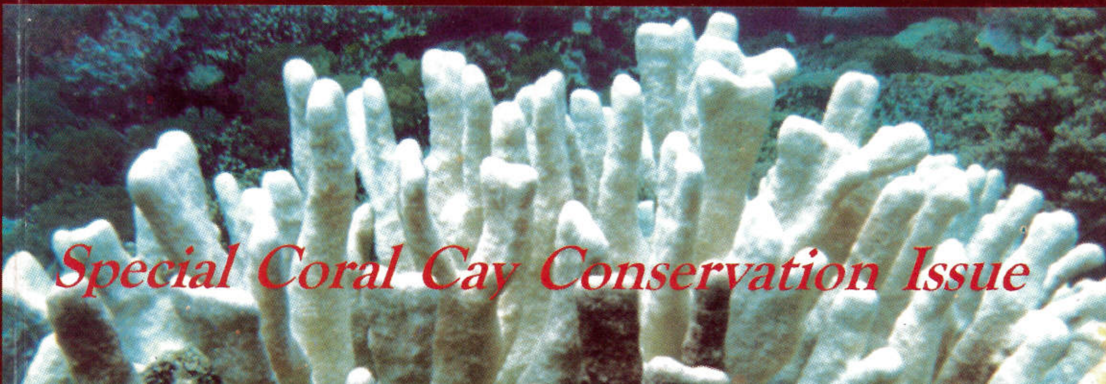
SILLIMAN JOURNAL



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NOTICE TO AUTHORS

The SILLIMAN JOURNAL welcomes contributions in all fields from both Philippine and foreign scholars, but papers should preferably have some relevance to the Philippines, Asia, or the Pacific. All submissions are refereed.

Articles should be products of research, taken in its broadest sense; a scientific paper should make an original contribution to its field. Authors are advised to keep in mind that SILLIMAN JOURNAL has a general and international readership, and to structure their papers accordingly.

SILLIMAN JOURNAL also welcomes the submission of "Notes" which generally are briefer and more tentative than full-length articles. Reports on work in progress, queries, updates, reports of impressions rather than research, responses to the works of others, even reminiscences are appropriate here. Book reviews and review articles will also be considered for publication.

Manuscripts should conform to the conventions of format and style exemplified in this issue. Whenever possible, citations should appear in the body of the paper, holding footnotes to a minimum. Documentation of sources should be discipline-based. Pictures or illustrations will be accepted only when absolutely necessary. All articles must be accompanied by an abstract and must use gender fair language. All authors must submit their manuscripts in duplicate, word-processed double-space on good quality paper. A diskette copy of the paper, formatted in MSWord 6.0 should accompany the submitted hard copy.

The Editorial Board will endeavor to acknowledge all submissions, consider them promptly, and notify authors of its decision as soon as possible. Each author of a full-length article is entitled to 20 off-print copies of his/her submitted paper. Additional copies are available by arrangement with the Editor or Circulation Manager before the issue goes to press.

EDITOR'S NOTES

**Here is a story about a land with a hole in the sky.
The ruin that fell on this land was a poisonous acid that
killed the trees. And only a few things grew in the soil because
it had been spoiled by strange chemicals the farmers used.
Sometimes the people would ask, "Why is it so?"
And the screen in the corner of every room would answer, calmly,
'It must be so.' The people didn't understand.
They forgot the question, and went about their business.
One day a young child woke to a grey morning.
The rain was falling through the hole in the sky,
on the soil where only a few things grew.
And like a line of sad ants,
the people went about their business.
The child was listening when one of the people stopped
and asked, 'Is this really the best way to be?'
And the screen in every room said,
'If you want wealth, fine goods, and luxuries,
you must pay a price. You must pollute the land.
It must be so.' And everybody forgot the question,
and began to wander off. But the child spoke up and said,
'There must be a better way to make the things we want,
a way that doesn't spoil the sky, or the rain or the land.'
And people listened, and switched off the screen,
and went about finding a better way.
The land began to blossom for the first time in a long time.
The sky shone a beautiful blue, and the rain tasted sweet.
It's time that we became the young child
to build a better kind of future.**

— Paul McCartney

IN THIS ISSUE: Once again, Silliman Journal renews its commitment to environmentalism and biodiversity conservation in this collection of conservation reports by the UK-based conservation group, Coral Cay Conservation. But the choice of Paul McCartney's poem to serve as the thematic underpinnings for the collection of conservation reports by his compatriots is purely coincidental. Quite apart from his fame as a Beatles singer, and quite apart from his strengths as a composer, musician, and vocalist who brought to the world the unforgettable lines of "Yesterday" or the poignant "Eleanor Rigby," Paul McCartney is also a sensitive poet with a social conscience whose works, such as this fable that introduces this issue, expose the selfishness, intolerance, and greed that are at the root of accelerating environmental destruction.

But there are still more important reasons why this engaging fable is a particularly apt choice to introduce this issue. Its message encapsulates the irony underlying the fate of the human race that as science and prosperity advance comes not only the possibility of even greater global wealth, but also the capacity to self-destruct. Alain Hervé of the Friends of the Earth in France captured this irony when he said:

> *My personal conviction is that till now man has been both a natural killer and a natural beautifier. It is not enough to say that we are ecologists, nature lovers, advocates of good feelings, pantheist poets. As ecologists, we must know that we are a plague on planet Earth, and that we are going to proliferate up to the point of destroying our own species. To get out of this lethal trap, we have only one chance. We do not need more technological contraptions, more scientific discoveries. We need to reach another level of consciousness.*

In much the same vein, but taking a more confrontational environmentalist stance, the pre-eminent geneticist and social activist, David Suzuki, lambasts society's punishing assault on the planet to critique what he believes is blinding us to the crisis we face:

> *Human beings seem to have forgotten their biological roots. We are animals with an absolute need for clean air, water and soil. In our mistaken belief that we no longer depend on nature's services, we have used air, water and soil as toxic dumps or*

development opportunities. It is suicidal. (author's emphasis)

Paul Erlich succinctly echoes these sentiments when he said: "In pushing other species to extinction, humanity is busy sawing off the limb on which it is perched."

Prior to the World Summit on Sustainable Development in Johannesburg in 2002, the United Nations Environment Program released the third Global Environment Outlook report. Also know as GEO-3, the report provided policy makers with an authoritative assessment of the state of the environment and its implications for all aspects of sustainable development. The report identified not only the most pressing issues, but highlighted the role of humankind in the alteration and destruction of habitats and ecosystem which threaten life on Earth. These are: [1]

- severe water shortages in many parts of the world, and are predicted to increase;
- increasing severity of desertification and land degradation, which in turn is projected to increase the difficulties in producing enough food for the Earth's growing human population;
- the disappearance of the Earth's forests;
- dramatic decrease in biodiversity and genetic resources as species become extinct;
- seas becoming deserts due to overfishing;
- crisis levels of urban air pollution in many megacities in the developing world;
- increasing threat of chemicals on human health;
- drastic consequences of climate change causing more frequent and more severe environmental disasters;

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1 *http://www.unep.org/GEO/geo3/*

- increasing concentration of carbon dioxide in the atmosphere;
- growing destabilization of the global nitrogen cycle.

Singled out by GEO-3 as the root causes of global environmental degradation are the social and economic problems such as pervasive poverty, unsustainable patterns of consumption and production, and vast and increasing inequities in the distribution of wealth. Speaking at the opening of the World Summit in 2002, Klaus Toepfer, Executive Director of United Nations Environment Programme, pointed out:

> *Our world is characterized by divided and dysfunctional cities, dwindling water supplies, and potential conflict over scarce resources and the accelerating loss of the environmental capital that underpins life on Earth. We suffer from problems of planetary dimensions. They require global responses. Investing in sustainable development will be investing in the future security of us all.*

However, despite considerable efforts and significant achievements since the Rio "Earth Summit" more than a decade ago, the latest readings, according to the UN Secretary General, "reveal a planet still in need of intensive care." Poverty, pollution and population growth; rural poverty and rapid urbanization; and wasteful consumption habits and growing demands for water, land, and energy continue to place intense pressures on the planet's life support systems, threatening our ability to achieve sustainable development. In every gathering that has the environment in its agenda, observers of the natural environment are increasingly speaking in one agitated voice that the major challenge of our age is how our growing numbers and technological power can live in harmony with the natural world. The same voice has stressed time and time again the necessary combination of scientific and traditional knowledge, technical skill, management ability, consumer pressure, and political will to get the world's economy back to sustainability. According to Kofi Annan, only with a greater sense of mutual responsibility will it become possible to protect the environment.

Conscious of these grim realities and sharing these concerns, Silliman Journal has committed itself to keeping environmental issues high on its publication agenda. For the past several years, consecutive special issues have focused on various environmental and conservation initiatives which highlighted the risks of unrelenting abuse of the fragile ecosystem. At the same time cognizant of the importance of hard scientific evidence, Silliman Journal endeavors to get the results of scientific studies and researches on the environment out to the public to show why they are relevant to people's lives. Each time, it faces the challenge of finding new and compelling ways of presenting these results. In connecting poetry and social conscience, Paul McCartney's poem reflects this thrust and allows Silliman Journal another way of reaching out to audiences of varying backgrounds.

But even more important, this fable is a fitting illustration of the view that the urgent task of rehabilitating the planet is no longer the preserve of biologists or conservationists or experts on the environment, but that of every woman or man, young and old alike, who shares the resources of this world. And while we cannot hope to duplicate the inimitable style of Paul McCartney in raising awareness of the importance of the environment to all our lives, myriad opportunities for involvement are available for us if we care deeply and demonstrate a willingness to take personal responsibility to make a difference, even if only to plant a single tree. In the words of Richard St. Barbe Baker,

> *It is not merely that the world is bettered by saving, replacing, and multiplying trees. It is that an aim of this kind becomes an impulse towards developing a mood and an outlook which will increasingly make it natural to think for the future, for other people, for generations yet unborn. Planting a tree is a symbol of looking-forward kind of action: looking forward, yet not too distantly.*

As the Chinese Proverb reminds us: "If I keep a green bough in my heart, the singing bird will come."

Sharing the vision of the UNEP that a comprehensive and coherent international approach to the implementation of sustainable development must include the involvement and partnerships both within the different sectors of governments as well as between governments and major groups, Coral Cay Conservation pursues its own goals through a pioneering volunteer participatory scheme that involves collaboration with both private and public sectors, educational institutions, expertise-specific voluntary initiatives, and community participation. A driving force underpinning the conservation work of CCC is the realization that partnerships are key to realistically pursue sustainable development.

The articles in this collection, like the rest that have been featured in our special conservation issues have so far functioned like subject headings in a book that everyone must all write together, with actions rather than words. Most importantly, by beginning within ourselves, we can be the change we want to see today, for a cleaner, healthier, more sustainable environment. With this commendable initiative, Coral Cay Conservation has provided an inspiring introduction. It is hoped that through the publication of this collected works, people may be inspired to make the changes in lifestyles and in government policies that are necessary for a healthier, safer, and more equitable future for humankind.

Many thanks to Craig Turner, Director of Terrestrial Science of Coral Cay Conservation, and his colleagues at CCC for being wonderful collaborators in this project. Our greatest appreciation we reserve for our reviewers and referees whose perspicacious judgment, critical insight, and broad range of knowledge have been matched only by the depth of their commentary and the generous time they poured on these manuscripts.

If you want to build a ship,
don't herd people together to collect wood
and don't assign them tasks and work,
but rather teach them to long for the endless immensity of the sea....
~ Antoine de Saint-Exupéry

Ceres E. Pioquinto

PREFACE

Until one is committed, there is hesitancy, the chance to draw back, always ineffectiveness. Concerning all acts of initiative and creation, there is one elementary truth, the ignorance of which kills countless ideas and splendid plans: that the moment one definitely commits oneself, then providence moves too. All sorts of things occur to help one that would never otherwise have occurred. A whole stream of events issues from the decision, raising in one's favor all manner of unforeseen incidents, meetings and material assistance, which no man could have dreamed would have come his way. Whatever you can do or dream you can, begin it. Boldness has genius, power and magic in it. Begin it now.

~ Johann Wolfgang von Goethe (1749-1832)

Coral Cay Conservation (CCC) is a not-for-profit, UK-based NGO. Founded in 1986, Coral Cay Conservation is dedicated to 'providing resources to help sustain livelihoods and alleviate poverty through the protection, restoration, and management of coral reefs and tropical forests' in collaboration with government and non-governmental organizations within a host country. CCC is associated with the Coral Cay Conservation Trust, the UK's only charity dedicated to protecting coral reefs and tropical forests, and the livelihoods of the people who depend on them (UK registered charity no. 1025534).

CCC's programs combine marine and terrestrial resource data collection with raising local environmental awareness while also providing capacity building in SCUBA, marine, and terrestrial organism identification, as well as surveying skills through counterpart training and scholarships. CCC operates by using teams of international volunteers to conduct tropical resource assessments with the primary aim of providing a baseline of data to facilitate habitat management and the development of natural resource management tools. The projects are self-financed through a pioneering volunteer participatory scheme whereby international volunteers are given the opportunity to join a phase of each project in return for a financial contribution towards the project costs. Volunteers receive full training from qualified and experienced field staff prior to assisting in the acquisition of data. Such a mode of operation enables the program to provide resources necessary in extending a range of services, including data acquisition, assimilation and synthesis, conservation education, technical skills training, and other capacity-building programs, all at minimal cost to the host country counterparts, who form a partnership with CCC.

CCC has been successfully operating collaborative conservation projects in the Caribbean since 1986 and in Southeast Asia since 1995. Initially working in the Philippines, CCC developed further coral reef and tropical forest projects both within other parts of the Philippines and the neighboring countries of Indonesia and Malaysia. Current projects in the Southeast Asian region are located in Pulau Perhentian and Pulau Redang, Malaysia, and in the provinces of Southern Leyte and Negros Occidental in the Philippines. Future operations are considered for Sabah, East Malaysia, and two locations in the Philippines, Palawan and Southern Luzon, where previous projects operated.

Since 1995, the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) and CCC have successfully cooperated in implementing programs supporting sustainable resource use and community based coastal zone management. The main aims of these activities were to undertake a resource assessment, raise environmental awareness among local people, and build capacities both educational and practical to implement the management schemes recommended as a result of the scientific assessment. The first such collaboration was conducted at Danjugan Island, Negros Occidental, between 1995 and 1998. The island's coral reefs and other shallow sub-tidal habitats were extensively surveyed by CCC volunteers to build up a comprehensive baseline dataset. Subsequent analysis led to recommendations for zoning and management of the marine resources around Danjugan Island. Concurrent marine education workshops conducted by PRRCFI for the local communities raised environmental awareness while the training provided by CCC for counterparts established a number of marine wardens qualified in scuba diving and marine survey techniques. In February 2000 the island was designated as National Marine Reserve and Wildlife Sanctuary. In recognition of the conservation achievements in the area, the Philippine government awarded the Danjugan project the 'Best Managed Reef Award' in 2001.

Following the initial success of the project at Danjugan, PRRCFI and CCC initiated similar projects in Southern Negros and Palawan. PRRCFI established the Southern Negros Coastal Development Project (SNCDP), a government-assisted program to accommodate coastal zone management and sustainable resource use in Southern Negros. Run in conjunction with the PACE program (Poverty Alleviation and Conservation Education), the aim was to develop and establish a prototype for an alternative approach to establishing integrated coastal management. Operating on voluntary community involvement, the program aims to instill an appreciation of the natural resources and establish a foundation for their sustainable use, as well as set up an inventory of resource data. Between 1997 and 1999, CCC undertook the inventory of resource data through the use of volunteer surveyors. As a result, a number of marine reserves in six municipalities in Southern Negros have been recommended for designation as integrated coastal management areas.

Another collaborative initiative between the PRRCFI and CCC was the Taytay Bay Conservation Project (TBCP) in northern Palawan. A pilot phase was conducted between July and September 1998 in conjunction with the University of Essex and the TBCP was fully established in April 1999. Although considerable progress was made in baseline data collection and in community education and training, the project was postponed in late 1999 for security reasons. Nevertheless, the potential exists to return to Palawan and continue this work.

Subsequent projects in the Philippines have also been undertaken at Anilao, Southern Luzon and in Sogod Bay, Southern Leyte. Between January and August 2002, CCC divers gathered information on the coastal and marine resources of the Anilao area (the Mabini-Tingloy Municipalities, Southern Luzon, Philippines) as part of the Mabini-Tingloy Marine Biodiversity Conservation Project (MTMBCP) in partnership with PRRCFI and WWF-Philippines. As the data revealed a considerable degree of both benthic habitat and coral diversity, the need to increase the number and range of marine protected areas within the region has been seriously considered.

Current Filipino CCC projects are the Southern Leyte Coral Reef Conservation Project (LRCP) and the Negros Rainforest Conservation Project (NRCP). LRCP was initiated in September 2002 in collaboration with PRRCFI and the Provincial Government of Southern Leyte (PGSL). The project is based in Sogod Bay, Southern Leyte Province in the Eastern Visayas. In addition to the implementation of a comprehensive marine surveying program, considerable progress with environmental awareness and training has been made. CCC, local universities, plus various local and national government bodies are presently collaborating to create a coastal management plan for the region.

Established in 1998, the NRCP is a joint program of cooperative research, education, and training between the Negros Forests and Ecological Foundation, Inc. (NFEFI) and CCC. The project is situated in the North Negros Forest Reserve (NNFR), Negros Occidental. The primary scientific objectives of the project are to collect biodiversity inventory data and conduct complementary ecological research on species involved in the NFEFI species recovery program to aid in-situ conservation initiatives. In addition, the project has also been working with the Provincial Environment Management Office to produce satellite-derived habitat maps for the watershed area where the project is focused. The objective is to combine spatially based biodiversity data with the mapping information and use them as basis for resource management planning. In conjunction with the empirical fieldwork, the NRCP has also assisted NFEFI with local environmental awareness and community extension initiatives, thus facilitating the future engagement of all stakeholders in local natural resource management planning.

In addition to the work in the NNFR, the NRCP has also worked with PRRCFI on Danjugan Island (Negros Occidental), producing some of the first detailed biodiversity information on the terrestrial habitats. Future surveys and training are being planned to aid PRRCFI in its objective to protect and sustainably manage an area that has now been designated a marine reserve and wildlife sanctuary.

Coral Cay Conservation's nine-year presence in the Philippines has demonstrated that volunteer efforts and participation, coupled with the involvement of professional practitioners in the field, play an immensely important part in wildlife conservation today. Similarly, CCC's experience continues to demonstrate the significance of continued local support and research collaboration for the success of conservation efforts. The scientific outputs that are featured in this edition of Silliman Journal highlight the importance of this collaboration. Through partnership and collaboration, and the continued involvement of volunteers and local communities, CCC will continue to assist in the protection and conservation of the Philippine's biodiversity.

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EFFECTS OF 1998 BLEACHING EVENT ON A LARGE PAVONA CLAVUS COLONY IN A PHILIPPINE MARINE PROTECTED AREA

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Terence P. Dacles, & Peter S. Raines

ABSTRACT

In September 1998, with water temperatures at 31^0 Celsius, the initial bleaching event spread over the whole of the Visayas region. Bleaching reduced much of the live coral at Danjugan Island to dead coral covered with filamentous algae within six months. Acropora spp. corals associated with the Pavona colony were most susceptible to bleaching. This same colony suffered live tissue loss in shallow (6m) areas. The original live coral cover of 80% was reduced to approximately 5%, with dead coral heads subsequently covered by filamentous and macroalgae.

Over two years the team from the Coral Cay Conservation investigated the effects of coral bleaching on a single colony of *Pavona clavus* at three depths at Danjugan Island, Negros Occidental, Philippines. Repeat monitoring of the area showed considerable recovery of *Pavona clavus* at medium depths (around 12m) from totally bleached live coral tissue cover to 88% healthy pigmented tissue by August 2000. This study highlights the important effect that depth at one site can have on coral bleaching and subsequent recovery within a single species of massive coral.

Introduction

Bleaching has been described as the whitening of corals (and other invertebrates) as a result of the loss of zooxanthellae from the coral/invertebrate host, or a decrease in photosynthetic pigment concentration residing in the host animal (Glynn, 1993).

Post-bleaching is the most critical period for corals as they lose the ability to synthesize carbohydrates from photosynthesis and rely solely on predatory feeding by the coral polyps (Wilkinson *et al.,* 1999). This process normally results in significant stress for the coral colony as they lose around 80% of the photosynthetic product (sugar) and carbon acquisition provided for them by the zooxanthellae (Muscatine, 1990; Sebens, 1987). Inter- and intra-specific variability in zooxanthellate species and temperature tolerance levels result in different susceptibilities of coral species to bleaching, given the same environmental parameters (Marshall and Baird, 2000; Jones, 1997). Different tolerance regimes within the coral host and zooxanthellae can lead to disparate patterns of bleaching on a spatial scale of kilometers during some bleaching events.

Depth has also been cited as having a significant impact on the severity of bleaching events within sites (Glynn *et al.,* 2001) as apparent thermoclines in the water column, and the lack of UV penetration to deeper waters can reduce bleaching effects on deeper corals. It has, however, been difficult to accurately test these hypotheses in the field, due to the patchy nature of coral communities, and geno- and phenotypic variances between colonies of the same species. This study is unique in that the experimental colony is the same (one large *Pavona clavus* colony), and may indeed be an individual of the same genotype as the framework appears to be contiguous throughout the area of the colony. If this indeed were an individual colony (approx 15m basal diameter by 15m height), the variable of genotypic separation between different individuals of the same species would be eliminated (Hoegh-Guldberg, 1999).

The global coral bleaching event of 1998 was a well-documented phenomenon (Hoegh-Guldberg, 1999; Wilkinson, 2000), and highlighted the effects of increased Sea Surface Temperatures (SSTs) on the susceptibility of different species of corals to bleach (Marshall and Baird, 2000). Some studies surveyed and monitored post-bleaching benthic community dynamics including competition between corals and algae (Diaz-Pulido and McCook, 2002). However, the Philippines has seen little published material on the effects of bleaching at both national and local levels, and especially studies concerned with recovery since the initial bleaching took place in August 1998. One study carried out from Silliman University in Negros Oriental revealed that bleaching in and around Bolinao in the central Visayas was nationally seen to be one of the worst areas affected by the increased Sea Surface Temperatures (SSTs), with 80% of corals bleached (Divinagracia, 2000 *in* Burke *et al.,* 2002). A study over a wide range of locations in the Philippines revealed that species of *Acropora, Pocillopora, Porites,* and *Pavona* were severely affected by the bleaching in areas as widespread as Tubbattaha, Bolinao, the northern Palawan shelf, and the Kalayaan Island group (west of Palawan) (Arceo *et al.,* 1999). Studies carried out at Apo Island after the 1998 bleaching event showed limited survival of established colonies (particularly *Galaxea fascicularis*), and that post-bleaching recruitment of this species has been limited. Branching *Acropora* has dominated shallow-water recruitment at Apo since the bleaching event (Raymundo and Maypa, 2002 & 2003). Findings from published literature revealed that members of the *Acroporidae* family were most susceptible to bleaching during 1998 in the Philippines (Arceo *et al.,* 1999).

It is important to quantify the recovery of the 1998 as well as the successive bleaching events that may occur on Philippine coral reefs. The unpredictable nature of both the spatial and temporal patterns of bleaching on these reefs makes assessment and monitoring of recovery that much more important (Westmacott *et al.,* 2000). Simple and effective monitoring methods can quantify these changes, while subsequent data can help with management decisions on how 'robust' a coral reef can be to withstand the effects of temperature increase. Resistance or otherwise to bleaching effects in the future may have a large part to play in determining zoning patterns in and around marine parks (Goreau *et al.,* 2000).

Methods

Our investigation recorded the effects of bleaching on one particularly large colony of *Pavona clavus* at Danjugan Island, Negros Occidental, Philippines (Fig. 1). Located west of Negros Occidental within the Western Visayas region of the Philippines, Danjugan Island supports extreme biodiversity of hermatypic corals (Fenner, pers. comm.), with 377 species recorded in eight months of subtidal survey work (Gill *et al.,* 1996).

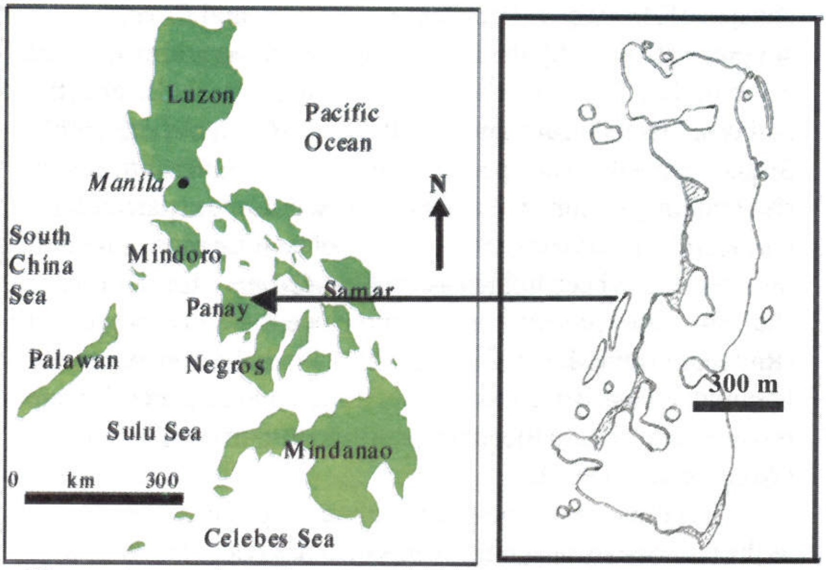

Figure 1. Location of Danjugan Island off the western coast of Negros Occidental, Philippines.

The *Pavona clavus* colony lies in waters between 6m and 22m depth. The basal diameter of this colony is estimated to be around 10m, tapering up to a pinnacle at 6m depth with a diameter of approximately 2-3 meters. The coral mound is not entirely monospecific and has other colonies growing over it, particularly near the upper surface where a large (1m wide at the base, and 1m tall) *Hydnophora pilosa* is dominant. There are also forms of the *Acroporidae*, *Montiporidae*, *Faviidae*, and *Poritidae* families attached to this colony. Most of this *P. clavus* colony can be described as massive in overall structure, with columnar sub-massive fists of between 2 and 20cm radius extending vertically from the main colony interior.

Percent cover data were recorded in three replicate 1m^2 quadrats at three depths – 6, 12 and 18m (lowest low water below chart datum). Permanent quadrats (made of welded iron reinforcement bar) were placed on the reef in September 1998, two weeks after the onset of the bleaching at Danjugan Island was first witnessed (Harding, pers. obs.). Quadrats were attached to the substratum using plastic cable tied at each corner, which were attached to dead coral. The quadrats were surveyed and photographed at the following time intervals:

- September 1998 (2 weeks into the bleaching event);
- February 2000 (18 months post-bleaching);
- August 2000 (24 months post-bleaching).

Categories recorded from each quadrat included healthy coral, bleached coral, rock, rubble, sand, other, algae (divided into groups – filamentous and macroalgae). All percent cover estimates were validated from photographs after being recorded *in situ* on waterproof slates. Volunteer divers collected quadrat information and water temperature. These surveyors were all trained in standard data collection techniques, and were tested in the classroom and *in situ* prior to collecting quadrat data (see Mumby *et al.*, 1995). Percent cover data were arcsin-transformed and subsequently analyzed (2-way ANOVA) for temporal and depth-related differences in cover.

Results

Coral and other cnidarians were bleached to a depth of 25m at a number of sites around Danjugan Island. Water temperatures reached 31^{0}C during August and September 1998, but never exceeded 30^0 C between October 1998 and August

2000 (temperature was recorded by calibrated thermometers). It appears that there was a mixed bleaching effect on hard corals around Danjugan Island which varied according to the species composition of sites coupled with the depth of the colonies (Table 1 and Fig. 2). During the bleaching event itself (August-September 1998), it was evident that increased depth resulted in a greater cover of remaining healthy coral (6m – 0% healthy corals; 12m – 4% healthy corals; 18m – 11% healthy corals) (Fig. 3).

Furthermore, different areas of each individual *P. clavus* column showed different susceptibilities to bleaching at varying depths (Fig. 2). In the shallow areas (6m), all areas of the coral were bleached (Figs 2A and B). However, in deeper waters (12 and 18m), corals bleached on the upper most surface of the individual columns but remained healthy (pigmented) on vertical walls (Fig 2C and D).

Figure 2. *Pavona clavus* at 6m in September 1998 (A), and the same quadrat August 2000 (B) – shows the change from bleached coral to dead coral covered by filamentous and macroalgae; image (C) shows the effect of bleaching at medium depth (12m) on the same colony (August 2000) – note the effect of bleaching only on the upper surface of colonies; and image (D) is of the bleaching effect on the colony at 18m (August 2000) – this photo shows the macroalgae community at this depth (*Lobophora variegata*), and bleaching only on upper surface of the *P. clavus* colonies.

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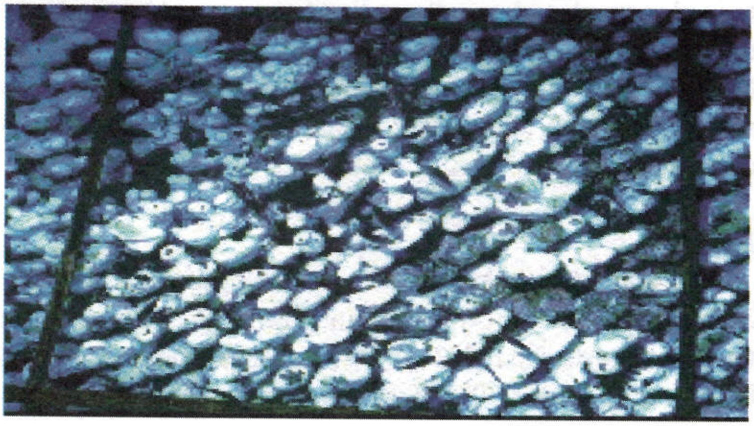

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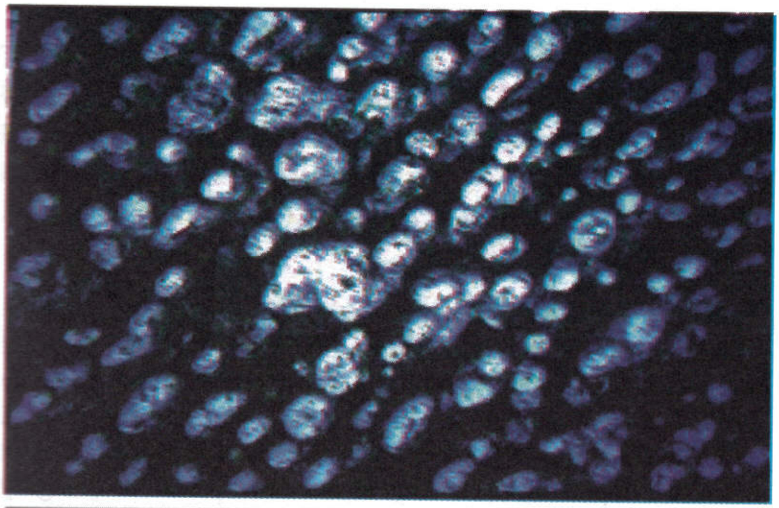

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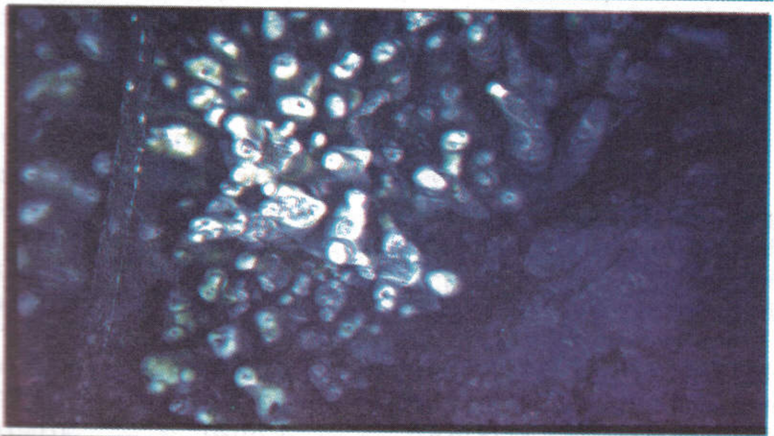

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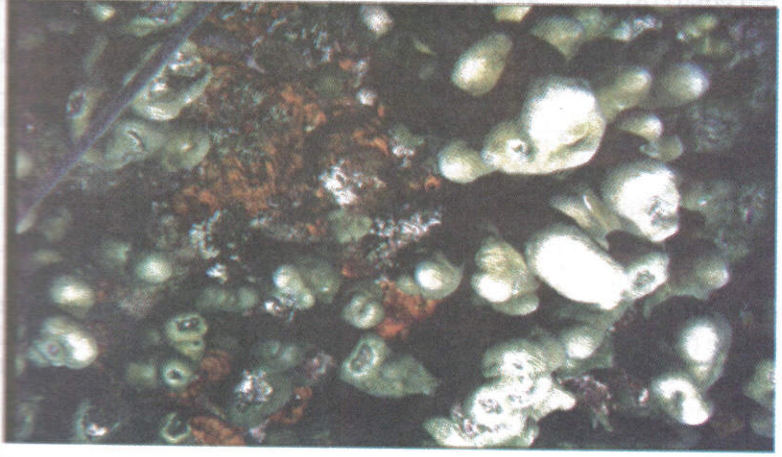


Depth was a significant factor in the post-bleaching recovery of the *Pavona clavus* colony. Areas of the colony at 12m and 18m were ultimately less affected by bleaching (from 85% healthy coral pre-bleaching, to 68.7% cover after 2 years at 12m) than areas in the upper 6m (from 80% healthy coral cover down to around 15%) (2-Way ANOVA, $F = 7.38$, $P < 0.024$).

