TRAINING MANUAL FOR

Monitoring Marine Protected Areas in the Asia Pacific Region

Capacity Building for Research and Monitoring of Marine Protected Areas: An Adaptive Mechanism for Climate Change in the Asia-Pacific Region

A Project Funded by
The Asia-Pacific Network for Global Change Research
Under the APN-CaPaBle Programme

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Monitoring Marine Protected Areas
In the Asia-Pacific Region
A Training Manual

De Guzman ● Abrea ● Nañola ● Uy

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2010

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In the Asia-Pacific Region: *A Training Manual*

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contents

PROJECT RATIONALE AND TRAINING OBJECTIVES

Marine Protected Areas as Adaptive Mechanisms for Global Change

Conventional methods of regulating fisheries, such as effort and gear restrictions, limited access to a fishing ground or constraints on catch, have often failed to prevent the continuous depletion of fish stocks (De Guzman 2004a). Shifting paradigms in fisheries management have been initiated by public concern about ecosystem integrity, which accounts for the fact that “fishing always does more than catch the target fish” (Walters et al., 1998). Despite their global importance marine ecosystems are by far the least known among the ecosystems in the world, especially in developing countries where research is often not a priority (Cheung et al 2002). Although new species continue to be discovered worldwide updated information on marine biodiversity in Southeast Asia is especially scarce. This region, which is considered an area of highest marine biodiversity, is also the most seriously threatened (Burke et al 2002).

Coastal marine habitats are being exploited beyond their capacity to recover as overfishing and destruction of coral reef, mangroves, seagrass, and estuarine habitats continue (White et al. 2006). The coastal zone sustains a wide array of impacts from increasing diversity of economic activities (Figure 1), many of them are not sustainable. In the Philippines, reducing fishing pressure and habitat destruction are considered critical management strategies and often means providing alternative source of livelihood and income. In many coastal communities tourism increasingly supplements or substitutes as income source for fisherfolk. On the other hand, tourism can contribute to habitat degradation through diver damage on coral reefs and gives rise to additional resource use conflicts in the coastal zone. Fortunately, everywhere in the Asia-Pacific region there has been a growing realization on the need for maintenance of high biodiversity levels and pristine coastal areas because they prove to be vital in attracting and sustaining tourism, and in maintaining healthy stocks of fish food (White et al. 2006).

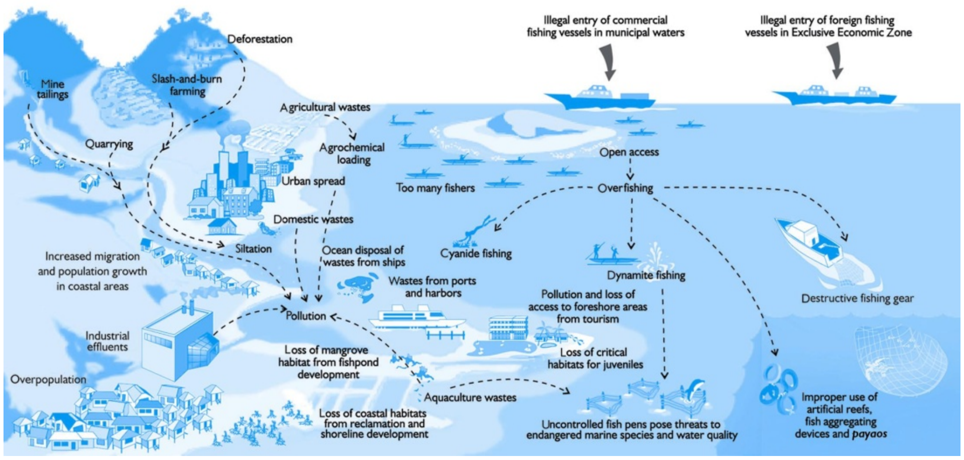


Fig. 1. Varied economic activities and their associated impacts in the coastal zone. (Source: *Philippine Coastal Management Guidebook Series No. 5, 2001).*

The concept of marine protected areas (MPAs) as a strategy in coastal resource management (CRM) has gained popularity in the last two decades. Many local communities of tropical countries have established marine reserves or fish sanctuaries to ensure the sustainability of fish stocks, and as an attempt to avert the downtrend of coastal capture fisheries. The creation of MPAs is probably the most appropriate option to protect biodiversity and sustain harvests from the reefs and thus would provide long-term benefits to fisherfolk. In marine reserves fish populations can grow and reproduce unimpeded by fishing of any kind, attain larger sizes and export fish biomass (larvae and adult fish) to non-reserve areas that, consequently, supplements surrounding fisheries (Holland & Brazee, 1996). Preservation of genetic diversity through protection also helps maintain the stability and integrity of the coastal ecosystem. Reserves also provide areas for recruitment of fish populations and a refuge from adjacent areas that are fished.

Marine protected areas (MPAs) - marine reserves, marine parks, and fish sanctuaries - achieve protection of particular well-defined critical habitats and biodiversity hotspots. MPAs, if properly designed and well-managed, can meet various marine resource and coastal conservation needs by preserving habitats and important species through strict protection of specific areas. Coral reef fisheries in particular can be managed effectively through implementation of “no take” areas within the reef (Roberts and Polunin 1993). Leading conservation organizations have adopted this approach as primary objective in global strategies for conserving biologically important areas (White et al. 2006).

Strategic goals of MPAs

Marine protected areas have multiple goals – all of which are considered strategic in sustaining marine biodiversity and fisheries (De Guzman 2004b):

- Conservation of marine biodiversity and genetic resources
- Protection of adjacent marine habitats (mangroves, seagrass beds & coral reefs)
- Refuge of fish from areas that are fished
- Areas where fish can freely grow to maturity and reproduce
- Help sustain and increase fish catch through protection of breeders and ensuring successful recruitment
- Export of fry and adult fish (“spillover effect”) to fished areas, thus, help prevent fishery collapse (i,.e. “insurance policy”)
- Helps improve fisher income from sustained fish catch

Marine protected areas promote ecosystem-based management - a holistic approach to ensure the protection of contiguous coastal habitats and conservation of the living resources. Marine protected areas are also considered potential measures for climate change adaptation, particularly in buffering the effects of coral bleaching resulting from increasing ocean temperatures and hastening recovery from both climate-induced stresses and overfishing (Arceo et al. 2002; Aliño et al., 2004). Protecting the high biodiversity inside MPAs increases the resilience of coral reefs to climate-induced environmental disturbance.

Various scales in Marine Protected Areas and MPA Networks

Declared and proposed MPAs have been classified as a) global/regional, b) national, and c) local priorities, based on the following criteria (Cheung et al. 2002):

i. the biodiversity and ecological values of the MPAs;
ii. consideration of the existing and potential threats imposed upon them, and
iii. feasibility of management which includes the social environment that is a determinant in the likelihood success.

Majority of the global/regional sites covers regional priority areas except those which are internationally recognized (*e.g.* Tubbataha Reefs National Marine Reserve as World Heritage Site and Olango Island Wildlfie Sanctuary as RAMSAR site). The prioritization process provides guidelines for resource allocation at the local, national, and international levels. Although local MPAs are of lower priority in the international context, they are essential in forming a healthy network of sites for marine conservation and for sustaining fisheries resources for local villagers depend upon them for livelihood (Aliño et al 2000; Aliño et al., 2004). More recent innovations in the MPA concept is the establishment of networks of small MPAs managed by local governments and communities to broaden the scope of protection. MPA networking has been pursued in many areas of the Philippines (Aliño 2009), and is seen as a cost-effective means of increasing the scope of protection and inter-LGU cooperation. Potential benefits of the MPA network include the conservation of major marine habitats and resources at the regional level (Pilcher 2009), such as the protection of marine turtles within the Sulu Sulawesi Seascape (SSS).

Importance of MPA monitoring: Ecological, economic, and governance perspectives

What is Monitoring?

Monitoring is using a standard method to observe one thing in one place over a period of time. Information from monitoring is like comparing two pictures of a person or place taken at different times to see if any changes have occurred. Similarly, monitoring collects evidence of changes from which trends may be deduced from a series of pictures and may help predict the direction and speed of future changes (Uychiaoco et al. 2010).

Project Goals and Training Objectives

Effective MPA management, however, is constrained by weak monitoring programs due to inadequately trained manpower. Majority of the MPAs established in the Philippines and other parts of Asia do not have a regular monitoring program, largely due to lack of funds and technical staff to undertake a regular bio-physical assessment. Recognizing the need to build local and regional capacity for MPA monitoring, the Asia-Pacific Network for Global Change Research (APN) is funding the project ***"Capacity Building for Research and Monitoring of Marine Protected Areas: An Adaptive Mechanism for Climate Change in the Asia-Pacific Region"*** under the CaPaBle Programme***.*** The project seeks to build the capacity of marine protected area (MPA) managers and technical staff of local government units in coral reef-rich countries particularly in the Asia-Pacific region.

Several countries in the Asia-Pacific region (e.g. Philippines, Indonesia, and Thailand) have considerable experience with establishment of MPAs as adaptive mechanisms for natural and anthropogenic impacts. The Philippines and Indonesia, two of six member states of the Coral Triangle Initiative, have MPAs that date back more than 30 years. Training of MPA monitoring teams will employ scientifically sound research and assessment methods of coral reef, seagrass, and mangrove communities. Developing a pool of MPA researchers and monitoring & evaluation (M&E) practitioners will hopefully help member countries increase their ability to adapt to climate change and human-induced stresses and contribute to the sustainable development of coastal ecosystems in the Asia-Pacific region. The capability building project in MPA monitoring shall be implemented at two levels: a Local (Mindanao-wide) and Regional (selected Asia-Pacific countries) training series. The training program targets to train a total of 40 technically capable MPA practitioners within the region who, in turn, shall become trainers in their respective countries.

MPA Database in Asia-Pacific Region

Apart from enhancing the ability of MPA monitors in the bio-physical monitoring of MPAs, the project shall also guide participants in formulating an effective M&E program and in implementing it in their respective areas. Participants will be encouraged to write their monitoring results for presentation and feedbacking to the community and the local government. The outputs of these monitoring programs can contribute to building of a MPA database in the Asia-Pacific region.

Trainers Tips *(adopted from Uychiaoco et al. 2010)*

Key Concepts

1. Monitoring and evaluation is essential for management to be responsive to the changes in the biophysical and socioeconomic realities as an area is being managed.
2. Observations must be done in places and times that represent the variations in the places and times of interest.
3. Observe those indicators that address what you want to know.
4. The monitoring plan must be feasible.

Though there are many definitions of adaptive management, the basic idea is that management strategies are continuously improved as understanding of the system being managed improves. It is very important that the indicators you decide to monitor are relevant to what the community wants to know. If current use is sustainable under the present management strategy, your indicator must either be stable or changing towards the direction desired (e.g. fish catch is stable or increasing). If you are evaluating management, your indicators must be potentially responsive to management.

MONITORING OF CORALS AND OTHER MACROBENTHOS IN MPAs

Coral Reef Diversity

Coral reefs are one of the most productive and biologically diverse of all marine ecosystems (Fig. 1-1) – a valuable resource for tropical coastal communities, providing social, cultural, and substantial economic benefits through industries such as fishing, tourism, and recreation. Coral reefs have sustained multiple resource uses through the decades many of which are not sustainable- as a result it is recognized that, globally, coral reefs are becoming increasingly stressed (Miller 1999).

Figure 1-1. Coral reefs, home to extraordinary diversity of flora and fauna, abound in the Asia-Pacific region. **(Photo by Renoir Abrea/ICE CREAM-CoastFish Project)**

Hard corals (known as scleractinian corals) are tiny animals whose individuals consist of tubular bodies with mouth ringed by tentacles at one end. These individuals secrete cup-shaped limestone skeletons within and around their bodies. Another group known as soft (non-sleractinian) corals do not secrete this skeleton so they are not as rigid. Individuals group and divide repeatedly, forming colonies. Coralline algae cement these colonies together into hard structures known as coral reefs. Coral reefs only develop in warm tropical climates and in seawater of high transparency. Corals easily get suffocated by silt, so they need water movement to continuously wash their surfaces. In addition symbiotic algae-which photosynthesize, live within corals, and help them grow faster, also need sunlight. Communities of plants, algae and, animals, and other living organisms interact with each other in and around coral reefs (Uychiaoco et al. 2010), forming a highly diverse biological system in the ocean (Fig. 1-2).

Parts of Indonesia, Malaysia and the Philippines, together with Papua New Guinea, Solomon Islands and Timor-Leste constitute the 'Indo-Pacific Coral Triangle', a biodiversity 'hot spot' containing 500 or more species of reef-building coral and extremely high fish diversity. The Coral Triangle is considered the epicentre of global marine diversity and abundance, however, these resources are seriously threatened by increased exploitation fuelled by an exploding human population. This scenario became the catalyst for the formation of the 'Coral Triangle Initiative' participated in by six countries. While maximum species richness of corals, fishes, and other inverterbrates is reached inside the Coral Triangle, species richness falls rapidly across the Pacific and although less rapidly, to the west across the Indian Ocean (Wilkinson 2008).

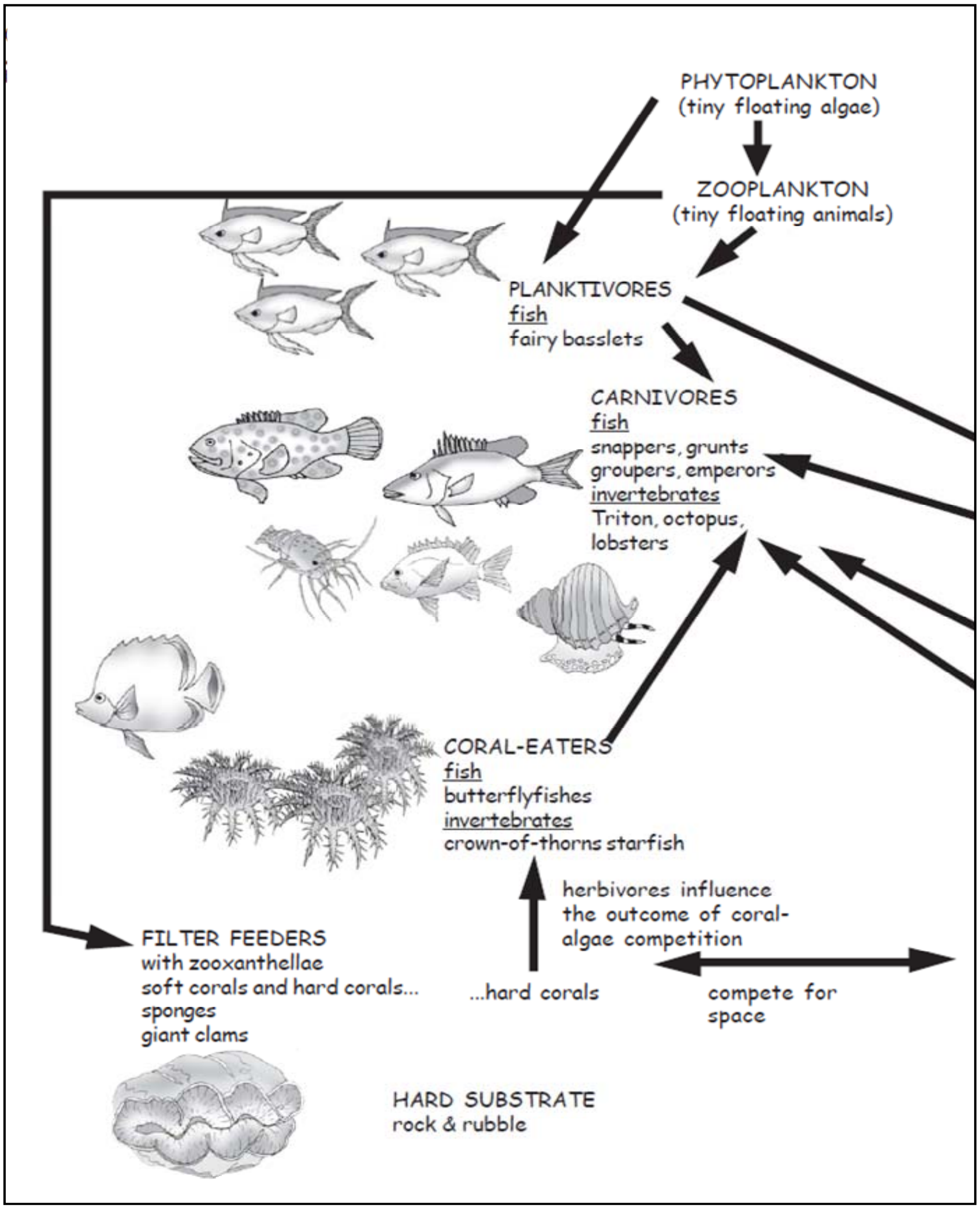


Figure 1-2. Various types of plant and animal organisms form a complex food chain in coral reefs (Source: Uychiaoco et al. 2010).

Status of Coral Reefs in the Asia-Pacific

Coral reefs are increasingly threatened by natural and human activities (Fig. 1-3). Less than 5% of Philippine coral reefs remain in excellent condition (Licuanan and Gomez 2000) while 20% of the world's coral reefs have been destroyed and show little sign of immediate recovery. The Philippines's contribution to the *Status of Coral Reefs in the World 2004* (Wilkinson 2004) contains time-series data on over 50 coral reef sites along the length of the archipelago, most of which were monitored since the 1990s. Unfortunately, this is a biased data set since an overwhelming majority of these time series data focused on managed (protected) reef sites. Despite this apparent data bias, Philippine reefs still exhibit an overall declining trend in the South China Sea and either stable or variable in other biogeogeraphic zones. In the Visayan Seas (Fig. 1-4), on the other hand, hard coral cover and reef fish abundance in the sites monitored are generally improving (Nañola et al. 2006).

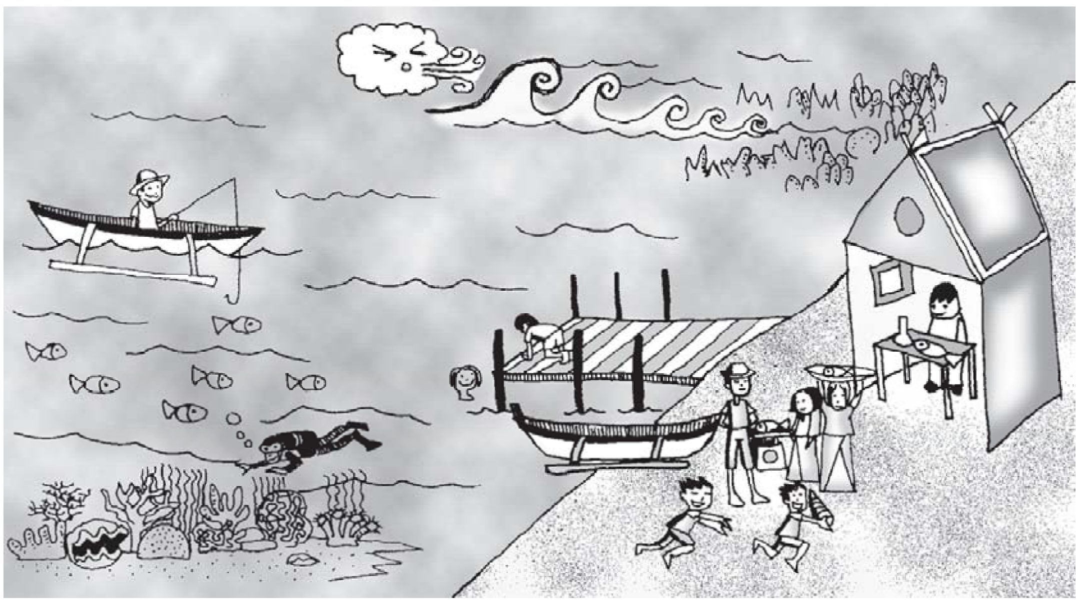


Figure 1-3. Coral reefs sustain a wide variety of human-induced stresses. (Source: Uychiaoco, et al. 2010).

At least 464 hard coral species have been identified in the Philippines, which amounts to about half of the reef-building coral diversity in the world. Current data suggest that the reefs are experiencing a steady decline of 3-5% in live coral cover at all sites examined. This degradation trend is corroborated by reports indicating that reefs in the 'poor' condition category have increased from 33% in the 1980s to nearly 40% two decades later (Tun 2004).

