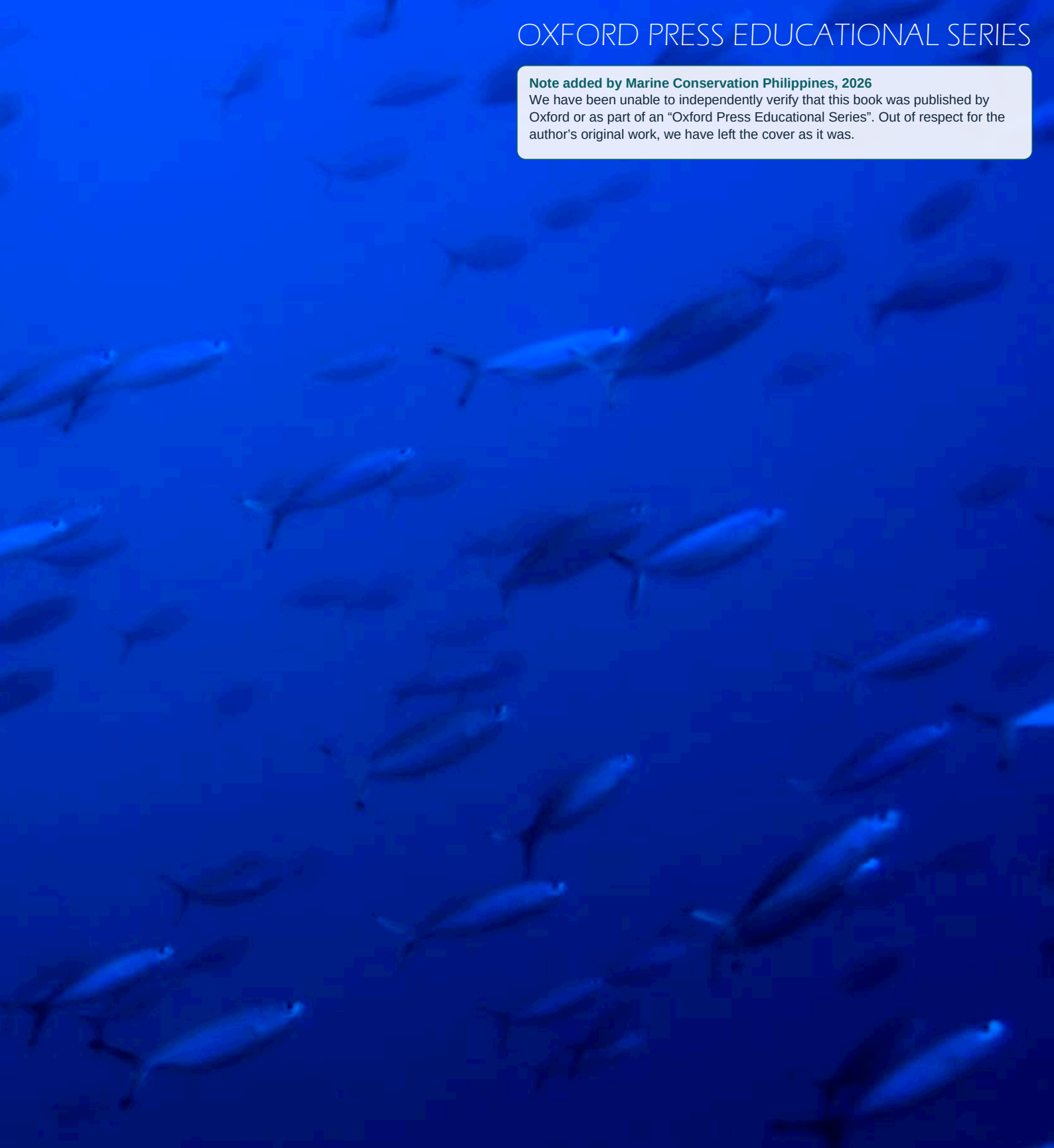


OXFORD PRESS EDUCATIONAL SERIES

Note added by Marine Conservation Philippines, 2026

We have been unable to independently verify that this book was published by Oxford or as part of an "Oxford Press Educational Series". Out of respect for the author's original work, we have left the cover as it was.



LIFE ON THE REEF

JILL GROOM

LIFE

ON THE REEF

WRITTEN & ILLUSTRATED
BY
JILL GROOM



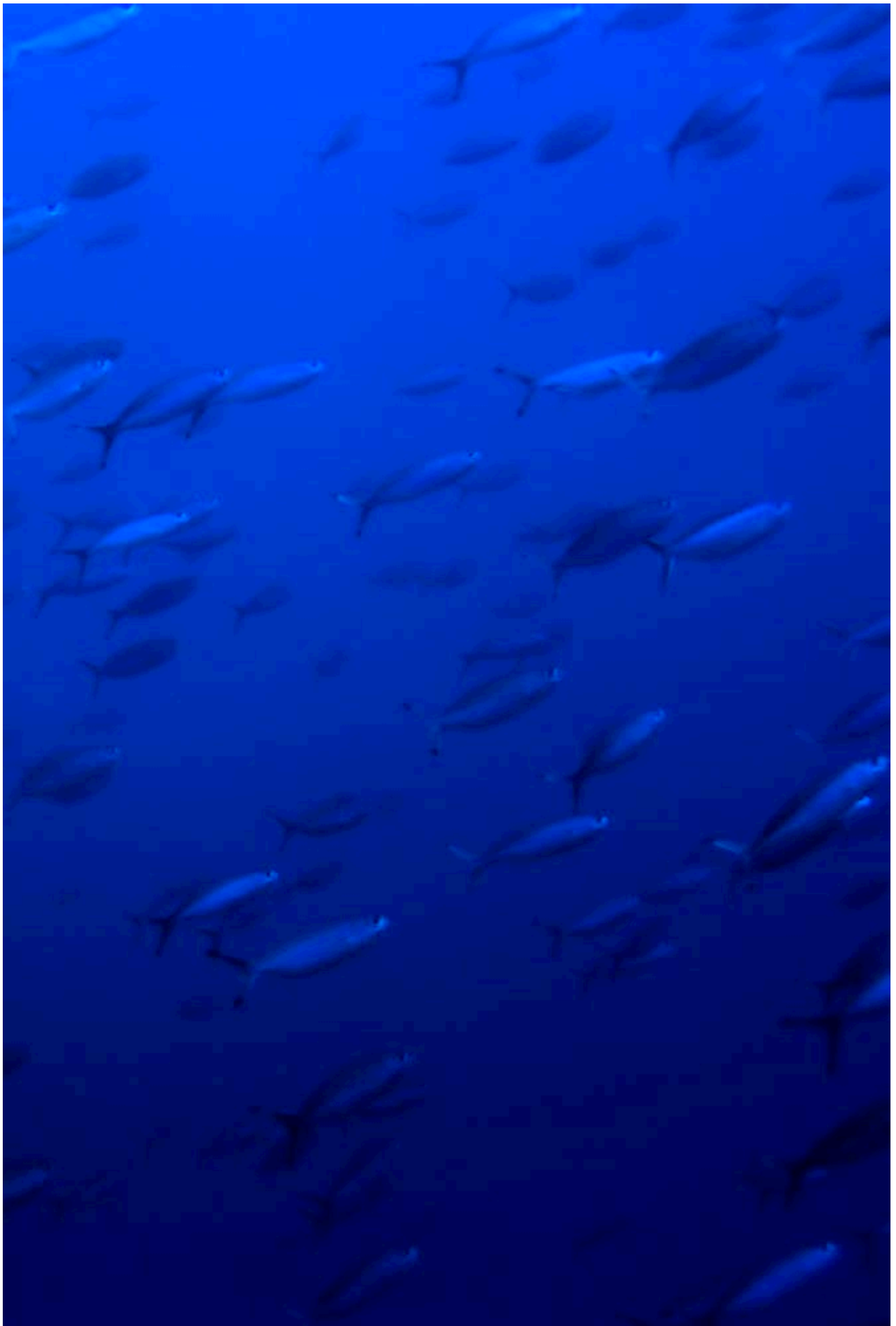
Napantao Coral Reef, Sogod Bay, Southern Leyte, Philippines

FOREWORD

LIFE ON THE REEF is intended as a detailed overview of the major issues facing coral reef habitats, and the role of coastal resource management in conserving the health of coral reef systems for the long-term benefit of the local communities dependant upon them. The ecology and biodiversity of the coral reef environment is outlined and illustrated with images from reefs of South East Asia. The Philippines is used as a specific example of a small island developing state (SIDS) trying to overcome many of the issues relating to coastal resource use, faced worldwide.

This book begins by describing the importance of coral reef ecosystems in sustaining the livelihoods of coastal populations worldwide. The book then addresses the current threats to coral reefs and the consequences this is having for those people who rely upon the resources they provide. Effective coastal resource management is vital in addressing this problem and thus the book focuses on the challenges of managing coastal resources, and identifies the current initiatives for overcoming them.

A large proportion of the world's poorest people are dependant upon reef-based resources for food and livelihood. The effective management of coral reefs is therefore essential not only for maintaining biological value but also for sustaining the lives of those millions reliant upon them. This book hopes to highlight the importance of this issue and identify the way in which coastal resource management can be implemented for the long-term benefit of the environment and coastal communities.



CONTENTS

FOREWORD	1
ACKNOWLEDGEMENTS	4
INTRODUCTION	5
STATUS OF CORAL REEFS	8
REEF ECOLOGY	11
REEF LIFE	17
RESOURCES	35
THREATS TO REEFS	43
MANAGEMENT	52
CONCLUSION	62
REFERENCES	64

ACKNOWLEDGEMENTS

The research behind this book was carried out in the Philippines, in order to address the role of NGO's in coastal resource management time was spent working with a marine NGO based in the Philippines. The NGO used in the case study of this book was Coral Cay Conservation (CCC), I would like to thank all those at CCC and the community of Napantao, Southern Leyte for their cooperation and support in the research that went into this book.

Special thanks is given to Pam Groom, Terry Groom and Nicholas Hutchings without whom this book would not have been possible.

INTRODUCTION

This book begins with setting the context of the topic by discussing the current status of coral reefs worldwide and the factors that continue to cause these ecosystems to decline. The understanding of the biology and ecology of coral reefs is essential to identifying the major threats to coral reefs and is necessary to create effective management initiatives appropriate to the biological social and cultural pressures placed upon coral reef systems by human activity. Therefore the book provides an overview of the basic ecological functioning of these systems. The next two sections explain how the considerable biodiversity coral reefs can sustain, results in numerous resources that can be utilised by human populations. Having identified the importance of coral reefs in providing resources, the book then identifies the factors threatening the source of these resources and the consequences this is having worldwide. The final section and the main focus of the book highlights the importance of coastal management in addressing those threats and identifies the methods that are most effective in ensuring sustainable use of coastal resources. The essay concludes that the small-scale success of marine protected areas (MPA's) can be used as an example of the importance of community involvement in the management process, and provides valuable lessons that can be applied to the wider context of coastal resource management worldwide.





Sonok, Southern Leyte is an example of a Philippine village dependent upon reef resources

STATUS OF CORAL REEFS

Coral reefs are home to a vast array of life and for centuries these highly productive systems have provided humans with extensive resources including, food, income and raw materials. The estimated global value of the goods and services from coral reefs is in excess of 375 billion US dollars per year (1997)¹, however the annual investment into conservation, research and management of coral reefs is less than 100 billion dollars², it is then perhaps no surprise that 20 % of the world's coral reefs have been destroyed by human activities³ and show no signs of immediate recovery, and 26% remain under threat from anthropogenic stresses³.