Table 1. Mean percent cover (±SD) values of key benthic categories between time and depth after the initial bleaching event on the *P. clavus* colony. The relationship between depth and time and each benthic category was investigated using a 2-Way ANOVA on arcsin transformed percent cover data. * Indicates significant difference in percent cover over time for that particular category (ANOVA, $P < 0.05$). $^{\Psi}$ Indicates a significant difference in percent cover between depths (ANOVA, $P < 0.05$) for that category.

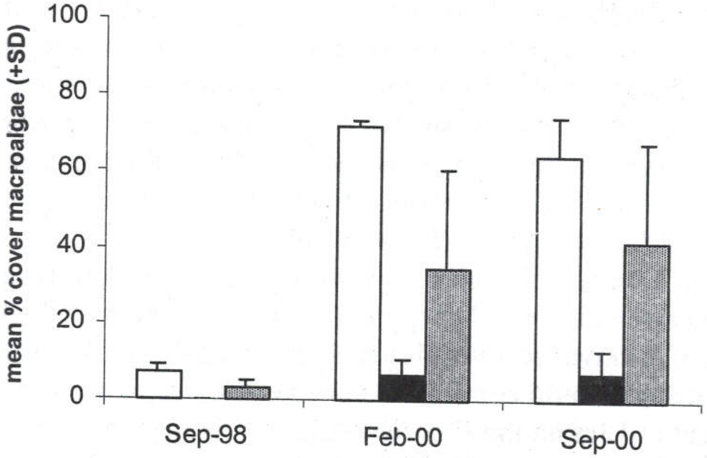
	TIME (post bleaching)		
	August 1998	February 2000	September 2000
Category (DEPTH)	%(±SD)	%(±SD)	%(±SD)
Healthy coral (6)	0.0(0.0) *$^{\Psi}$	2.5(0.7)* $^{\Psi}$	15.0(13.8)* $^{\Psi}$
Healthy coral (12)	4.0(3.5)* $^{\Psi}$	45.0(5.0)* $^{\Psi}$	68.7(8.1)* $^{\Psi}$
Healthy coral (18)	10(15.49)*	25.7(29.9)*	30.0(34.7)*
Bleached coral (6)	83.0(11.0)*	0.0(0.0)*	0.0(0.0)*
Bleached coral (12)	86.7(11.6)*	3.3(2.9)*	0.3(0.3)*
Bleached coral (18)	81.0(16.4)*	1.7(0.6)*	0.0(0.0)*
Bare rock (6)	2.0(1.0)*	7.5(1.0)*	20.0(10.0)*
Bare rock (12)	4.0(3.5)*	6.7(3.5)*	10.2(8.5)*
Bare rock (18)	1.7(2.9)*	3.0(2.7)*	11.0(10.2)*
Rubble (6)	0.0	0.0	0.0
Rubble (12)	0.0	0.0	0.0
Rubble (18)	0.0	3.7(6.4)	5.7(8.1)
Filamentous (6)	8.0(3.0)*	18.0(0.0)*	0.7(0.6)*
Filamentous (12)	5.3(4.6)*	11.3(10.3)*	0.2(0.3)*
Filamentous (18)	4.0(1.7)*	20.0(14.8)*	3.0(1.0)*

Macroalgae (6)	7.0(2.0)*$^{\Psi}$	72.0(1.7)*$^{\Psi}$	64.3(10.2)*$^{\Psi}$
Macroalgae (12)	0.0*$^{\Psi}$	6.7(3.8)*$^{\Psi}$	7.3(6.1)*$^{\Psi}$
Macroalgae (18)	3.0(2.0)	34.8(26.1)	41.7(26.0)

In September 1998, the deep (18m) sample site showed 80% bleached coral, with 11% remaining unaffected. Healthy coral cover from this depth increased from 11% in 1998 to 30% by August 2000.

The proportion of bare rock increased significantly over time at all depths, and particularly so in shallow depths. This is likely to have been caused by increased herbivorous fish grazing at shallow depths on this colony before and after bleaching (Table 1).

The relative tissue recovery of the *P. clavus* colony at different depths over the sampling period had a significant impact on the colonization of algae after the initial bleaching event (Fig. 3). At 6m, bleaching was succeeded by a 57% increase in macroalgae cover after two years. This resulted in macroalgae cover of 64.33% of the benthos (August 2000) compared to an original cover of 7% (September 1998) at 6m. At medium (12m) depths, the cover of macroalgae increased from 0 to 7.33% over the whole sampling period, which was significantly less than at shallow depths (2-Way ANOVA, $F = 5.91$, $P < 0.0001$). At the deep site (18m), macroalgae cover increased from 3 to 41.67% over the 2-year sampling period while filamentous algae increased from 4% to 20% cover at 18m by February 2000, and then decreased considerably by August 2000, indicating either some form of succession within the benthic community or possible grazing effects.



Discussion

The severity of the bleaching event witnessed in this study was comparable to that observed in other areas of the Southeast Asian region and wider Indo-Pacific (Burke *et al.*, 2002; Wilkinson, 2000). However, the recovery of deeper (>10m) coral appears to be encouraging. Although significant areas were heavily bleached in the initial August event, deeper corals went on to regain pigmentation (zooxanthellae) by the end of the sampling period. Shallow branching, and even massive species such as *Diploastrea heliopora* and massive *Porites* spp. were almost totally bleached around Danjugan Island, yet much of the coral tissue regained zooxanthellae pigmentation in the early stages of the two year monitoring period (in fact, within the first four months).

Areas that had monospecific massive stands of corals, such as at shallow Hilary's reef on the east coast of the island (with *P. clavus* colonies being monospecific), showed overall bleaching patterns where both the apical and vertical surfaces of colonies were totally bleached. In deeper waters some of the sub-massive stems regained pigment almost immediately, but predominantly on the vertical surfaces. The pattern of bleaching on the apex of colonies, and not on the vertical walls, is likely a result of increased Ultra Violet (UV) light penetration during periods of very calm weather on coral reefs (Fisk and Done, 1985). In these circumstances the upper tips of rounded colonies, such as *P. clavus*, and larger *Porites lobata* colonies, are more exposed to UV than the adjacent vertical surfaces and polyps, making the former more susceptible to bleaching (Brown, 1997).

What appeared to change throughout the monitoring period (at medium and deep depths) was that the bleached areas of *P. clavus* recovered sufficiently such that the colony at this depth could continue to survive. This is particularly evident at 12m on the *P. clavus* colony (Fig. 3). There was also some recruitment of coral at the 12 and 18m depth areas, principally of *Acropora* species, but also of *Galaxea fascicularis*, *Pocillopora*, *Seriatopora,* and some *Fungiid* species.

Other species of corals with more delicate growth structures, such as branching bottlebrush *Acroporaidae,* were more susceptible to bleaching at similar depths than the *P. clavus* colony (Solandt, pers. obs.). *Acropora* spp. fared worse after the bleaching event and have been observed to be more susceptible to bleaching than more massive species of the genera *Porites*, *Favia*, *Pavona,* and other massive species (Baird and Marshall, 1998).

Algae growing on bleached colonies increased in cover within the first year due to the free space available on the bleached coral. After one to two years, most of the algal species and biomass that had colonized the recently dead coral were absent. Fish herbivory increased as the quantity of ephemeral algae settling on the substratum increased (Solandt, pers. obs.). Consequently, there was a reduction in the cover of these species of algae and the recruitment and growth of more structurally complex macroalgae, such as *Halimeda* spp. or *Dictyota* spp (in some cases, these areas were colonized by coral recruits).

The observations and measurements within this study confirm that hard corals have different susceptibilities to bleaching from increased prolonged sea surface temperatures. *Porites lobata, Pavona clavus,* and other species (many faviids and fungiids) appear to recover zooxanthellae faster than the faster growing branching genera such as *Acropora*.

Since the start of the monitoring period on this *P. clavus* colony and surrounding reefs at Danjugan Island, it appears that this particular colony has recovered fairly well in terms of live tissue cover after the initial bleaching event. Managed by the Philippines Reef and Rainforest Conservation Foundation Inc., Danjugan Island was made a fully gazetted marine reserve on February 2000. Areas such as 'Hilary's reef' where this spectacular *Pavona clavus* coral is located are within one of the three designated and clearly marked no-take zones (fish sanctuaries) where fishing of any description is prohibited. Monitoring of the reefs of Danjugan Island is on-going (monitoring of bleaching recovery; Reef Check surveys; fish-tagging experiments by members of the University of the Philippines; a giant clam seeding project). It is hoped that the success of the reserve, recently voted Best Managed Philippine Reef, 2001, will help to provide marine resource conservation for this unique area of natural heritage for future generations of Filipinos.

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EFFECTIVENESS OF FISH SANCTUARIES IN THE MABINI MARINE RESERVE, PHILIPPINES, AFTER A DECADE OF PROTECTION

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ABSTRACT

Three marine no-take zones (fish sanctuaries) were established by municipal ordinance in Mabini, Balayan Bay, Southern Luzon in the northern Philippines in 1991. Eleven years later Reef Check surveys were carried out by Coral Cay Conservation volunteers in order to assess reef fish populations and hard coral cover both inside and outside the no-take zones. Results indicated that within the Mabini reserve on the southwest Calumpan peninsula, hard coral cover compared favorably with the rest of the Philippines and Indo-Pacific region, especially in shallow (<10m) water where the coral cover in places was high (>50% in Cathedral and Arthur's Rock sanctuaries). Sanctuaries generally had higher hard coral cover than non-sanctuary areas, especially in shallow (5m) waters.

In the Mabini reserve both predatory commercial fish families such as groupers (*Serranidae)* and herbivorous parrotfish (*Scaridae*) were low in abundance both inside and outside the sanctuaries at shallow and medium depths. The very small number of these reef fish indicates that the no-take areas are currently having little direct effect on increasing the abundance of commercially important reef fish species relative to surrounding unprotected reefs. Patterns of increased fish diversity could be seen inside sanctuaries, with individual parrotfish, bumphead parrotfish (*Bolbometopon muricatum*), and *Scombridae* all recorded on one or two dives in the sanctuaries at medium depths. It appears that hard coral cover had a positive influence on fish abundance in the whole Mabini reserve.

Sanctuaries also had a positive impact on reef fish diversity at medium depths compared to areas outside the sanctuaries, but had limited influence on diversity at shallow depths. Fish feeding by dive operators within Cathedral sanctuary may increase the diversity and abundance of smaller site-attached species found at this popular dive site (e.g. butterflyfish). Results indicate that the fish sanctuaries may be too small and have too much surrounding fishing pressure and encroachment to have a significant positive effect on the biomass of more valuable commercial fish species in the area. However, our data imply that sanctuaries are showing some success in establishing greater fish family and species diversity.

Introduction and Background to the Area

Fish sanctuaries (also known as 'no-take zones') are fundamental to the development of marine conservation initiatives, as they can conserve and increase fish stocks both in tropical artisinal and temperate industrial fisheries (Gell and Roberts, 2003; Roberts and Hawkins, 2000). There can be considerable advantage in developing effective reserves at a small local scale as they encourage communities to drive management and policing of the reserve themselves (Ledesma *et al.,* 1998). However, problems associated with incursions into fish sanctuaries by fishermen can occur if education of local communities and enforcement is poor (Gilman, 1997; Alder, 1996; Erdmann *et al.*, 2003). Realistically, many marine reserves in the Philippines are failing to protect fish stocks, even after having achieved statutory status (Christie *et al.*, 2002; Pajaro *et al.*, 1999; Russ and Alcala, 1994).

Effective fish sanctuaries can provide spill over of adults when the carrying capacity of commercial fish populations within the sanctuary boundary is reached (McClanahan and Mangi, 2000). Fishermen on the edge of the sanctuary can then legally harvest these fish. Another beneficial effect of sanctuaries is that larvae from fish and shellfish within sanctuaries can also spill over into unprotected areas, and 'seed' reefs which may have had poor previous recruitment (Tawake *et al.*, 2001; Gell and Roberts, 2003; White *et al.*, 2002). Therefore, there can be long-term advantages in the use of protected areas, as has occurred in community-based reserves in the Philippines in the past, such as Apo Island (Russ and Alcala, 1996) and to a lesser extent, Sumilon Island (Alcala, 1981).

Anilao (named because of the main fishing village commonly associated with the Mabini-Tingloy dive area) is the most famous and historically rich of the Philippine dive areas (Fig. 1). Only three hours by road from the capital city, it began to emerge in the 1970s as one of the most popular dive areas for Manila residents, with around 400 dives carried out in the area during peak weekend periods (Trono, pers. comm.). Since the fall in foreign tourist numbers from the west, mainly Korean, Japanese and Filipino tourists have continued to dive in the region. It has also been an important fishing area for both artisinal local fishermen and a tuna fishery working from larger vessels (White *et al.*, 2001).

Between the late 1970s and 1980s, considerable efforts were made by the National Environment Protection Council to create marine parks around Sombrero Island, Sepoc, and Layag-Layag in Mabini-Tingloy municipal waters. These initiatives were unsuccessful and the areas remain accessible for all stakeholders and resource users to this day. The Haribon Foundation introduced a community-based conservation project along the shores of San Teodoro and Bagalangit barangays in Mabini in 1990 (White *et al.*, 2001; White and Vogt, 2000), which led to the creation of the first fish sanctuaries by municipal (Mabini) ordinance in 1991 in the areas of Cathedral Rock, Arthur's Reef, and Twin Rocks (Fig. 2). All these sanctuaries lie on the southwesterly facing the coast of the Calumpan peninsula within the Mabini reserve. During the mid 1990s, the Sulu Fund for Marine Conservation Foundation Inc., now known as the Coastal Conservation and Education Fund (CCEF), funded by Earthwatch, began a series of surveys in the Mabini sanctuaries and reefs surrounding the Anilao dive area. These surveys have continued throughout the 1990s with the most recent survey completed in 2001 (White *et al.*, 2001).

In 1997, WWF-Philippines (KKP - Kabang Kalikasan ng Pilipinas) became actively involved and promoted the area as one of its key sites within the Sulu-Sulawesi Marine Eco-Region program. Work initiated by WWF, The Center for Empowerment and Resource Development, and the Sulu Fund for Marine Conservation Foundation led to the inception of The Mabini-Tingloy Coastal Area Development Council in 1997 (White and Vogt, 2000).

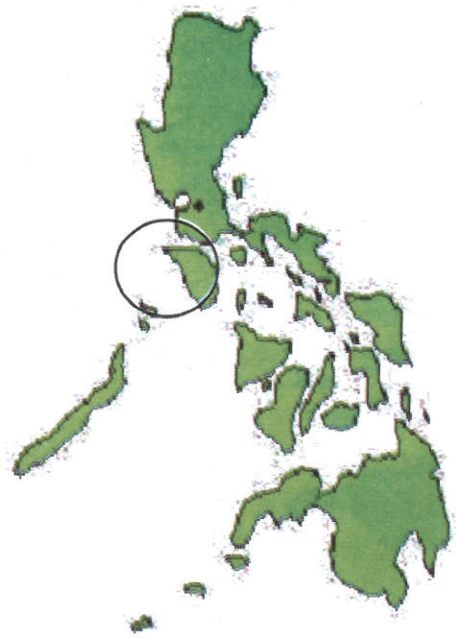
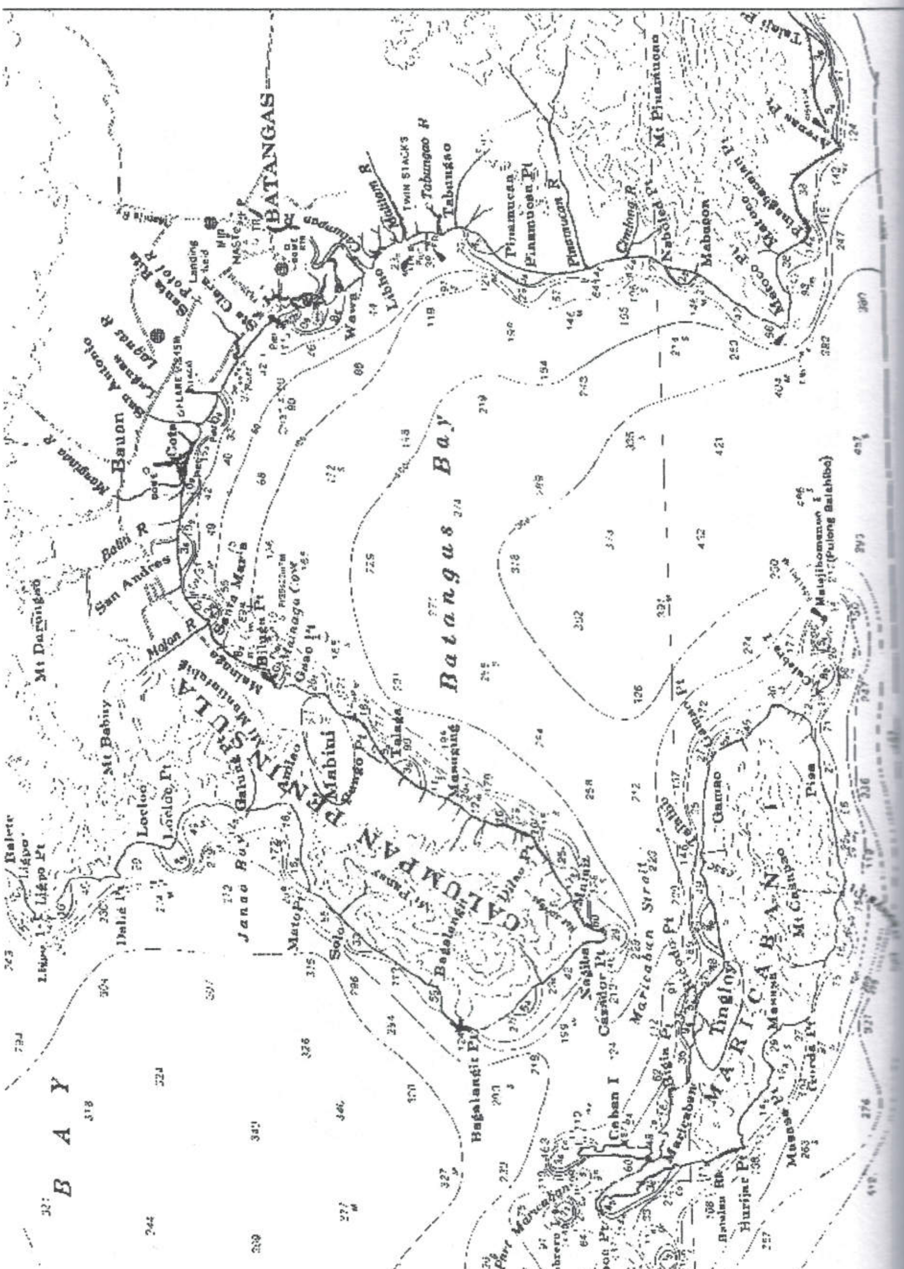


Figure 1. Location of the Anilao area (Mabini and Tingloy municipalities) in southern Luzon, Philippines. (For an enlarged view, see next page.)


BATANGAS
Batangas Bay
CALUMPAN PENINSULA
MARICABAN I
Maricaban Strait
Balayan Bay
Mabini
Tingloy
Bauan

This legislative council was formed in order to discuss trans-boundary issues related to conservation in the waters of Batangas and Balayan Bays and around the island of Maricaban (Tingloy municipality). WWF also initiated a resort-owners' NGO known as 'The Friends of Balayan Bay' in 2000 so that divers and resort stakeholders could have a single voice concerning environmental issues. In September 2001, NGOs, Governmental Organizations, local businesses, as well as oil and shipping companies of the area signed an MOU agreeing to support efforts to protect the environment in the Batangas region.

The area has therefore seen considerable investment in both community-based and legislative initiatives to introduce marine environmental conservation practices to aid the protection of local coral reef resources. This culminated in WWF working with another Philippine-based NGO, the Philippine Reef and Rainforest Conservation Foundation Inc., and the invitation of the UK-based not-for-profit NGO, Coral Cay Conservation (CCC), into the Mabini-Tingloy region. CCC was invited to conduct a baseline assessment of the coral reefs for the purposes of habitat mapping (Solandt *et al.*, 2002; Trono *et al.*, 2003) and a rapid quantitative assessment of reef health using the internationally recognized Reef Check survey methodology (Hodgson, 2001). Between January and June 2001, CCC carried out more than 300 dives involving over 70 personnel (Solandt *et al.*, 2002; 2003).

This study focuses on data collected from the Reef Check dives undertaken in the Mabini reserve and concentrates on reef fish populations at shallow (5m) and medium (10m) depths inside and outside the three fish sanctuaries of Cathedral Rock, Arthur's Reef, and Twin Rocks. The primary aim of the study was to establish whether the sanctuary designation had any significant effect on reef fish populations and benthic communities inside and outside the sanctuaries.

Methods and materials

The Reef Check methodology was designed in 1997 in order to allow volunteers to gather reliable data on the status of coral reef health, (www.reefcheck.org). The method was designed to be easily replicable both temporally and spatially so that a database of information can be built up from a number of locations. Six years of data have been collected which has allowed a global spatio-temporal comparison of reef health (Hodgson and Liebeler, 2002; Hodgson, 2001).

For the diving surveys undertaken in this study, the standard Reef Check protocol was modified to collect more detailed information at a greater taxonomic resolution and hence provide a more comprehensive assessment of reef health. Such modifications are possible because CCC volunteers receive more intensive training than regular Reef Check divers (Solandt, *et al.*, 2002; Mumby *et al.*, 1995).

The survey protocol utilized two transects at depths of approximately five and ten meters as this is where the greatest coral reef diversity and benthic cover occurs on the majority of fringing coral reefs (Fig. 2). Along each depth contour, a 100m transect was deployed parallel to the reef slope. Each 100m transect consisted of four 20m replicate transects separated by 5m spaces (Fig. 3). Further details on the methodology can be found in the Reef Check survey manual (Hodgson *et al.*, 2003).

Data were recorded from three fish sanctuaries (Cathedral Rock, Arthur's Reef, and Twin Rock). Data were pooled from four other dive sites within the Mabini reserve but outside the fish sanctuaries at the two same depth bands to represent control (fished) sites.

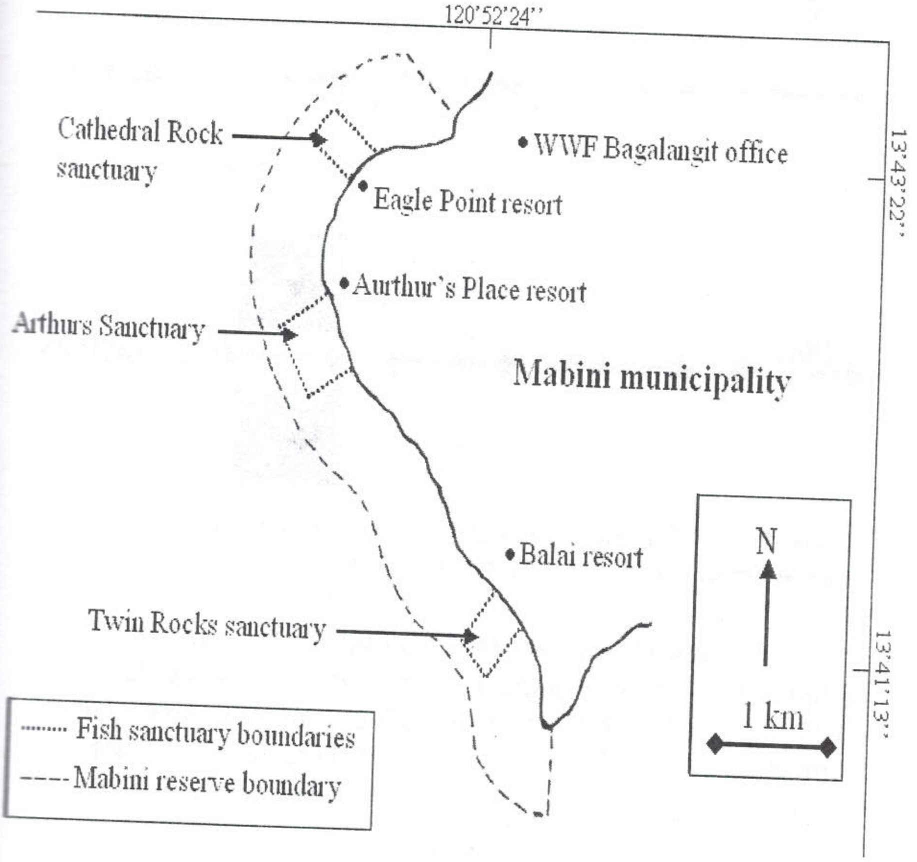


Figure 2. Location of the three fish sanctuaries within the Mabini reserve.

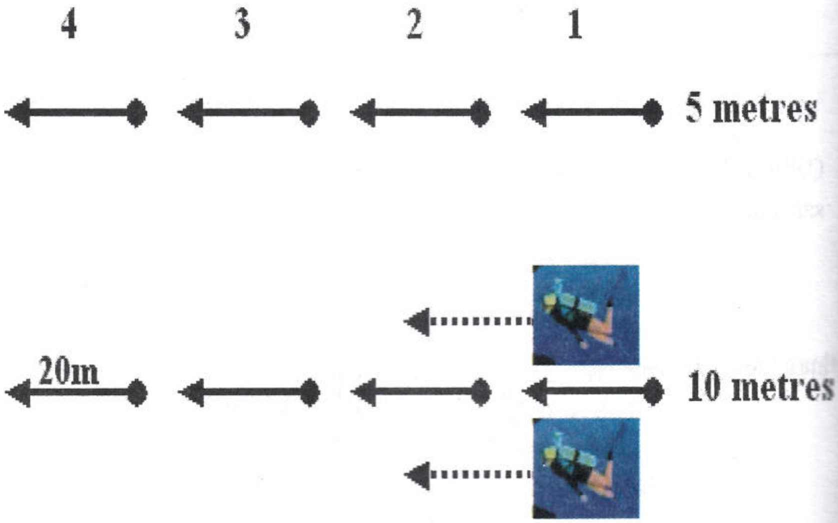


Figure 3. Schematic diagram showing the position of the transect lines at two depth bands during a Reef Check survey.

The presence and absence of commercially important fish families and target species were recorded, particularly those targeted by fisherfolk and aquarium collectors (see Appendix 1). Fish were counted if they were present in each $5m^3$ block of water (up to 5m above the transect line and 2.5m either side) giving each replicate an area of 20 x 5 x 5m = $500m^3$. The divers assigned to fish surveys waited for three minutes before each 5 meter section of a 20m transect to allow reef fish to resume normal behavior. They then swam slowly along the 5m section recording all targeted reef fish along the way. The process was then repeated for subsequent 5 meter blocks. See www.reefcheck.org and Hodgson *et al.* (2003) for the full methodology of replicate transect design.

Following fish surveys, the four 20m long transects at each dive site were point sampled to determine the substratum types and benthic community of the reef. For these surveys, the diver recorded the benthic cover or substratum at 50 cm point intervals along each transect. Reef Check categories recorded were hard coral, soft coral, recently killed coral, dead coral, fleshy seaweed, sponge, rock, rubble, sand, silt/clay, and 'others.' In addition, the surveyors recorded hard coral life-forms following the protocol in English *et al.*, (1997) and a number of target coral, algae, invertebrate and fish species developed by Coral Cay Conservation. All data were transferred to specially-designed recording forms immediately after dives, and checked thoroughly by the scientific staff on site.

For coral cover information, data were pooled from three sanctuary areas and compared to data pooled from all control (non-sanctuary) sites at the two specified depth bands.

Statistical analysis

Reef fish populations were compared between sanctuary (on an individual basis) and non-sanctuary (control) areas within the Mabini reserve. Non-parametric ranked (Kruskal-Wallis) tests were used to compare fish counts between the four different reserve areas: Cathedral Rock, Arthur's, Twin Rocks, and non-sanctuary (control) areas. Tests were performed separately on shallow (5m), and deep (10m) reef fish populations (Fig. 5 and 6).

Multivariate analysis

In order to describe the various fish assemblages present both inside and outside the fish sanctuaries, data were analyzed with multivariate statistics using PRIMER software (Clark and Warwick, 1994). Multivariate analysis can be used to cluster the site records into several groups, which represent distinct fish populations (assuming the fish populations remain within the study sites). Firstly, the similarity between fish assemblages at each site record was measured quantitatively using the Bray-Curtis Similarity Coefficient without transformation (Bray and Curtis, 1957). This coefficient has been shown to be a robust measure of ecological distance.

Agglomerative hierarchical cluster analysis with group-average sorting was then used to classify survey replicates into groups. The resulting dendrogram grouped site records together based on biological similarities (Fig. 7). SIMPER (SIMilarity PERcentage) analysis of the data was subsequently used to determine key fish species and families which contributed to each 'cluster' (see Solandt *et al.,* 2001, 2003).

Shannon-Weiner biodiversity indices were calculated for reef fish data at each survey site and then pooled to compare reef fish diversities inside and outside sanctuary areas.

Results

Hard Coral Cover

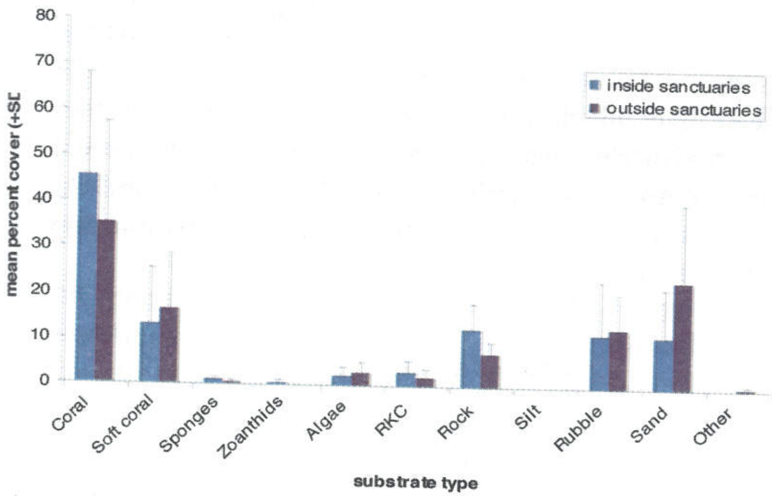
Mean hard coral cover was similar both inside and outside sanctuaries within the Mabini reserve (Fig. 4), although there was slightly greater coral cover at 5m depth inside sanctuaries (45.4% ± 22.6 S.D.) compared to cover outside sanctuaries (35.0% ± 22.3). Both these values compare favorably with average coral cover for previous ReefCheck dives; approximately 35% for Indo-Pacific reefs between 1997 and 2001 (Hodgson and Liebeler, 2002).

There is considerable difference in hard coral cover between depths at all sites in the reserve (both sanctuary and non-sanctuary sites). Coral cover inside sanctuaries at 10m fell to 20.4 ± 16.7%, and outside sanctuaries to 20.0 ± 9.0%. However none of these relationships was significant when compared between depths (paired t-test) or sites (Mann-Whitney test).

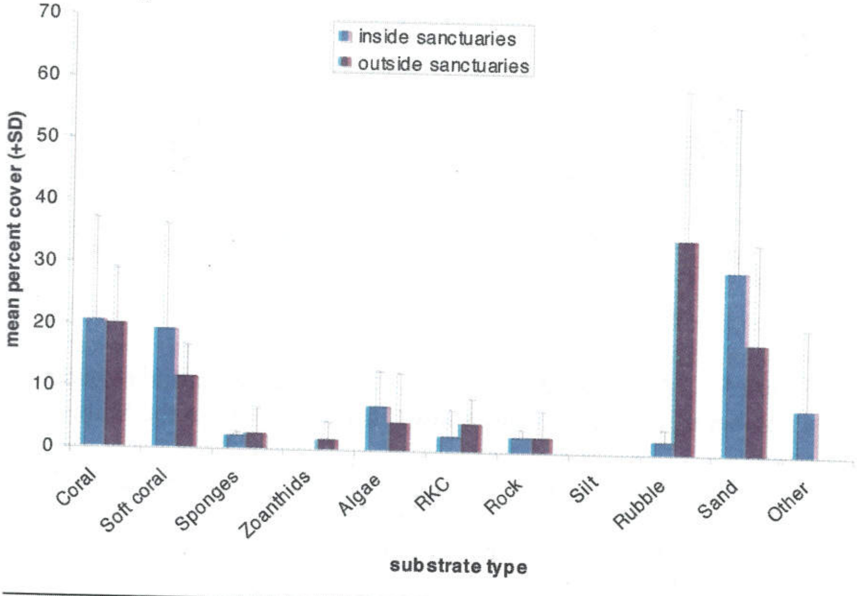
Hard coral cover at medium depths was generally lower than at the shallow reef crest and was apparent at many other survey sites in the Mabini-Tingloy area. Branching and table *Acropora* colonies, digitate *Montipora* and *Pocillopora* forms, and *Acropora palifera* dominated much of the coral cover in shallow water. Deeper (10m) waters of the Mabini reserve were dominated by sand, rubble, macroalgae, and soft coral communities, with rubble considerably higher in non-sanctuary areas (34.6 ± 24.2%) compared to sanctuary areas (2.08% ± 1.91).

Figure 4. Substratum cover inside and outside fish sanctuaries at the 5 (4.a) and 10 metre (4.b) depth bands.

4.a: 5m depth band



4.b: 10m depth band.