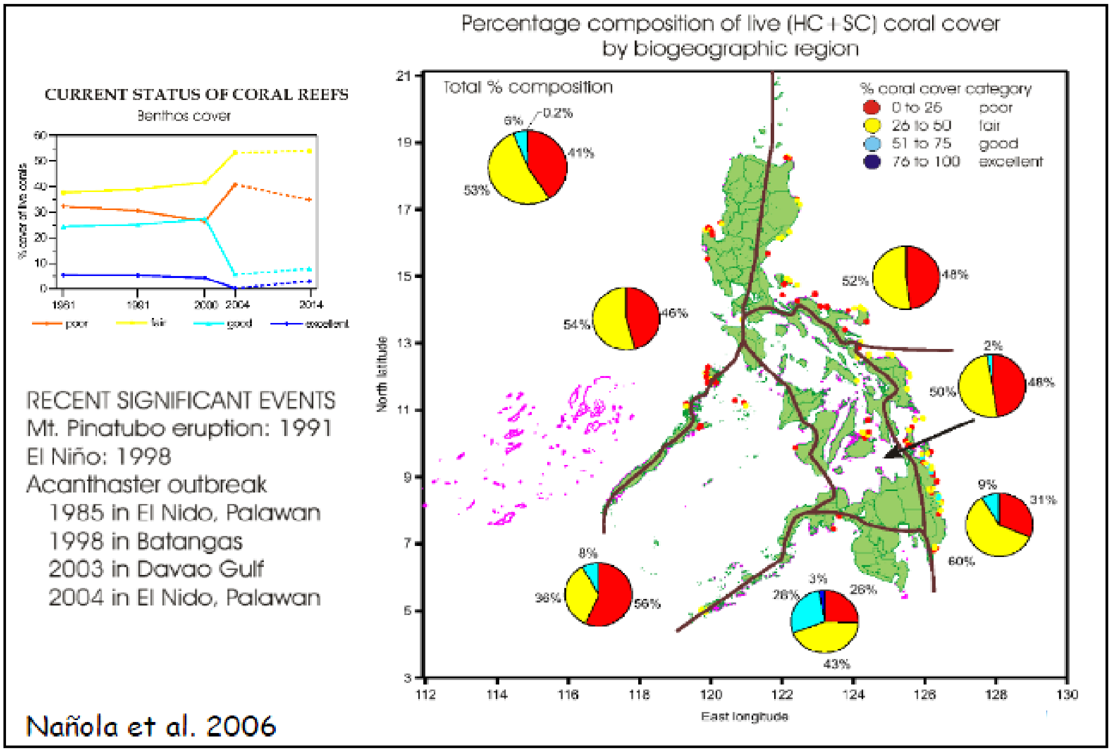


Figure 1-4. Profile on live coral (hard and soft) in the different biogeographical regions of the Philippines (Source: Nañola et al. 2006).

Monitoring programs are essential in detecting changes in coral communities in order to, among others, provide data for making effective management decisions. Given the relatively high costs of monitoring programs, selection of the appropriate monitoring method for specific objectives is therefore important. Corals and coral reefs are the focus of MPA protection because they are less accessible to monitor and evaluate than either mangrove forests or seagrass beds (Uychiaoco et al. 2010). Because of their naturally high productivity and aesthetic beauty, coral reefs are more frequently the centerpiece of Marine Protected Areas. Managing coral reefs will ensure the longevity of the social, economic and ecological benefits that humans derive from them. There is also a need to keep track of the changes in their community structure (diversity and coral cover) to find out whether present use and management are sustainable or if they could be improved. Constant monitoring of the reef's condition will also enable MPA managers to respond appropriately in the context of adaptive management.

Southeast Asia (SEA) contains the largest area of coral reefs with about 100,000 km2 (34% of world's total). The region is regarded as the global centre of tropical marine biodiversity, with 600 hard coral species and more than 1300 reef-associated fish species (Wilkinson 2008). The biodiversity value of Southeast Asian coral reefs is unparalleled in the world with more coral and fish species than anywhere else including a high proportion of endemic species of fish, corals and invertebrates. Over-fishing and unsustainable fishing practices have led to declining fish stocks in almost all SEA countries, pushing many fishers to resort to destructive fishing practices. Coral reef monitoring between 2004 and 2008 indicate that reefs continue to show an overall decline in condition in Indonesia and Malaysia, while there have been slight improvements in the overall reef condition in Philippines, Singapore and Thailand. The greatest improvement in reef condition however, was seen in Vietnam where most reefs in the 'poor' category shifted to the 'fair' category.

Tools and Techniques in Monitoring Coral Reefs

The following section describes the most common benthic lifeform survey methods used in baseline assessment and monitoring corals and other macrobenthos on the reef.

A. Broad-scale assessment: Manta Tow Reconnaissance Technique

The manta tow method has been widely used in Micronesia and the Great Barrier Reef for assessing broad-scale changes in reef cover due to cyclone damage, coral bleaching and outbreaks of the crown-of-thorns starfish, *Acanthaster plancii*. A good synopsis of the method is given in English *et a*l (1997) which forms the basis of the following description.

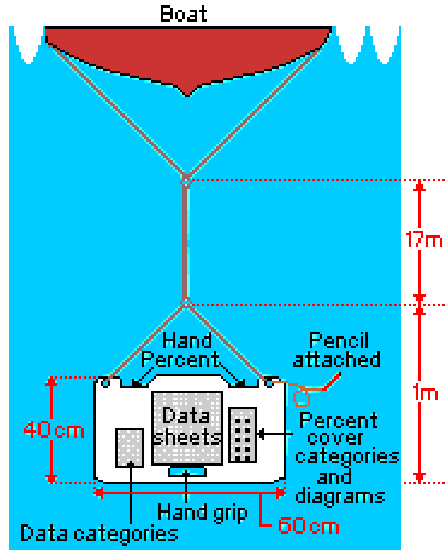
The manta board (Fig. 1-5) is attached to a motor boat with a 17 m length of rope which has buoys placed at distances of 6 m and 12 m from the board. A snorkeller grips the board and is towed for approximately 2 minutes, at the end of which the boat pauses to allow the surveyor to record data (usually on a plastic slate or water-resistant paper attached to the board). The coverage of bottom features may be recorded on a percentage scale (for an example, see Fig. 1-6) or on a scale of 1–5, where 5 indicates the greatest cover and 0 is used for absence. However, a scale of 1–5 has the short-coming that observers may be tempted to place a disproportionately large number of values in the middle category (i.e. 3), thus creating observer bias. If possible, a scale of 1–6 or 1–4 is more desirable (see Kenchington 1978).

Features of the coral reef which should be amenable to this type of survey include the following:

Living biotic features	Substrata	Others
live hard corals	sand	geomorphology
soft corals	mud	visibility
macroalgae	bedrock	depth
sponge	rubble	
	dead coral	

Figure 1-5. ***Detail of the manta board and associated equipment***. It is recommended that the board be made from marine ply and painted white. Two indented handgrips are positioned towards both front corners of the board and a single handhold is located centrally on the back of the board.

(Redrawn from: *English et al. 1997*.)



Estimating percent cover

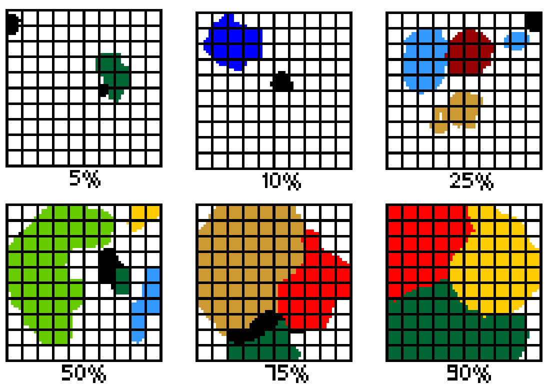


Figure 1-6. Estimating percent cover on the benthos using a metre-square quadrat with string or fishing line strung across at 10 cm intervals. In each example, shaded regions represent different types of substratum that are included collectively in the total percent cover estimate. (*Source: Rogers et al 1994.*)

B. Line-Intercept Transect

Coral reef communities have been monitored using **Line Intercept Transect** Technique (LIT), a method adopted by coral reef ecologists from terrestrial plant ecologists (Loya 1978, Marsh et al 1984, English et al 1994). The LIT method requires *in situ* identification of the lifeforms directly under the transect tape. The community is characterized using lifeform categories which provide a morphological description of the reef community. These categories are recorded on data sheets by divers who swim along lines which are placed roughly parallel to the reef crest at depths of 3 meters and 10 meters at each site. For future monitoring, the location of each site is recorded and marked on the reef. If the expertise of the observer allows the identification of coral species, this methodology may be expanded to include taxonomic data in addition to the lifeform categories. Where possible, monitoring should be repeated each year or at least every two (2) years (English et al. 2007).

The LIT is used to estimate the cover of an object or group of objects within a specified area by calculating the fraction of the length of the line that is intercepted by the object. This measure of cover, usually expressed as a percentage, is considered to be an unbiased estimate of the proportion of the total area covered by that object, as long as the following assumptions apply: that the size of the object is small relative to the length of the line; and that the length of the line is small relative to the area of interest (English et al. 1997).

This technique, however, has raised concerns regarding data quality, since the identification of the lifeform will be affected by the observer's level of taxonomic training and factors that may affect the actions or decision of the observer such as bad weather, water currents, temperature, or physical health. Another main limitation of the method is the extended diver bottom time depending on the diversity of the coral community being surveyed (Vergara and Licuanan 2007).

Logistics needed in LIT (All texts in this section reproduced from IUCN 1993)

- **Personnel**
  - A team of at least 3 personnel is required - 2 divers and a person in the boat.
  - All observers should be familiar with the definitions of each lifeform (see Plates 1-4; Table 1-1). For example, branching forms are defined as those with at least secondary branching.
  - Training should be carried out in the field, but may include the use of slides and/or photographs in the laboratory.
  - Standardization between observers, and continuity of observers throughout the project is very important, as observer variability may obscure or complicate any real spatial patterns.
  - Observers should spend 30 - 45 minutes in the water at the beginning of each field trip, comparing and standardizing their interpretations of the various lifeforms. Particular attention should be given to the following lifeforms: CE, CS, CM, ACB, ACS, ACD, and the algae (see Table 1-1 for abbreviations).

- **Equipment**
  - Small boat/s, with outboard motors and safety equipment
  - SCUBA equipment
  - 4 fiberglass measuring tapes – 50 meters in length with hooks attached to the end of the tape and to the casing (Fig. 1-7). This tape length is recommended when visual fish censuses are conducted in conjunction with the LIT, otherwise a shorter transect length could be used.

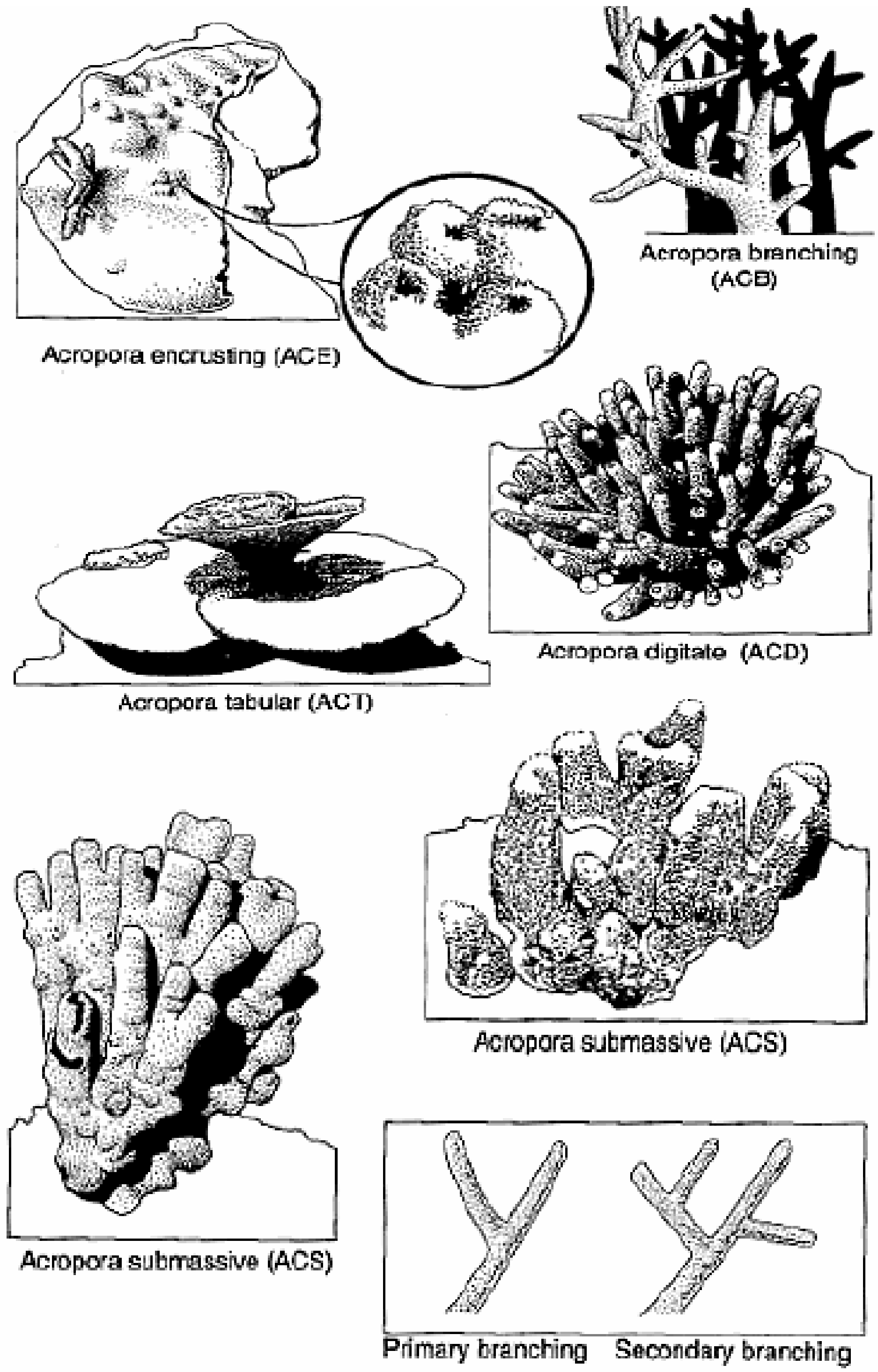


Plate 1-1. Examples of lifeforms categories which group benthic communities through the use of morphological characteristics. Inset shows primary and secondary branching (*Source:* English et al 1997).

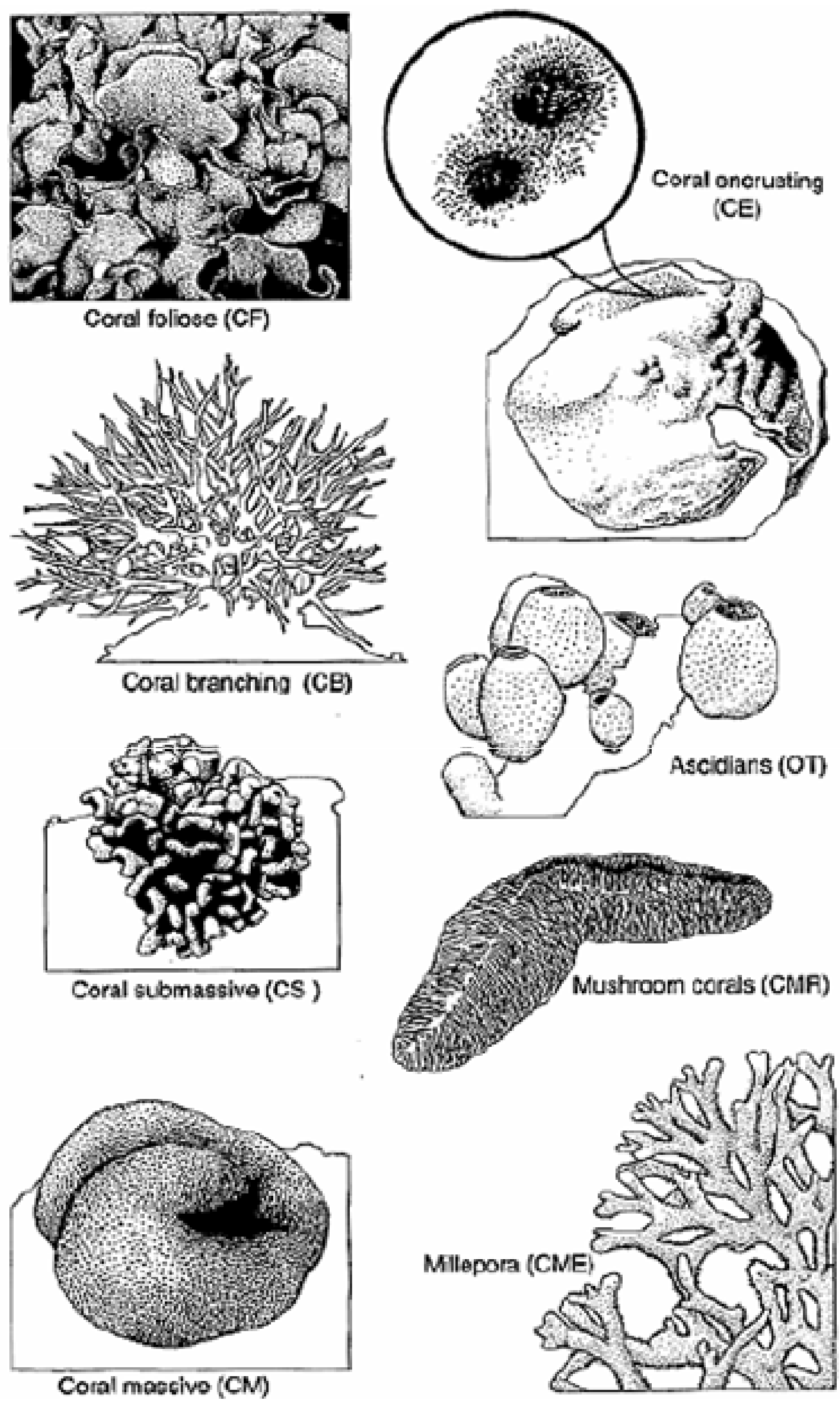


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Plate 1-2. Examples of lifeforms categories which group benthic communities through the use of morphological characteristics. (*Source:* English et al 1997).

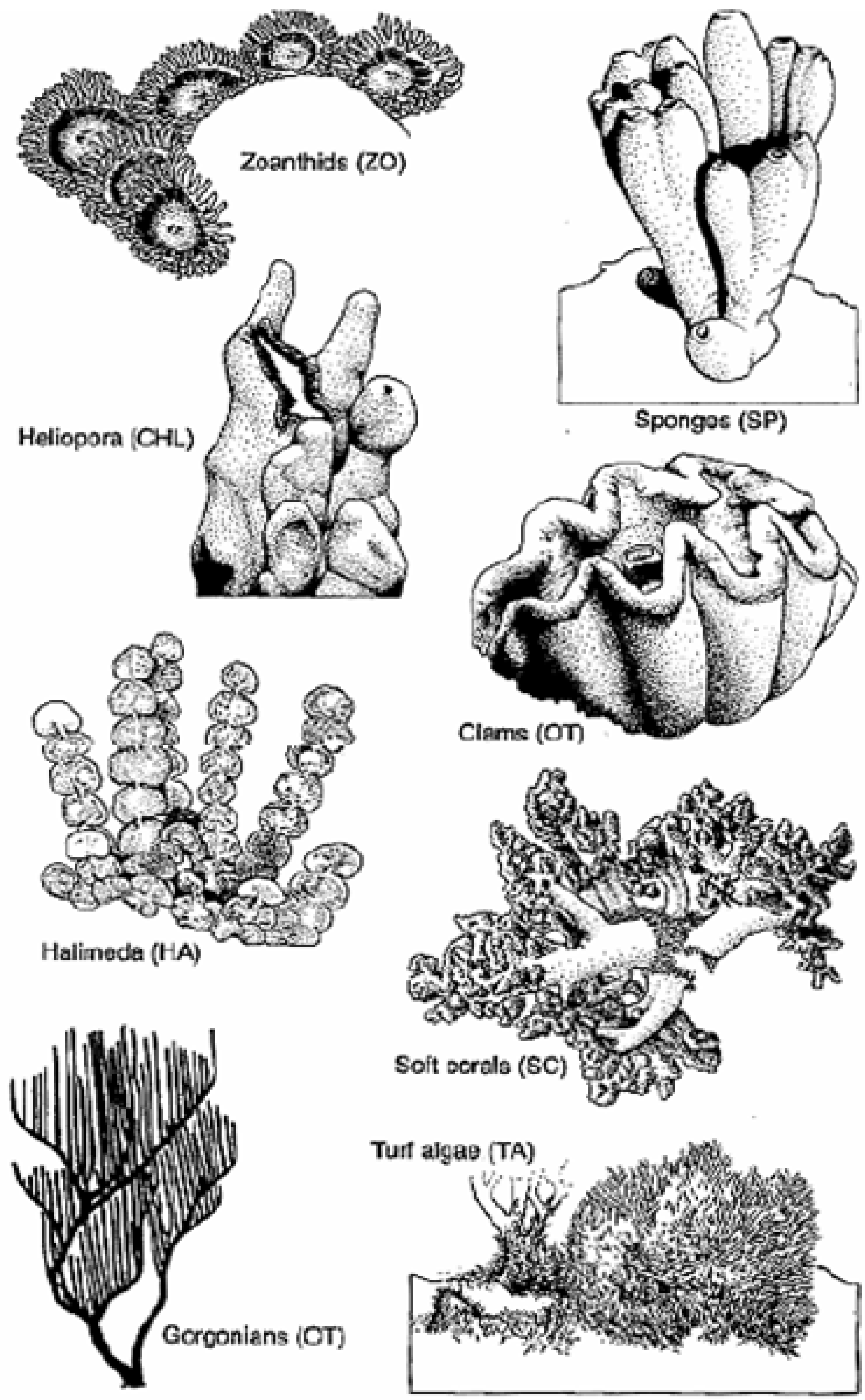
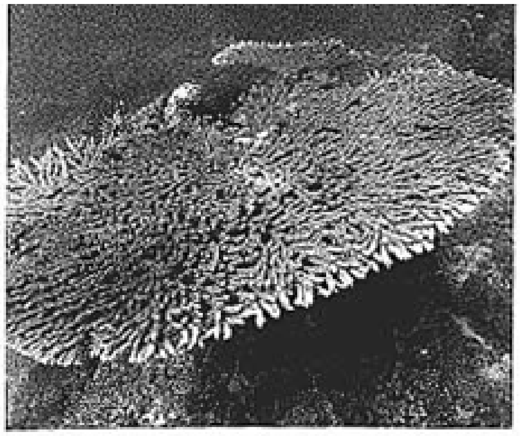
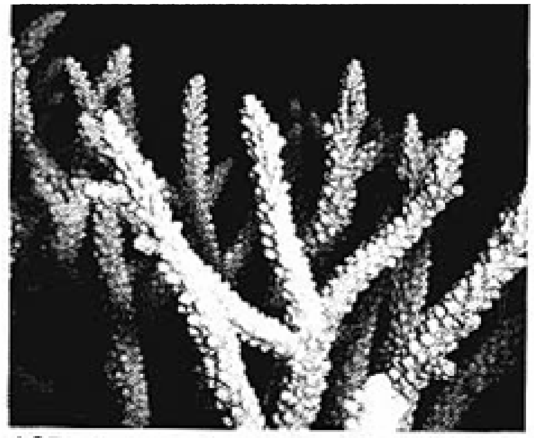


Plate 1-3. Examples of lifeforms categories which group benthic communities through the use of morphological characteristics. (*Source:* English et al 1997).