Despite the increased awareness of this problem and the recent efforts to implement sustainable management systems coral reefs continue to decline. Destructive and excessive fishing is a major cause of reef degradation, as is inappropriate development and the great population increase in coastal regions. The change in climate in recent years has also had huge impacts upon the health of coral reefs worldwide. This issue received global attention in

1998 when it was estimated that 16% of all reefs worldwide were seriously damaged by a global coral-bleaching phenomenon, the scale of which has never been seen in the past 1000 years of records³. Scientists now predict that with the climate showing no signs of stabilising the events of 1998 are likely to become more frequent in the coming decades³.

The continuing degradation of coral reefs is having significant impacts upon the quality of life of the millions of people living in coastal communities. Some of the world's most diverse marine habitats are found in some of the poorest regions of the world and coral reefs are a prime example of this. The majority of coral reefs are found in the Indo-Pacific where a large proportion of the coastal countries are still considered developing, and in the many Small Island developing states (SIDS) found in the Indo-Pacific, coral reefs are often the only or major resource in the area. It is estimated that approximately 500 million people worldwide³ rely on coral reefs for food, income, protection, and cultural practices, and of these 500 million it is thought that 30 million³ of the world's poorest people

are dependant on the food provided by productive coral reef habitats to survive. When considered in this context it becomes apparent why the conservation of marine systems, and in particular coral reefs, is critical not only from an ecological perspective, but also to the millions of people who's lives depend upon the success of these conservation efforts.

In recent years the traditional top down management structure of such resources has been challenged and a move to a more community-based approach to management has been adopted. Emphasis is now placed on the sustainable development of coastal regions and the establishment of protected areas to reduce the loss in biodiversity occurring on reefs around the world. However, such initiatives have only just begun and it remains to be seen how successful new management attempts will be. Among the many challenges facing successful management of coastal resources are the political and social implications that may be in direct conflict with the interests of the reefs and the communities that rely on them. This study looks at the resources reefs provide



The majority of the world's coral reefs are found in Southeast Asia, this area is known as a centre of marine biodiversity (highlighted), sometimes referred to as the coral triangle. The Philippines falls within this area of high biodiversity.

for local communities and the attempts being made to improve livelihoods by proper management of these resources, with specific reference to the coral reefs of the Philippines. The status of reefs in the Philippines is reflective of the trend worldwide, and the global threats and challenges facing the sustainable use of coastal resources are typified by the problems encountered by coastal management initiatives throughout the Philippines.

Coral Reefs of the Philippines

The Philippines is made up of over 7000 islands⁴ and

has 18,000 km of shoreline⁵. For generations the coastal regions of the Philippines have provided resources that sustain local populations. The large proportion of the population living in coastal regions reflects this, 54% of municipalities in the Philippines are coastal⁶, and over 62% of the population live in coastal areas⁶. This puts considerable strain upon the natural resources found in the coastal zone, such as coral reef habitats.

Coral reefs cover over 27,000 km² of the Philippine coastline⁵, however it is estimated that over 75% of these have been degraded by human activity⁶. In a nation that derives over 50%

of its protein intake from marine fisheries⁵, the health of these habitats is critical to the well being of the population as a whole. The large increase in the coastal population, combined with the poverty that is suffered by that population, only adds to the stresses placed upon these habitats. In 2000 34% of the Filipino population was living below the national poverty line⁷, and the poorest of these are often small fishing communities. The increasing environmental degradation of coral reefs and the subsequent reduction in the productivity of fisheries, due to unsustainable fishing practices, is having severe impacts upon the livelihoods



of millions of Filipinos^{7,8}, for whom coastal resources are often their only significant source of food or income.

Despite the seemingly imminent exhaustion of coral reef habitats there is hope for the successful and sustainable management of marine resources; in the Philippines over 400 marine protected areas (MPA's) have been established⁹ in an attempt to improve the health of coral reefs. However the enforcement and management of these areas is less than straightforward and it is estimated that only 10% of marine protected areas in the Philippines are appropriately managed¹⁰. The future of coral reefs and the populations that are dependant upon them will depend on the success of such management initiatives.



REEF ECOLOGY

► The Philippines falls within the 'coral triangle', and a large proportion of the world's coral reefs are found along the coastline of the Philippines.

Coral reefs are unique habitats that support a wide variety of colourful life (pictured left).

Coral Reefs are the most diverse of all marine habitats³, even when compared to terrestrial habitats such as rainforests coral reefs are by far the most biologically rich environments on earth¹¹, hence their importance in sustaining biodiversity. The majority of reefs are found in the tropics between latitudes of 30 degrees north and south, this geographical distribution is dictated by the conditions that are necessary for the growth

of the coral. Corals require warm, shallow, highly saline waters to sustain their health and their growth rate.

The growth of coral polyps is reliant upon the symbiotic relationship with microscopic algae named zooxanthella, found in the tissues of many corals. The symbiotic algae photosynthesise in the tissues of the coral, producing sugars and oxygen that help to sustain the coral. The algae require sunlight to photosynthesise,





Coral Reef seascape, shallows of Leyte House Reef, Napantao, Philippines

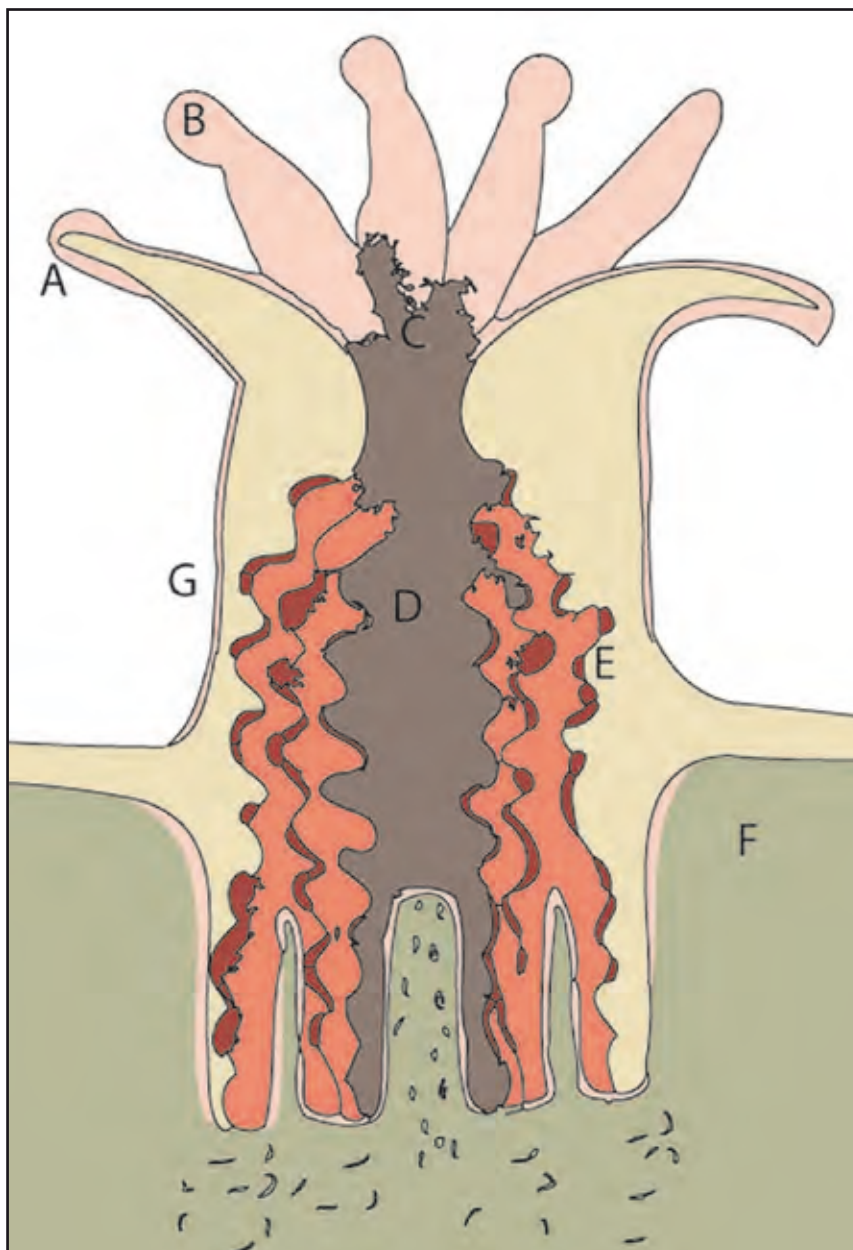
the growth of corals is therefore restricted to the euphotic zone, generally up to 50 meters. This mutually beneficial relationship with algae allows corals to grow rapidly and gives excess energy which contributes to the amount of calcium carbonate that can be laid down in the coral skeleton, the zooxanthella are therefore a critical factor in the building of reef systems. Due to coral's dependence on photosynthesis, coral

growth is also restricted by temperature limits. The optimum temperature for growth is between 20-28 degrees; outside of this temperature range coral growth is limited or non-existent. The specific requirements for coral growth make coral reefs vulnerable to a variety of threats. Despite the high growth rate of individual corals the creation of whole reef structures is a relatively long process, the

development of which can be severely damaged by rapid changes in environmental stresses.

Formation of coral reefs

Coral reefs are living structures built by generations of hard corals which lay down calcium carbonate skeletons. After time when the corals die they leave behind the skeletons which provide an ideal place for the next generation of



► **Figure 1**

The Anatomy of a Coral Polyp

A. Outer epidermis

B. Tentacle

C. Mouth

D. Stomach

E. Tissues containing zooxanthellae

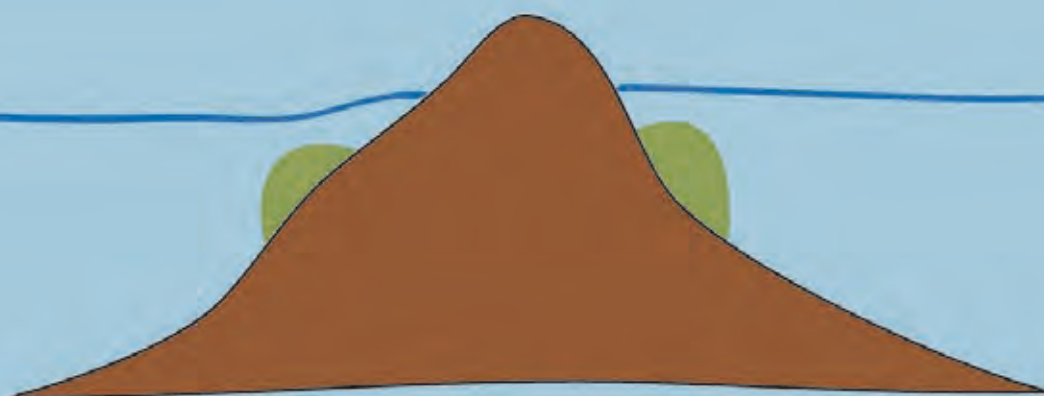
F. Calcium skeleton base

G. Gastrodermis

Figure 2 ◀

Coral Reef Formation

The development of different reef types over time results in one of the three basic reef formations; fringing, barrier or atoll.

