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RESEARCH REPORT

No. 2004-RR6

A Fishery in Transition:Impact of a Community Marine Reserve on a Coastal Fishery in Northern Mindanao, Philippines

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This report provides information on the environmental and economic impact of a marine protected area in Danao Bay, in the Philippines. It looks at how the biodiversity in the reserve has improved thanks to the protection it has been given. It also investigates how much of this biodiversity 'spills out' into surrounding waters and whether this has benefited local fishermen, in terms of improved catches. The research involved a combination of underwater biodiversity surveys, community interviews and secondary research on historical trends in fishery production in the area. The report finds that the establishment of the MPA has had a significant positive effect on the overall ecological condition of both the protected reserve area and of some of the reefs outside it. There is also strong evidence to suggest that the sanctuary had helped protect spawning fish and so helped boost catches. This impact has not, however, been large enough to create a truly sustainable and economically viable fishery area. The author therefore recommends that other policy instruments and fishery management strategies are needed in the bay to reduce overall fishing levels. She concludes that if these are put in place, the reserve could act as the centrepiece of a sustainable fisheries area- a model for other regions where fishing is in crisis.

Published by the Economy and Environment Program for Southeast Asia (EEPSEA)
Tanglin PO Box 101, Singapore 912404 (www.eepsea.org)
tel: +65-6235-1344, fax: +65-6235-1849, email: eepsea@idrc.org.sg

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Library and Archives Canada Cataloguing in Publication

De Guzman, Asuncion B.

A fishery in transition : impact of a community marine reserve on a
coastal fishery in Northern Mindanao, Philippines

(Research report, ISSN 1608-5434 ; 2004-RR6)
Co-published by the International Development Research Centre.
Includes bibliographical references.
ISBN 1-55250-124-8

1. Marine parks and reserves – Economic aspects – Philippines – Danao Bay.
2. Fishery management – Philippines – Danoa Bay.
3. Fisheries – Philippines – Danoa Bay.
4. Marine resources conservation – Philippines – Danoa Bay.
I. Economy and Environment Program for Southeast Asia.
II. International Development Research Centre (Canada)
III. Title.
IV. Series: Research report (Economy and Environment Program for Southeast
Asia); 2004-RR6.

QH91.75P45 333.78’09599’7 C2004-980242-0

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April 2004

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EEPSEA is supported by the International Development Research Centre (IDRC); the Swedish International Development Cooperation Agency (Sida); and the Canadian International Development Agency (CIDA).

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ACKNOWLEDGEMENTS

This research was implemented with the generous funding of the Economy and Environment Program for Southeast Asia (EEPSEA).

The author would like to sincerely thank EEPSEA Director, Dr. David Glover; Deputy Director, Dr. Herminia A. Francisco; Ms. Catherine Ndiaye; and all the EEPSEA staff for their administrative support; and Dr. Nancy Olewiler and Dr. Jack Ruitenbeek for the technical assistance and guidance they provided.

The author also graciously thanks the Philippine Council for Aquatic and Marine Research and Development (PCAMRD) of the Department of Science and Technology (DOST) for the scholarship grant that enabled her to pursue her Ph.D. in Environmental Science at the University of the Philippines Los Baños.

Last but not least, she thanks the members of her Thesis Advisory Committee: Dr. Felino P. Lansigan, Chairperson and main advisor; Dr. Porfirio M. Aliño, Co-Chairperson; and Dr. Reynaldo L. Tan and Dr. Nicomedes D. Briones, for their invaluable support and assistance.

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A FISHERY IN TRANSITION:
IMPACT OF A COMMUNITY MARINE RESERVE ON A COASTAL FISHERY IN NORTHERN MINDANAO, PHILIPPINES

Asuncion B. de Guzman

EXECUTIVE SUMMARY

The potential of a community marine reserve (or marine protected area) in Baliangao, Misamis Occidental, in enhancing the coastal fishery of Danao Bay through the spillover of fish biomass was evaluated through a research study and analysis of biological and economic data. The aims of this research were to: a) determine if the marine reserve had contributed to the improvement of the ecological condition of the bay; b) evaluate the economic profitability of the municipal fishery; and c) determine how existing institutional arrangements influenced the management of the marine reserve and the surrounding fishery.

Results of the study indicate a significant improvement in the overall ecological condition of the Baliangao marine reserve and even of the reefs outside it. Mean cover (46.24%) and species variety of corals (80 species) and fish (more than 240 species) are higher inside the reserve. However, some portions of adjacent reefs (Tinago and Tugas) also exhibit good coral growth and diversity. These observations can be attributed to the eradication of blastfishing and other destructive fishing practices since 1998. Abundance of fish inside the marine reserve supports the assumption that biomass builds up rapidly in the absence of fishing. The occurrence of large-sized target food fishes (i.e. choice fish for human consumption) for example, lethrinids, lutjanids and acanthurids inside the sanctuary core, indicates the potential of the Baliangao Marine Reserve (BMR) in exporting post-larval recruits (small fish that have passed the larval stage and which are new entries to the population) to adjacent fishing areas.

The municipal fishery is a multi-gear, multi-species system typical of tropical fisheries. Total annual fishery production from Danao Bay in 2001-2002 amounted to 14.28 tonnes/km^2/year. Analyses of fishing costs and revenues indicate a differential profitability of certain gears (fishing equipment such as nets, hooks, and traps) over others. However, net incomes are low due to low average catch per effort (2.26 kg/fishes/day). Less capital- and manpower-intensive gears such as bamboo traps and fish corrals capture most of the rent (profits) from the Danao Bay fishery, which amount to a midpoint of PhP 104,317 annually. Results indicate that the coastal fishery surrounding the marine reserve is still open-access, characterized by high fishing effort and small profits. The fact that some fishery rent is being earned, however, indicates that the fishery is on a transition towards becoming a viable economic system.

Despite the array of problems confronting the management of the Baliangao marine reserve, (for example, sustainability, poaching, and poor local government support and enforcement), fishery resource management in Danao Bay has achieved a significant amount of success and is one of the few well-managed marine protected areas (MPAs) in the Philippines. Much of this success is attributed to the support and involvement of a large sector of the community under a federation of organizations called the Danao Bay

Resource Management Organization (DB-REMO). Presently, resource management in the bay is undergoing a process of evolution, as the declaration of the marine reserve as the Baliangao Protected Landscape and Seascape (BPLS) under the National Integrated Protected Areas System (NIPAS) has led to the formation of a broader, more integrated and more complex institutional arrangement under a Protected Area Management Board (PAMB). Under this new management, the participation of local government units (Baliangao and Plaridel, both under the province of Misamis Occidental) and agencies such as the Department of Environment and Natural Resources (DENR) and the Department of Agriculture (DA), will become more prominent. This research has shown that the establishment of the Baliangao marine reserve has improved habitat quality, fish biodiversity, and fish biomass, and has enhanced the economic profitability of the coastal fishery. Community involvement in the management of the bay has also played a significant role in the successful implementation of the marine reserve and in sustaining the coastal fishery of Danao Bay.

1. INTRODUCTION

1.1 Research Background

Tropical fisheries are complex, multi-gear, multi-species systems that are very difficult to manage due to a myriad of social, economic and policy considerations. The open-access nature of the ocean's fishery resources has resulted in over-fishing in many traditional fishing grounds around the world. Near-shore ecosystems such as coral reefs are particularly vulnerable because of their accessibility to marginal fishermen (small-scale fishermen who are dependent on the fishery and earn very little income) with little access to capital. Coral reefs contribute between 5 and 36.9 tonnes/km^2/year (Alcala & Gomez 1985) to the total fish production of coastal areas in the Philippines, and about 10-15% of total capture fisheries production (capture fisheries is a technical term referring to fish production through the harvesting of natural stocks) (Russ & Alcala 1996). Over-fishing has been compounded by the widespread use of destructive fishing methods, such as dynamite fishing, resorted to by fishermen to increase yields (Roberts & Polunin 1993). Presently, less than four percent of more than 27,000 km^2 of fringing reefs in the country remain in excellent condition, while the rest are in varying states of degradation (UPMSI 1985 cited in White & Trinidad 1998).

Conventional methods of regulating fisheries have often failed to prevent the continuous depletion of fish stocks. In an attempt to avert the downward trend of capture fisheries, many local communities of tropical countries have established marine reserves or fish sanctuaries to ensure the sustainability of fish stocks that support municipal or reef fisheries. The concept of marine reserves is founded on the premise that fish population levels recover once fishing stops (Holland & Brazee 1996). Many fishery scientists (Roberts & Polunin 1993; Russ 1996) believe that considering the alarming levels of over-exploitation of many reefs, marine reserves may be one of the few management options available to maintain a critical spawning stock of biomass needed to sustain reef fisheries.

One of the most popular concepts about marine reserves is their contribution to the enhancement of fish stocks and fisheries in non-reserve areas through the export of adult fish biomass into these areas. This “spillover effect” is now the subject of many investigations as to the efficacy of marine reserves in enhancing the fisheries surrounding them. The popular theory is that in the absence of fishing, biomass builds up rapidly, and given the limited space within a marine reserve, fish will eventually ‘spill over’ into the areas surrounding the reserve, and thus contribute to fishable biomass in nearby fishing grounds (Alcala 1999). The strongest selling point of marine reserve establishment as a fishery management tool is its potential to deliver socio-economic benefits to resource users by sustaining fish stocks through improved ecological conditions.

1.2 Research Constraints and Hypotheses

Available data on the ability of marine reserves to enhance the coastal fisheries in surrounding areas through biomass spillover is meager and invariably relies on ‘circumstantial evidence’. While a large body of literature on habitat improvement and fish biomass build-up inside marine reserves (sometimes referred to as ‘no-take’ reserves) is available, there is a dearth of studies that measure actual yield enhancement from the reserves. The pioneering work of Russ and Alcala (1996) in Apo Island in central Philippines provided some early evidence of the occurrence of spillover of adult fish biomass from a reserve to fished areas. A recent study by Rodwell and Roberts (2000) in the Mombasa Marine National Park showed, through simulation, that full protection leads to increase in total fish biomass, and that the movement of adult and larval fish from a reserve increases the total fishery catch of the surrounding areas.

The major policy question that this research seeks to address is: do marine protected areas (MPAs) help enhance the fish catch of the surrounding fishing grounds? Enhancement of fisheries is understood in the context of the generation of positive economic rent or profits by the fishermen. Moreover, such fishery rent should be sustained over the long term, rather than generated in ‘pulses’ against periods when profits are zero. Sustaining profits, however, depends on the ability of fishery managers to effectively regulate fishing activities within fishing grounds. One management option that is gaining popularity among municipal fishermen is to stop ‘open access’ fishing, either through the exclusion of fishers not residing in the area, or to issue fishing permits or fishing rights at a fee payable to the municipal government.

An economic analysis of fisheries in the surrounding areas of the MPAs would generate critical data to convince policy makers and local communities of the necessity of protecting their coastal ecosystem. Although valuation methodologies are available, hardly any analysis has been carried out on marine reserves in the Philippines. It is equally important to analyze the existing institutional arrangements that lend support to the management of MPA projects, and how these and social relations among various sectors of the fishing community can influence the success or failure of a project. A review of existing fishery management approaches being implemented in marine reserve projects is needed to determine what will work best for the local area.

This research is guided by the following hypotheses:

1) Establishment of marine reserves can enhance biodiversity and build-up of fish biomass and spawning stock within them.

2) Marine reserves help enhance the catch of fish population, and economic value of unprotected areas outside the reserves. This is achieved in the following ways:

   i) improved yields through larval recruitment and adult spillover,
   ii) decreased fishing costs resulting from reduced and focused fishing effort and the use of less capital-intensive fishing gear, and
   iii) improved management through the involvement of the community in protection and advocacy, thus increasing compliance to fishery regulations by fishers outside the marine reserve.

3) Establishment of marine reserves can induce the transition from an open-access scenario to an effectively managed fishery in surrounding areas.

1.3 Research Objectives

The general objective of this research is to provide empirical data, using biological and economic indicators, to show that a community-managed marine reserve can contribute to the enhancement of the fishery in the surrounding areas.

This study specifically aims to:

1) determine if the establishment of the marine reserve in Baliangao has contributed to the improvement of the ecological conditions of Danao Bay in terms of habitat quality, fish population levels, and diversity in surrounding fishing areas,

2) evaluate the economic profitability of the municipal fishery, and

3) determine how existing social and institutional arrangements influence the management of the MPA and the surrounding fishery.

1.4 Scope and Limitations

This research is limited by its short time frame of only one year, during which discernable changes in the bio-physical and socio-economic environment may not be readily observed. Furthermore, the dearth of historical fisheries data on the study area makes it difficult to make any reliable 'past and present' comparisons of the condition of the coastal fishery. Information obtained from a survey of fishermen's perceptions and their detailed recounting of the past, however, helped in painting a picture of the history of fishery in Danao Bay.

Results of this study are indicative rather than absolute evidence that the establishment of the marine reserve has enhanced fishery production and fishing revenues, either through improved habitat conditions or the export of fish biomass from the reserve. A more important concern is how any evidence on the positive impacts of the ten-year old Baliangao marine reserve on the fishery may be used as a basis for policy recommendations to improve the management of near-shore fish resources.

2. METHODOLOGY

2.1 The Study Area: Geography and Management History

The study area is a 74-hectare mangrove-seagrass-coral reef marine reserve located in Danao Bay, Baliangao, a small (total water area is about 2,000 ha or 20 km^2) and shallow embayment fronting the Mindanao Sea in the northern shore of Misamis Occidental (Fig. 1). A 1992 processed LandSat map estimated the mangrove area to be around 259 ha; the seagrass bed, 253 ha; and the fringing reef area, 763 ha. The reserve was established in 1991 as the Misom Sea Sanctuary, a joint venture between the local government and Pipuli Foundation Incorporated[1], although the latter was responsible for much of the project implementation. The reserve was renamed the Baliangao Wetland Park after the inclusion of the rich mangrove forest into the protected area (Heinen and Laranjo 1996). The marine reserve was declared a national protected area under the National Integrated Protected Area System (NIPAS) Act of 1992 (RA 7586) on November 22, 2000, and is presently called the Baliangao Protected Landscape and Seascape (BPLS). It covers much of the mangrove forests of Baliangao.

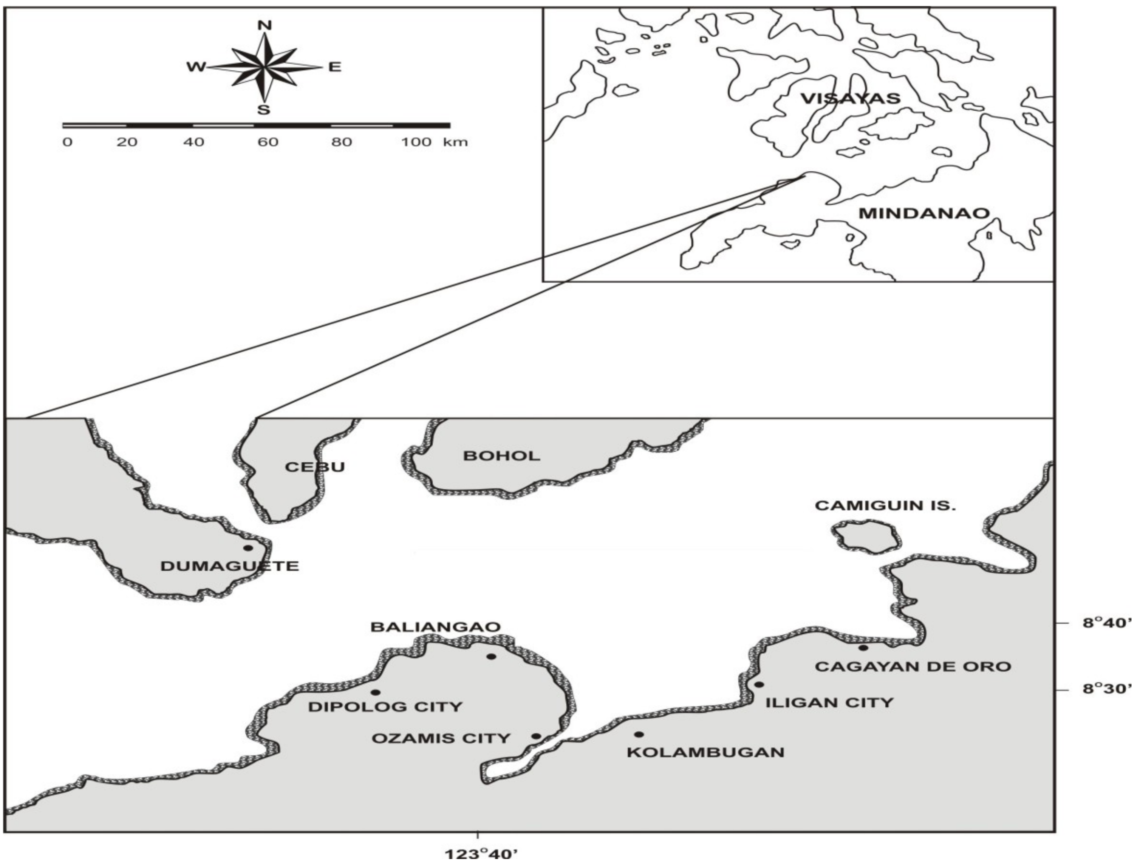


Fig. 1. Map of Northern Mindanao showing the location of Danao Bay.

[1] The Pipuli Foundation is an environmental non-governmental organization (NGO) based in Misamis Occidental, dedicated to the conservation of natural resources through the empowerment of local communities. Pipuli was founded by Mr. Neil Fraser, and started off by organizing agroforestry communities in the Mt. Malindang watershed. It later expanded to coastal resource management in Danao Bay and Murcielagos Bay. 'Pipuli' is an indigenous Subanen term in Mindanao, meaning 'to put back' or restore.

Today, the BPLS is an excellent example of a community-based marine reserve, largely managed by a federation of people's organizations made up from the six coastal villages or 'barangays' fringing Danao Bay, with the continued support of the Pipuli Foundation. It is an integrated mangrove, seagrass and coral reef ecosystem with an elliptical central or core area of about five hectares (about 7% of the total reserve area). Running along the length of the 74-ha sanctuary is a 25-ha buffer zone (Fig. 2). Strict 'no fishing' regulations are implemented inside the sanctuary, while only reef gleaning, or the gathering of shells, sea cucumbers, and fish on reef flats by hand or by use of minor implements, is allowed within the buffer zone.

Fishing in Danao Bay is primarily municipal and artisanal (using minor or small-scale gears) in nature, and confined to shallower areas during much of the year, since fishing in open seas is perilous during the strong northeast monsoon ("amihan"). The coastal fishery is a multi-gear, multi-species industry that employs more than 400 full-time and part-time fishers. Non-resident fishers, (or so-called 'strikers') from neighboring towns, increase fishing pressure in the bay. The 1980's showed the long-term effects of declining catch, a result of high fishing intensity, more efficient technology and the destruction of vast (800-ha) mangrove forests by massive cutting for commercial charcoal production and fishpond development that started in the 1960s.

2.2 Field Methods

2.2.1 Protocol and Linkage-building

Groundwork or preparatory activities in relation to this research were conducted as early as November 2000. These included protocol visits to the municipal mayors of the two towns (Baliangao and Plaridel) who had political jurisdiction over Danao Bay, the chairmen of the six coastal barangays, the Executive Director and staff of the Pipuli Foundation, and the Danao Bay Resource Management Organization (DB-REMO). A Memorandum of Agreement between the University of the Philippines Los Baños, the Pipuli Foundation and the researcher of this report was drawn up to formalize the cooperation.