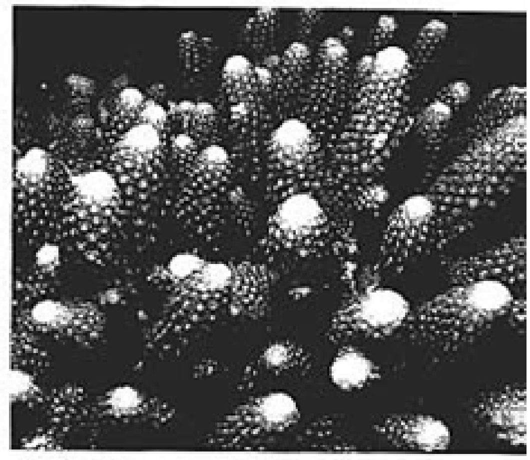


ACT *Acropora* tabular



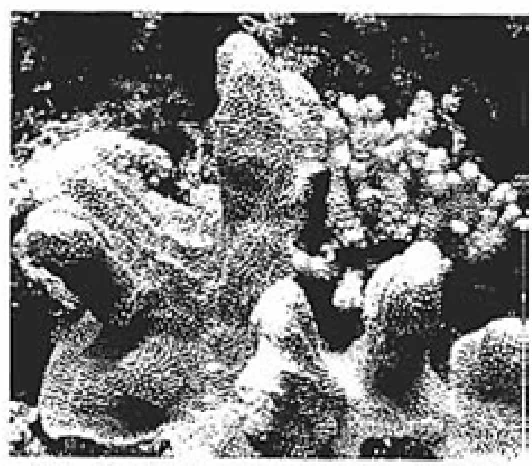
ACB *Acropora* branching. Note axial corallites on branch tips

ACE *Acropora* encrusting (*A. palifera*)



ACD *Acropora* digitate

ACS *Acropora* submassive (*A. palifera*)



ACS *Acropora* submassive (*A. palifera*)

Plate 1-4. Various growth forms of *Acropora.*

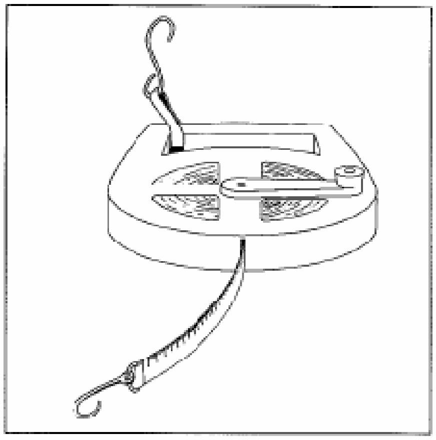


Figure 1-7 . Hooks attached t o the casing help secure the tape (Source: IUCN 1993).

- Slates, data sheet (A4 underwater paper is recommended), and pencils
- Printed data sheets will assist the observers to record their intercept data (Table 1-2).
- Float or other materials (e.g. plastic bottles) to mark site.

- **Maintenance**
  - Wash equipment, especially fiberglass tapes after use.
  - Develop a routine of maintenance which is adhered to before and after each trip.

- **Site selection and survey tips**
  - Conduct a general survey of the reef to select suitable sites on the reef slope which are representative of that reef. Manta towing is a useful technique for site selection.
  - At least 2 sites should be selected. If distinct windward and leeward zones exist, sites should be selected in each zone.
  - The precise location of sites should be recorded while at the site, noting landforms or unique reef features such as bays or indentations, points or channels, which may be useful for relocating the site. An aerial photo or chart of the area is extremely useful.
  - Mark the transect site of the reef. Metal stakes, such as angle iron or star-pickets, should be hammered deep into the substratum to deter 'human predation'. Attachment of subsurface buoys may help reduce human predation of site markers.
  - For each site, at least 5 transects of 20 meters length are located haphazardly at each of two depths, identifying shallow (3 meters) and deep (10 meters) coral communities.
  - If a typical reef flat, crest, and slope is present, the shallow transects will be located on the reef slope, approximately 3 meters below the crest. The deeper transects will be located approximately 9-10 meters below the crest. If the site is on a reef without a well-defined crest, then transect depth should be approximated to depth below mean low water.

Table 1-1. Lifeform categories and codes used in LIT (*Source: English et al. 1997*).

CATEGORIES		CODES	NOTES/REMARKS
Hard Coral:			
Dead Coral		DC	recently dead, white to dirty white
Dead Coral with Algae		DCA	this coral is standing, skeletal structure can still be seen
Acropora	Branching	ACB	at least 2° branching, e.g. *Acropora palmata, A. formosa*
	Encrusting	ACE	usually the base-plate of immature *Acropora* forms, e.g. *A. palifera* and *A. cuneata*
	Submassive	ACS	robust with knob or wedge-like form e.g. *A. palifera*
	Digitate	ACD	no 2° branching, typically includes *A. humilis, A. digitifera and A. gemmifera*
	Tabular	ACT	horizontal flattened plates e.g. *A. hyacinthus*
Non-*Acropora*	Branching	CB	at least 2° branching e.g. *Seriatopora hystrix*
	Encrusting	CE	major portion attached to substratum as a laminar plate e.g. *Porites vaughani, Montipora undata*
	Foliose	CF	coral attached at one or more points, leaf-like, or plate-like appearance e.g. *Merulina ampliata, Montipora aequituberculata*
	Massive	CM	solid boulder or mound e.g. *Platygyra daedalea*
	Submassive	CS	tends to form small columns, knobs, or wedges e.g. *Porites lichen, Psammocora digitata*
	Mushroom	CMR	solitary, free-living corals of the *Fungia*
	Heliopora	CHL	blue coral
	Millepora	CME	fire coral
	Tubipora	CTU	organ-pipe coral, *Tubipora musica*

***Note**: if permanent quadrats are monitored in the area, care should be taken to lay the transects away from the quadrats in order to avoid damage.*

- The number of observers recording data should be kept to a minimum. Those observers should collect data at all sites and, where possible, during repeated surveys.

- If the personnel are available, it is more efficient if there are two observers recording data from the transects and a third diver rolling out, and rolling up the tapes.
- Each individual transect should be completed by a single observer.
- The diver responsible for the tapes should firmly attach the hook on the beginning of the tape (Fig. 1-8) to a coral and other suitable anchor and then roll the tape out parallel to the crest, following a constant depth contour (use depth gauge).
- The tape must remain close to the substratum (0-15 cm) at all times and should be securely attached to prevent excessive movement. This can be achieved by using the coral as a natural hook. *e.g.* by pushing the tape between branches. Do not wrap the tapes between coral heads/ branches or other lifeforms as this will affect intercept measurements. Cares should be taken to minimize areas where the tape is suspended more than 50 cm above the substratum*, i.e.* the water category.
- After the transects have been completed, divers should mark the study sites by stakes or subsurface buoys. A global positioning system (GPS) can be very useful in relocating sites.

Note: when dive teams are limited and individuals must complete a number of transects on any one day, they must be aware of ***decompression safety****. Divers must start with the deeper transects. When these are completed they can proceed to the transect at 3 meters depth.*

Table 1-2. Example of a printed sheet used by observers to record line intercept data.

Reef/Island: ______________**Depth:**____________ **Date:** ____________ **Time:** _______
Reef zone : ______________**Site No:** ___________ **Temp. Top**______ **Salinity. Top** ______
Bot______ **Bot**_______
Transect no: ____________ **Visibility:** _______________ **Collector:** ________________________

Transition	Category	Taxon	Transition	Category	Taxon

Note: The column headed "Taxon" is only used if the observer has expertise in coral taxonomy.
If there is little or no coral at 10 meters then transects should be laid at 6-8 meters depth and the difference should be noted.

- **Data recording**
  - Before entering the water record the precise location of the site and any ambient parameters onto the datasheet. The precise location of the study area should be included.
  - While the transect is being laid out the observer should record details of the site, depth etc. onto the data sheet. Detailed comments about the conditions of the site at the time of survey should be included.
  - Once the transect has been laid out, the observer moves slowly along the transect recording onto the data sheet the lifeforms encountered under the tape (Fig. 1-9). At each point where the benthic lifeform changes, the observer records the transition point in centimeters and the code of the lifeform. Hence, along the length of the transect (XY) a number of transition points (T) are recorded for each of the lifeforms. The intercept of each lifeform encounterd under the transect (I) is the difference between the transition point recorded for each lifeform.
  - To facilitate accurate calculation of the number of occurrences of each lifeform, observers should note instances when the tape intercepts a single lifeform or colony more than once. For example, when a massive *Porites* colony includes both living tissue and dead patches with algal growth, each intercept with living tissue should be recorded as belonging to the same colony (Fig. 1-10). Thus, the recorded identifies 2 intercepts of CM (coral massive- *Porites*) as belonging to the same colony.
  - Some colonies may be encountered which could be recorded as either of two lifeform categories, depending on where the colony is intercepted by the tape. Such colonies should be recorded by their dominant lifeform (*i.e.* the lifeform displayed more than 50% of the colony). For example, large digitate *Acropora* species (*A. digitifera, A. humulis*) may have secondary and tertiary branching at the ends of some of their branches. However, the proportion of the colony which displays these characteristics relative to the digitate form is small and hence the colony would be recorded as ACD.

Figure 1-8. A diver records lifeform categories encountered under the transect tape (Source: IUCN 1993).

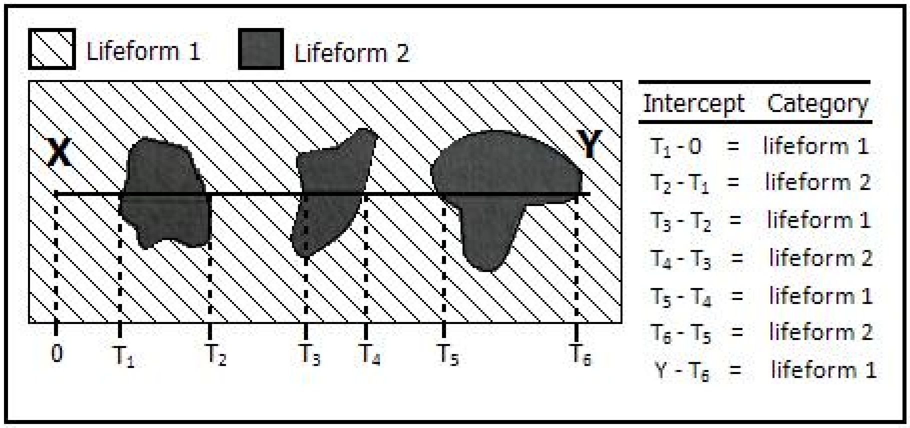
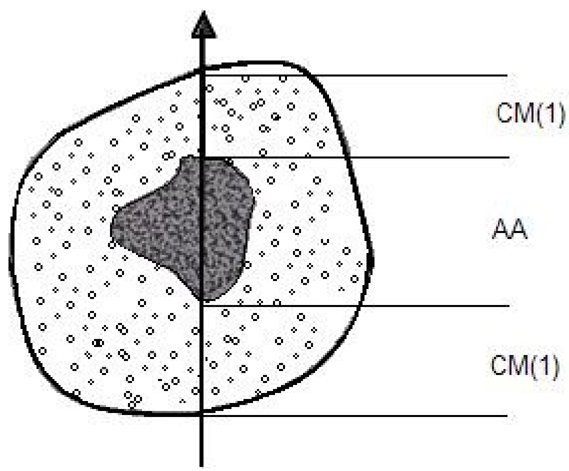


Figure 1-9. Schematic diagram of a transect (XY) showing the transition points (T) for each lifeform crossed by the transect. The difference between the consecutive transition points is the intercept of the lifeform (Source: IUCN 1993).

Figure 1-10. Diagram showing a transect crossing a single colony more than once.



- More specific taxonomic identification may be included in addition to the life form category, dependent on the observer's knowledge.
- It must be emphasized that the lifeform categories specified are the minimum requirements for a regional database. If there is a need to add new categories for specific purposes, the category must allow retrieval of the minimum information (*i.e*. the new list of categories can readily be collapsed into the old one). For example, if the SC (soft corals) group is divided to note the growth form of soft coral, provision must be made to allow the combination of the new categories back into SC for purposes of exchange.

- **Standardization**

    - Observers must be as consistent as possible when recording the types of colonies, they should collect data at all sites and, where possible, during repeat surveys.
    - Regular training and discussion of lifeforms should be undertaken in the field to ensure that interpretation of lifeform categories is the same for all observers, and that it does not change over time (*i.e.* data are comparable).
    - The minimum requirements must always be met to ensure that data exchange is possible.

- **Data Analysis**

    - Relatively large amounts of data will be collected, therefore adequate space for data storage and manipulation must be available.
    - Summary data showing percent cover and number of occurrence of each lifeform may be calculated using the line intercept data. After calculating the intercept from the transition points recorded along the transect, the percent cover of a lifeform category is calculated.

$$\text{Percent cover} = \frac{\text{Total length of category}}{\text{Length of transect (Y)}} \times 100$$

Hence, for Fig. 1-7,

$$\text{Percent cover lifeform 1} = \frac{I\,1 + I\,3 + I\,5 + I\,7}{Y} \times 100$$

$$\text{Percent cover lifeform 2} = \frac{I\,2 + I\,4 + I\,6}{Y} \times 100$$

- Preliminary calculations of percentage cover and number of occurrences can also be made from the data collected using the **Lifeform program**.
- These analyses will provide quantitative information on the community structure of the sample sites. Successive samples can also be compared when the sites have been sampled repeatedly over time.
- If reefs have been selected to represent both disturbed and pristine sites, then comparison of change detected in these sites may allow recognition of change due to disturbance from natural and man-induced pressures. This provides a predictive tool in reef management.
- Where rigorous statistical comparisons of reef community structures within and between sites are needed, greater replication of transects at each

sampling site will be required. This should be identified in a pilot study, but will be at least 8-10 transects.

- **Advantages**
  - The lifeform categories allow the collection of useful information by persons with limited experience in the identification of coral reef benthic communities.
  - LIT is a reliable and efficient sampling method for obtaining quantitative percent cover data.
  - LIT can provide detailed information on spatial pattern.
  - If LIT is repeated through time with sufficient replication (see Chapter 7) it can provide information on temporal change. Meaningful temporal data requires regular comparisons between observers to overcome observer differences.
  - LIT requires little equipment and is relatively simple.

- **Disadvantages**
  - It is difficult to standardize some of the lifeform categories.
  - Objectives are limited to questions concerning percent cover data or relative abundance.
  - It is inappropriate for assessing demographic questions concerning growth, recruitment, or mortality. If the objectives of a study specifically address these questions, then photo-quadrat techniques should be used in addition to LIT.
  - While the LIT can provide detailed information on spatial pattern, it cannot provide precise information on temporal change. Therefore, if the objectives specifically address demographic questions or detailed information regarding temporal change in the benthic community is required (*i.e*. impact studies), then belt transects and/or photo-quadrat techniques should be used in addition to LIT.

C. Photo-Transect Method

The video transect technique (Osborne and Oxley 1997, Page et. Al. 2001) reduces the bottom time of the observer to as short as 8 minutes per transect as compared to 45 minutes with LIT. On the other hand, the video transect technique incurs high cost of underwater video camera setup (Php150,000.00) and the associated laboratory processing time to grab frames from the videos to be analyzed.

The Photo-Transect method is a modification of the video transect technique described by Osborne and Oxley (1997). It involves the use of digital still cameras attached to a distance bar. A digital camera inside a waterproof case is attached to an aluminum distance bar, the length of which is predetermined so that the substrate covered by the image is 0.5m wide (Fig. 1-11 & Fig. 1-12). Photographs of the substrate are taken at 1m intervals to come up with 51 frames per 50m transect. As with the video transect technique, the digital images are analyzed using the 5-point method (English et al. 1997).

The photo transect method is proposed over other survey methods because of several advantages, such as:

1) equipment outlay is much cheaper and laboratory processing time is reduced in comparison to the video transect technique;

2) the survey can be conducted by non-technical persons (with little knowledge of advanced technology and even non-biologists);

3) diver bottom time is reduced in comparison to the LIT, and

4) taxonomic identification of biota is improved since image resolution is much better than video camera resolution (0.3 megapixel vs. 10 megapixel or higher).

Image and data processing protocols such as color correction, image overlay and considerations on camera selection have been presented by Vergara and Licuanan (2007). The photo transect technique can be promoted as an alternative low-cost and non-technical method to survey coral communities.

Figure 1-11. a) Photo showing how the photo transect technique is conducted, b) sample digital output showing the 5-point image overlay used as guide for scoring the image*. (Source: Vergara and Licuanan 2007)*

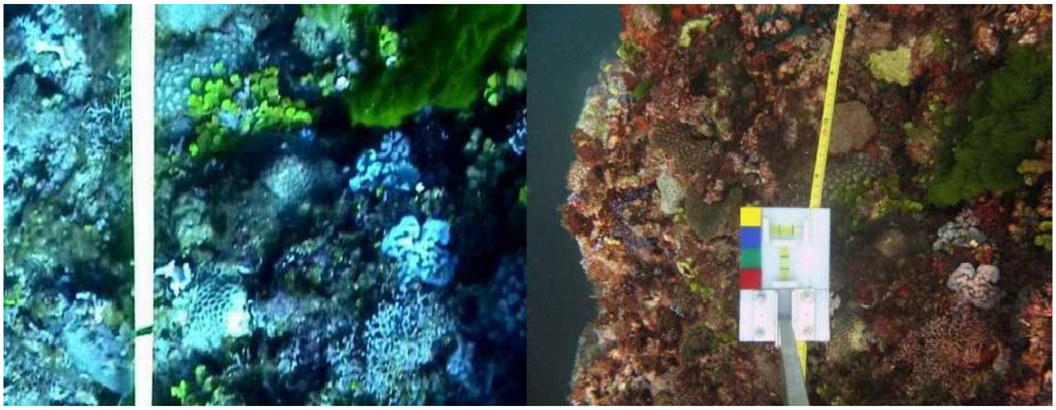


Figure 1-12. Sample digital outputs of the same spot on the reef taken with a) video camera (image dimension is 640 x 480 pixels), compared with b) one taken with a digital camera (image dimension is 2592 x 1944 pixels). *(Vergara and Licuanan 2007)*

The Photo-Transect technique is fast gaining popularity in monitoring changes in coral community structure, and is the standard method used by the ICE CREAM Program in monitoring the impacts of climate change on Philippine reefs (Licuanan et al. 2010; Garcia and De Guzman, 2010).