Fish Abundance

Butterflyfish (*Chaetodontidae*) were significantly more abundant at shallow (5m) depths at Cathedral Rock than at other sites (ANOVA, $F = 6.49$, $P<0.0067$) (Fig. 5). Another significant difference occurred in the distribution of parrotfish (*Scaridae*), which were absent from 52 non-sanctuary replicates but occurred inside Arthur's Reef sanctuary (0.25 ± 0.46 individuals per 500m³, Kruskal-Wallis test, $H = 17$, $P < 0.0007$). This number represents only two fish in eight replicate dives, but these were significant observations as they all occurred inside a sanctuary. The only other reef fish category to show reasonable numbers at shallow depths were the Surgeonfish (*Acanthuridae*), dominated by planktivorous and herbivorous species.

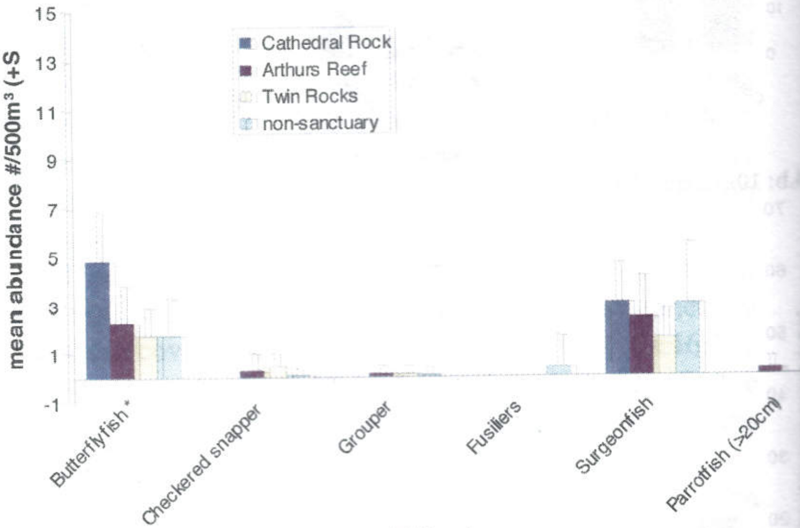


Figure 5. Mean abundance (+SD) of reef fish inside and outside a number of sanctuaries at shallow (5m) depths within the Mabini reserve.

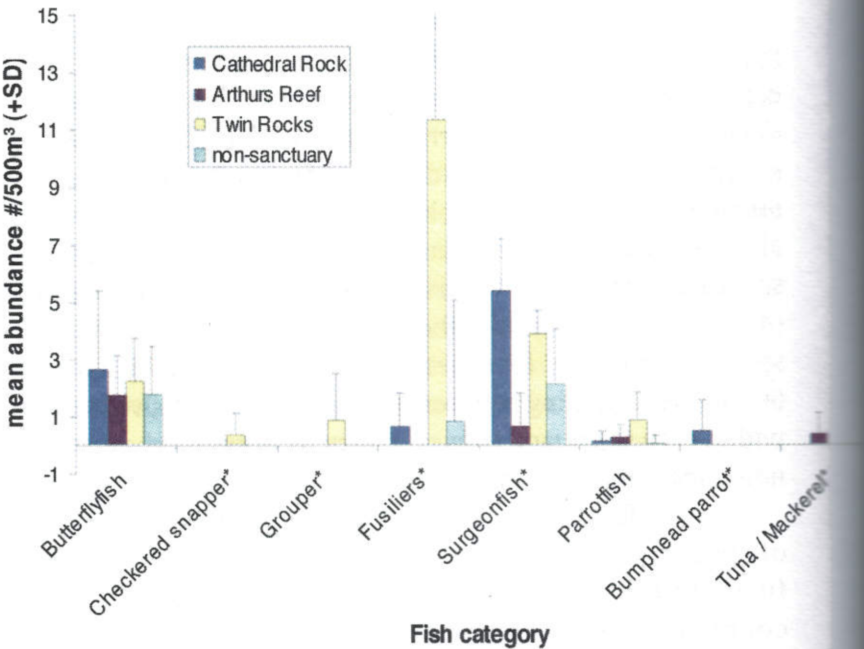
* - designates a significant difference in fish abundance in butterflyfish numbers, with highest abundance of this family at Cathedral Rock (ANOVA, $P<0.05$). All other populations were not significantly different from each other.

A greater diversity of reef fish (families and species) was recorded at medium (10m) rather than at shallow depths (5m), especially within sanctuaries. Checkered snapper (*Lutjanus decussatus*), groupers (Serranidae), fusiliers (*Caesionidae*), surgeonfish, bumphead parrotfish (*Bolbometopon muricatum*), and tuna/mackerel species (*Scombridae*) were all significantly more abundant inside rather than outside sanctuaries (Kruskal-Wallis, $P < 0.05$). Abundances of most of these species, especially the wide-ranging, larger commercial species were very low (between 0.375 and 0.875 fish per $500m^3$), representing between only one and three fish observed within each sanctuary. However, they were totally absent from non-sanctuary areas (41 replicates).

Twin Rocks supported significantly greater numbers of checkered snapper (*Lutjanus decussatus*), grouper, and fusiliers (in one replicate, 60 individual fusiliers were counted) at 10m compared to other sanctuary sites (Fig. 6). Twin Rocks is located a little further away from other reserve areas and at certain times was seen to support large numbers of *Carangidae* which may be feeding on the considerable numbers of planktivorous fish present at this site.

Figure 6. (See next page) Mean abundance (+ SD) of reef fish inside and outside a number of sanctuaries at medium (10m) depths within the Mabini reserve.

* designates a significant difference in fish abundance for Checkered snapper, Grouper, Fusiliers, Surgeonfish, Bumphead Parrotfish and Tuna/ mackerel, between dive sites (K-W test, $P < 0.005$).

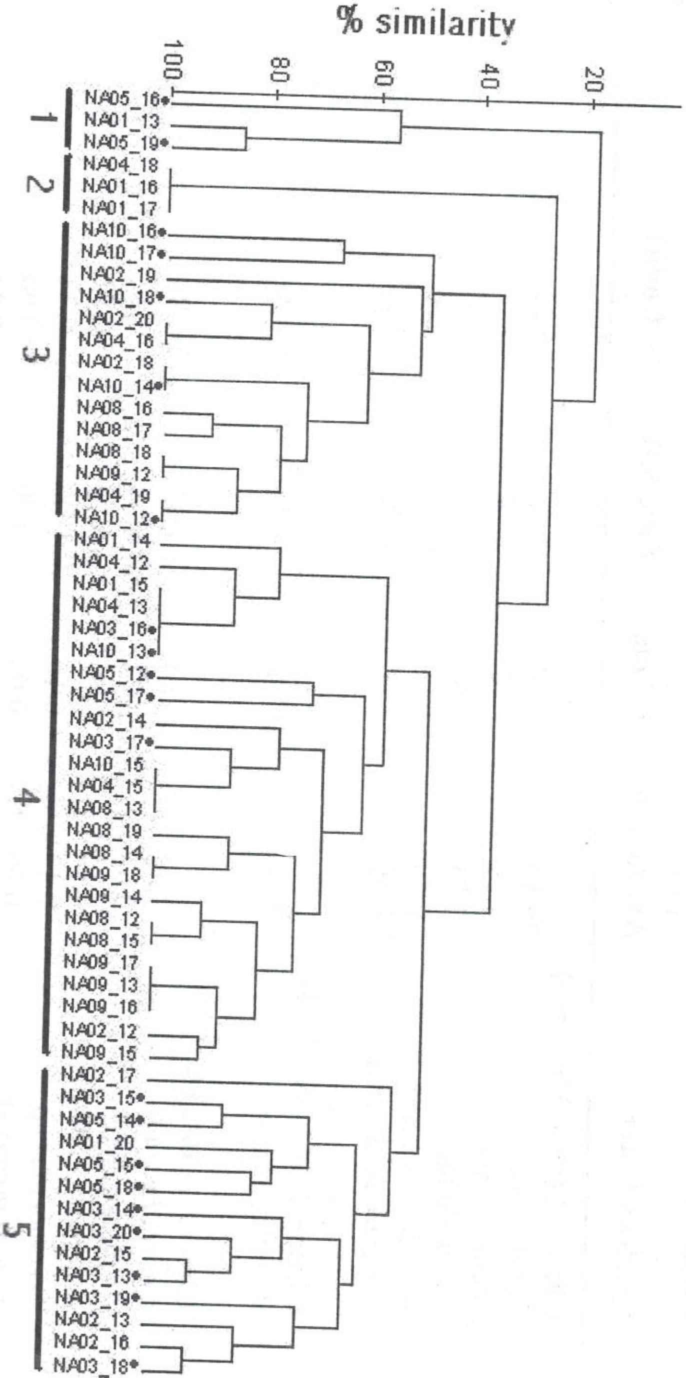


Fish population assemblages

Reef fish species and family assemblages were fairly randomly mixed between sites at shallow depths (5m), indicating that there was no significant influence of location on species diversity, or fish trophodynamic assemblages at this depth.

At medium (10m) depths, however, there did appear to be a difference between reef fish recorded inside and outside sanctuaries (pooled data for this analysis) (Fig. 7, next page).

Figure 7. Dendrogram of percent similarity (cluster analysis) in reef fish populations between survey dives. Five population 'clusters' (assemblages) fall out of the analysis. Those surveys from within fish sanctuaries are marked by a black dot '•' beside the code of that dive.


% similarity
100
80
60
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1
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Table 1. Analysis of SIMPER of clusters 1-5 in Figure 6. Simper shows the percentage contribution of the most important species to define each cluster. **FS** - is the percent of survey dives from **F**ish **S**anctuary areas in that cluster. (*N* is the total number of replicates in that cluster).

Species/Cluster	Av. Abund.	Av. Sim.	Sim./S.D.	% Contrib.
Cluster 1 (66% FS, *N* = 3)				
Caesionidae	26.50	27.36	0.87	76.22
Acanthuridae	2.75	6.00	2.79	16.71
Chaetodontidae	1.75	2.54	0.85	7.07
Scaridae (>20cm)	0.50	0.00	0.00	0.00
Lutjanus decussatus	0.50	0.00	0.00	0.00
Cluster 2 (0% FS, *N* = 3)				
Acanthuridae	1.00	100.00	0.00	100.00
Cluster 3 (36% FS, *N* = 14				
Chaetodontidae	2.94	49.84	1.97	91.86
Acanthuridae	0.62	3.73	0.34	6.87
Scaridae (>20cm)	0.19	0.50	0.16	0.92
Scrombridae sp.	0.19	0.19	0.09	0.34
Plectropomus sp.	0.06	0.00	0.00	0.00
Epinephalus sp.	0.06	0.00	0.00	0.00

Table 1. (Continued)

Species/Cluster	Av. Abund.	Av. Sim.	Sim./S.D.	% Contrib.
Acanthuridae	2.59	46.63	2.61	69.80
Chaetodontidae	1.64	19.96	1.07	29.87
Scaridae (>20cm)	0.23	0.22	0.11	0.33
Caesionidae	0.05	0.00	0.00	0.00
Lutjanus decussatus	0.05	0.00	0.00	0.00
Cluster 5 (66% FS, $N = 14$**)**				
Acanthuridae	5.71	48.32	4.20	75.81
Chaetodontidae	2.43	10.01	1.02	15.70
Caesionidae	1.64	4.96	0.53	7.78
Scaridae (>20cm)	0.21	0.30	0.18	0.47
Bolbometopon muricatum	0.29	0.15	0.10	0.23
Siganidae sp.	0.14	0.00	0.00	0.00
Lutjanus biguttatus	0.07	0.00	0.00	0.00
Seranidae (all species)	0.21	0.00	0.00	0.00

Reef fish assemblages within sanctuaries generally consisted of two assemblage types ('clusters'); assemblages dominated by fusiliers (Table 1, cluster 1) and those assemblages dominated by surgeonfish and butterflyfish but with a wide diversity of other species (Table 1, cluster 5). The dendrogram indicates that these two assemblages are clearly defined by the cluster analysis (Fig. 7) and that they are both dominated by surveys from inside sanctuaries (66% of both groups are made up of sanctuary replicate surveys).

The analysis also reveals that most of the reef fish populations in sanctuaries at 10meters depth are either characterized by large numbers of fusiliers, or by populations dominated by surgeonfish and butterflyfish with a suite of other less abundant families such as parrotfish, grouper, and wrasse. The factor that distinguishes cluster 5 (which contains most of the sanctuary dives) from other clusters is the increased diversity of the less abundant species recorded.

Fish species diversity inside and outside sanctuaries

Shannon-Weiner diversity indices were calculated using PRIMER for 5m and 10m sanctuary and non-sanctuary fish populations from the original data set. There was no significant difference in diversity between sanctuary and non-sanctuary populations at shallow depths (Mann-Whitney on pooled Shannon-Weiner diversity indices, $P>0.05$). However, sanctuaries contained greater diversity of reef fish (Shannon-Weiner index: 0.744 ± 0.42) than in non-sanctuary areas (0.41 ± 0.34) at the 10m depth band (Mann-Whitney, $P< 0.0012$).

Discussion

The results reported here indicate that patterns of hard coral cover, reef fish abundance, and reef fish diversity were slightly greater inside than outside the sanctuaries.

Some of the three Mabini sanctuaries were originally chosen because they were established dive sites with interesting benthic topography, high coral diversity and health, and better than average fish numbers. Indeed, the shallow sites at Cathedral Rock and Arthur's Reef have good coral cover, often exceeding 50% in places, which are dominated by branching, tabulate, digitate, and submassive forms of the *Acropora* family. Higher coral cover has previously been shown to support greater abundance and diversity of site-attached fish species (Roberts and Ormond, 1987) and may have resulted in higher *Chaetodontid* abundance in some of the sanctuary areas reported in this study. Indeed, the abundance of small site-attached species at sites such as Cathedral Rock may be more attributable to the degree of habitat availability rather than as a result of hand-feeding by sport divers. The evidence of greater diversity recorded within cluster 5 (Fig. 7), comprising a high proportion of replicates from sanctuary areas, could have been as a result of both these factors.

Coral reefs of Mabini have seen considerable historical investment of resources in community- based coastal resource management in the past 10-20 years (Solandt *et al.*, 2003; White *et al.*, 2001; White and Vogt, 2000). This background of education and awareness-raising in coastal communities of coral reef conservation issues will no doubt provide a stronger chance of long term resource protection in Mabini than for many other Philippine reefs. Unfortunately, there is only limited evidence from the data that sanctuaries are having a positive effect on building up the biomass of commercial fish families and species, although some patterns did emerge from the deeper sites. The presence of higher species diversity within the deeper sanctuary areas bodes well for the future. Many of the extra species found in deeper sanctuary waters were commercial species, including groupers, bumphead parrotfish and other parrotfish species, all of which can attain considerable biomass. However, increased size of reef fish individuals or populations usually results in an increase in the required home range of a species. Unfortunately, the largest sanctuary in the Mabini reserve (Arthur's Reef) is only approximately 300m x 100m, which is probably too small to effectively protect any population of larger predatory species from fishing pressure, unless encroachment into the sanctuaries is completely eliminated. Even if the fishermen were to fish many of the reefs at the edge of these boundaries, it would be likely that at some time or other, larger members of the *Serranidae*, *Lethrinidae*, *Lutjanidae*, *Carangidae*, and *Sphyrenidae* would be caught by hook and line, spear or net fishing at the edge of the reserve boundary. Many of the larger species in these families need areas of up to one square kilometer in order to maintain a feeding 'home range' and therefore be immune from effects of fishing by local fishermen at the boundary-line of the sanctuary.

As a result, it appears that the sizes of the sanctuaries within the Mabini reserve may be too small to support anything other than the smaller planktivore, herbivore, and corallivore species such as *Caesionidae*, *Acanthuridae*, and *Chaetodontidae* in reasonable numbers. All of these trophic groups can be supported in larger numbers within smaller areas than the larger carnivores. Kramer and Chapman (1999) showed that the larger the area of a reserve (fish sanctuary), the lesser the significance of effect of fishing the boundary line, as many fish would still be entrained within the sanctuary. By inference, one can assume that the larger the area of the reserve (for the same fishery), the lesser the impact of fishing the boundary line.

The size of the reserve becomes less important if one has carefully considered matching the life history and home range of the species to the size of the sanctuary and, more significantly, if one can be sure of complete compliance by local communities to the closed area (Halpern, 2003). As an illustration, CPUE of the hook and line fishery around the 0.74 km^2 Apo Island reserve increased ten-fold over twenty years of protection, from 0.13-0.17 kg per person/hour in 1981 to 1-2 kg per person/hour in 1997-2001 (Maypa *et al.*, 2002). It may be that if total fishing effort in the Mabini reserve was reduced, allied with complete compliance of the boundaries of the sanctuaries, the abundance and biomass of larger commercial fish species within the sanctuaries would increase.

Recommendations

Fishermen in the Mabini-Tingloy area stand to benefit in the long term if there was complete compliance with the boundaries of the marine reserve and if a network of marine protected areas was established in the region. Part of the recommendations of the recent CCC survey of Tingloy and Mabini (Solandt *et. al.*, 2003) suggested allocating the north-western tip of Tingloy Island for MPA and fish-sanctuary status as a result of the high diversity of habitats (100% coral cover on reef flats; sheer coral walls; large 'backreef' *Porites* mounds; spur and groove formations), and its potential for supporting high fish biomass within them. The sanctuaries and reserves of Mabini are a good starting point for an overall conservation strategy for the area. However, by including other sanctuaries from slightly further afield in the management plan and with greater compliance from local populations to areas closed to fishing, we may see a positive effect on reef fish populations based on the result of networking marine protected areas (Roberts *et al.*, 2001).

The above recommendation and a number of others by Solandt *et al.* (2003) are in close agreement with those suggested by another recent study in the region (White *et al.*, 2001). As well as increasing the number of MPAs, both the above reports state that local environmental awareness and education programs should be implemented to increase understanding and ultimately compliance with any marine conservation regulations, either currently in place or implemented in the future. There is also a need for a local sense of stewardship of the marine environment so that fishing communities and other stakeholders act to maintain and enhance the resources that are provided by the coral reef ecosystem.

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APPENDIX I

The following table lists all the reef fish categories recorded by CCC divers during Reef Check surveys in the Anilao region in 2002. A combination of families and particular target species were recorded. All reef fish within a particular family were recorded to species if known.

Reef Fish Categories	Family	Species
Butterflyfish	*Chaetodontidae*	
Sweetlips	*Haemulidae*	
Snappers	*Lutjanidae*	
Two-spot	"	*Lutjanus biguttatus*
Checkered	"	*Lutjanus decussatus*
Black-and-white	"	*Macolor macularis*
'Bluelined'	"	*Lutjanus kasmira*
Paddletail	"	*Lutjanus gibbus*
Groupers (<30cm TL)	*Serranidae*	
Groupers (>30cm TL)	"	
Barramundi Cod	"	*Chromileptes altivelis*
Flagtail	"	*Cephalopholis urodeta*
Peacock	"	*Cephalopholis argus*
Lyretail	"	*Variola louti*
'Honeycomb'	"	*Epinephelus merra*
	"	*(E. hexagonatus, E. quoyanus*
Humphead wrasse	*Labridae*	*Chelinus undulatus*
Bumphead parrot	*Scaridae*	*Bolbometopon muricatum*
Parrotfish (>20 cm TL	*Scaridae*	
Tuna / Mackerel	*Scombridae*	
Fusiliers	*Caesionidae*	
Surgeonfish	*Acanthuridae*	
Rabbitfish	*Siganidae*	
Barracuda	*Syphrenidae*	
Jacks / Trevally	*Carangidae*	
Moray eel	*Muraenidae*	

SPILL-OVER EFFECTS OF A COMMUNITY-BASED MARINE PROTECTED AREA: THE CASE OF THE DANJUGAN ISLAND MARINE RESERVES AND SANCTUARIES

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ABSTRACT

The Philippine Reef and Rainforest Project (PRRP) began in 1995 as a collaborative project between the Philippine-based NGO, the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI), and the UK-based NGO, Coral Cay Conservation (CCC). The initial aims of the project were to gather information on the natural resources of Danjugan Island, facilitate training in scientific survey techniques and eco-tourism related professions, and to provide comprehensive coral reef education to schools and local communities. The results of scientific surveys carried out by CCC volunteers and PRRCFI staff between 1995 and 1999 led to the establishment of the Danjugan Island Marine Reserve and Sanctuaries (DIMRS) as a statutory marine reserve under the Philippine provincial law in February 2000. Interest in the reserve has filtered through to communities beyond Danjugan and the work expanded to mainland Negros to survey two further municipalities through another project, the Southern Negros Coastal Development Project (SNCDP), between 1998 and 2001.

The positive influence of the DIMRS has led local barangays to develop their own voluntary marine reserves with the technical assistance of PRRCFI staff. Dive surveys in southern municipalities between 1998 and 2001 have provided information on four more proposed marine reserves. Effective long-term community-based education and training, coupled with the provision of alternative livelihood capacity, has resulted in the success of the project

near to source, at Danjugan Island, and within the municipality of Cauayan, Negros Occidental. However, the impact of the overall project is reduced in areas further to the south of Negros Occidental as a likely result of limited resources.

Introduction

The development of networks of marine protected areas has increasingly been recognized as key to the successful implementation of coral reef conservation (Christie *et al.*, 2002; Roberts, 2000; Roberts and Hawkins, 2000) and reef fisheries management (Ward *et al.*, 2001; Roberts and Polunin, 1991; Russ and Alcala, 1989 and 1996 a and b). With the increasing populations of Philippine coastal communities and the growing use of destructive fishing practices (White and Vogt, 2000), the need is greater than ever to conserve the remaining healthy coral reef areas.

Although the Philippines is well known for its coral reef biodiversity, with well over 490 species of hard coral described from the archipelago (Chou, 1998), this is tempered by the fact that only 5% of Philippine reefs remain in pristine condition (Licuanan and Gomez, 2000). Many near-shore Philippine reefs have not only suffered the effects of over-fishing, but also sediment run-off caused by deforestation (Heaney and Regalado, 1998; Hodgson, 1993, 1997). Heaney and Regalado (1998) also documented that the rise in development of the sugar-cane industry has pushed many subsistence farmers to the coasts, which is likely to have resulted in further pressure on coral reefs. Negros Occidental is typical of this situation. The conversion of considerable portions of the countryside to sugarcane farms meant the destruction of original forest cover (causing sedimentation) and the consequent contamination of adjacent fringing reefs by chemical fertilizers (via river run-off). In a recent study by Grimes (2001) carried out at Danjugan Island, nutrient levels for dissolved phosphates appeared to be at 'threshold' levels (Bell, 1992), which could potentially result in increased algal growth and thereby a shift from coral to algal dominated communities.

However, there is hope as the Philippines is recognized as one of the leading countries in community-based coastal zone management in South East Asia (Rivera and Newkirk, 1997; Uychiaoco *et al.,* 2000), and has been cited for model approaches to managing coral reefs (Christie *et al.,* 2002; White and Deguit, 2000). Indeed, the second International Tropical Marine Ecosystem Management Symposium held recently in Manila (March 2003) gave details of many successful case-study projects in the Philippines (e.g., Trono *et al.,* 2003).

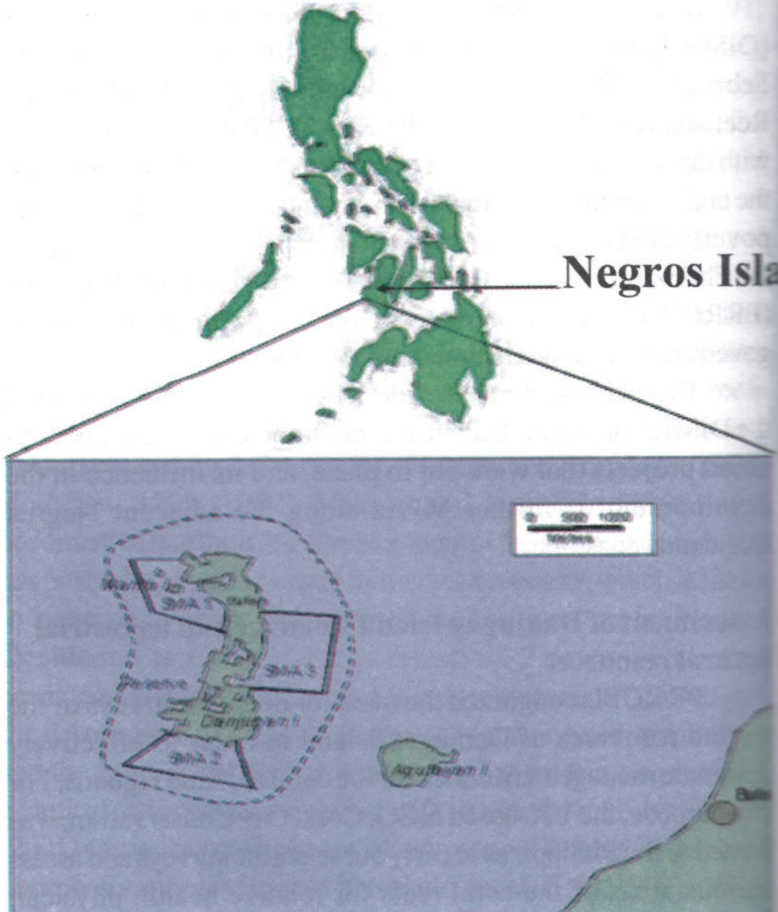
The Danjugan Island Marine Reserve and Sanctuaries (DIMRS) was established under a provincial ordinance in February 2000 as a result of work carried out by the Philippine Reef and Rainforest Project (PRRP). The PRRP began in 1995 with the aims of conserving reef and coastal resources, improving the understanding of coastal environmental issues, and alleviating poverty (Ledesma *et al.,* 1998). The project was facilitated by the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) which worked with the local community, local government, and international collaborators.

This paper seeks to provide details of the relative impact of the DIMRS on the immediate reef environment, the community-based projects that were put in place, and its influence in the development of further MPAs along the adjacent Negros Occidental coastline.

Assessment of Danjugan Island's marine and terrestrial natural resources

PRRCFI recognized the need for detailed surveys of the marine resources of Danjugan Island in order to effectively designate management zones for the coral reef and lagoons. For this purpose, the UK-based NGO, Coral Cay Conservation, was invited to the Philippines to carry out scientific surveys and assess various areas of the coral reefs for relative health, physical, oceanographic, and anthropogenic impacts. Coral Cay Conservation baseline (Mumby and Harborne, 1999; Mumby *et al.,* 1995) and Reef Check (Solandt *et al.,* 2001a; Hodgson, 1997) survey methods were used to provide data.[1] SCUBA Surveys and discussions with local fishermen provided the baseline data for selecting three distinct Special Management Areas (fish sanctuaries) around Danjugan Island (Fig. 1).

Figure 1. The location of Danjugan Island Marine Reserve and Sanctuaries (DIMRS). The boundary of the reserve is represented by the dotted line, where permits are needed to fish and extract other resources. The boundary of the three Special Management Areas (fish sanctuaries) are shown by the solid lines.



Further survey work and collaboration with the SEAMAP group from the University of Newcastle resulted in a habitat map (White *et al.*, 2003). A number of maps were generated from acoustic surveys (using RoxAnn sonar) which yielded information on distribution and extent of marine habitats. From this information, maps of substratum distribution were published and validated by the transect data from volunteer surveys. An example of one of the maps describing three broad habitats is presented here (Fig. 2, next page). More detailed maps with five and seven described habitats were also produced to help facilitate management and zoning of the reserve.

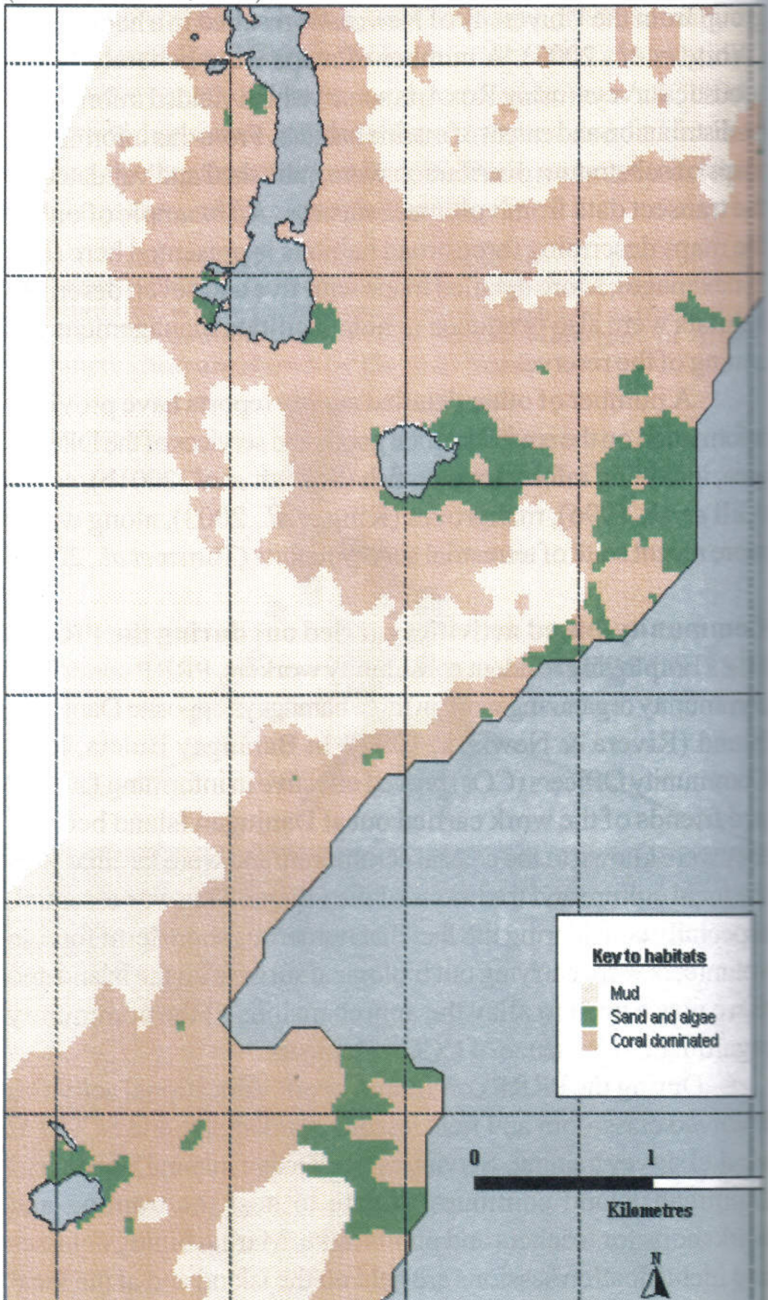
A number of other detailed survey reports have provided information on the environmental goods and services of the DIMRS area, including information on fish (Solandt *et al.*, 2001b), corals (Gill *et al.*, 1996), mangroves (King *et al.*, 2003), along with a more recent suite of terrestrial survey reports (Turner *et al.*, 2002).

Community-based activities carried out during the PRRP

Employing resident community workers, PRRP conducted community organizing work in three barangays opposite Danjugan Island (Rivera & Newkirk, 1997). In Barangay Bulata, local Community Officers (COs) proved effective in informing families and friends of the work carried out at Danjugan Island because they were known to the coastal community and were familiar with the local culture and traditions of the village. This was essential, especially considering the fact that numerous short-term foreign volunteers were carrying out biological surveys on the island and there was a need to allay the apprehensions of the community regarding the presence of CCC volunteers.

During the PRRP community work, educational activities involved classroom and field lessons, workshops, and SCUBA/snorkel survey training. Serving as an effective 'natural laboratory,' Danjugan Island continues to date to host the training and workshops for teachers and pupils alike. Marine biology classes and identification sessions are held on the island and at the local

Figure 2. Habitat map of Danjugan Island (at top of map), and adjacent Negros coastline showing the distribution of three different marine habitats (after White *et al.*, 2003).



school in Bulata where a marine mural was painted on the school wall. Since most Filipino children seldom get the opportunity to see underwater life, taking the pupils reef snorkeling and on guided walks through the local mangrove could already stimulate conservation awareness. Teacher-training sessions were also carried out on the island to enable schools to introduce local marine wildlife to their classroom lessons.

Participation in coastal clean-up, mangrove growing, and planting and turtle tagging has led the local community to feel a sense of 'ownership' over the local marine resources and encouraged them to engage in other marine conservation activities. A mangrove multi-species nursery project was developed in one of the lagoons of the island to provide seedlings for the adjacent coastal area that had been stripped of natural mangrove vegetation.

About 15 local people were trained in SCUBA use and participated in the CCC-led 'Skills Development Programs.' This activity provided effective integration between the CCC-volunteer science program and PRRCFI community-based resource assessment training. A number of Filipino divers have been trained to PADI Dive Master level and taught detailed coral and fish surveying (reef monitoring abilities) skills. Currently, they constitute the local pool of experts who monitor the effectiveness of the DIMRS and provide information about the benefits of sustainable resource use to other members of the coastal community.

Both the volunteer-driven approach to both the PRRCFI-led community-based training and the CCC-led resource surveys have resulted in the formation of a sustainable Community-Based Coastal Resource Management (CBCRM) program within and around Danjugan Island and the adjoining coast. While many similar projects often collapsed after the withdrawal of funding agencies and personnel, the PRRP's volunteer-driven approach has enabled the project to thrive. The 'built-in' respect for the environment engendered within the community through volunteerism has led to long-term stability within the ecosystem.

Alternative livelihood mechanisms at Danjugan Island

To take pressure off the reef fishery, alternative income was also introduced as an important component of the PRRP. The main alternative livelihood schemes in Bulata centered around two projects: mud crab (*Scylla* spp.) farming, and pig-raising. The mud crab project required a penned area of mangroves to be developed as habitat for adult crabs on the coastal mainland just to the north of Bulata village. Consequently, juvenile mangroves were planted at this site to provide the necessary habitat for the project. These mangrove juveniles originated from trees reared at one of the lagoons on Danjugan Island, thereby leaving the natural mangrove community of the area unaffected. Juvenile crabs were grown from larval stock in one of the lagoons of Danjugan Island and subsequently transferred to the coastal enclosure where they were grown on to marketable size.