2.2.2 Assessment of Coral Reefs and Contiguous Habitats

A broad examination of the reef slopes fringing Danao Bay was conducted in mid-February 2001 employing the Manta Tow Reconnaissance Technique. A total of 25 two-minute tows were made to cover some seven kilometers of reef within the boundary of Danao Bay. Each tow station was marked by global positioning system (GPS) readings, and descriptions of substratum characteristics were recorded based on a broad 1-5 scale for live and dead corals, and other macrobenthos. This data was used as the basis for selecting dive sites for detailed coral reef and fish surveys. Results of the manta tow survey showed that most of the fringing reef areas in the bay were relatively poor (scale of 1-2) in live coral cover, with the exception of the reef slope within the Baliangao marine reserve, and parts of Tinago, Tugas, Bato and Danao (scale of 2-3).

Six dive stations were established along the fringing reefs of the bay based on the results of the manta tow survey for a detailed investigation of the status of the coral reefs inside and outside the reserve (Fig. 2; Table 1). The assessment of corals and other macrobenthos was conducted in May 2001 using the Line-Intercept Technique (LIT) described in English et al. (1997).

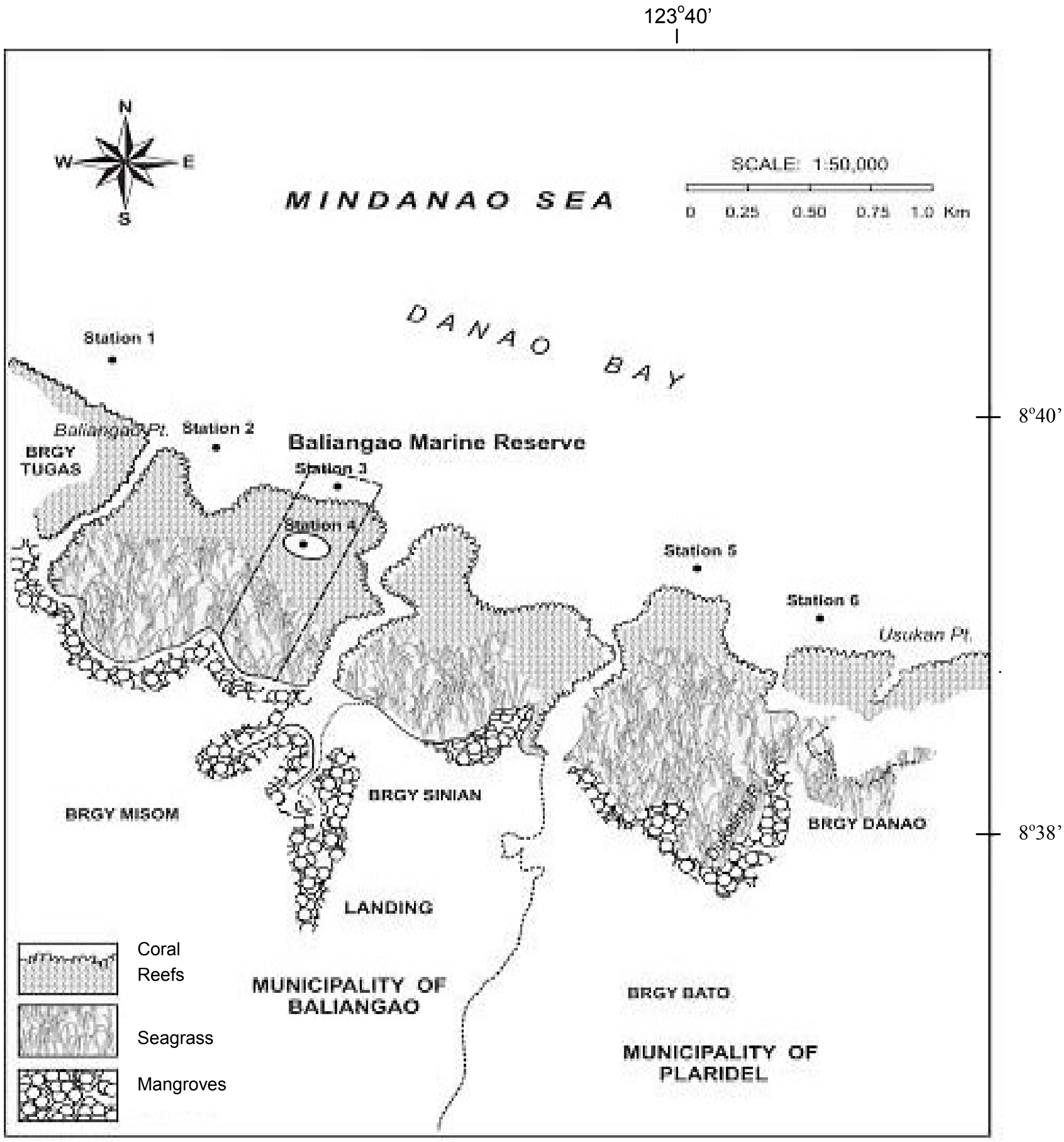


Fig. 2. Map showing the location of the Baliangao Marine Reserve in Danao Bay (area drawn by dotted lines) and of the different reef stations.

Danao Bay is characterized by wide seagrass flats, inshore of the fringing reefs, and a large mangrove area of high diversity. A survey of plant biodiversity and cover in these ecosystems was conducted in selected sites inside and outside the reserve. This information is relevant in describing the ecological conditions of various habitats in the bay, and indicate how effectively protection of these contiguous ecosystems is being implemented.

Table 1.Location of six monitoring sites for coral and fish community structures inside and outside the Baliangao Marine Reserve

Site	Location	Description	GPS coordinates	Estimated distance between each station
1	Danao, Plaridel	1 Site Shallow (3-5m)	8°39.048' N 123°40.117' E	NA
2	Bato, Plaridel	2 Sites Shallow (3-5m) Deep (10-12m)	8°38.999' N 123°39.424' E	1.27 km
3	BWP Reef Slope	2 Sites Shallow (4-5m) Deep (7-12m)	8°39.444' N 123°38.329' E	2.17 km
4	BWP Core Area	1 Site Shallow (2-3m)	8°39.191' N 123°38.127' E	0.60 km
5	Tugas, Baliangao	1 Site Deep (7-8m)	8°39.698' N 123°37.659' E	1.32 km
6	Tinago, Baliangao	1 Site Deep (12-15m)	8°39.850' N 123°37.465' E	0.45 km

2.2.3 Assessment of Fish Abundance, Diversity and Biomass

Species diversity and abundance of fish populations in stations inside the marine reserves and in surrounding reefs waters were monitored through the daytime fish visual census (FVC) technique using self-contained underwater breathing apparatus (SCUBA) (English et al. 1997). Although reef dives were originally planned at quarterly periods, the monitoring of fish populations was accomplished in only three periods, namely from May – June 2001, and in October 2001 and July 2002. Alterations in the original schedule were caused by weather phenomena, such as a succession of tropical depressions between August and September 2001, and stormy sea conditions resulting from the northeast monsoon between December 2001 and April 2002.

A fish visual census was conducted in the six coral reef stations at two depth levels, namely shallow (3-6m) and deep (10-15m), where applicable. All species of fish found along the transect were identified and counted, and an estimate of their total length (in cm) was recorded and later used in estimating the biomass value available on the reef. Particular attention was given to large predators, such as groupers (Serranidae), snappers (Lutjanidae), emperors (Lethrinidae), parrotfishes (Scaridae), and the herbivorous siganids or rabbit fish (Siganidae), which are preferred catches by fishermen because of their high economic value.

Using data on population density and average body size of each species, fish biomass (or live fish weight) was estimated from the length-weight relationship established for fish (Pauly 1984). This simple mathematical procedure enabled an estimate of the amount of harvestable biomass of fish in the reef to be calculated, and compared across stations and months as evidence of the fishery potential of the marine reserve. Moreover, population counts were low in some reefs, but the presence of older and larger fish resulted in substantial biomass compared with reef areas dominated by small or juvenile fish.

High population levels and diversity of fish would demonstrate the positive impacts of strict protection inside the sanctuary or marine reserve, and could indicate the occurrence of biomass export into fished areas. The more direct tagging-recapture method of demonstrating the occurrence of 'spillover' of fish biomass from the marine reserve to the surrounding areas was not used due to logistic and social limitations. A comparison of fish communities inside the marine reserve with the areas outside it is a common method to evaluate the impact of a reserve on fish populations (Alcala and Russ, 1990). This 'inside-outside' dichotomy was adopted in lieu of the ideal 'with-or-without' analysis to obtain empirical evidence that marine reserves indeed enhance surrounding fisheries by exporting biomass. The stochastic nature of ecological processes and fishery exploitation would preclude the selection of an area with the same ecological conditions as the marine reserve which differs only in terms of the absence of a 'no-fish' reserve.

A fish population census was also conducted in the shallow seagrass beds to determine the species diversity and abundance of common fish associates of this habitat. Similarity in species composition occurring in both areas indicates the occurrence of biomass exchange between coral reefs and adjacent seagrass beds. Only two 50-meter transects were surveyed by snorkeling in an adjacent seagrass area (also in Barangay Misom) in January and May 2002 using the standard daytime fish visual census technique.

2.2.4 Economic Assessment of the Coastal Fishery

One way to demonstrate that the Baliangao MPA has a positive impact on the surrounding coastal fishery is the use of economic indicators such as increased fish catch-per-unit of effort (Alcala & Russ 1998) and income of municipal fishermen who fish in areas adjacent to the marine reserve. Demersal fish (fish associated with coral reefs, seagrass beds and other shallow bottoms, in contrast to pelagic fish) catches from the reef were segregated from those caught in offshore waters in order to avoid bias and to make sure that only catches from Danao Bay were analyzed. Past information, such as amounts of fish catch of selected fishing gears, fishing effort levels, prices of fish, types of target species, and other pertinent data were obtained as secondary data from Pipuli's own participatory monitoring activities in the bay. Supplemental information was also generated from interviews with the older fishers of the community. This information together with data generated by fishery monitoring were used to establish the 'before' and 'after' components of the marine reserve establishment.

Baseline fisheries data on most MPAs in the Philippines is not readily available. However, it is not too difficult to assume that in tropical, 'open access' systems, most fisheries are already over-fished. In the same vein, it can easily be assumed that prior to the establishment of marine reserves, these fisheries were not generating any positive economic rent (personal communication with Dr. J. Ruitenbeek, Hanoi, November 2001). Conversely, a steady-state fishery (a stable fishery which sustains high fishing effort) which is on its way to becoming an 'open access' system, can temporarily generate positive rent (personal communication with Dr. N. Olewiler, November 2001). Apart from these arguments, however, it is important to consider the importance of time-series fisheries data to evaluate whether or not an MPA-supported fishery would generate resource rent on a sustainable basis.

Fish Catch and Fishing Effort

A combination of strategies in fish catch monitoring was adopted. Whenever possible, a participatory approach was employed where fishers recorded their catches on prepared data forms. Logbooks were also left with fish buyers (or "comprador") to collect data where the first approach did not work. A third strategy was to assign field enumerators (themselves members of the participatory monitoring team of DB-REMO) in different fishing villages and to record the catches of fishers as they arrived from the sea. More than 200 full-time and part-time fishermen (about 50% of the fisher population) were monitored, although the number tended to vary each month as other activities prevailed upon some and steered them away from fishing.

Most fishing gears operated in Danao Bay, such as fish corrals, gillnets and bamboo fish traps, are stationary i.e. fixed in one location at one time or another. On-site surveys of fish catch of fish corrals were also conducted as a means of validating recorded catch data from fishermen. The species composition, population estimates and body size and weight of fish populations, especially target food groups were recorded each month. Only about a quarter of the fish corrals deployed could be regularly sampled because fishermen did not stay long at sea once the catch was removed – by the time the researchers reached the area, most of them had gone home.

The fish catch data was presented as total monthly yields (in tonnes) of all demersal fishes and compared among the six monitoring stations or barangays outside the reserve. The monthly data from the random sample of fishermen in the six barangays was extrapolated to obtain estimates of total fish production of the municipal fisheries in the bay.

Fishing Costs, Revenues and Income

A survey of costs and off-vessel prices of fish caught by each gear type was conducted on a random sample of municipal fishermen. Costs included investment and operation costs of fishing (Trinidad et al. 1993). Investment costs included capital costs of the boat, engine, and gears, while operating costs were classified as fixed and variable. Fixed costs included licenses, salaries and depreciation costs of boat and engine. Variable costs included running costs (fuel, oil, ice, food and other miscellaneous expenses), shore and marketing expenses, repairs, and maintenance, and were calculated by multiplying the quantity consumed by the unit price (Trinidad et al. 1993). The cost of labor was estimated using an average value of the prevailing daily wage rate (in PhP) in the locality. This rate was used to estimate the value of salaries paid to fishing crew, or to represent the value of family labor involved in the municipal fishery business.

More than 150 fishermen were surveyed. Unfortunately, an examination of the completed forms revealed that many respondents did not provide estimates of operating costs, while some entered values that were improbable and had to be discarded. Thus, in the end, data on fishing costs from only 118 fishermen could be used. Revenues from fishing were determined from the sale of fish and were dependent on current prices. The daily catch of fishermen was classified by species and the type of gear used. These values were then multiplied by the corresponding (per species) price per kilogram in order to obtain estimates of daily gross revenues. For consistency, off-vessel prices or the buying prices of the fishermen themselves(and not the middlesmen or market prices) were used, since this would indicate how much an individual fisherman actually received as a total value of his fish catch. A list of prices for different species and size groups of fish was generated from the surveys.

Determination of Resource Rent

The spillover of benefits from marine protected areas may be demonstrated through an evaluation of the economic production system, such as the municipal fishery surrounding the reserve. Evidence that fish biomass spillover has indeed enhanced the adjacent fishery is indicated by the generation and maintenance of positive economic rent by the resource. To demonstrate whether or not the municipal fishery of Danao Bay is generating rent, a cost-revenue analysis was made, after which estimations of "net values" and "net present values" of fishing activities were done. This was accomplished through a step-wise process, following the method outlined by Trinidad et al. (1993) and Gustavson (1999).

According to the work of Gustavson (1999), the net present value (NPV) may be considered as the current "net value" associated with the use of Danao Bay waters as a fishing ground, or the contribution of marine biodiversity to economic production on an annual basis over an infinite time stream. In other words, this value would be tantamount to the "resource or economic rent" that can be sustained with proper fisheries management.

2.2.5 Survey of Socio-economics, Community Perceptions and Institutional Arrangements

A questionnaire survey was conducted in each barangay to obtain relevant information on demographic, economic status, livelihood options and resource use patterns of the community. These are important factors in understanding the nature of fishers involved in the municipal fishery and the driving mechanisms that determine why some choose to remain in the industry despite the absence of positive economic rent. Such information will also help in the analysis of the economic impacts of the marine reserve establishment project. A total of 180 fishermen, including a few women, representing the six coastal villages in Danao Bay, were surveyed. Interviews with key informants (community leaders, heads of people's organizations, heads of non-government organizations, local government officials, and line agency staff) were conducted to identify existing institutional arrangements, current fisheries management strategies, and policy formulations with regard to the management of the BPLS. Annual reports and relevant secondary data from earlier studies conducted by the Pipuli Foundation were also obtained to supplement the results of the surveys.

2.3 Data Analysis

2.3.1 Statistical Analysis of Coral Reef Data

Data on live coral cover and reef fish populations were compared among stations and sampling (dive) periods using simple analysis of variance (ANOVA) and t-tests, incorporated in the Statistical Package for Social Sciences (SPSS, version 10). Coral cover, fish abundance, diversity, and biomass inside the marine reserve and in non-reserve reef areas were analyzed to determine if there were significant differences between these parameters.

2.3.2 Estimates of Total Annual Fish Production and CPUE

An estimate of the total annual fishery production of Danao Bay in the period 2001-2002 was obtained by extrapolating the monthly recorded catch figures in each fishing village using raising factors (RF), determined from the ratio between the total number of fishing days and the days monitored. Catch-per-unit-effort (CPUE) was calculated for each fisherman and gear type. Then an annual average was obtained.

2.3.4 Calculation of Fishery Rent

The calculation of the net values of fishing rent was made following the procedure described by Gustavson (1999):

1) Calculation of gross annual revenues per fisher and gear type.

2) Determination of capital and operating costs of fishing for each gear from a fishing costs survey of a sample group of fishers.

3) Calculation of net operating values:
   Total monetary values from fishing (gross revenues)
   – Total variable or operating costs = Net operating values (NOV)

4) Conversion of net operating values (NOV) to true net values:
   Annual Net Operating Value (ANOV) – Equivalent Annual Capital Cost (cost of boat, engine and fishing gear)

   where $\boldsymbol{E = C / AF}$; and

   where E = Equivalent annual capital cost
   C = Value of capital cost
   AF = Annuity factor, assuming an infinite time horizon,
   $AF = 1/i$; i being the discount rate used in calculating the net present value (NPV) specific to each gear

   An *annuity factor* represents a fixed value of annual benefits or annuity received for a number of years at a given interest rate. In assuming an infinite time horizon, the annuity factor becomes a perpetuity or annual benefit that continues indefinitely (Boardman et al. 2001).

5) Calculation of Net Present Value

   It is assumed that the fishery resource can be used on a sustainable basis at a certain level of effort. Thus, we are interested in determining the total value that takes into account an infinite stream of benefits. In this context, the net present value (NPV) of the fishery represents the amount of annual benefits fishers receive in perpetuity.

Net present values for different gear types were calculated using three discount rates (5%, 10% and 15% per year) as a way to show the sensitivity of the analysis to varying discount rates.

$$\mathbf{NPV} = \frac{\mathbf{(R - C)}}{\mathbf{i}} = \frac{\mathbf{NV}}{\mathbf{i}}$$

where R = revenues;
C = costs
NV = annual net value
i = discount rate

Total revenues were obtained by adding up daily revenues of fishermen using a certain gear type, while daily revenues were obtained by multiplying the average daily catch (in kilograms) per species with its corresponding price. This was done to remove the bias of using average prices, since the price of fish varied according to quality and size.

3. FINDINGS

3.1 Attributes of Coastal Ecosystems in Danao Bay

Despite its small size, Danao Bay is a natural complex of marine ecosystems that are interdependent and share mutual benefits. Mangrove forests and seagrass beds in the bay are as important as its coral reefs in providing a habitat for a myriad of marine organisms. A quick appraisal of the mangrove forest and seagrass beds inside the marine protected area provided important information on the diversity and abundance of these contiguous ecosystems. More detailed assessments of the coral and fish communities of the bay's fringing reefs generated the first comprehensive database on the ecological condition of the bay. These results are discussed in the foregoing sections.

3.1.1 Mangroves and Seagrass

The mangrove forest inside the Baliangao marine reserve is a highly diverse ecosystem, with a total of 20 species of mangrove trees (Table 2). The most abundant mangroves are three species of *Rhizophora (R. apiculata, R. mucronata* and *R. stylosa*) which comprise 67% of the tree population and are widely used in reforestation activities. Two species, namely *Ceriops tagal* and *Heriteria littorali,* are rare, and although they are found in the mangrove forest inside the marine reserve, they were not intercepted by the transects (of this survey). This high diversity of mangrove species in the BPLS confirms earlier assessments conducted by Silliman University from 1993 to 1995 (Heinen & Laranjo, 1996) which recorded 17 species in their last survey in 1995, while Calumpong and Meñez (1997) noted 21 species of mangroves in the wetland park of Baliangao. Results of present and previous studies indicate that the original mangrove diversity of 17 species had been enhanced through protection from all forms of exploitation, and probably also through reforestation through over the years.