Considerations for long-term coral monitoring of MPAs

Monitoring the habitats and resources inside marine protected areas has both short term and long term goals. In the short term, data on the bio-physical condition of the MPA project provide vital information for local government and community implementers on the success or impact of law enforcement, fund allocation, and community participation in protecting the marine sanctuary. In the long term, monitoring would provide data on the positive (or negative) changes in habitat quality and resource abundance through time and an evaluation of project sustainability, governance, and the spillover function of the MPA. Long-term monitoring becomes even more relevant and critical in the face of global environmental change, particularly climate change, which is expected to impact coral reefs more than any other tropical ecosystem.

Monitoring of MPAs should be done at regular intervals (White et al. 2004) using key indicators to detect changes in the bio-physical condition of the habitat and resources. This implies that the MPA should have baseline data with which to compare subsequent monitoring results. The effect of scale and frequency of monitoring is also important. For example, significant changes in coral cover might not be detected from using only a few transects or quadrats. The following are some important considerations in implementing a long-term habitat and resource monitoring of MPAs:

- Comparison of changes in coral cover inside (no-take area) and outside (open-access fishing) the MPA to demonstrate the impact of protection;
- Establishment of permanent (fixed) transects is a recommended approach to detect long-term changes in coral community structure;

- o Transect location can be fixed by deploying concrete blocks on the reef along which the transect line will be established upon assessment;
  - o Location of the monitoring site shall be fixed by getting GPS coordinates;
  - o Depth of permanent transect locations is preferably shallow (8-10m) for easy monitoring;
- The number of transects to deploy in both No-Take and Fishing zones should be sufficient to detect significant changes (*e.g.* the ICE CREAM program deploys at least five (5) 50-m transects in each site (Licuanan, pers.comm.);
- Where possible, identification of coral species should be made to indicate changes in coral diversity through time; and
- Employing the Photo-Transect technique is highly recommended for long-term reef monitoring.

In addition to biophysical monitoring, a regular evaluation of management performance of the MPA should be conducted based on key indicators. Certain instruments to do this are already available, such as the MPA Report Guide (adopted from CRMP 2001) available with the Coastal Conservation and Education Foundation, Inc. (Email: ccef-mpa@mozcom.com or at website **www.coast.ph**).

Monitoring impacts of climate change and other environmental events

Climate change largely induced by global warming is upon us. Long-term data show an unprecedented rise in average global temperature and carbon dioxide concentrations in the atmosphere in the last four decades (Fig. 1-13). Coral reefs are constantly under pressure from human-induced environmental changes, overfishing, and other unsustainable resource uses. Apart from these, reefs now face the impending impacts of climate change that could increase frequency and severity of natural hazards (storms, landfalls, flooding, coastal erosion), sea level rise, and increasing sea temperature (Fig. 1-14).

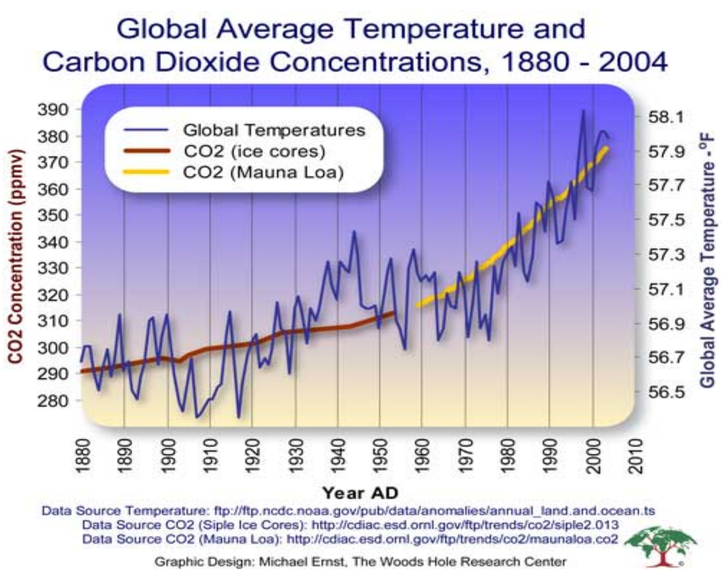


Figure 1-13. Rising trend in average global temperature shows very good correspondence with CO_2 concentrations. Climate experts say the increase in the last few decades has never been experienced by Earth.

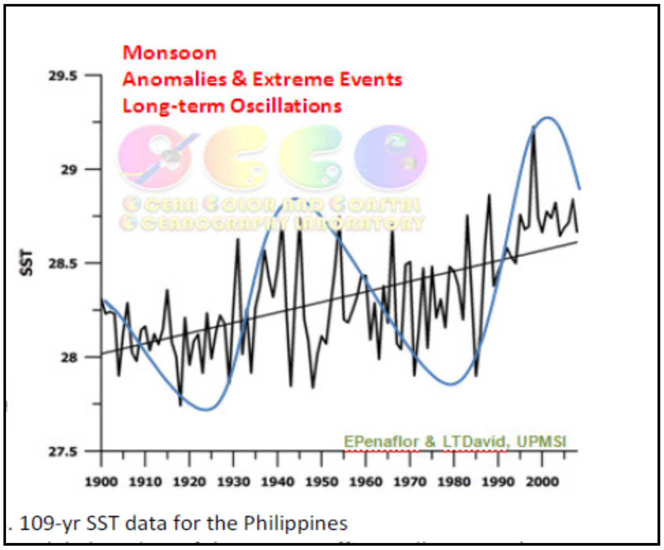


Fig. 1-14. Analysis of 109-year data on sea surface temperature of Philippine seas shows increasing trend in SST despite interdecadal fluctuations (Source: Penaflor and David, 2010).

Experts also predict increasing risk of the Philippines to more frequent and severe El Niño and La Niña events resulting in droughts and floods from more intense precipitation events (Fig. 1-15). Coral bleaching and emergence of diseases as a result of warming seas can hasten biodiversity loss, reduce fisheries production, and threaten the sustainability of coastal livelihoods such as coastal tourism.

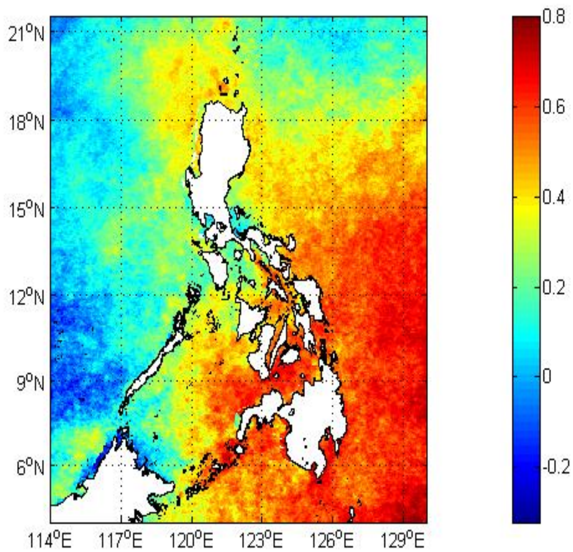


Figure 1-15. Correlation between climate data shows that the Philippines, especially Mindanao (higher values in red), is vulnerable to more frequent El Nino-La Nina (or ENSO) cycles. (Source: Villanoy, et al. 2010)

Recent evidence also suggests that climate change, by increasing sea temperatures and ocean acidity, may worsen the plight of coral reefs. This has serious consequences for tens of millions of people and billion-dollar fishing and tourism industries (CRTR 2008). When corals get too warm, the symbiosis with brown plant-like organisms known as zooxanthellae breaks down, and results in coral bleaching.

Coral Bleaching and Climate change

Mass coral bleaching caused by global warming is threatening the health of the world's reefs since the 1980s (Fig. 1-16). The most recent El Niño (2009-2010) has caused massive bleaching in the Coral Triangle, a vast marine region that is home to 76% of all known corals in the world (WWF 2010 – www.wwf.org.ph). The Malaysian government recently closed portions of world-famous dive sties (e.g. tropical islands of Tioman and Redang), saying they would be off limits until October to give the fragile coral reef ecosystems time to heal. In the Philippines, bleaching has been reported in Anilao and Nasugbu, as well as off the coast of the western municipality of Taytay, Palawan. Numerous other Philippine reefs are likely to have been affected as well, exacerbated by localized outbreaks of Crown-of-Thorns seastars. Recent incidents of bleaching in the Philippine reefs (Plate 1-5) of Masinloc, Zambales were reported (Deocadez/ICE CREAM, May 2010).

Massive bleaching was also observed in many reefs throughout the Philippines during the 1997-98 El Nino event. Arceo, et al. (2001) reported that bleaching occurred beginning early June until late November 1998, coinciding with thermal anomalies ('hotspots') observed in the country during this same period shown by satellite-derived SST data. Coral communities suffered significant decrease in live coral cover of up to 46%.

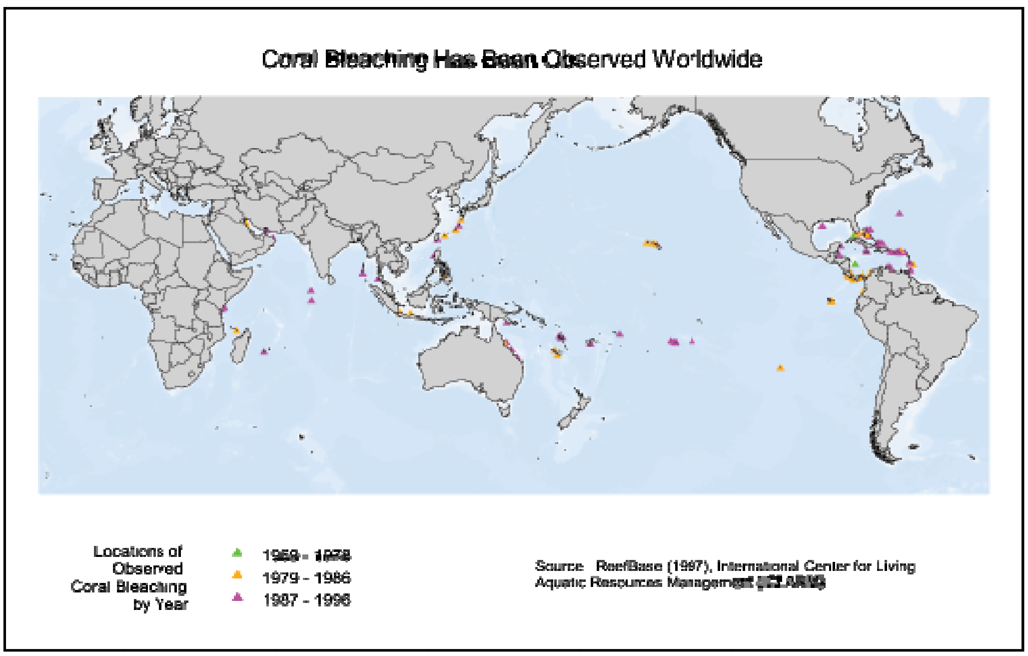


Fig. 1-16. World-wide occurrences of coral bleaching from 1969 to 1996 (Source: ReefBase 1997).

The Great Barrier Reef Marine Park Authority considers climate change to be the greatest threat to the Great Barrier Reef, causing ocean warming which increases coral bleaching. Mass coral bleaching events due to elevated ocean temperatures occurred in the summers of 1998, 2002 and 2006, and coral bleaching is expected to become an annual occurrence. Climate change has implications for other forms of reef life such as fish, predatory seabirds and sea turtles which have preferred temperature range which leads them to seek new habitats when SST changes become intolerable.

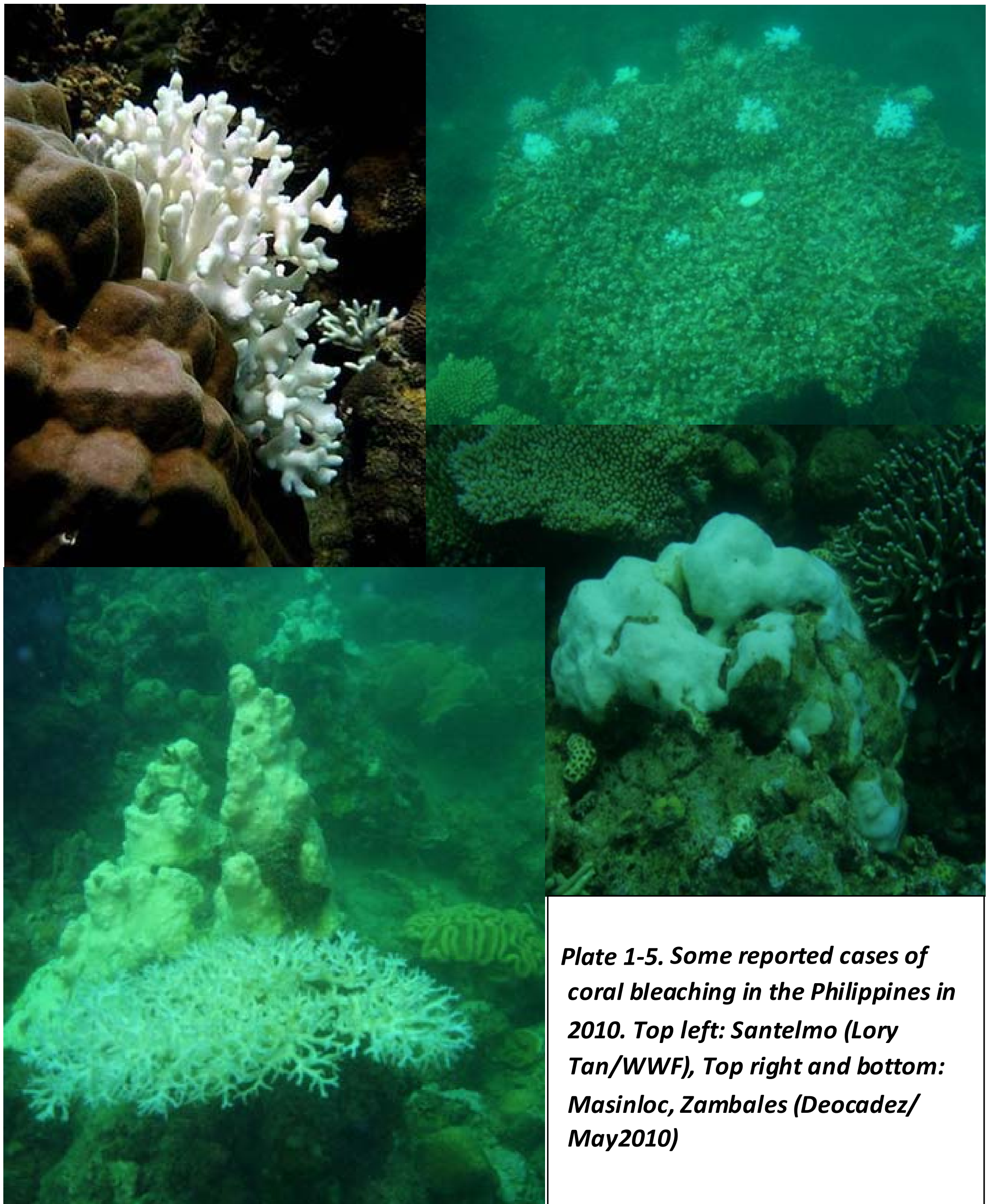


Plate 1-5. Some reported cases of coral bleaching in the Philippines in 2010. Top left: Santelmo (Lory Tan/WWF), Top right and bottom: Masinloc, Zambales (Deocadez/ May2010)

Coral bleaching is a phenomenon that is a consequence of global warming. Increased seawater temperatures, which in some regions have grown as much as 2°C above the long-term average maximum, can push the algae living inside corals beyond the brink, causing reefs to eventually turn white and die. Aside from increased sea temperatures, other causes of stress include disease, pollution, sedimentation, cyanide fishing, changes in salinity, and storms. Since March this year, about 50 different organizations and individuals have reported signs of coral bleaching in the Coral Triangle region. Up to 100% bleaching on susceptible coral species have been reported, and in some areas, severe bleaching has also affected the more resistant species.

With many areas showing signs of mass bleaching, it has become apparent that more weight needs to be put behind long-term conservation strategies, such as marine protected area management, preventing coastal and marine pollution, as well as promoting sustainable fisheries. Richard Leck, Climate Change Strategy Leader of the WWF Coral Triangle Programme, declared that this widespread bleaching is alarming because it directly affects the health of our oceans and their ability to nurture fish stocks and other marine resources on which millions of people depend for food and income. Leck suggested that "well-designed and appropriately-managed networks of marine protected areas and locally managed marine areas are essential to enhance resilience against climate change, and prevent further loss of biodiversity, including fisheries collapse"

Coral Diseases

Despite their importance coral reefs continue to be impacted by human activities, climate change, land and marine-based pollution, habitat degradation and overfishing. Many of these impacts have obvious and immediate effects often leading to mass mortality of corals. Some effects, however, such as those from chemical pollutants, wastes or excess nutrients are more insidious, and their impacts may be difficult to understand and quantify. One phenomenon which has recently gained the attention of coral reef scientists and managers is the increased incidence in coral disease. Diseases affecting corals particularly in the Caribbean reefs, have increased in both frequency and severity within the last three decades (Raymundo and Harvell 2008).

What is a coral disease?

Diseases are a natural aspect of populations – they are one mechanism by which population numbers are kept in check. Disease involves an interaction between a host, an agent, and the environment. Infectious biotic diseases are caused by microbial agents, such as bacterium, fungus, virus, or protest that can be spread between hosts and organisms and negatively impact the hosts' health (Raymundo and Harvell 2008). Other forms of disease that may have impacted corals may be considered abiotic diseases; they do not involve microbial agents but impair health, nonetheless. Environmental agents such as temperature stress, sedimentation, toxic chemicals, nutrient imbalance and UV radiation are such examples. In addition, noninfectious diseases are not transmitted between organisms, though they may be caused by a microbial agent. For example, certain microbes secrete toxins released by the bacterium *Clostridium botulinum* cause a non-infectious but deleterious disease in organisms that consume it.

Research on coral diseases is an emerging field in marine science. Pioneers in the field have identified five coral diseases for which Koch's postulates have been fulfilled showing disease, host coral and microbial pathogen (Fig. 1-17). The classic way to prove a microorganism cause disease is to satisfy Koch's postulate. A microorganism must be isolated from a diseased individual. That "isolate" is then used to infect a healthy individual. The same disease must develop, and the same organism must be isolated from the new infection. This classic method is a tough challenge in the face of unculturable marine microorganisms and polymicrobial syndromes, requiring molecular approaches.

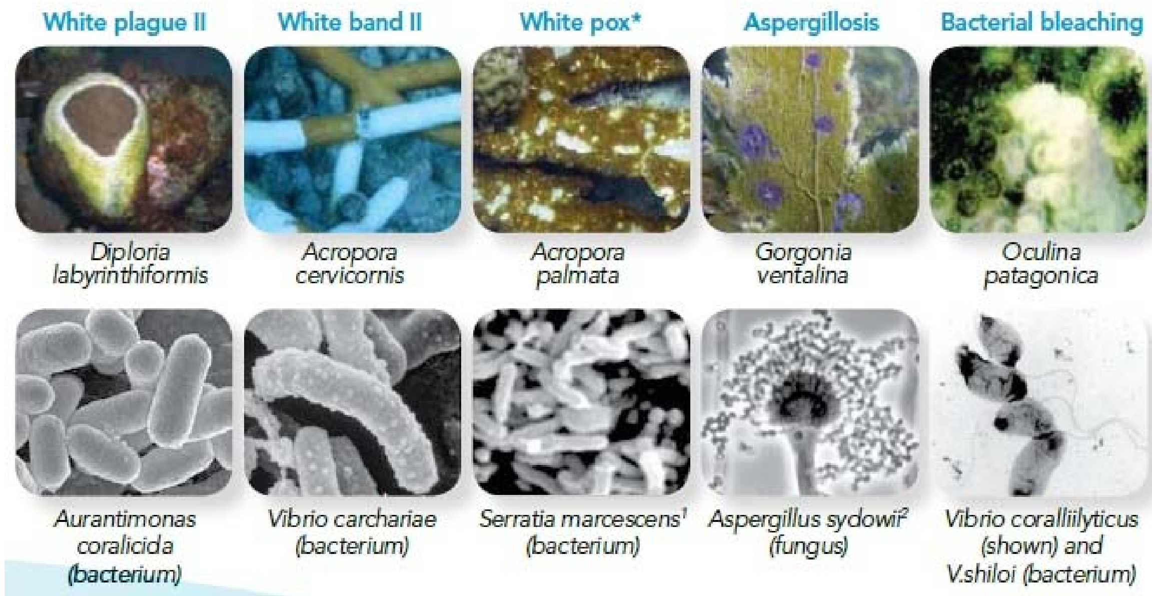


Fig. 1-17. Five most common groups of coral diseases (Source: Raymundo and Harvell 2008).

Carribean sea fan *Gorgonia ventalina* with multiple aspergillotic lesions.

Photo. E. Weil

Environmental stress and Coral Disease

An understanding of the influence that the environment plays in disease outbreaks could guide the development of useful management strategies (Fig. 1-18).

