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NATIONAL CONSERVATION COMMISSION

Folkestone Marine Reserve, St. James Barbados

Centre for Resource Management and Environmental Studies

CERMES

University of the West Indies Barbados

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Community-Based Coral Reef Monitoring And Management

An annotated bibliography of coral reef monitoring and management information related to the Folkestone Marine Reserve, St. James, Barbados

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Blackman, K. 2008. An annotated bibliography of coral reef monitoring and management information related to the Folkestone Marine Reserve, St. James, Barbados. The Community-based Coral Reef Monitoring and Management project. Report No. 2. A Caribbean Conservation Association project in collaboration with the National Conservation Commission and The Centre for Resource Management and Environmental Studies. 26pp.

*-These documents are available on the CD ROM at the Folkestone Marine Reserve, St. James, Barbados.

1 Introduction

Over the years studies have been conducted and data have been collected about the Folkestone Park and Marine Reserve relating fisheries, coral reef monitoring, park development and management. Unfortunately the status of this information is unknown and has not been catalogued. Furthermore these studies are not easily accessible to stakeholders particularly the local communities and schools. Thus the aim of this report is to contribute to the information sharing process between local communities, scientists and Reserve staff. This is one of the objectives of the Community-based Coral Reef Monitoring and Management Project which was initiated by the Caribbean Conservation Association.

This bibliography attempts to compile a listing of papers and reports regarding marine research and management in relation to the Folkestone Marine Reserve. The report covers 91 articles and it is not limited to scientific research only but also technical reports, college theses, conference proceedings and internet resources. This was done to gather as much information as possible about the Reserve. As research is an on-going process, the bibliography will be updated over time. In some cases, for articles that have not been found, only the citation is provided.

2 Annotated Bibliography

Axys Environmental Consulting (Barbados) Inc. 1998a. Feasibility Study of Carlisle Bay and Folkestone Park and Marine Reserve and Harrison's Cave and Associated Sites. Folkestone Park and Marine Reserve Inception Report. May 1998. 95pp.

In 1998, AXYS Environmental Consulting commenced feasibility studies for the Government of Barbados to assess the long term sustainability of tourism development in two coastal parks on the island of Barbados: Folkestone Marine Reserve and Carlisle Bay Marine Park. The inception report reflects the current understanding of the key issues in the Folkestone area relative to future management and development. It describes the specific tasks that will be completed to fulfil each major component of the Feasibility Study.

Axys Environmental Consulting (Barbados). 1998b. Feasibility Study of Harrison's Cave and Associated Sites, Carlisle Bay and Folkestone Park and Marine Reserve: Draft Report (subject to revision). Baseline Information for the Folkestone Park and Marine Reserve. Prepared for the Ministry of Health and Environment, Environmental Special Projects Unit. November 1998. 165pp.

This report provides a thorough overview of the baseline environmental, social and administrative condition for Folkestone Park and Marine Reserve. The surrounding regional regime information in the report will be used to develop thematic and detailed planning options for the study area. This report served as a reference document throughout the Feasibility Study conducted by AXYS Environmental Consulting.

Axys Environmental Consulting (Barbados). 1998c. Interim report: A Summary of Baseline Information and Assessment of Thematic Options for the Folkestone Park and Marine Reserve. Prepared for the Ministry of Health and Environment, Environmental Special Projects Unit. November 1998. 138pp.

The report describes the preliminary findings, conclusions and recommendations relating to the Folkestone Park and Marine Reserve to identify any problems or issues that have arisen

or are expected to arise that will or could constrain the successful completion of the Feasibility Study.

Axys Environmental Consulting (Barbados) Inc., Environmental Planning Group, Gillespie and Steel Associates and Bellairs Research Institute. 2000a. Feasibility of Carlisle Bay, Folkestone Park and Marine Reserve and Harrison's Cave and Associated Sites. Final Report- A Feasibility Study and Preliminary Design for Folkestone Park and Marine Reserve. Prepared for Ministry Environment, Energy and Natural Resources, Environmental Special Projects Unit. March 2000. 624pp.

This is the final report of the 16 month Feasibility Study that commenced in 1998 by AXYS Environmental Consulting. It builds on previous work undertaken during this study: Folkestone Park and Marine Reserve Inception Report, Folkestone Park and Marine Reserve Baseline Report and Interim Report. The report fulfils the requirements in the Terms of Reference for submission of a Final Report. It describes the detailed design components of a proposed Folkestone Marine Management Area with offshore and foreshore features and makes recommendations for a management plan encompassing the establishment, enhancement and maintenance of Folkestone Marine Management Area and Folkestone Park.

Axys Environmental Consulting (Barbados) Inc., Environmental Planning group and Gillespie and Steel Associates. 2000b. Feasibility studies of Harrison's Cave and Associated Sites, Carlisle Bay Marine Park and Folkestone Park and Marine Reserve: Logical framework analysis. Prepared for Environmental Special Project Unit. April 2000. 60pp.

This report analyses the proposal by the Government of Barbados to diversify the tourism product through redevelopment in the three study areas (Carlisle Bay Marine Recreational Park, Folkestone Marine Management Area and Harrison's Cave). It relies upon information provided in a series of three technical reports and two business plans whereby it utilises the logical framework methodology.

Axys Environmental Consulting (Barbados) Inc., Environmental Planning group and Gillespie and Steel Associates. 2000c. Business Plan for the Carlisle Bay Marine Park and Folkestone Marine Management Area. Feasibility studies of Harrison's Cave and Associated Site, Carlisle bay marine park and Folkestone park and marine reserve: Prepared for Ministry of Environment, Energy and Natural Resources, Environmental Special Project Unit. 50pp.