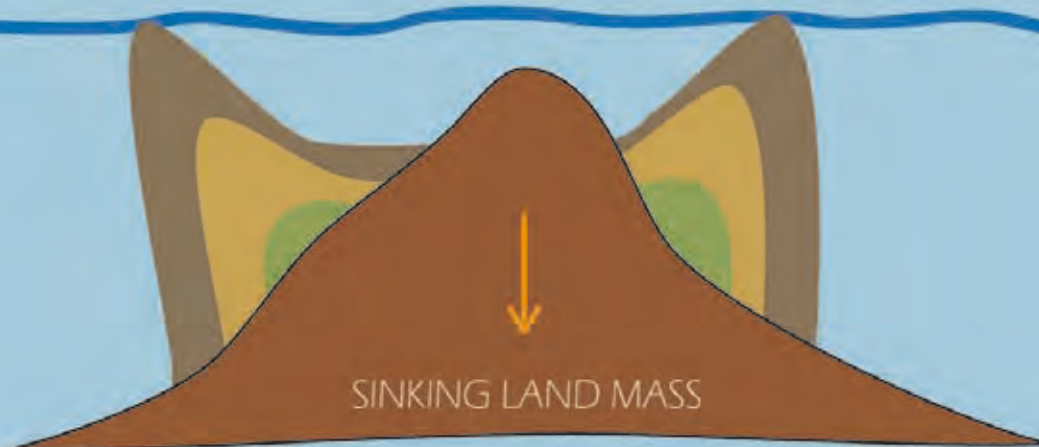


FRINGING



SINKING LAND MASS

BARRIER



SINKING LAND MASS

ATOLL

corals to settle, each leaving behind successive layers of calcium skeleton eventually a large limestone structure is created around which all reef life congregates.

Although reefs all follow this basic principle in their conception there are differences in the types of reef created dependant upon the geological processes involved. Coral reefs essentially form in one of two ways, either by growing from the seabed upwards or seawards from the coastline. However different forms can be taken

dependant on other factors, the three main types of reef are considered to be fringing reefs, barrier reefs, and atolls.

Fringing reefs are the most common type of reef structure; these are reefs that grow from the coast seawards. Barrier reefs grow from the seabed to the surface and normally lie off the coast often by some distance; it is often hard to distinguish a developed fringing reef from a barrier reef because fringing reefs may sink in the centre portion leaving a higher reef

off the coast which over time appears much like a barrier reef.

Atolls form initially as fringing reefs around a land mass often volcanoes. Over time erosion or the movement of the landmass can cause it to sink; the corals in the outer shallows continue to grow, forming a lagoon. As the land mass continues to sink only the ring of corals in the shallowest water can continue to grow and so a ring shaped coral atoll is formed. Atolls are characterised by very deep surrounding waters and



Branching *Acropora* Spp

can reach down as far as a thousand meters.

The most common reef type in the Philippines are fringing reefs¹², the physical structure of most of these reefs is very similar and the types of species they support are largely the same. Coral reefs of all formations are part of a larger tropical coastal ecosystem, along side sea grass beds and mangroves. These three ecosystems are mutually beneficial and together, are crucial in maintaining the health and diversity of the coastal ecosystem as a whole.



Mushroom coral, *non-acropora* spp.

REEF LIFE

► Hard corals (pictured top right, and on opposite page) form the basis of the coral reefs physical structure over generations. They have a symbiotic relationship with zooxanthellae which is crucial in the process of building coral reefs.

Coral reefs the most biologically diverse habitats on earth¹¹, and in particular in the Indo-Pacific coral reefs have the highest levels of diversity and endemism of any coral reefs¹³. Understanding the ecosystem functioning of coral reefs is essential in creating appropriate protection for these habitats, therefore understanding the species and their interactions is integral to effectively managing resources.

There are a great variety of coral types; the main distinction is between those corals that build reefs by laying down calcium

carbonate skeletons and those which do not. Reef building corals are known as scleractinia corals or more commonly hard corals. Those that do not lay down calcium carbonate skeletons are known as octocorallia or soft corals.

Hard corals create the majority of the physical structure of the reef in the form of calcium carbonate, which is taken from the seawater and secreted on the outer layers of the coral giving it solid structure. Few hard corals would be able lay down a substantial calcium skeleton from the energy they are able to gain



themselves, but rely on the crucially important symbiosis which occurs in hard corals and accounts for a large proportion of the amount of calcium carbonate that the corals are able to lay down. It is estimated that reef-building corals gain up to 80% of their energy via the symbiotic relationship with zooxanthellae, and in return the zooxanthella receives the products of respiration, carbon dioxide and water, which it can use for the process of photosynthesis. While all reef-building corals have this symbiotic relationship with the algae not all corals containing zooxanthellae are reef-building corals.

Soft corals (pictured left), as the name would suggest, lack the hard calcite skeleton found in hard coral species. Soft corals like their harder counterparts contain colonies of polyps that feed on planktonic food, although many soft corals also contain symbiotic zooxanthellae which contribute significantly to the nutritional needs of many soft coral species.



Sea fans or gorgonians are soft corals, despite the fact they possess a hard rind made of gorgonin, which is strengthened by lime deposits. Thus, these particular species of soft coral can make a small contribution to the reef structure after death. However, they are not true

Hydroids are related to corals, they both possess stinging cells known as nematocysts





Anemones have formed a mutually beneficial relationship with the anemone fish, the stinging tentacles, pictured opposite page, provide protection from predators

reef building corals.

Gorgonians unlike hard corals and other reef species are rarely seen with encrusting growths such as sponges or algae. This has led scientists to investigate the potential to yield a substance from soft corals which is able to prevent growths, such species could be of great medical importance and it is hoped that one day they may provide an answer to the prevention of cancerous growths and other diseases¹⁴.

While corals form the basis of the reef structure there are numerous species that live upon the reef, many of which it is thought are still unidentified. The basis of all this diversity is the zooxanthella, which provides the energy for the basis of the coral reef food web. The variety of life forms found is vast, from simple single celled species to large sea mammals, the array of life found in these habitats is astonishing and undoubtedly contributes to the fascination that reefs provide for observers and researchers alike.

Sponges are among the simplest multi-celled species found on reefs, the simple yet effective body plan of sponges makes them very efficient filter feeders. A major source of nutrition for sponges is bacteria; therefore sponges are often abundant in nutrient rich

waters such as harbours or river mouths. Sponges like corals have developed a symbiotic relationship with a blue-green algae the algae provides the sponge with sugars as a product of its photosynthesis some sponges can gain up to 100% of their nutrition in this way¹⁵.

Hydroids are also common inhabitants of coral reefs and are related to corals and jellyfish, they all belong to the phylum cnidaria. Like all cnidaria hydroids contain stinging cells known as nematocysts. Hydroids are colonial animals and include a wide variety of species.

Anemones also belong to the phylum cnidarians but are not hydroids, they are closely related to hard corals both belonging the

class anthozoa. Anemones appear much like an overgrown coral polyp and this is essentially what they are. Like hard coral polyps they have symbiotic algae associated with their tissues. Anemones have also established another mutually beneficial relationship with anemone fish, which are able to avoid the harmful affects of the anemones stinging tentacles because of the mucus coating they possess. There are several benefits of this relationship; anemone fish are highly territorial and protect the anemone from predatory fish¹⁶, it is also believed that anemone fish remove harmful parasites from the anemone¹⁷, and provide the anemone with vital nutrients such as nitrates and sulphur through excretion of waste products¹⁸. In return



the stinging cells of the anemone tentacles provide protection from predators of the anemone fish^{16,19} and provide a safe habitat in which to locate their nests¹⁶. This is just one example of the many symbiotic relationships that occur on reefs.

While some species have developed a mutually beneficial relationship others seem to have developed a more destructive relationship. Marine worms can cause large amounts of damage to coral reefs, many species are burrowers, causing great structural damage and it is thought that some species secrete chemicals¹⁵,

which actually dissolve the calcium carbonate skeleton of corals. Despite the apparent harm caused to the reef marine worms actually play an important role in the continual regeneration and renewal of coral reefs, as long as a balanced ecosystem is maintained. Coral reefs are home to a great number of marine worms; these creatures are often well hidden and therefore may seem deceptively scarce on observation of reefs.

Nudibranchs are often mistaken for a type of worm. This species must surely be one of the most visually impressive among the vast array of reef life. Small in

size these species make up for their miniature scale with bright colours and patterns, these small creatures can be difficult to spot but are numerous on reefs and found in the shallows and at depth. Their bright colours are thought to be a warning to potential predators, as the flesh of these species is often toxic and contains various chemicals¹⁵.

► Marine worms (pictured right and below left) are numerous on reefs and play a vital role in the continual process of regeneration of the reef. Nudibranchs (below right) are often mistaken for marine worms



**Christmas tree worm,
Spirobranchus spp.**



The nudibranch *Chromodoris magnifica*



The Feather duster worm





► Nudibranchs are found on coral reefs worldwide, but these tiny creatures can be hard to spot. Their bright colours and elaborate appendages are a warning that these creatures possess dangerous chemicals within their tissues. Some nudibranchs can also store the unfired stinging cells, from the hydroids on which they feed, in the projections on their back, these are used as vital weapons against predators.

Starfish are a more widely recognised member of the reef community, they belong to the echinoderm family which are common upon reefs in a variety of forms. The five main classes include the sea stars, brittle stars, sea urchins, sea cucumbers and feather stars. Echinoderms are identifiable from their radial symmetry. In the sea stars or starfish this symmetry is easy to recognise, however in sea cucumbers, and some other echinoderms, this symmetry may seem less obvious.

Feather stars are perhaps the most abundant echinoderms on reefs and because of their location, often protruding from an edge of coral to take advantage of the current that flows past there, filter feeders are easy to spot. Although these animals may appear sessile they are able to crawl using tiny cirri on the underside of the body and can swim minimal distance using the feather like appendages, although this type of behaviour is more often observed at night.

Urchins which also show radial symmetry like the other echinoderms are somewhat more robust than their feathery cousins. Like the feather stars, Urchins are also largely nocturnal, although they can be seen hiding in crevices



during daylight hours

Sea cucumbers (or holothurians), despite being echinoderms, do not show obvious radial symmetry in their body plan, instead the radial symmetry is only obvious internally. Sea cucumbers have tubular feet for movement and those feet around the mouth are also developed for feeding, allowing the echinoderm to ingest large amounts of sand from which they extract the organic matter within the sand and expel the inedible components leaving a trail of sand behind them.

► Echinoderms are visible on reefs throughout the world, sea stars or starfish (pictured left) are instantly recognisable, however feather stars (bottom left) and sea cucumbers (below) are also part of the echinoderm family and are equally common on coral reefs throughout the tropics





At first glance ascidians (or sea squirts) may appear no more robust than the anemones; however, these creatures have a larval tail strengthened with cells like the backbone seen in the embryos of vertebrates¹⁵. Therefore, ascidians belong to the phylum chordates. There are a wide variety of shapes, sizes and colours of sea squirts and species can be found as solitary individuals or in colonies. Ascidians feed by filtering water through their mouth and expelling it out of a smaller opening; beating cilia are responsible for creating the current from one opening to the other

and as the water passes through the pharynx of the animal planktonic species such as phytoplankton and bacteria are filtered out.

Many of the species described are reliant upon plankton, usually considered as the basis of the marine food web; plankton provides the nutritional basis for a productive system and directly or indirectly is responsible for sustaining the wide variety of species found on reefs from simple sponges to the many fish species that live on the reef.

► Sea squirts are abundant on Philippine coral reefs. These creatures can be found in a variety of shapes, colours and sizes

► Like many sessile reef species they are effective filter feeders, extracting plankton from the water column.