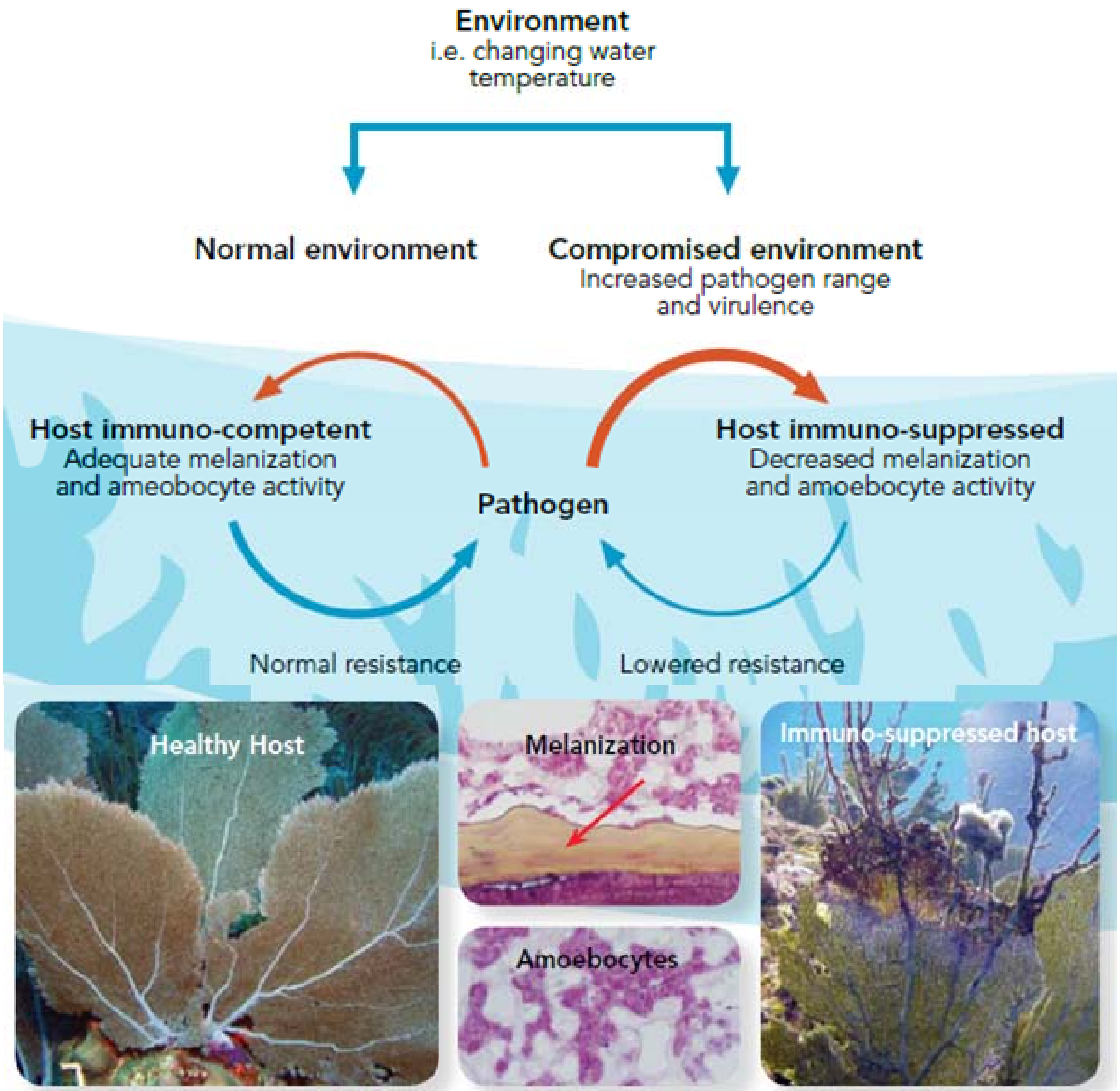


Fig. 1-18. Relationship between host and disease agent in corals *(Source: Raymundo and Harvell 2008).*

As with most aspects of management of infectious disease in a marine setting, it is a work in progress and it is critical to keep in mind that all infectious syndromes are different and may respond in different ways to environmental change. However, identifying the factors that control the most important infectious syndromes is a key management strategy. Morbidity or mortality in corals can be caused by tissue loss from predation or disease (Fig. 1-19 to Fig. 1-20).

A. Tissue loss due to known predation or stress resulting in compromised health

- **Fish Bites**


Parrotfish

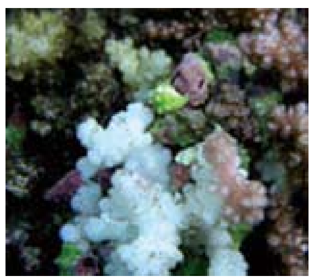

Pufferfish


Damselfish

- **Predation by *Acanthaster plancii*, Crown-of-thorns starfish (COTS)**

- **Tube formers and gastropod predation**


Tube worms


Drupella


Coralliophilia

- **Sedimentation and algal overgrowth**


Sediment damage


Colonization by algae

Fig. 1-19. Predation and other impacts on corals.

B. Tissue loss due to biotic and abiotic diseases

This refers to lesions that do not have any of the discrete patterns of tissue loss or skeletal damage consistent with predation or compromised health states described above.

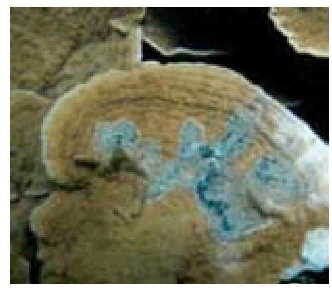



Black band disease (a&b) Skeletal eroding band Brown band

C. Tissue loss: within distinct bands

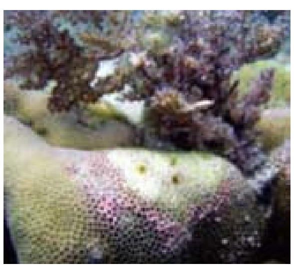
Ulcerative white spots

White syndrome



Atramentous necrosis

D. Tissue discoloration



Pigmentation response

Trematodiasis

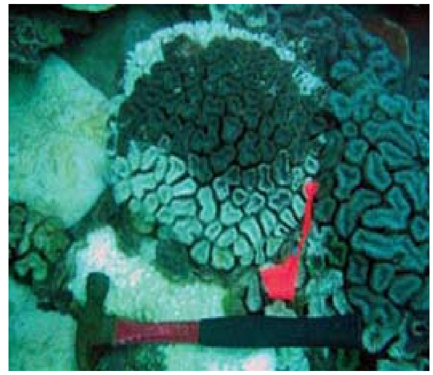

Unusual bleaching patterns

E. Growth anomalies (Skeletal deformations)

Galls


Growth anomalies of unknown causes

Top view of white syndrome outbreak spreading among at least 5 species in the genera *Lobophyllia*, *Mycedium*, *Merulina*, *Fungia*, *Favia* in Palau. Photo: B. Willis



Flagging tape tied to a dead portion of a colony or the substrate is an effective temporary means of marking an outbreak area boundary so that spread beyond an initial observation point can be tracked over time. Photo: K. Rosell

Figure 1-20. Tissue loss of corals due to disease and other stresses.

Coral disease rapid assessment and monitoring protocols
(*Source: Weil et al 2008; Raymundo and Harvell 2008*)

Validity and reliability of all types of quantitative assessments require satisfying a fundamental condition: an adequate estimation of the natural variation of the chosen parameters (disease prevalence, coral cover etc.). Reef monitoring to identify coral diseases must consider spatial and temporal scales. Rapid regional assessments can reveal the expansion rate of a particular disease from an infection ‘hotspot’ to nearby reefs and serve as an early warning system to identify and track disease outbreaks.

Saving the World’s Reefs: It’s Now or Never

The GEF Coral Reef Targeted Research & Capacity Building for Management (CRTR) program forecasts three future scenarios for coral reefs with increased CO_2 (measured in ppm) in the earth’s atmosphere and mean temperature associated with climate change (Fig. 1-21). These future scenarios bring forth the following key points (CRTR 2008):

- Coral reefs may not survive the rapid increase in global temperatures and increasing CO_2 levels
- Livelihoods of millions of people living along the coasts of tropical developing countries may be the first casualties
- Some drastic action from world leaders needs to be done to bring down CO_2 emissions
- Policy makers and reef managers should immediately address overfishing, pollution and other unsustainable coastal development. The urgency is great in implementing measures to save what remains of the global reefs before it is too late.

<table>
<tr>
<td>Scenario A- 380 ppm. Today’s situation: 10-60% coral cover, a diversity of marine life; mass bleaching impacts continue and coral dominated reefs struggle to survive. The formation of calcium carbonate is slower than 100 years ago but can still keep up with erosion.

This image shows a rich coral community on the southern Great Barrier Reef</td>
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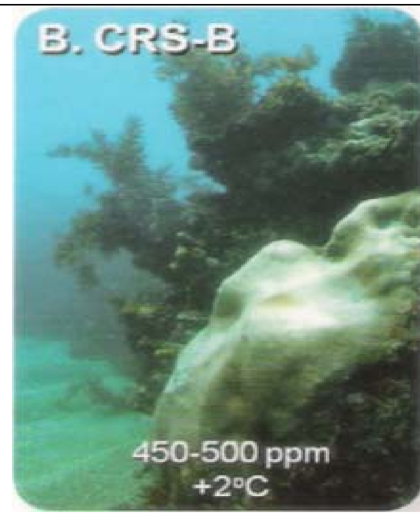
<tr>
<td>Scenario B – 450-500 ppm. Reef structures reach a tipping point and reef erosion in most parts of the world exceeds reef calcification. The structures of coral reefs begin to crumble. Coral bleaching events occur almost annually and coral cover declines as a result to less than 10%of what it was previously. Coral dominated reefs are rare but still exist in afew places.

This image was taken in the inshore of Great Barrier Reef.</td>
<td>
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<tr>
<td>Scenario C - >500 ppm. The concentration of carbonate ions decreases well below the carbonate threshold; coral-dominated reef ecosystems are rare or non-existent. Those few corals that exist grow very slowly and do not produce the amount of carbon required to maintain reef structures. Coral reefs collapse into ruble.

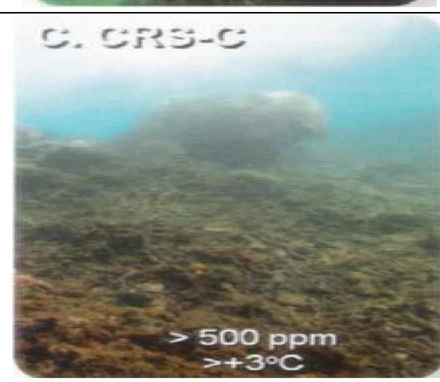
This image shows a reef that once grew in the inshore region of the Great Barrier Reef.</td>
<td>
</td>
</tr>
</table>

Figure 1-21. Forecasts on climate change effects on coral reefs which show the risk of losing the world’s reefs unless drastic policy and management measures are undertaken. *(Source: CRTR Advisory Paper; Science Magazine, 2007)*

Drawing up a Monitoring Plan

One important consideration in reef monitoring is we cannot observe all things at the same time. There is an urgent need to draw up a monitoring plan for the long-term observation of changes on the reef ecosystem (Fig. 1-22). Community participation is also essential; complementing the indigenous knowledge of fishers with scientific knowledge and information from monitoring can give us a very representative picture of what is happening.

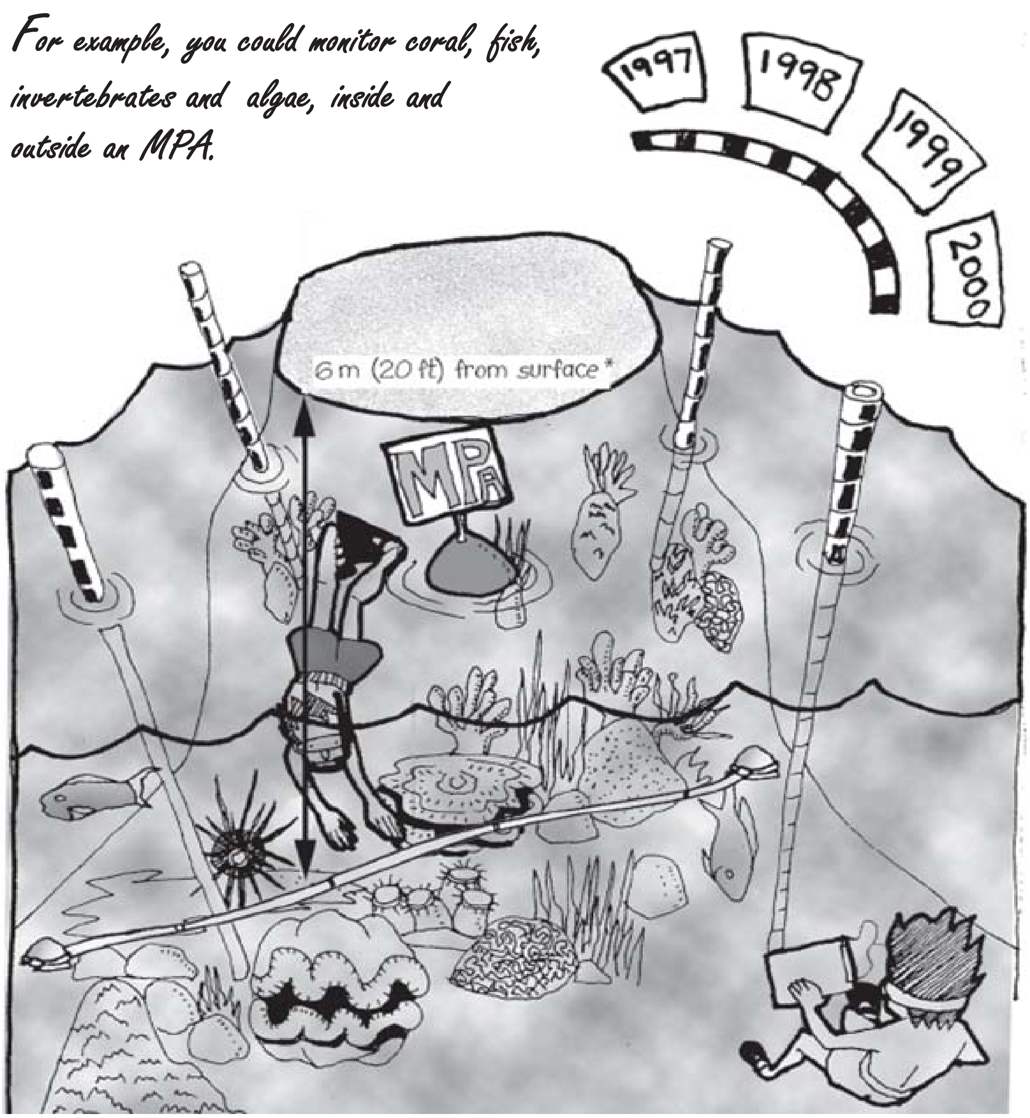


Figure 1-22. Some monitoring activities that can be conducted to compare benthos, fish, invertebrates and vegetation inside and outside MPAs. (Source: Uychiaoco et al. 2010).

Trainer's Tips:

Below are some useful tips from Uychiaoco et al. 2010:

1. Be clear about what you want to know, then select a few things to observe in several places through time.
2. Observe the things of interest that are likely to change due to poor or good management.
3. Observe in different kinds of places: inside and outside the management zone or use zone (e.g. inside and outside the marine protected area (MPA)). Try to observe at 5 stations within each management zone.
4. Observe before, and every year after establishment of the management actions, during each season. Things that don't change much can be observed less frequently.
5. Monitor every year: during the dry season, the northeast monsoon and the southwest monsoon...so that changes from season to season can be noted. (Corals may be monitored only once a year since they change very slowly).
6. You could monitor algae, fish, and invertebrates inside and outside an MPA.
7. It is important to note what factors may cause the decrease (-) or increase (+) in certain parameters, such as coral cover, fish abundance, algal growth, etc.

MONITORING REEF FISH COMMUNITIES

Fishes are the most widely distributed and highly diverse vertebrates on earth (Kuiter and Debelius 2006). Coastal areas and nearshore waters (i.e., within city/municipal waters) have the highest fishery productivity. Many of the pelagic and offshore fisheries are also linked to the coastal area. The Philippines hosts 43 percent of the world's marine aquarium fish and accounts for 35 percent of the invertebrates traded globally (World Bank 2005).

Fish populations can be exploited using various kinds of fishing gears. A study conducted by MSU Naawan (1992) in Panguil Bay suggest that potentially, many finfish can be caught by more efficient fishing gears. The fisheries sector hosts some of the worst environmental problems of the Philippines. Because of this, it is a critical arena in the effort to attain a more sustainable form of development in the country. The search for solutions to the environmental problems in the fisheries sector has been going on for years. Amidst the current economic crisis engulfing much of Asia, however, this task may have been relegated to some degree as national attention focuses on more pressing economic issues and resources are allocated to meeting immediate needs.

The sustainable development of the fisheries sector should remain a top priority. An important law, the Philippine Fisheries Code of 1998 (R.A. 8550), was enacted to develop, manage and conserve the fisheries and aquatic resources of the country (Congress of the Philippines 1998), also the Agriculture and Fisheries Modernization Act of 1997 (R.A. 8435) or AFMA, was passed to revive, modernize, and develop the agriculture and fisheries sectors (Congress of the Philippines 1997). These laws are significant to sustainable development because they explicitly recognize the conservation, protection and sustained management of resources as a major objective in the fisheries sector (Israel and Roque 1999).

Reef Fish Diversity

Coral reef fish are known for their bright and complex colors and highly associated with the coral reefs, thus named 'reef fishes' (Fig. 2-1). Coral reef fish are important to local and national economies as source of food and income. One of the most popular economic values of reef fish is supplying the global aquarium trade, which is largely responsible for the overexploitation and rapid decline in biodiversity which is highest in Southeast Asian reefs (Fig. 2-2).

Figure 2-1. Colorful butterflyfish and bannerfish are common inhabitants of coral reefs in the Asia-Pacific region.

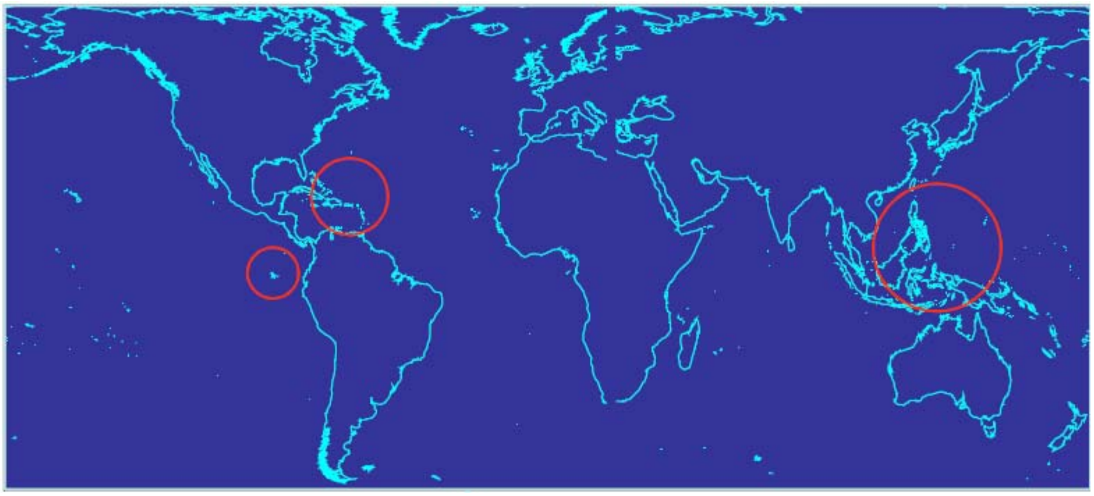


Figure 2-2. Global comparison of reef fish diversity (size of red circle represent diversity).

The following is a list of major groups and families of fish that are highly associated with the coral reefs:

Blennies (Blenniidae)
Butterflyfishes (Chaetodontidae)
Cardinalfishes (Apogonidae)
Damselfishes (Pomacentridae)
Goatfishes (Mullidae)
Jacks (Carangidae)
Parrotfishes (Scaridae)
Soldierfishes (Holocentridae)
Surgeonfishes (Acanthuridae)
Wrasses (Labridae)

Other groups that have close association with the reefs are termed as 'reef associated fishes':

Snappers (Lutjanidae)
Sweetlips (Haemulidae)
Emperors (Lethrinidae)
Groupers (Serranidae)
Fusiliers (Caesionidae)

Characteristics of coral reef fish

Coral reef fish are highly diverse; up to 4,000 species are found in the Indo-Pacific region (18% of all living fishes). About 2,500 species are found in the Philippines, touted as the Center of the Center of reef fish diversity (Carpenter and Springer 2005). They occur in many forms and sizes – some fish as tiny as 3 cm SL (*Minilabrus striatus*), others as big as the Napoleon wrasse *Cheilinus undulatus* which can reach 290 cm SL.