Seven species of seagrass were found on the reef flats of the Baliangao marine reserve. The seagrass habitat of Tinago-Tugas, found outside of the marine reserve, however, was more diverse with eight seagrass species, including narrow-leaf varieties of two species not found during the survey inside the reserve (Table 2). Average values of seagrass cover in the two areas were comparable, with 41.2% inside the reserve and 44.3% in Tinago-Tugas. In both stations, the most dominant plants were the tropical eel grass *Enhalus acoroides,* turtle grass *Thalassia hemprichii,* and round-tipped seagrass *Cymodocea rotundata.* Associated animals in the seagrass habitat were surprisingly more numerous and diverse in Tugas than inside the protected marine reserve. This observation is rather curious, particularly since gleaners are allowed only in the buffer zone adjacent to the reserve, while they have unrestricted access in Tugas. Verbal and written accounts (*Danao Bay Monitor,* June 1998) indicate massive poaching violations inside the sanctuary to gather primarily sea cucumber and edible urchins. Such large-scale harvesting could have reduced the population levels of these invertebrates making recovery slow.

Table 2. Some ecological indicators of the Baliangao marine reserve (BMR) and adjacent unprotected areas

Parameter	Inside BMR	Outside BMR
Live coral cover (%)	46.24	36.89
Coral diversity (number of species)	80 (2 sites)	90 (4 stations)
Fish diversity (number of species) Total (over three survey periods) Mean (of diff. stations and periods)	 246 102	 236 # 72
Fish population density @ No. of fish per m^2 No. of fish per $500m^2$	 1.20 626	 1.49 780
Fish biomass @ Grams per m^2 Grams per 500 m^2	 31.93 15,964.27	 18.09 9,044.42
Mangrove species richness (number of species)	20	Not assessed
Seagrass species richness (number of species)	7	10*

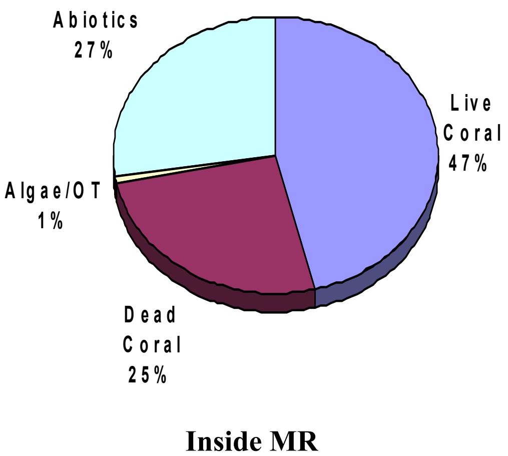
Note: # : Number of species in July 2002 survey exceeded that inside the reserve.
@ : Mean of three survey periods within one year.
* : Includes narrow- and wide-leaf varieties of *Halodule species.*

The rich seagrass ecosystem in Danao Bay is considered by many fishermen as responsible for the high productivity of fish in the area. Most of the fish corrals are deployed in the shallow seagrass flats, and much of their catch is made up of seagrass-associated fish such as siganids and wrasses. A 1992 LandSat image estimated the total area of seagrass beds in the bay at 253.4 ha, constituting about 12.7% of the bay's area.

3.1.2 Coral Communities

Coral Cover and Diversity

The fishing ground within Danao Bay is characterized by an extensive reef flat terminating in a narrow (about 100 m wide) fringing coral reef that slopes abruptly from a wave-swept reef crest. The reef slope has a narrow band of branching and massive coral life forms that grow abundantly at 12-15 meters deep, beyond which the bottom is made up mostly of sand and rubble. The coral reefs may be considered to be in fair (Danao, Bato and Tugas) to good condition (Misom marine sanctuary and Tinago). Average live coral cover inside the marine reserve is higher (46.3%) than in reefs outside the reserve (mean = 36.9%) (Table 2; Fig. 3). This can be attributed to active protection of the reserve, where the absence of fishing and other forms of human exploitation has allowed the coral communities to flourish. This is not an absolute conclusion, however, since Tinago reef has the highest coral cover compared with any of the other stations outside of the reserve (Appendix 1) despite being open to fishing. It is possible that Tinago reef has a higher potential for recovery after damage than other stations, although this theory requires an ecological validation outside the scope of this study. Certain portions of the reefs in Tugas and Danao also show spreading colonies of fast-growing branching coral. The presence of several small colonies inside the shallow sanctuary core is encouraging and provides evidence of the beneficial effects of protection.



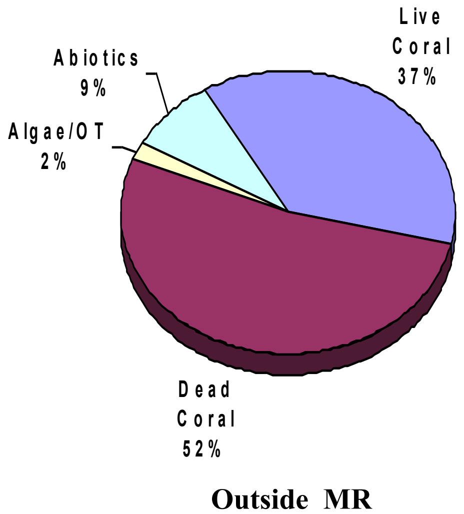


Fig. 3. Pie charts showing higher live coral cover inside the marine reserve and higher dead coral cover outside it.

Results of the analysis of variance (ANOVA) indicate that the differences in live coral cover data among reef stations in Danao Bay are not statistically significant (probability <0.05). A t-test (conducted to determine if the difference in the means of two variables is statistically significant) was used to compare coral cover between reserve and non-reserve sites. Results of the analysis likewise did not indicate a significant difference between the two sites. This result may be explained by the occurrence of higher coral cover in some transect sites within each reef, particularly on the reef slope at depths of 10-12 meters. Corals along the reef crest have relatively poor cover.

More than 90 species of hard corals belonging to 46 genera were identified in the six reef stations inside the bay. The reef area of the marine reserve exhibited the highest coral diversity with 80 species, followed by the Danao (59 species) and Bato (48 species) reefs. Although the Tinago reef is characterized by good live coral cover, its diversity is low (42 species) as it is dominated by branching types (e.g *Porites sp.*) that tend to spread quickly across the benthos.

Comparison with Other MPAs

Estimates of live coral cover in the Baliangao marine reserve and the reefs outside it are comparable with data from other MPAs in the Philippines, such as in Caw-oy, Olango Island, Cebu, with 48% hard coral cover inside the marine reserve and 32% in reefs outside (Sotto et al. 2002). Coral cover inside the Gilutungan Marine Sanctuary in Cordova, Cebu is 48.5% while that in adjacent areas is 40.6% (Deguit and Morales 2002). Coral cover inside the fish sanctuary of Santa Cruz Island, Zamboanga City, is much higher at 58% and lower (40%) in other areas of the island. In Apo Island, central Philippines, where one of the earliest marine reserves was established in 1982, coral cover increased from 68% (1983) to 77.5% in 1995 (Reboton 2002). In contrast, coral cover in non-reserve areas exhibited a slight decrease between 1983 (49.8%) and 1993 (40.3%). Data on live coral cover of the Sumilon Island Reserve in the Visayas (the first in the Philippines) (Russ & Alcala 1998) shows a steady increase from 30.2% (1985) to 55.8% (1993).

Coral diversity of 92 species in the fringing reefs of Danao Bay is much lower than in Danjugan Island marine reserve in Negros Occidental with 236 species belonging to 72 genera (Dacles et al. 2002), but it is more diverse than Santa Cruz Island marine sanctuary (24 genera) (Lasola et al. 2002).

Changes in Coral Community Structure

A significant impact of a marine reserve establishment is that it allows protection of the habitat from further damage by human-related causes; it induces changes in the coral community structure, and improves habitat quality. Intact habitats support higher biodiversity by providing feeding and breeding areas for fish and invertebrates. An assessment of the area inside and outside the marine sanctuary, conducted by Pipuli in 1997, reported 11 families of hard corals and four families of soft corals inside the sanctuary (Fraser 2003). The results of the present study indicate a great deal of improvement in coral diversity (92 species) and quality of coral reef habitats both inside the reserve (47% live coral cover or LCC) and outside it (37% LCC).

There have been reports of rampant blast fishing in the bay even after the establishment of the sanctuary in 1991. If so, this would account for much of the damage in the reefs outside the reserve, such as in Danao, Bato and Tugas reefs (32-41% dead coral cover). The occurrence of rubble in the deeper reef area inside the reserve is evidence of either these blast fishing activities or damage from storm surges prevalent in the bay during the northeast monsoon. Fishermen are positive that since dynamite fishing has been completely banned in the bay since 1998, any present loss of coral cover can be attributed to biophysical rather than anthropogenic stress. Since most fishermen use paddle boats, they have little use for anchors and thus, it would be incorrect to attribute the large amount of coral rubble to anchor damage. Only a single specimen of the predatory sea star *Acanthaster plancii,* was encountered in the area and thus predation can be ruled out as a factor.

Some fishermen who double up as sanctuary guards declare that coral cover was higher in earlier years, but a bleaching event caused by the El Niño phenomenon has reduced coral cover. In a compiled report on the mass bleaching event on coral reefs caused by the 1997-1998 El Niño, Wilkinson (1998) cited a bleaching event in Danao Bay, as reported by Pipuli researchers, that caused the death of several species of hard corals and the rotting of soft corals. No statistics were provided. Nevertheless, this information provides an awareness of the existence of a richer coral community before 1997.

Data generated in this study and several studies indicate the beneficial effects of establishing marine reserves in improving the conditions of coastal ecosystems. Live coral cover in one transect site in the reef slope of the Baliangao reserve was more than 79% in May 2001. Although a full analysis of variance (ANOVA) indicates that coral cover in the reserve and non-reserve areas are not statistically different, other results of this study suggest that the Baliangao marine sanctuary exhibits positive impacts of protection, not only of the reserve but of coral reefs in surrounding areas. Findings of this study show that a large proportion of live coral in the reefs (22-56%) is composed of branching corals, which are fast-growing and recover from damage much quicker than massive forms. Since 1998, resource management efforts have been expanded to cover the rest of the bay around the sanctuary, after the Pipuli Foundation launched the community-based coastal resource management (CB-CRM) program for Danao Bay. Presently dynamite fishing is non-existent in the bay following a massive campaign to ban it permanently. The coral communities outside the sanctuary recovered once the threat of explosive fishing was removed. Similar observations were made in Sumilon Island reserve in the Visayas, where the coral communities inside the reserve regained their original cover after 10 years.

3.1.3 Fish Communities

Associated fish communities in the coral reefs form the bulk of coastal fishery resources. All the fishermen in Danao Bay exploit these coastal resources in a variety of ways typical of artisanal and marginal fishing industries. A major purpose of scuba diving activities in this research is to evaluate the status of fish communities associated with coral reefs. Apart from coral cover, this parameter is an important indicator of the impact of an MPA and its ability to improve fish communities in outside reefs.

Diversity

A total of 325 species of reef and reef-associated fish belonging to more than 35 families were identified in the different reef stations within the year (2001-2002) in Danao Bay. The fish communities in the Baliangao marine reserve are more diverse (246 species) than in the reefs outside (Table 2). However, the variation in species richness between these areas is not significant. Results of a fish census conducted in July 2002 showed that more species of fish (182) were found across four reef stations outside the reserve than in the two sites inside the protected area (159). This difference could be an effect of scale more than it is an actual increase in diversity. Average values across reef sites and survey periods indicate that species diversity of fish in the reserve (102 species) is higher than that in the unprotected reefs (72 species). Of particular interest is the occurrence of a high diversity of fish (about 199 species.) found inside the small (five-ha area) sanctuary core or lagoon, representing more than 60% of the total fish community of the whole reef system. This result indicates the importance of the sanctuary core area in providing shelter to a wide variety of organisms in Danao Bay.

Of these reef fishes, the food species most abundantly caught by various fishing gears are the rabbitfishes or siganids, mojarras, goatfishes, emperors, parrotfishes and snappers. Fish diversity is much higher inside the core area where protection is at a maximum level compared with the other sites. Noteworthy is the large number of acanthurids, labrids and pomacentrids. In all stations, the most diverse families are of the smaller fishes such as wrasses and damselfishes (Fig. 4). ANOVA estimations on the number of fish species did not reveal significant variations in fish diversity among the reef sites.

A comparison of fish diversity among different diving periods, however, showed a significantly lower diversity during the October 2001 survey (170 species) than in the May 2001 (209 species) and July 2002 (227 species) survey periods (Fig. 5). This is partly attributed to the absence of data from Bato station, where an attempted dive in October was aborted because of the occurrence of a sudden storm while diving was in progress. Most species of fish observed in Bato were found in other stations, with very few unique species in between; thus the absence of data from Bato does not fully explain the low diversity in October. The number of species of major families (e.g. Acanthuridae, Labridae and Scaridae) in other reef stations also decreased in October. Many fishermen suggested that many fishes are retained near-shore at the height of the northeast monsoon when wave energy is extremely high along the reef crest. This argument is indeed tempting to adopt, particularly since diversity and abundance of reef fishes were much higher during the July 2002 (SW monsoon) census. However, judging by the data of a single point in time is not safe in assuming that diversity has in fact decreased in the reef areas as a result of seasonal effects. Other factors may have contributed to this apparent anomaly. Poor underwater visibility could have affected the accuracy of the visual census, thus underestimating fish diversity and abundance. Strong undertow and turbulence may have also driven some territorial fish to reef crevices.

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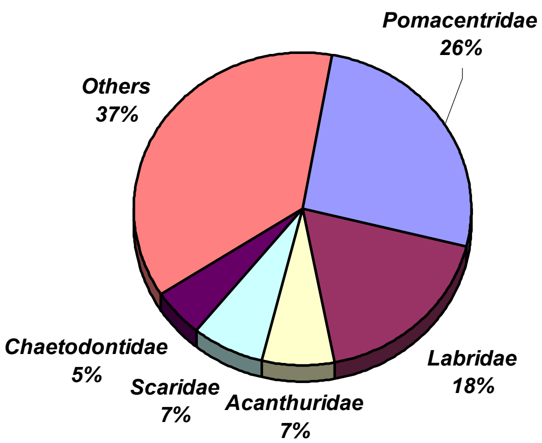


Fig. 4. Most diverse coral reef fish groups in Danao Bay

Despite its limitations, this study indicates higher species diversity in the reefs of Danao Bay as compared to the years following the establishment of the marine reserve. The earliest resource surveys in the Baliangao marine reserve were conducted by Silliman University in 1993, 1994, and 1995 (Heinen & Laranjo, 1996) but on a limited number of parameters (Table 3). Species richness and number of fish steadily increased in the three years. The 1997 assessment by Pipuli reported 77 species of fish under 25 families inside the reserve. Abundance of these fishes was higher inside (453 fish/400m^2) than outside (193 fish/400m^2) the reserve. These values suggest that fish populations inside the reserve and adjacent areas have increased over the years since 1995. The high biodiversity of corals and fish observed today is convincing evidence that the protection of coastal ecosystems bring about significant positive changes in habitat and resource quality. The presence of rare species on the reefs can be a positive indicator of build-up of diversity, either by entry of new species from surrounding areas, or a return of previous expatriate or emigrant species.

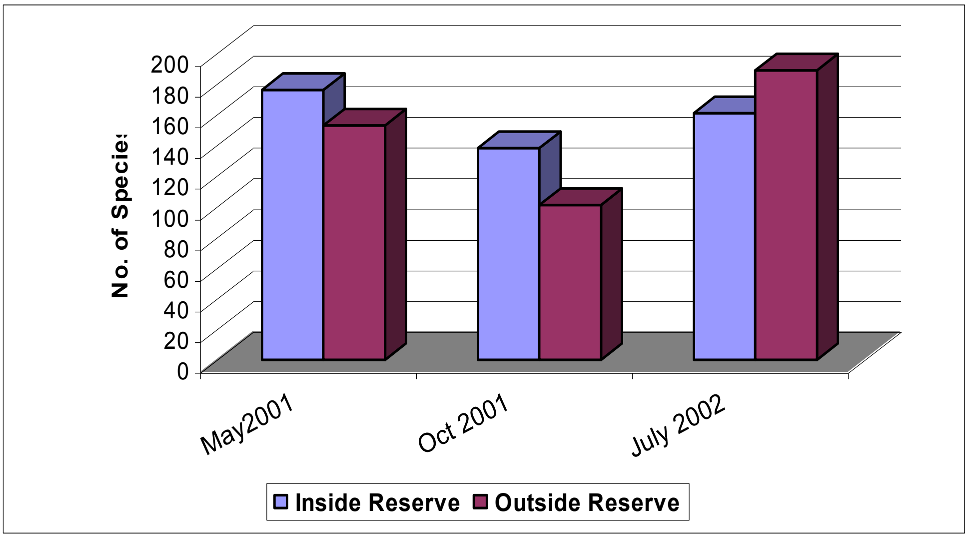


Fig. 5. Time-series comparison of fish species richness in the coral reefs of Danao Bay

Table 3. Data on fish and benthic populations in the Baliangao marine reserve, based on surveys conducted by the Silliman University Marine Laboratory

Parameter	1993	1994	1995
Number of fish species	48	75	85
No. of individuals per 400 m^2	364	617	692
Body length (cm)	3-15	2-36	No data
Number of invertebrate macrofauna species	28	48	74

Source: Heinen & Laranjo, 1996

Fish diversity (325 species) in Danao Bay is lower than in other diverse reef systems such as Tubbataha Reefs (Palawan) and Bolinao reef system (Pangasinan). However, it is much higher than those reported in the reserves of Danjugan Island (229 species), Nogas Island (167 species) and Guimaras Island (155 species in January 2001; 202 species in June 2001) (Campos et al. 2002).

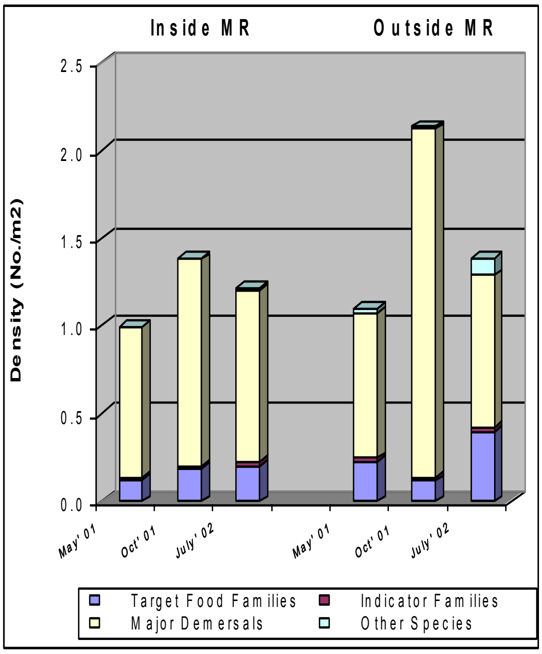
During the early part of this research, it was observed that many of the fish species that compose the catch of major gears such as fish corral, spears and fish pots were more seagrass-associated rather than reef-associated. In particular, such species comprise much of the diverse species composition of fish corral catches. Results of the visual census on seagrass beds show a fairly diverse fish community with a total of 59 species belonging to 27 families. Although diversity is comparable to some reefs in the bay, the population levels are low. Most of the fish are small in size (<10 cm), while larger fishes (>20cm) are quite rare. Some juvenile fishes of herring and anchovy were intercepted along the transect. While some fish such as *Siganus fuscescens, S. guttatus* (siganids)*, Leptoscarus vaigiensis* (seagrass parrotfish) and *Cheilio inermis* (cigar wrasse) are generally considered seagrass-dependent, about 40% are also found in coral reefs within the bay. This is hardly surprising, as Danao Bay is a complex structure of contiguous habitats, and with seagrass flats diffusing into the reef crest at many points within the bay. These results would explain why a mixture of reef and seagrass-associated fish dominate the catch of many gears operating in near-shore areas.