Schooling Big mouth Barracuda, Koh Haa, Thailand

The abundance of fish found around coral reefs is so great that more fish species are found on coral reefs than in any other aquatic habitat marine or freshwater³. The amount of fish found around reef systems is an indication of the critical food sources and shelter that this environment provides to fish species. The number and variety of fish on a reef is often the first indication of the health of the reef system as a whole, as these freely mobile creatures are the first to be able to leave when food or shelter becomes scarce. Despite the apparent chaos of the reef fish, most are

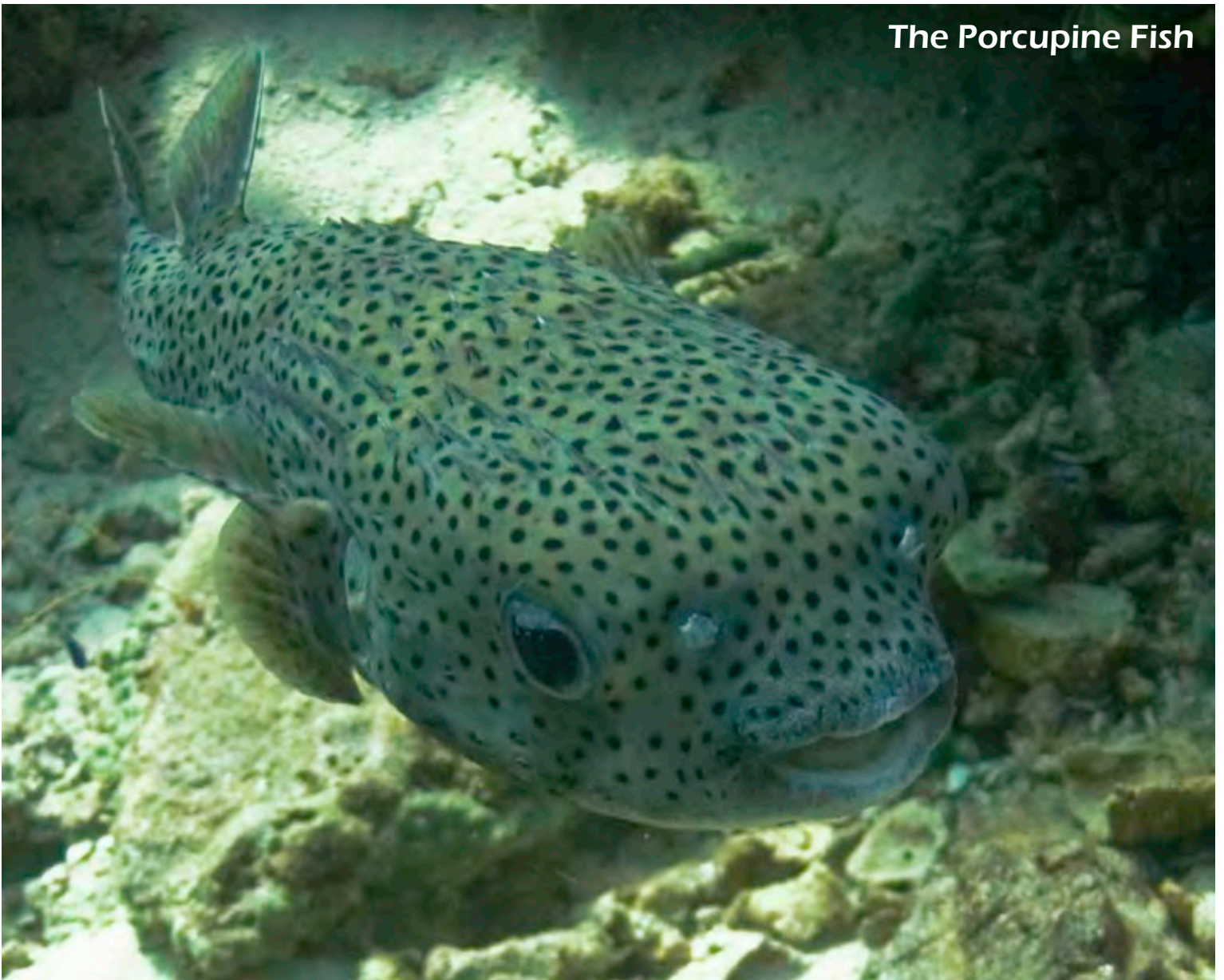
territorial and remain in the same region of the reef, although these areas may change throughout the life cycle of particular fish.

As well as maintaining fish biodiversity, reefs sustain a number of commercially valuable reef species such as surgeonfish, jacks and mackerel. As well as these valuable fisheries species, many more fish species are seen on reefs such as lionfish, anemone fish, and angelfish, all of which are of value to the aquarium trade.

Larger species of marine

► Coral reefs are home to a huge diversity of marine fish, from the unusual porcupine fish (bottom left), to the plain damsel fish (top right) and the uniquely spectacular lion fish (bottom right.)

The Porcupine Fish





The common, spotted damselfish



The common Lionfish
Pterois volitans

life such as sharks, and turtles can also frequently be seen near to reefs exploiting widely available food resources found here. However due to human exploitation some of these impressive creatures are becoming increasingly rare, all eight species of marine turtles are now considered threatened or endangered by the IUCN (International Union for Conservation of Nature and natural resources). These ancient creatures have swum the seas since the prehistoric age but the increasing pressure from anthropogenic induced changes is having great impacts on the turtle. Conserving the health of reefs where many larger



mammals feed is going to play a crucial role in maintaining the populations of larger ocean dwelling mammals.

► The array of species found on coral reefs ranges from small gobies (bottom, left), to valuable species such as snappers (right) and the well loved sea turtle (pictured above).



RESOURCES

The high biodiversity associated with coral reefs can provide a productive system that can protect and sustain local communities by providing a wide variety of ecological goods and services; indeed coral reefs are the most significant coastal habitat for providing resources to the Filipino population⁵. Traditionally coastal communities have relied heavily on reef fish as a source of protein, in the Southern Philippine Islands up to 80% of the diet is sourced from coral reef resources²⁰. This protein

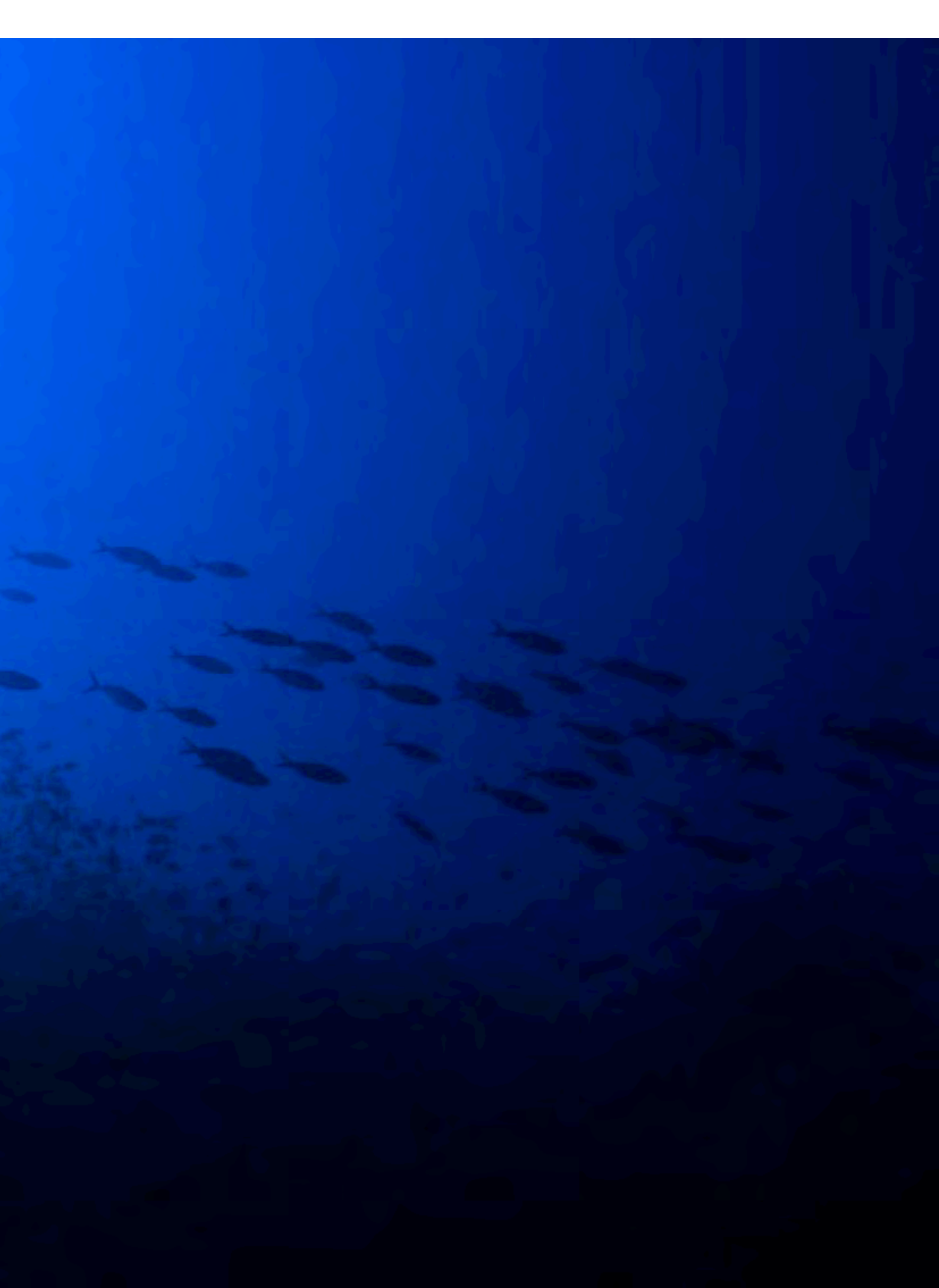
may be derived from a variety of species such as mussels, crustaceans, sea cucumbers and fish. These seafood products not only provide a crucial source of nutrition for coastal populations but account for a significant proportion of the income of coastal dwelling communities. It is estimated that coral reef fisheries sustain the livelihoods of over a million artisanal fishermen and contributes almost 1 billion US dollars annually to the economy of the Philippines⁵.

However, reefs do not simply sustain a food resource; there are several other assets that are valuable to coastal populations. Coral reefs have long been a source of raw materials, the limestone skeletons of corals can be used for the production of cement²¹, while sand and hard coral substrate are major sources of construction materials. Mining of coral reefs to extract large blocks of coral and rubble is a hugely destructive activity and in some SIDS reef products are the main sources of

Blue & gold striped snappers







Coral Reef seascape, Leyte House Reef, Philippines

building materials putting enormous pressure on reefs systems²².

Many species found on coral reefs have characteristics which have attracted interest from medical researchers hoping to find products that could be beneficial in fighting cancer, AIDS, and various other infections and diseases⁸. This is an area of increasing scientific interest with potential benefits both in monetary and health terms.

The Philippines is a large supplier to the aquarium trade, exporting live fish and corals in vast quantities to countries such as America. It is estimated that in 1996 32 million dollars worth of live fish were exported to the US for use in the aquarium trade²³, sadly this massively destructive industry is also incredibly wasteful it is estimated that up to 70% of the live fish harvested from Philippine reefs will die before they reach the buyers (personal communication,

C. Mason-Parker, marine resource manager based in the Philippines).

Fish are not the only organisms harvested from reefs, many types of seaweed are also taken from coral reefs and used for a variety of purposes such as the production of agar, carrageen and fertilisers^{8,24}. The Philippines is also one of the worlds largest exporters of shells and related products²⁵. It is estimated that up to 1500 different shelled species are collected from Philippine waters and used to make jewellery and souvenirs for the international market^{5,25}, the extent of such exports is difficult to quantify but in 1988 it is estimated that up to 10, 000 tonnes of shells and related materials were exported from the Philippines²⁵. Despite a general decline in the quantity of exports since the late 1980s, the export of shell products from the Philippines is still estimated at up to 3, 000 tonnes (2002)²⁵.