Reef fish have highly specialize feeding structures used as basis for functional groupings as grazers (scarids or parrotfish), invertebrate feeders (labrids or wrasses), piscivores (groupers, cardinal fish, lizardfish), planktivores (fusiliers, many damselfish).

Figure 2-3. The Napoleon wrasse, Cheilinus undulates, is one of the giants of the reef.

Ecological & economic importance

Coral reef fish play an important ecological role in the marine ecosystem, such as maintenance of complex trophic structure, standing stock to support fisheries and biodiversity, nutrient recycling, and reef habitat modification.

They are also important as high-value food source, and their colorful variety and aesthetic value feed the world aquarium trade and attract a multi-million dollar tourism industry in many countries in Asia-Pacific.

Status of Philippine Reef Fishes

Figure 2-3 presents the profile on fish biomass across seven biogeographic zones of the Philippines based on biomass estimates. On a scale of very low (red) to very high biomass (dark blue), the figure shows that most Philippine reefs currently support low fish biomass, most possibly a consequence of overfishing and habitat degradation.

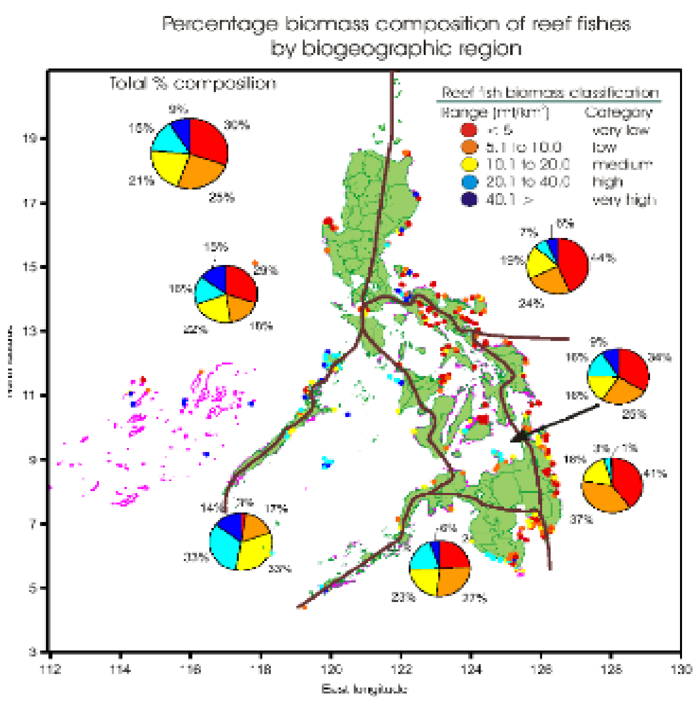


Figure 2-4. Comparison of fish biomass across different biogeographic zones (Nañola 2006).

Methods of Monitoring

Why monitor fish communities in MPAs?

Monitoring the status of reef fish communities allows management to find out if the MPA project has achieved its goals, and if positive impacts of protection are already observed. It is also a means of evaluating management performance in terms of enforcement of sanctuary rules, particularly the "no take" areas.

Long-term monitoring of reef fishes requires the availability of baseline assessment conducted before MPA establishment or during the early years of the project. Many MPAs, however, do not have the benefit of a baseline assessment

Assessment or monitoring of reef fish communities in MPAs will gather the following information:

- Species richness
- Biodiversity
- Determine the status of the stocks inside the MPA
- Degree of overexploitation (in areas outside the MPA)
- Determine the classification of fish groups, e.g. top carnivores/food fishes, Indicator of reef health, grazers, etc.

Methods on reef fish assessment

1. ***Fishery- based survey***
   - Municipal fishery monitoring (i.e. different fishing gears)
   - Catch composition
   - Extraction rate
   - Length-frequency analyses (i.e FiSAT) to obtain estimates of population exploitation rate

   Constraints of this method include:
   - Difficulty in getting the total (all or major species) stock
   - Bias brought about by the selectivity of the fishing gears

Fisheries-Independent survey to obtain data on fish diversity, abundance and biomass are available, but many of them are destructive, such as blast fishing, use of poison and use of fishing gears.

2. ***Underwater fish visual census***

   Fish visual census (Fig. 2-5) is a fishery-independent survey technique that has a number of advantages, as follow:
   - Rapid

- Non-destructive
- Inexpensive
- Can be done repeatedly
- Gives a snap shot of the fish composition per unit time and area

The FVC technique obtains three types of information:

- Species diversity = listing of fish at the species level but limited within the desired width of the transect
- Fish density = number of fish per unit area (as area surveyed is known)
- Size class distribution = fish sizes are estimated during the census

Fish Visual Census (FVC) - identification and counting of fishes observed within a define area. Fish Visual Census can be used to estimate the variety, numbers, and even sizes of common, easily-seen, easily-identified fishes in areas of good visibility. This information may reflect the health of the fish stocks within the surveyed coral reef areas.

Figure 3-5. Underwater fish census requires scuba diving skills but may be done by snorkeling.

Requirements

- Picture Book of the animals (e.g. fishes) to be counted
- Goggles or mask and snorkel
- One or two 50-m lines each marked every 5 m
- Underwater slate with attached pencil

Optional

- Boat (depending on where the survey site is)
- Laminated fish identification guide (if observers are not familiar with the various fish types)
- Laminated butterflyfish identification guide to (if indicator species are to be censused)
- Fins
- Life jackets

The FVC Procedure

1. Select the sampling stations and fish communities to be censused.
2. Copy the Data Form 5A (Uychiaoco et al. 2010) onto the slates and draw columns for the different size classes.
3. Lay the transect line on a constant depth contour. Record the depth.
4. Wait 10-15 minutes for the disturbed fishes to return. Be careful not to disturbed the fishes during census.
5. Starting at one end of the line, each observer floats on each side of the transect line while observing 5-m to his/her side of the transect and forward until the next 5-m mark.
6. Both observers swim to and stop every 5-m along the line to record the count of fish per size class until the transect is completed. Generally, the faster moving fishes are counted before the slower moving fishes are counted. Each transect covers an area of $500m^2$ (50 m x 10 m width). Obtain the total count on both sides of the transect and transcribe onto Data Form 5A.
7. Classify the group of transect according to your purpose for data summarization. For example:

   * reef zones or types (e.g. reef flat, reef slope, fringing reef, offshore reef, etc.)

   * time of sampling (e.g. year 1/dry season, year 1/wet season, year 2/dry season, etc.)

   * management or use zones (e.g. sanctuary, fishing grounds), and or

   *intensity of impacts (e.g. high poluution, medium pollution, low pollution)

   List the transect by groups along the upper portion of the Summary Form.
8. List the fish groups or fish types (by groups) along the left side of the Summary Form.
9. Total the counts of the different size classes for each type of fish per transect.
10. Write these sub-totals onto the appropriate boxes on a copy of the summary form.
11. Sum up sub-totals for each transect group.
12. Standardize the sub-total by sample size; divide the total counts by the number of transect actually observed.

    Example $\frac{12+11+5+3+5}{5 \text{ transect}}$ = 7 Fishes/ transect
13. Choose a few fish type of interest and list these along the left side of the Fish Graphing Form.
14. List the zone/sector, month, and year on the designated space on the form.
15. Use the following guide to represent the average observed in each zone/sector and month/year.

Sample data sheet

size estimate in cm
total count

March 8, 2003
Site: T4, depth 20ft, steep slope, clear water

0-5 Poma brachialis 7-10
Chae trifasciatus 10-1
Labr dimidiatus 5-2
Chro viridis 8-20, 5-8
5-10 Amb curacao 12-3
Labr dimidiatus 7-1
Bali undulatus 15-1
Lut decussatus 20-1

Fish density computation = total count/area
Size class distribution = bar graph of frequency distribution by species or family

Strengths: 1) Useful for simultaneously censusing many species.

2) Can also be used for other organisms like crown-of-thorns starfish and urchins.

Limitations: 1) Only the shallower depths (upper 3-7 m [5-20 ft] depending on visibility) may be censused by non-divers.

2) Fishes may be frightened by or attracted to the census takers thus biasing observations.

3) Not suitable for cryptic, sparse or highly mobile fishes.

Exercises on data standardization

- Knowledge on the biology and ecology of reef fishes
- Training on fish taxonomy laboratory and field exercises
- Size estimate standardization using dummy fishes field exercises
- Census time 20-30 min for a 50m transect45-60 min for a 100m transect

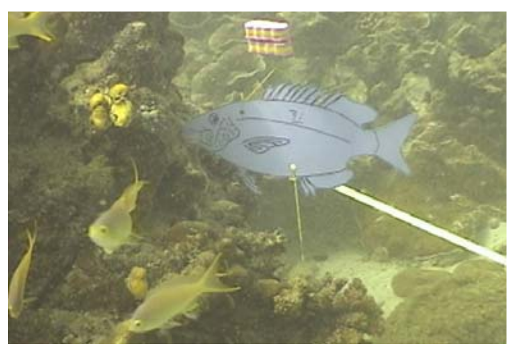


Figure 2-6. Underwater exercise for standardization of fish size estimates

Data Management and Analysis

1. Fish Abundance – obtain mean density (number of fish/m^2) per species or family, then add up densities of all species; obtain relative abundance (%) of each species or family: RA (%) = mean density per family/total number of all fishes x 100
2. Fish biomass estimate = based on the size estimate and using the relationship of $W=aL^b$, weight can be computed, where *a* and *b* are growth parameters that are unique to each species (available at www.fishbase.org).

e.g. *Acanthurus nigricans*

a=0.067; b=2.669 [*a* and *b* values from existing length-weight (cm-g) relationship data];

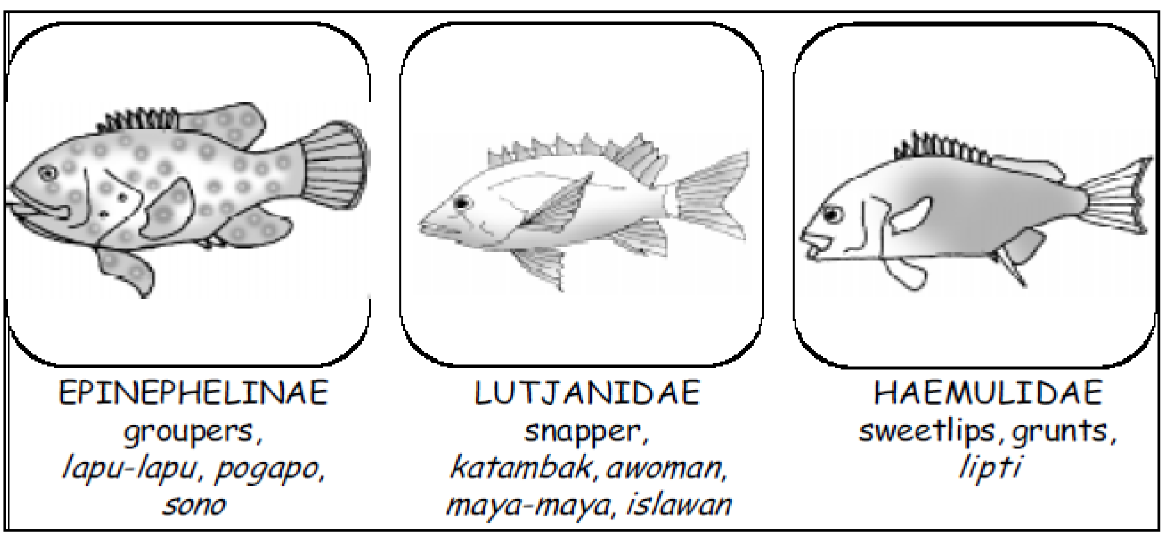
from data recorded: L=15cm, total count = 5

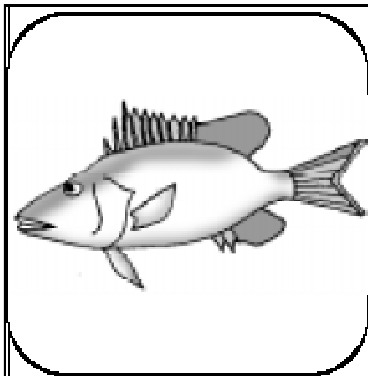
W= 0.067(152.669)*5

W= 461.352 grams

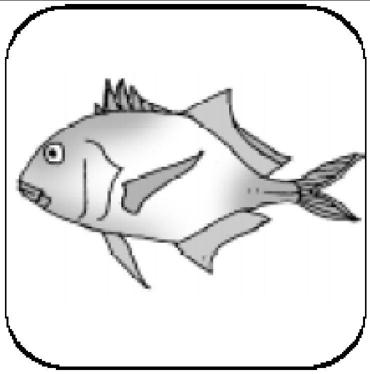
Common Reef Fish Families

Figure 3-7 ***show the common fish families useful in getting familiar with the general shape and morphology of various reef fish (reproduced from Uychiaoco et al 2010:)***



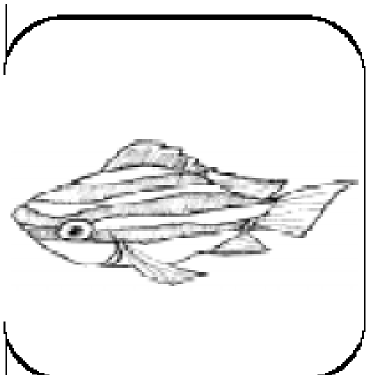


LETHRINIDAE
emperors,
katambak, dugso

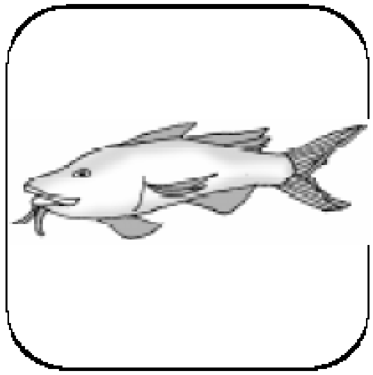


CARANGIDAE
jacks, trevallies,
talakitok, mamsa

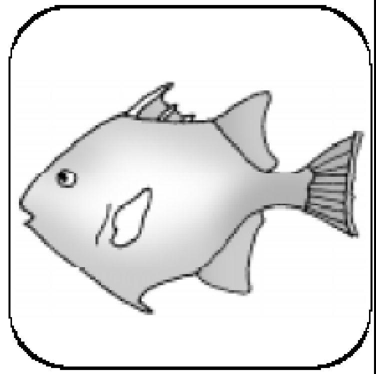
CAESIONIDAE
fusiliers,
dalagang-bukid, solid



NEMIPTERIDAE
coral breams,
silay

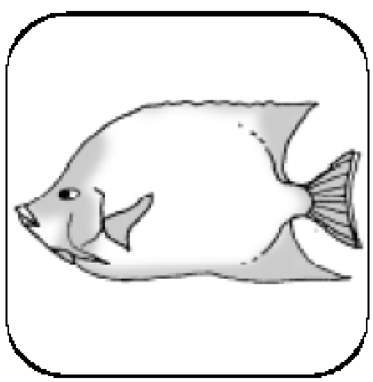


MULLIDAE
goatfish,
timbongan

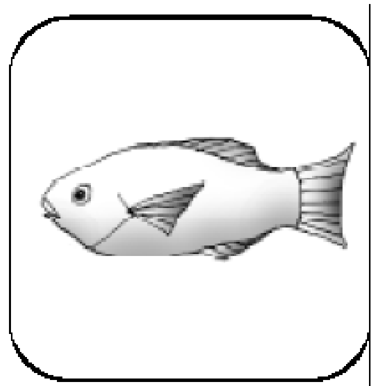


BALISTIDAE
triggerfish,
pakol, pugot

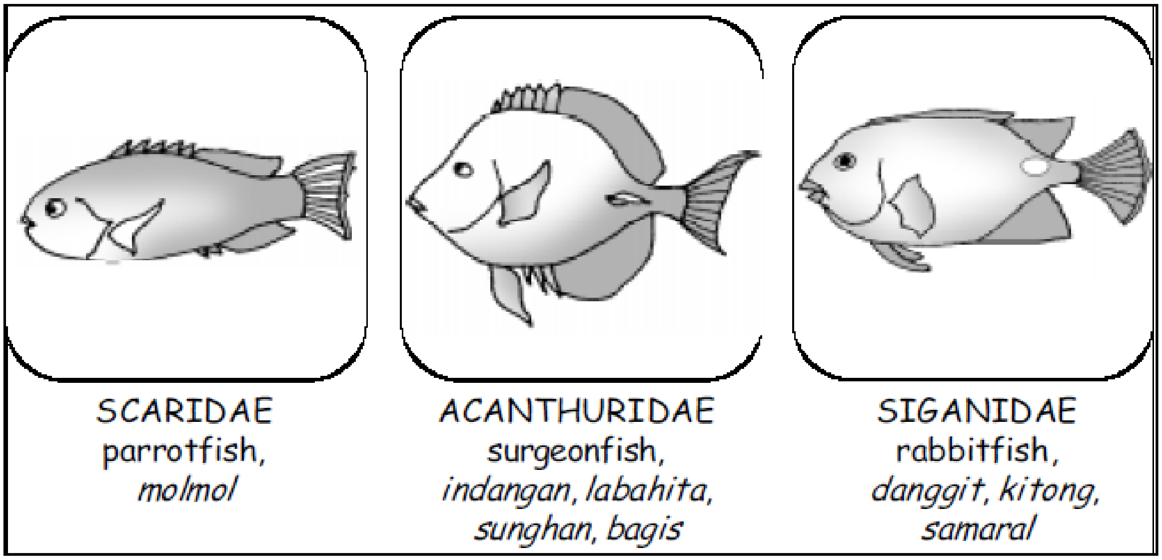
CHAETODONTIDAE
butterflyfish,
alibangbang,
pisos-pisos



POMACANTHIDAE
angelfish,
adlo



LABRIDAE
wrasses,
labayan



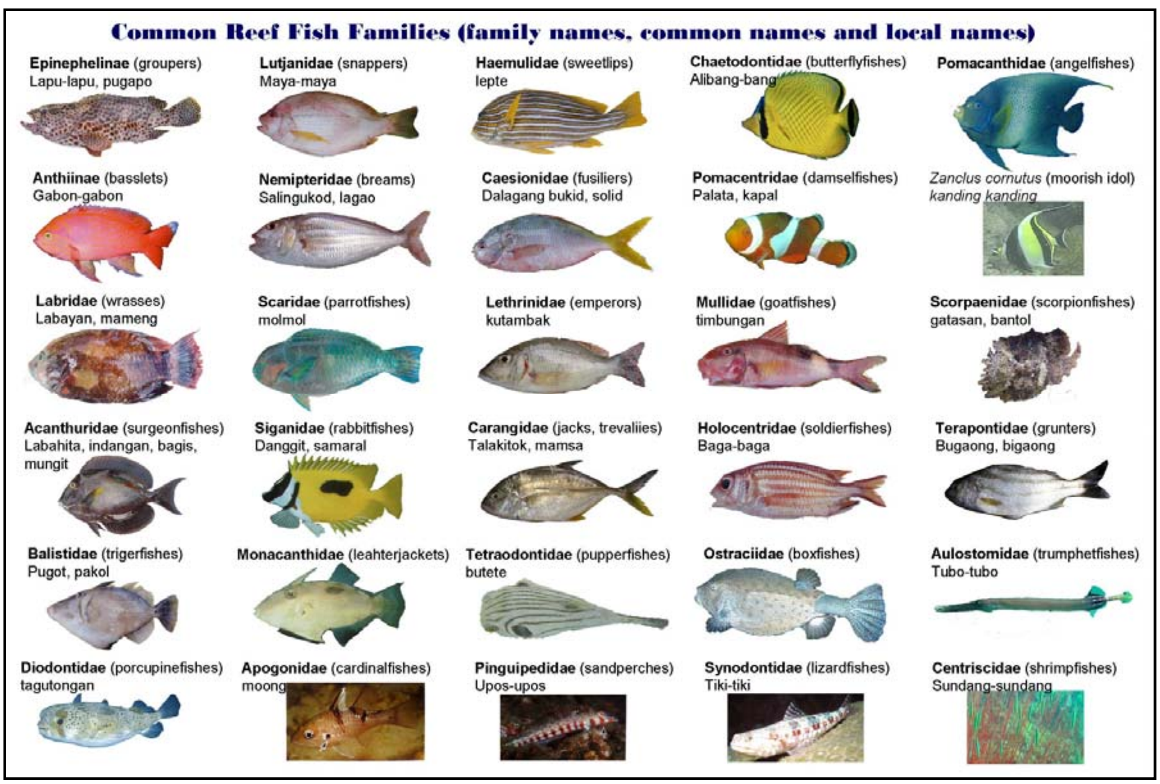


Figure 3-8. Field guides on common fish families with color pictures like the above are very useful. (Source: Nañola et al 2006)

MONITORING SEAGRASS COMMUNITIES

Seagrasses are considered as unique, submerged vascular plants found in shallow coastal areas of the marine environment (Hemminga and Duarte 2000). Morphologically they compose of creeping and erect rhizomes which serve as roots and are also used for attachments as they grow. They are the only submerged angiosperm found mostly in all coastal waters of the world except in the arctic (Den Hartog 1970).