Abundance and Biomass

A time-series comparison of population densities of reef fishes showed no consistent spatial pattern of abundance of the various family groups inside and outside of the reserve across time periods. ANOVA analyses indicated no significant differences in fish abundance among reef sites and monitoring periods, although overall population density was much higher in October 2001 in the reefs outside the reserve (Fig. 6). This apparent anomaly is attributed to the abundance of small demersal fish, particularly damselfishes (family Pomacentridae) in the Tugas and Tinago reefs (Table 4). Small pomacentrids are consistently the most abundant resident in reef environments. Overall population densities in both reserve and non-reserve areas are extremely low (less than 2 fish/m^2) compared with other marine reserves in the country such as the Sumilon Island reserve (36 fish/m^2 in 1983) (Alcala 1988).

The higher abundance of target food species in reefs outside the reserve runs contrary to the expected higher abundance of fish inside it. The unique basin-like topography of the sanctuary core makes it a natural refuge for large predator families. The time of day and tidal level are likely to have influenced the results of the surveys conducted inside the sanctuary core area. Fishermen observe that fish aggregations move out of the reserve at high tides to feed in nearby reef and seagrass meadows. Research monitoring may have coincided with these movements. Snorkeling surveys conducted at low tides revealed that a higher number of large predatory fish occurred inside the core area than at the time of the visual census conducted during high tides. Several aggregations of tiny recruits (of undetermined species) occurred inside the sanctuary core, but these were not intercepted by the transect survey. Results of fish population surveys also show a high similarity (55-65%) in dominant species (top 20) compositions across monitoring periods. Although abundant, most of these fishes are small (<15 cm) and are common herbivores or omnivores. Target food species or larger predators, with the exception of the fusilier *Caesio caerulaurea* and surgeonfish *Naso thynnoides*, are absent.

Spatial differences in fish biomass are more apparent, with significantly higher values for target species, indicator families and major demersal groups inside the reserve ($p<0.005$) than outside across different time periods (Fig. 6; Appendix 2). Biomass, however, did not seem to vary much over time ($p>0.05$). High biomass estimates (mean of 36.2 g/m^2) inside the sanctuary core area, despite the low population density, suggest that fish inside this strictly protected zone are much bigger. Schools of emperors (Lethrinidae) and snappers (Lutjanidae) with mean lengths of 25-30 cm are found inside the sanctuary core. Large surgeon fishes (Acanthuridae) and sweetlips (Haemulidae) also abound inside, although only a few were encountered along the transect. Biomass is also high in Tinago, but this is attributed to high population densities (mean >1.9 $fish/m^2$) rather than large sizes at this station.



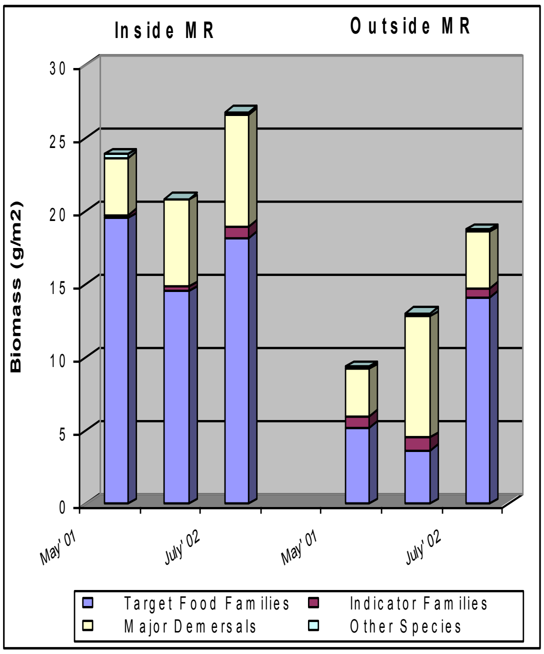


Fig.6.Time-series companies of abundance and biomass of fish groups in reefs inside and outside the marine reserve.

Average biomass (17.4 g/m^2) of target families in the three survey periods inside the reserve is more than double the mean biomass (7.7 g/m^2) outside. Results of studies conducted in Philippine marine reserves corroborate the results of this study. Long-term monitoring of the Sumilon Island marine reserve in central Philippines showed that overall fish biomass inside the reserve was twice the biomass in fished areas (Roberts & Polunin 1993). Of more significance is the observation that biomass of large predators was between 6 to 31 times more than on the fishing ground.

The pioneering work of Russ & Alcala (1996) on investigation of biomass export from the Apo Island marine reserve indicated that the density of large predators in reefs outside of the reserve steadily increased with the duration of reserve protection. Their results agree with the hypothesis that as fish density builds up in the reserve over time, some fish moved from the reserve to the surrounding fishing ground, leading to positive correlation between fish abundance and years of reserve protection.

Biomass of important food fishes in the reefs of Danao Bay amounts to a total of 16.85 g/m^2 (reserve and non-reserve areas), which converts to about 17 tonnes per km^2 of harvestable biomass, the target of the artisanal fishery in the bay. Biomass of all fish in all stations amounts to a mean standing stock of 25 t/km^2. This value is relatively low compared with stock biomass of other MPAs, such as Santa Cruz Island (73.9 t/km^2) and Nogas Island, Antique (89.1 t/km^2) (Campos, et al. 2002), but fall within the range reported from Danjugan Island (35–75 t/km^2) and island reserves in Southern Guimaras (21.0–52.9 t/km^2).

Table 4. Time-series comparison of abundance (no. of fish/500m^2) of major fish groups in Danao Bay

	Inside MR			Outside MR		
CATEGORY/FAMILY	**May-01**	**Oct-01**	**Jul-02**	**May-01**	**Oct-01**	**Jul-02**
Acanthuridae	13	29	39	34	15	68
Serranidae (Anthiinae)	21	7	6	53	21	4
Haemulidae	3	1	2	0	0	69
Scaridae	5	7	13	14	13	18
Lethrinidae	11	9	9	0	0	0
Caesionidae	2	22	7	0	0	1
Pomacentridae	332	405	432	333	749	311
Labridae	18	17	23	74	235	32
Total	392	487	522	508	1033	504
Other Families	106	205	88	40	35	123
TOTAL	**498**	**692**	**609**	**548**	**1067**	**626**

Fish Movements

Visual observations of fish movements in and out of the sanctuary core area were made as an exploratory method of determining the frequency with which fish moved out of the reserve into areas where they can be fished. A number of fish corrals occur in adjacent areas very close to the lagoon core of the sanctuary, with gillnets commonly deployed right outside the bamboo boundary. The concept of biomass spillover from protected marine areas rests upon the natural tendency of fish to move in and out of an arbitrary boundary separating an MPA from the fished areas. Once outside the protected zone, fish become vulnerable to various fishing gears deployed around the reserve. The concentration of fishing effort along the boundary of marine reserves is a worldwide phenomenon (Walters et al. 1998). Fishing effort tends to pile up at the boundary in response to local increases in fish availability, presumably as a result of biomass export.

Snorkeling surveys reveal that many of the large adult fish populations inside the lagoon or core area frequently move out of the boundary. Five-minute observations show that some of them go back immediately while others swim out as far as 10-15 meters. This observation indicates the potential spillover of adult fish biomass to surrounding areas where they are intercepted by any one gear waiting outside. Although it is difficult to prove that the fish caught by fishers outside of the boundary are the same fish that move out of the reserve, it is not difficult to assume that this is so, particularly if the species compositions and size ranges are very similar. Among the species observed moving out at high frequencies were emperors (*Lethrinus harak*), snappers *(Lutjanus species*), rabbitfishes *(Siganus fuscescens* and *S. guttatus*) and goatfishes *(Parupeneus barberinus* and *P. indicus).* Surgeonfishes and parrotfishes were abundant inside but were not observed to move out despite their ability to swim fast. Approximately 12% of the fish observed show a potential for biomass export into unprotected areas adjacent to the marine reserve (Appendix 3).

Although the visual method of observing fish movement is exploratory, it nonetheless shows potential for obtaining data on local fish migrations to support the spillover concept from reserves where more direct methods such as tagging fish cannot be used. Observations on the distances traveled by adult fish can be used in designing an MPA, such as the size of buffer zones to establish around the protected area. A curious attribute of the Baliangao MPA is the establishment of a 25-ha buffer zone running along one side of the sanctuary while the other side is not buffered. The resource management council (RMC) of Danao Bay explained that this design was the product of consultation with fishermen, who agreed to keep the other side open, as it was a traditional location for fish corrals. As a result, fish corrals and gillnets are deployed very close to the reserve boundary on the buffer-less side. This situation increases the vulnerability of foraging fish moving in and out frequently to being fished as soon as they are out of the boundary.

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3.2 The Coastal Fishery of Danao Bay

The coastal fishery adjacent to the Baliangao marine reserve can be described as a multi-species resource system that supports the economic needs of the coastal populace. Danao Bay is a small bay with an estimated area of 20 km^2 and with a reef area of about 0.5 km^2 which supports a heavy fishing industry. A total of 430 fishermen are involved in the coastal fishery in either full-time (260) or part-time (170) capacity. This number converts to a fisher density of about 22 fishers per km^2 of the bay, and would be even higher if these fishers were to concentrate fishing activities along the narrow fringing reef. The fishery is primarily artisanal and largely confined to the municipal waters of the bay. There exists, therefore, a scenario of a small coastal fishery being subjected to intense fishing pressure. The following analysis will determine the current state of a coastal fishery in Mindanao and evaluate the effectiveness of the community-managed MPA in sustaining the fishery.

3.2.1 Profile on Fishing Effort

In 1996, more than 1,000 resource users were identified in Danao Bay, of which about 400 were classified as full-time and part-time fishers (Heinen and Laranjo 1996; Heinen, 2003) and the rest, a host of reef gleaners and other resource users. In addition, about 167 fishers were identified as non-residents of the bay and have been dubbed as 'strikers' (Heinen and Laranjo 1996). Field enumerators of this research helped compile an updated list of fishers in each barangay (Table 5). A total of 430 fishers, of which 260 full-timers and 170 part-timers, currently 'employed' in the municipal fishing industry of Danao Bay. The highest number (102) comes from Bato, while Danao has the lowest number of fishers. Turnover rate is reportedly higher in Danao, where many drop fishing for more lucrative economic activities out of town. However, others soon join as part-time fishers, many with very little skills. With the help of enumerators, an attempt was made to identify and determine the number of 'strikers', but only 13, who come from neighboring barangay Usukan, were identified. Responses of fishermen as to the number of outsiders they have observed vary widely. Most of them say that the number is much smaller (<20) than in past years. These fishers are usually identified by their motorized fishing vessels. However, many of these vessels that enter the bay are just passing through to get to the fishing grounds outside the bay. The banning of trammel nets ("triply") and a modified drive-in net ("lampornas") in the bay may have discouraged many of these 'strikers' who prefer to continue fishing with such gears elsewhere than use less efficient ones.

Many fishermen in Bato double up as farmers, and prefer to work in rice fields during the northeast monsoon months rather than risk fishing in turbulent seas. A large number of fishermen in Bato use hook and line gear and normally fish along reef crests. In fact, many of these fishermen were working on rice fields in May to help in the harvest, and again during the planting season between December and January. Changes in fishing effort at other stations were small, with some turnover attributed to the death of a few fishers and the migration of younger men to other places, although this was easily compensated by the entry of fishermen's children. One of the goals of the community-based coastal resource management program in Danao Bay is to regulate fishing effort, particularly to control entry of fishermen from other areas. The local government of Baliangao started a licensing system for fishermen in the year 2000 in an effort to control fishing, but this has not been fully implemented, nor sustained. Instead of decreasing, there are now even more fishers than before. Bay-wide community management efforts do not seem to have been successful in regulating fishing activities in the fishery.

Table 5. Estimates of total number of fishermen in the six fishing villages of Danao Bay

Village	Full-time Fishers	Part-time Fishers	Total
Tugas	33	36	69
Misom	36	15	51
Landing	33	42	75
Sinian	62	32	94
Bato	74	28	102
Danao	22	17	39
Total	260	170	430

Source: This study, January 2002.

The municipal fishery in Danao Bay involves a diverse fishing gear technology, with at least six major gear types, some of which have been modified according to mode of operation and the target fish catch (Table 6). Gillnets are either drift gillnets or bottom-set ones, and hook-and-lines are either single, multiple or long-line. Various modifications of bamboo fish traps exist, such as fish traps ("paligid"), crab pots ("panggal"), and eel traps ("bokatot"), and other ingenious technologies.

The present number of fish corrals (50) is far smaller than mentioned in a Pipuli report (Heinen & Laranjo 1996), where a total of 82 fish corrals were deployed. Fish corrals have an average lifespan of two years, and many of those deployed years ago, in

1996-1998, would have long been dilapidated and removed, and some were not replaced. Fishers also tend to move their corrals every few months, particularly when catch in the same site is very poor.

Table 6. Inventory of fishing gears and methods used by fishers of Danao Bay

GEARS/METHODS	**FISHING VILLAGES**						**TOTAL**
	Tugas	Misom	Landing	Sinian	Bato	Danao	
Fish Corral (*Bungsod)*	24	17	5	1	1	2	50
Gill Net *(Pukot)*	20	5	30	10	8	23	96
Single Hook and Line (*Pasol)*	2	8	13	18	45	2	88
Multiple Hook/Line (*Palangre)*	1	2		2	2	2	9
Fish Pots (*Bubo; Paligid; Bocatot)*	4	8	2	22	5	3	44
Spear Gun *(Pana)*	10	1	19	26	5	5	66
Scissor Net *("Trawl")*					2		2
Beach Seine (*Baling)*					1		1
Other gears and minor implements	8	10	6	15	33	2	74
Total	69	51	75	94	102	39	430

Note: * Values refer to the number of fishers using such gears and methods.

Fishers in the different villages along Danao Bay seem to prefer some gears over other types, although many use a combination of gears presumably to increase their daily catch. Fish corrals are preferred by fishers from Misom and Tugas, while the majority of Bato fishers use single hook-and-line and a modified hook specifically for squid ("ankla"). Most gillnets are operated by fishers from Danao and Landing, while most spearfishers come from Sinian (Fig.3; Table 6).

3.2.2 Economics of the Coastal Fishery

Annual Fish Production and Catch-per-unit-effort

Landed fish catch from the bay by a total of 259 fishermen from the six coastal barangays were monitored daily by local enumerators. Total recorded catch amounted to 49.3 t/yr, with an overall daily average of 64.5 kg/day. The total annual fish catch, obtained by raising / extrapolating recorded catch to the total number of fishermen in the bay, amounted to 285.7 tonnes (Table 7). Dividing this number by the total bay water area (2000 ha or 20 km^2) results in an annual fish yield of 14.28 $t/km^2/yr$. Several reports over the last twenty years of marine reserve protection suggest that Apo Island, one of the first marine reserves in the Philippines, can sustain high reef yields of 15 to 30 $t/km^2/yr$ (Alcala 2001). The latest 2000 survey (Maypa et al. 2002) in Apo Island reported total reef and reef-associated fish yields of 19.23 $t/km^2/yr$. Sumilon Island (Southern Cebu) was also reported to yield fish between 14 and 37 t/km^2/yr (White & Trinidad 1998). The estimated fish yield in Danao Bay just approaches the lower limit of Apo Island's and Sumilon Island's reef yields. However, it is higher than reef yields of Selinog Island, Pamilacan Island and Bolinao Reef (White & Trinidad 1998).

Table 7. Estimated total fish catch (kg) from Danao Bay obtained by raising recorded catches to the total number of fishermen in each coastal village (March 2001 to February 2002)

Village	**March 2001**	**April**	**May**	**June**	**July**	**August**
Tugas	3995.65	1790.25	2136.14	4443.38	3551.90	4527.42
Misom	6670.33	12427.13	5384.52	5014.09	3101.03	3136.05
Landing	7866.22	2604.67	4299.30	4928.13	4030.08	3486.56
Sinian	4163.78	2755.90	4903.07	6735.81	8573.44	8286.97
Bato	3100.11	3340.28	3540.92	3505.37	2852.54	2753.88
Danao	2592.56	935.76	1813.31	3316.38	4572.52	3818.51
Total	**28388.64**	**23854.00**	**22077.26**	**27943.16**	**26681.51**	**26009.40**
	Sept	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**
Tugas	4274.46	3996.41	4803.44	4367.90	2332.49	2994.47
Misom	3403.43	3337.88	3185.56	4510.70	3590.93	2765.52
Landing	4972.81	4531.74	3489.62	6004.03	3915.88	3987.49
Sinian	9851.84	6252.74	6378.40	5863.78	5998.69	6803.81
Bato	1855.70	1930.27	2542.90	644.41	1411.49	2501.52
Danao	2078.28	2173.97	1330.12	731.90	656.42	1250.19
Total	**26436.52**	**22223.00**	**21730.03**	**22122.71**	**17905.90**	**20302.98**

Total Annual Catch (tons)	**285.68**
Total Annual Production (tons/km2/yr)	**14.28**

Daily catches in each station ranged widely from March 2001 to February 2002 (Fig. 7), and showed an increasing trend from May to September 2001, followed by a progressive decline toward January 2002, with a slight increase in February 2002. Patterns in daily fish catch coincided with the monsoon-induced changes in fishing effort. The northeast monsoon ("amihan") occurs in Danao Bay from December to April, while the southwest monsoon ("habagat") occurs from May to November (Heinen & Laranjo 1996). Fishermen observe a short interim period of calm seas between April and May during which fishing beyond the reef is common. Surprisingly, average daily fish production in these months is lower than in March, which can be attributed to lower catch-per-unit-effort (CPUE) in some stations such as Tugas, Bato and Danao (Fig. 8). Many fishermen from Bato worked on rice farms during this period, which coincided with the harvest. In Danao, a number of fishers shifted to gathering of milkfish fry mainly along the river mouth.

Higher catch from June to September coincided with the calmer SW monsoon, while decline in total catch from October to January may be attributed to the rougher seas during the northeast (NE) monsoon, during which fishing along the reef crest is difficult and perilous. Fishermen agree that fish yields in Danao Bay follow this general pattern.

Many fishermen in the bay are involved in daytime and nighttime spear fishing, and hook-and-line fishing, usually along reef crests and slopes during the southwest monsoon ("habagat") when the sea is calm. Strong wind and wave action during the NE monsoon between December and April render such fishing activities perilous, thus there tends to be a shift in fishing effort towards inshore waters, such as reef flats and river areas. This pattern has also been observed to be consistent over the years in Apo Island (Maypa et al. 2002).