In addition to the goods that can be extracted for use by humans, coral reefs provide many ecological services, that is those services that through the natural functioning of the ecosystem, result in direct or indirect benefits to human populations. Such services include shoreline protection as coral reefs act as buffers to wave action and can withstand great forces of nature. In tropical regions such as the Philippines where storm events can be severe and frequent, coral reefs are vital for the protection for local communities that are vulnerable to the impacts of natural disasters.

► The Philippines is a major exporter of shell products, which are made into jewellery and souvenirs for the international market.





Rainbow Runners, *Elegatis bipinnulata*, pictured, often feed near to coral reefs, and are an important food source in the Philippines

While coral reefs alone may not have a substantial effect in a large storm event, the role they play in maintaining the health of coastal ecosystems as a whole is critical in maintaining effective natural coastal defence. Coral reefs are rarely found in isolation instead they form part of a larger ecosystem involving sea grass beds and mangroves. Mangroves and coral reefs are closely associated and both provide the other with benefits.

Mangroves have been shown to have great coastal defence potential, the dense root systems are thought to give stability to the sediment

and can attenuate wave action, giving protection to the coastline behind them²⁶. Studies of regions hit by the Asian tsunami of 2004 showed that regions associated with dense mangrove areas sustained less fatalities and destruction than adjacent villages where mangroves had been degraded or removed^{26,27}.

As well as being an integral part of an ecosystem providing protection against natural disasters coral reefs continually protect the shoreline from erosion by dissipating wave action and preventing sediment being carried away from the

coastline. Coral reefs do not only reduce erosion through preventative measures; the sediment created from coral reefs, by natural breakage or by continual grazing by boring species, provides the fine sediment which is washed onto beaches and gives tropical beaches their characteristic white sand. This aesthetically pleasing aspect of tropical regions is a large asset in attracting tourism to coral reef areas. Tourism is by far the fastest expanding industry in tropical regions and is an opportunity to improve the economy and livelihoods of local communities through the sustainable development of coastal areas.

In the Philippines there is currently a large emphasis on increasing tourism. A major asset of the Philippines is the availability of dive sites, if these areas were correctly managed they could provide a substantial source of sustainable income. Recent trials on Apo Island in the southern Philippines, showed that an initial investment of 75,000 US dollars to protect an area of 1km² coral reef could yield returns of up to 113,000 US dollars annually from increased fish catch and local tourism⁵. If correctly managed this type of initiative could realistically be a major source of renewable income for the Philippines.

As well as the goods and physical services provided by coral reefs, the cultural, social and livelihood assets

provided by such resources are often forgotten. In the Philippines it is estimated that the degradation of reefs has led to the loss of over 100,000 fishing jobs⁸, having great impacts upon the communities that are dependant on the jobs and income provided from the reef. The extent of these losses may be even greater than the statistics would suggest. As well as the millions of fishermen directly involved in fishing many more people are dependant upon the activities indirectly related to fishing, for example many women in coastal communities are involved in preparing and packaging fishing products, maintaining nets or making saleable goods from shells and corals, and many more people are involved in the transportation of fishing goods to larger cities.

Therefore the impacts of jobs losses or the reduction in fishing activities is likely to have wide-ranging social and economic implications.

The extensive resources provided by coral reefs are also the reason for their downfall, the overexploitation of products and services derived from reefs has led to an unsustainable level of decline and degradation, and the affects of these threats on the productivity of coral reefs resources is beginning to show in the impacts it is having on those people who's livelihood is dependant upon them.

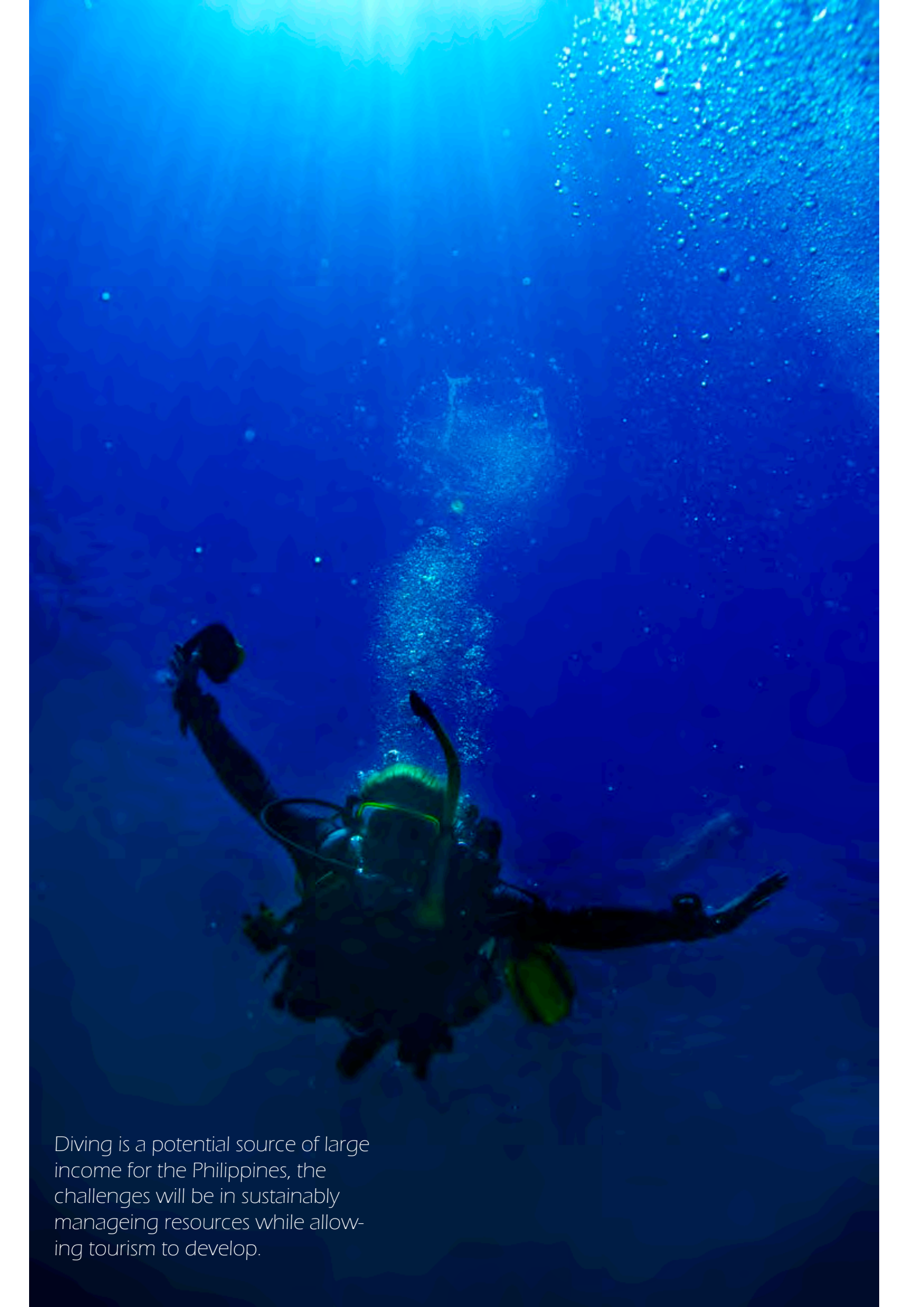
► Unique fish, such as those pictured, are removed from reefs using destructive techniques and sold to the aquarium trade



The False Clown fish,
Amphiprion ocellaris



The Banner fish,
Heniochus Acuminatus



Diving is a potential source of large income for the Philippines, the challenges will be in sustainably managing resources while allowing tourism to develop.

THREATS TO REEFS

With such a complex functioning which is still not fully understood it is difficult to predict what thresholds would be considered sustainable for coral reef resource use. There is no doubt however, that as things stand very few if any of these vast resources are being used in a sustainable way, and the current rate of degradation to reef resources means that all of these valuable resources are at risk of exhaustion.

Coral reefs have survived for over 500 million years³ and their resilience to natural destructive forces is remarkable however, the extra pressure placed on reefs by coastal development, global climate change and population growth is causing high rates of decline in reef coverage and health. The risks to coral reefs are immense and varied.

Natural risks such as predation and natural destructive forces such as hurricanes, typhoons and tsunamis have affected coral reefs for as long as they have existed. However, coupled with the increased stress from human activity, coral reefs are finding it increasingly difficult to recover from these disturbances. For a

coral reef to survive such natural disturbances, their rate of growth must be greater than the rate of degradation. However, as the climate alters and storm events such as hurricanes seem to increase in frequency the ability of coral reefs to recover may become compromised.

Predation is again a natural factor of coral reef ecology however, the affects of natural predation may be exacerbated by anthropogenic activities. The crown of thorns star fish (COTS) is currently a major threat to reefs worldwide. Found naturally on reefs these coral predators have shown a dramatic population increase in recent years²⁸, thought to have been assisted by the effects of humans. It is postulated that the over fishing of key starfish predators has led to the sustained increase in the COTS observed within the past decades²⁸. It has also been discovered that plagues of COTS are greater near areas of human activity and it is suspected that the increased nutrient run off into coastal waters near human settlements favours the planktonic larval stages of the COTS, adding to its reproductive success²⁹. Although the reasons for the increase of this natural

predator remain unclear the damage being caused to coral reefs is evident.

Disease just like predation is a natural occurrence in marine habitats but coral reefs have been left more vulnerable to certain diseases because of the damage already sustained to the reef by human disturbance. Recent studies have suggested that marine diseases have increased globally³, the reasons why are not clear but it seems likely that the presence of human activity either by increased pollution, changes in ocean temperatures or over fishing has contributed to the problem. Of these it is thought the affect of climate change is a major contributor to the susceptibility of coral reefs to disease³.

Global climate change threatens the health of coral reefs worldwide. Coral bleaching induced by climate change is considered to be one of the single greatest threats to reefs³, and as the large scale bleaching events of 1998 have proven, can cause large-scale devastation to coral reefs³⁰. Coral bleaching can be caused by a significant rise in water temperatures. This change in temperature causes corals to expel the symbiotic zooxanthellae



The abundance of life sustained by coral reefs is threatened by anthropogenic impacts such as global climate change.



from their tissues, because of the critical role zooxanthella plays in providing corals with enough energy to live and lay down a calcium carbonate skeleton this can result in the death of the coral polyp. Corals' ability to survive and regain their symbiotic algae is dependant upon the severity and longevity of the stressor, if a coral reef is already somewhat degraded its ability to recover from a bleaching event is likely to be substantially decreased³⁰.

While it is true that the global climate naturally fluctuates over time, the accelerated rate of change in environmental conditions caused by global climate change is predicted to make such bleaching events much more frequent and could potentially have great impacts on coral reefs worldwide. Another aspect of the rapid change in climate observed in recent years is the rising level of CO² in the atmosphere, this also results in greater concentrations of CO² in seawater³, which can inhibit the ability of coral to produce the calcium carbonate skeletons on which a coral reef is built.

