If yes, what type of protection?				
How long have ornamentals been collected from this area?				
Does the Collection Area Management Plan apply to survey area?	*yes_____*	*no_____*		
If yes, when enacted				
Number of collectors working site , what number are MAC Certified				
Primary species targeted by collectors				
Observed collection methods				
Suspected collection methods				
Additional information or comments				