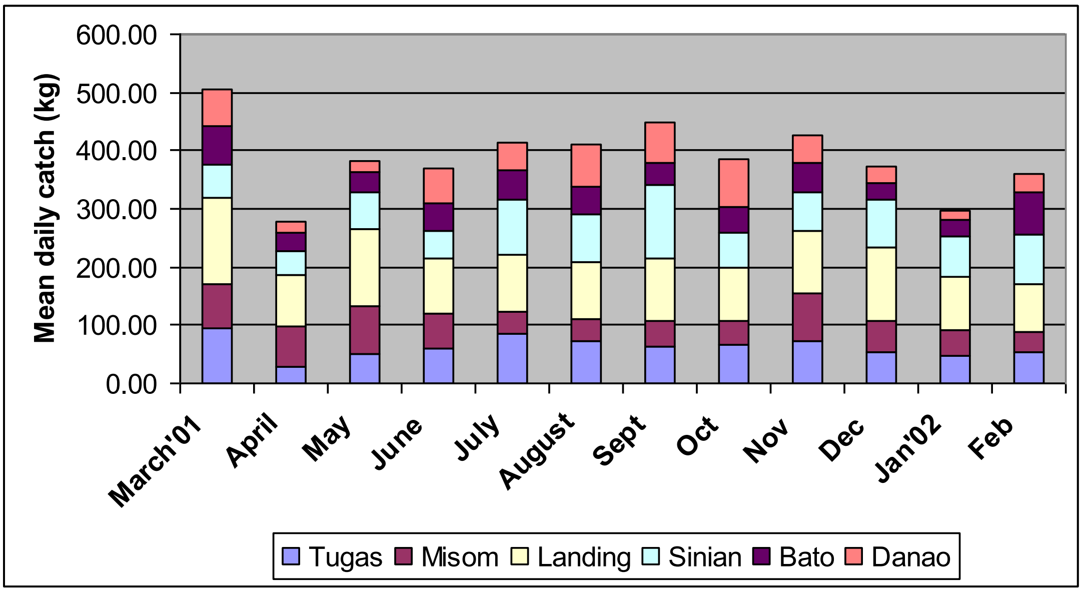


Fig. 7. Monthly profile of daily fish catch using various gears

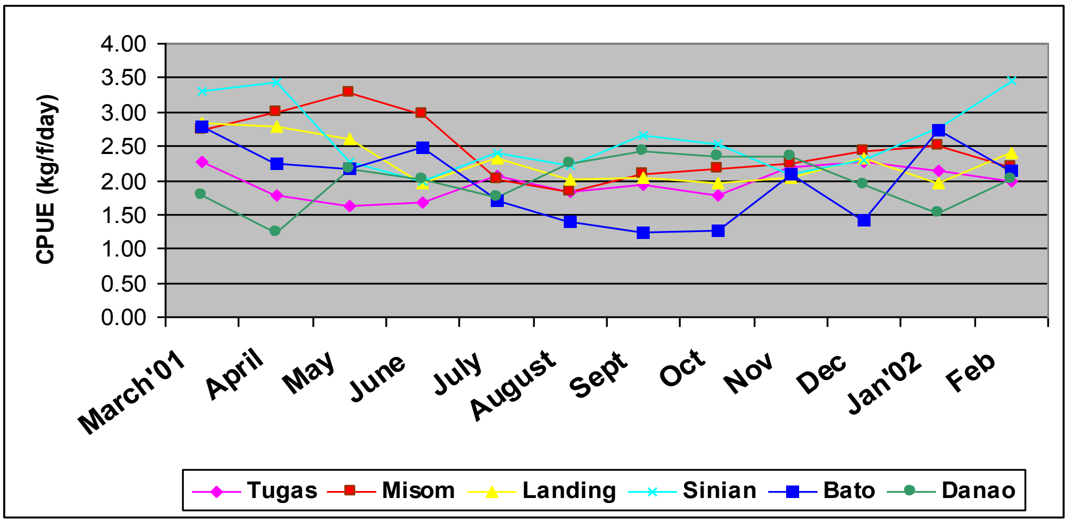


Fig. 8. Trends in CPUE profiles of fishermen in Danao Bay

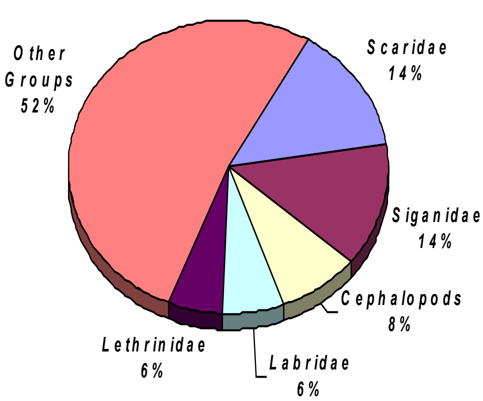
Average CPUE (kg/fisher/day) values, on the other hand, are not so variable (Fig. 8), with a few outliers (values that fall outside of a range) for example, high values in Sinian in April 2001 and February 2002 and low values in Danao in April 2001. These outliers resulted from having recorded only a few fishermen with widely divergent catch. The widest range in mean CPUE values each month was observed in Bato (1.25-2.80 kg/f/d) while the narrowest gap in daily catch was observed in Tugas (1.63-2.28 kg/f/d). On average, Danao Bay fishers had a daily CPUE of 2.26 kg/f/d (Table 8).

Table 8. Comparison of CPUE estimates of fishermen in the six coastal villages of Danao Bay waters surrounding the marine reserve (Mar 2001 – Feb 2002)

Fishing Village	No. of Fishers	AVERAGE CPUE (kg/fisher/day)					
		March	**April**	**May**	**June**	**July**	**August**
Tugas	48	2.26	1.78	1.63	1.67	2.06	1.84
Misom	24	2.73	2.99	3.27	2.98	2.02	1.83
Landing	55	2.84	2.79	2.60	1.95	2.33	2.02
Sinian	51	3.30	3.43	2.27	1.99	2.40	2.21
Bato	40	2.80	2.25	2.18	2.47	1.71	1.40
Danao	41	1.77	1.25	2.18	2.01	1.76	2.24
Total	**259**	**15.70**	**14.49**	**14.13**	**13.07**	**12.28**	**11.54**
Mean		**2.62**	**2.42**	**2.36**	**2.18**	**2.05**	**1.92**
	Sept	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**MEAN**
Tugas	1.93	1.79	2.19	2.28	2.14	1.98	1.87
Misom	2.09	2.16	2.25	2.42	2.51	2.20	2.64
Landing	2.05	1.95	2.03	2.31	1.97	2.41	2.42
Sinian	2.67	2.52	2.10	2.29	2.77	3.45	2.60
Bato	1.25	1.27	2.09	1.41	2.73	2.15	2.14
Danao	2.43	2.36	2.36	1.94	1.51	2.02	1.87
Total	**12.42**	**12.05**	**13.02**	**12.65**	**13.63**	**14.21**	
Mean	**2.07**	**2.01**	**2.17**	**2.11**	**2.27**	**2.37**	**2.26**

Catch Rates and Catch Composition of Fishing Gears

Fish corrals contributed to the biggest proportion (30.6%) of landed catch from Danao Bay in 2001-2002, followed by gillnets (23.5%) (Fig. 9). A large portion of fish corral catch comes from Misom and Tugas, where most of this gear is concentrated (Table 9). Monthly corral catch tends to be higher during the storm months of November and December (Fig. 10). Fishers have observed that many fish species tend to move to the calmer waters inwards of the reef during the NE monsoon, and eventually find their way into the traps.



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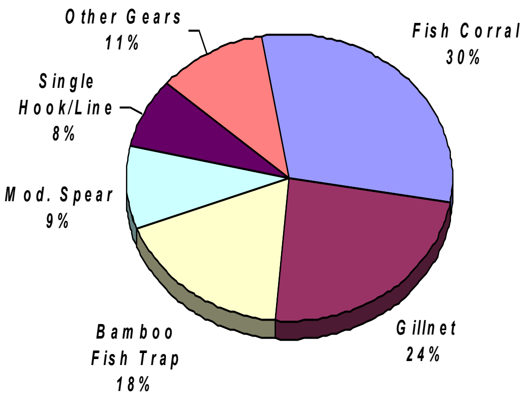


B

Fig 9. Most abundantly caught fish groups (A) and contribution of major fishing gears to total landed catch in Danao Bay (B)

Table 9. Municipal catch profile by gear type in Danao Bay between March 2001 and February 2002

GEAR TYPE	STATION						TOTAL	%
	Tugas	Misom	Landing	Sinian	Bato	Danao		
Fish Corral	3720.50	8985.25	1491.60	95.40	275.10	514.25	15082.10	30.57
Gillnet	1997.59	2015.65	4022.10	501.10	485.26	2579.60	11,601.30	23.52
Bamboo Fish Traps/pots (5 kinds)	807.85	3852.76	151.70	4025.50			8837.81	17.92
Modified Spear	1095.20	692.52	640.75	1129.52	51.15	1032.32	4641.46	9.41
Handlines								
Single H/L	160.00	445.65	1062.48	500.70	1553.29	137.30	3859.42	7.82
Modified SH/L			15.45	314.00	1377.25	235.78	1942.48	3.94
Longline	328.40			27.40			355.80	0.72
Multiple H/L	18.45		185.52		31.55	4.69	240.21	0.49
Other methods	345.32	392.86	1272.97	443.90	283.15	32.85	2771.05	5.62
Total Recorded Catch (kg)	**8473.31**	**16384.69**	**8842.57**	**7037.52**	**4056.75**	**4536.79**	**49331.63**	**100.00**

Notes: H/L stands for 'hook and line'.
SH/L stands for 'single hook and line'.

Another interesting observation by many fishers is the tendency for fish corral catch to increase when the water is turbid, especially following heavy rains. This result is consistent with the observation made by Heinen (1998) of higher catch of fish corral during the NE monsoon.

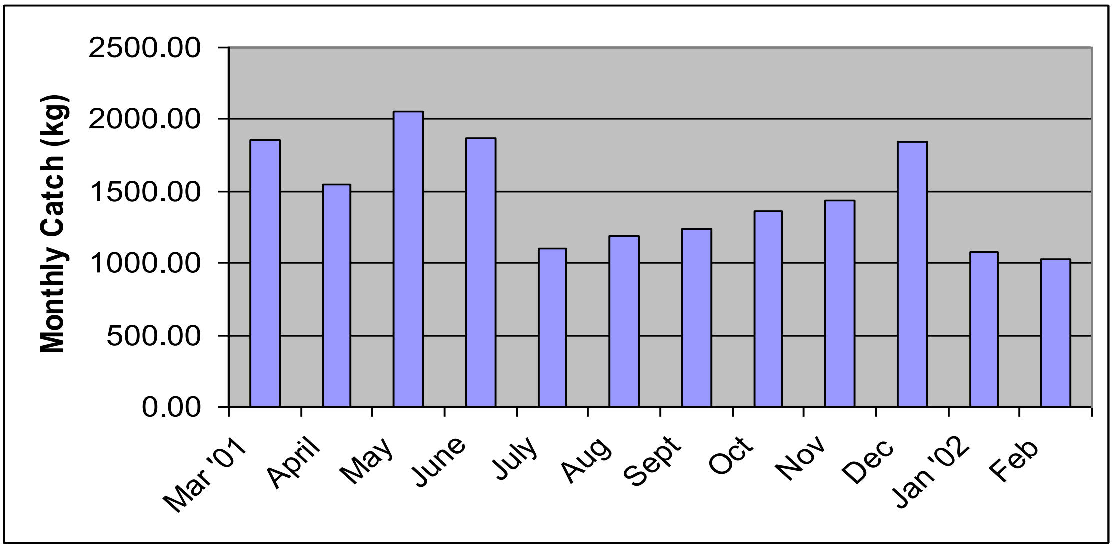


Fig. 10. Monthly profile of fish catches of fish corrals in Danao Bay (March 2001 to February 2002)

Of the major gear types operating outside the marine reserve in Danao Bay, gillnets exhibit the largest mean catch-per-unit-effort rate or CPUE (4.79 kg/unit/day) values, followed by bamboo fish traps (2.31 kg/unit/day) and fish corrals (2.29 kg/unit/day). Spear fishing, various types of handlines and other minor implements output lower CPUE values (Table 10).

Table 10. Catch-per-unit-effort (kg/unit/day) of various fishing gears used in the coastal fisheries of Danao Bay

	STATION						
GEAR TYPE	**Tugas**	**Misom**	**Landing**	**Sinian**	**Bato**	**Danao**	**MEAN**
Fish Corral (Bungsod)	1.65	2.35	2.36	1.49	3.04	2.85	2.29
Gill net (Pukot)	6.15	2.78	3.34	9.39	3.75	3.30	4.79
Bamboo traps (Panggal,etc.)	2.94	2.75	1.54	1.925	2.42	2.3	2.31
Modified Spear (Pana)	2.46	2.26	1.98	1.96	1.34	2.81	2.14
Handlines							
Single H/L (Pasol)	1.85	1.71	1.46	1.39	1.81	1.96	1.70
Modified SH/L (Angkla)			1.98	1.71	1.34	1.91	1.74
Single H/L (Labyog)	0.83			0.83			0.83
Multiple H/L (Palangre)	0.90			1.82	1.65	1.43	1.45
Modified H/L (Pataw)	1.37						1.37
Minor gears/methods (10 kinds)	2.18		1.28	1.79	1.89	7.53	2.93

Note: Local names of gears in parentheses.

The shallow seagrass beds and reef flats of Misom and Tugas are traditionally preferred locations for fish corrals. However, many gear owners who live in Tugas deploy their stationary gears in Misom. The presence of the marine reserve project in Misom acts like a magnet for fishers who rush to obtain rights to establish their fishing gear as close to the sanctuary as possible. The Municipal Ordinance No.1 series of 1995 had set a minimum distance of 25 meters from the sanctuary boundary for deployment of stationary fishing gears. Two units of fish corral owned by different fishermen, however, were found to be deployed very close (less than 10 meters away) to the elliptical lagoon designated as the sanctuary core area where large adult fish are most abundant. Less prominent and therefore, more difficult to monitor are gillnets often operated at night along the sanctuary's periphery.

A total of 154 species of fish and invertebrates comprised the catch of various fishing gears operating in Danao Bay between 2001 and 2002 (Table 11). The top 30 species comprised 68.9% of the catch, and the other 124 species formed the remaining 31.1%. The most abundant fish caught was the brownish parrotfish, locally called "molmol" (8.9%), followed closely by the common rabbitfish *Siganus fuscescens*, a seagrass herbivore locally called "danggit" (8.5%). Historically, the wide seagrass ecosystems in Baliangao were associated with abundant catch of "danggit", and its close relative "kitong" (*Siganus guttatus*). In the 1980's, catches of rabbitfish comprised about one-half the total catch of all gears and species, but in 1997 "danggit" catches comprised only about one-fourth of the landed fish (Heinen 1998). Observations of the decreasing relative abundance of the rabbitfish as early as the 1980s led to the imposition of a ban in 1988 on all fishing activities for two days each month, purportedly to protect the spawning stock of this fish (Heinen & Laranjo 1996). This two-day prohibition period, which continues to be implemented in Danao Bay at the present time, begins on the third day after the new moon and ends on the fifth day in order to allow completion of the spawning activity.

Unfortunately, enforcement of the fishing prohibition is controlled by the municipal Mayor, who has authority to suspend it under certain circumstances, such as a town fiesta, tax payments, and market days coinciding with the ban (Heinen & Laranjo 1996). Such wide latitude in implementation has made for an uneven application of this fisheries management measure, which does not seem to have a positive impact on the fishery resources of Danao Bay. In the late 1990's, a low recruitment (i.e. birth of new individuals into the population) of this siganid was observed. Very few juvenile fish were found in catches of fish corrals and other nets (Heinen & Fraser 2001). There were indications that recruitment overfishing (overharvesting of large reproducing fish or spawners) had occurred in the siganid fishery of the bay.

Although this fish ranked second in abundance in 2001-2002 (Table 11), its relative abundance during the first quarter (March to May 2001) decreased to less than a tenth of the landed catch by all gear types by the third quarter (September to November 2001) of the assessment. A quarterly profile of species abundance revealed that the rabbitfish was the top species caught between March and May 2001, but slid to third and eighth place in the second and third quarters, respectively. It climbed up to second rank during the last quarter of the study (December 2001 to February 2002), indicating a seasonal pattern that is possibly associated with the northeast monsoon. The proportions of important food species such as the spotted emperor, *Lethrinus harak* ("katambak"); the gold-spotted rabbitfish *Siganus guttatus ("*kitong"*);* and the squid, *Sepioteuthis lessoniana* ("nokos"), in the catches were low. The usual sizes of the common rabbitfish (7–16 cm) caught by most gears were smaller than the theoretical maximum size of 40 cm, even specimens reaching 18–20 cm were very rare. Between August and October 2001, this researcher observed large quantities of juvenile siganids sold in the market of nearby town, Calamba. Fish vendors declared that they came from Baliangao, particularly from the western Murcielagos Bay. A fish monitoring survey recorded an abundance of juvenile siganids in the catches of fish corrals in Tugas and Misom between December 2001 and January 2002. About the same time, juveniles of this fish were sold in the local market of Baliangao.

Table 11. Most abundantly caught species of fish in Danao Bay between March 2001 and February 2002.

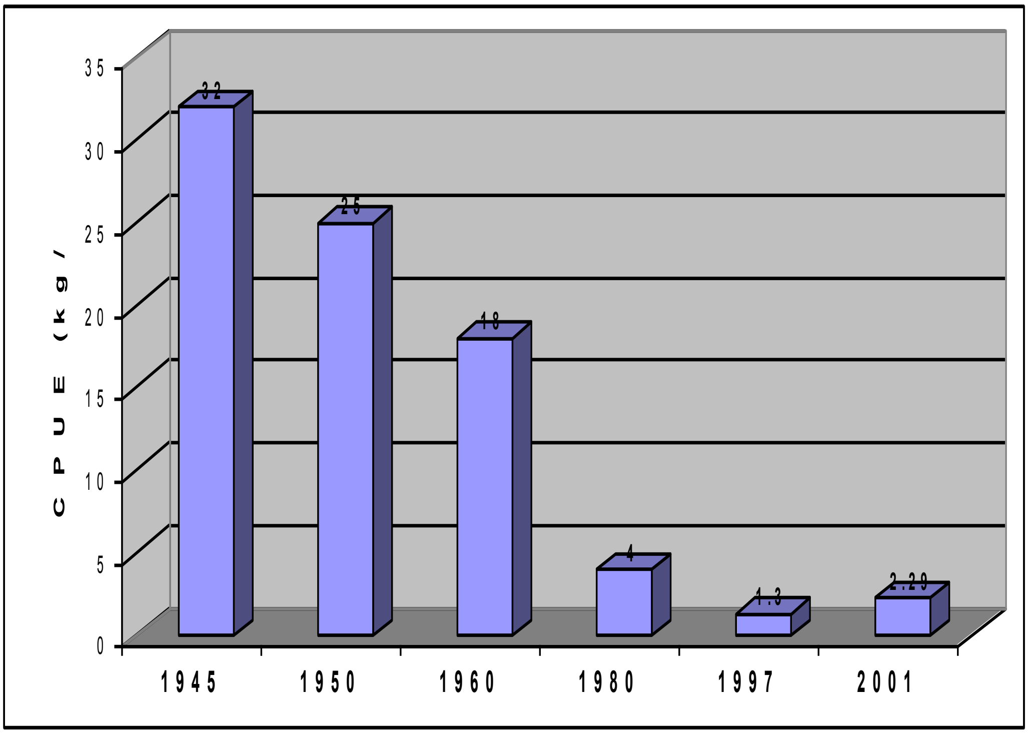
	Local Name	Scientific Name	Common English Name	Family or Group	Total Recorded Catch	Percent (%)
1	Molmol	*Scarus spp.*	Brownish Parrotfish	Scaridae	4,425.98	8.97
2	Danggit	*Siganus fuscescens*	Dusky Rabbitfish	Siganidae	4,214.02	8.54
3	Katambak	*Lethrinus harak; lentjan*	Emperor	Lethrinidae	2,590.99	5.25
4	Bogalbog	*Leptoscarus vaigiensis*	Seagrass Parrotfish	Scaridae	2,499.20	5.07
5	Barawan	*Loligo sp.*	Common Arrow Squid	Cephalopoda	2,383.35	4.83
6	Kitong	*Siganus guttatus*	Golden Spot Rabbitfish	Siganidae	2,144.16	4.35
7	Samolok	*Gerres oyena*	Spotted Mojarra	Gerreidae	1,918.00	3.89
8	Labayan	*Anampses;Halichoeres*	Seagrass Wrass	Labridae	1,804.96	3.66
9	Balakasi	*Gymnothorax spp*	Moral Eel	Muraenidae	1,292.30	2.62
10	Bonog	*Unidentified fish*	Seagrass Goby	Gobiidae	1,264.95	2.56
11	Bun-ak	*Scarus spp.*	Greenish Parrotfish	Scaridae	1,221.00	2.48
12	Talad	*Cheilio inermis*	Cigar Wrasse	Labridae	1,060.53	2.15
13	Nokos	*Sepioteuthis lessoniana*	Broad-finned Squid	Cephalopoda	1,020.61	2.07
14	Ibis	*Apogon spp*	Cardinal Fish	Apogonidae	842.95	1.71
15	Lambay	*Portunus sp.*	Pelagic Crab	Portunidae	816.10	1.65
16	Banak	*Mugil spp*	Common Mullet	Mugilidae	790.65	1.60
17	Kogita	*Octopus spp*	Reef Flat Octopus	Cephalopoda	574.04	1.16
18	Olang	*Metapenaeus spp.*	Penaeid Shrimp	Penaeidae	477.55	0.97
19	Timbongan	*Parupeneus barberinus*	Dash-dot Goatfish	Mullidae	477.05	0.97
20	Ngisi 2x	*Siganus spinus*	Sribbled Rabbitfish	Siganidae	399.75	0.81
21	Langis	*Naso spp*	Unicornfish	Acanthuridae	226.30	0.46
22	Dugso	*Lethrinus olivaceus*	Long-faced Emperor	Lethrinidae	194.45	0.39
23	Balo	*Hemiramphus sp.*	Halfbeak	Hemiramphidae	193.85	0.39
24	Lagaw	*Nemipterus sp.*	Lined Sea Bream	Nemipteridae	193.49	0.39
25	Alimango	*Scylla spp.*	Mudrab	Portunidae	188.10	0.38
26	Ipos-ipos	*Cheilinus spp*	Coral Wrass	Labridae	174.60	0.35
27	Bangsi	*Cyselurus spp*	Flying Fish	Exocoetidae	161.30	0.33
28	Sulong	*Scolopsis lineatus*	Spinecheek	Nemipteridae	153.95	0.31
29	Kubotan	*Sepia spp.*	Cuttlefish	Cephalopoda	149.25	0.30
30	Malubgas	*Stolephorus sp.*	Anchovy	Engraulidae	141.20	0.29
	Subtotal				33,994.63	68.91
	Other Species				15,336.99	31.09
	TOTAL CATCH				**49,331.63**	**100.00**