The report examines the market (local and Caribbean) to develop a plan for the two marine areas. It further explores the business model and discusses the commercial feasibility, provides and economic assessment, develops an implementation plan and schedule and recommendations

Axys Environmental Consulting (Barbados) Inc., Environmental Planning group and Gillespie and Steel Associates. 2000d. Feasibility studies of Harrison's cave and Associated Site, Carlisle Bay Marine Park and Folkestone Park and Marine Reserve. Business plan for the proposed Carlisle bay marine recreational park and Folkestone marine management area. July 2000. 101pp.

This is the proposed business plan for the operation of the proposed Carlisle Bay Marine Recreational Park, and Folkestone Marine Management Agency. The business plan incorporates a market forecast and plan, an organisational plan and an assessment of project's economic and financial viability. It is not an independent report and as it is part of the final technical report.

Axys Environmental Consulting (Barbados) Inc., Environmental Planning group and Gillespie and Steel Associates. 2001a. Feasibility studies of Harrison's Cave and Associated Sites, Carlisle Bay Marine Park and Folkestone Park and Marine Reserve: Phase II Integrated development programme: Price proposal for the establishment of marine management agency, Barbados. November 2001. Prepared for Environmental Special Projects Unit, Government of Barbados. 10pp.

This is the proposal describing the budget including professional fees disbursements for the completion of work outlined in the technical proposal for the establishment of the Marine Management Agency for Barbados.

Axys Environmental Consulting (Barbados) Inc., Environmental Planning group and Gillespie and Steel Associates. 2001b. Feasibility studies of Harrison's cave and associated site, Carlisle bay marine park and Folkestone Park and Marine Reserve: Phase II Integrated development programme: Technical proposal for the establishment of a marine management agency, Barbados. May 2001. 18pp.

This is the technical proposal indicating the approach for providing technical assistance for the establishment of a Marine Management Agency for Barbados, with respect to staff, administrative operations, enforcement, training needs and community consultation.

Axys Environmental Consulting (Barbados) Inc., Environmental Consulting (Barbados) Inc., Environmental Planning group and Gillespie and Steel Associates. 2001c. Feasibility studies of Harrison's cave and Associated Sites, Carlisle Bay Marine Park and Folkestone Park and Marine Reserve: Phase II Integrated development programme: Technical proposal for the establishment of a marine management agency, Barbados. November 2001. 24pp.

This proposal provides a work plan for the institutional and organisational framework, e.g. enabling legislation for the Marine Management Agency mandate and the business model-partnership opportunities and funding models.

Axys Environmental Consulting (Barbados) Inc., and Jacques Whitford Ltd. 2006a. Phase II: Feasibility Study Of Harrison's Cave and Associated Sites, Carlisle Bay Marine Park and Folkestone Park and Marine Reserve. Integrated development programme for the establishment of marine management agency, Barbados. Sept 21, 2006-Volume 1-main report. 65pp.

The report presents the results of a study undertaken for the government of Barbados by AXYS to develop an implementation plan for the establishment of a Marine Management Agency. It was developed to address institutional and organisational framework for the MMA, funding of the MMA and Marine Management Area, legal modifications and changes that will be required for the implementation, an implementation plan, and a stakeholder involvement programme.

Axys Environmental Consulting (Barbados) Inc., and Jacques Whitford Ltd. 2006b. Phase II: Feasibility Study Of Harrison's Cave and Associated Sites, Carlisle bay marine park and Folkestone Park and Marine Reserve. Integrated development programme for the establishment of marine management agency, Barbados. Sept 21, 2006-Volume II- appendices. 127pp.

This is part of the aforementioned project listing the results from interview on the MMA, interviews with other marine management agencies, summary of round table discussion, operational consideration-benefits of the marine environment-results of beach users survey,

watersport survey, funding of marine resource management, review of existing and proposed legislation and regulations.

Bateson, R. and Hendry, M. 1996. Land based pollution, reef health and nearshore sediment production on oceanic islands: a Barbados case study. UNESCO-IOC-UPR/SGCP Workshop on "Integrated framework for the management of beach resources in the smaller Caribbean islands." Puerto Rico, October 21-25, 1996.

Between the 1970s and the 1990s, deterioration in the ambient nearshore water quality resulted in changes in the benthic ecology of west coast fringing reefs of Barbados. Reduction in the abundance of reef forming organisms, namely corals and coralline algae, as well as mass mortality of the grazing urchin (*Diadema antillarum*), and increases in macroalgal cover has resulted in dramatic changes to the sediment budget. Calculations suggest that on the north Bellairs fringing reef, calcification has declined to 17% of its 1970's level, whilst bioerosion has remained at a constant level. This has resulted in bioerosion now exceeding calcification, a reversal of the 1970's situation. Data from other west coast fringing reefs suggest that this is indicative of the condition along that coast. A sustained imbalance between reef bioerosion and construction will lead to a decline in sediment generation, the potential loss of reef structure and increased hydrodynamic activity at the shoreline. Medium to long-term changes in associated beach cells are expected, with accelerated modification if impacted by severe storm events.

Bellairs Research Institute. 1984. Marine studies component of the south and west coast sewage project. Technical report 13, Barbados W.I. 140pp.

Not seen.

Bellairs Research Institute. 1989a. Community Descriptors (1987) for Nearshore and Offshore Reefs on the South and West Coasts of Barbados. Technical Report for the Coastal Conservation Project Unit, Ministry of Employment, Labour Relations and Community Development, Barbados, W.I. 99pp.*

Given the abundance of reefs on west and south coast their social economic and biological value and the evidence suggesting that reefs may be deteriorating through human activities, the need for management of coral reef communities in Barbados becomes evident. A first step was to establish a management program. This involved acquiring baseline data which characterises the presence of coral reefs around the island, through comparison with data obtained in subsequent surveys; quantification of the rate of change in coral reef communities and assessment of the impact of any measures implemented. The study provided baseline community descriptors for 16 nearshore reefs on the south coast of Barbados, 21 nearshore reefs on the west coast of Barbados and offshore reefs on the south coast and 3 offshore on the west. A secondary objective was to comment on any conspicuous differences between reefs that were presently evident.