However, the mud crab project was not altogether successful because the crabs needed a much larger natural territory area per crab than was originally anticipated by the project. Attempts to set up higher than natural stocking densities on an area approximately $100m^2$ x $100m^2$ only caused crabs, which are highly territorial, to escape from the crowded enclosure through the mesh net. Moreover, with overhead cost proving too high and fieldwork requiring intensive labor, this project was not economically worthwhile.

The pig-raising project focused on fattening and breeding of animals within the village and surrounding areas. Unlike the mud crab project, the expansion of the already present pig-fattening project was more successful mainly because this was already an existing industry within the village before the start of the project and as such, many members of the community already knew the methods and pitfalls of this activity.

Other complementary alternative income schemes were weaving products from pandanus palms (*Pandanus* spp.), production of banana chips, and waste utilization schemes. The only issue was to convince fishermen to switch entirely to this livelihood.

Spill-over effects of the DIMRS on the surrounding communities

The influence of the PRRCFI/CCC partnership on the successful development of protected areas has inspired local mainland communities to develop their own voluntary fish sanctuaries. The first community to approach PRRCFI was Elihan, located to the South of Bulata (Fig. 3). A small area of coastal reef was identified as a suitable site for a voluntarily-managed fish sanctuary to be managed by the community members themselves. The unique biological features of the Elihan fish sanctuary include many young coral colonies (corals less than 5cm diameter) at areas further offshore (control site 1), and much higher numbers of recruits than reefs located adjacent to Bulata town (control site 2) (Figure 3 + 4, next page). Detailed CCC volunteer surveys also showed that the shallow waters of the bay south of Binigsian Point were dominated by silt and sandy habitats. At the more exposed headland of Binigsian Point, current and wave action is stronger, which is likely to result in higher cover of hard substrate and live corals (at the proposed Elihan fish sanctuary). High coral cover is correlated with, and intrinsically linked to, greater reef fish biomass as it provides greater niche variation and habitat per unit surface area (Roberts and Ormond, 1987) to support fish in greater densities. It is precisely for these reasons that Elihan was chosen as a fish sanctuary (Figure 3).

Barangay Inayauan, located north of Bulata, also sought assistance from PRRCFI to establish a fish sanctuary (Fig. 5). Dives carried out by PRRCFI and CCC scientists (TD and JLS in January 2001), however, deemed the area inappropriate for the establishment of a reserve at the time, as the influence of sedimentation was considerable from a nearby river mouth, while coral cover and fish biomass were minimal.

Figure 3. Location of voluntary fish sanctuary at Elihan (Elihan MPA), and two other control sites surveyed during Reef Check dives in 1999.

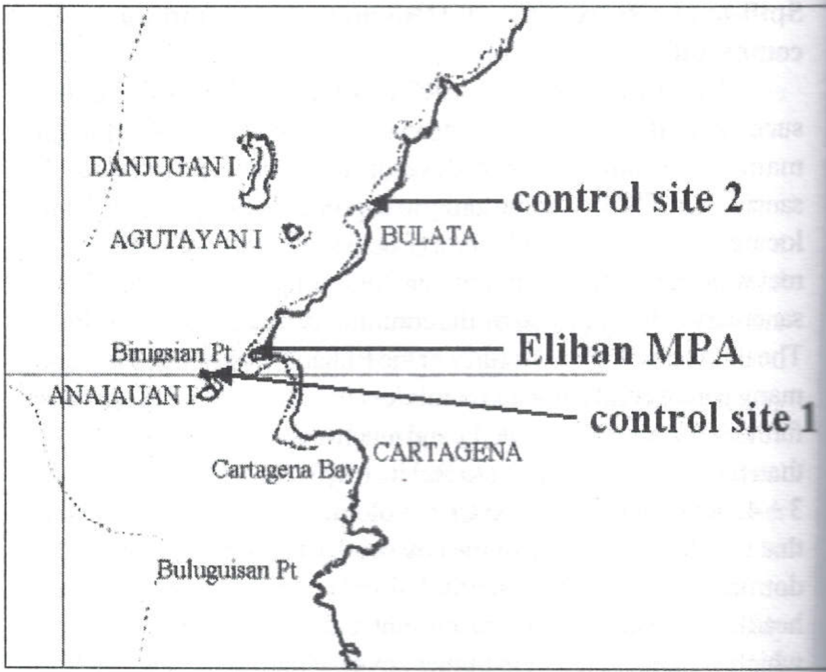
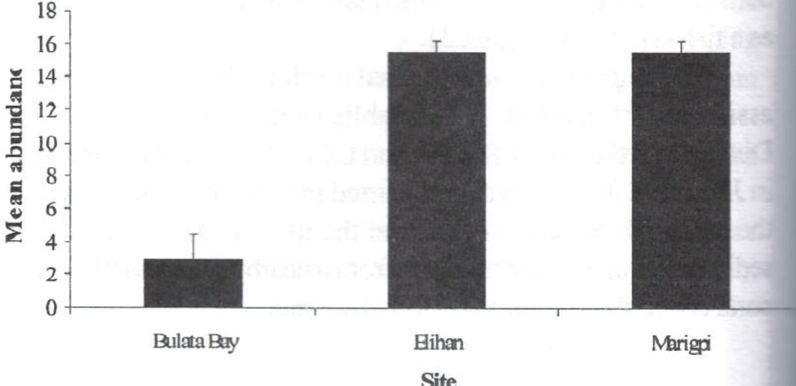


Figure 4. Mean abundance of coral recruits at control site 2 (Bulata Bay), control site 1 (Marigpi), and at the location of the voluntary fish sanctuary (Elihan).



The development of the Southern Negros Coastal Development Programme - Poverty Alleviation and Community Education

The success of the Philippine Reef and Rainforest Project at Danjugan Island in establishing a community-managed marine reserve, coupled with interest from local communities and the support of Governor Rafael Coscolluela of the Province of Negros Occidental, led to the development of the Southern Negros Coastal Development Programme (SNCDP). This provincial program was implemented to carry out scientific reef surveys and community-based training in communities further to the south of Danjugan as well as in the other southern municipalities of Negros Occidental.

In line with the objectives of SNCDP (Table 1), PRRCFI established, led, and coordinated a program called PACE (Poverty Alleviation and Conservation Education). PACE facilitated a modular approach to coastal management and conservation through education and community work aimed at developing alternative livelihoods. PACE was initially funded by a grant from the British Partnership Program (BPP) over a three-year period (1997- 1999) following a joint application from PRRCFI and CCC. PACE aimed to make the communities appreciate their natural resources and to establish the foundation for the sustainable use of these resources through research, education, organization, and skills development.

Activities under PACE started in 1997 when a two-month coral reef assessment pilot project was carried out by CCC in Campomanes Bay (Figure 5+6). From July 1998 until January 1999 the CCC survey project was permanently based in Campomanes Bay where both coral reef assessments and community work took place (Solandt *et al.,* 2002) between Sipalay and northern Nabulao Bay (Fig. 5). Underwater surveys showed that the area of fringing reef to the northern mouth of Campomanes Bay had high coral diversity and has since been recommended for MPA status (Solandt *et al.,* 2002; Beger and

Figure 5. Southern Negros Occidental coastline from the municipality of Cauayan in the north to the municipality of Hinoba-an in the south. Location of all MPAs (statutory, voluntary or proposed) as discussed in this paper is as follows: 1 – DIMRS (statutory); 2 – Elihan (voluntary); 3 – Campomanes Bay (proposed); 4 – Nabulao Bay patch reef (proposed); 5 – Catmon Point (proposed); 6 – Palm Reef (proposed).

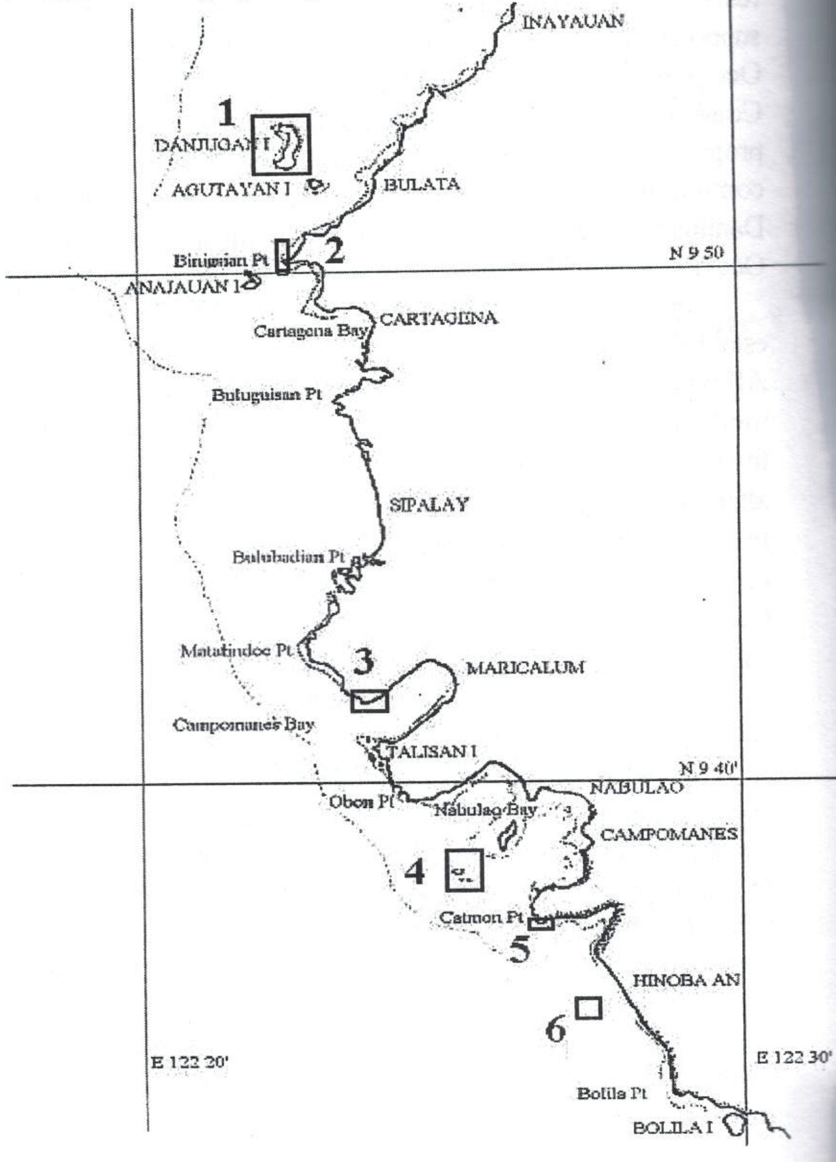
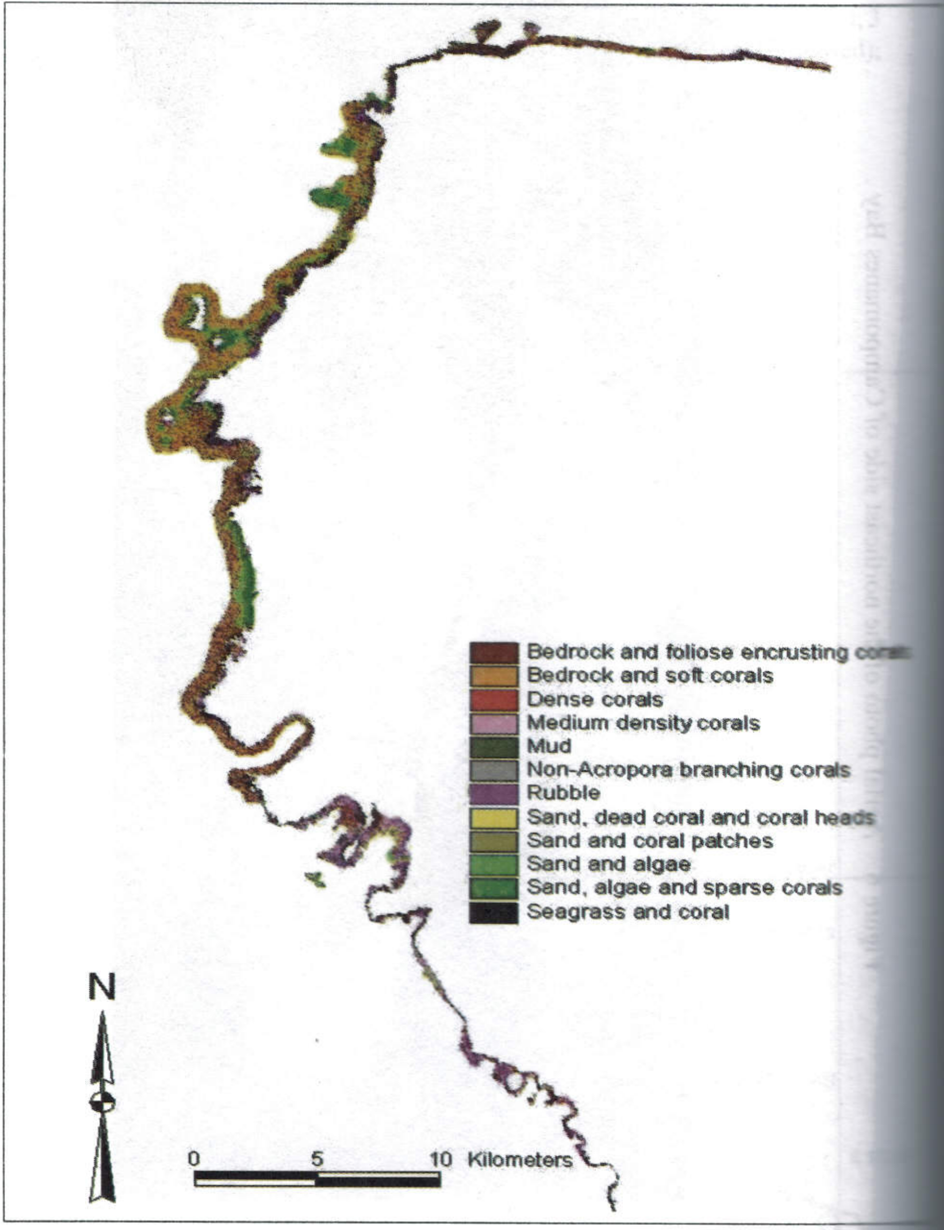


Figure 6. Aerial photo of the northeast side of Campomanes Bay .

Figure 7. Habitat map of South-West Negros developed through resource assessment surveys carried out by CCC/PRRCFI divers, and the University of Leicester (Stephens 2000). (Refer to Figure 5 for town names.)



Harborne, 2000; Dacles *et al.*, 2000) (Fig. 5). PRRCFI community workers were based in Maricalum (adjacent to Campomanes Bay) and Sipalay from where they carried out community-based training in the area.

When all reefs had been surveyed between Danjugan Island and northern Nabulao Bay, activities then moved south to the town of Hinoba-an (2000-2001). Further surveys from this base camp identified three more sites which merited protected area status: Nabulao Bay Patch Reef, Palm Reef, and Catmon Point (Fig. 5). Local agricultural officers from Hinoba-an municipal offices were trained in the use of SCUBA and reef-monitoring techniques at the Hinoba-an base camp.

The initial stages of the SNCDP project carried out baseline resource assessment surveys, training of local communities, and the development of school partnership projects. As a direct result of the scientific investigations, coastal management recommendations have since been presented to the local community via the Mayor's office of the municipalities of Sipalay and Hinoba-an respectively. These reports recommended at least 5 potential sites to be designated as Marine Protected Areas for Sipalay (Dacles *et al.*, 2000), and Hinoba-an (Solandt *et al.*, 2001c) reefs. The aim of this proposal was to establish a chain of marine reserves in three municipalities in Southern Negros (see Fig. 5).

Lessons learned and challenges ahead

The principal successes of the project were the publication of four key reports recommending the development of Marine Protected Areas in the municipalities of Sipalay and Hinoba-an for the purpose of providing a network of protected areas which will benefit genetic flow and larval transfer of reef fish and invertebrates between different coastal areas (Beger and Harborne, 2000; Dacles *et al.*, 2000; Solandt *et al.*, 2001b; Solandt *et al.*, 2002).

Monitoring quadrats and Reef Check surveys were laid at two of the southern-most sites in the municipality of Hinoba-an, Catmon Point, and Palm Reef, and the coordinates of these quadrats have been noted for future repeat monitoring by local communities.

Around 2500 UK-based and hundreds of Philippine volunteers and staff have contributed to the success of the survey project along the coast. As a result, a habitat map which shows areas of high coral cover at different locations along the Negros Occidental coast (Fig. 7) was also developed between CCC/PRRCFI in collaboration with the University of Leicester (Stephens, 2000).

As a result of community training at CCC base camps in Campomanes Bay and Hinoba-an, local fishermen and employees of local government offices have been introduced to CCC survey methodologies, and trained in the identification of reef flora and fauna (fish, invertebrates, algae, and coral). (Table 1). SNCDP program staff visited local schools and invited children from both Sipalay and Hinoba-an to visit Danjugan Island and to participate in educational camps. Formal meetings between PRRCFI, CCC, and municipal staff have led to an ingrained sense of responsibility for the marine environment at municipal level in the south of Negros. However, it will take more time and effort to carry this process through to action on the ground such as has been the case for communities like Elihan and Bulata.

Notes

[1] It is beyond the scope of this paper to go into detailed descriptions of methodology - please see Mumby and Harborne, 1999; Mumby *et al.*, 1995; Solandt *et al.*, 2002)

Table 1. Main aims, objectives and anticipated outputs of the Poverty Alleviation and Community Education (PACE) programme in line with the Southern Negros Coastal Development Programme (SNCDP), and its achievements thus far with regard to all areas described in this paper (after Beger and Harborne, 2000).

		Achieved at:		
Aim	**Objective**	**DIMRS**	**Elihan**	**SNCDP**
➲ Resource assessment coral reefs.	❶ Undertake a scientific survey of target coral reefs. ❷ Conduct preliminary human impact assessment studies. ❸ Establish a baseline database. ❹ Provide management tools and recommendations for the establishment of marine reserves and sanctuaries.	Yes Yes Yes Yes	Yes Yes Yes Yes	Yes Yes Yes Yes
➲ Resource assessment and restoration mangroves.	❶ Undertake a scientific survey of mangroves. ❷ Re – establish mangroves in coastal areas.	Yes Yes	No No	No No
➲ Environ-mental Monitoring.	❶ Establish and validate a monitoring program within the project area.	Yes	Yes	Yes
➲ Training and conservation education.	❶ Provide coral reef ecology and SCUBA training for local counterparts and CCC volunteers. ❷ Heighten awareness of marine and coastal resources, their use and protection.	Yes Yes	No Yes	Yes Yes
➲ Community organization and alternative livelihood.	❶ Provide organizational training for local communities. ❷ Organize environmental activities with local and CCC volunteer groups. ❸ Develop a sense of community stewardship in monitoring and managing the coastal zone. ❹ Develop alternative livelihood projects.	Yes Yes Yes Yes	No Yes Yes No	No No No No
➲ Resource management.	❶ Establish community based coastal zone management plan. ❷ Establish a chain of marine reserves in three municipalities: • Hinoba-an • Sipalay • Cauayan ❸ Community based and controlled nature tourism.	Yes N/A Yes	No N/A No	No No No

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REEF CHECK DATA REVEAL RAPID RECOVERY FROM CORAL BLEACHING IN THE MAMANUCAS, FIJI

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Ryan C.J. Walker, Dianne Walker, Jessica Taylor,
Simon Haycock, Melanie T. Davis, and Peter S. Raines

ABSTRACT

Twenty two fringing reef sites within the Mamanuca Islands, western Fiji were surveyed during 2001 and 2002, using Reef Check methods. A mean increase of 14.3% in hard coral cover was recorded over the 12-month period. This increase in hard coral cover suggests a significant recovery of scleractinian coral colonies that were originally impacted by the 2000 mass bleaching episode in the South Pacific. The event was reported to have caused >80% coral mortality in the southern and eastern regions of Fiji. Between 2001 and 2002 the coral reefs of the Mamanucas progressed from "poor" to "fair" in accordance with the Association of South East Asian Nations (ASEAN) system for describing the health of coral reefs. Our results also show that trained non-specialist volunteers undertaking marine surveys such as Reef Check can competently collect simple, yet important quantitative data regarding the physical health of coral reefs.

Introduction

Fiji is one of the wealthiest countries in the South Pacific. The nation's wealth is partly attributed to its extensive marine resources, which generate significant revenue through tourism and marine resource utilization. For example, Fiji is the world's second largest exporter of live reef products for the aquarium trade, after Indonesia (Sulu *et al.*, 2002). Importantly, Fiji's marine environments are a significant source of protein for local coastal populations, with subsistence catches estimated at

17,000 tons per annum (Spalding *et al.*, 2001). Fiji's reefs support high marine biodiversity (Wilkinson, 2002), with approximately 298 species of coral recorded to date (Veron, 2000; Spalding *et al.*, 2001). The country is made up of approximately 844 volcanic islands, dominated by the Viti Levu and Vanua Levu platforms, which account for 87% of the total land area (Vuki *et al.*, 2000).

Although the coral reefs of Fiji are of vital importance both ecologically and economically, they are under threat through rapid economic and population growth. The country's coral reef ecosystems are being adversely affected by a range of anthropogenic activities including over-fishing, destructive fishing through the use of explosives and poison from the *Derris* root, sedimentation, eutrophication, and pollution (Sulu *et al.*, 2002). Outbreaks of the coral predating crown-of-thorns starfish (*Acanthaster planci*) have been reported annually since 1996 at widely dispersed sites, including the Mamanucas (Sulu *et al.*, 2002). Recent coral bleaching events and storm damage have exacerbated these effects to further reduce reef health (South and Skelton, 2000). Such impacts represent possibly the most substantial threat to the ecological balance and health of reef ecosystems in Fiji on a variety of temporal and spatial scales. With the exception of reefs to the far north of the archipelago, considerable areas of Fiji's reefs were affected by mass coral bleaching in March-April 2000. The presence of elevated temperatures as monitored by the US National Oceanographic and Atmospheric Administration (NOAA) showed progressive warming around the island group (Lovell, 2000). Coral mortality was recorded at 40% for many sites, and >80% for some reefs in southern and eastern Fiji (Sulu *et al.*, 2002; Cumming *et al.*, 2003).

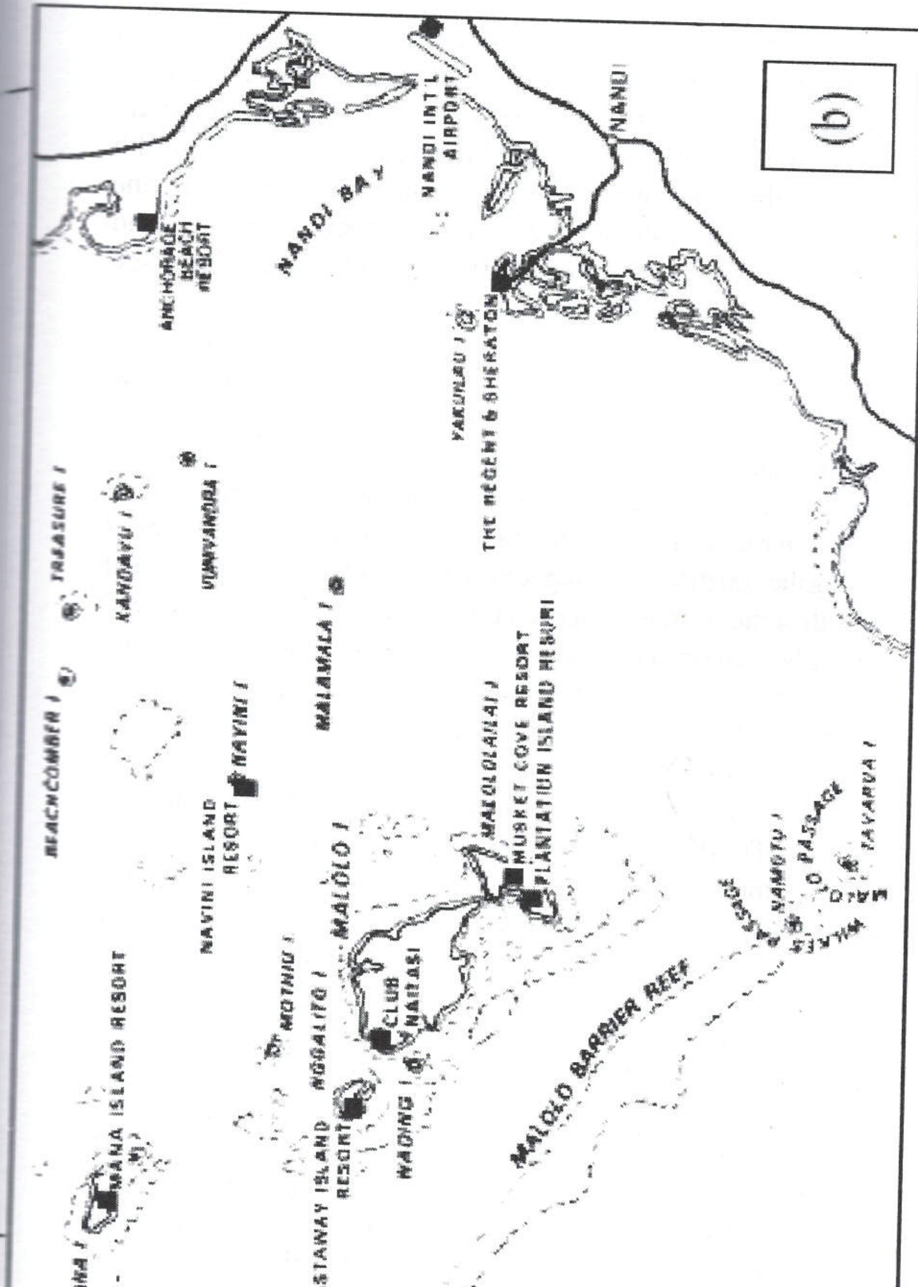
If left unchecked, the current suite of impacts will ultimately lead to reduced financial returns for coastal communities and other stakeholders who rely on fishing and marine-based tourism for their livelihoods. The 2000 mass bleaching event catalyzed the first major Global Coral Reef Monitoring Network (GCRMN) activity in the region where eight independent research groups collaborated to assess bleaching at 19 sites throughout Fiji (Wilkinson, 2002; Cumming *et al.*, 2003). Since 1996, the GCRMN has assisted with the Seawater Temperature Monitoring Programme at the University of the South Pacific (USP) to record temperatures throughout Fiji. Data from approximately 100 Fijian reefs have been collected by researchers, reef-based tourist operations, such as the Fiji Dive Operators Association (FDOA), and non-governmental organizations (NGOs), namely Coral Cay Conservation (CCC), Greenforce, and the International Marine life Alliance (IMA).

Study Area and Methods.

The Mamanuca Islands in the west of Fiji (Fig. 1) have been the focus of tourism development from at least the mid-1960s. Similar to other Fijian island groups, coastal zone management in the Mamanucas has been relatively nascent (Comley *et al.*, 2003), but the tourism industry in Fiji is very much aware of the value of conserving the coral reefs and fostering sustainable development (Walker *et al.*, 2002). The Fiji Coral Reef Conservation Project (FCRCP), a collaboration between the UK-based NGO Coral Cay Conservation (CCC) and the Fijian Ministry of Tourism, Culture, Heritage and Civil Aviation, has been operating in the Mamanucas since 2002 (Comley *et al.*, 2003). The full project was preceded by a three-month pilot program, the Mamanuca Coral Reef Conservation Project – Fiji 2001 (MCRCP) in the previous year (Harborne *et al.*, 2001).

In an effort to collect baseline resource data to be used in coastal management plan, the MCRCP undertook a rapid assessment of the coral reefs of the region with the use of trained, self-financing volunteer divers. One component of the work undertaken was an assessment of reef health using the "Reef

Figure 1. a) The Fiji islands, showing the project area (dashed line) for the MCRCP and FCRCP. *Source:* Fiji Visitors Bureau. (b) Major islands with the Mamanucas.


(b)
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NANDI INT'L AIRPORT
NANDI
ANCHORAGE BEACH RESORT
THE REGENT & SHERATON
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TREASURE I
KANDAVU I
MALAMALA I
NAVINI I
NAVINI ISLAND RESORT
MALOLO I
MALOLO
CLUB NAITASI
MALOLOLAILAI I
MUSKET COVE RESORT
PLANTATION ISLAND RESORT
MANA I
MANA ISLAND RESORT
CASTAWAY ISLAND RESORT
MALOLO BARRIER REEF
NAMOTU I
TAVARUA I

Check" methodology. Reef Check is the largest international coral reef monitoring program and is designed for non-professional divers. Reef Check surveys generate relatively simple but useful quantitative information on general reef health through the abundance of indicator mobile and sedentary marine organisms, benthic structure, anthropogenic impacts, and abundance of commercially harvested species.(See www.reefcheck.org for further details).

The standard Reef Check survey protocol utilizes transects at two depth bands of approximately 3 and 10 m. During the MCRCP/FCRCP survey, the vast majority of transects were carried out between 2 and 10 m.

A 100 m transect was deployed at each depth at each site. Four replicate transects, each 20 m in length, were surveyed along the 100 m line. The replicate transects followed the designated depth contour in sequence but the start and end point of each 20 m replicate were separated by a 5 m space. Therefore the distance between the start of the first transect and end of the last transect was 20 + 5 + 20 + 5 + 20 + 5 + 20 = 95 m.

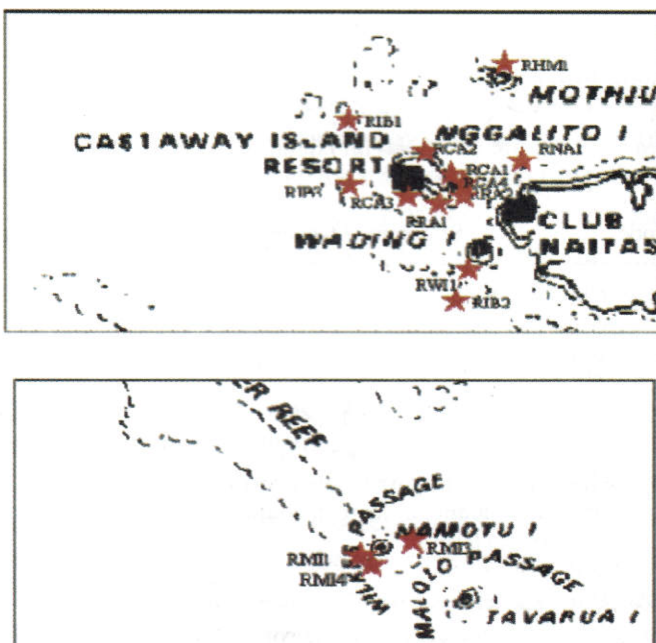
The four 20 m long transects were point sampled at 0.5 m intervals to determine the substratum types and benthic community present. The divers noted down the substratum type directly under each point. The standard Reef Check protocol splits the benthic substratum into 10 basic categories (hard coral, soft coral, recently killed coral, nutrient indicator algae, sponge, rock, rubble, sand, silt/clay, and others). Definitions are provided in Hodgson *et al.* (2003). However, for this study, hard corals were further divided into the categories *Acropora* and non-*Acropora*, and silt/clay was omitted due to its infrequent abundance.

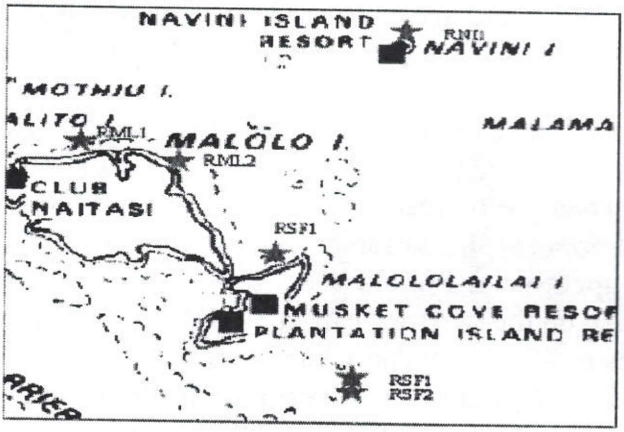
Furthermore, the presence of coral recruits, defined as colonies < 5 cm in diameter, was recorded along each transect line. This enabled recovery to be recorded both as the presence of healthy existing coral colonies, which may have partially bleached in the 2000 event and the recruitment of new hard coral colonies on stable non-living substrata (reef rock and dead coral).

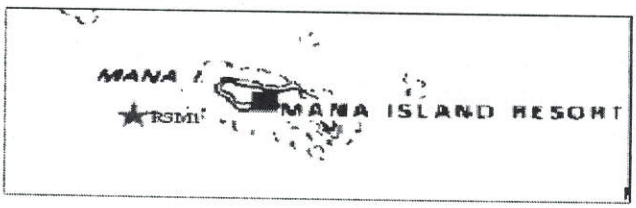
Table 1. (Continued)

Site code	Site name / General location	Depth (m)
RML 1	Malolo Island	7
RML 2	Malolo Island	4
RML 3	Malolo Lailai	6
RNA 1	Nayanu Levu	3
RNI 1	Navini Island	5
RRA 1	Raviniake (close to CCC base)	3
RRA 2	Raviniake (close to CCC base)	4
RSF 1	Sunflower	14
RSF2	Sunflower	4
RSM 1	Supermarket	8
RWI 1	Waidigi Island	6

Figure 2. Location of Reef Check sites (red stars) completed during the pilot phase of the MCRCP (July/August 2001), and subsequently during the Fiji Reef Conservation Project in June/July 2002. (Key to codes in Table 1)







Results

An overall increase in hard (scleractinian) coral cover for the 22 transects was recorded, from 13% mean total cover in 2001, to 27.3% mean total cover in 2002 (Figure 3). Hard coral cover included all living colonies of scleractinian corals whether they were large established colonies or recent recruits over the twelve-month period. Statistically the increase was significant (paired t-test; $p < 0.01$, Table 2). A significant increase in coral recruits recorded along the transects was also found between 2001 and 2002 (Mann-Whitney test; $p = 0.025$, $n = 20$). In 2002 Haycock (pers. obs.) noted that coral recruits were generally more prevalent at Navini (RNI1), Honeymoon (RHM1), and Sunflower (RSF1/RSF2). Conversely, at the Malolo Island and Castaway sites, recovery of large coral colonies was more prominent than the recruitment of juvenile corals (Walker, D., pers. obs.).