The catch composition of landed fish in 2001-2002 indicates the increased dominance of small, poor quality fish catch which suggests that species replacements are taking place, a common phenomenon in highly exploited municipal fisheries. From Table 11, it can be noted that at least six species of small, low value fish make up about 14% of the total catch of the top 30 species. High-value, large predatory fishes are being replaced by small, low-value species that occur lower in the food chain. At least three kinds of fish are not the usual targets of coastal fishery effort. Tiny cardinal fishes are a common by-catch of fish corrals and bottom-set gillnets. Although unappealing as food to some people, the fishermen in Danao Bay consume this fish. Moreover, fishermen seldom throw away the by-catch of their gears, as these provide ready food for the table while the better quality fish are sold. The common seagrass goby ("bonog") and moray eel ("balakasi") seem to be the target species of bamboo traps ("paligid", "bokatot" and "sugong") in Misom. Although fishermen occasionally land a good catch of these fishes, revenue earned from them is small as the fish are sold cheap at PhP15-20/kg.

Many fishing gears employed in the coastal fishery catch a large assortment of fish species. Siganids, mojarras, wrasses and emperors most commonly comprise the catch of fish corrals, gillnets, spears and hook-and-lines, although size ranges may vary. Fish caught by corrals are usually smaller in size compared to those of the same species caught by spear fishing or hook-and-line. Fish corrals usually use nets with fine mesh (#12 or <2 cm mesh opening). As early as 1997, community managers realized that fish corrals remove very small fish, and this led the Pipuli Foundation and DB-REMO to encourage fishers to replace their nets with coarser mesh (#8 or 3 cm mesh size) in order to increase the size range of fish, and hence monetary value of the catch. However, the absence of a legal basis for bay-wide implementation has not encouraged fishers to shift. They continue to use corrals to catch the small, less valuable fish low on the food chain. This worsens the overfishing scenario by removing prey populations that support larger predators.

The undesirable fishing practice of using fine-meshed nets further indicates that fishery regulations are not effectively implemented in Danao Bay and neighboring fishing grounds. Some fish corral owners admitted that they have no option but to harvest the juvenile siganid that are mixed with other fish species inside the collection chamber of the corral. A clear case of biological or growth overfishing occurs in the bay, that is, when fishing removes post-recruits or juvenile fish of very small biomass so they can no longer contribute to fish production. On a positive note, however, such observations suggest that siganid recruitment in these waters is once again on the rise following its supposed failure in past years. Notwithstanding this, if such fishing practice persists, the very important siganid fishery in Danao Bay and contiguous waters would soon be on the brink of collapse.

Empirical data on the coastal fishery of Danao Bay is meager, but is supplemented by information generated through workshops and a very detailed resource-users survey conducted by the Pipuli Foundation in 1998 (Heinen 2003). Through a participatory method known as 'focus group discussion', older fishermen helped construct a fishery history for fish corrals and invertebrate production in the bay. However, much of the information available is qualitative rather than quantitative. Figure 11 shows that catches of fish corrals had undergone a sharp decline from 32 kg/day in 1945 to a mean catch of only 1.31 kg/day in 1997. The latter value is a result of a participatory research conducted in 1997 by Pipuli staff (Heinen 1998) and fishermen to monitor catches of fish corrals. Data on fish corral catches averaged over the six fishing villages indicated a slight increase in daily catch rates from 1.3 kg/day in 1997 to 2.29 kg/day in 2001-2002. Results of the *in-situ* monitoring of fish corrals conducted in this study, however, present a much lower catch rate of 1.26 kg/day. This estimate is probably biased toward the minimum value since it is based on only a few fish corrals sampled for two days each month.



Source: Heinen & laranjo, 1996; Heinen, 2003

Fig. 11. Trend of average daily catch of fish corrals in Danao Bay from 1945 to 2001 - 2002

Average CPUE of 2.29 kg/day obtained in the present study suggests that fish corral catch may be improving slightly; possibly as a result of bay-wide fishery management efforts. It is also possible to attribute this improvement to the increased availability of juvenile and adult fish, presumably from improved recruitment resulting from protection of the spawning stock in the sanctuary. Visual surveys inside the sanctuary core found that large adult (and reproductive) siganids, emperors and snappers, commonly represented in fish corral catches, were abundant here. Fish of the same species caught by fish corrals, gillnets and fish traps were often small juvenile and sub-adult fish. Siganids and emperors were observed to be highly mobile and tended to move out of the sanctuary at high frequency, and are therefore, the most likely to spill over into fished areas outside the reserve.

Fishing Revenues, Costs and Income

An important component of an economic evaluation of a fishery is an identification of revenues and costs associated with fishing from which estimates of fishermen's income may be obtained. Larger-sized fish are valued higher than smaller ones of the same species. These prices range from PhP 15/kg for tiny, less palatable fish (e.g. cardinalfishes and squirrelfishes), to PhP 60/kg or PhP 80/kg for large commercially important food species (e.g. emperors, jacks, siganids and squid). The calculation of revenues based on variable prices for different kinds of fish resulted in larger monetary values than previous estimates using average prices.

Estimates of daily gross revenues earned by fishermen showed wide variations among individuals, even those using the same gear. Gross daily revenues are a function of the amount of catch and its corresponding value or price per unit weight. However, gross income is not an indicator of the amount of profit, which is the monetary value left after costs of capital and all operation costs have been deducted. This is the amount that accrues to the fisherman and which indicates if fishing still earns him a viable livelihood.

Annual gross revenues from fishing were calculated for each fisherman – the mean values for each gear type are presented in Table 12, together with total fishing (capital and operational) costs obtained from the fishing cost survey. Capital costs had been amortized according to the life or longevity of the capital asset (boat or gear). Since the nature of the municipal fishery in Danao Bay is largely artisanal, very few fishers share boats or gears. Sharing arrangements between fishing operators and crew, if any, are neither clear nor consistent. In many instances, the catch is small, and the operators and crew simply divide up the catch prior to selling. The boat and gear owner normally purchases the fuel in the case of motorized boats and occasionally brings the food (often only rice) for the fishing trip. Estimates of daily gross revenues reflect the fisherman's share of the catch. Thus in calculating net income, it is assumed that the gear owner is fishing alone, and that he captures all and any profits from fishing. Results on handline fishing were classified according to boat type, since total operating costs of motorized (5-16 HP) boats are much higher than non-motorized "bancas" or paddle boats.

Differential Profitability of Gears

Estimates of gross revenues and net incomes (Table 12) suggest that some gear types are more profitable than others. Differential profitability of gears appears to be a function of catch per effort and fishing costs. Gillnets, fish corrals and handlines obtained the highest gross annual revenues. Fishers who fish using paddle boats (non-motorized canoes ("bancas") earn positive net annual incomes, while those on motorized boats do not seem to earn any profit at all owing to large fishing costs. Estimates of net incomes by gear type show that fish corrals, bamboo fish traps and gillnets using non-motorized boats derive small profits from fishing. Spear fishing at night, and motorized gillnet and hand-line operations are obviously unprofitable. Negative net incomes exhibited by motorized boats in the sample are the result of high capital and fuel costs, and since CPUE values are generally low (mean of 2.26 kg/day), gross revenues are also small. Negative values indicate that the fishing activity is not profitable to the fishers.

Average monthly incomes of all gears and fishing villages, ranging from PhP 300 to PhP 2000, are way below the poverty threshold for rural communities. This indicates that fishermen are still earning very little profit from the fishery, in spite of the establishment of a protected area and the eradication of destructive fishing practices from the bay. It should be noted that fishing effort remains high and the number of fishers, still unregulated even after years of management intervention. Entry of new fishers into the fishery continues, although many of them are part-time fishers, which drives CPUE values and consequently, net incomes, even lower.

Table 12. Comparison of estimated average fisher incomes (in PhP) among fishing villages and types of fishing gear

STATION	NO. OF FISHERS	BOAT TYPE	TOTAL FISHING COSTS	ANNUAL GROSS REVENUES	ANNUAL NET INCOME	MONTHLY INCOME
Tugas	19	Non-motorized	23276.50	25787.85	2511.35	209.28
	1	Motorized	35800.00	18854.16	-16945.84	-1412.15
Misom	18	Non-motorized	20950.46	24464.68	3514.22	292.85
Landing	23	Non-motorized	24117.37	23341.13	-776.25	-64.69
Sinian	18	Non-motorized	16360.55	18090.94	1730.38	144.20
Bato	21	Non-motorized	26438.08	29064.93	2626.85	218.90
Danao	10	Non-motorized	23779.85	29777.96	5998.11	499.84
	9	Motorized	52858.92	44495.43	-8363.49	-696.96
	119					

GEAR/BOAT TYPE	NO. OF FISHERS	PERIOD OF GEAR OPERATION	TOTAL FISHING COSTS	ANNUAL GROSS REVENUES	ANNUAL NET INCOME	MONTHLY INCOME
Fish Corrals	23	Day	13509.79	19725.98	6216.19	518.02
Bamboo fish traps	12	Day	17190.89	22746.83	5555.94	463.00
Spears	17	Night	21004.63	20855.15	-149.48	-12.46
Gill nets (NMB)	28	Day	29472.11	30679.71	1207.60	100.63
Gill nets (MB)	6	Day/Night	51804.47	44560.85	-7243.62	-603.63
Handlines (NMB)	26	Day	24418.16	24882.07	463.90	38.66
Handlines (MB)	7	Night	41574.60	44518.59	-7350.55	-612.55
	119					

Note: Gillnets and handlines are operated by either non-motorized boats (NMB) or motorized boats (MB).

An examination of the catch composition of major gears reveal similarity in species dominance of most gear types and also similar selling prices and thus, the monetary value of each unit of catch. Hook and line fishing, however, commonly catch high-value fish such as the squid *Loligo* (“barawan”), a pelagic species of seasonal abundance in the bay, particularly in the months April to June. Handline fishing is the most dominant fishing activity of fishermen from Bato, and is often conducted beyond the reef crest where aggregations of this squid and a species of threadfin bream, *Nemipterus sp.* occur. Exceptionally large catches of the long-nosed emperor *Lethrinus olivaceus* (“dugso”) have also been recorded in Bato in the month of February. However, due to the lack of biological data on these organisms, it cannot be ascertained if these are spawning aggregations, or the fish are simply feeding along the reef slopes. Various modifications of the bamboo fish trap target specific kinds of fish, such as moray eels, goby, and different kinds of mangrove crabs.

Selectivity for larger fish can result in differential profitability of certain gears over other types, since larger fish are valued higher in the market. On the other hand, certain high-quality species, such as squid, and cuttlefish, caught by multi-species fish corrals, are valued much more than others despite their smaller size. Spear fishing is probably the most selective gear since it allows the fisher to discriminate among the different kinds and sizes of fish on the reef. Species composition of spear catch, however, reveal that most fishers are do not discriminate at all, and spear even low value fish such as common wrasses, small octopus and parrotfishes. One possible explanation is that spear fishing is limited to shallow parts of the reef, where the kinds of fish available are of low value. The fisherman compensates for this by maximizing his efforts and gathering as much of the small fish as possible, instead of looking for better quality fish. Another possible reason is that spear fishing is most commonly done at night, thus incurring costs of kerosene or alcohol for lamps, and it would be more profitable to concentrate one's efforts within a limited area.

The coastal fishery of Danao Bay is more complex than expected of a small fishery. Many fishermen operate a combination of gears to increase catch within a fishing day. The most common combinations are different kinds of hook and line, gillnets, spear fishing and fish traps. From monthly summaries of daily catch data, it can be observed that several fishermen shift from one fishing gear to another within the year. Fishers declare that some shifts are periodic, and such shifts were observed when Bato fishermen shifted *en masse* from simple hook and line ("pasol") to a modified type ("ankla") from May to September 2001 in order to exploit the squid ("barawan") resources beyond the reef slopes, and some Danao fishermen shifted to milkfish fry gathering using scissor or push nets between May and June 2001.

Perhaps of more importance is the apparent permanent shift of some fishermen from capital-intensive gear such as fish corrals to cheaper bamboo traps in Tugas and Misom, and spear fishing in Sinian. One fisherman who owned the fish corral nearest to the sanctuary core area decided, in January 2002, to shift to fish trap ("panggal") fishing. Of all the fish corral owners in both Tugas and Misom, he was the only one who consistently recorded very low catches and daily revenues of <PhP 100. This researcher personally interviewed him and accepted his testimony of unprofitable fishing with fish corral which was corroborated by his neighbors. Catch data from his new gear, unfortunately, had yet to show a perceptible improvement in CPUE at the end of this study, but data from other fishers using this gear shows that "panggal" can earn as much as an average of PhP 200 a day.

This shifting behavior of fishermen with regard to specific gears may be a natural consequence of trying to get out of an economic activity that has become unprofitable, and the observation that other fishers are earning better from other methods. This phenomenon could also be interpreted as a positive response to the availability of fish resources that allows shifts toward more profitable fishing methods. It is very likely that the presence of the sanctuary has contributed to the continued availability of fish through recruitment and biomass export. Fish visual census on the reefs at three different periods within the period 2001-2002 consistently demonstrated the co-occurrence of small and large fish of the same species inside the reserve.

The presence of large stocks of adult or spawning biomass inside the sanctuary core not observed elsewhere in the vicinity can be a sound basis for concluding that the coastal fishery would be worse off in the absence of the reserve. Without this protected source of fish recruits, the harvestable biomass of fished areas in the bay would have dissipated long ago due to the sustained high levels of fishing effort that have persisted in spite of fishery management restrictions imposed. Large predatory fish are the target of every open-access fishery, and without the sanctuary, it is very likely that these resources would have been fished out.

Fishery Resource Rent

A final step in the economic analysis of the coastal fishery of Danao Bay is the determination of economic rent from fishery resources. Derivation of total annual net operating values for each gear show a range of estimates, including zero and negative values for motorized operation of gillnets and handline fishing, respectively. Calculated net annual values (NAV) in Table 13 are considered as the producer's surplus (Trinidad et al. 1993; Gustavson 1999), a profit over costs, which accrues to the gear owner. It also represents the annual value of contribution of the marine ecosystem (coral reefs, seagrass and mangroves) to the municipal fishery of the bay. Summing-up the NAV for all gears results in a range of values for total NAV, with a midpoint of PhP 104,317.12 (at 10% discount rate). This sum indicates the amount of fishery rent generated by the bay's fishery resources.

It may be noted in Table 13 that NAV values for all fishing gears, with the exception of fish corrals, include negative and zero values. The largest negative values were obtained from gillnet and handline fishing. In fact, motorized handline operation did not obtain positive values at all, indicating that these fishing activities were not profitable. Most of these fishermen come from barangay Danao, known for having most of the capital intensive boats and gears, and also the highest dependence on fishing as a major form of livelihood (Heinen 2003). The high costs of fuel and the inclusion of the cost of family labor in the estimates of total operational costs have driven down the NAV estimates of most gears. Average CPUE value for gillnets (4.79 kg/f/day) is higher than for other gears, however, the number of crew involved in the fishing operation increases the total costs of operation through increased labor cost.

Positive midpoints of total NAVs, however, indicate that some fishery rent is being earned, although it is probably below the rent that would be earned if the fishery were managed efficiently. Fish corrals appear to be the most profitable gear, although the annual rent they earn is quite small. This differential profitability can act as an incentive for other fishers to invest in this gear; however, this would increase gear density and thus fishing pressure on the resource. The deployment of more stationary gears which take up much of the shallow fishing ground, would also exclude artisanal gears such as spears and smaller traps. Moreover, an increase in the number of efficient gears can drive CPUE values, and consequently gear profits lower. An important consideration in fishery management is the carrying capacity of the bay to support various types and numbers of fishing gears.

The present study has identified a number of indications that the coastal fishery surrounding the marine reserve in Danao Bay could be on a transition towards becoming a viable, sustainable industry. Present mean CPUE values from fish corrals show a reversal of the downward trend experienced by this fishery from 1945 to 1997 (Fig.11). Results of cost-returns analyses of the fishery show that stationary gears, namely traps and fish corrals, capture most of the fishery rent. Capital-intensive boats and gears (namely, motorized gillnets) obtained negative operating values, not generating any rent at all (Table 13). If spear fishing were conducted during the day, the net values would be greater than from night time operations, based on the findings of Gustavson (1999) who obtained the largest net values and NPVs from spear fishing than from any other gear in a Jamaican fishery.