Bellairs Research Institute. 1989b. Environmental deterioration and marine water quality at fringing reefs on the west coast of Barbados. Technical report for the Inter-American Development Bank, Washington DC. 27pp.

Not seen.

Bellairs Research Institute. 1996. Bacteriological contamination levels at bathing beaches on the west coast of Barbados. Prepared for Stanley International and the Government of Barbados, 57 pp.

The Government of Barbados sought to determine if marine waters exceeded the bacteriological standards recommended by the US Environmental Protection Agency. Ten beaches on the west coast of the island: Brandons, Batts Rock, Paynes Bay, Holetown, Folkestone, Glitter Bay, Reads Bay, Gibbes Beach, Gooding Bay and Heywoods Beach were used as sample sites. Comparison of bacteriological contamination levels were made at each of the ten beaches with the standards recommended. Comparison of bacteriological contamination levels at two sampling locations at each beach was made and the study also assessed the effects of rainfall on bacterial contamination levels.

Bellairs Research Institute. 1997. Environmental deterioration and marine quality at fringing reefs on the west coasts of Barbados. Technical Report for the Inter-Amercian Development Bank, Washington, D.C. 27pp.

Not seen.

Bird, J.B. no date. Beach changes and recreational planning on the west coast of Barbados, W.I. Geographica Polonica 36:31-41.

Not seen.

Bird, J.B., Richards, A. and Wong, P.P. (1979) Coastal subsystems of the western Barbados, West Indies. Geografiska Annaler 613-4):221-236.*

Concern over the loss of shore property and local deterioration of the physical condition of beaches in the west coast of Barbados has led to extended analysis of the coastal subsystems. The main features of the west coast are inherited from events associated with complex sea-level fluctuations and extension of coral terraces in the Quaternary. The contemporary coast was established at the close of the Flandrian transgression along an early Wisconsin rocky shoreline. Introduction of sand into the shore system from cliff erosion (2 to 10 m retreat during the [period), reef destruction and terrestrial sources has formed a sand beach that has moved seawards with time leaving a narrow sand terrace between the shore and the earlier coastline. 19 beach cells were identified along the west coast and intensive studies of wave current processes leading to changes in beach platform and profile were made at two (Gibbs and Sandy lane bays). Whilst the volume-shape mechanism operating through an annual cycle leaves a beach cell in quasi-equilibrium, overall loss of beach sand in the past 13 years has been accompanied by a 45% linear increase of exposed beach rock.

Chapman, M.R. 1997. Coral reef fish movements and the effectiveness of the Barbados Marine Reserve. MSc Thesis, Department of Biology, McGill University, 67pp.

This study examined whether movements of fishes across reserve boundaries reduced the difference in density and size of fish between reserve and non-reserve areas. Visual censuses, experimental trapping, habitat measurements and tagging were performed at 10 sites on two nearly contiguous fringing reefs at the northern edge of the Barbados marine reserve and at 10 sites on the two fringing reefs closest to the boundary on the non-reserve. The visual census showed that overall density and size of fishers large enough to be caught in Antillean fish traps were higher on reserve reefs than on non-reserve reefs. The difference in density and size varied considerably among species and were not statistically significant for individual species. In contrast to a previous study, experimental trap catches were not higher in the reserve than in the non-reserve. Visual censuses, trap catches, and their ration (trappability) were affected by habitat variables. Species mobility, estimated by the maximum distance between locations at which an individual was captured, corrected for the sampling effort at that distance, was highly variable among species

(medians 0-116m). For the more mobile species, movements within the fringing reefs and between the nearly contiguous reserve reefs was high but extremely rare among reefs separated by expanses of sand and rubble. For this discrete fringing reef system, there is no evidence that movement across the reserve boundary influences the relative density or size of fish between the reserve and non-reserve.

Chapman, M.R. and D.L. Kramer. 1999. Gradients of coral reef fish density and size across the Barbados Marine Reserve boundary: effects of reserve protection and habitat characteristics. Mar. Ecol. Prog. Ser. 181: 81-96p. *

Reductions in fishing mortality within no-take coral reef marine reserves can produce gradients in the density and size of fishes across reserve boundaries. Such gradients may be affected by other factors, however, including differences in habitat quality between reserve and non-reserve areas and the movement of fish across reserve boundaries. To examine the effects of protection from fishing mortality and of habitat quality on an assemblage of exploited reef fishes, we measured the spatial patterns of fish density and size on fringing reefs near the boundary of the Barbados Marine Reserve (Barbados, West Indies) and statistically controlled for habitat correlates of fish density and size. Reserve sites supported a higher total density and size of fishes than non-reserve sites. Most species had a non-significantly higher mean density and size at reserve sites. The density and/or size of many species were correlated with the depth, rugosity, and/or substrate composition of sites. After statistic-ally controlling for the effects of habitat correlates, the difference in total density between reserve and non-reserve sites remained significant, and the mean density and size of most species remained non-significantly higher at reserve sites. Neither the mobility of species nor their vulnerability to capture by Antillean fish traps was correlated with their relative difference in density or size between reserve and non-reserve sites. Spearfishing target species had a significantly higher relative in size between reserve and non-reserve sites than non-target species. Protection from fishing mortality and higher habitat quality appear to contribute to the increased density and size of fishes on study reefs in the Barbados Marine Reserve and this difference is not compromised by emigration from the reserve.