Figure 3-1. A healthy seagrass meadow is one of most productive ecosystems in tropical coasts.

Seagrass and seagrass meadows (Fig. 3-1) are widely distributed and considered to be among the most productive marine ecosystems (Fonseca and Calahan 1992; Agostini 2003). About 60 species of seagrasses have been recorded worldwide (Den Hartog 1970; Kuo and McComb 1989), 16 species of which are found in the Philippines, considered to be among the richest in the world (Fortes 1989 and Vermaat et al. 1995).

The seagrass ecosystem provides enumerable environmental functions; they help reduce current and wave energy, filter suspended sediments from water, and stabilize bottom sediments (Fonseca and Calahan 1992). They serve as primary producers (and play an important role in the complex food chain), habitat, feeding and spawning grounds for both juvenile and adult marine organisms (invertebrates and vertebrates), including commercially important fish species (Duffy 2006).

The seagrass ecosystem in the Southeast Asian regions is threatened by both natural and human-induced disturbances. In Philippine coastal waters, seagrass losses are largely attributed to the use of destructive fishing methods, and increasing pollution and siltation (Fortes 1990).

Seaweeds are macrobenthic marine algae that forms a conspicuous component of the primary producers in the shallow marine environment. They possess different types of pigments such as chlorophylls, carotenoids, phycobilins, and other accessory pigments which enable them to synthesize organic compounds from simple compounds such as water and carbon dioxide in the presence of light as source of energy.

Monitoring Methods

Monitoring seagrass communities consider several factors in order to determine changes in community structure and environmental conditions. Assessment of areal coverage (seagrass cover) can provide a quick assessment of the extent of vegetation, but ocular readings could be very subjective and depend largely on the ability of the person doing the survey. Shoot density could provide a more accurate data if done properly. Changes in shoot density would indicate vigor of the vegetation or its ability to reproduce or expand under a given environmental condition.

To detect changes in habitat condition with time, a regular monitoring protocol is necessary. Quarterly monitoring is recommended, but if this is not possible, at least a survey every six months should be done. In every monitoring site, two permanent transects should be established. Both ends of the transect should be marked with a post, and the corresponding coordinates taken using the GPS. Markers should be reinforced later for future monitoring.

This training module, although technical in nature, can be used to train village people to conduct survey and monitoring of seagrass habitats in their area. It is a simplified yet robust enough method to generate information to detect changes in the seagrass habitat in terms of seagrass cover, species composition and abundance, flora and faunal associates composition and abundance.

Materials needed

- 50m pvc transect tape or calibrated polyethylene rope (calibrated every 5 m interval)
- Mask & snorkel or goggles
- Underwater slates with attached pencil
- Boat and fuel
- Laminated seagrass, invertebrates, and fish identification guides (optional)
- Global positioning system (GPS)
- Herbaria presser and associated paraphernalia

Field assessment procedure

1. Before conducting the transect survey, it is important to standardize readings among observers or monitors. This is to ensure validity of data particularly on seagrass cover. Values for cover of the same species in the same area are very subjective and may differ greatly among observers as shown in Table 3-1 below:

Table 3-1. Example 1. Variable readings of percent cover of the two seagrass species by local monitors during the start of the standardization technique.

	Participants						
Species	A	B	C	D	E	F	G
Thalassia	20	15	5	20	50	20	10
Enhalus	50	70	10	60	90	50	40

2. As observed during many training activities, wide ranges of values were generated from the participants from a single quadrat. For example, participant C gave a very low score while participant E gave a relatively high score. After explaining the assumptions and some techniques for reading, variability among values can be greatly reduced as shown in Table 3-2.

Table 3-2. Example 2. Improvement in readings of percent cover by local monitors after the standardization technique.

	Participants						
	A	B	C	D	E	F	G
Thalassia	20	10	15	30	20	10	15
Enhalus	30	40	20	40	40	40	20

3. If done with careful planning and frequent discussion with the local researchers or monitors, standardization of readings can be achieved. Although values may still vary, it will be within the acceptable range.
4. Locate the permanent markers, and then attach both ends with the pre-calibrated rope. The rope should be calibrated every 5 meters with a high visibility tape or string to facilitate survey while swimming over.
5. Start sampling five meters from the post and at every 5 meters interval until the end of 50 meters. There shall be a total of ten (10) quadrats for every transect line.
6. In the slates, write down the date of survey, time, location, coordinates (latitude & longitude) using the GPS, transect number, observer's name, depth and other observations.
7. At least two observers are needed to conduct the sampling. In case this is not possible, one person or observer can do everything – although this may take some time. Ideally, one person shall record the percent cover and density for seagrass, and another person shall do the invertebrates and fish count. It is recommended further that the same person shall do the visual census of fish in both the seagrass and coral transect.

A. Seagrass and seaweed community structure

The recommended quadrat size for assessing vegetation is 0.5 x 0.5 meter (0.25 m^2), placed at every 5 m interval along the right side of the transect. For every 0.5 x 0.5 meter quadrat, record the following:

a. List of seagrass and seaweed species
b. Percent cover per species – refers to the space occupied by the living seagrass within the quadrat when viewed from the top (see laminated pictures in Plate 3-1 for guide);
c. Density of the two dominant seagrass species only (*Thalassia* and *Enhalus*);
d. Canopy height determined by ignoring the tallest 20% of leaves
e. Identify any grazing evidence; and
f. Substrate type (sandy, muddy, rocky, coral rubbles or combination)

Cymodocea can be easily mistaken as *Thalassia* but can be differentiated by their relatively straight leaves and presence of lines running parallel on the leaves. *Thalassia* has leaves that are curved, similar to a scythe or reaper while *Cymodocea* leaf is shaped like a sword. *Enhalus* is generally tall and has very distinctive leaves that are rough with short spines on the underside and rigid edges or margin (Fig. 3-2).

For seagrass shoot density, count the total number of seagrass found inside the quadrat. Count only the seagrass whose base or stem is found inside the quadrat. (Note: for small species such as *Halophila* & *Halodule*, use a separate quadrat with 25 subsquares. Count only shoots found inside the 5 subsquares representing 4 corners and center).

For the seaweeds, only large species such as *Sargassum*, *Turbinaria* and *Padina* shall be recorded. While doing the transect, take note of flowering and fruiting of seagrass species.

B. Associated fauna/Invertebrates

a. The suggested protocol is using a modified belt transect. Using the same transect laid on the seagrass bed, an observer records invertebrates found inside the area beneath 1m from the transect tape until 5m (1m x 5m quadrate size). Associated fauna are indentified based on species (local names) or major groupings (shells, bivalves, seastars, sea urchins, echinoderms, etc).
b. List all invertebrate species and the total number of individuals per species inside the quadrat.

   Note: Invertebrate species shall be recorded in their English names or local names whichever is convenient for the observer, but scientific names should be identified later; and
c. Record substrate type.

Important Note: Do not overturn rocks during the survey since this will create disturbance in the habitat. In case this is necessary, please return the rocks properly. There are several cryptic invertebrates in the area, thus, an observer may have to look closely inside the leaf canopy or on the leaves. Further, take note of other invertebrates such as tube worms or fan worms (polychaetes). For burrowing animals (such as clams, mantis shrimps, etc) take note of holes or burrows in the substratum.

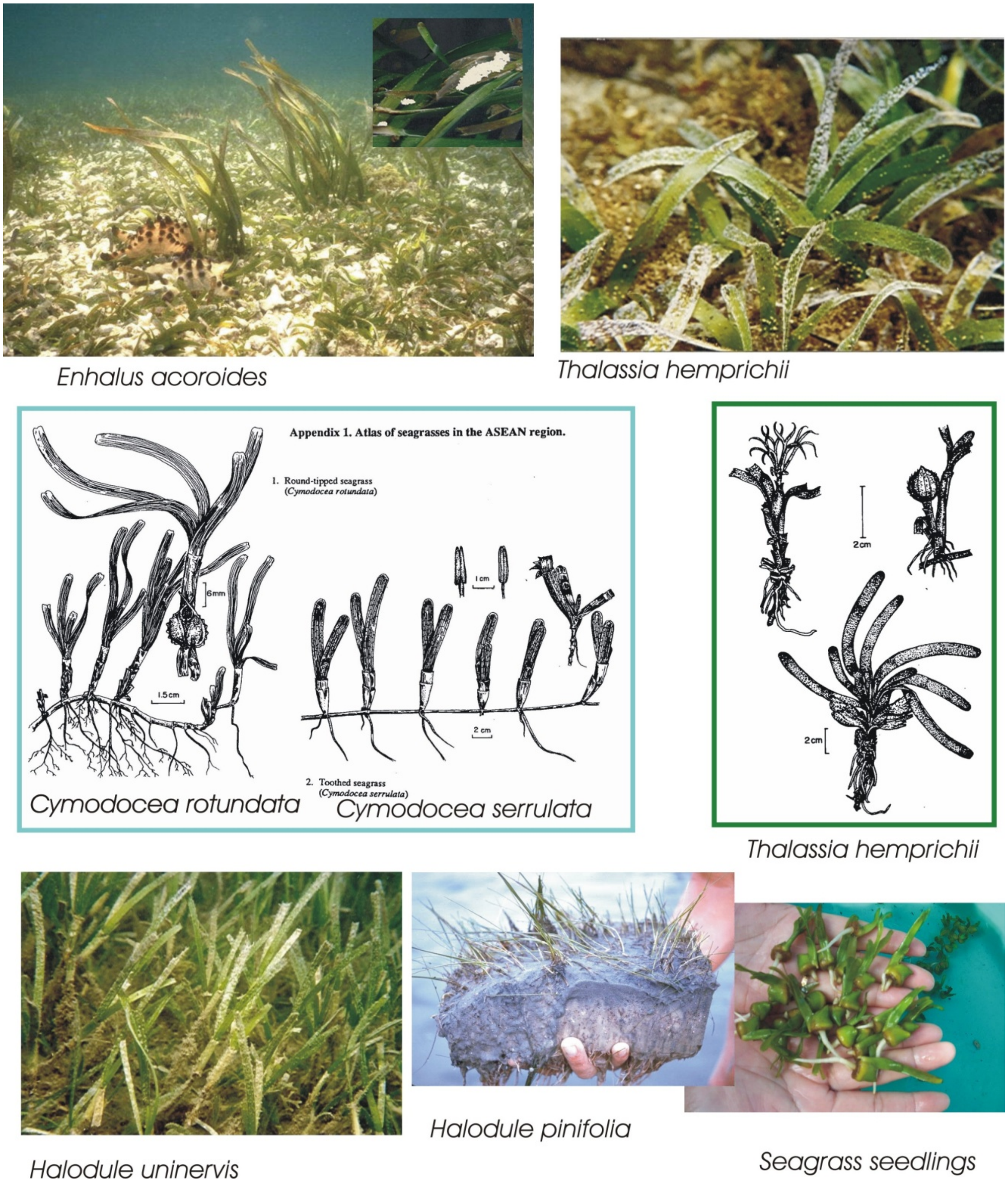


Fig. 3-2. Example of different species of seagrass.

For the shellfish, only record those that are alive. In case of hermit crabs, just record "hermit" and not the type of shell. Hermit crabs are scavengers of dead shells and make them their temporary shelter.

C. Fish

a. Using the same transect, record the presence of fish within the 2.5-meter belt on both sides of the transect and at each interval of 5m (quadrat size is 5m x 5m). The following shall be recorded:

b. The observer briefly stops at every 5m along the line to record the species of fish and count the number number of individuals per species until the transect is completed.

c. Ideally, survey should be done during high tide where a good amount of water or depth is available for better view of the fish.

Data Processing

Seagrass Cover

1. Add all values for every species and divide by the total number quadrats used (in this example 10 quadrats were used). The result below showed that average seagrass cover for *Thalassia* is only 18.5% even though in some quadrats, cover was higher than 50%.
2. Determine the frequency of occurrence by counting the number of times a certain species was recorded in the transect. For example, *Thalassia* only occurred 4 times in the transect, while *Enhalus* only occurred 2 times. This indicates that *Thalassia* is more common than *Enhalus* (Table 3-3).

Table 3-3. Example 3. Percent seagrass cover at Transect 1 of Nangka, Rizal.

Species	1	2	3	4	5	6	7	8	9	10	Total	Average (per quadrat)	Frequency
Thalassia	50	60	25	0	50	0	0	0	0	0	185	18.5	4
Enhalus	0	0	0	0	0	5	0	0	0	1	6	0.6	2
TOTAL												19.1	

3. Do the same for other sites.

Seagrass Density

Multiply the average values in example 4 with 4 (since the quadrat used was 0.5 x 0.5m or equivalent to 0.25m^2 or ¼ of 1m^2. Therefore to be able to present the values per square meter, all values should be multiplied by 4 (Table 3-4).

Table 3-4. Example 4. Density of seagrass at Transect 2 of Site A.

Species	1	2	3	4	5	6	7	8	9	10	Total	Average (/ quadrat)	Density (per sq. m)
Thalassia	4	2	26	20	17	2	15	16	13	25	140	14	56
Enhalus	3	3	3	5	16	12	0	0	0	0	42	4.2	17
TOTAL	8	5	29	25	33	14	15	16	13	25	182	18.2	73

Invertebrates density and composition

1. List down all invertebrates present in the area and write down their corresponding values below the quadrat number (Table 3-5).
2. The average values should be in square meter since the quadrate size is 1 x 1 m. The resulting values, after dividing by the total number of quadrats, will be small and in fraction. It will be difficult to imagine 0.3 individual per square-meter thus we may have to convert all our values to per hectare. In this case, we shall multiply all average values by 10,000 (1 hectare = 10,000 m^2) and shall be expressed as number of individuals per hectare.
3. Determine frequency of occurrence by counting the number of times a certain species occurred in the transect. The calculation and assumption is the same for item no. 16.

Table 3-5. Example 5. Invertebrate count per transect using the 1 x 1 meter quadrat size at Site B.

Species	1	2	3	4	5	6	7	8	9	10	Average (per quadrat)	Density (per hectare)	Frequency of occurrence
Urchins	0	0	0	0	0	0	0	0	0	0	0	0	0
Conch	0	0	0	0	0	0	0	0	1	0	0.1	1000	1
Shells	0	0	0	0	0	2	0	0	1	0	0.3	3000	2
Clam	4	2	0	1	0	0	1	0	0	0	0.8	8000	4
seastar	2	3	2	1	0	1	0	2	2	2	1.5	15000	8

Fish composition and count

1. List down all fish species present in the area and write down the corresponding values per quadrat.
2. The average values obtained is equivalent to the number of fish found in the 5 x 5 m quadrat (equivalent to 25m^2). Again it is difficult to imagine values that are small and in fractions. In this case, we have to multiply our average values with 400 (10,000 m^2 divided by 25 m^2 will yield 400) to be able to express them as abundance per hectare.
3. Determine the Frequency of Occurrence by counting the number of times a certain species was recorded in the transect. In Example 6 (Table 3-6), data generated shows that catfish was the dominant fish species with a density of 2400 fish per hectare. However, it only appeared once during the transect (quadrat no. 5) with a very high value of 50. In the case of wrasses, density is relatively low at 1120 fish per hectare, but it was recorded in 7 quadrats out of 10, which indicates that wrasses are more common than catfish.

Table 3-6. Example 6. Fish count per transect using 5 x 5 meter quadrat size at Nanca, Rizal conducted last April 18, 2004.

SPECIES	1	2	3	4	5	6	7	8	9	10	Average (per quadrat)	Density (per hectare)	Frequency of occurrence
Catfish	0	0	0	0	60	0	0	0	0	0	6	2400	1
Damsel fish	1	6	1	17	2	3	0	0	12	5	4.7	1880	8
Glass fish	0	0	0	15	0	0	0	0	15	0	3	1200	2
Wrasse	2	0	1	9	0	6	0	1	6	3	2.8	1120	7
Gobies	1	0	0	0	0	2	0	0	0	2	0.5	200	3
Siganids	0	0	0	0	0	0	0	3	0	0	0.3	120	1

Data Presentation

Data can be presented in a pie chart using any values of interest. For Example 6, the resulting pie chart using the density values is given below (Fig. 3-2). Bar charts can also be used to present a comparison of cover and density of seagrass, seaweed, invertebrates or fish across sites.

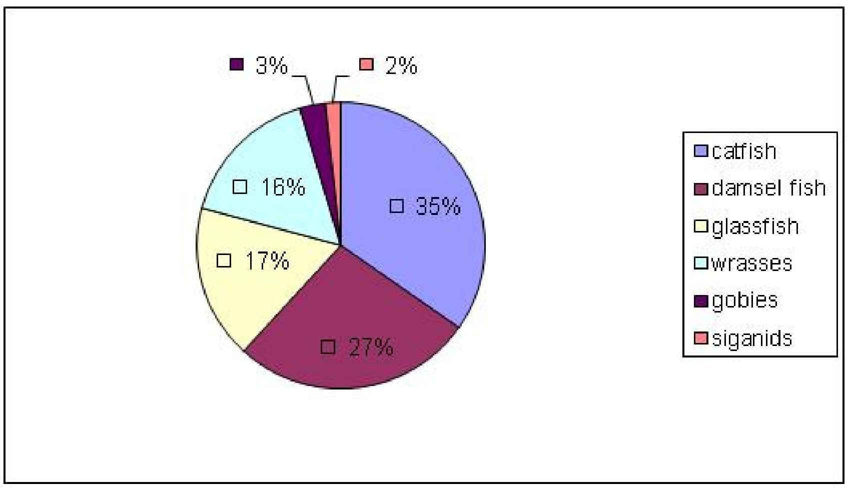
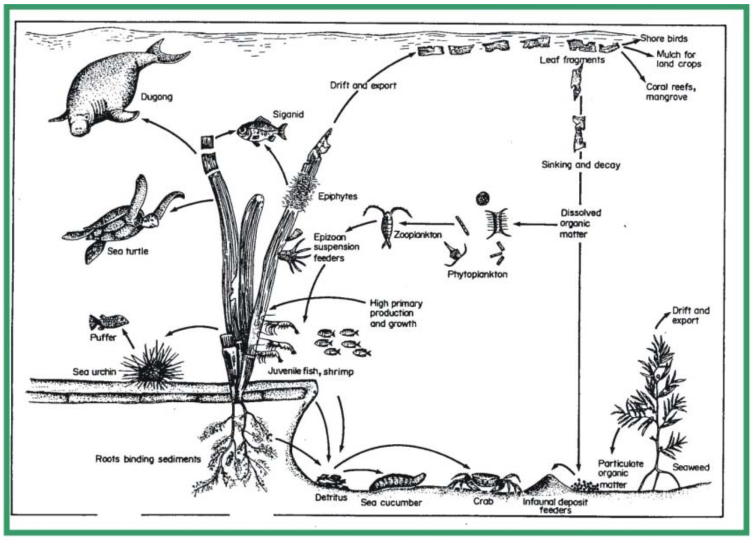
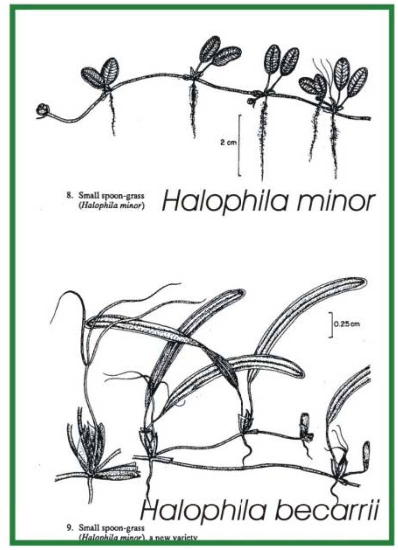
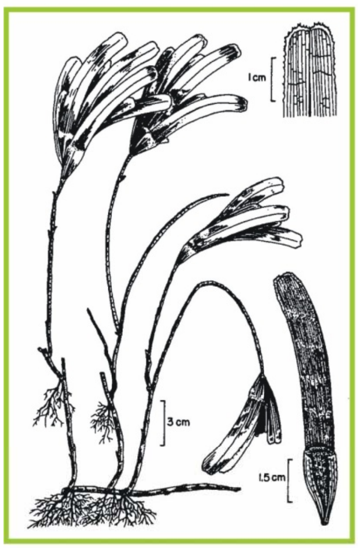


Figure 3-2. Sample pie chart to show relative abundance.







Thalassodendron ciliatum

Syringodium isoetifolium

Halophila ovalis

SEAGRASSES

"lusay"

Plate 3-1. Example of other species of seagrass and their uses (note). Figures 2 & 3 can be printed in special thick paper (back to back) and laminated to be used in field survey.