An increase in hard coral cover was also shown by both non-*Acropora* and *Acropora* corals over the period of a year; non-*Acropora* increased from 9.8% in 2001 to 19.3% in 2002 (p <0.01), whilst *Acropora* cover more than doubled, from 3.3% in 2001 to 8.0% in 2002 (p <0.05). All sites surveyed in 2002 (with the exception of RCA4, RNI1 and RRA2) had greater recorded cover of non-*Acropora* corals than *Acropora* corals (Table 2) (mean cover of 19.2% and 8% respectively, Fig. 3). The highest coral cover was recorded on the two transects at Sunflower reef (Table 2). Counts of 82 and 79 and means of 49.4% and 51.3% for total hard coral cover were recorded for RSF1 and RSF2 respectively. Both Sunflower transects also recorded the highest coral cover in 2001. The increase in hard coral cover was generally recorded across the sites in the Mamanucas, with the exception of RCA2 and RRA2 (Table 2).

The 2002 surveys showed a similar amount of algal cover to the 2001 surveys (27.8% and 24.6% respectively). Sponges and soft corals were rarely seen on the transect lines (both had mean coverage of <2%). The only other benthic class to show a significant change over time was that of rock, decreasing in cover (p <0.01).

Figure 3. (Next page) Temporal changes in benthic cover (%) between 2001 and 2002 across the 22 survey sites.

Notes: RKC = Recently killed coral.

Significant increases occurred in the percent cover of *Acropora*, Non-*Acropora*, total coral and Other (OT) categories (t-test, *P*< 0.05). There was also a significant decrease in the % cover of rock (RC) between 2001 and 2002.

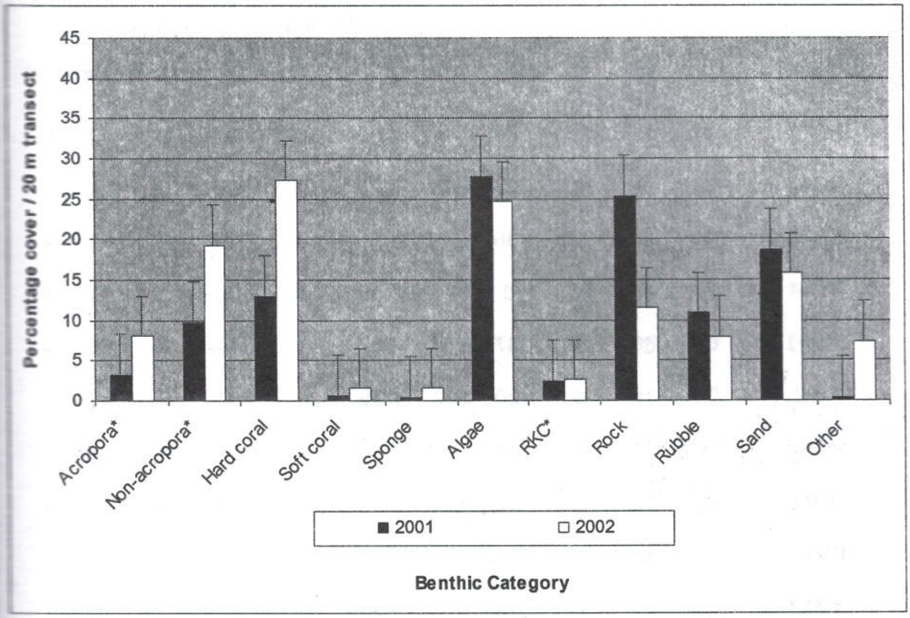


Table 2. (Following pages) Total transect substrate counts for the 22 repeat surveys (2001-2002). Results of paired t-tests display differences between in total cover for each substrate type across the Mamanucas. *RKC = Recently killed coral.

	Acropora		Non-Acrop-ora		Total Hard Coral		Soft Coral		Sponge	
Site/Year	01	02	01	02	01	02	01	02	01	02
RCA1	1	1	9	49	10	50	0	0	0	0
RCA2	1	0	26	23	27	23	2	0	0	1
RCA3	0	0	10	36	10	36	0	0	0	1
RCA4	2	9	2	1	4	10	3	0	1	1
RHM1	6	30	9	37	15	67	2	4	2	1
RIB1	0	19	2	20	2	39	0	0	0	2
RIB2	13	20	24	44	37	64	1	5	0	3
RIB3	8	10	7	12	15	22	0	0	0	0
RMI1	0	0	27	21	27	21	6	11	6	0
RMI3	4	6	27	32	31	38	3	0	0	13
RMI4	0	1	33	36	33	37	5	19	7	8
RML1	0	23	11	41	11	64	0	4	1	0
RML2	0	1	19	49	19	50	0	0	0	3
RML3	1	0	36	23	37	23	0	0	0	3
RNA1	11	31	16	33	27	64	0	2	0	5
RNI1	6	34	18	30	24	64	1	11	0	3
RRA1	0	1	4	23	4	24	0	0	1	2
RRA2	4	7	15	3	19	10	1	0	0	1
RSF1	14	21	57	58	71	79	1	1	1	0
RSF2	34	39	11	43	45	82	1	3	2	0
RSM1	0	0	11	37	11	37	0	1	0	2
RWI1	1	4	1	10	2	14	0	0	0	3
t-test(42)	-2.12		-3.01		-3.35		-1.44		-1.83	
P	<0.05		<0.01		<0.01		>0.05		>0.05	

	Algae		RKC*		Rock		Rubble		Sand		Other	
Site/Year	01	02	01	02	01	02	01	02	01	02	01	02
RCA1	54	34	0	0	28	4	30	25	38	46	0	1
RCA2	57	15	2	3	26	16	14	18	32	35	0	49
RCA3	60	70	5	0	18	15	31	13	36	22	0	3
RCA4	40	61	3	1	42	19	21	23	45	39	1	6
RHM1	58	44	2	0	64	18	4	0	10	0	3	26
RIB1	82	31	1	2	26	33	8	4	41	46	0	3
RIB2	10	41	12	7	88	33	10	5	1	0	1	2
RIB3	77	22	2	42	6	5	8	4	52	65	0	0
RMI1	63	35	0	0	36	5	3	0	9	0	10	8
RMI3	39	30	11	1	55	37	3	0	18	35	0	6
RMI4	39	81	4	2	57	7	8	0	7	1	0	5
RML1	24	16	0	0	17	17	18	6	89	31	0	22
RML2	70	51	2	2	27	2	18	15	21	23	3	14
RML3	44	4	5	0	15	45	41	16	18	13	0	13
RNA1	60	20	1	7	25	43	25	3	20	16	2	0
RNI1	34	34	3	8	70	13	12	2	14	3	2	22
RRA1	37	56	2	1	36	16	28	14	52	46	0	1
RRA2	35	52	9	3	34	16	28	44	34	33	0	1
RSF1	22	38	12	0	32	0	15	12	5	0	1	30
RSF2	60	4	3	2	22	24	14	4	11	16	2	25
RSM1	12	63	2	0	116	35	1	0	18	13	0	9
RWI1	21	26	5	1	24	14	52	60	56	33	0	9
t-test(42)	1.25		0.0884		3.23		1.31		0.83		-3.84	
P	>0.05		>0.05		<0.01		>0.05		>0.05		<0.001	

Discussion

The most striking difference between 2001 and 2002 data sets is the increase in both *Acropora* and non-*Acropora* and therefore, total scleractinian coral cover at almost all of the study sites. The significant decrease in the total recorded cover of rock across the survey sites suggests that the available space was becoming occupied by coral recruits during the period between the surveys. The significant increase in the number of recruits recorded between the two sampling times verifies this suggestion. Survey sites spanned the complete range of geomorphological reef types present in the Mamanucas region at widely dispersed localities. The increase in hard coral cover can generally be viewed as extremely encouraging.

The Association of South East Asian Nations (ASEAN) system for describing the health of coral reefs (Chou *et al.*, 1984) states that coral reefs with hard coral cover of less than 25% are described as being in 'poor' health, whilst those of cover in excess of 25% are described as 'fair.' Therefore, the reefs in the region appear to have doubled in live hard coral cover in one year, thus increased their ASEAN health rating from poor to fair.

Acropora coral, normally known for its susceptibility to bleaching (Brown, 1987; Lovell, 2000) also recovered significantly with branching *Acropora* coral cover in areas such as Sunflower reef (to the south of Malolo Lailai) recording high levels of abundance. *Acropora* corals are biologically designed to recover quickly from physical damage (Brown and Howard, 1985). They are adapted for life in high-energy shallow environments (i.e. reef crests) and are amongst the fastest growing corals with high fecundities. This life history strategy as a disturbance-adapted ruderal (*r*-selected traits) enables them to recover more quickly from population crashes than slower-growing *K*-selected (competitors) or *S*-selected (stress-tolerators) corals

(Goodman, 1974; Pianka, 1972 but see also Edinger and Risk, 2000). Lovell (2000) also states that a high survival rate of corals at depth or inshore ensures a high level of recruits to stock recovering bleached colonies on some of Fiji's reefs.

As no permanent markers of the transects were used, two sources of error are apparent when comparing the 2002 data with that of 2001. GPS points were taken over the start and end points in 2001, and in 2002 when the sites were revisited using these GPS readings. Dive teams were dropped in as close to the original points as possible.

However, due to several factors, including adverse weather conditions and currents, accurate positioning of survey divers was only possible to within about 10-15 meters in some cases. It would be very difficult to drop divers in on the same point that was used as the start point from the year before, unless the start and end points were permanently marked underwater. Similarly, it would be difficult to know exactly how the measuring tape was originally laid in 2001, and that the bearing of the line may be slightly different without submerged markers. As a result, all transects will have probably been taken along a slightly different line in 2002 to that swum in 2001. In light of these factors it is highly likely that the data collected will be valid only for gross temporal comparison in benthic cover and faunal abundance rather than specific changes at individual sites. Data were collected along the same depth contours at all sites in both years, and trends in increased coral cover existed at over 80 % of the sites visited.

Cumming *et al.* (2003) state that an estimated 10-40% of coral colonies died from bleaching within four months of the onset of bleaching in 2000. The Mamanucas were not as badly affected as reefs in southern and eastern regions of Fiji, commonly displaying >80% mortality rates. Sea surface temperature (SST) in the Mamanucas exceeded expected summertime maxima for 5 months and peaked at 30-31°C prior to bleaching between March and early April 2000 (Walker *et al.*, 2002). The watershed point at which corals start to bleach is generally regarded as 30°C (Brown, 1997) whilst the bleaching threshold in Fiji appears to be in the range of 29.5-30°C (Cumming *et al.*, 2003).

Our results suggest that a significant degree of recovery from bleaching by scleractinian corals has occurred across the Mamanucas island group. The increase in hard coral cover can be attributed to a combination of recruitment of new corals on available reef rock and the recovery of previously partially bleached colonies. An increase in recruitment was recorded along transect lines over the time period of the study. Lang *et al.* (1992) and McField (1999) state that bleached colonies are able to begin recovery within 3.5-4 months of a bleaching event in some cases. Bleached colonies in 2000 may have been recorded as non-recoverable (see Cumming *et al.*, 2003) only to begin recovering after four months in the bleached state. The results presented here also support the idea that the Mamanucas region is of national importance in Fiji as it shows demonstrable capacity to recover from bleaching events and storm episodes (Cumming *et al.*, 2003).

Conclusion

Our results indicate a significant recovery from bleaching by scleractinian corals in the Mamanucas region of Fiji and further support the argument that trained non-specialist volunteers can be invaluable for the collection of reliable biological, quantitative data sets for coral reefs as part of a well-coordinated survey or monitoring program (Mumby *et al.*, 1995; Darwall and Dulvy, 1996; Harding *et al.*, 2000; and Evans *et al.*, 2001). Adequately trained volunteers can be a cost effective substitute to qualified marine biologists, where the use of such professional personnel would be unfeasibly expensive or logistically impossible due to time constraints. Reef Check is perhaps the most ambitious and successful reef-monitoring program which uses volunteer divers. Reef Check has gained considerable momentum since it was launched in 1997. The recent five-year report contained data collected by over 5,000 people from 1,500 reefs in more than half of the coral reef countries of the world (Hodgson and Leibeler, 2002). Despite the information collected being data in their simplest form, our results show that these data can reveal spatial trends and impacts over short timescales that are important for many coastal management decision-making processes.

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THE BATS (MAMMALIA, CHIROPTERA) OF THE UPPER IMBANG-CALIBAN WATERSHED, NORTH NEGROS FOREST RESERVE, NEGROS OCCIDENTAL, PHILIPPINES

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ABSTRACT

Lack of available information about ecological requirements, habitat ranges, and abundance provides continual problems for chiropteran conservation initiatives in the Philippines. Negros Island (Central Visayas, Philippines) represents one of the ten highest-ranking sites globally for megachiropteran diversity yet it is also listed as a priority site for survey work. This paper reports on the first survey on the bat fauna of the Imbang-Caliban watershed of the North Negros Forest Reserve, Negros Island. A total of 13 species of bats from 369 individuals were recorded. These included 9 megachiropterans and 4 microchiropterans. Over 40% of the species recorded were endemic to the Philippines. The most notable species present was *Nyctimene rabori.* These initial results stress the need for more comprehensive surveys in order to implement effective conservation measures for both endemic and threatened species.

Introduction

Members of the order Chiroptera are of particular importance in tropical forest environments. Numerous studies have investigated ecological and evolutionary aspects of the linkages between fruit consumption by vertebrate frugivores and seed dispersal of tropical forest trees (Flemming & Estrada, 1993). Such case studies suggest that regeneration of tree species will suffer if this dispersal capability is lost (Gibson & Wheelwright, 1995). Within the Philippines, few such studies have been completed but Hamann and Curio (1999) suggest that on Negros Island up to 80% of the forest community is dependent on this regeneration mechanism.

This has particular significance for two reasons. Firstly, although in the past the Philippines was almost completely covered in tropical forest, it now has one of the highest rates of tropical forest loss (Collins *et al.*, 1991). The forest coverage of Negros has been reduced from over 90% to just 4% with two thirds of this lost in the last 50 years (Heaney & Regalado, 1998). Secondly, while bats (Chiropterans) often make up a large proportion of the mammalian diversity of forest habitats in the Philippines (Heaney, 1993; Heaney *et al.*, 1997), the Megachiropteran fauna contains a high percentage of threatened taxa as a result of the large-scale deforestation and hunting (Mickleburgh *et al.*, 1992).

The interdependencies of tropical forests and bats are well recognized, and in Philippine montane forests frugivorous bats rather than birds play the dominant role in dispersing early successional species (Ingle, 2003). However, very little data are available in the literature regarding the response by bats to destruction and alteration of their natural habitat (Estrada & Coates-Estrada, 2002). There are at least 15 species of Megachiroptera thought to be present on Negros Island, of which, approximately 20% are known to be endemic to the Philippines, and a high proportion of these species are threatened (Heaney *et al.,* 1998).

However, the status of the Microchiropteran fauna on Negros is still poorly known (Heaney, 1993) and they are recognized as probably the most poorly known mammalian order in the Philippines (Ingle & Heaney, 1992). Nevertheless, there has been notable progress on the ecological understanding of this group, both within specific geographic areas of the Philippines (Sedlock, 2001; Sedlock, 2002), and with particular ecological focus, e.g. seed dispersal (Utzurrum, 1995).

Conversely, the Megachiroptera (particularly the Pteropodidae family) are arguably one of the best-known groups of mammals within the Philippines (Heaney *et al.,* 2000) in terms of the relative distributions. However, it is also acknowledged that sampling effort has been skewed geographically, with many areas that have yet to be sampled. Thus, with little information about this threatened bat species, one can only state that it is believed or known to occur in the North Negros Forest Reserve (Heaney & Mallari, 2000).

Forest habitats have been identified as particularly important for bats and a priority for conservation efforts on a global scale (Mickleburgh *et al.*, 2002). However, an information deficit has been acknowledged (Oliver & Heaney, 1996; Heaney & Regalado, 1998; Turner *et al.*, 2001). With regard to Chiropterans, while new species have recently been discovered, there are concerns that several species may now be threatened and possibly extinct (Ingle & Heaney, 1992). Heaney and Heideman (1987) reported that it has not been possible to estimate the number of species of bats in the Philippines that are extinct or endangered because of a lack of basic surveying information, and they suggested that faunal surveys were needed in nearly all parts of the country. More specifically, Mickleburgh *et al.* (1992) stressed (as one of twenty priority global projects) the urgent need to survey the Negros Island area which is ranked eighth highest in the world for Megachiropteran diversity and has been listed sixteenth globally for requiring the establishment of protected areas for world fruit bat conservation.

The principal aim of the research was to complete an initial inventory of the Chiropteran species within the different major forest habitats of the Imbang-Caliban watershed of the North Negros Forest Reserve (NNFR).

Study Area

Negros Island forms part of the Negros-Panay Faunal region of the Philippines. The moist forests of the Philippines, including the NNFR, are among the eight most vulnerable forest ecosystems in the world (WWF 2001). It is the largest remaining area of wet evergreen rainforest in Negros and the second largest in the Negros-Panay Faunal region.

Initially the NNFR was established by legislation in 1946 to protect more than 100,000 ha of virgin forest. By 1996, however, only 9,900ha of virgin forest remained in a total area of 16,687ha of forested area (Hamann 2002). The NNFR contains different types of habitats due to its varying degrees of elevation. Lowland dipterocarp forest has been cleared except in a few inaccessible valleys, and 6,600ha of secondary forest grows on areas that have been logged over in the past.

Table 1. Major habitat types within the NNFR in which mist-net surveys were undertaken.

Habitat	Description	Altitudinal Range
Heavily Disturbed Old-growth forest	*Montane forest selectively logged 35 years ago.	1100-1400m
Old-growth forest	*Transitional montane-lowland forest logged legally and illegally for commercial species until 11 years ago.	1200-1600m
Secondary forest	*Transitional montane-lowland forest Legally and illegally logged for commercial species resulting in complete exploitation until 11 years ago.	800-1000m
Forest edge	Forest / non-forest border.	800-1000m

*Classification adapted from Heaney (2001) and history derived from interviews with local community members.

The reserve, however, still contains 4,700ha of mid-elevation old-growth forest and over 5000ha of high-elevation mossy forest. The NNFR is still struggling against illegal logging, hunting, pet traders, rebel activity, and encroachment of the farming populations (Hamann 2002). Further details on the survey areas are also given by Slade and Turner (2003).

The survey work was undertaken within four-hours trek of the village of Campuestohan (10° 39'N, 123° 08'E), on the southwest edge of the NNFR. The surveys were concentrated on four main habitat types (Table 1) within the Municipalities of Talisay and Murcia, Province of Negros Occidental.

Methods

Mist-Net Survey

Mist-nets (38mm mesh, 6m x 2.6m) were used within four habitat types (Table 1), representing both forested and forest edge habitats within the study area of the NNFR. The sites were a minimum of two hours trekking apart. To maximize capture efficiency, nets were established across likely flight-paths such as clearings, along ridges, or by water (Heaney *et al.*, 1989), in a variety of combinations, such as 'Z' and 'T' formations (Kunz *et al.*, 1996), and at heights ranging from 1m to 10m above the ground. High nets were operated on a pulley system and, when possible, were complemented by a low net positioned on the same pulley system (following Ingle, 1993). Generally, nets were opened before dusk and closed anytime up to midnight, depending on weather and personnel. Sampling took place between February 2002 and February 2003 with each site being sampled at regular intervals throughout this period.

The trapping effort is summarized in mist-net hours (calculated as hours per square-meter of net): secondary forest sampled for 224 mist-net hours; disturbed old-growth forest sampled for 213 mist-net hours; old-growth forest sampled for 198 mist-net hours; and forest edge sampled for 189 mist-net hours. Nets were checked every 30 minutes.

For each survey night, the location, weather conditions, and time the nets were operational were noted. As nets were open for variable lengths of time, net-effort for each location was calculated as hours per square-meter of net.

Species Identification

Bats captured were identified using Ingle and Heaney (1992), sexed by observation of genitalia and nipples, and aged (to adult or juvenile) by assessment of the ossification of the joints of the digits of the wing. Forearm length was measured using dial callipers, and weight using spring balances. When new species were encountered, ear, hind-foot, and total length were also recorded. No samples were taken during the survey period and the work was completed under a Gratuitous Permit issued by the Department of the Environment and Natural Resources.

Data Analysis

Three measures of local diversity were calculated for each survey location and these included: Total number of species (S), Shannon-Weiner diversity H=å(P_i*Log_e(P_i)) where P_i is the number of individuals of the *i*th species as a proportion of the total number of all *i*th species, and Pielou's eveness $J=H/Log_e S$ (Carr 1996).

Results

A total of 369 bats representing three Chiropteran families and 13 species were recorded across the survey locations, of which nine were Megachiropteran and four were Microchiropteran species (Table 2). The disturbed old-growth forest had the highest species richness and the greatest number of captured individuals among the habitats sampled, whereas the old-growth forest had the lowest values for both metrics. Over 45% of the species recorded are endemic to the Philippines (Table 2), including the highly endangered *Nyctimene rabori*.

Only three species, *Cynopterus brachyotis, Macroglossus minimus*, and *Rousettus amplexicaudatus* were recorded in all four of the habitat types. Additionally, *Cynopterus brachyotis* and *Haplonycteris fischeri* (a Philippine endemic) were the most abundant species. Of the 369 bats captured during the general mist-net survey, only a small proportion (<5%) were Microchiropterans. Morphological data were recorded for each species (Tables 3-4).

Table 2. Summary of Megachiropteran and Microchiropteran species captured during the surveys within NNFR.

Species	Common name	Forest Edge	Secondary Forest	Disturbed Old-growth	Old-growth forest	Total caught
Cynopterus brachyotis	Common short-nosed fruit bat	48	40	37	7	132
**Haplonycteris fischeri*	Philippine pygmy fruit bat	-	29	55	35	119
**Harpylonycteris whiteheadi*	Harpy fruit bat	-	-	-	1	1
**Nyctimene rabori*	Philippine tube-nosed fruit bat	2	-	3	-	5
Macroglossus minimus	Dagger-toothed flower bat	38	25	4	3	70
**Ptenochirus jagori*	Musky fruit bat	-	3	6	-	9
Pteropus hypomelanus	Common island flying fox	1	-	-	-	1
**Pteropus pumilus*	Little golden mantled flying fox	1	-	-	-	1
Rousettus amplexicaudatus	Common rousette	1	3	3	6	13
Rhinolophus arcuatus	Arcuate horseshoe bat	-	1	1	-	2
**Rhinolophus virgo*	Yellow-faced horseshoe bat	-	1	12	-	13
Myotis macrotarsus	Philippine large-footed myotis	1	-	1	-	2
Pipistrellus spp.	Pipistrelle sp	-	1	-	-	1
Total abundance		92	103	122	52	
Species richness		7	8	9	5	
Shannon-Weiner diversity		1.33	1.51	1.67	1.01	
Pielou's eveness		0.51	0.68	0.67	0.64	

* Endemic species.

Table 3. Megachiropteran adult morphological data.

Species			Adult Female				
		Mass (g)	Body length (mm)	Forearm (mm)	Hind foot (mm)	Tail(mm)	Ear (mm)
Cynopterus brachyotis	range	18-40	65.5-104.7	50-68.5	9.8-15.6	2.2-9	8.8-19.2
	mean (sd)	34.98 (5.25)	91.84 (7.88)	64.23 (3.65)	12.58 (1.38)	5.46 (1.9)	13.717 (2.38)
	n	38	29	39	29	23	30
Haplonycteris fischeri	range	11-22	54.7 -84.5	43.5-52.5	7-14	-	6.3-13
	mean (sd)	23.01	72.25 (5.46)	49.95 (5.33)	9.98 (1.58)	-	10.17 (1.62)
	n	48	45	49	49	-	49
Macroglossus minimus	range	16 -24	55.2- 73.6	41.5 -48	8.2- 14	-	9- 14.6
	mean (sd)	19.27 (2.12)	66.79 (4.95)	44.18 (1.44)	11.15 (1.63)	-	12.56 (1.91)
	n	22	12	22	15	-	15
Nyctimene rabori	range	63-68	132-136	71-79	15.2-16.3	-	18-22
	mean (sd)	65.5 (2.5)	134 (2.0)	75 (4)	15.75 (0.55)	-	20 (2)
	n	2	2	2	2	-	2
Ptenochirus	range	90-107	117.5-150.7	84.1-93	17.4-17.8	6.1-9.1	12.5-18.2
jagori	mean (sd)	98.5 (12.02)	134.1 (23.48)	88.55 (6.29)	17.6 (0.28)	7.6 (2.12)	15.35 (4.03)
	n	2	2	2	2	2	2
Rousettus amplexicaudatus	range	62.1-8-5.2	127.1-141.3	75-82.1	-	14.5-16.3	17.9-19.5
	mean (sd)	76.6 9.19	135.06 (5.28)	78.4 (3.04)	-	15.6 (1.14)	18.64 (0.69)
	n	5	5	5	-	5	5

Adult Male					
Mass (g)	Body Length (mm)	Forearm (mm)	Hind foot (mm)	Tail (mm)	Ear (mm
17-45	78.4-103.9	50.1-68.8	8.5-16.2	1.5-7.4	8.1-24
33.93 (6.13)	88.66	62.45 (3.3)	12.48 (1.61)	5.15 (1.89)	13.83 (2.89)
47	37	50	46	23	46
17-25	6.9-13.4	56.1-61.2	31 -52.1		7.9-12.9
23.61 (18.3)	69.50 (3.51)	48.64 (3.48)	10.34 (1.57)	-	10.18 (1.25)
33	33	33	33		33
17.5- 24	65.2 -85.4	42-64.6	11.1 - 14.7	0-6.5	9.1-14.6
21.7 (3.55)	70.87 (6.42)	46.3 (4.62)	11.28 (1.32)	2.167 (3.75)	12.88 (1.52)
20	13	20	14	3	14
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
80-93	109.5-135.4	82-89.3	15.2-19.9	3.7-12.3	16.5-17.6
88.92 (6.53)	122.08 (8.74)	86.40 (2.87)	18.38 (2.07)	8.93 (3.51)	17.02 (0.38)
6	6	6	6	6	6
65-88	129.1-146.2	77.7-83.1	-	14.9-17.2	18.1-21.2
78.6 (9.23)	137.8 (6.3)	80.7 (2.22)	-	15.78 (0.95)	19.4 (1.28)
6	6	6	-	6	6

Species listed in Table 2 but not in Table 3 were juveniles.

Table 4. Microchiropteran adult morphological data.

Species			Adult Female				
		Mass (g)	Body length (mm)	Forearm (mm)	Hind foot (mm)	Tail(mm)	Ear (mm)
Hipposideros	range						
Ater	mean (sd)	-	-	-	-	-	-
	n						
Rhinolophus	range	6-13	49.2-51.8	45.1-50	6.3-9.3	13-23	15-17
arcuatus	mean (sd)	10.5 (3.11)	50.33 (1.33)	47.73 (2.01)	7.83 (1.23)	18.48 (4.14)	16.13 (0.94)
	n	4	3	4	4	4	4
Rhinolophus	range	6-18	33.9-52.8	37.8-41.3	4.4-8	9-29.9	9-16.8
virgo	mean (sd)	12.88	42.63 (6.55)	39.83 (1.25)	6.63 (1.09)	17.16 (4.18)	12.45 (2.79)
	n	8	6	8	8	8	8
Pipistrellus	range						
sp.	mean (sd)	-	-	-	-	-	-
	n						

Adult Male					
Mass (g)	Body Length (mm)	Forearm (mm)	Hind foot (mm)	Tail (mm)	Ear (mm
6	40.9	40.9	7	29.7	15.5
1	1	1	1	1	1
8-15	46.9-50	47-50.4	6.8-17.8	3.7-24.6	9.9-21.5
11.19 (2.53)	50.34 (2.42)	49.05 (1.49)	10.08 (3.4)	17.48 (6.73)	16.85 (4.17)
8	6	8	8	8	8
6-14	30.5-63	37.2-40.5	6-7.2	16-21	10-16.4
8.71 (3.04)	42.09 (9.73)	38.9 (1.09)	6.63 (0.41)	19 (2.16)	14.81 (1.95)
7	8	9	9	9	9
4	49.5	32.5	6.3	30.9	12.1
1	1	1	1	1	1

Species listed in Table 2 but not in Table 4 were juveniles.

Discussion

Thirteen of the 73 species known to exist in the Philippines (Heaney *et al.*, 1998) have been recorded, representing over 17% of the Philippine bat fauna. However, this only represents 31% of the 41 species known to occur on Negros (Heaney *et al.*, 1998). The comparatively low numbers of species encountered may be explained by the limited number of areas (habitat types) surveyed and by the survey techniques employed. The combination of effort and techniques used may also partly explain the observed differences in the community metrics calculated.

The majority of the recordings consist of fruit bats, in particular, the Common short-nosed fruit bat (*Cynopterus brachyotis),* Dagger-toothed flower bat *(Macroglossus minimus),* and Philippine pygmy fruit bat (*Haplonycteris fischeri).* The prevalence of megachiropterans is probably a facet of the survey method employed since microchiropterans are known to be able to detect and avoid mist-nets and thus tunnel trap methodologies are recommended for sampling this group (Sedlock, 2001).

Perhaps the most important record is the Philippine tube-nosed fruit bat (*Nyctimene rabori*) which is not only endemic to the Philippines but is only known to exist on three islands, Cebu, Sibuyan, and Negros (Heaney *et al.*, 1998). Discovered only in 1984, this species is currently classified as Critically Endangered by the World Conservation Union (IUCN Red List). It is thought that numbers of this species are now reduced to about one percent of the original population size. Such a decline is due to their dependency on lowland tropical forest where they feed and roost.

The capture of the Philippine pygmy fruit bat (*Haplonycteris fischeri)* is potentially very important since this species has declined in recent years and is listed as vulnerable (Heaney *et al.*, 1998). It is also known to prefer primary (old-growth) forest and rarely found in secondary forest, as confirmed by the results presented.

Other species encountered included both threatened and endemic species. The Little golden-mantled flying fox *(Pteropus pumilus)* is rare and endemic to the Philippines and well known to frequent islands where it is usually associated with primary and well-developed secondary forest (Heaney *et al.*, 1989), and uncommon to rare on larger islands (Heideman & Heaney, 1989; Utzurrum, 1992). Catch data suggest that densities are quite low although it has been hypothesized that this species forages high in the canopy and therefore it may be more abundant than current catch data suggest (Mickleburgh, *et al.,* 1992). The presence of this species within the reserve is very encouraging as it is considered globally vulnerable by the IUCN and is fourth on the conservation priority list for Philippine fruit bats (Mickleburgh, *et al.,* 1992).

Another species captured in low numbers was the Common island flying fox (*Pteropus hypomelanus)* which is also endemic to the Philippines. However, the species is. known to fly high above normal netting reach and thus it may be more abundant than the catch-rates suggest. Of the microchiropterans, the Pallid Large-footed myotis (*Myotis macrotarsus)* is an uncommon species that is dependent upon caves to roost in (Heaney *et al.,* 1998) and is currently listed as near-threatened (Mickleburgh *et al.*, 1992).

We acknowledge that the reported data may represent a biased portrait of the bat community present in the area since we only sampled one level of the habitats studied during part of the night and because species of bats may be caught unequally by mis-nets. Since Microchiropterans are known to be able to detect and avoid mist-nets, tunnel trap methodologies are recommended for sampling this group (Sedlock, 2001).

Conclusion

The overall results demonstrate that even within the restricted geographic area surveyed, the forest habitats of the NNFR support a comparatively diverse and important bat fauna both on local and national scales. The records for the Philippine tube-nosed fruit bat even suggest this is a globally important site.

Further surveys employing a range of methods and over a greater number of habitat types (e.g. riparian forest; high-elevation mossy forest) are required for a comprehensive assessment. In addition, social and ecological assessments of the relevant threats posed to the bat fauna within the surveyed area of the NNFR should be made in order that appropriate conservation recommendations can be proposed.

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BIRD RECORDS FROM DANJUGAN ISLAND, NEGROS OCCIDENTAL, PHILIPPINES

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ABSTRACT

The bird fauna of Danjugan Island, which forms part of one of the most globally threatened Endemic Bird Areas (EBA 152), was recently surveyed as part of a wider biodiversity survey program completed by Coral Cay Conservation and the Philippine Reef and Rainforest Conservation Foundation, Inc. Observations were made over a four-month period in 2001 and a number of species of conservation interest were recorded. Species found to be breeding on the island included Rufous Night-heron (*Nycticorax caledonicus*), Tabon Scrubfowl (*Megapodius cumingii*), White-bellied Sea-eagle (*Haliaeetus leucogaster*), and Black-naped Tern (*Sterna sumatrana*). Species endemic to the Philippines included Black-chinned Fruit-dove (*Ptilinopus leclancheri*), Philippine Hawk-owl (*Ninox philippensis*), and Philippine Leaf-warbler (*Phylloscopus olivaceus*). Several migrant species, such as Red-necked Phalarope (*Phalaropus lobatus*) and Blue Rock-thrush (*Monticola solitarius*), were recorded on dates as early as any previous records from the Philippines. These preliminary results highlight the importance of the island as a refuge for a diverse avian fauna, and in light of the island's protective designation, locally-focused conservation and research recommendations are proposed.