Chapman, M.R. and D.L. Kramer. 2000. Movements of fishes within and among fringing coral reefs in Barbados. Environ. Biol. Fishes. Vol. 57, no. 1, pp. 11-24. *

Movement of coral reef fishes across marine reserve boundaries subsequent to their initial settlement from the plankton will affect the ability of no-take reserves to conserve stocks and to benefit adjacent fisheries. However, the mobility of most exploited reef species is poorly known. We tagged 1443 individuals of 35 reef fish species captured in Antillean fish traps in the Barbados Marine Reserve and adjacent non-reserve over a two-month period. Trapping and visual surveys were used to monitor the movements of these fish during the trapping period and the subsequent two months. Estimates of distances moved were corrected for the spatial distribution of sampling effort and for the number of recaptures of individual fish. Recapture rates for individual species ranged from 0-100% (median = 38%). Species mobility estimated by recapture and resighting were highly correlated. Most species were strongly site attached, with the majority of recaptures and resightings occurring at the site of tagging. However, only one of 59 tagged jacks (*Caranx latus, C. ruber*) was ever resighted, suggesting emigration from the study area. All species were occasionally recorded away from the sites where they had been tagged (20-500 m), and several species, including surgeonfish, *Acanthurus bahianus, A. coeruleus*, filefish, *Cantherhines pullus*, butterflyfish, *Chaetodon striatus*, angelfish *Holocanthus tricolor* and parrotfish, *Sparisoma viride*, ranged widely within reefs. In contrast, few movements were observed between reefs separated by more than 20 m of sand and rubble, and no emigration from the Reserve was recorded. Most reef fishes vulnerable to Antillean traps appear sufficiently site-attached

to benefit from reserves. However, many species move over a wide enough area to take them out of small reserves on continuous reef. Use of natural home range boundaries could minimize exposure of fishes in reserves to mortality from adjacent fisheries.

Cotter, P. 1981. The establishment of the Barbados Marine Reserve, (Abstract). Proc. 4th Int. Coral Reef Symp. Manila, Philippines 1: 332.*

The ideas for the formation of a Marine Park on the West Coast of Barbados were born in 1967. The site under consideration was the historic region near Holetown. Initially, only a small are was selected to serve as an underwater attraction. In October of 1979, with aid of the U.S. Peace Corps, serious plans began to take shape. The size of the park was increased to cover an area 2.5 km by 1 km. The name was changed to reflect a broader authority which incorporated three separate sections. The Marine Museum contains the office space and display rooms for local fauna. The Underwater Park contained two fringing reef systems nearshore on jutting headlands and an offshore bar reef with 35 different species of coral. The section is divided into four zones: Scientific Zone, the Northern and Southern Water Sports Zones and the Recreation Zone. The third section under jurisdiction of the Reserve is the 118m "Stavronikita" which serves as an artificial reef. The Barbados Marine Reserve was officially opened on November 29, 1980. The future goals of the authority include maintenance of the Museum, monitoring of the marine environment and education of the local people and tourists concerning conservation and the importance of the coral reef ecosystems.

Cotter, P. 1982. Barbados new marine reserve. Parks 7: 8-11.*

Details of the establishment of the marine reserve at Holetown are followed by the management plan. The reserve is composed of three sections: the M. V. Stavronikita, an underwater wreck; the underwater park, and the Marine Museum. The park has four zones: one for educational and research work, two for sports and the fourth for recreation. The museum is land based with conference, laboratory and display facilities.

Cumberbatch, J. 2001. Case Study of the Folkestone Park and Marine Reserve, Barbados. Caribbean Natural Resources Institute (CANARI) Technical Report. Number 281. 11pp.*

This report examines the stakeholder identification and analysis process that was used to include stakeholders in making recommendations for upgrading the Folkestone Park and Marine Reserve on the west coast of Barbados. This study used focus groups and case study research involving stakeholder representatives to revise the four zones and management system within the Reserve. The aim was to determine the feasibility of upgrading and enhancing the facilities at Folkestone as a recreational park and marine reserve.

CZMU. 1998. Integrated Coastal Management. The Barbados Policy Framework. Prepared for the Coastal Zone Management Unit, Ministry of Health and Environment by Halcrow Group. 34pp.

This document is Volume 1 of the Coastal Zone Management Plan which describes Government policies and the institutional framework for Integrated Coastal Management in the Barbados. It describes the policy framework in which management of the coastal environment will take place. It has been prepared to inform public and private organisations, agencies and individuals of the requirements, responsibilities and opportunities for integrated coastal management (ICM) in the country. Mini case studies and Technical Discussion boxes are presented throughout the document to outline ICM progress to date in Barbados.

CZMU. 1999. Integrated Coastal management Plan for South and West Coasts of Barbados. The Caribbean coast. Prepared for the Coastal Zone Management Unit, Ministry of Health and Environment by Halcrow Group. 94pp.

This document is volume 2 of the Coastal Zone Management Plan. It provides guidance for the management of the west and south coasts of Barbados in the form of an Integrated Coastal Management Plan.

Declan International Corporation. 1995a. The Integrated management Plan for the South and West Coasts of Barbados. Report prepared for the Coastal Conservation Project Unit, Ministry of Tourism, International transport and the Environment, Government of Barbados. 80pp.*

The south and west coasts of Barbados are prominently the area of the island's socio-economic structure. They have historically been the preferred site for settlement by nature of their calm waters, natural harbours and gentle slopes. Development has resulted in coastlines dominated by tourism and residential infrastructure this concentration has reflected in the density of the population. Impacts of development include loss of natural habitat, encroachment on active beach areas, poor water quality and lowered reef health. A fragmented institutional and legislative structure has historically restricted government's capacity to respond to these problems. This coastal management plan provides policies, standards and guidelines for improved control of development, for rehabilitation of degraded environmental and the maintenance of natural environments and resources on the south and west coasts.

Declan International Corporation. 1995b. Feasibility Studies on Coastal Conservation. Littoral Regime for Barbados: Volume 1, Part A- Introduction and Methodology, Part B-Sector Descriptions (text only). Government of Barbados, Ministry of Health and Environment, Coastal Conservation Project Unit. 54pp.