Table 13. Estimates of "true" net annual values and net present values (in PhP) of the municipal fishery of Danao Bay, derived from net operating values and equivalent annual capital costs

Type of Fishing Gear	Number Of Owners	Total Annual Net Operating Values	DR = 0.05	Net Annual Values DR = 0.10	DR = 0.15
Fish Corrals	23	2045.08 to 44,334.40	1728.93 to 43701.40	1412.78 to 43068.40	1097.10 to 42436.35
Gillnets (Non-Motor.)	31	-18,045.28 to 29,219.64	-18213.78 to 28994.69	-18382.28 to 28769.74	-18550.53 to 28545.13
Gillnets (Motorized)	7	-22,330.00 to 63,677.84	-23661 to 39486.84	-24992 to 37975.84	-26321 to 36467.11
Bamboo Fish traps	12	-146.72 to 40,997.84	-279.72 to 27,946.00	-412.72 to 27756.00	-545.52 to 27566.28
Spears	17	-8,978.00 to 27,270.80	-9199.75 to 27100.80	-9421.50 to 26930.80	-9642.92 to 26761.05
Handlines (Non-Motor)	26	-14,766.32 to 18,990.00	-14879.32 to 18783.25	-14992.32 to 18666.50	-15105.15 to 18549.93
Handlines (Motorized)	3	-28,843.84 to -13,565.84	-29876.09 to -14490.84	-30908.34 to -15415.84	-31939.04 to -16339.45
Total	119	n/a			
	Total Net Annual Value		-62368.36 to 502,214.18	-64693.36 to 493,813.18	-67014.87 to 485,424.78
		Midpoint	109,053.62	104,317.12	99,587.72
	Net Present Value		-1247367.20 to 10,044,283.00	-646933.60 to 4,938,131.80	-446765.83 3,236,165.17
		Midpoint	2,181,072.31	1,043,171.16	663,918.11

Notes: (1) A sensitivity analysis derived values for different discount rates.
(2) DR = discount rate

The net present value (at 10% DR) of the fishery rent has a mean of PhP 1.04 million, but can reach as much as PhP 5.0 million in the best fishing scenario. The latter represents the maximum rent that can be earned by the fishery in perpetuity, assuming that the present level of resource exploitation in the bay is sustainable. The NPV values indicate that the coastal fishery of Danao Bay is generating modest economic profits for municipal fishers. On the other hand, Danao Bay is presently still an open access system. Community-led efforts in resource management do not seem to have helped in regulating the entry of new fishers. There are too many part-time fishers who could find gainful employment in alternative forms of livelihood. The continued participation of non-resident fishers in the bay's fishery implies the dissipation of some of the fishery rent, while making fishery monitoring even more difficult. Improved fishery management through fishing and gear regulation would increase the amount of economic rent for resident fishers. This management intervention must be complemented by other strategies, such as stock enhancement and the provision of alternative livelihood for fishers who do not enjoy profits from the fishery.

3.3 Enhancement of the Coastal Fishery

From foregoing discussions, the crucial question to ask here is whether spillover of fish biomass from the MPA in Baliangao has occurred. Results of this study provide a number of indicators, as listed below, that the implementation of the marine reserve has contributed to the enhancement of the coastal fishery of Danao Bay.

a) Improvement in the ecological conditions of the bay's ecosystem over time, namely, improved live coral cover and mangrove diversity has led to increase in fish diversity and population size, and relatively high fish biomass inside the reserve and nearby reefs.

b) Differential profitability of gears. Certain fishing gears operating in Danao Bay, such as fish corrals and bamboo fish traps, are more profitable than others either because of the relative abundance of high value fish species or reduced fishing costs and capital.

c) The increase in CPUE for certain gears e.g. fish corrals which showed an increase in CPUE from 1.3 kg/day in 1997 to 2.29 kg/day. Some fishers have claimed increased catch from other gears namely, spears and fish traps, since the establishment of the marine reserve.

d) Large aggregations of big adult (spawning) stock and juvenile populations of important food fishes area (e.g. emperors, siganids and snappers) inside the small (~5 ha) sanctuary are most likely the abundant source of young fish caught by various gears outside the reserve.

That a spillover of biomass from the MPA to surrounding fished areas has really occurred cannot be proven definitively given the limited data. The one-year study conducted allows only a snapshot view of the dynamics of this fishery. Even advocates of the MPA admit that spillover of benefits from a protected area cannot be easily demonstrated within a short period of time. Some important lessons can, however, be learned from the experience of fishery scientists.

Periodic investigations of fish populations in the Apo Island marine reserve have been conducted by Silliman University and collaborators since its establishment in 1982 (Alcala 1999). Evidence is accumulating that the marine reserve is enhancing the fisheries in adjacent areas through the export of adult (post-settlement recruits) fish biomass from the "no-take" reserve to fished areas. Russ and Alcala (1996) found that densities of large predatory coral reef fish (e.g. groupers, snappers, emperors and jacks) in areas closest to the reserve increased over time, but this effect only became obvious with data from 9 – 11 years from the time the reserve was established. Their results show a positive correlation between the years of protection and fish densities. There has been an increase in catch rates (particularly of hook and line) and in the sizes of fish caught by most gears. Moreover, the relative abundance of important families targeted by fishers has remained fairly constant over time, meaning the marine reserve has helped maintained population levels and yields of certain families (Acanthuridae and Carangidae) have even increased two-fold (Maypa et al. 2002).

The estimated total reef and reef-associated fish yield of Apo Island in 2000 was 19.23 t/km^2/yr, but earlier assessments have shown that fish production from the island can reach more than 31 t/km^2/yr. Results of the present study suggest that the coastal fishery of Danao Bay produces as much as 14.3 t/km^2/yr, which falls midway between the maximum yields recorded in the two older reserves; Apo Island and Sumilon Island (Table 14). Yield values from other marine reserves in the Philippines such as Selinog Island (6.0 t/km^2/yr), Pamilacan Island (10.7 t/km^2/yr) and San Salvador (14.0 t/km^2/yr) are lower than that from Danao Bay. This comparison would seem to indicate that the current fishery in Danao Bay is on a transition toward becoming a viable, sustainable industry characteristic of better-established tropical marine reserves.

Table 14. Time-series data on fish yields in Sumilon Island and Apo Island marine reserves from 1976-1985 and 1980-2000 respectively

Location	**Area of reef (per km^2)**	**Fish Yield (t/km^2/yr)**	**Year of Data Collection**
Sumilon Island	0.5	9.7	1976
		14.0	1977
		15.0	1978
		23.7	1979
		19.9	1980
		36.8	1983
		19.9	1985
Apo Island	1.5	11.4	1980
		31.8	1985
		24.9	1987
		19.3	2000

Sources: White and Trinidad 1998; Maypa et al 2002.

3.4 The Issue of Sustainability

Resource or fishery rent is an important indicator of the economic production attributable to the natural environment that supports resource use. The critical question to ask is whether or not such rent will be sustained in the years to come. This research has presented enough evidence to show that the coastal fishery is still open-access and in distress. The average CPUE remains low for most gears, and thus daily gross incomes remain small. High fishing costs of most gears result in too small or marginal profits. Many fishermen show a willingness to expand their fishing effort to offshore areas, but the lack of capital prevents them from exploring more productive areas. Another indicator of fishery distress is the increasing dominance of small, low value fish in the catches of various gears. On top of these economic and biological concerns, there is also the influence of exogenous factors as well as a host of management issues. The reef is subject to seasonal weather phenomena that induce typhoons which, in turn, cause massive damage to coral communities, jeopardizing habitat improvement.

Despite earlier efforts to broaden the scope of community involvement in fishery management, many fisherfolk remain unperturbed and indifferent. Enforcing marine reserve regulations has become the responsibility of a handful of DB-REMO organization members who started out as volunteers, but who now all receive token honoraria from foreign donors through the Pipuli Foundation. Problems of inefficient monitoring and enforcement of boundary regulations, continued poaching, allegations of collusion between poachers and sanctuary guards, and declining membership in people's (fishers' in this case) organizations (PO's) are just a few of the many challenges confronting the management of the MPA.

3.5 Impact of Community-Led Efforts on Coastal Fishery Management

The Baliangao Protected Landscape and Seascape (BPLS) and the entire Danao Bay system is presently one of the most popular and long-running community-based coastal management programs in Mindanao. A wide range of programs and management measures have been implemented in the area since the inception of the marine reserve project by the Pipuli Foundation in 1991.

The results of this study seem to indicate that the coastal fishery of Danao Bay is in a much better state than it was before the Baliangao marine reserve was established. Indications that the MPA has contributed to this improvement are provided by biological and economic data on the coastal ecosystem and fishery of the bay.

The role of MPAs in enhancing coastal fisheries, however, does not depend only on the ability of the marine reserve to export biomass to fished areas (i.e. the spillover effect), but also on its ability to inspire and rally community support and involvement in fishery management.

The establishment of the Baliangao marine sanctuary has led to the evolution of its management from NGO-led (Pipuli Foundation) efforts to a community-based, bay-wide coastal resource management. The primary goal of establishing the Misom Sea Sanctuary was to improve the fisheries of Baliangao and the whole of Danao Bay and to restore them to their former abundance. The introduction of the marine sanctuary project by Pipuli Foundation in Baliangao marked the birth of a new management regime that introduced a novel concept of giving prominence to local communities in managing the coastal fishery. Initial support for the project was poor, but slowly built up to the time when it was formally launched through a municipal resolution on July 31, 1991. In 1996, the Danao Bay CB-CRM program was implemented to cover a broader scope of stakeholders, based on the recognition that Danao Bay was a complex and integrated system whose management problems required an integrated solution. Strictly protecting an area of the bay would have very little impact unless fishery management measures were also implemented across the bay. At the time, blastfishing activities still took place, although much reduced, and highly efficient but destructive gears such as trammel nets ("triply") and drive-in nets ("lampornas") were operated freely. The main objective of the program was to unite the resource users around the goal of an improved management of Danao Bay, and to enable them to develop and implement resource management strategies that would lead to the rehabilitation of the bay's ecosystems, increase fish production and ensure a sustainable use of the bay's resources.

3.5.1 Institutions and Their Role in Fishery Management

Apart from the Pipuli Foundation as the forerunner of the resource management program in the bay, three other institutions, which have jurisdictional interests in the marine reserve project, exist. Their brief histories and roles in resource management are described below:

Danao Bay Resource Management Organization (DB-REMO)

The DB-REMO is a community management body formed in 1998 to undertake all future management programs after the Pipuli Foundation contract to assist communities in Danao Bay expired at the end of 2002. It is a federation of seven people's organizations from the six coastal villages all duly registered as legal entities with the Securities and Exchange Commission. A Resource Management Council (RMC) acts as both executive arm and secretariat of the DB-REMO. The organization maximizes community participation by ensuring community membership in several committees assigned specific tasks in resource management, such as law enforcement or "bantay dagat", advocacy and networking, participatory research, monitoring and evaluation, and generation of livelihood options. The mangrove reforestation initiatives of different organizations have resulted in a total of 37.44 ha of planted mangroves, between three and six feet tall in 2001 (Pipuli's DB-CBCRM Project Annual Report, 2001).

A major accomplishment of the DB-REMO RMC is the drafting of and lobbying for a special municipal ordinance declaring Danao Bay as a "special demarcated fisheries area", in line with the provisions of the new Philippine Fisheries Code (Republic Act 8550). This ordinance was passed in August 2002 (Municipal Ordinance No. 1 Series of 2002) and made DB-REMO a partner of the local government in implementing resource management programs in Danao Bay. Under this legislation, exclusive fishery rights are granted to duly registered municipal fisherfolk and fishing permits issued after they pay user fees. This is a bold move by the community organization towards achieving the goal of an exclusive fishing ground and is envisioned to further improve the fisheries of Danao Bay. Integrated into this ordinance are specific management measures that have been recommended by the RMC, to achieve sustainable fisheries.

The Protected Area Management Board (PAMB)

Under the Republic Act 7586, otherwise known as the National Integrated Protected Areas System (NIPAS) Act of 1992, a Protected Area Management Board (PAMB), responsible for major decisions on budget allocations, planning, protection and general administration of the protected area was created on October 4, 2001. The PAMB is a government-led management body with multi-sectoral membership and the Department of Environment and Natural Resources (DENR) acting as secretariat. It provides technical and administrative support to the BPLS through its Protected Area Supervising Unit (PASU), which is a coordinating unit of the PAMB. Since its inception, the PAMB has undertaken a number of activities, namely information campaigns, the launching of the BPLS as part of the World Wetland Day year celebration, training in deputation of the law enforcement group or "Bantay Kalikasan" for BPLS, repair of marine sanctuary fences and routine patrols of the MPA.

The PAMB also plans to map stationary gears operating in the area, review the marine sanctuary design and prepare a zonation plan. An initial funding of PhP 100,000 was allocated from the DENR General Fund to support early management activities. This amount will later be supplemented by revenue generated from the collection of user and entry fees. Under the NIPAS Act any income from user fees from the BPLS must go the Integrated Protected Area Fund (IPAF), from which 75% will be plowed back to the management of the protected area.

The Local Government Unit (LGU)

Danao Bay is under the political jurisdiction of two municipalities: Baliangao and Plaridel, although 90% of the area belongs to four barangays of Baliangao and the remaining area to two barangays in Plaridel. The Local Government Code of 1991 (RA 7160) mandates local government units with jurisdiction over a body of water to implement a coastal resource management program for the sustainable development of these waters. The most recent national legislation with direct impacts on coastal management is the New Fisheries Code (RA 8550 of 1998), which has expanded municipal waters from 7 km (stipulated in the old fisheries code or the Presidential Decree (PD) 704 of 1975) to 15 km, and also mandated community-based resource management in their area of jurisdiction. The New Fisheries Code legitimizes partnership between the LGU and community groups/NGOs in undertaking coastal resource management. Support of the Baliangao LGU for the coastal management program in Danao Bay may be categorized as legislative and administrative, including the provision of some funding support for the program. At least three municipal ordinances issued by the LGU of Baliangao have direct relevance to coastal resource management.

3.5.2 Community Support and Perceptions of the Marine Reserve Project

Semi-structured and key informant interviews provided information on community perceptions of, and the extent of fisher support for the reserve project. More than half (52%) of the respondents were members of a fisher-organization, while the rest (48%) were not. Among the people's organization members, 55.3% exhibited a high level of awareness of the goals and benefits of the project, while about 36.2% knew about the reserve project but were not aware of its economic and ecological benefits. A small fraction (8.5%) did not seem to know much about the project. Among non-members, awareness was low (41.9%), but at least a third of them understood the goals and reasons behind the establishment of a marine reserve.

People's organization members unanimously agreed that the establishment of the marine sanctuary project would bring about a stream of benefits for them in terms of increased fish catch and income. Surprisingly, agreement with the project was also high (68.5%) among non-PO members. They believed the project would be beneficial if properly managed and all violations, stopped. The remaining 31.6% unequivocally dismissed the sanctuary project as useless and non-beneficial to fishermen; on the contrary, it could even make them poorer.

Table 15 lists the specific arguments for and against the marine sanctuary project as volunteered by respondents. A large number (22%) of those who support the project believe that the sanctuary can help increase fish abundance by providing protection for breeding populations. Many also believe that a sanctuary can bring about economic benefits to fishers in terms of improved catch and incomes. They further believe that fish spills over from the reserve either because of their large numbers or because they move out to forage in neighboring areas. Many of the fishermen interviewed showed sincerity in their responses, and gave unequivocal answers. These fishermen believe that the establishment of the sanctuary has helped the fishery of Danao Bay by ensuring that fish is available for future generations. Many of these fishermen have observed the increase in fish abundance inside the sanctuary, and they agree that without the sanctuary, the condition of the neighboring fishery would be worse and fish stocks even lower. One spear fisher pointed out that he could now catch large-sized fish even on the reef flat, which he did not experience a few years ago. There were, however, a few who said they supported the project but could not give definite reasons for doing so, probably because they have not experienced economic benefits nor visited the sanctuary.

Most of those who disagree with the sanctuary establishment (45.3%) say the area is too big and limits their fishing ground. The area covered by the sanctuary was a common fishing ground during times when fishing along the reef crest was difficult due to the monsoons. Many of these fishermen perceive that fish was abundant when the sanctuary was newly established, but that fish inside the sanctuary is much fewer today. Anti-sanctuary sentiment is prevalent in certain parts of barangays Tugas, Misom, and Landing. Some of these respondents are quite well-known for their stubbornness and have been apprehended in the past for violations of sanctuary rules. Another reason why the project cannot gain their support is that rumors are rife that sanctuary guards are involved in incidents of poaching. Members of the enforcement team and DB-REMO deny these, and hasten to dismiss them as rumor-mongering by malicious individuals and those who oppose the project. Nevertheless, such rumors reaching into the larger community of non-PO members can discourage participation and support for fishery management programs.

Reports of poaching in the reserve were acknowledged by sanctuary managers. These reports indicate that efforts to strictly enforce 'no-entry, no-fishing' regulations in the sanctuary have not been successful. Guards bewail the lack of patrol boats, radio monitoring equipment and insufficient personnel. Patrol duty in the sanctuary at night is rotated among a few members – women even accompany their husbands in roving around the reef. Leakage of fish biomass due to poaching complicates the interpretation of data from fish population surveys and catch monitoring, as the amount of biomass leaking from the reserve in this way cannot be measured through conventional methods. However, the fact that poaching does occur implies that biomass inside the reserve would be higher than present estimates if the poaching did not occur.

An attempt was made to relate the type of fishing gear used by fisher respondents with their attitude towards the marine reserve. An interesting observation was that fishers who had experienced profitable fishing were more likely to react positively to the sanctuary project. From Table 15, it can be observed that both groups of respondents (for and against the project) operate similar kinds of gear, and therefore, no correlation can be made on the differential profitability of gears and perceptions of fishermen about the reserve establishment.

Table 15. Reasons identified by respondents for / against the sanctuary project.

Pro-Sanctuary (131/total respondents = 73.60%)	No. of respondents	Types of gear owned or method used	Membership in PO / Fishers' group	
			Member	Non-Mb
Positive changes in ecological conditions (mangroves, coral reefs)	16 (11.9%)	Gillnets	7	9
Marine sanctuary an effective mgt. strategy; Increase in fish catch brings economic benefits to fishers through biomass spillover (to unprotected areas)	25 (18.7%)	Fish corrals	18	7
		Spear fishing		
Experienced economic & social benefits from the project (hired as guard, given honorarium, knowledge/skills improved)	12 (9.0%)	Hook & lines	12	
Preservation of fish stocks for future generations	13 (9.7%)	Bamboo fish traps	8	5
Without the marine sanctuary, fish numbers would have dwindled long ago	6 (4.5%)	Crab pots	6	
Sanctuary offers protection & safe breeding ground for fish (thus fish population increases)	29 (21.6)	Handy net implements	16	13
Project led to total ban of destructive fishing	11 (8.2)	Reef gleaning	8	3
Communities were organized into PO's	7 (5.2%)	Fishing with lamps	6	1
Attraction of tourists increases income from reserve	3 (2.2%)		3	
No reason /conditional agreement	12 (9.0%)		3	9
Anti-Sanctuary (47/total respondents = 26.40%)				
No perceptible increase in fish abundance in fishing grounds / No clear benefits	5 (9.4%)	Spear fishing		5
Unreliable guards; many rumors about involvement of sanctuary guards in poaching	6 (11.3%)	Gillnets	1	5
		Hook & Lines		
Poor sanctuary mgt.; failure to stop violations, thus fish population still low	5 (9.4%)	Bamboo fish traps		5
Size of marine sanctuary too big – limits fishing area; fishers must be free to fish where they want	24 (45.3%)	Fish corrals	2	22
Project benefits only those members of PO's given incomes or honoraria; majority of fishers not benefited	3 (5.7%)	Reef gleaning		3
Public education/advocacy programs are wanting; Do not reach non-P.O. members.	2 (3.8%)			2
No reason	8 (15.1%)			8
Total number of respondents = 178				

Note: Some respondents gave more than one reason.

It would appear that the motivation behind fishermen support and involvement in fishery management comes from not only economic, but also social and cultural factors. Some fishers respond positively to community organizing efforts and are open-minded enough to make independent decisions in supporting management efforts, while others are strongly influenced by the opinions of friends or kin. A critical factor in ensuring community support for the project is the level and extent of involvement of fishers in management initiatives. In the case of Danao Bay, it was observed that those who were most actively involved in the MPA and fisheries management program were the same persons who were given large responsibilities in various working committees.