Introduction

The Philippine Archipelago, consisting of over 7000 islands, exhibits one of the highest levels of species endemism in the world (e.g. 33% for birds, Collar *et al.* 1999), and boasts ofnine regions designated by BirdLife International as Endemic Bird Areas (EBAs) (Stattersfield *et al.,* 1998). One of these (EBA 152), located in the central Philippines and comprising of the islands of Negros, Guimaras, Panay, Masbate, and Ticao, has been ranked as one of the 12 highest-ranking EBAs worldwide, in terms of biological importance and threat level (Bibby *et al.,* 1992; Brooks *et al.*, 1992) and is classified as priority critical for conservation (Stattersfield *et al.,* 1998).

With forest cover on Negros island having been reduced from approximately 80% to just 4% in the last one hundred years (Heaney and Regalado, 1998), Danjugan Island, lying 3km off the west coast of Negros, opposite the village of Bulata, is one of very few areas within EBA 152 that is protected from further habitat loss. Since 1995, the area has been managed by the Philippine Reef and Rainforest Conservation Foundation Incorporated (PRRCFI) (Ledesma *et al.*, 1999). In February 2000 the island was granted reserve status as the Danjugan Island Marine Reserve and Sanctuaries (DIMRS) by the municipal government of Cauayan and the provincial government of Negros Occidental. This small island of just 43 hectares supports a variety of habitats, including relatively undisturbed mixed-species limestone forest, rapidly regenerating secondary forest, beach and cliff scrub, extensive mangrove stands, open and closed salt-water lagoons, and tidal mud-flats (Harborne *et al.,* 1996; Turner *et al,*. 2002). The conservation of these habitats, coupled with the protection from hunting pressures, provides a small but significant haven for the local populations of several migrant, endemic, and threatened bird species, as illustrated by a number of brief and unpublished surveys (Toledo 1994; Gonzalez and Dans 1997; Ebreo 1993; Lambert and Lee 1994). These were completed between May and August, for 2-4 days in duration and a species list has been compiled from these studies by Turner *et al.* (2002). However, this report, based on part of the Danjugan Island Biodiversity Survey conducted by PRRCFI and Coral Cay Conservation (CCC) (Turner *et al.*, 2002), describes the first extensive observations of the bird fauna of Danjugan Island, and highlights several species of particular conservation concern.

Observations were made between June (27th) and November (10th), with continuous presence on the island from late June to early October, followed by irregular visits. A full list of species identified is given in the Appendix, while records of particular interest are described below. Observers for specific sightings are given as two-letter codes in parentheses (GE-Gareth Ellis; JB-James Benares; RM-Roger O'Malley; ST-Simon Tyler; TK-Tony King). Identification in the field was based on du Pont (1971) and Kennedy *et al.* (2000). Nomenclature and taxonomy follows Sibley and Monroe (1990) and Kennedy *et al.* (2000), while systematic order follows Dickinson *et al.* (1991). All locations referred to are detailed in Figure 1 (see next page).

Species endemic to the Philippines

Phapitreron leucotis, White-eared Brown-dove

Regularly recorded at all locations singly or in pairs, except on the southeast beach area (Figure 1) and throughout the survey period. Often heard calling, and distinguished from similar species (Amethyst and Dark-eared Brown dove) both by call and lack of purplish collar.

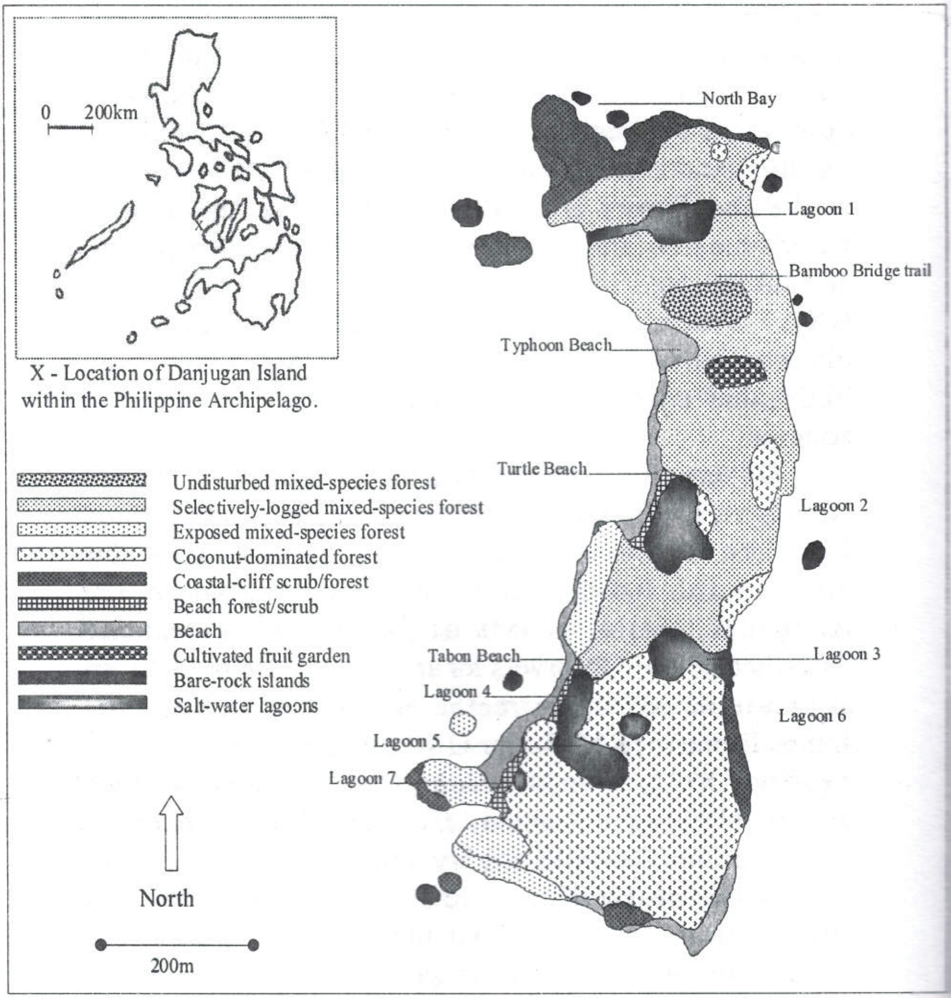

Figure 1. Location of Danjugan Island within the Philippine Archipelago and distribution of major habitat types on the island (modified from Turner *et al.*, 2002).

***Ptilinopus leclancheri*, Black-chinned Fruit-dove**

This uncommon species is more common on small islands (Kennedy *et al.*, 2000) and was recorded infrequently across the island, and throughout the survey period. Always observed as singletons or pairs, and sometimes associated with *T. vernans* at large fruiting trees, such as the strangler fig at Typhoon Beach (Figure 1). Both males and females were recorded, possibly as resident breeding pairs.

***Centropus viridis*, Philippine Coucal**

This species was seen and heard throughout the island, but most frequently in the high-canopy mixed species forest surrounding, and north of, Typhoon Beach (Figure 1). This species is very similar to the Lesser Coucal (*Centropus bengalensis),* however, the observed absence of mottling on the dark chestnut wings and lack of buff shaft streaks, distinguished it as *Centropus viridis*. It was recorded at several locations across the island.

***Ninox centralis*, Philippine Hawk-owl**

Heard at night throughout the island and seen during the day on two occasions. The sightings, on 4 and 18 August, were both of a single bird perched in the mid-story of mixed species forest, and were both at the same location near the northeast corner of Lagoon 1 (JB and RM). Several races have been documented across the Philippines (Kennedy *et al.*, 2000) and the taxonomy of this group is currently being revised (P. Rasmussen, pers. comm.). The striped under-parts and audible (and conspicuous) call suggest the form may be either *philippensis* or *centralis*. Known distributions (Kennedy *et al.*, 2000) suggest *centralis* but further observation would be required to confirm the identification.

Phylloscopus sp.

Recorded on only two occasions during the survey period. The first record, at 0900 hrs on 29 September, was of a pair observed foraging for over 10 minutes amongst flowers of the mangrove *Xylocarpus granatum*, along the southeast border of Lagoon 2 (TK). Noticeable presence of yellow eyebrow and yellow in undertail coverts rule out individuals being *Phylloscopus borealis*. Additionally, no yellow throat was observed, indicating they were not *Phylloscopus cebuensis*. The second sighting was of a singleton on 13 October, again in mangroves in Lagoon 2 (TK). Individuals were possibly *Phylloscopus olivaceus*.

Species resident in the Philippines, but not endemic

***Treron vernans*, Pink-necked Green-pigeon**

Commonly observed throughout the island and throughout the survey period. Often in small flocks of up to 5 or 6 individuals, feeding in the canopies of fruiting trees. Larger numbers (10-15) observed over a period of several days at the end of November (23-28/11/2001) feeding in the canopy of a large strangler fig (Moraceae, *Ficus* sp.) at Typhoon Beach (TK).

***Nycticorax caledonicus*, Rufous Night-heron**

Observed throughout the survey period, most frequently at Lagoons 5, 6 and 1, occasionally at Lagoon 4, and rarely at Lagoon 3. They were not recorded from Lagoon 2 or from other habitat types. During June and July they were generally observed in small family groups, often of two adults and two immatures, while subsequent observations tended to be of singletons.

***Megapodius cumingii*, Tabon Scrubfowl**

Singletons and pairs were sighted frequently throughout the island and throughout the survey period. Fresh excavations were often observed at the communal nesting mound behind Tabon Beach, and were particularly frequent from 20 August. A group of 5 chicks were recorded during the first week of July on a beach in the southwest corner of the island (JB, RM, ST).

***Haliaeetus leucogaster*, White-bellied Sea-eagle**

Two adults and an immature were sighted throughout the survey period, although were absent between 26 July and 22 August. Their old nest, in a tall tree near Typhoon Beach, was lost during high winds at the beginning of July, but an adult was observed back in the tree on 27 September (GE, JB, TK), and the nest was rebuilt during the course of the following two months (TK).

***Sterna sumatrana*, Black-naped Tern**

Commonly observed around the perimeter of the island upon arrival in June. Three pairs appeared to be nesting on a single rock off Tabon Beach, with a juvenile seen flying on 3 July (TK). Additional pairs may have been nesting in other, less conspicuous sites. By 20 July all terns had left and were not observed on the island again during the course of the survey.

***Gerygone sulphurea*, Golden-bellied Flyeater**

This species was commonly observed and heard throughout the island, and throughout the survey period. The very conspicuous song was still heard at the end of November (TK).

Migrant species

***Actitis hypoleucos*, Common Sandpiper**

First recorded on 1 August from a beach on the west side of the island when a singleton was disturbed from low rocks at 1200 hrs (TK). Subsequently recorded frequently as singletons or pairs, and occasionally in groups of up to 4 individuals, on all western beaches, on exposed rocks at low-tide, and in Lagoons 1, 2 and 5. The species was still present at the end of November.

***Phalaropus lobatus*, Red-necked Phalarope**

A single sighting, on 4 September at Lagoon 1, the most northern lagoon on the island, and one with a westward-facing opening to the sea. A singleton in non-breeding plumage, the bird was observed for over an hour, swimming along the steep and rocky perimeter of the lagoon, apparently foraging, and allowing observers to swim to within 3 meters of it (ST, TK).

***Cuculus saturatus*, Oriental Cuckoo**

A single, unconfirmed sighting, on 14 August at Bamboo-bridge Trail, a grassy clearing between two hills of mixed-species forest. From 1700 hrs, an unidentified long-tailed bird was observed several times flying across the clearing between the 2 hills (GE, TK). At dusk (1800 hrs) the bird settled in a large *Terminalia cattapa* tree at the eastern end of the clearing. With a powerful spotlight, the bird was observed until 18:30 hrs, as it remained perched in the tree (ST, TK). Field characters noted were a plain throat, a barred breast and belly, a darker back, and of a size slightly larger than *Aplonis panayensis*. Although some doubt remains due to the poor light, recorded characteristics rule out common confusion with juvenile Cacomantis variolosus.

Cuculus saturatus seems the most reasonable identification. No calls were heard.

***Alcedo atthis*, Common Kingfisher**

First recorded on 20 September in Lagoon 3, a lagoon open to the sea on the east side of the island. The singleton was observed for several minutes while perched motionless on low rocks extending into the lagoon, before flying low across the lagoon and into an area of mangroves (TK). Two further sightings, both of singletons, on 2 October, again at Lagoon 3 (TK), and on 13 October at Lagoon 2, a closed lagoon with extensive areas of mangroves (TK).

***Hirundo rustica*, Barn Swallow**

First recorded on 6 August from Tabon Beach, on the southwest coast of the island, when a singleton with a long tail was observed flying low over an area of beach-scrub and coconut trees (TK). The species was subsequently recorded on five other occasions, at locations throughout the island.

***Monticola solitarius*, Blue Rock-thrush**

First recorded on 13 September from Turtle Beach, on the west of the island. A single male was observed for 15 minutes while perched on a rock at the northern end of the beach (ST). At the same location on 15 September, at midday, three males were disturbed from a single coastal rock, and were subsequently observed for 10 minutes as they perched in nearby scrub vegetation (JB). At 0800 hrs on 16 September, a single male was again observed perching still, while looking around, on a bamboo railing at Lagoon 3, a lagoon on the east of the island (JB). Singletons (males and females) and pairs were subsequently observed fairly frequently along the western coast of the island, from the entrance to the most northern lagoon to the southern tip of Tabon Beach in the south. Usually the birds were observed perched on coastal rocks, remaining motionless for lengthy periods of time. At the end of November, a male and female were observed on Tabon Beach exhibiting what was believed to be courtship behavior, as they stood on the beach within a meter of each other, both upright and with their necks extended upwards, making short calls to each other (TK). Occasionally moving a short distance, the pair continued this behavior for over ten minutes, before they flew about 30 meters to a rocky area of shoreline, where they continued to behave in a similar manner.

***Lanius cristatus*, Brown Shrike**

First recorded on 14 September, perched on a tree and singing, in a clearing within an area of mixed-species forest (ST). The species became commonly observed and heard during the second half of September and the beginning of October. It was still present in November, but in low numbers (TK).

Discussion

Danjugan Island was found to support large numbers of frugivorous birds, particularly pigeons (Columbidae). Two species from this family, *Phapitreron leucotis* and *Ptilinopus leclancheri*, are endemic to the Philippines, and appear to take advantage of the high density of figs (Moraceae, *Ficus* spp.) present in the limestone forest. Two other endemic species were also recorded regularly, *Centropus viridis* and *Ninox philippensis*, and are likely to breed on the island. A third, *Phylloscopus sp.*, was observed just twice and was a new record for the island. It may be a transient, but possibly unlikely since resident *Phylloscopus sp.* tend to have short primaries (Tom Brooks, pers. comm) and are thus unlikely to cross the distance to the mainland regularly.

Of the non-endemic residents, the continued abundance of *Megapodius cumingii* may be attributed to the lack of hunting on the island; and the annual nesting of a pair of *Haliaeetus leucogaster* and of several pairs of *Nycticorax caledonicus*, to the lack of disturbance. As such, the island may be considered of some significance to the breeding capacity of the local populations of these three 'large-bodied' species. Further notable observations included the completion of breeding of *Sterna sumatrana* by the first week in July, and the prolonged period of singing of *Gerygone sulphurea*, which was still heard at the termination of the survey period in late November. Both observations confirm the tentative suggestions made regarding these species by Kennedy *et al.* (2000).

The timing of the survey ensured that several migrant species were recorded as they arrived on the island. A number of these were recorded on dates very close to the earliest recorded sightings for the species in the Philippines. For example, the single sighting of a *Phalaropus lobatus* (on 4 September) was within 2 days, the first of *Actitis hypoleucos* (1 August) within one day, and the first of *Monticola solitarius* (13 September) was eight days earlier than the earliest recorded sightings given in Kennedy *et al.* (2000), while the unconfirmed sighting of *Cuculus saturatus* (14 August) was almost a month earlier.

Recommendations

The main importance of Danjugan Island is clearly as a marine reserve, but such a designation offers a positive spin-off for the terrestrial fauna and flora as well. While it is acknowledged that the island is far from being the most important site in terms of bird conservation in the Philippines, and the current survey represents a far from comprehensive list of the birds of Danjugan Island, several issues of particular conservation concern have been uncovered. Considering that the island is already designated as Danjugan Island Marine Reserve and Sanctuaries (DIMRS), and the area is managed for wildlife conservation and sustainable resource-use (e.g. eco-tourism), the following recommendations can be made specifically regarding the bird fauna.

1. Ensure protection of remaining areas of mixed-species forest as habitat for resident populations of several species endemic to the Philippines, including *Ptilinopus leclancheri*, *Centropus viridis*, and *Ninox philippensis*.
2. Minimize disturbance to Lagoons 5, 6, and 1, especially during breeding season of *Nycticorax caledonicus*.
3. Minimize disturbance to nesting sites of *Megapodius cumingii* and *Haliaeetus leucogaster*.
4. Complete inventory of bird species utilizing the island through regular surveying throughout the year.
5. Determine breeding season of *Sterna sumatrana*, and ensure protection of nesting sites.
6. Determine breeding seasons of all other resident endemic or rare species.
7. Record yearly arrival and departure dates for migrant species.
8. Undertake quantitative monitoring of bird populations through point-counts and other standard methods.

Acknowledgments

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Appendix

Summary of species recorded on Danjugan Island during the four-month survey period.

Species name	English name	Status	Comments
Fregata ariel	Lesser Frigatebird	M	Observed frequently between 14/Aug/01 and 01/Sept/01, singly or in groups of up to 7 birds.
Butorides striatus	Striated Heron	M	Commonly observed in lagoons and on exposed off-shore rocks or corals at low-tide.
Nycticorax caledonicus	Rufous Night Heron	R	See text
Haliastur indus	Brahminy Kite	R	A single sighting on 13/Sept/01, flying over 3rd lagoon.
Haliaeetus leucogater	White-bellied Sea-Eagle	R	See text
Megapodius cumingii	Tabon Scrubfowl	R	See text
Porzana cinerea	White-browed Crake	R	Two sightings, both at 5th lagoon, 24/Aug/01 and 28/Aug/01. Probably largely over-looked due to secretive behavior.

Actitis hypoleucos	Common Sandpiper	M	See text
Phalaropus lobatus	Red-necked Phalarope	M	See text
Sterna sumatrana	Black-naped Tern	R	See text
Treron vernans	Pink-necked Green-Pigeon	R	See text
Phapitreron leucotis	White-eared Brown-Dove	E	See text
Ptilinopus leclancheri	Black-chinned Fruit-Dove	E	See text
Streptopelia chinensis	Spotted Dove	R	Most frequently recorded from the north of the island.
Chalcophaps indica	Emerald-Dove	R	Secretive, first recorded from mist-nets 04/Aug/01, then sighted occasionally.
Cuculus saturatus	*Oriental Cuckoo*	*M*	*See text*
Eudynamys scolopacea	Common Koel	R	First sighted 30/Aug/01 on Tabon Beach, then regularly for the remainder of the survey period.
Centropus viridis	Philippine Coucal	E	See text
Ninox centralis	Philippine Hawk-Owl	E	See text
Collocalia esculenta	Glossy Swiftlet	R	Very commonly seen everywhere. 14 individuals were mist-netted flying in and out of the main bat-cave at 3rd lagoon, between 1720 and 1755, 12/Sept/01.

Species name	English name	Status	Comments
Alcedo atthis	Common Kingfisher	M	See text
Halcyon capensis	Stork-billed Kingfisher	R	Recorded from all lagoons and beaches.
Halcyon chloris	White-collared Kingfisher	R	Common and conspicuous throughout island.
Hirundo rustica	Barn Swallow	M	See text
Hirundo tahitica	Pacific Swallow	R	First sighted 02/Aug/01, then occasionally from then on.
Lalage nigra	Pied Triller	R	Common but relatively inconspicuous.
Oriolus chinensis	Black-naped Oriole	R	Very common and conspicuous.
Corvus macrorhynchos	Large-billed Crow	R	Occasional sightings.
Copsychus saularis	Oriental Magpie-Robin	R	Recorded throughout survey period, but seemingly becoming more conspicuous at the end of September.
Monticola solitarius	Blue Rock-Thrush	M	See text
Gerygone sulphurea	Golden-bellied Flyeater	R	See text
Phylloscopus olivaceus	Philippine Leaf-Warbler	E	See text
Megalurus timoriensis	Tawny Grassbird	R	An unconfirmed record from 5th lagoon, 06/Aug/01, then confirmed sightings from North Bay 18/Aug/01 and Bamboo-bridge Trail, 14/Sept/01.

Cyornis rufigastra	Mangrove Blue Flycatcher	R	Rarely seen, but mist-netted several times (particularly immatures) in forest areas.
Rhipidura javanica	Pied Fantail	R	Commonly recorded and netted in all habitats of the island.
Artamus leucorynchus	White-breasted Wood-Swallow	R	Commonly recorded throughout the island, often harassing the sea eagles.
Lanius cristatus	Brown Shrike	M	See text
Aplonis panayensis	Asian Glossy Starling	R	Commonly observed in small groups throughout the island.
Nectarinia jugularis	Olive-backed Sunbird	R	Common and conspicuous, often seen feeding from flowers of coconut.

R: resident; M: migrant; E: endemic (Kennedy *et al.*,2000).

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NEGROS AVIFAUNA: A COMPARISON OF COMMUNITY COMPOSITION BETWEEN DIFFERENT HABITAT TYPES WITHIN THE NORTH NEGROS FOREST RESERVE, NEGROS OCCIDENTAL, PHILIPPINES

Craig Turner, Alexia Tamblyn, Robert Dray, Jose-Maria Ledesma, Louisa Maunder, & Peter Raines

ABSTRACT

The avifaunal species richness and levels of endemism in the Philippines are of global importance, yet the country has the highest number of threatened restricted range bird species in the world. Despite this, few studies have attempted to assess areas for conservation. Coral Cay Conservation (CCC) has recently completed an inventory survey of the birds of the North Negros Forest Reserve (NNFR), Negros Occidental, Philippines.

The Mackinnon list surveys completed across six habitat types during 2002 identified 96 species from 35 families, of which 68 (69%) were endemic to the Philippines. The species records include several IUCN Red Listed species and the results of the survey are used to give a preliminary assessment of the conservation importance of the different habitats of the NNFR for threatened, near-threatened, restricted range and endemic bird species. These results further stress the need for long-term conservation management of this remaining forest area.

Introduction

The avian diversity of the Philippines is of global importance. The conservation importance has been stressed elsewhere (Stattersfield *et al.*, 1998; Myers *et al.*, 2000; Collar *et al.*, 1999) and currently 12% of the country's avifauna is under threat of extinction, one of the highest proportions in the world (IUCN

2003). The Philippines also has the highest number of threatened restricted range bird species in the world (Stattersfield *et al.*, 1998). It is estimated that nearly half of the Philippines' 184 endemic bird species are threatened by deforestation (Brooks *et al.*, 1997), and other causes of decline are attributable to hunting and the growing pet trade (WCSP 1997). Such problems are prevalent across most of the major islands in the Philippines, yet relatively few studies have analyzed distributional patterns or attempted to assess areas for conservation (Peterson *et al.*, 2000; Ong *et al.*, 2002; Collar *et al.*, 1999).

Negros supports more than 190 species of birds of which approximately 100 are thought to be forest dependent. Restricted range species are consequently under serious threat by further loss and fragmentation of the forests. Many of these species are endemic, with 59 species found on Negros endemic to the Philippines and a further nine restricted to the Negros-Panay faunal region (Brooks *et al.*, 1992). Due to excessive hunting in the North Negros Forest Reserve (NNFR), larger birds, including hornbills and fruit pigeons, are scarce (Haribon, 2002; Hamann, 2002). At least 15 species are threatened on Negros, and such species include the endangered Visayan flowerpecker (*Dicaaeum australe haematostictum*) found in the NNFR, and the Negros bleeding-heart (*Ptilinopus arcanus)* whose status is Critical (BirdLife, 2000).

The bird fauna of Negros would appear to have been well studied and documented over the past sixty years with details of previous ornithological work given elsewhere (Dickinson *et al.*, 1991; Brooks *et al.*, 1992). However, these studies have focused on the southern part of the island (Alcala & Carumbana, 1980; Brooks *et al.*, 1992; Paguntalan *et al.,* 2000) and/or have particularly focused on Mount Canlaon (Brooks *et al.*, 1992; Lambert, 1993). By comparison, the avifauna of the NNFR and the montane forest habitat it encompasses has received only very limited attention. The relatively few recent studies of the avifauna of Mount Silay and Mount Mandalagan (which comprise the

NNFR) have either been very limited in duration (Brooks *et al.*, 1992) or limited in ecological and geographical scope (Hamann & Curio, 1999; Dolino *et al.*, 1999). It is acknowledged that the NNFR is biologically poorly known and further field surveys should be completed in order to provide adequate baseline data to develop conservation assessments and management strategies (Evans *et al.*, 1993; Collar *et al.*, 1999; Mallari *et al.*, 2001).

Similarly, bird surveys tend to refer to the NNFR as a whole, whereas it is comprised of many different habitat types (Hamann, 2002). Whilst ongoing work has developed a detailed inventory of bird species present within specific areas (e.g. the Upper Imbang-Caliban Watershed) of the NNFR (Turner *et al.*, 2001; Turner *et al.*, 2003), such observations indicate that habitat preferences and spatial distributions vary between species and species groups. The status and distribution of species within the different forest habitat types of NNFR is currently very poorly known. While species inventory work is of great importance, such spatially non-specific studies provide limited information for applied avifaunal conservation recommendations within a multiple stakeholder environment (Turner *et al.*, 2002a).

The present study was undertaken as part of the Negros Rainforest Conservation Project (NRCP), a joint programme of research, restoration, and education between the Negros Forests and Ecological Foundation, Inc. (NFEFI) and Coral Cay Conservation (CCC). The study set out to complete the first detailed species inventory of the bird fauna in the Upper Imbang-Caliban watershed area of the NNFR, through survey of the major habitat types, and to make the first comparison between habitat types. The data presented are the culmination of inventory work completed between January 2002 and January 2003. The NRCP and survey area are described in more detail elsewhere (see Slade and Turner 2003; Turner *et al.*, 2001).

Study Area

The NNFR is an old forest reserve with extensive areas of old growth forest on the higher slopes of Mount Mandalagan and Mount Silay, and it lies 35 km to the North of Mount Canlaon on Negros Island, Philippines. The area of the NNFR is 80,454ha, but only 16,687ha of forest remain (Collar *et al.*, 1999). The old growth forest is predominantly above 1000m, with very little forest found below 800m. With parts of the reserve still threatened by 'timber poaching,' the hunting of wildlife has been identified as the greatest immediate threat to the reserve (Hamann, 2002).

The inventory work was undertaken within four hours trek of the village of Campuestohan (10° 39'N, 123° 08'E) on the southwest edge of the NNFR. The surveys were concentrated within the Municipalities of Talisay and Murcia, Province of Negros Occidental (see Mallari *et al.*, 2001; Turner, Slade & Ledesma, 2002), which forms the Upper Imbang-Caliban Watershed. The NRCP and survey area are described in more detail elsewhere (see Slade and Turner 2004; Turner *et al.*, 2001).

Methods

The bird fauna of the NNFR was surveyed by observation using Mackinnon lists (Mackinnon & Phillips 1993). The observer makes a list of species sighted by recording each new species until a predetermined number of species is reached. Based on preliminary surveys, the list length was set at the advised minimum of 10 species (Bibby *et al.*, 1998). A species can only be recorded once on each list but may be recorded on subsequent lists. Surveys should be repeated until at least 25 lists are completed at each survey location. Such data then permit the calculation of species discovery curves and an index of relative abundance or detectability (Bibby *et al.*, 1998; Turner *et al.*, 2002b).

Lists were compiled at 11 survey locations within the NNFR but were predominantly focused on three major habitat types: secondary (regrowth), secondary (disturbed), and old growth (see Table 1). All habitats were surveyed throughout the duration of the 12- month study period, covering both wet and dry seasons. Surveys were completed across a range of times from dawn to dusk. Occasionally, the 10 species could not be recorded in a single visit; in these cases the site was revisited later in the day or the following day to complete the list.

Surveys were undertaken by CCC-trained volunteers (Turner *et al.*, 2001) and staff in the different habitat types within the NNFR (Table 1, next page), and each observational count was undertaken with paired observers in order to minimize observer heterogeneity (Cunningham *et al.*, 1999). Observation surveys were repeated in each location by independent observers (two or more) in order to validate records and such steps permit well-trained volunteers to play a key role in undertaking bird surveys in forested habitats (Bildstein, 1998; Turner *et al.*, 2001).

Analysis

Species discovery curves were calculated for each survey location by replacing surveyor effort with the number of lists and plotting this against the cumulative total number of species. The total number of species (Species Richness) was also calculated for each site (Table 2).

An Index of Relative Detectability (IRD) rather than abundance was calculated for each species calculating the proportion of lists on which it appears at each location, and thus the index can vary between 0 (species not recorded) and 1 (species recorded on every list). The term "index of relative detectability" has been used here, rather than the standard "index of relative abundance," as the frequency of a species occurring on a list is dependent on several factors, of which abundance is only one. Other factors include surveyor effort and identification bias.

Table 1. Locations of Mackinnon List and mist-net surveys.

Location	Habitat type	Elevation (m)	Description
Dam	Secondary (regrowth)	800-1000	*Transitional montane-lowland forest legally logged for dipterocarps, illegally logged for other commercial species, and cut for charcoal production resulting in complete exploitation until 11 years ago.
Aeroplano	Secondary (disturbed)	1000-1200	*Transitional montane-lowland forest legally logged for dipterocarps, and illegally logged for other commercial species until 11 years ago.
Mawa	Old Growth	1200-1400	*Sub-Montane forest selectively logged for Almaciga (*Agathis philippinensis*) 35 years ago.
Crater	Mossy	1500	*Montane & Mossy forest, not logged.
Caliban Valley	Riparian	700	Low altitude areas in close proximity to watercourses.
Imbang Valley	Riparian	700	Low altitude areas in close proximity to watercourses.
Campuestohan	Non-forest	700	Land cleared for subsistence agriculture. Predominantly grassland and low level scrub
Concepcion Road	Non-forest	600	Land cleared for subsistence agriculture. Predominantly grassland
Bamboo Platform	Edge	800	Land cleared of forest but not cultivated. Scrub bordering secondary forest
James' Farm	Edge	750	Scrub land bordering secondary forest
NFEFI House	Edge	750	Scrub land with small banana plots, bordering secondary forest.

*Classification according to Heaney (2001) and history derived from interviews with local community

Further patterns in community composition were assessed using PRIMER (Clarke & Warwick, 1994a). The Bray-Curtis similarity measure was then calculated (from IRD data) between every permutation of sample pairs (Clarke & Warwick, 1994b). The relationship between survey sites was analyzed using a Non-metric Multi-Dimensional Scaling (NMDS) ordination and a hierarchical agglomerate clustering technique (Clarke & Green, 1988). NMDS offers a non-statistical testing framework to assess whether sites substantially differ from one another. The strength of relationship between sites is measured by Kruskal's stress value (essentially a measure of "badness of fit"), lower values indicating better distribution of sites. Clarke and Green (1988) suggest that < 0.15 is good and < 0.10 is ideal. The CLUSTER analysis successively fuses the samples into groups and the groups into larger clusters, starting with the highest mutual similarities then gradually lowering the similarity level at which groups are formed. The result is a dendrogram defining the levels at which samples were fused. Close groupings of communities reflect similarities in community structure (Clarke & Warwick, 1994a).

Results

The Mackinnon lists completed during 2002 at all locations identified 96 species from 35 families (see Appendix), of which 68 (69%) were endemic to the Philippines (see Appendix). These records increase the overall inventory for the project area to 136 species recorded since 2001, with 80 (58%) of these endemic. Species discovery curves (Figure 1) indicate a similar rate of discovery at all survey sites, yet not even Dam, Mawa and Aeroplano reached discernable plateau. The total number of lists completed at each location with species richness is given in Table 2.