This report summarises what is known from a coastal engineering perspective about the contemporary geological and man-made structure and the sedimentary and hydrodynamic conditions along the south and west coasts of Barbados within limits of the present Study Area. This includes all known man-made constructions that may interact with natural processes. Specifically, the west coast littoral system begins from North Point to the Bridgetown Port.

Declan International Corporation. 1995c. Feasibility Studies on Coastal Conservation. Littoral Regime for Barbados. Volume 2, Part B- Sector Descriptions (figures only).

This document provides the photos and graphs about the various sectors that are referenced on Volume 1, Part A.

Edwards, A.E. 1994. Anchor damage to coral reefs on the south and west coasts of Barbados: Present status and Management Suggestions. MSc. Project Thesis, Marine Resource and Environmental Management Programme, University of the West Indies, Cave Hill, Barbados. 147pp.*

At a public consultation held in March 1993 to canvas recommendation for coral reef management in Barbados, user-groups identified anchor damage as one of the most critical non-pollutant stressors of coral reefs. Interviews held with coastal boat users suggested that the main source of anchor damage to the reefs was from dive boat anchors at dive sites. Eleven of these dive sites with varying levels of reported use were surveyed. Measured damage ranged from 0-1.5% of colonies within a survey area of $160m^2$ for all except one site where damage was comparatively higher at 5.5%. This latter site is located

in the Quarantine Anchorage, an area frequented by larger vessels including commercial cargo ships with larger and heavier anchoring systems. Although the survey revealed a small amount of damage, there is still need for concern since any form of damage can have serious implications for the sensitive reef community and where reefs may already be under stress from factors such as pollution and sedimentation, for example at Holetown, the cumulative effect can be significant. In addition, the potential for increasing the harmful impacts of anchors is high, since the number of dive operators is increasing significantly and there are plans by the diving and tourism sectors to attract more diving tourists to Barbados. Strategies recommended for protecting reefs from anchor damage include placing mooring buoys at the most popular dive sites; designating severely damaged sites no-anchoring areas, while providing alternative anchoring areas; and education of the resource users. The dive operators represent one of the key user-groups of reef resources in Barbados and one with clear incentive for protecting the reefs. Consequently, they should be involved, with other user-groups, at all levels of the management plan being developed by Coastal Conservation Project Unit (CCPU) to protect reefs. This will allow for important user-group input into what has been predominantly a top-down approach by CCPU to environmental management. The user-groups can bring substantial knowledge, skills and expertise to all levels of a management programme, from planning to the implementation and evaluation stages.

ECNAMP. 1980. Barbados. Preliminary Data Atlas. Survey of conservation priorities in the Lesser Antilles. Eastern Caribbean Natural Management Program.

Not seen.

Fisheries Division. 2004. Barbados Fisheries Management Plan: Schemes for the Development and Management of Fisheries in the Waters of Barbados. Fisheries Division, Ministry of Agriculture and Rural Development, Barbados, 61pp.*

The Barbados Fisheries Management Plan provides a detailed description of the strategies used for managing fisheries in Barbados. The plan describes the importance of the fishing industry and the need for fisheries management planning. It looks at the fisheries resources, fishing vessels and gear, landing facilities, stakeholders, visions for the sector, barriers to the visions and strategies to overcome the barriers in the harvest sector and the various marketing strategies. The plan ends with the management plans for the eight fisheries in Barbados and the conservation strategies for sea turtles, which are no longer legally fished.

Geoghegan, T., A. H. Smith, and K. Thacker. 2001. Characterization of Caribbean Marine Protected Areas: An Analysis of Ecological, Organizational, And Socio-Economic Factors CANARI Technical Report N. 287. 29pp. *

This characterization study of Caribbean marine protected areas (MPAs) forms one component of a larger study, *Institutional evaluation of Caribbean MPAs and opportunities for pro-poor management*, which is being carried out by MRAG Ltd. under the framework of the Natural Resources Systems Programme of the United Kingdom Department for International Development. The geographic scope for the study was originally defined as all SIDS [small island developing states] and larger island states from two biogeographic zones of the Wider Caribbean: the Central Caribbean and Lesser Antilles, as well as Belize and the Turks and Caicos Islands. At the end of the document is the MPA Characterisation Data Form for Folkestone Park and Marine Reserve.

Government of Barbados. Statutory Instrument 1981, No. 28., Marine Areas (Preservation and Enhancement) (Barbados Marine Reserve) Regulations, 1981. *

In the Park there are created 4 zones, namely; (a) the Scientific Zone; (b) the Northern Watersports Zone; (c) the Recreational Zone; and (d) the Southern Watersports Zone. Section 5 prohibits a series of activities in the Reserve including injuring, destruction or removal of shellfish and/or starfish, and use of speargun, hook, and various other devices for the purposes of taking fish. Other activities may be permitted subject to restrictions imposed by the Parks and Beaches Commission. Remaining rules regulate various activities in the reserve such as entrance of fishing boats (reg. 13), use of other vessels, mooring or buoying, etc. (29 regulations).

Government of Barbados. 1985. Marine Areas (Preservation and Enhancement) Act. *

An Act for the preservation and protection of the marine life in certain submarine areas of Barbados and for the establishment of underwater parks and art centres in connection therewith. Areas can be restricted by the Minister for preservation and enhancement of areas, protection of flora, fauna and wrecks in the area, promotion of public enjoyment, promotion of scientific study and research. The Act also identifies the regulations that can be made by the National Conservation Commission.

Government of Barbados. 1985. National Conservation Commission Act. *

This is an Act to revise and consolidate the law relating to public parks, beaches and caves and related matters, and to make provision for the conservation of sites and buildings of national interest. It looks at the establishment and function of the National Conservation Commission, their finances and selling in public parks, public gardens, beaches and caves.