While such large-scale climatic changes have a variety of indirect impacts on the health of coral reefs globally, there are several more direct impacts that equally threaten the well being of reefs. The extent and type of these direct

pressures vary greatly by region. Over fishing is perhaps the most destructive and widespread of the direct human impact on reefs. Years of over fishing and damaging fishing practices have left the fish stocks around the majority of reefs severely depleted. Years of poor fisheries management has resulted in an unsustainable industry, which has of late felt the impact of declining fish stocks, and often those worse affected are the world's poorest who rely on the protein yielded from the sea to survive. Indeed in some SIDS children are still suffering high levels of malnutrition linked to the reduced intake of protein as a result of the drop in the availability of fish, this trend is observed in the Philippines where over 30% of children under 5 are malnourished⁷.

Over fishing has wide ranging impacts on the ecosystem, in addition to the direct removal of species it can lead to further decline in other fish populations and in the health of the habitats on which they rely. Over fishing of the top predators is an example of this degrading of ecosystem function, by removing species at the top of the food chain the balance that regulates species population numbers is disturbed. This can result in trophic cascades where lower species are released from the normal

predation pressures and their populations can flourish, the continuing effects this can have on the whole ecosystem may be significant. This has been seen in the coastal regions of the Philippines where the abundance of economically valuable species such as groupers and snappers has declined over the past 20 years⁶.

There are many more direct consequences of fishing activities which degrade the health of the reef system, destructive fishing practices such as explosives, poisons and trawling have been widely used until recent years. Despite the ban on many of these activities, destructive fishing practices still occur on reefs throughout the Philippines. The economic gains from destructive methods such as blast fishing can reach

► The populations of many commercially valuable reef fish, such as the coral grouper (pictured) have declined in recent years, having a devastating impact upon fisheries in the Philippines.

**The Coral Grouper,
*Amphiprion ocellaris***





up to 15, 000 US dollars (per 1km² of reef over 25 years)²², however the overall economic losses as a result of habitat degradation over the same temporal and spatial scales may be in excess of 750, 000 US dollars²² the benefits of such destructive methods of fishing are clearly outweighed by the long term negative impacts, both socially and economically.

While the negative impacts of fishing seem obvious, human populations have a number of additional 'direct impacts' on the coastal system. As well as harvesting the sea, coastal populations farm the land adjacent to the coastline. This often involves removing areas of forest to create farm land which can vastly alter the topography of the land. This poorly planned land

use can result in instability in the land surrounding coastal areas, because of this excess sediment can be washed into the sea by rainwater and rivers. This greatly increases the level of sediment in the surrounding coastal area; this sediment can have severely detrimental impacts on corals ability to grow. As corals are so dependant on the



► Destructive and dangerous fishing practises, such as spear gun fishing (pictured) have now been banned in many regions throughout the Philippines.

from fertilised farmland, direct sewage inputs, and chemical waste which is deposited into the sea. The increased organic matter in the coastal waters favours the growth of algae. Once algal growth exceeds that of corals the corals are further smothered and cannot compete for resources, such conditions can cause a phase shift from a coral reef to an algal dominated ecosystem³¹. Such events have been repeatedly observed in the Caribbean³¹. Once a reef becomes dominated by algae the variety of life that can be sustained is vastly reduced and the biodiversity of the area begins to decline.

The affect of anthropogenic activities adjacent to coastal zones is of particular importance in many under developed countries where the population growth rate is often high. The Philippines typifies this problem, the population growth rate is estimated at 1.7% (2007)³² because of this, areas are often developed in haste with little preparation or consideration for the environmental impacts of the development, in the Philippines this results in many problems with intensified land use which is not sustainable.

Coral reefs are exposed to a wide variety of threats, and because of the complexity of coral systems and of the problems that affect them, there is a need for an integrated and considered approach to management. However poor governance and management does itself pose a risk to coral reefs. Developing countries like many of those where coral reefs occur have significant rates of population growth exerting unsustainable pressure on vital coastal resources. Most coral reef countries often lack the infrastructure, finance and efficient capacity to manage the population or the countries natural resources effectively^{6,7}. Politics are also important in the effective management of coastal regions, political regimes have a considerably 'high turnover', when conservation efforts can take up to twenty years or longer to display positive results^{6,33}, political interest may be lost before the end result of protection can be seen. The challenge for the management of these habitats is therefore far greater than the environmental or biological aspects of reef systems, but must also include the social, economic and political issues surrounding the use of coral reef resources.

photosynthetic processes of the zooxanthella a reduction in light quality caused by an increase in particulate matter in the water column can result in decreased rates of coral growth, in effect the sediment smothers the corals and prevents growth.

This smothering affected is exacerbated by increased nutrients which can be washed into coastal waters





Population growth and development in coastal regions puts great strain on coral reef ecosystems

MANAGEMENT

Historically the management of coastal resources in the Philippines and many other SIDS has been minimal or non-existent, and while the pressure upon the coastal region remained minimal traditional methods of resource protection such as the ceasing of fishing activities during certain seasons or temporary no take zones, were sufficient to conserve a productive coastal environment. However in the 1950s the demand for resources derived from coastal habitats in the Philippines began to exceed the productivity of the habitats⁶, largely due to the rapid increase in population and migration to coastal zones, and so began the decline of the resource base. The need for a formal management regime to be enforced was recognised in the 1950-60s, however it wasn't until the 1990s that a national legal management framework was put in place to protect coastal resources⁶.

Currently there are no shortages of laws and policies governing the use of coastal resources in the Philippines^{6,34}, however few are adequately enforced or suitable for purpose^{6,34}. Such top down management systems face a variety of

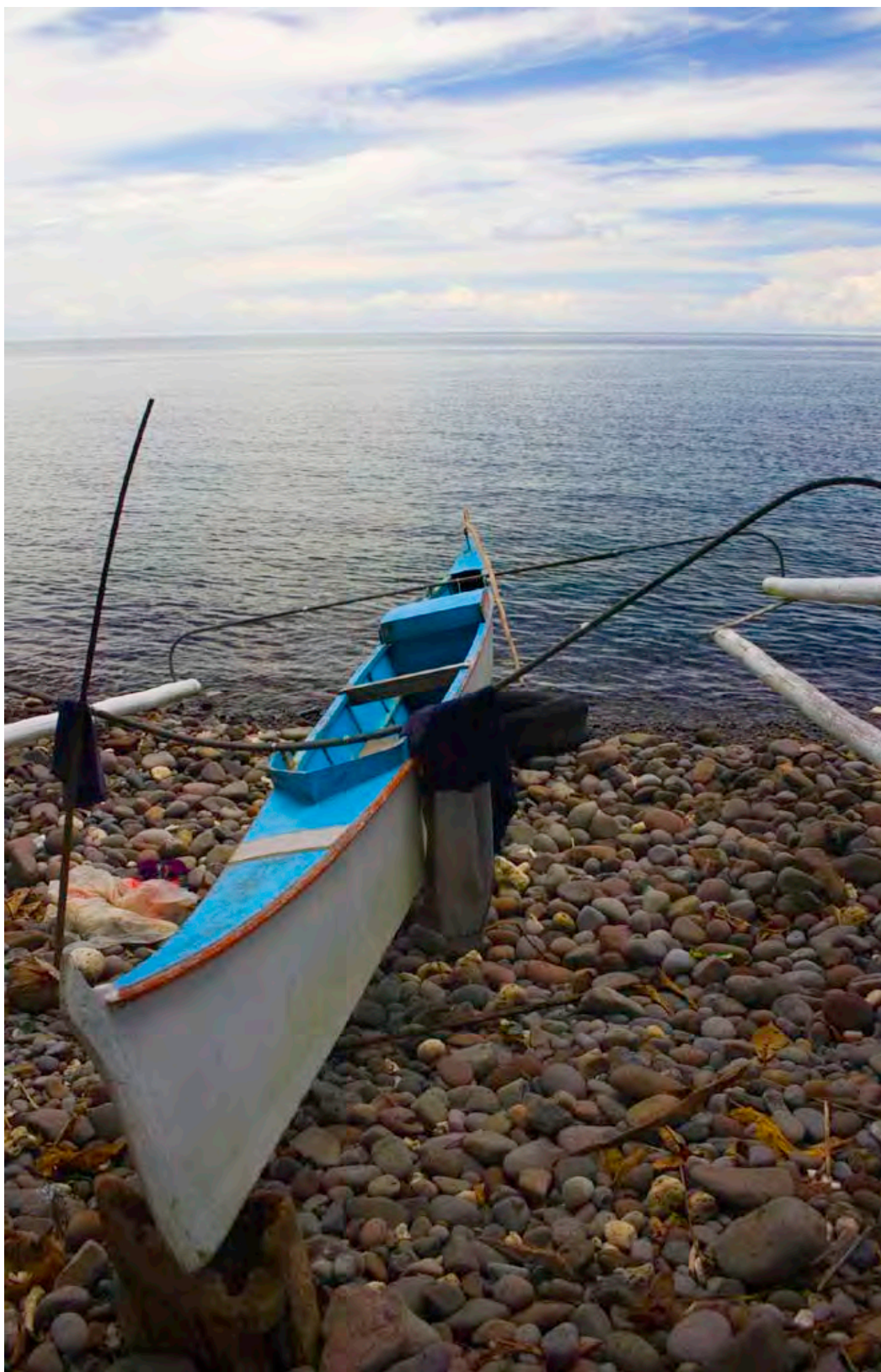
problems, in developing countries such as the Philippines the single sector policies that result from the hierarchy of management are often inappropriate for resolving such integrated and complex issues as those found in the coastal zone³⁵. In addition to this the full implementation of a top down management structure requires considerable funds, an expense which is rarely affordable in developing countries. The result is a poorly supported management system, which is inadequately enforced and ultimately fails to meet its objectives.

This top down management structure is now widely recognised as a redundant method for such wide ranging and complex issues as those found in tropical coastal regions. Instead the need for a change in attitude towards a more collaborative approach to resource management has been recognised worldwide. Collaborative management is the joint responsibility between government and local resource users, to sustainably manage resource use³⁶.

MPA's as a tool in coastal management

An example of a collaborative-based management tool now being widely used in coral reef management throughout the Philippines is the establishment of MPA's. An MPA is an area protected by law, these are strict no take zones where fisheries activities are completely prohibited¹². The potential benefits of effectively managed MPAs are demonstrated in many studies where the size and biomass of the target fish have significantly increased within MPA's¹². There is strong evidence of a spill over effect that occurs from MPA's when fish biomass becomes so great that a proportion of the biomass migrate to areas outside of the protected area. The spill over effect is an important factor in the benefits that MPAs can have for fisheries³⁷ and for increased food security in SIDS that are so dependent on reef based food resources.

In addition to increasing fish biomass the continued protection of MPAs make resources sustainable, which results in further benefits. The improvements in abundance of reef related species within MPAs^{12,37}, and increased coral coverage that has been recorded after a substantial protection



Artisanal small scale fisheries have existed in the Philippines for centuries

period^{12,38}, maintains aesthetically valuable reefs systems. Such habitats can attract large amounts of tourism that can provide a sustainable source of income to the surrounding areas. In the Philippines entrance fees for diving and snorkelling within MPAs are a large source of potential income, however the current lack of appropriate enforcement means that the potential economic gains are not maximised.