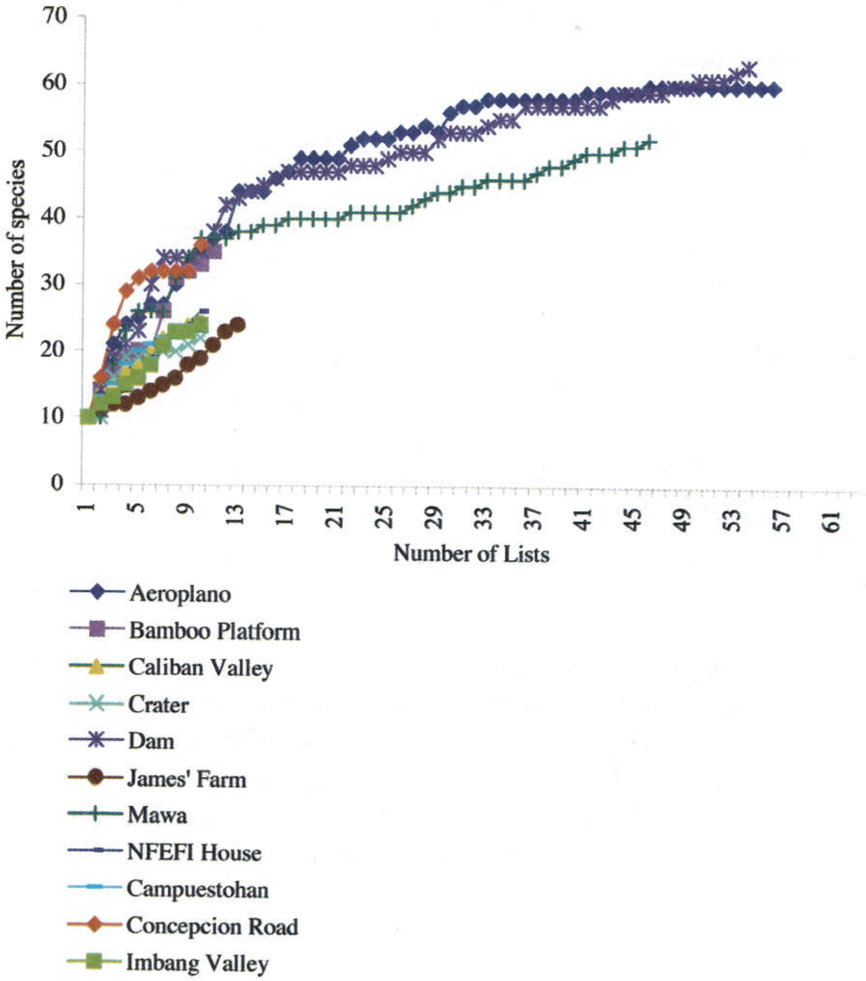


Figure 1. Bird species accumulation curves for MacKinnon Lists (for list with 10 species)

Table 2. Number of Mackinnon lists (>ten species) completed at each location

Location	Number of lists	Species Richness	Endemic Species	Threatened Species	Near-threatened Species
Bamboo Platform	10	35	8	0	0
Campuestohan	10	23	2	0	0
Dam	50	62	8	2	0
Aeroplano	52	58	13	1	1
Mawa	43	66	25	3	2
Crater	10	22	5	0	0
Caliban Valley	10	25	8	0	0
Concepcion Road	10	36	8	0	0
James' Farm	10	23	5	0	0
Imbang Valley	10	24	9	0	0
NFEFI House	10	26	3	0	0

Comparison of community metrics for each survey location (Table 2) summarizes the differences between sites in terms of overall species richness and relative richness of endemic and threatened species. Higher numbers of total species (including endemic and threatened) were recorded at the three main forested survey sites (Dam, Aeroplano, and Mawa).

The IRD scores varied between species and location (see Appendix) with few species common at several locations, e.g. Reddish Cuckoo-dove (*Macropygia phasianella)*, Glossy Swiftlet (*Collocalia esculenta*), and Yellowish White-eye (*Zosterops nigrorum*). Many species were relatively rare within the study areas being recorded at low frequency and at limited locations, e.g. Snowy-browed Flycatcher (*Ficedula hyperythra*) and Mountain Leaf-warbler (*Phylloscopus trivirgatus)*. Several species appeared to be restricted to particular habitat types as they were only found at single survey locations. The following species were only recorded in the old-growth forest of Mawa: Philippine Frogmouth (*Batrachostomus septimus*), Pygmy Woodpecker (*Dendrocopos maculatus*), and White-vented Whistler (*Pachycephala homeyeri*).

Further patterns in community composition were elucidated using multivariate ordination (Figure 2) and clustering techniques (Figure 3). The strength of relationship between sites in the NMDS (Figure 2) is measured by Kruskal's stress value (essentially a measure of "badness of fit") so lower values indicate better distribution of sites. This is further illustrated by the cluster analysis (Figure 3).

The NMDS suggests that community composition differs most distinctly between the forested and non-forested sites. The cluster reinforces this observation, more clearly indicating the dissimilarity between forested and non-forested sites (Figure 2: blue circle - non-forest; red circle - forest-edge; green circle-forest). However, it also illustrates the high level of similarity in community composition between the 3 main forested sites (>75%). Interestingly the secondary forest site (Dam) is very similar to the old-growth forest sites (Mawa & Aeroplano). These analyses collectively suggest that the bird communities do vary with some significance both in species composition and relative abundance between the survey sites, and even between the different forest habitat types.

Figure 2. (Next page) NMDS ordination of IRD values for each survey location. solid circle - non-forest; solid circle (bold) - forest-edge; dotted circle – montane forest; dashed circle – mossy forest.

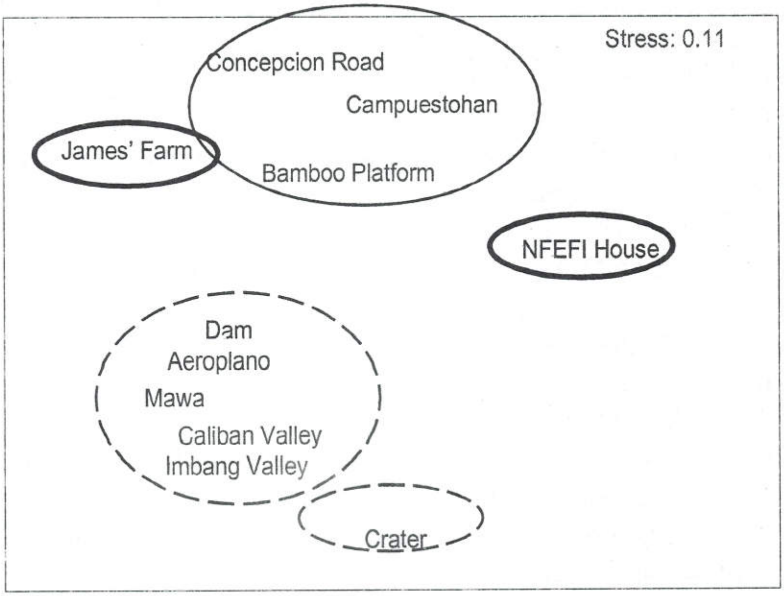
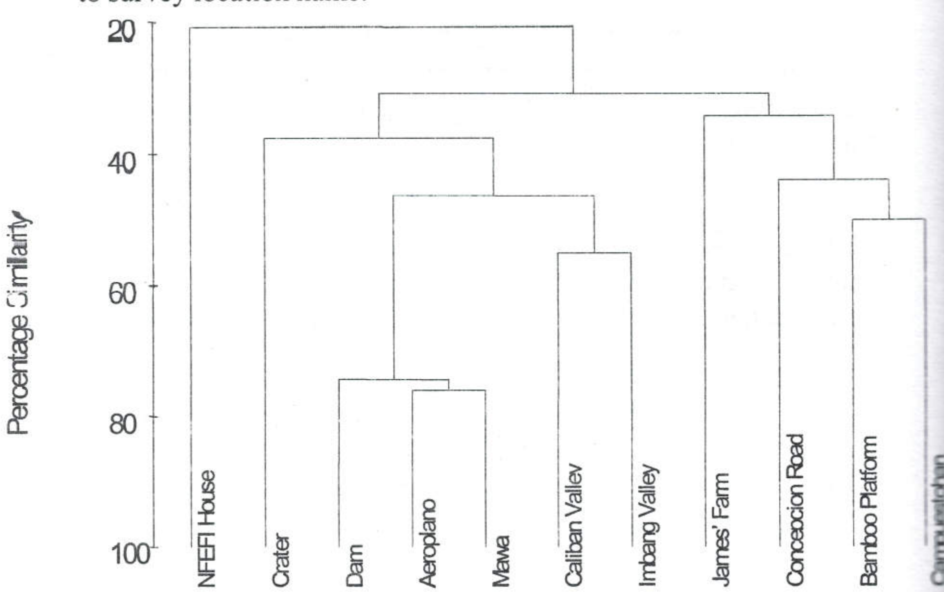


Figure 3. Dendrogram of bird community composition calculated using group-average linking of Bray-Curtis similarities and labelled according to survey location name.



Discussion

The data presented here are only preliminary but serve to illustrate that the Imbang-Caliban watershed and the NNFR support a diverse avifauna with over half the species recorded dependent on forest habitat, and many of which are restricted range and threatened species. Over 20% of the Philippine avifaunal species have been located within the surveyed area of the NNFR, and nearly half of all species previously documented on Negros Island. Perhaps more important, from a biodiversity conservation perspective, is the significant proportions of these species that are endemic to the Philippines, or further restricted within the Philippines. The majority of endemic species recorded were located in the forest habitats (as were the threatened species) but this may be a function of survey effort.

This has identified 96 species and to date the NRCP has located 136 bird species within the NNFR (see Turner *et al.*, [2003] for additional species), which is greater than previous studies (Brooks *et al.*, 1992; Hamann & Curio, 1999). Such a detailed avian inventory is clearly a function of surveyor effort, but it serves to illustrate the value of long-term studies when attempting to generate species inventories. The surveys also reinforce the ecological importance of the NNFR for both endemic and IUCN Red Listed species, consolidating earlier works (Brooks *et al.*, 1992; Hamann & Curio, 1999; Turner *et al.*, 2003). It is acknowledged that the current study only concerns birds and thus is not necessarily representative of other faunal groups.

Bird species diversity is largely explained by habitat diversity, as illustrated by the multivariate analysis (Figures 2 & 3). The NNFR not only supports species solely dependent on forest such as the Pink-bellied Imperial pigeon (*Dicaeum poliocephala*) and the Snowy-browed Flycatcher (*Ficedula hyperythra*) but also species with less specific habitat requirements, such as the White-collared Kingfisher (*Halcyon chloris*) and the Barn Swallow (*Hirundo rustica*). The NNFR also appears to represent one of the few remaining refuges on Negros for many forest species that are limited in their ecological and/or altitudinal range and thus cannot be supported by the other habitat types remaining on Negros. The Endangered Visayan Flowerpecker (*Dicaeum haematostictum*) is generally restricted to forest below 750m (Collar *et al.*, 1999) and observations generally support this, with no individuals recorded above 800m.

With regard to other threatened species, the only confirmed hornbill sighting was of the Visayan Tarictic hornbill (*Penelopides panini),* seen on several occasions in all forest types, and an unconfirmed sighting of Walden's Hornbill (*Aceros waldeni)* in old-growth forest (Mawa). Both species have previously been recorded in the NNFR (Hamann & Curio, 1999) but are restricted to the Western Visayas (Stattersfield *et al.*, 1998) and are dependent on tall forest below 1200m.

There is an acknowledged abundance of forage trees for both hornbill species within the NNFR (Hamann & Curio, 1999) but tree size may limit their distribution due to nest hole requirements. Perhaps the greatest threat is the widely reported hunting (Hamann & Curio, 1999, Collar *et al.*, 1999). During the current survey, members of the research team were aware of hunters in all forest types but there has been limited assessment of this threat. Despite this, the NNFR has recently been recognized as one of three 'key sites' for remnant populations of *A. waldeni* (Collar *et al.*, 1999) and thus may be globally important for this Critically Endangered species.

Also of interest are the species that were not recorded by this study but listed by Brooks *et al.* (1992) as forest-dependent. These include species common to lowland areas such as the Pompadour Green-pigeon (*Treron pompadora*) and species that may be altitudinally restricted, such as the White-throated Jungle-flycatcher (*Rhinomyias albigularis*), and the Lovely Sunbird (*Aethopyga shelleyi*). Clearly many of the species are known to be uncommon or rare and some species such as the kingfishers and pittas may well have been missed since they are difficult to locate. More importantly, some of the restricted range species listed as Endangered or Critically Endangered may be locally extinct. This is postulated since the Negros Fruit-dove (*Ptilinopus arcanus*) was last seen in 1953, the Ashy-breasted Flycatcher (*Muscicapa randi*) in 1970, and the Celestial Monarch (*Hypothymis coelestis*) in 1959 (Stattersfield *et al.*, 1998; Paguntalan *et al.*, 2000). It is also suggested that the Philippine Cockatoo (*Cacatua haematuropygia*) may also be locally extinct on Negros (Paguntalan *et al.*, 2000).

The NNFR is still an area under threat and many bird species have been the target of sport hunting and collection for illegal pet trade (Hamann, 2002). It is recommended that areas such as the NNFR should be given greater legal protection under the National Integrated Protected Area System (NIPAS) (Collar *et al.*, 1999). The current study reinforces this recommendation on two counts. Firstly, the inventory data clearly demonstrate the importance of the area for Philippine avifauna, and secondly, the results indicate that the study area within the NNFR supports similar (if not greater) species richness as that of Mount Canlaon, where 62 species were recorded of which just less than half were endemic (see Brooks *et al.*, 1992). Admittedly, the surveyor effort for the Canlaon study was far less than the current, but Mount Canlaon was recommended for protective status by Brooks *et al.* (1992) and now forms part of the NIPAS.

The lack of historical data for the NNFR means it is difficult to comment on the changes in status of particular species, and only limited insight into temporal changes in the diversity of the NNFR avifauna can be deduced. The cluster analysis (Figure 3) suggests that the Dam area (which represents secondary forest) has recovered to support bird communities very similar to those of less exploited forest habitats (e.g. Aeroplano and Mawa). Without historical data, such a theory is difficult to prove but does illustrate the potential biological importance of forest restoration. Additionally, it is also imperative that survey effort is increased in a spatial context (since only a limited number of habitat types have been assessed) and that data (diversity, abundance, distribution) are related to habitat (or forest) type if effective conservation management strategies are to be proposed and implemented at a local level.

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Appendix. Species IRD value by species and list location.

Genus/Species	Common Name	Status	Bamboo Platform	Campues-tohan	Dam	Aeropla-no	Mawa	Crater	Caliban Valley	Concep-cion Road	James' Farm	Imbang Valley	NFEFI House
Pernis celebensis	Oriental Honeybuzzard	R/M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pernis celebensis	Barred Honeybuzzard	R	0.10	0.67	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00
Haliaetus indus	Brahming Kite	R	0.10	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	1.00
Accipeter soloensis	Chinese Goshawk	M/A	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.50	0.00
Accipeter trivirgats	Crested Goshawk	R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spilornis cheela	Crested Serpent-eagle	R	0.10	0.00	0.00	0.00	0.16	0.00	0.00	0.13	0.00	0.00	0.00
Spizaetus philippinesis	Philippine Hawk-eagle	E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Falco peregrinus	Peregrine Falcon	R/M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gallus gallus	Red Junglefowl	R	0.00	0.00	0.00	0.00	0.12	0.67	0.50	0.00	0.00	0.00	0.00
Phapitreron leucotis	White-eared Brown dove	E	0.10	0.00	0.00	0.10	0.19	0.67	0.50	0.00	0.00	0.50	0.00
Ptilinopus leclancheri	Black-chinned Fruit dove	E	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Ducula poliocephala	Pink-bellied Imperial pigeon	E	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Ducula aenea	Green Imperial pigeon	R	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Columba vitiensis	Metallic Pigeon	R	0.00	0.00	0.00	0.00	0.07	0.33	0.00	0.00	0.00	0.00	0.00
Macropygia phasianella	Reddish Cuckoo-dove	R	0.20	0.33	0.01	0.00	0.14	0.00	0.00	0.13	0.00	0.50	0.00
Steptopelia chinensis	Spotted Dove	R	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.13	0.00	0.00	0.00
Cuculus saturatus	Oriental Cuckoo	M/A	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Cuculus micropterus	Indian Cuckoo	M/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00
Centropus viridis	Philippine Coucal	E	0.40	0.67	0.01	0.00	0.21	0.00	0.00	0.25	0.03	0.50	1.00
Ninox scutulata	Brown Hawk-owl	R/M	0.00	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Ninox philippensis	Philippine Hawk-owl	E	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	1.00
Batrachostomus septimus	Philippine Frogmouth	E	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Collocalia vanikorensis	Island Swiftlett	R	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
Collocalia mearnsi	Philippine Swiftlet	E	0.40	0.67	0.01	0.00	0.05	0.00	0.00	0.13	0.00	0.00	0.00
Collocalia esculenta	Glossy Swiftlet	R	1.00	0.67	0.01	0.05	0.14	0.67	1.00	0.63	0.06	1.00	1.00
Collocalia troglodytes	Pygmy Swiftlet	E	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.13	0.00	0.00	0.00
Mearnsia picina	Philippine Needletail	E	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Hirundapus celebensis	Purple Needletail	R	0.40	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Genus/Species	Common Name	Status	Bamboo Platform	Campuestohan	Dam	Aeroplane	Mawa	Crater	Caliban Valley	Concepcion Road	James' Farm	Imbang Valley	NFEFI House
Apus affinis	House Swift	R	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eurystomus orientalis	Dollar Bird	R	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Halcyon chloris collaris	White-collared Kingfisher	R	0.00	0.33	0.01	0.00	0.05	0.00	0.00	0.13	0.00	0.00	0.00
Actenoides lindsayi	Spotted wood Kingfisher	E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Merops philippinus	Blue-tailed Bee-eater	R	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00
Penelopides panini	Tarictic Hornbill	E	0.00	0.00	0.15	0.10	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Dendrocopos maculatus	Pygmy Woodpecker	E	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Dryocopus javanensis	White-bellied Woodpecker	R	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Hirundo rustica	Barn Swallow	M/A	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
Hirundo tahitica	Pacific Swallow	R	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coracina striata	Bar-bellied Cuckoo-shrike	R	0.00	0.00	0.00	0.00	0.05	0.33	0.00	0.00	0.00	0.00	0.00
Lalage nigra	Pied Triller	R	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pericrocotus flammeus	Scarlet Minivet	R	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Pycnonotus goiavier	Yellow-vented Bulbul	R	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Hypsipetes philippinius	Philippine Bulbul	E	0.90	0.00	0.00	0.00	0.70	0.00	0.50	0.63	0.06	1.00	0.00
Hypsipetes everetti	Yellowish Bulbul	E	0.00	0.00	0.05	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00
Dicrurus balicassius	Balicassiao	E	0.30	0.00	0.00	0.00	0.60	0.00	0.50	0.00	0.00	0.00	0.00
Oriolus chinensis	Black-naped Oriole	R	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Corvus enca	Slender-Billed Crow	R	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corvus macrorhynchos	Large-billed Crow	R	0.10	0.00	0.00	0.00	0.00	0.33	0.00	0.25	0.00	0.00	0.00
Parus elegans	Elegant Tit	E	0.20	0.00	0.00	0.00	0.00	0.00	1.00	0.13	0.01	0.50	0.00
Sitta rontalis	Velvet-fronted Nuthatch	R	0.00	0.00	0.00	0.00	0.42	0.33	0.00	0.00	0.00	0.00	0.00
Rhabdornis mystacalis	Stripe-headed Rhabdornis	E	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Brachypteryx montana	White-browed Shortwing	R	0.00	0.00	0.00	0.00	0.16	0.67	0.00	0.00	0.00	0.50	0.00
Saxicola caprata randi	Pied Bushchat	R	0.10	0.00	0.00	0.00	0.00	0.33	0.00	0.75	0.08	0.00	0.00
Zoothera andromedae	Sunda Ground thrush	R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Turdus poliocephalus	Island Thrush	R	0.00	0.00	0.00	0.00	0.02	1.00	0.00	0.00	0.00	0.00	0.00
Phylloscopus borealis	Arctic Warbler	M/A	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Phylloscopus olivaceus	Philippine Leaf-warbler	E	0.00	0.00	0.00	0.05	0.09	0.00	0.00	0.13	0.00	0.50	0.00
Phylloscopus cebuensis	Lemon-throated Leaf-warbler	E	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	1.00	0.00
Phylloscopus trivirgatus	Mountain Leaf-warbler	R	0.00	0.00	0.00	0.00	0.07	0.67	0.00	0.13	0.01	0.00	0.00

Genus/ Species	Common Name	Status	Bamboo Platform	Campues-tehan	Dam	Aeropla-ne	Mawa	Crater	Caliban Valley	Concep-cion Road	James' Farm	Imbang Valley	NFEFI House
Megalurus timoriensis	Tawny Grassbird	R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.05	0.00	0.00
Megalurus palustris	Striated Grassbird	R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.00
Orthotomus canasteiceps	Philippine tailorbird	E	0.00	0.00	0.00	0.10	0.40	0.00	0.50	0.00	0.00	0.50	0.00
Rhinomyias albigularis	White-throated jungle-flycatcher	E	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Eumyias panayensis	Mountain Verditer flycatcher	R	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.13	0.01	0.00	0.00
Ficedula narcissina	Narcissus Flycatcher	M/A	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Ficedula hyperythra	Snowy-browed Flycatcher	R	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.13	0.00	0.00	0.00
Ficedula westermanni	Little Pied Flycatcher	R	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.13	0.01	0.00	0.00
Cyanoptila cyanomelana	Blue and white Flycatcher	M/A	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Culicapa heianthea	Citrine Canary-flycatcher	R	0.00	0.00	0.00	0.00	0.28	0.67	0.00	0.00	0.00	0.00	0.00
Rhipidura javanica	Pied Fantail	R	0.10	0.00	0.00	0.00	0.02	0.00	0.00	0.25	0.00	0.00	0.00
Rhipidura cyaniceps	Blue-headed Fantail	E	0.00	0.00	0.00	0.10	0.74	0.33	1.00	0.13	0.01	1.00	0.00
Pachycephala albiventris	Green-backed Whistler	E	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Pachycephala homeyeri	White-vented Whistler	E	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Motacilla cinerea	Grey Wagtail	M/A	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00
Anthus novaeseelandiae	Richard's Pipit	M/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
Anthus hodgsoni	Olive Tree-pipit	M/A	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Artamus leucorhynchus	White-breasted Wood swallow	R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Lanius schach	Long-tailed Shrike	R	0.00	0.00	0.00	0.00	0.02	0.33	0.00	0.63	0.06	0.00	0.00
Lanius cristatus	Brown Shrike	M/A	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.03	0.00	1.00
Sarcops calvus	Coleto	E	0.90	0.00	0.00	0.00	0.44	0.33	0.00	0.00	0.00	0.00	1.00
Anthreptes malacensis	Plain-throated Sunbird	R	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Nectaria jujularis	Olive-backed Sunbird	R	0.60	0.00	0.00	0.00	0.02	0.00	0.50	0.25	0.03	0.00	0.00
Aethopyga siparaja	Crimson Sunbird	R	0.20	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00
Dicaeum bicolor	Bicolored Flowerpecker	E	0.20	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Dicaeum australe	Red-keeled Flowerpecker	E	0.10	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Dicaeum trigonostygma	Orange-bellied Flowerpecker	R	0.00	0.00	0.00	0.00	0.30	0.67	0.50	0.13	0.01	0.00	1.00
Dicaeum pygmaeum	Pygmy Flowerpecker	E	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Zosterops nigrorum	Yellowish White-eye	E	0.60	0.00	0.00	0.00	0.12	0.67	0.50	0.13	0.01	1.00	0.00
Zosterops montanus	Mountain White-eye	R	0.20	0.00	0.00	0.00	0.77	1.00	1.00	0.50	0.05	1.00	0.00

Genus/Species	Common Name	Status	Bamboo Platform	Campuestohan	Dam	Aeroplano	Mawa	Crater	Caliban Valley	Concepcion Road	James' Farm	Imbang Valley	NFEFI House
Passer montanus	Eurasian tree Sparrow	R	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
Lonchura leucogastra	White-bellied Munia	R	0.10	0.00	0.00	0.00	0.02	0.00	0.00	0.25	0.00	0.00	0.00
Lonchura punctulata	Scaly-breasted Munia	R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
Lonchura malacca	Chestnut Munia	R	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00

Status follows Kennedy *et al.* (2000): E - endemic species; R – resident; M/A – migrant/accidental; R/M – resident and migrant populations.

AN INVENTORY OF THE BUTTERFLY SPECIES (LEPIDOPTERA: RHOPALOCERA) OF THE UPPER IMBANG-CALIBAN WATERSHED, NORTH NEGROS FOREST RESERVE, PHILIPPINES

Eleanor M. Slade & Craig S. Turner

ABSTRACT

Coral Cay Conservation (CCC) recently completed an inventory survey of the butterfly fauna of the Upper Imbang-Caliban watershed area of the North Negros Forest Reserve (NNFR), Negros Occidental, Philippines. The NNFR is one of the last significant areas of moist tropical forest in the Negros-Panay Faunal Region of the Philippines and therefore is considered to be vital for the conservation of a high number of forest-dependent and endemic species. The inventory results revealed that 45% of all species and 84% of sub-species recorded were Philippine endemics, with 21% of sub-species recorded occurring only on Negros. This is the first published account of the butterfly species in the NNFR and highlights the relative importance of the NNFR for the conservation of endemic and restricted-range butterfly species and the need for long-term conservation management of the remaining forest area. Suggestions for conservation and sustainable management of the butterfly fauna of the NNFR are discussed.

Introduction

The Philippines is one of the richest and most distinct biogeographical regions of the world. It has an extraordinarily high percentage of endemicity, with over two-thirds of its plant and animal species being found nowhere else in the world (Oliver & Heaney, 1996). In excess of 57% of the terrestrial vertebrate fauna is unique to the Philippines (Oliver & Heaney, 1996) and with regard to invertebrates approximately 40% of its butterfly species are also found only in the Philippines (Baltazar, 1991;

Treadaway, 1995). The Philippines has much higher levels of endemicity than any other biogeographic province in the whole of the Indo-Malayan Realm - itself one of the richest and most distinct biogeographic regions in the world (MacKinnon & MacKinnon, 1986). However, only 25% of endangered or critically endangered butterflies are thought to have a population in the existing protected areas of the Philippines, compared to 67% of terrestrial mammal species (Danielsen & Treadaway, 2004).

Thirty percent of the world's highest priority areas for conservation are in the central Philippines (Oliver & Heaney, 1996). However, the 14 existing terrestrial Priority Sites in the Philippines only cover 2.7% of the land area (Danielsen & Treadaway, 2004). The forest fragments of the central Philippine islands, including Panay, Guimaras, Negros, Cebu, Sibuyan, and Masbate, which make up the islands of the Visayas (Figure 1), form a distinct faunistic region. These islands also fall into the International Union for the Conservation of Nature (IUCN) category of the highest conservation priority (Dinerstein *et al.*, 1995), and have been identified as centers of plant biodiversity (Davis, 1995). Cebu, Masbate, and Guimaras have been completely deforested, and most of their native and endemic species of flora and fauna are now extinct, 'functionally extinct', or critically threatened (Oliver & Heaney, 1996). However, small forest fragments still exist on Panay and Negros, which together make one of the largest faunal regions in the area, the Negros-Panay Faunal Region. Thus, it seems crucial that these remaining forest fragments be preserved and studied.

The North Negros Forest Reserve (NNFR) is one of the last remaining wet tropical rainforest ecosystems of the Negros-Panay Faunal Region and is an important refuge for a large number of endemic species (Hamann *et al.*, 1999). In 1875, 95% of NNFR was primary rainforest; while the official figures calculated it to be 7% in 1996 (Diestel, undated, unpublished report), it is estimated that less than 3% actually remains (Gerardo Ledesma (NFEFI), pers. comm.). Originally established in 1946 to protect more than 100,000 ha of virgin forest, the NNFR is now reduced to 80,500 ha. Yet, protection of the reserve is largely ignored (Hamann *et al.*, 1996, unpublished) and virtually all of the lowland dipterocarp forest has been illegally cleared. However, the steep topography of the higher slopes has protected them from extensive logging. Thus, two major fragments of old growth forest exist in half-craters of extinct volcanoes, Mt. Mandalagan and Mt. Silay, and form, together with the Mt. Canlaon area, the last intact watershed of Negros Occidental (Figure 1) (Hamann *et al.*, 1996, unpublished). A commonly identified threat, especially to tropical butterfly faunas, is collection and trade in species. This does not appear to be a problem in the NNFR, and no collectors were encountered. However, dead specimens of Philippine butterflies, including species found in the NNFR, were seen for sale in the nearby city of Bacolod. Hunting, non-timber resource extraction, and clearance of the forest for agriculture are however still common problems in the NNFR (Turner, Slade, & Hesse, 2002, unpublished), and action is desperately needed to protect this unique rainforest fragment.

While several butterfly studies have been carried out in South East Asia (Hill *et al.*, 1992; Spitzer *et al.*, 1993; Hamer *et al.*, 1997; Hill & Hamer, 1998), a literature review of major scientific peer-reviewed journals found no accessibly published research into the ecology of the butterflies of the Philippines. In particular, the butterflies in the North Negros Forest Reserve have never been studied. Although an inventory of Philippine butterflies (Baltazar, 1991) is available, this only gives taxonomic information and known geographical distributions to date but does not contain descriptions or illustrations. More recently, a more comprehensive checklist of the butterflies of the Philippines, which also includes photographs of many of the species (Treadaway, 1995) and checklists focusing on specific groups, has been published (Page & Treadaway, 2003). However, as this checklist is not published in the major scientific literature or in a Philippine journal, it is not widely available.

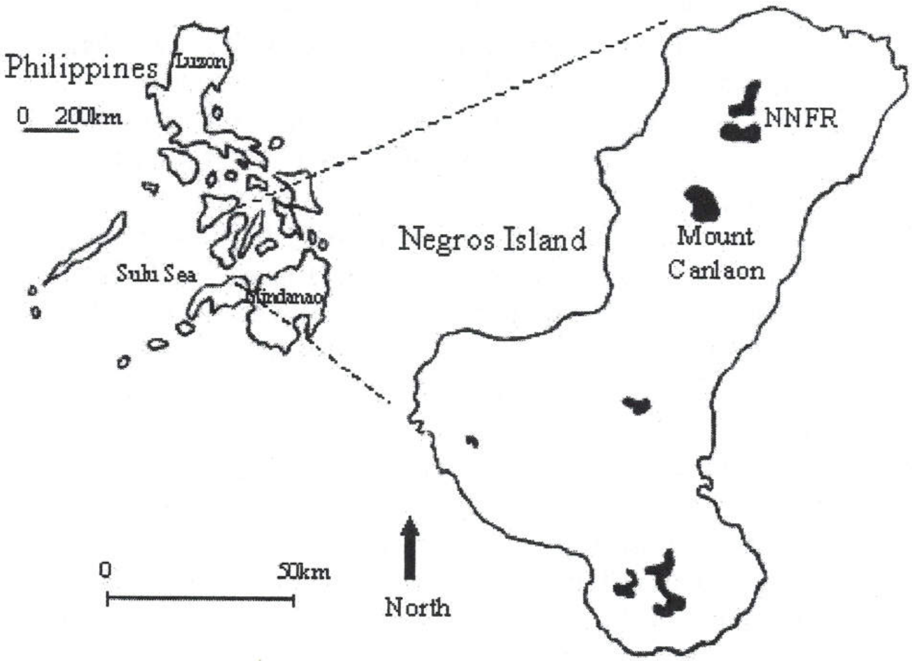


Figure 1. The remaining forest patches of Negros Island and the location of the North Negros Forest Reserve (NNFR) within Negros Island, Philippines.

Thus, it is hoped that publishing our inventory in a local Philippine journal will make it accessible to local biologists. As butterflies of some areas of the Philippines have still not been studied comprehensively, it is expected that new species and sub-species will continue to be discovered. Since 1990, 38 endemic species and 212 endemic subspecies have been described (Danielsen & Treadaway, 2004). Moreover, as the forests of the Philippines continue to decline, the distributions and occurrance of butterflies will continue to change. A revised checklist of Philippine butterflies will be published in 2004 (Treadaway, pers. comm.). At the current time 29 butterfly taxa in the Philippines are under risk of extinction in the near future, and of these only five are thought to occur in an established conservation site (Danielsen & Treadaway, 2004). Lastly, all previous records of the species and sub-species found on Negros are for Southern Negros and the other northern forest fragment, Mount Canlaon National Park (Baltazar, 1991). The NNFR could therefore act as a good back up to the Mount Canlaon National Park as the two areas are only 35 km apart. Thus, this represents the first inventory of butterflies in the NNFR forest remnant, and is published in complement with a photographic field guide of the butterflies of the NNFR (Slade, Cummings, & Turner, 2002).

Inventories of Philippine butterflies (Baltazar, 1991; Treadaway, 1995) have already noted the high endemicity (~ 40%) of Philippine butterflies. However, current knowledge is still incomplete and with forest cover in the Philippines declining from 70% to 18% cover in the last 100 years (ESSC, 1999; DENR/UNEP, 1997), it is of paramount importance that inventories of both butterflies and other invertebrates continue to be undertaken so that species can be catalogued and informed conservation measures and further research can be carried out to protect those endemic or restricted-range species. Moreover, insects, in particular butterflies, respond rapidly to forest disturbance, and thus may be useful in assessing how forest disturbance affects biodiversity (Hill & Hamer, 1998; Kremen, 1992). Tropical butterfly assemblages are particularly diverse, with many sites having large numbers of endemic species, most of which are dependent to some extent on forest habitat (Sutton & Collins, 1991). Butterflies are a suitable group for ecological studies; they are relatively conspicuous, mostly diurnal, their taxonomy is relatively well known, and some data on their geographic distributions and, for some species, on their life history, are available (Hill *et al.*, 1992; Beccaloni & Gaston, 1995; Spitzer *et al.*, 1993). Needless to stress, a detailed inventory and photographic guide to the butterflies of the NNFR would greatly aid future ecological research and conservation decisions. Ultimately, butterflies may act as an 'umbrella' group for less easily studied invertebrate groups within the NNFR.

Aims and Objectives

The present study was undertaken as part of the Negros Rainforest Conservation Project (NRCP), a joint program of research, restoration, and education between the Negros Forests and Ecological Foundation, Inc. (NFEFI) and Coral Cay Conservation (CCC). The study set out to complete the first detailed species inventory of the butterfly fauna in a representative portion of the NNFR (the Upper Imbang-Caliban Watershed), surveying the major habitat types. The data presented form part of an inventory completed between February 2000 and July 2001. As no previous inventory work had been conducted within the NNFR, and data regarding other areas in Negros were scarce, there were no field guides in existence. Therefore, this study aimed to facilitate the development of a local field guide and to aid further habitat specific surveys. Consequently, this work does not intend to present a definitive list of the butterfly fauna of the NNFR, but attempts to outline the first representative inventory, of a specific catchment, that forms part of the wider conservation research being undertaken by the NRCP (Turner, Slade, & Ledesma 2001). The work was completed in collaboration with the NFEFI and under the aegis of the Philippine Department of the Environment and Natural Resources.