Government of Barbados. 1995. Fisheries Act. *

This is an Act to provide for the management and development of fisheries in Barbados. The Act is divided into four parts: Part I fisheries management and development provides details and conditions for obtaining various licences, stowage of gear, prohibited fishing methods and associated penalties for their use, registration of fishing vessels and activities in relation to fish processing, marketing and distribution. The other sections focus on safety of commercial fishing vessels and accidents at sea and enforcement.

Government of Barbados. 1998a. Coastal Zone Management Act. *

The coastal zone is one of the island's most important and valuable economic and social assets. Unfortunately development overtime has impacted on the coast in a negative way. The Coastal Zone Management Act provides a comprehensive statutory basis for coastal zone management and planning in Barbados. It provides for more effective management of the coastal resources of Barbados and for the conservation and enhancement of those resources. It makes provision for the protection of coral reefs and establishment of marine reserves.

Government of Barbados. 1998b. Fisheries (Management) Regulations. *

This stipulates the fisheries regulations relating to use of prohibited fishing methods and gears, fishery species e.g. sea urchins, lobsters, sea turtles and ornamental fish. Penalties for contravening these regulations are liable for a conviction not exceeding $50,000 BDS or two years imprisonment.

Government of Barbados. 1998c. Marine Pollution Control Act. *

As a result of physical development along the island's tourism oriented coasts, marine water quality has deteriorated. This can have serious implications for fisheries and the health of

the marine ecosystem. This Act was developed to prevent, reduce and control pollution of the marine environment of Barbados from whatever source.

Government of Barbados. 2000. Fisheries (Amendment) Act 2000-8. *

An amendment to the Fisheries Act sections 2, 8, 10, 11, 12, 13, 18, 24, 31, and 46 of Cap. 391.

Grindal, S.D., S. Carrington, D. Riven-Ramsey and K. Watson. 1998. Wildlife and vegetation surveys of Carlisle Bay, Folkestone Park and Marine Reserve, and Harrison's Cave and Associated Sites, Barbados. Technical Report-Draft. Prepared by Axys Environmental Consulting Ltd for the National Conservation Commission Barbados.

Not seen.

Hunte,W., I. Côté, and T. Tomascik. 1986. On the dynamics of the mass mortality of Diadema antillarum in Barbados. Coral Reefs 4:135-139. *

Widespread mortality of the black sea urchin *Diadema antillarum* occurred in the Caribbean in 1983; beginning in Panama in January, and having its major impact at Barbados in September. Mortality on ten reefs surveyed in Barbados was 93.2%, with the highest being 99.9% and the lowest 86.9%. Mortality on each reef was independent of the pre-mortality density on the reef. Urchins with test diameters between 20 and 40 mm were more severely affected than smaller or larger urchins. Populations on reefs exposed to incoming oceanic water suffered heavier mortality than those on protected reefs. Mean size of urchins was smallest on high density reefs. This may indicate a negative effect of density on urchin growth. At post-mortality densities, urchins may grow faster and reach sexual maturity sooner. Two sites included in the study included North and South Bellairs.

Hunte, W. and _P. Allard. 1994. Temporal changes in coral reef communities on the west and south coasts of Barbados: 1982-1992. Technical Report to the Government of Barbados and the Inter-American Development Bank. 67pp. *

The study documents the rate and nature of changes in coral community characteristics of nearshore reefs on the west and south coast of Barbados and it also identifies possible causes of community changes. This report is a result of the Barbados Coral Reef Monitoring Program which was conducted by the Coastal Zone Management Unit of the Government of Barbados in collaboration with the Bellairs Research Institute. The report states the changes in coral reef community characteristics on the fringing, patch and bank reefs on the west and south coasts of Barbados. While the report does not focus particularly on the Folkestone Marine Reserve, some reef surveys were conducted at two reef sites within the Reserve boundaries, Sandy Lane and South Bellairs.

Hunte, W., N. Callinoiu, and A. Johnson. 1994. Recovery of *Diadema antillarum* (Phillipi) on the west coast fringing reefs of Barbados, 1984-1993. For submission to Marine Biology.

Not seen.

Hunte, W., l. A. Vermeer, and R. Goodridge. 1998. Temporal changes in coral reef communities on the west and south coasts of Barbados: 1987-1997. Technical Report for Coastal Zone Management Unit of the Government of Barbados and the Inter-American Development Bank. 142pp.*

The study documents the rate and nature of changes in coral community characteristics of nearshore reefs on the west and south coast of Barbados and it also identifies possible causes of community changes. Noteworthy are the changes in community coral reef characteristics of the nearshore west coast reefs from 1982-1992, 1987 to 1992. This report is a result of the Barbados Coral Reef Monitoring Program which was conducted by the Coastal Zone Management Unit of the Government of Barbados in collaboration with the Bellairs Research Institute. The report states the changes in coral reef community characteristics on the fringing, patch and bank reefs on the west and south coasts of Barbados. While the report does not focus particularly on the Folkestone Marine Reserve, some reef surveys were conducted at two reef sites within the Reserve boundaries, Sandy Lane and South Bellairs.

Inniss, L. 1992. Review of the performance of the Barbados Marine Reserve. CCPU Report.12pp.

Not seen.

Kramer, D.L. and M.R. Chapman. 1999. Implications of fish home range size and relocation for marine reserve function. Environ. Biol. Fish. 55: 65-79p.