A large focus of MPA management is community involvement in the decision making process, it is hoped that through such activities a sense of community ownership and empowerment can be instilled³³. In areas where MPAs have been successfully established this empowerment has led to further improvements in livelihoods. The improved involvement and communication encouraged

by the integrated approach of MPAs has in some cases led to a greater general community cohesion and helped provide a process to resolve general conflicts within the community¹². In many SIDs many of the poorest individuals in the community have been empowered both economically and socially by the opportunities created from MPAs¹². Women in particular have been able to gain employment in



Barracuda are an important food source and a commercially valuable species found on Philippine reefs

high-income jobs such as tourism³³. As well as improving their financial situation it has been found that women once in positions of employment were given a greater voice within community meetings and decision-making processes³³.

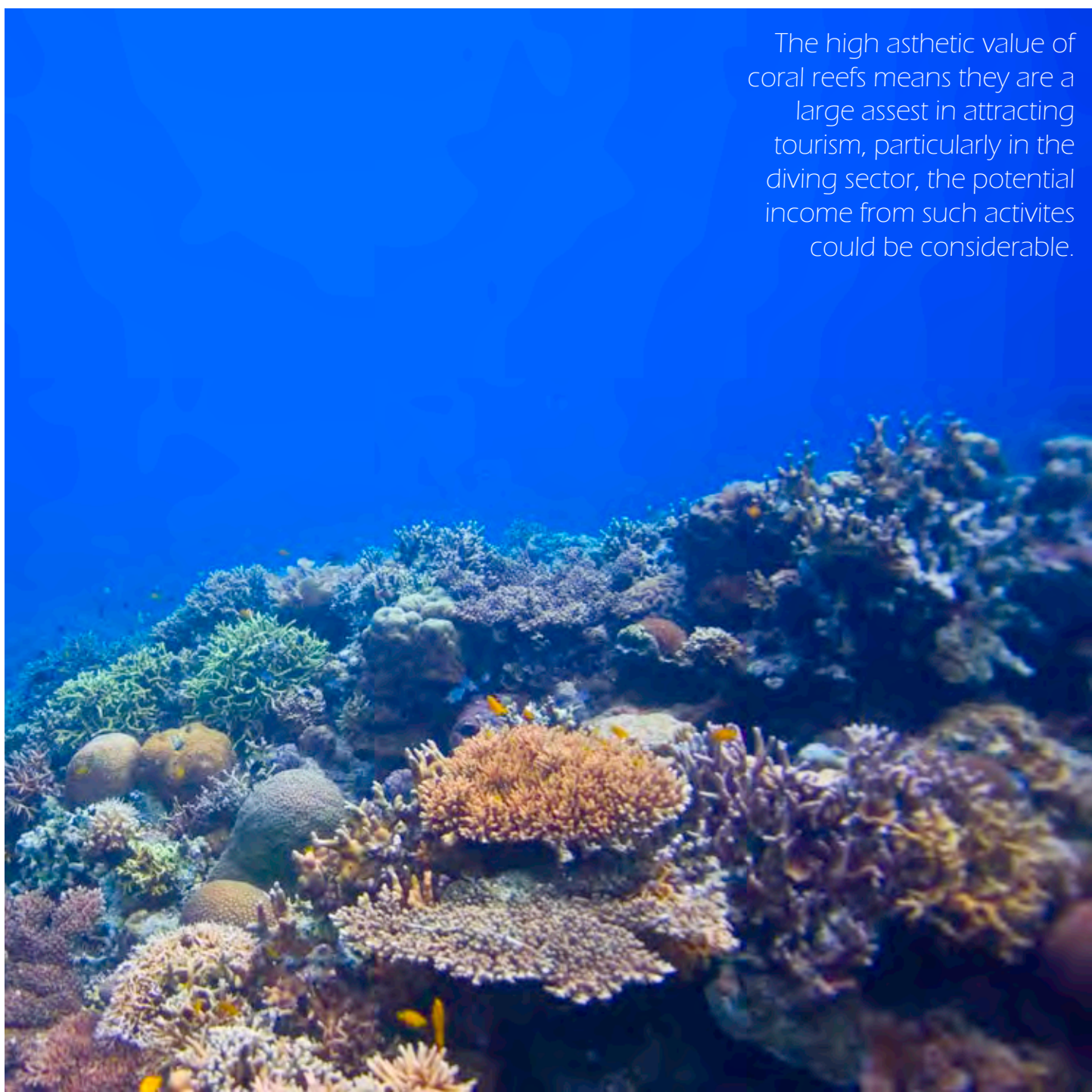
The establishment of MPAs in SIDs has been shown to make a significant contribution to poverty alleviation in the surrounding

areas^{7,33}. In some areas of the Philippines the introduction of an MPA has increased household incomes through elevated fish catch and the introduction of new job opportunities^{7,33}. This has allowed more coastal families to fund their children through school, and the increased income in the community has led to such health benefits as the employment of a full time nurses and midwives³³. An improvement in children's health has also

been observed in areas associated with MPAs due to increased protein intake³³. Improved sanitation and waste disposal has been possible through profits made from entrance fees to MPAs^{12,33}. Such income has also funded fresh water supplies and washing facilities, increasing the overall quality of life for the whole community¹².

The extent to which such benefits can be accrued

The high aesthetic value of coral reefs means they are a large asset in attracting tourism, particularly in the diving sector, the potential income from such activities could be considerable.



through the creation of MPAs is dependant upon the success of the management regime behind the MPA. Over 400 MPA's have been established in the Philippines⁹, however only 20-25% are thought to be achieving successful outcomes³⁴. While it is clear that MPAs can be a successful management tool for improving livelihoods through the conservation of marine resources, it has become apparent that there are certain conditions that aid the success of such initiatives. These include;

- Inputs from the municipal government
- Sufficient baseline scientific data and the continual monitoring of resource base
- Continuing advice from the organisations involved in MPA establishment
- The provision of successful alternative income
- A high level of community involvement
- Communication and education at all levels to address the issues and solutions to resource user conflicts

It is widely accepted that community involvement and perceptions play a huge role in the successes of MPAs in the Philippines. As well as the benefits discussed previously, community involvement is essential to many stages of the MPA process. It has been found that areas with a strong

sense of ownership of local resources have been much more successful in sustainably managing resources³³. This resource user based approach has many benefits; it allows the quick identification of issues in the practicalities of implementing management policies in the field. Having strong links with the resource user base is also of great importance in defining the area set out for protection in the first instance. In SIDs where standard scientific data is scarce the best source of information regarding the health of the resource base is often from those whose daily lives are reliant upon it. This is certainly true in the Philippines where local fishermen and coastal communities are only too aware of the dwindling fish stocks, however without the appropriate mechanisms in place they feel helpless to do anything about it. This is where the empowerment of the resource user to effectively manage their resources becomes so important. A large factor in the community cooperation is the improved education regarding the use of coastal resources. Successful methods of achieving such goals have included free community education days, guided snorkelling activities and the introduction of educational programmes within local schools. Once the community are fully aware of the issues and the procedures necessary

to resolve them a greater support for the CRM process is usually observed. This education is seen as a key tool in the long-term success of coastal zone management, creating a community that is as a whole more environmentally aware should be a major aim of coastal resource management.

While the community may be supportive of the management regime there is still a need to consolidate the initial losses caused by the restricted use of resources, the generation of alternative livelihoods has been identified as a key component in the success of MPAs in the Philippines and many other SIDs⁷. Such alternative livelihoods may involve the establishment of seaweeds farming projects, locally made handicrafts or tourism related jobs^{7,33}. While such alternatives have proven to generate income initially, the long term sustainability of such trades is largely dependant on market demand for products and the cost of inputs for raw materials³³. It is suggested that generation of alternative livelihoods should be used to initially off set the losses of the reduced access to fishery based income, rather than as a long term alternative livelihood. Tourism is perhaps the exception to the rule, if managed in a sustainable way with regard for the environmental



Coconut farming is currently a valuable alternative livelihood for the people of the Philippines

consequences; tourism could potentially be the largest source of income for coastal communities in the Philippines. The challenge lies in enforcing the appropriate legislation and procedures so that the industry remains sustainable.

In the Philippines agriculture is an alternative source of income for many coastal communities, coconut and

rice plantations are common in coastal regions and with the current rise in the market price of such commodities this is a major source of income. Once again this is largely dependant on the market demand for the product and should not be viewed as a long-term sustainable livelihood asset that negates the need for the development of marine based resources.

In addition to the criteria outlined above, basic practicalities such as the location and size of the area under management, has been shown to be of significance in the success of MPAs. Lessons learnt from previous management attempts have shown that small MPAs (approx <16,000 ha), associated with smaller populations, often provide a greater degree of livelihood enhancement^{33,34}.

In the Philippines this recognition has led to aims for establishing a large network of smaller MPAs for the benefit of the whole coastal region³⁸, rather than individual regions. It has also been observed that MPAs are often more accepted by the community when the resource base is already perceived to be in a critical state³⁴.

Once all of these criteria have been fulfilled the need for ongoing support from NGOs, government bodies and local government units

is vital for the management to continue to function effectively. One potential stumbling block for the long-term success of MPAs in the Philippines is political support. The government representation at a local level can change as frequently as every three years¹², the cooperation of the local government is vital in the logistics of collaborative management initiatives, as all community based decisions and processes are traditionally coordinated by local government. MPAs have been shown to need a

minimum of 5 years in the initial stage⁵ and potentially even longer (up to twenty years) before substantial benefits can be observed within the community, therefore the maintenance of political will is necessary throughout changes of regime. It is hoped that continued education and communication can overcome any potential issues of political conflict throughout this process.

With so many factors relating to the success of MPAs the need for communication



and cooperation between all sectors is necessary. However in the Philippines the management structure is often poorly defined¹²; there is no one organisation clearly responsible for the coordinated management of the coastal region. This can lead to misunderstanding and conflict, in some cases up to 50 different government sectors may have an aspect of legal jurisdiction over the coastal areas¹², and several more agencies such as NGOs, academic institutes, and donor agencies participate

in the management regime. With so many different interested parties the process of establishing management initiatives, such as MPAs can be complex and lengthy.

In the Philippines NGOs have largely been the catalyst behind the majority of community based management projects, and the implementation and success of coastal management initiatives in the Philippines are largely dependent upon the involvement of NGOs. In developing countries NGOs have a critical role in providing much of the baseline data required to begin the process of setting up management structures such as MPAs. NGOs also assist with fieldwork and continuing scientific monitoring once management tools are in place as local government units rarely have the finance or skills to do so.

NGOs in the Philippines are also at the forefront of providing education

regarding the use of coastal resources and effective management procedures. However despite the critical role that NGOs play in the success of sustainable coastal management in the Philippines they alone cannot uphold a successful management regime and nor should they. The mainstreaming of coastal resource management into government policies and planning is of major importance if the benefits of resource management are to be sustained, and involvement of organisations at all levels is needed.

MPAs are part of a wider management strategy that can lead to improvements in coastal resources. They typify many of the obstacles and conflicts that can occur over the management of resource use. Strategies used in MPA management to overcome such obstacles, for example increased education and community involvement, are effective methods that can be applied to all areas of resource management.



► New management initiatives are attempting to ensure the local community are actively engaged in the process of coastal resource management.. Focus groups and regular meetings with the local resource users are vital in maintaining efficient communications. Pictured is a focus group conducted with the local women in the village of Napantao, Southern Leyte.

CASE STUDY: CORAL CAY CONSERVATION

Coral Cay Conservation (CCC) is an example of an international NGO which has been active in the Philippines since 1995, working in partnership with the Philippine Reef and Rainforest Conservation foundation. Invited by the provincial government of the Philippines, CCC has been instrumental in the setting up and management of many MPAs throughout the Philippines. Currently the organisation is focused in the Eastern Visayas Region in the province of Southern Leyte. The current project site is based in Napantao overlooking Sogod Bay.