Study Area

The NNFR is an old forest reserve with extensive areas of old growth forest on the higher slopes of Mount Mandalagan and Mount Silay. Located 35 km to the North of Mount Canlaon on Negros Island, Philippines (Figure 1), the area of the NNFR is 80,454ha, but only 16,687ha of forest remain (Collar *et al.* 1999). The old growth forest is predominantly above 1000m, with very little forest found below 800m. The inventory work was undertaken within four-hours trek of the village of Campuestohan (10° 39'N, 123° 08'E) on the southwest edge of the NNFR. The surveys were concentrated within the Municipalities of Talisay and Murcia, Province of Negros Occidental (see Mallari *et al.*, 2001; Turner, Slade, & Ledesma, 2002), which forms the Upper Imbang-Caliban Watershed.

Methods

Two methods were used to inventory the species richness of the NNFR: transect walks and opportunistic collections. Collections were made during wet and dry seasons and in six major habitat types represented in the NNFR (Table 1). The species inventory was compiled through collections made between June 2001-July 2002. The habitat types varied from cultivated land to old-growth and mossy forest and the forest habitats also varied in their degree of disturbance. Sites also varied in altitude from 700m-1600m.

The inventory was undertaken by CCC trained volunteers (Turner, Slade, & Ledesma, 2001) and were conducted along established transects; two transects in each site; each transect 500m in length. The use of transects meant that a wide variety of habitats and microclimates (streams, canopy gaps, different aspects, etc.) were surveyed (Hill, 1999). The transects had been established according to standard biodiversity assessment methods for tropical forests (see Alder & Synnott, 1992; Dallmeier, 1992; Turner, Slade, & Ledesma, 2001 for further details).

Table 1. Major habitat types within the NNFR in which surveys were undertaken (taken from Turner, Slade, & Hesse, 2002, unpublished).

Habitat	Code	Description	Altitudinal Range
Old-growth forest	OF	*Montane forest selectively logged for economic species 35 years ago.	1200-1400m
Secondary forest (intermediately disturbed)	SF	*Sub-montane forest legally logged for economic species, and illegally logged for other commercial species until 11 years ago.	1000-1200m
Secondary re-growth forest	RF	*Sub-montane forest legally logged for economic species, illegally logged for other commercial species, and cut for charcoal production resulting in complete exploitation until 11 years ago.	800-1000m
Mossy forest	M	*Montane forest above 1400m; not logged.	1400-1600m
Scrub/Grassland	SG	Land cleared of forest but not cultivated.	700-900m
Cultivated	CU	Land cleared for subsistence agriculture.	700-900m

*Classification according to Heaney (2001) and history derived from interviews with local community members.

In accordance with other studies (e.g. Hamer *et al.*, 1997; Spitzer *et al.*, 1993, 1997), the butterfly families Lycaenidae and Hesperiidae, which are difficult to identify and catch, were omitted from the inventory. Thus, only butterflies from the five families, Papilionidae, Nymphalidae, Pieridae, Satyridae, and Danaidae, were collected. As it was not the intention of this work to provide a definitive list of the butterfly fauna of the NNFR but to outline the first representative inventory, of a specific catchment, that could be used to identify a subset of the butterfly fauna that could be monitored (e.g. Sparrow *et al.*, 1994), and to identify endemic and endangered species in need of protection, it was thought to be sufficient to sample only the five most conspicuous families to begin with.

Peak butterfly density has been noted to occur from late morning to early afternoon (Hill *et al.*, 1995; Pollard, 1977; Pollard, 1988; Walpole & Sheldon, 1999). In accordance with other studies, transect walks were therefore only conducted between 10 00 hours and 15 00 hours, and only in good weather (i.e. sunny, and no rain), as temperature/irradiance differences are known to affect butterfly flight (Pollard & Yates, 1993; Willott *et al.*, 2000). Opportunistic collections were made while moving between survey sites or around the research base in Campuestohan.

Butterflies were caught using English kite nets and killed by pinching the thorax. It was found that killing agents, such as ammonia, tended to cause discoloration of the scales, and damage often occurred to the wings while the butterflies are in the killing jar. Pinning and preservation followed the guidelines set out in "A Lepidopterists Handbook" (Dickson, 1992). Only one type specimen, of each sex where possible, of each new 'species' encountered (within the target families) was collected and preserved where possible; any duplicates were released.

Each type specimen was given a code consisting of letters and numbers. This separated specimens into the five main families (Papilionidae (PA), Nymphalidae (N), Pieridae

(PI), Satyridae (S), and Danaidae (D)) which are relatively easy to distinguish on the basis of color and wing shape. Each specimen was then given a number (See Table 2). Photographs of the dorsal and ventral surface of each specimen were then taken. All butterflies were collected under a Wildlife Gratuitous Permit issued to NFEFI by the Department of the Environment and Natural Resources.

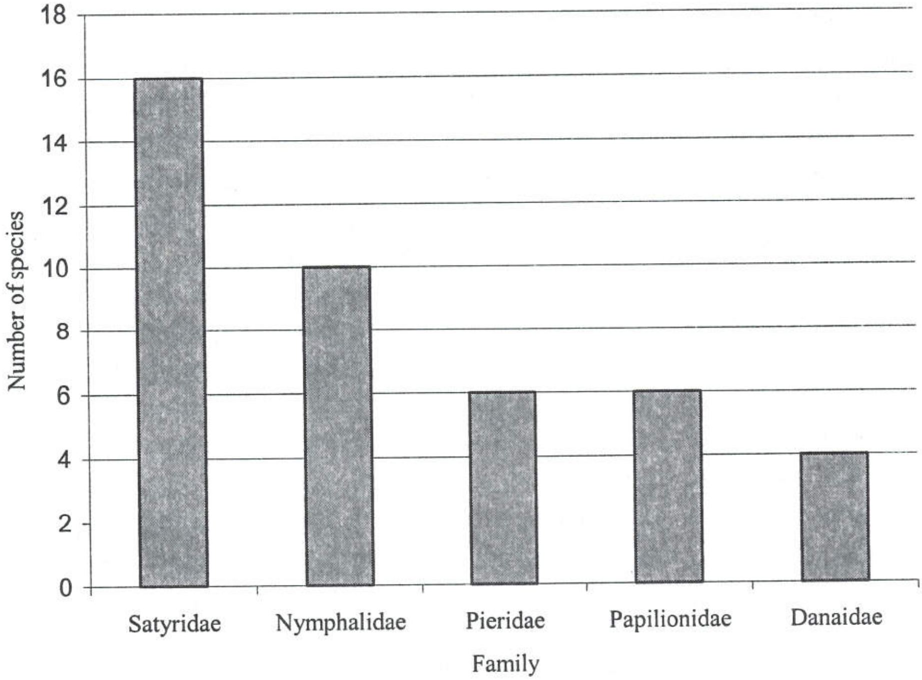
Butterfly species identification and taxonomic classifications followed that given by D'Abrera (1982, 1985, 1990) and Tsukada (1981, 1982*a*, 1982*b*, 1985, 1991). Sub-species were identified using Baltazar (1991), Treadaway (1995), and with the help of Dr. Jumalon of the Butterfly Sanctuary in Cebu, Philippines. The classification and geographical distribution of species and sub-species follow those given by the above authors (Table 2). The occurrence of butterflies is taken from Treadaway (1995) to give an idea of rarity. However, due to the limited work conducted on butterflies in the Philippines and the rapid loss of forested areas, knowledge of distributions and rarity, especially of sub-species, is constantly changing.

Results

Forty-two species from five families (Papilionidae, Nymphalidae, Pieridae, Satyridae, and Danaidae) were collected (Table 2). The Satyridae was the most speciose taxon, and the Danaidae the least (Fig. 2).

Using nested levels of endemism, there appears to be exceptionally high endemicity of both species and sub-species. Forty-five percent of species and 84% of sub-species collected are Philippine endemics. Ten percent of species and 50% of sub-species are endemic to the Negros-Panay faunal region, while a staggering 21% of sub-species are found only on Negros. However, no species found were endemic to Negros (Fig. 3 & Fig. 4).

Figure 2. Frequency distribution of butterfly species within families located in the NNFR.



Eighty-eight percent of the species were recorded in one of the four forest habitats. Of these, 62% rely entirely on forest, the remaining 26% being recorded in both forest and non-forest (i.e. scrub/grassland or cultivated) habitats, with only 12% of the butterflies found only in habitats outside the forest (Fig. 5). However, of these five species, two are species endemic to the Philippines, and four are sub-species that are Philippine endemics. Two of these sub-species (*Ragadia luzonia negrosensis* and *Atrophaneura semperi baglantis*) are Negros endemics, with the latter listed by Treadaway (1995) as rare (Table 2). Following Treadaway (1995), all species encountered in this study are listed as either common (57% of species) or uncommon/local (40% of species); except for *Atrophaneura semperi baglantis,* we did not find any species listed as rare or very rare.

Figure 3. Classification of species identified according to increasing nested levels of endemism.

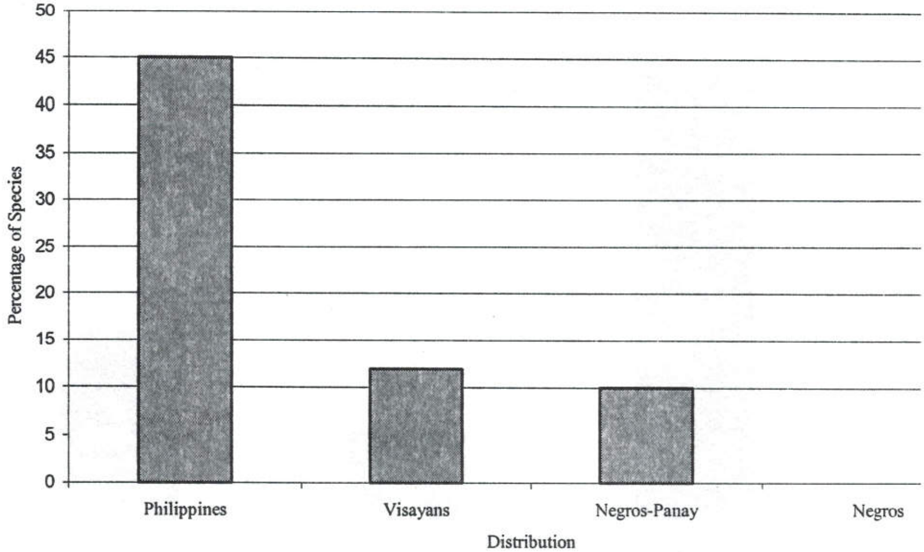


Figure 4. Classification of sub-species identified according to increasing nested levels of endemism

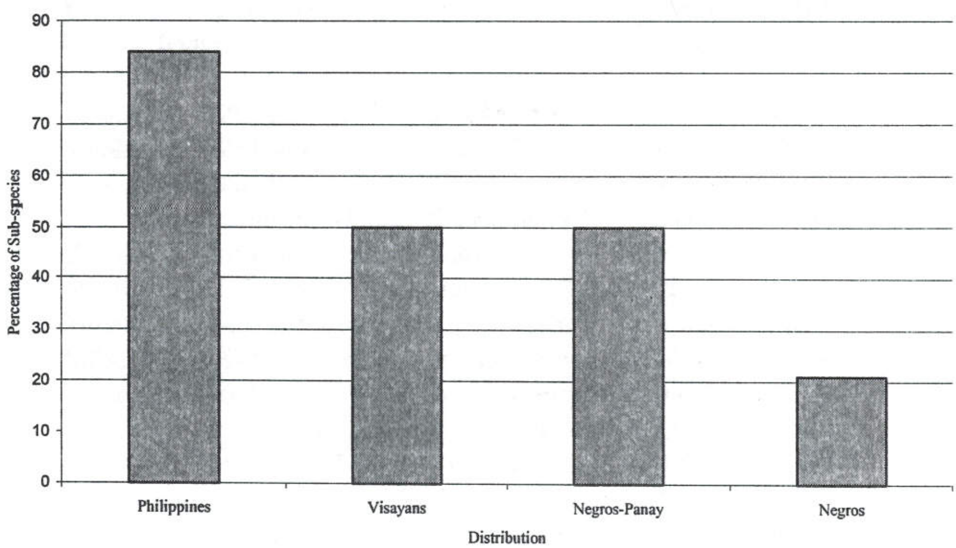


Figure 5. Habitat preferences of butterfly species recorded in the NNFR.

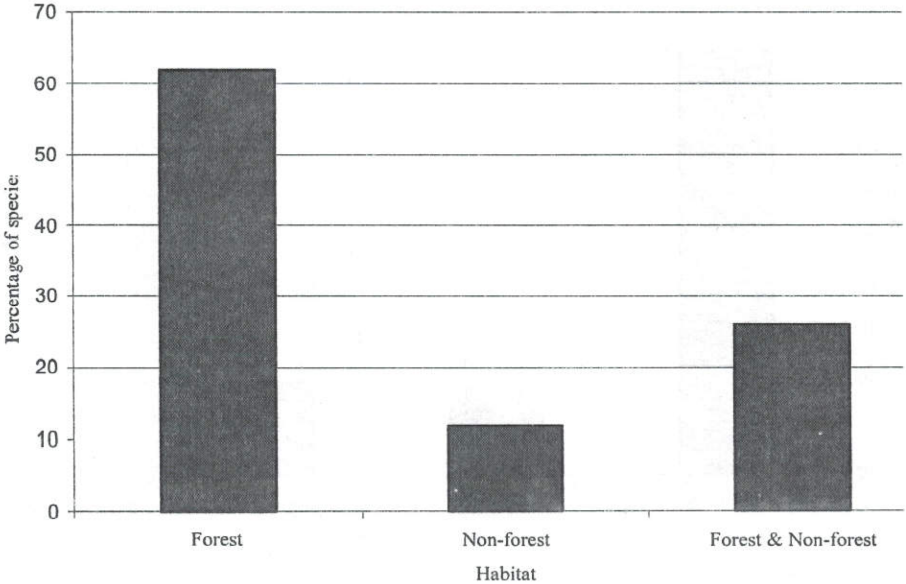


Table 2. (Next page) Butterfly species and sub-species recorded within the survey areas of the Imbang-Caliban watershed.

Classification and distribution based on: D'Abrera (1982); D'Abrera (1985); D'Abrera (1990); Tsukada & Nishiyama (1982); Tsukada (1981); Tsukada (1982); Tsukada (1985); Tsukada & Azumino (1991); Baltazar (1991) and Slade (2002). Occurrence based on Treadaway (1995): 1 = very rare; 2 = rare; 3 = uncommon or local; 4 = common. Habitat classification based on Table 1. Distributions: Asia = Asia (i.e. China, India etc) (includes one that occurs worldwide); SE Asia = Insular and mainland Southeast Asia; Phil = Throughout Philippines; Visayans = Central islands of the Philippines (incl. Negros, Panay, Cebu, Sibuyan, Bohol, Leyte, Samar, Masbate); N-P = Negros-Panay Faunal Region (incl. Masbate, Ticao, Panay, Guimeras, Negros, Cebu, Siquijor); Negros = Only occurs on this island.

Species code	Species	Habitat	Described by (sp)	Described by (ssp)	Distribution (sp)	Distribution (ssp)
S 1	*Mycalesis georgi georgi*	OF, SF, RF	Aoki & Uemura, 1982	Aoki & Uemura, 1982	Phil	Phil
S 2	*Mycalesis teatus teatus*	OF, SF, RF	Felder, 1863	Fruhstorfer, 1911	Phil	N-P
S 3	*Mycalesis perseus caesonia*	SG	Fabricius, 1775	Wallengren, 1860	Asia	Phil
S 4	*Melanitis leda leda*	OF, SF, RF	Linnaeus, 1758	Linnaeus, 1758	Asia	Asia
S 5	*Melanitis boisduvalia boisduvalia*	OF	Felder, 1863	Felder, 1863	SE Asia (Phil & Indonesia)	Phil
S 6	*Melanitis atrax soloni*	OF, SF, RF	Felder, 1863	Okano, 1991	SE Asia (Phil & Indonesia)	N-P
S 7	*Lethe chandica canlaonensis*	OF, SF, RF	Moore, 1857	Okano, 1991	Asia	N-P
S 8	*Ptychandra leucogyne*	OF, SF, RF	Felder, 1867		Phil	
S 9	*Ypthima stellera stellera*	RF, SG	Eschscholtz, 1821	Eschscholtz, 1821	Phil	Phil
S 10	*Acrophtalmia yamashitai*	OF, SF, RF	Uemura & Yamaguchi, 1982		N-P	
S 11	*Zethera musides*	OF, SF, RF	Semper, 1878		Visayans	
S 12	*Elymnias sansoni sansoni*	RF, SG	Jumalon, 1975	Jumalon, 1975	N-P	N-P
S 13	*Ragadia luzonia negrosensis*	SG	Felder, 1861	Yamaguchi & Aoki, 1982	Phil	Negros
S 14	*Faunis phaon carfinia*	OF, SF, RF	Erichson, 1834	Fruhstorfer, 1911	Phil	N-P
S 15	*Amathusia phidippus negrosensis*	RF	Linnaeus, 1763	Okano, 1986	Asia	N-P
S 16	*Discophora ogina pulchra*	RF	Godart, 1824	Nihira, 1987	Phil	N-P
PI 1	*Eurema hecabe tamiathis*	OF, SF, RF, SG, CU	Linnaeus, 1758	Fruhstorfer, 1910	Asia (China & Phil)	Phil
PI 2	*Catopsilia pomona pomona*	OF, SF, RF	Fabricius, 1775	Fabricius, 1775	Asia	Asia
PI 3	*Appias phoebe montana*	M	Felder, 1861	Rothschild, 1896	Phil	Negros
PI 4	*Cepora boisduvaliana negrosensis*	SF, RF	Felder, 1862	Okano, 1991	Phil	N-P
PI 5	*Delias henningia henningia*	OF, SF, RF, SG	Eschscholtz, 1821	Eschscholtz, 1821	SE Asia (Phil & Borneo)	Phil
PI 6	*Delias hyparete luzonensis*	SF	Linnaeus, 1758	Felder, 1862	Asia	Phil

Species code	Species	Habitat	Described by (sp)	Described by (ssp)	Distribution (sp)	Distribution (ssp)
PA 1	*Menelaides deiphobus rumanzovia*	RF, SG, CU	Linnaeus, 1758	Eschscholtz, 1821	SE Asia	Phil (exc. Palawan)
PA 2	*Menelaides helenus hystaspes*	OF, SF, RF	Druce, 1864	Felder, 1862	Asia	Phil (exc. Palawan)
PA 3	*Troides rhadamantus rhadamantus*	RF	Lucas, 1835		Phil	Phil (exc. Palawan)
PA 4	*Atrophaneura semperi baglantis*	SG, CU	Felder, 1861	Rothschild, 1908	Phil	Negros
PA 5	*Graphium eurypylus gordion*	SG	Linnaeus, 1758	Felder, 1864	SE Asia	Phil (exc Palawan)
PA 6	*Graphium sarpedon sarpedon*	RF, CU	Linnaeus, 1758	Linnaeus, 1758	Asia	
N 1	*Lexias satrapes amlana*	OF, SF, RF	Felder, 1861	Jumalon, 1970	Phil	N-P
N 2	*Tanaecia lupina howarthi*	OF, RF	Jumalon, 1975	Jumalon, 1975	N-P	Negros
N 3	*Charaxes amycus negrosensis*	RF	Felder, 1861	Schroeder & Treadaway, 1982	Phil	Negros
N 4	*Cyrestis maenalis negros*	SF, RF	Erichson, 1831	Martin, 1903	SE Asia	Negros
N 5	*Rhinopalpa polynice panayana*	RF, CU	Cramer, 1779	Fruhstorfer, 1912	SE Asia	N-P
N 6	*Junonia almana almana*	RF, SG	Linaeus, 1758	Linaeus, 1758	Asia	Asia
N 7	*Junonia hedonia ida*	RF, SG	Linaeus, 1758	Cramer, 1775	SE Asia	SE Asia
N 8	*Moduza jumaloni jumaloni*	RF	Schroeder, 1976	Schroeder, 1976	N-P	N-P
N 9	*Hypolimnas anomala anomala*	CU	Wallace, 1869	Wallace, 1869	SE Asia	SE Asia
N 10	*Hypolimnas bolina philippensis*	RF	Linaeus, 1758	Butler, 1874	Asia	SE Asia
D 1	*Euploea mulciber kochi*	OF, RF	Cramer, 1776	Moore, 1883	SE Asia	N-P
D 2	*Ideopsis gaura canlaonii*	OF, SF, RF	Horsfield, 1829	Jumalon, 1971	SE Asia	Negros
D 3	*Parantica luzonensis luzonensis*	RF, SG	Felder, 1863	Felder, 1863	SE Asia	Phil
D 4	*Parantica vitrina oenone*	RF, SG, CU	Felder, 1861	Butler, 1865	Phil	Phil (Visayans & Mindana

Discussion

The NNFR supports a diverse butterfly fauna with most of the species recorded dependent on forest habitat. Most importantly, from a biodiversity conservation perspective, many of these are endemic to the Philippines or more restricted geographic ranges within the Philippines, and 40% of species encountered are listed as uncommon or local in occurrance. The species found exclusively outside the forest habitats were also found to have restricted geographical ranges. Thus, the NNFR appears to represent one of the few remaining refuges on Negros for many forest species that are restricted in their ecological range and thus can only be supported by the remaining similar, but limited, habitat types on Negros.

The Satyridae was the most speciose family. The main food plants of the Satyridae family mean that they can colonize diverse habitats; tropical Satyridae larvae feed mainly on grasses and palms (D'Abrera, 1982, 1985), and this may in part account for the high number of species of this family recorded in this study. In disturbed forest the reduction in the canopy encourages growth of pioneer trees, herbaceous plants, and grasses; however, palms, which are harvested by local communities, are often very rare. In old-growth forest, however, palms are abundant, although the density of the canopy reduces the grasses and herbaceous plants occurring on the canopy floor (Turner, Slade, & Ledesma, 2001; Slade, 2002).

It appears that only one species (*Melanitis boisduvalia boisduvalia*) is in danger of localized extinction if the old-growth forest is lost. This species was absent from the disturbed forest sites, being present only in the old-growth forest. While it is not a Negros endemic, it is endemic to the Philippines, and appears from our study to require undisturbed/old-growth forest for its survival, although in other sites it has been found in disturbed forest areas

(Treadaway, pers. comm.). In agreement with our observations, Treadaway (1995) lists this species as uncommon or only occurring locally. With so little undisturbed forest left in the Philippines, this species could be at risk of global extinction in the years to come.

It could be argued that since 38% of the species were found outside the forest boundaries, they are of less conservation importance. Thus, Slade (2002) proposed that of primary conservation importance is the old-growth forest with its high abundances of restricted-range forest species. However, it should also be noted that most of the species found outside the forest also had restricted geographical ranges, and two of the species occurring only outside the forest habitats were endemic to Negros at the sub-species level. Moreover, one of these species, *Atrophaneura semperi baglantis*, is listed as rare (Treadaway, 1995). Thus, these species must also be of conservation interest.

Several authors have stressed the importance of sub-species endemism, particularly if the goal of conservation is to preserve genetic diversity (Vane-Wright, Humphries, & Williams, 1991; Brooks *et al.*, 1992). Of the sub-species recorded, 84% are endemic to the Philippines, 50% endemic to the Negros-Panay faunal region, and 21% endemic to Negros island alone. These results are similar to those of Slade (2002). The Philippines has already been identified as a 'critical' area for butterfly conservation (Danielson & Treadaway, 2004). Baltazar (1991) found that 44% of the butterflies occurring in the Philippines were endemic, while 45% of the total species and sub-species were endemic. Similarly, Treadaway (1995) concluded that 39.3% of butterflies in the Philippines were endemic. Ackery & Vane-Wright (1984) identified areas that are centers of diversity for butterflies of the family Danaidae, with Mindanao in the southern Philippines listed as the third of 31 critical faunas for Danaidae butterflies. A similar critical fauna analysis by

Collins & Morris (1985) listed the Philippines second among 170 countries for Papilionidae butterflies, with only Indonesia having more endemic species. Similarly, considering only the Papilionidae, the highest Philippine percentage species endemism is found on Mindanao (50%), followed by Luzon (46%), Leyte (44%), Samar (37%), Mindoro (36%), and Negros and Panay (31.6%) (Treadaway, 1995). Thus, NNFR, along with other large, forested areas of the Philippines, should be high on the list of sites to be given priority protection.

Treadaway (1995) records 145 species of butterflies, of the families inventoried for this study, on Negros. Of these, we recorded 42 species during our survey period. While this at first appears to be only a small sub-set of known species, it must be remembered that this inventory was primarily aimed at recording forest species in a small area of sub-montane rainforest. Many butterfly species, such as some species of Nymphalidae and Papilionidae, are sun-loving and ruderal and are primarily found outside forest areas. Moreover, forest species tend to be more habitat specific and thus endemitic (Hamer *et al.*, 1997; Spitzer *et al.*, 1993, 1997), perhaps explaining the higher endemicity values compared to when the butterflies of the Philippines are taken as a whole. Butterflies also respond to elevational gradients (Wolda, 1987; Sparrow *et al.*, 1994), with lower species richness at increased elevations. Other studies in montane rainforests in Vietnam found species richness to be between 23-60, depending on the time of year the study was conducted (Spitzer *et al.*, 1993, 1997).

It is also probable that conspicuous, active species will be more easily observed than cryptic, sedentary ones, perhaps resulting in an under-representation of the latter. It has been suggested that the opening up of the forest in disturbed sites, and the lowering of the canopy may make it easier to observe butterflies and thus increase species richness and abundance relative to closed canopy, old-growth forest (Willott *et al.*, 2000). This argument is similar to the one that ground-based transect sampling may underrepresent canopy species (Bowman *et al.*, 1990). It is often suggested that the lower canopy levels in disturbed forest allow canopy species to descend to the ground and thus be observed to a greater extent than in undisturbed forest. This may account for the absence of species known to visit the canopy and migrant species (which are often found in the canopy rather than in the understory) from the old-growth forest, while being present in the highly disturbed forest (e.g. *Troides rhadamantus*, *Graphium sarpedon sarpedon*, *Hypolimnas bolina philippensis*). However, evidence for vertical stratification in tropical butterflies is uncertain, and several other canopy visitors and migratory species (e.g. *Catopsilia pomona pomona*, *Menelaides helenus hystaspes*, *Euploea mulciber kochi*) were encountered in the old-growth forest as well as in disturbed sites. This suggests that 'canopy' species were being sampled effectively, and that stratification was perhaps not as important as other factors, such as availability of food plants.

Species accumulation curves plotted by Slade (2002) as part of a study into the effects of forest disturbance on butterflies in the NNFR showed that during a two-month period most species had been accounted for, except in the secondary re-growth forest where the curve had not yet reached a plateau. This study recorded only 29 of the species listed here. The species not found during the study were primarily the non-forest ruderal species, as only forested habitat was sampled. This again points to the lower species richness of sub-montane and montane forests compared to lowland forests and non-forested areas. As stated earlier, this work does not intend to present a definitive list of the butterfly fauna of the NNFR but attempts to outline the first representative inventory, of a specific forest catchment. It forms part of an on-going research program, including continued inventory work on the butterflies. Further inventory work will now be expanded to include the canopy, lower elevations, and areas outside the forest reserve, as many species that have been recorded on Mt. Canlaon have not yet been recorded in the NNFR (Treadaway, pers.comm.). Surveys will also be expanded to include early morning and late afternoon hours, overcast, but not rainy days, and sunny breaks during rainy days, as some species are known to fly at these times and be easier to catch (Treadaway, pers.comm.). The other method available for butterfly surveys is trapping using baits. This method only samples the guild of fruit-feeding butterflies, and not all the species in the habitat (Daily & Ehrlich, 1998; Wood & Gillman, 1998). Several authors have suggested that baited traps can, however, provide complementary data to visual censuses (Sparrow *et al.*, 1995; C.G. Treadaway, pers. comm). Pilot trials during the study period using traps, baited with both fruit and carnivore dung, did not result in any new species not encountered during visual censuses. However, it is accepted that species attracted to traps can change with season and further surveys will expand the trapping regime to include more traps at varied heights from the ground.

Conclusion

This study has found that the Upper Imbang-Caliban Watershed of the NNFR is similar to many forested areas in the Philippines, as it has a butterfly fauna that is species rich and exceptionally endemic, both at the species and sub-species level. If this holds true for the rest of the NNFR, then, as one of the last tracts of forest left on Negros, it is clearly in need of protection. A continuation of this inventory and further studies in other areas of the NNFR is necessary to draw firm conclusions and recommendations. However, this study confirms that of Slade (2002) that the preservation of the remaining forest areas of the NNFR, and in particular any tracts of undisturbed or old-growth forest, is of primary importance for conservation if populations of restricted-range forest butterflies are to be preserved. Further loss of this could eventually lead to the localized elimination of some species. It is hoped that this inventory and the resulting field guide will assist much-needed butterfly research within the NNFR in the future. Danielsen & Treadaway (2004) have just published a list of priority conservation areas for Philippine butterflies, listing Mt. Canlaon National Park on Negros as one of the irreplaceable conservation areas. It is suggested that the NNFR could provide a second conservation area for many of the butterfly species found in the Mount Canlaon National Park.

Sustainable management, by definition, means that the Reserve will not be an area set aside only for conservation but will probably eventually have a degree of sustainable extraction of certain monitored timber and non-timber forest products, as well as ecotourism, and human habitation (Turner, Slade, & Ledesma, 2001). The results of this study suggest that protection of the remaining areas of old-growth and undisturbed forest is paramount. However, while undisturbed forest is important for some butterfly species, disturbed forest may also be important for sun-loving butterflies (Sparrow *et al.*, 1994; Wood & Gillman, 1998). Moreover, it has also been suggested that butterflies could play a key role in the sustainable management of the NNFR through butterfly farming and ecotourism initiatives (see Slade, 2002).

Although previous studies have already highlighted the clear conservation importance of the NNFR for other taxa (Hamann *et al.*, 1996, unpublished; Turner, Slade, and Ledesma, 2001; Turner, Slade, & Hesse, 2002, unpublished), the Reserve is yet to receive legal protection. Turner, Slade, & Hesse (2002, unpublished) suggest that while actual timber extraction is now minimal due to most valuable species having already been removed, unmonitored non-timber extraction of bamboo and rattan still exists, while settlement and localized clearance of lower forest areas by *kaingin* (slash and burn agriculture) continue to eat into the forest. Moreover, the hunting of birds and, to a lesser extent, mammals both for food and for trade, is still prevalent (Hamann *et al.*, 1996, unpublished). Legal protection under the National Integrated Protected Areas System (NIPAS) has already been suggested based on data collected on birds in the area (Collar *et al.*, 1999; Turner, Slade, & Hesse, 2002, unpublished). This study reinforces this recommendation, based on the high endemicity of butterfly species found in the Reserve.

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Alexia Tamblyn completed an MA in biological sciences at the University of Oxford and an MSc at Imperial College, London. She has worked on an array of conservation/environmental projects over recent years around the world, including Ghana, Belize, Philippines, Malaysia, Peru, and Mexico. She has previously worked with CCC as project Scientist on forest projects in the Philippines, Malaysia, and Mexico.

Jessica Taylor completed a degree in Marine Biology at the University of Newcastle in 2002. Previous voluntary employment includes work at a Seal Sanctuary, on Pilot whale watching boats, at a loggerhead turtle project, at a Dolphin Research Centre, and as a science research assistant for CCC in the Head Office. Recently, she assisted with a photo i.d. study on Hector's dolphins in New Zealand.

Romeo Trono is the Country Executive Director for Conservation International-Philippines. Previously, he worked as the Director of the Sulu-Sulawesi Marine Ecoregion Conservation Programme.

Craig Turner is the current Director of Terrestrial Science at CCC, and has coordinated the terrestrial conservation work of CCC for the past four years. Prior to this, Craig has worked on conservation initiatives in Tanzania, Costa Rica, USA, and the UK, in collaboration with various NGOs and universities. He also recently completed his PhD on Ecosystem Approaches to Environmental Management.

Simon Tyler is a Biological Sciences graduate previously working on wildlife studies (Badger - *Meles meles*). Since working with CCC on the Negros Rainforest Conservation Project, he has been employed as a Freshwater Biologist with Severn Trent Water, researching macrofauna of inland watercourse throughout the Midlands region of England. For the last 12 months he has been employed as the Country Manager for Trekforce Expeditions, a UK-based charity providing support to protected areas of Belize, Central America through implementing environmental projects for volunteers.

Diane Walker studied Marine Biology at King's College, University of London. After completing her degree, Diane worked for over 2 years with Coral Cay Conservation as Project Scientist gaining valuable experience in both the Caribbean and the South Pacific regions. Currently Diane is heading the Mamanuca Environment Society in Fiji as Project Manager, working with hoteliers and communities to raise environmental awareness and ensure the protection and preservation of the marine environment of the Mamanuca Islands.

Ryan Walker holds a Masters Degree in Tropical Coastal Management from the University of Newcastle in the UK. His background and experience are in tropical marine and coastal resource utilization and its associated management. He has field-based research experience undertaken in Belize, Indonesia, USA, and Madagascar, in association with WWF, various university departments, and other NGOs. Ryan is currently the Mesoamerican Marine Science Coordinator for Coral Cay Conservation, overseeing the scientific output of projects in the Yucatan, Mexico, and the Bay Islands, Honduras.