3.6 Cost of Resource Management

The CB-CRM project in Danao Bay is externally funded by Oxfam-Great Britain (2000-2002), ICCO of the Netherlands, and other sources, including small amounts from the provincial local government unit (LGU). Table 16 shows the budgetary allocations for different program components in fiscal year 2001. The total management cost of PhP 1.77 million/yr is rather large. Salaries, honoraria and other personnel costs amounting to PhP 878,839 form the bulk of each component cost (49.7%) of the total project cost. Meanwhile, the cost of fishery management including sanctuary protection comprises only 13.2%. The Oxfam funding ended after 2002, and hopefully new funding sources will be found to sustain management activities in the bay. An important concern, however, is what will happen to sanctuary protection and other activities should funding fall short of expectations. An alternative is to improve the promotion of ecotourism projects in order to generate more revenue from entry and user fees. This would require an improvement in sanctuary building facilities to accommodate more guests and attract a broader range of tourists.

DB REMO must ensure effective financial planning if it wants to sustain the current level of personnel expenditure. On the other hand, DB-REMO should also rethink their management approach. For the program to be truly community-managed and sustainable, it has to rely on self-reliant financial instruments or mechanisms.

Table 16. Summary of budgetary allocations of the CB-CRM project in Danao Bay in the fiscal year 2001

Component	Budget	Percent
I. Community Organizing	854,616.4	48.31
II. Sustainable Fisheries	233,880.4	13.22
III. Sustainable Livelihood	213,590.0	12.07
IV.Networking/Advocacy	213,590.0	12.07
V. Education/Training	176,682.4	09.99
Total Direct Project Cost	**1,692,359.2**	
Institutional Support	76,752.8	4.34
Grand Total	**1,769,112.0**	

Source: DB REMO office file.

3.7 Management Issues in Danao Bay

Despite the long list of measures that have been implemented by the various institutions, the coastal fishery of Danao Bay is still characterized by a range of management problems.

3.7.1 Open-access Fisheries

Danao Bay continues to be an open-access fisheries system. Studies on fishing effort and CPUE figures show that programs to regulate fishing effort in the coastal fishery have not been successful due to institutional and policy failures. Attempts by the municipal government to introduce fishing permits failed due to lack of effective collection and monitoring strategies. Although allegedly fewer now, fishers from other bays or municipalities continue to fish in the bay. A joint municipal ordinance between the municipalities of Baliangao and Plaridel proposed by DB-REMO to turn Danao Bay into an exclusive fishing ground for their residents was passed in August 2002. It is not certain, however, how effectively this statute will be implemented without the widespread support of the fishing community. Persistence of poaching in the sanctuary derails efforts at effective enforcement and protection. If such activities continue to increase, the MPA runs the risk of losing the benefits it has started to provide for the fishing community in Danao Bay.

3.7.2 Institutional Weakness

An evaluation of the role of the local government in the CB-CRM program of Danao Bay brings to the surface three important issues, namely the lack of participation, the lack of fiscal support, and weak political will. Participation of the Baliangao and Plaridel LGUs in CRM programs within the bay has been nominal, providing support to NGO/PO-led programs only upon request. Another issue is the role of "power politics" in resolving resource-use conflicts in the bay, which was evident in the conflict between fish corral and trammel nets ("triply") fishermen which started with the introduction of the latter gear in 1984 (Heinen & Fraser, 2001), and ended only when trammel nets were banned completely from the bay sometime in 1998. Power politics may achieve quick results, but is often a stumbling block in careful, rational and equitable solutions to resource problems in any given system.

3.7.3 Problem of Project Sustainability

The Pipuli Foundation pulled out from the DB management program at the end of 2002, as part of its plan to transfer full ownership and implementation of the project to the community. This development has triggered a number of concerns with regard to the sustainability of resource management and sanctuary projects. Can DB-REMO stand on its own without guidance from the Pipuli Foundation? Many of the officers and committee heads have little management training or experience. Can they prevail against hardened violators whose bravado is buoyed up by their influential political allies? Community involvement is very fragile; long-term efforts can crumble and benefits can easily dissipate through violations and sabotage. Leaders of the seven P.O.'s admit that their memberships are declining, and few attend organization meetings. Support from the LGU and other sectors is currently limited, although recent developments such as the formation of a Protected Area Management Board (PAMB), seem to indicate that the local government can easily increase its support.

The provincial government of Misamis Occidental has also been giving funding support for specific needs, such as radio communication equipment and patrol boats, as an allocation from its Provincial Development Fund.

3.7.4 Potential Areas of Conflict

Two important issues have confronted members of DB-REMO in relation to the formation of the Protected Area Management Board (PAMB) in Baliangao. One is the perceived overlap of management roles and functions of the PAMB and DB-REMO, and the other is conflict over jurisdiction. DB-REMO has bay-wide management scope, covering six coastal barangays, whereas the PAMB covers only the Baliangao Protected Landscape and Seascape situated in the barangay of Misom. Some sectors express apprehension that the PAMB will later replace or ease out DB-REMO, particularly since the local government (the Mayor and four barangay captains) is highly represented in the PAMB but not in DB-REMO. There are concerns by DB-REMO of losing ‘ownership’ of the program to which they have given their active support and commitment. Another concern is the well-known bureaucracy of government-led organizations such as the PAMB, which may drag, rather than hasten implementation of the project. There are also potential problems with fund administration under the terms of the National Integrated Protected Area System that need to be addressed.

4. CONCLUSIONS AND RECOMMENDATIONS

This study provides biological and economic data that support the concept that marine protected areas (MPAs) or marine reserves are a strategic tool in fishery management, particularly in overfished coastal ecosystems. The results of this study are short-term, and show only a ‘snap shot’ of the fishery, but they are sufficient to form a sound basis for a number of general conclusions.

4.1 Some General Observations and Conclusions

Biological and economic data provide the following indications that the Baliangao marine reserve has been successful in improving the conditions of the coastal fishery of Danao Bay:

1. Improvement in ecological conditions – improved live coral cover and mangrove diversity, increase in fish diversity and populations, and high fish biomass inside the reserve and on nearby reefs – indicates positive effects of protection.

2. High biomass of fish inside the protected core area supports the assumption that fish biomass builds up within marine reserves. The sizes of important predators or target food fish are also much larger (25-30cm) than on outside reefs. Although fish densities on reefs inside and outside the reserve are comparable, the abundance of large adult predators is higher per unit area inside the sanctuary core. Comparison with earlier research data indicates steadily increasing diversity and numbers over time, indicating a positive impact of the MPA.

3. Observations on fish movements found that large adult target fish (emperors, rabbitfish, snappers) frequently move out of the sanctuary core, thus becoming vulnerable to the concentration of fishing effort right outside the sanctuary boundary.

4. The MPA, in providing a protected habitat for adult target predatory fish, allows build-up of fish biomass inside the reserve, which spills over into neighboring (fished) areas, allowing differential profitability of gears, especially gears with low capital and operational costs. Economic analyses show that small fishery rent is being earned; without the MPA, economic rent would have been driven to zero.

5. Support for the sanctuary project by fishermen is very high (73.5%).

6. Successful reserve management has led to the complete eradication of explosive fishing techniques and certain destructive gears.

7. Community involvement and support have played an important role in ensuring the success of the reserve project.

This study also provides some information on the nature of the coastal fishery of Danao Bay as a fishery in transition. As such, it is beginning to show some positive net benefits from management, but it still faces several problems:

- High fishing effort results in low catch-per-unit-effort of many gears.

- Despite showing signs of recovery or improvement, the fishery remains open-access, as indicated by:
    - high effort level (many part-time fishers)
    - there is additional stress from non-resident fishers e.g. they still enter the fishery
    - too many kinds and units of gears
    - no effective method of regulating fishing effort

- The fishery is still in distress. This can be demonstrated by the following:
    - average CPUE is still low and thus, so are daily gross incomes
    - high fishing costs result in too small or marginal profits
    - lack of viable livelihood options to encourage part-time fishermen to exit the fishery
    - shifts in species composition of catch by various gears, with increasing dominance of small, low value fish in the catches
    - high fishing effort reduces the average size of fish in the fishery, a condition known as biological overfishing;
    - monitoring and enforcement of sanctuary regulations is still inefficient (i.e. poaching still common)

- The MPA alone is not a sure solution to problems of the fishery. Other policy instruments and fishery management strategies are needed.

Experience in the establishment and monitoring of marine protected areas worldwide indicates that (positive and negative) impacts can be either short-term or long-term, short-range or long-range. Some positive effects of protection may be observed immediately only after a few years, while others can be seen only after several years.

Spillover of larval and adult fish biomass from a marine reserve may take years before empirical data can provide irrefutable proof that it has occurred in a given area. Evidence of spillover or export of adult biomass from reserve to non-reserve areas of Apo Island was observed only after eight years of monitoring. Evaluating whether this spillover has enhanced the adjacent fishery and improved incomes from fishing would take an even longer time, as the benefits may build up gradually.

Coastal fisheries can be complex management systems, subject to a stochastic dynamics that are difficult to predict with a high degree of certainty. Lessons from monitoring the Apo Island reserve seem to suggest that even with a better set of time-series data on the coastal fishery of Danao Bay, it would still be difficult to attribute changes in fish populations and fish catch, to the spillover effect. Absolute, empirical proof of transfer of biomass between the unfished reserve and fished areas can only be provided by tagging experiments, or genetic analysis of fish stocks across space and time. What this study can do is to provide a sound basis for making some conclusions about what benefits the MPA can bring. There is sufficient evidence from literature that if fishing effort can be completely excluded from the MPA, then fish stocks (particularly of large economically important groups) would increase over time. With biomass build-up, competition for space and food would induce some of this stock to move out and spill over into adjacent fished areas.

4.2 Policy Recommendations

This analysis has illustrated that an MPA as a sole management tool cannot restore fishery health nor ensure the sustainability of a coastal fishery. In spite of its many real and perceived advantages, MPAs are not a panacea or universal remedy to the multiple and complex problems of a tropical coastal fishery. Other policy instruments and fishery management strategies are needed to complement the positive net benefits of a protected area. The following are the specific policy recommendations of this study:

1) There must be a reduction in overall fishing effort in Danao Bay. This can be achieved by:
   a. completely excluding non-resident fishers from the participating in the coastal fishery
   b. registration of all resource users and strict (rather than selective) imposition of fishing permits and licenses
   c. providing incentives to encourage part-time fishers to exit the fishery (e.g. providing gainful employment in viable alternative economic activities)

2) Institute a schedule of stiffer penalties or disincentives for violators in order to sufficiently reduce incidences of poaching and use of destructive fishing methods.

3) Implement a gear zoning plan for the bay, using data on the CPUE of different gear types and species composition of catches coupled with biological information from literature.

4) Review the currently implemented ban period (two days each month after a new moon) for its biological soundness.

5) Review the design of the MPA, and establish buffer zones on both sides to increase protection of fish stocks inside.

6) The local government units (municipal and provincial) should allocate an annual management sum from its internal revenue allotment (IRA) to fund enforcement activities and provide infrastructure and equipment for night monitoring.

7) Create a legal/paralegal support system for the arbitration of violation cases.

8) Create one integrated management body to formulate and execute an integrated coastal development plan for bay-wide adoption.

9) Organize and improve public information and education campaigns for broader advocacy.

All these policy measures should lead towards creating a fishery system that is not "open-access", but one that is protected by law in the form of private property rights. Such a management shift is expected to increase resource rent. Maintenance of fishery rents in the bay will only be possible in the absence of open-access fishing. Unless Danao Bay becomes exclusive to its residents, and effort regulation can be enforced effectively, whatever rent is presently being captured by fishermen will easily dissipate. Improved community management of the MPA should also ensure continued biomass spillover to sustain the adjacent fishery.

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APPENDIX 1

Comparison of cover of live coral and other macrobenthos among the reef stations in Danao Bay

LIFEFORM CATEGORY	Danao	Bato Shallow	Bato Deep	BWP Core	BWP RS Shallow	BWP RS Deep	Tugas	Tinago
LIVE CORAL								
Acropora								
Acropora (Branching)	0.07	2.61	0.88		0.50	1.03	0.13	0.97
Acropora (Submassive)					2.20			
Acropora (Tabulate)		0.78						0.41
SubTotal	**0.07**	**3.39**	**0.88**		**2.70**	**1.03**	**0.13**	**1.38**
Non-Acropora								
Branching Coral	22.04	2.98	16.76	29.05	10.00	36.90	29.15	22.24
Encrusting Coral	3.34	6.74	2.28	1.48	1.48	1.39	1.76	2.24
Foliose Coral	0.44	0.72	1.87		0.43	0.14	0.46	2.15
Heliopora	0.44	0.54	0.80		17.47	4.62		
Massive Coral	6.96	6.25	2.90	5.23	7.42	6.01	2.35	12.19
Millepora	0.34	1.06	1.09		0.42			0.01
Mushroom Coral	1.09		2.73	0.07	0.20	0.74	0.86	0.46
Submassive Coral	2.47	0.84	0.87	1.75	0.91	1.18	1.46	3.40
Unknown (Live Coral)					0.29	0.18		0.27
Soft Coral	4.16	2.91	2.98	4.95	1.63	1.06	1.83	2.19
SubTotal	**41.28**	**22.04**	**32.28**	**42.53**	**40.25**	**52.22**	**37.87**	**45.15**
Total Live Coral	**41.35**	**25.43**	**33.16**	**42.53**	**42.95**	**53.25**	**38.00**	**46.53**
DEAD CORAL AND OTHER MACROBENTHOS								
Dead Corals								
Recently dead coral	0.27		0.90	0.25	3.55	1.94	4.74	0.94
Dead Coral w/ Algae	32.09	41.01	19.31	4.88	10.26	9.34	27.84	15.2
Rock/Boulder	14.21	12.60	43.97	4.88	25.51	15.25	23.46	26.47
SubTotal	**46.57**	**53.61**	**64.18**	**10.02**	**39.32**	**26.53**	**56.04**	**42.61**
Algae and Other Macrobenthos								
Algal Assemblage						0.16		
Coralline Algae	0.29	0.41	0.06		0.09			0.26
Macrobenthic Algae	0.55	2.03		0.30	0.08	0.09		
Turf Algae					0.01			
Seagrass				1.13		0.12		
Sponge	1.17	1.01	0.65		0.09	0.68	0.76	0.64
Other Benthos (Inverts.)	0.44	0.07	0.28	0.07		0.10	0.33	
SubTotal	**2.45**	**3.52**	**0.99**	**1.50**	**0.27**	**1.15**	**1.09**	**0.90**
Substratum								
Sand w/ coral rubbles		5.54	0.60	42.12	9.38	13.88	0.82	0.23
Silt	0.34	1.83					0.89	
Deep Water	9.29	10.07	1.07	3.83	8.08	5.19	3.16	9.73
SubTotal	**9.63**	**17.44**	**1.67**	**45.95**	**17.46**	**19.07**	**4.87**	**9.96**
GRAND TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

APPENDIX 2
Time series comparison of fish biomass (g/m2) in Danao Bay reefs

CATEGORY/GROUP	*INSIDE MARINE RESERVE*			*OUTSIDE MARINE RESERVE*		
	May-01	Oct-01	Jul-02	May-01	Oct-01	Jul-02
TARGET FOOD FAMILIES						
Acanthuridae	2.9949	4.3820	7.1051	1.9515	0.7050	5.4151
Balistidae	0.2408	0.3107	0.1575	0.4575	0.0871	0.0483
Caesionidae	0.6487	1.7182	1.9679	0.1488	2.1666	6.4028
Carangidae				5.2848		
Haemulidae	0.9641	0.3226	1.7319	0.0546		0.0389
Lethrinidae	25.8860	7.5846	4.5130	0.6880		
Lutjanidae	1.1748	1.9787	0.5797	0.1495		0.0729
Mullidae	0.1769	0.2575	0.7731	0.2756	0.1673	0.4837
Nemipteridae	0.1248	0.7580	0.5483	0.1716	0.1119	0.1834
Scaridae	0.5234	1.0747	1.0784	1.3462	1.0231	1.4915
Serranidae (Epinephilinae)	0.0226		0.0296	0.0311		
Siganidae	1.1870	0.0705	0.7592	0.2818	0.0624	0.1613
	33.9438	**18.4576**	**19.2436**	**10.8409**	**4.3234**	**14.2978**
INDICATOR FAMILIES						
Chaetodontidae	0.0750	0.0913	0.3209	0.3128	0.2286	0.2149
Eppiphidae			0.1960	0.6309	0.1778	0.0891
Pomacanthidae	0.0846	0.0515	0.1077	0.1735	0.1049	0.1975
Zanclidae	0.1730	0.3332	0.2381	0.2306	0.4718	0.2527
	0.3326	**0.4759**	**0.8626**	**1.3479**	**0.9831**	**0.7541**
MAJOR DEMERSALS						
Apogonidae	0.6773	2.1503	0.2869	0.0954	0.0533	0.0903
Holocentridae	0.2153	0.1497	0.0768	0.0931	0.0155	0.0155
Labridae	0.2969	0.8596	1.0068	0.6272	1.5455	1.0699
Pomacentridae	3.0307	3.8549	6.3360	2.4919	7.5791	2.5967
Serranidae (Anthiinae)	2.4749	0.0054	0.0000	0.5111	0.3049	1.8973
	6.6952	**7.0198**	**7.7064**	**3.8187**	**9.4983**	**5.6697**
OTHERS						
Aulostomidae	0.2224		0.0389	0.0911	0.6863	0.1729
Atheriniidae				0.7588		
Bleniidae	0.0040	0.0030	0.0030	0.0087	0.0121	0.0077
Centriscidae						0.0214
Gerreidae	0.0291	0.0398				
Monocanthidae			0.0577			0.0233
Ostraciidae						0.0189
Pingueppedidae	0.0436		0.0127	0.0676	0.0319	0.0251
Priacanthidae						0.0523
Pseudochromidae		0.0220	0.0190			0.0617
Scorpaenidae			0.0172			
Sygnathidae			0.0339			
Synodontidae	0.2536	0.0193	0.0030	0.0267	0.0048	0.0136
Tetraodontidae	0.1043		0.1213	0.0863	0.0261	0.0503
Unknown					0.4848	
	0.6570	**0.0841**	**0.3067**	**1.0393**	**1.2461**	**0.4471**
Total	**41.6287**	**26.0375**	**28.1194**	**17.0468**	**16.0509**	**21.1687**
Mean of 3 periods	**31.9285**			**18.0888**		

APPENDIX 3

Patterns of fish movement from inside the core area of the Baliangao Marine Reserve into surrounding areas

SPECIES	SIZE RANGE In cm	TOTAL NUMBER	PERCENTAGE OF TOTAL Remained Inside Core	Moved Outside	Returned Inside	Potential Export
Lethrinus harak	15-30	187	54.01	45.99	52.33	21.93
Siganus guttatus	15-22	98	80.61	19.39	57.89	8.16
Siganus fuscescens	15-20	132	71.21	28.79	28.95	20.45
Acanthurus spp	15-25	46	46.00	0.00	0.00	0.00
Naso sp	20-30	28	96.43	3.57	0.00	3.57
Lutjanus ehrenbergi	15-20	57	92.98	7.02	75.00	1.75
Scarus spp	15-20	29	96.55	3.45	0.00	3.45
Scarus ghobban	15-18	9	100.00	0.00	0.00	0.00
Parupeneus barberinus	10-18	50	72.00	28.00	50.00	14.00
Parupeneus indicus	10-12	6	66.67	33.33	100.00	0.00
Gerres oyena	6-8	23	8.70	91.30	47.62	47.83
Cheilio inermis	20-30	13	76.92	23.08	66.67	7.69
Lethrinus sp.	12-18	6	66.67	33.33	0.00	33.33
Other species	10-25	42	83.33	16.67	28.57	11.90
Total		**726**				
Mean			**72.29**	**23.85**	**36.22**	**12.43**