The Southern Leyte Coral Reef Conservation Project (SLCRCP) was established in 2002 with the main aim of recording baseline scientific data regarding the status of the coastal marine resources of Sogod Bay. Sogod Bay contains some of the most pristine reefs in the Philippines yet there has



been very little research into the marine habitats in this area.

Primary objectives of SLCRCP;

- **HABITAT MAPPING**

The collection of baseline data has been carried out in Sogod Bay for the past 2 years. The data is being used to compile detailed habitat maps for use in planning an MPA network throughout the Bay. The monitoring of coral reefs in the Bay can be used to estimate the conservation management values of an area and identify areas that are high priority for the implementation of MPAs.

- **COMMUNITY EDUCATION**

Educational workshops held for teachers and open days for local schools are used to educate the local community in an attempt to increase the awareness of marine issues and instil a sense of local ownership of the marine environment. Educating local resource users regarding the economic and social benefits that can be generated by the establishment of MPAs

is also a major priority of CCC.

- **CAPACITY BUILDING**

CCC plays an important role in training local government units and academics in underwater MPA survey techniques and coastal management issues with the aim of providing the region with skilled persons that will be an important force in maintaining the long-term management of coastal resources.

Advantages of CCC to the coastal management process

- Provides services and training that the local government units of Southern Leyte are unable to afford.
- Encourages regular communication between different sectors.
- An international NGO such as CCC raises the profile of marine related issues both within the Philippines and to the wider global community.

Main Problems Faced by CCC operating in the Philippines

- Funding and availability of



RUNNING AN INTERNATIONAL NGO IN THE PHILIPPINES

resources are a significant problem for CCC within the Philippines.

- Possibly the greatest problem faced by the SLCRCP is the red tape and bureaucracy faced at all levels. The Philippines has many levels of government, each of which has a body with a significant interest in the coastal region, at times the practicalities of arranging communications and correspondence between all of these groups proved to be an insurmountable obstacle.
- An international NGO such as CCC also faces the problem of acceptance from the local community and from the other sector bodies with which it works. In Southern Leyte CCC seem to be very welcome, and the extensive community activities such as snorkelling days and open days for local villagers has no doubt led to the positive attitude towards the presence of CCC.
- Another problem is the rapid change in local politics in the region. Each village elects a new Captain every 3 years; relationships with the captain are essential in maintaining contact with the local community because traditionally meetings and processes are coordinated via the village Captain. Therefore, a change in political will

can have great impacts on CCCs ability to engage with the local community.

CCC in action. The main structure of the field operation in Napantao involves the following components;

The Project Scientist is trained in coastal management issues and is responsible for the co-ordination and planning of science and community activities. The project scientist is also the main face of CCC in the field, attending meetings and giving presentations to the wider community about the objectives of CCC. Science officers are trained biologists responsible for the training of volunteers in correct underwater survey techniques, and the educational activities carried out by CCC. Volunteers undertake surveys of the coral reef habitats in order to provide information on reef health and species abundance used for habitat mapping and resource

assessment.. Volunteers also provide the main source of funding for the project site and the activities undertaken by CCC.

The Community Liaison Officer is a recent introduction to the Philippine project in recognition for the need to integrate coastal management issues with wider social issues. Currently the main focus of the community liaison team is to undertake a detailed socio-economic survey of the region in order to further establish the main issues hindering the process of coastal resource management. Crucial to the activities of the community liaison team is the local interpreter who is not only invaluable in facilitating communications but also in the acceptance of CCC within the local community.

► Underwater surveying and consultation with the local community are two of the main focuses of the work undertaken by CCC in Southern Leyte, (see images)



CONCLUSION

Coral reefs are a critically important habitat for maintaining global species diversity, they are also hugely important in providing food and resources to millions of the world's poorest people. The state of coral reefs worldwide continues to decline, with so many vital roles both biologically, socially and economically there is an urgent need for the improved conservation and management of these valuable ecosystems. This book highlights the need for a community based integrated approach to management, in order to address the complex issues of coastal resource use. MPAs are recognised as a vital and increasingly used tool in coastal management; this study identifies the benefits such initiatives can have for local populations, particularly in SIDS where the finance and resources for large top down management regimes are insufficient. This book concludes that successful management of coastal resources is reliant upon the effective engagement of local communities this can often be achieved through education and capacity building.

While this study has focused on the use of MPAs as a management tool within

the Philippines, the lessons learnt from the management of MPAs can be applied to

the wider context of coastal resource management worldwide. The sustainable



future of coastal resources will depend upon the ability of management regimes to establish local ownership and empower resource users to be instrumental in the effective management of their own resources.

While there are many obstacles to this process, it is vital that all parties involved in coastal resource use, work in collaboration to conserve the world's most biologically diverse habitat, for the benefit of millions of

the world's poorest people who's lives depend upon it.



Coral Reef Silhouette,
Napantao Wall,
Philippines

REFERENCES

1. Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., et al. (1997). The value of the world's ecosystem services and natural capital. *Nature*, 387, 253–260.
2. <http://www.noaa.gov/>
3. <http://www3.aims.gov.au/pages/research/coral-bleaching/scr2004/index.html>
4. White AT, & Vogt HP (2000) Philippine Coral Reefs Under Threat: Lessons Learned After 25 Years of Community-Based Reef Conservation Coastal Resource Management Project, Tetra Tech EM Inc., 5th Floor, CIFIC Tower, Cebu City, Philippines
5. White AT, Vogt HP, & Arin T (2000). Philippine Coral Reefs Under Threat: The Economic Losses Caused by Reef Destruction Marine Pollution Bulletin Vol. 40, No. 7
6. DENR, DA-BFAR, DILG, CRMP, 2001. Philippine Coastal Management guidebook No.1. Coastal Management orientation and overview.
7. Gjertsen H (2005) Can habitat protection lead to improvements in Human Well-Being? Evidence from marine protected areas in the Philippines. *World Development* Vol. 33, No. 2, pp. 199–217, 2005
8. Moberg F & Folke C (1999) Ecological goods and services of coral reef ecosystems *Ecological Economics* 29 (1999) 215–233
9. Crawford B, Balgos M, Pagdilao CR. Community-based marine sanctuaries in the Philippines: a report on focus group discussions. Coastal Management Report #2224, PCAMRD Book Series No. 30, Coastal Resources Center and Philippine Council for Aquatic and Marine Research and Development, Narragansett RI, USA, Los Banos, Laguna, Philippines, 2000.
10. Alcala, A. C. (2001). Marine reserves in the Philippines: Historical development, effects and influence on marine conservation policy. Makati City: The Bookmart Inc. 1
11. Connell, J.H., 1978. Diversity in tropical rain forests and coral reefs. *Science* 199, 1302–1310.
12. DENR, DA-BFAR, DILG, CRMP, 2001. Philippine Coastal Management guidebook No. 5 Managing Coastal Habitats and Marine Protected areas.
13. Roberts, C. M., McClean, C. J., Veron, J. E. N., Hawkins, J. P., Allen, G. R., McAllister, D. E., (2002). Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science*, 295, 1280–1284.
14. Sorokin, Yu I., 1993 (Ed.). *Coral Reef Ecology*. Ecological Studies 102. Springer Verlag, Berlin, pp. 4–28.
15. <http://www.reefbase.org/>
16. Opala A (2003/ Sea Anemones and Anemonefishes: A Symbiotic Relationship
Biol 515 at SDSU
17. Perry, N. 1983. *Symbiosis*. Sterling Publishing Co., Inc., New York, New York, USA.
18. Fautin, D.G. 1991. The Anemonefish Symbiosis: What is Known and What is Not. *Symbiosis* 10 :23-46.
19. Buston, P. 2003. Forcible eviction and prevention of recruitment in the clown anemonefish. *Behavioral Ecology* 14:576-582.
20. Rubec RJ (1988) The need for conservation and management of Philippine coral reefs *Environmental Biology of Fishes* Vol. 23, No. 1-2, pp. 141-154, 1988
21. Dulvy, N.K., Stanwell-Smith, D., Darwall, W.R.T., Horrill, C.J., 1995. Coral mining at Mafia Island, Tanzania: a management dilemma. *Ambio* 24 (6), 358–365.
22. Cesar, H., 1996. *Economic Analysis of Indonesian Coral Reefs*. The World Bank.
23. Barber, C. V. and Pratt, V. R. (1997) *Sullied Seas Strategies for Combating Cyanide Fishing in Southeast Asia and Beyond*. World Resources Institute, International MarineLife Alliance.
24. Birkeland, C., 1997a. *Life and Death of Coral reefs*. Chapman and Hall, New York, p. 536.
25. Floren AS (2003) *The Philippine shell industry with special focus on Mactan, Cebu*. Department of environment and Natural Resources
26. Danielsen F, Sørensen MK, Olwig MF, Selvam V, Parish F, Burgess ND, Hiraishi T, Karunakaran VM, Rasmussen MS, Hansen LB, Quarto A, Suryadiputra N (2005) The Asian Tsunami: A Protective Role for Coastal Vegetation. *Science* 310:643
27. Dahdouh-Guebas F, Jayatissa L., Di Nitto D, Bosire JO, Lo Seen D, Koedam N (2005) How effective were mangroves as a defence against the recent tsunami? *Current Science* 15:12
28. Roberts CM. Effects of fishing on the ecosystem structure of coral reefs. *Conservation Biology*, Vol. 9, No. 5 (Oct., 1995), pp. 988-995
29. Sano, M, Shimizu, M, Nose, Y Changes in structure of coral reef fish communities by destruction of hermatypic corals: Observational and experimental views. *Pacific Science*. Vol. 38, no. 1, pp. 51-80. 1984.

30. T. P. Hughes, A. H. Baird, D. R. Bellwood, M. Card, S. R. Connolly, C. Folke, R. Grosberg, O. Hoegh-Guldberg, J. B. C. Jackson, J. Kleypas, J. M. Lough, P. Marshall,¹⁰ M. Nyström, S. R. Palumbi, J. M. Pandolfi, B. Rosen, J. Roughgarden Climate Change, Human Impacts, and the Resilience of Coral Reefs *Science* 15 August 2003 Vol. 301. no. 5635, pp. 929 – 933
31. McCook LJ Macroalgae, nutrients and phase shifts on coral reefs: scientific issues and management consequences for the Great Barrier Reef. (1999) *Coral Reefs*. Vol18:4
32. <https://www.cia.gov/library/publications/the-world-factbook/print/rp.html>
33. Leisher C, Van Beukering P, Scherl LM. Natures Investment Bank How marine protected areas contribute to poverty reduction. Environment and water resources Australia 2007.
34. Pollnac RB, Crawford BR, Gorospe MLG (2001) Discovering factors that influence the success of community-based marine protected areas in the Visayas, Philippines. *Ocean & Coastal Management* 44, 683-710
35. McClanahan, T. (1999). Is there a future for coral reef parks in poor tropical countries? *Coral Reefs*, 18(4), 321–325.
36. Pomeroy RS (1995) Community-based and co-management institutions for sustainable coastal fisheries management in South East Asia. *Ocean & Coastal Management* 27:143-162
37. Russ GR, Alcala AC, Maypa AP, Calumpong HP, White AT (2004) Marine Reserve Benefits Local Fisheries *Ecological Applications*, 14(2) pp. 597–606
38. Bunce L, Townsley P, Pomeroy R, Pollnac R (2000) *Socioeconomic Manual For Coral Reef Management*. Australian Institute of Marine Science.

LIFE ON THE REEF