Reserves are being used increasingly to conserve fish communities and populations under threat from overfishing, but little consideration has been given to how fish behavior might affect reserve function. This review examines the implications of how fish use space, in particular the occurrence and size of home ranges and the frequency and direction of home range relocations. Examples are drawn primarily from the literature on coral reef fishes, but the principles apply to other habitats. Reserves can protect fish species only if individuals restrict their movements to a localized home range during at least part of the life cycle. Home range sizes increase with body size. In small reserves, a significant proportion of fish whose home ranges are centered within the reserve can be exposed to fishing mortality because their home ranges include non-reserve areas. Relocation of home ranges following initial settlement increases exposure to the fishery, especially if habitat selection is frequency-dependent. Distance, barriers, and costs of movement counter such redistribution. These considerations lead to predictions that population density and mean fish size (1) will form gradients across reserve boundaries with maxima in the center of the reserve and minima outside the reserve away from the boundary; (2) will increase rapidly in newly established reserves, only later providing `spillover' to adjacent fisheries as density-dependent emigration begins to take effect; and (3) will be higher in reserves that are larger and have higher area: edge ratios, more habitat types, natural barriers between reserve and non-reserve areas, and higher habitat quality inside than outside the reserve. (4) Species with low mobility and weak density-dependence of space use will show the greatest increase in reserves and the strongest benefit for population reproductive capacity, but those with intermediate levels of these traits will provide the greatest spillover benefit to nearby fisheries.

Lewis, J.B. 1984. The Acropora Inheritance: A Reinterpretation of the Development of Fringing Reefs in Barbados, West Indies. Coral Reefs 3:117-122. *

The discovery of the widespread occurrence of the remains of the reef coral *Acropora palrnata* within the fabric of the fringing reefs on the west coast of Barbados requires a new interpretation of their Holocene development. Radiocarbon dating of the *A. palmata* framework suggests that reef construction by this species began as early as 2,300 years B.P. *A. palmata* probably flourished in Barbados into the present century but has now declined. The present fringing reefs are characterized by a core and base of *A. palmata* upon which subsequent colonization took place, especially by *Montastrea annularis, Porites*

porites and coralline algae. The report provides data on the occurrence of *Acropora palmata* on the reefs: Bellairs North, Bellairs South and Holetown.

Lewis, J.B. 2002. Evidence from aerial photography of structural loss of coral reefs at Barbados, West Indies. Coral Reefs 21:49–56. *

In response to concerns about widespread degradation of coral reefs at Barbados, West Indies, over the past two decades, maps and planimetric areas of 20 fringing coral reefs were estimated from enlargements of aerial photographs of the island, using geographic information system analysis. There were statistically significant reductions in reef areas over a 40-year period from 1950 to 1991. Areal losses exceeding measurement and boundary interpretation errors of 10% were detected on eight of the 20 reefs. Ground validation carried out by divers on six of the reefs confirmed physical losses of reef structures and accumulation of rubble and sand substrata at sites where substantial planimetric area loss was detected on aerial photographs. Structural losses occurred along the ''spur and groove'' system of the reef seaward edge, within deep channels or breaches in the reef front, and along the flanks or ends of reefs. The location and nature of the observed losses suggest that storm damage and seasonal alterations in beach morphology are the two most important factors contributing to geomorphological structural loss of the reefs. The report provides planimetric data of fringing reefs along Sandy Lane, Sunset Crest and Bellairs.

Lewis, J.B. and H.A. Oxenford. 1996. A Field Guide to the Coral Reefs of Barbados. Biology Department, McGill University, 28pp. *

The field guide is based on numerous underwater surveys recording descriptions of habitats, abundance and occurrence of scleractinian coral and other prominent invertebrates and algae. Reefs to the west of Bellairs Research Institute have the best known reefs. The Bellairs reef is therefore described in detal first as a model for comparison with other localities in order to introduce reef terminology and spatial zonation. Bellairs and other west coasts transects are based on descriptions reported by Lewis (1960), MacIntyre (1967), Ott (1975), Stearn, Scoffin and Martindale (1977), Stearn and Harrison (1977) and from surveys compiled by Bellairs Research Institute (1984).

MacIntyre,I.G. 1968. Preliminary mapping of the insular shelf off the west coasts of Barbados, West Indies. Caribb. J. Sci. 8:95-100. *

A rapid reconnaissance was made of the narrow insular shelf off the west coast of Barbados, West Indies wit the aid of a sea sled and aerial photographs. Four distinct area noted on the shelf in order of increasing depths- fringing reefs, a belt of sand; a distinct band of dead coral rubble and a deeper area of prolific coral growth. Most of the insular shelf is an erosional terrace that was probably eroded in the last 7000 to 8000 years.

MacIntyre,I.G. 1967a. Recent sediments off the west coast of Barbados, W.I.: Unpublished PhD. Thesis, McGill University.

Not seen.

MacIntyre, I.G. 1967b. Submerged coral reefs, west coast of Barbados, West Indies. Can. J. Earth Sci. 4, 461-474. *

Seven sonar profiles of the sea floor were made at 3-mile intervals approximately perpendicular to the west coast of Barbados, W.I. Evidence from these profiles, first-hand observations, and deep-sea camera photographs indicate that two submerged barrier reefs parallel the coast at approximate depths of 70 and 230 ft. A trench is present in a deeper part of the sloping sea floor behind a small ridge at an average depth of 619 ft. The positions of the submerged barrier reefs probably were controlled by pauses in the post-

Pleistocene eustatic rise in sea level. The First Ridge was established on an erosional terrace that could have been cut during a stillstand between 12 500 and 11 500 years B.P. The Second Ridge may have been established on a narrow ledge eroded during a stillstand between 16 500 and 15 000 years B.P. The trench appears to have resulted from faulting or submarine outcropping of Tertiary sedimentary rocks.