MANGROVE ECOSYSTEMS

Mangrove communities: their role in ecosystem interconnectivity

Mangroves are a taxonomically diverse group of salt-tolerant, mainly arboreal, flowering plants that grow primarily in tropical and subtropical regions (Ellison and Stoddart 1991). The term “mangrove” can refer to either the ecosystem or individual plants (Tomlinson 1986). Mangrove ecosystems have been called “mangals” (Macnae 1968) to distinguish them from the individual plant species. The term “mangrove” as used in this report refers to the mangrove habitat type and not the constituent plant species (McLeod and Rodney 2006).

Mangrove ecosystems are forests that grow along tidal mudflats and also along shallow coastal areas extending inland along rivers, streams and their tributaries where the waters are generally brackish. These ecosystems are dominated by mangrove trees that act as primary producers interacting with associate aquatic fauna, physical and social factors of the coastal environment (Melana et al. 2000).

The mangrove flora consists of 47 “true mangroves” and associated species belonging to 26 families (Melana and Gonzales, 1996). True mangroves grow in the mangrove environment; associated species may grow on other habitat type such as the beach forest and lowland areas. Mangrove fauna is made of shore birds, some species of mammals, reptiles, mollusks, crustaceans, polychaetes, fishes, and insects (McLeod and Rodney 2006).

Mangroves have tremendous social and ecological value (Figure 4-1). The annual economic value of mangroves, estimated by the cost of the products and services they provide, has been estimated to be $200,000 - $900,000 per hectare (Wells et al. 2006). The mangrove ecosystem provides income from the collection of the mollusks, crustaceans, and fish that live there. Mangroves are harvested for fuel wood, charcoal, timber, and wood chips. Services include the role of mangroves as nurseries for economically important fisheries, especially for shrimp. Mangroves also provide habitats for a large number of mollusks, crustaceans, birds, insects, monkeys, and reptiles. Other mangrove services include the filtering and trapping of pollutants and the stabilization of coastal land by trapping sediment and protection against storm damage.

Perhaps the greatest contribution of mangrove ecosystems to coastal fisheries is in producing large amounts of detritus material from litterfall (Figure 4-2). Schatz 1991 estimated that one hectare of mangrove trees produces up to 3.6 tons of litterfall annually. One hectare of healthy mangrove ecosystem produces about 1.08 tons of fish per year.

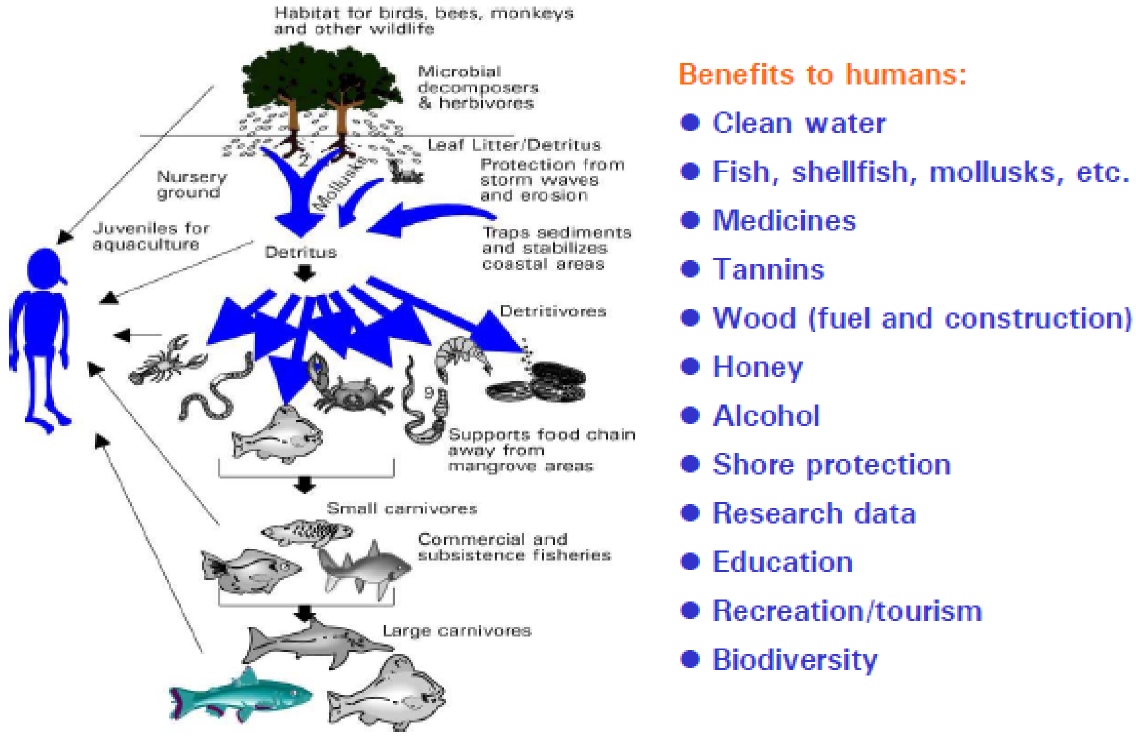


Fig. 4-1. Ecological and economic benefits from healthy mangrove ecosystems (Source: CRMP 1998.)

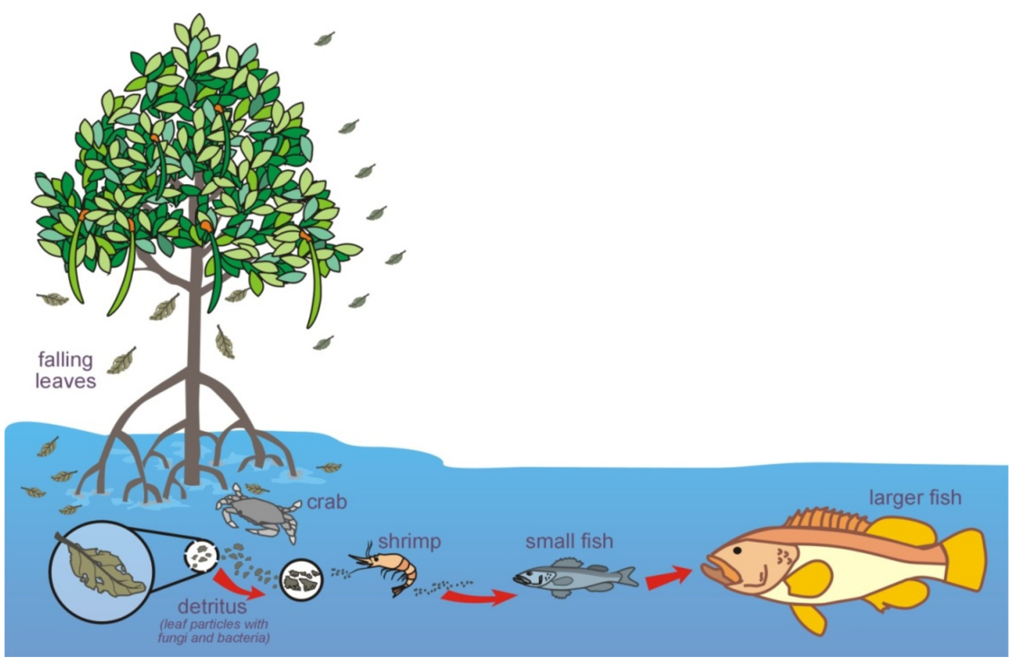


Fig. 4-2 . Contribution of mangrove litterfall to marine food chains (Source: Schatz 1991).

Status of mangrove resources in the Asia-Pacific Region

From about 450,000 hectares of mangrove area at the turn of the century (Brown and Fischer 1918) Philippine mangroves have declined to only 120,000 ha while fish/shrimp culture ponds have increased to 232,000 ha. The country's environment agency (DENR 1995) reported that conversion to fishponds, prawn farms, salt ponds, reclamation, and other forms of coastal (industrial) developments have reduced the mangrove area of the Philippines. As matter of fact, more than one in six mangrove species worldwide are in danger of extinction due to coastal development and other factors, including climate change, logging and agriculture, according to the first-ever global assessment on the conservation status of mangroves for the IUCN Red List of Threatened Species.

Urgent protection is needed for two mangrove species that are listed as Critically Endangered, the highest probability of extinction measured by the IUCN Red List, *Sonneratia griffithii* and *Bruguiera hainesii*. *Sonneratia griffithii* is found in India and Southeast Asia, where 80 percent of the total mangrove area has been lost over the past 60 years. *Bruguiera hainesii* is an even rarer species and grows only in a few fragmented locations in Indonesia, Malaysia, Thailand, Myanmar, Singapore and Papua New Guinea. It is estimated that there are fewer than 250 mature trees of the species remaining. All across the Asia Pacific region mangroves had given way to conversion into fish and shrimp ponds to bolster the aquaculture industry since the 1960s. Belatedly nations are now broadening efforts at reversing the trend of destruction by massive mangrove reforestation programs and establishment of mangrove reserves or MPAs. Local governments are increasingly tapping the ecotourism potential of a pristine mangrove forest (Fig. 4-3).

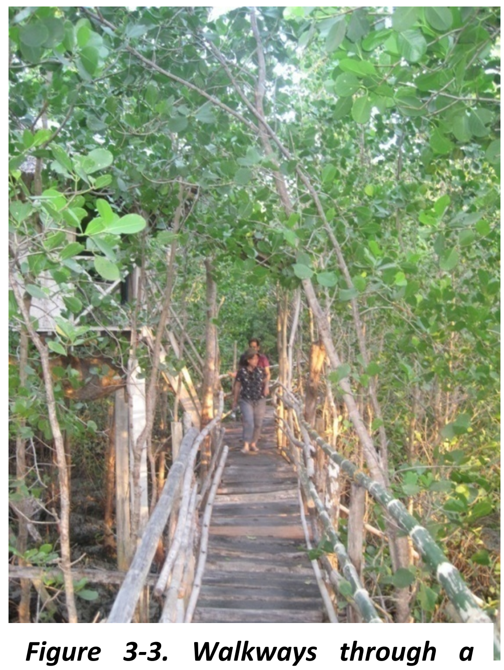


Figure 3-3. Walkways through a well-preserved mangrove forest in Siquijor Island, Philippines help ecotourism. *(Photo: A de Guzman*

Methods in mangrove assessment

Integral to the proper management of mangrove resources is a system of assessment and monitoring of the changes occurring in the mangrove ecosystem. Spatial and temporal data on mangrove community structure would help resource managers and policy makers in planning for the sustainable use of these important resources. An outline of standard procedure in mangrove monitoring is given here.

1. **Site Identification** for the mangrove assessment and monitoring should be determined in each bay or coastal area.

2. Methods

a. Mapping mangrove area – obtain estimates of total mangrove area in each site using GPS; data will be inputted to an appropriate mapping software (e.g. Surfer, GIS-based software) to a generate mangrove resource map.

b. Assessment of community structure

i. Species composition/diversity - all mangroves found in the area (inside and outside sampling plots) will be identified based on *Primavera et al. 2004* and *Calumpong and Meñez 1997.* Classification of mangroves and associated species will be made after Tomlinson (1986). Morphological or anatomical features of mangroves such as leaf margin, leaf arrangement, root system, floral structures (inflorescence) and fruits are useful taxonomic guides (Primavera et al. 2004).

ii. Plant density, tree size, zonation and regeneration potential - Transect-Plot method described by English et al. (1997) will be employed to obtain data on mangrove community structure. At least three (3) perpendicular transects (sea-landward orientation) will be established, and 10x10 plots will be established at 10-20m interval. The following parameters are measured:

- Plant density – number of trees, saplings and seedlings of all species of mangroves found inside the plot will be counted and recorded on slates.
  - Tree - diameter-at-breast height (DBH) > 4cm (40mm)
  - Sapling – DBH <4 cm but height > 1 meter
  - Seedling – height less than 1m
- Tree size or basal area – obtained by getting DBH measurements of trees; on field girth-at-breast height (GBH) will actually be measured, to be converted to DBH later to obtain estimates of basal area.
- Occurrence of flowers and fruits will be noted in each mature tree; together with data on saplings and seedlings this will indicate maturity and regeneration potential of the forest.

iii. Zonation – all species of mangroves intercepted by the transect line will be identified; life stages (tree, sapling, seedling) will be noted.

iv. Invertebrate associates such as bivalves, univalves and crustaceans will be noted and counted where possible.

FIELD GUIDE TO PHILIPPINE MANGROVES

(*JH Primavera and RDB Dianala)

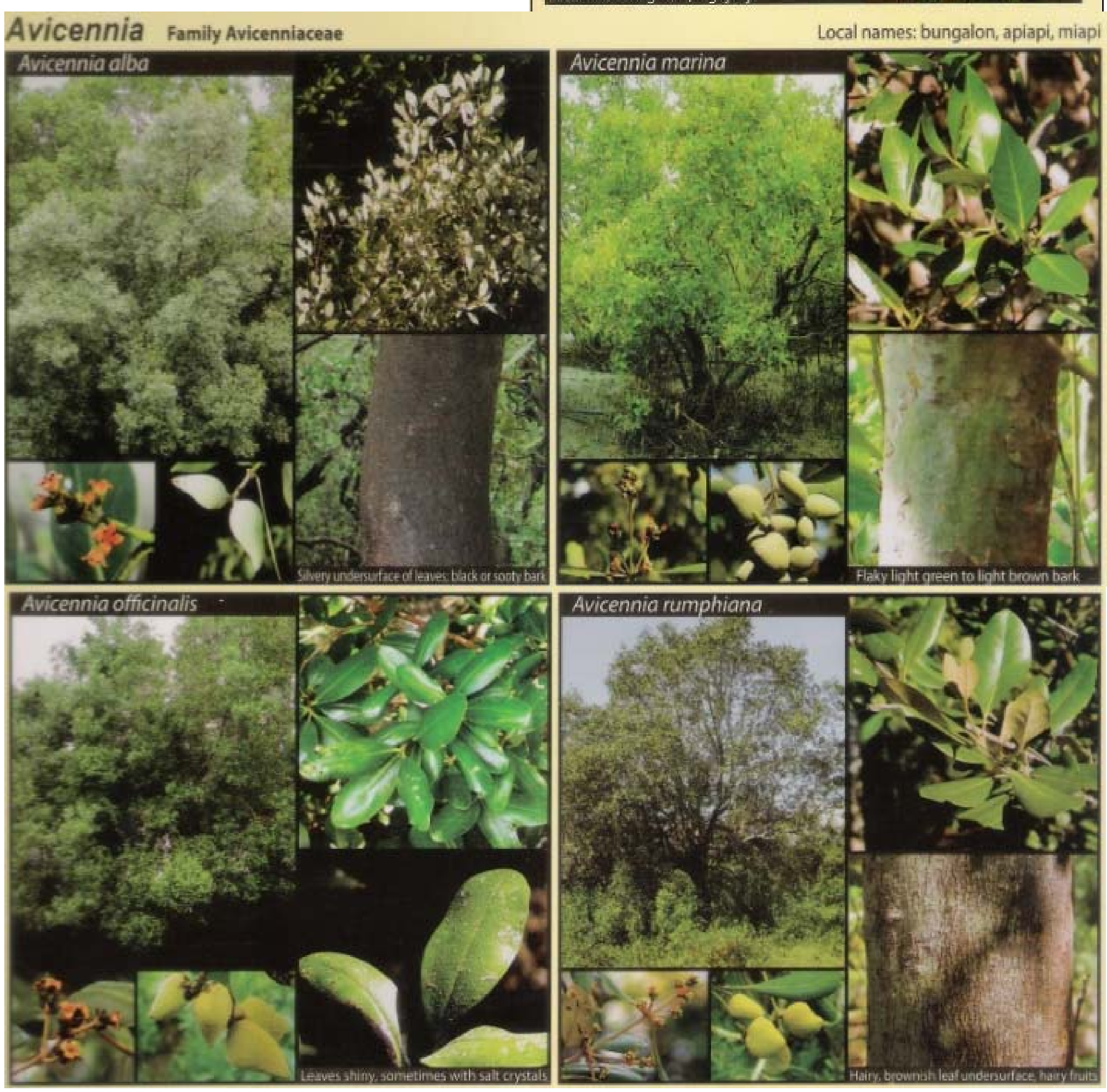


Plate 4-1. Laminated field guides to mangrove species identification are useful.

Data Management and Analysis

Relative Abundance (%)

- Per mangrove species: no. plants of each species / total number of plants along the transect x 100
- Tree, sapling, seedling: counts per plant type/total no. in transect x 100

Note: Present results in a pie chart or bar chart and compare among transects or sites

Basal Area Measurements – obtained by following these steps:

- Convert girth (circumference) measurements to diameter: **dbh = c/π**
- Example: c = 25 cm d = 25/3.1416 = 7.96 cm
- Calculate for basal area (per species): $\mathbf{A = \pi r^2}$
- Example: d = 7.96 cm will obtain a radius r = 3.98
- Thus, $A = 3.1416 (3.98)^2$ or a Basal Area = 49.74 cm^2
- Sum up BA for all species
- Convert to m2/hectare

Note: Present basal area estimates in a table or bar chart, then compare among transects or sites.

Figure 4-4. Natural and human impacts can threaten a pristine mangrove forest such as this (*Photo: AB de Guzman)*

Assessing Impacts on Mangrove Ecosystems

Table 4 shows how impact on mangroves is assessed on a scale from 0 to 5 where 0 is no impact and 5 is severely impacted. Do this by looking up at the forest canopy- notice the average height of trees, and assess how many are at that level, whether they touch and overlap (code 0) or whether there are gaps between them (English et al. 1997). Other impacts or threats such as tree cutting and garbage pile up should also be noted (see Table 5). Noteworthy too are mangrove reforestation efforts in the site. For example, many well-meaning rehabilitation efforts involve planting monospecific seedlings in inappropriate location or substrata, often times ending in wasted money and manpower investment.

Table 4 Codes used to record the impact of pressure on mangrove ecosystems.

Code	Impact	% Cover Canopy	Example
0	No Impact	96-100	Even canopy of trees. No gaps. No evidence of human interference.
1	Slight Impact	76-95	Canopy of trees fairly continuous but some gaps. Some regrowth. Isolated cutting/ stripping of trees or some evidence of pigs digging up saplings.
2	Moderate Impact	51-75	Broken canopy of trees with lower regrowth and recruitment areas. Some trees cut and stripped.
3	Rather High Impact	31-50	Tree canopy is uneven, the majority of the area is not showing regrowth and there is bare mud.
4	High Impact	11-30	Only a few trees remain at canopy height. Extensive clearance and some recruitment, large areas of bare mud
5	Severe Impact	0-10	Extensive clearance to bare mud, little recruitment, few trees remain alive

Table 5 Codes used to describe the type of impact at a site (Adapted from Table 3.5 English et al. 1997).

Code	Type of Impact
CO	Infrastructure including, piggeries, garbage dumps, developments
ER	Erosion- shown by uneven mud surfaces or little scarps/ cliffs
EC/BS	Extensive cutting or Bark stripping (for tannins/ dyes)
MI	Mining activities such as sand collection
MU	Multiple impact. Note codes of multiple impacts in Remarks.
OT	Others eg. pig foraging. Note this in remarks.

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Appendix 1. Glossary of terms often used in coral reef monitoring.

GLOSSARY OF TERMS

Abiotic	non-living
Acroporid/Acropora	category of a dominant form of reef-building coral in the IndoPacific area
Ambient environmental parameters	surrounding characteristics of the site including temperature, salinity, turbidity, light penetration, cloud cover and wind
Anthropogenic	produced or caused by humans
Assemblage	a collection of individuals, usually different types
Baseline study	first assessment of a situation against which subsequent changes are measured
Belt transect	a unit of data collection using transect lines of a fixed width
Benthic communities	groups of organisms living on the sea floor
Biotic	living
Data sheet	a paper form used to record field observations
Dichotomous	divided into two parts
Ecosystem	a dynamic complex of plant, animal, fungal and micro-organism communities and the associated non-living environment interacting as an ecological unit
Foliose	thin and leaf-like
Global Positioning System (GPS)	satellite-based navigation system
Habitat	area where organisms live
Leeward	side protected from the wind
Lifeform	external appearance of organisms resulting from the interaction of genetic and environmental factors
Line intercept transect	used to estimate the sessile benthic community of a specified area of coral reef
Manta tow technique	used to assess broad changes in the benthic communities of coral reefs where the unit of interest is the entire reef, or a large portion thereof
Monitoring	repeated observation of a system, usually to detect change
Non-*Acroporid*/non-*Acropora*	corals not belonging to the *Acropora* family
Population	all individuals of one or more species within a prescribed area
Qualitative	descriptive, non-numerical assessment
Quantitative	numerical, based on counts, measurements or other values
Reef crest	the highest point of the seaward edge of a coral reef
Reef slope	the face of a coral reef extending seawards from the reef crest
Replicate	a repeated sample from the same location and time
Sample	any subset of a population
SCUBA	self-contained underwater breathing apparatus
Soft coral	animal consisting of anemone-like polyps with eight feeding tentacles surrounding mouth
Survey	organised inspection
Transects	a line or narrow belt used to survey the distributions of organisms across a given area
Visual fish census	a method of assessing fish along a transect
Windward	side exposed to the wind

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