Mahon, R. and M.B. Mascia. 2003. "The Barbados (alias Folkestone) Marine Reserve, Barbados: A Late Bloomer?" Gulf and Caribbean Research. Volume 14. Number 2. 171 to 180p. *

The Barbados Marine Reserve (BMR) is a 2.2 km^2 no-take marine reserve occupying one of the most intensely used and impacted sections of the coast and comprises four zones: Scientific, Northern Watersports, Recreational, Southern Watersports. Establishment of the BMR in 1981 did little to change the de facto marine resource governance regime for the area. There was minimal consultation of stakeholders in determining the zoning and regulations. Fishers were negatively impacted, and no user group derived significant benefits from the reserve. A mandate to maximise revenues led the National Conservation Commission (NCC), responsible for BMR management, to virtually abandon the reserve. Efforts to spur institutional change were not effective, because of the centralized authority of the NCC and the belief that the BMR could not generate revenue. In 1998, the Government initiated a study to reform marine resource governance within the BMR and adjacent areas. Stakeholder consultation revealed complex patterns of use in the area. Recommendations, adopted by the Government in March, 2001 included establishing a broader Marine Protected Area (MPA) along an expanded coastline (from 2.6 km to 9.5 km) with seven types of management zones, and renaming the area as the Folkestone Marine Managed Area. Also proposed was a Marine Management Area Authority, within the Ministry of the Environment's Coastal Zone Management Unit, to designate and manage MPA's.

Mah, A.J. 1984. The effects of Hurricane Allen on Bellairs fringing reef, Barbados. M.Sc thesis McGill University, Montreal, Canada.213pp.

Not seen.

Mah, A.J. and C.W. Stearn. 1985. Changes produced by a hurricane on a fringing reef (Barbados). Proceedings of the 5th Int'l Coral Reef Congress, Tahiti, 1985 2:232.

Not seen.

Mah, A.J. and C.W. Stearn. 1986. The effects of Hurricane Allen on Bellairs fringing reef, Barbados. Coral Reefs 4:169-176.*

On August 4, 1980 Hurricane Allen damaged the northern fringing reef located just offshore from the Bellairs Research Institute of McGill University on the west coast of Barbados. During the summer and one winter month of 1981 a resurvey of the reef was done and the results were compared with a similar survey made in 1974. On a reefal scale the changes in the proportion of substrates before and after Hurricane Allen were statistically significant for all substrates and species with the exception of *Millepora* spp. Among the corals, *Porites porites* has been most affected by the catastrophe: its coverage was reduced by 96%. The other corals (*Siderastrea sidera, Porites astreoides, Montastrea annularis*, and *Agaricia agaricites*) were reduced by 75 to 25%. Onshore transport is suggested by the high abundance of *Acropora cervicornis* (20%) and *Madracis mirabilis* (30%) in the rubble on the fringing reef (the former only grows seaward of the reef). Offshore transport is suggested by the relatively poor representation of *Porites porites* (32%) in the rubble. Shannon-

Weaver diversity indices of the corals dropped from 1.61 to 1.26. The changes in diversity are best explained by the intermediate disturbance hypothesis.

Mascia, M.B. 1999. Emergence, Evolution and Performance of the Folkestone Marine Reserve in Institutional Emergence, Evolution and Performance in Complex Common Pool Resource Systems: Marine Protected Areas in the Wider Caribbean. Durham, NC: Ph.D. Dissertation, Department of the Environment, Duke University. 388pp.

A comparative study of three MPAs in the wider Caribbean: Exuma Cays Land and Sea Park, Bahamas; Barbados Marine Reserve, Barbados and Hol Chan Marine Reserve, Belize. The study was based on two questions: "what are factors shape the social and biological performance of MPAs?" and "what factors shape MPA emergence and evolution?" This would assist in explaining the variation in MPA performance and inform development of more effective MPA policy and also provide insights into a theoretical issue at the heart of positive political economy: the relationship between institutions and individual choices. In his findings, Mascia showed that political theory accurately predicts the general relationship between institutions and the state of social biological systems. Secondly he developed an integrated theoretical framework for analysing institutional change that explains MPA emergence and evolution and a theoretically derived, empirical grounded framework for MPA governance that could significantly improve the performance of current environmental policies.

National Conservation Commission. 1997. Integrated development programme feasibility studies of Carlisle Bay, Folkestone Park and Marine Reserve and Harrison's Cave and Associated Sites, Barbados. Part 1: Technical Proposal. Folkestone Bay: Program specifics. April 25. 1997. 96pp.

This report provides details of the proposal for the Feasibility Study. It examines the conservation needs, residential uses and needs, tourism needs, biophysical site assessment, diagnostic assessment, public consultation and development of the concept plan-economic analysis, marketing sustainable tourism, visitor information and interpretation.

Nicholls, J. 1995. Recommendations for the future Operation of Folkestone Park. Jan 3rd 1995.

This brief report provides an overview of the park and provides recommendation for it e.g. promotion of FMP as a revenue earning attraction, patrolling of park.

Ott, B. 1975. Community patterns on a submerged barrier reef at Barbados, West Indies. Int. Revueges. Hydrobiol. 60:719-736.

A quantitative survey of a submerged barrier reef was undertaken in Barbados, West Indies, over a two year period (1971-73). Photo-line transects were employed to obtain coverage data on corals and other benthic organisms. Light, sedimentation, currents, oxygen, temperature and salinity were also monitored. Results indicate corals cover about 30 per cent of the bottom with living colonies; another 7 per cent is contributed by other zoobenthos. The most abundant coral species are *Montastrea annularis, M. cavernosa* and *Siderastrea siderea*, each contributing between 4 and 5 per cent of bottom cover. Light is the only physical factor monitored that correlated significantly with biomass; sedimentation may have a secondary effect. Most of the barrier reef is composed of mixed coral associations forming a biologically accommodated community. Comparisons are made between the barrier reef in Barbados and deeper reefs in Jamaica and Curacao. Reefs are, in the main, similar but coral species and community structure differences do occur.

Oxenford , H. A., M. Wittenberg, L. Vermeer. 1993. Nearshore Benthic Marine Communities of the West and Southwest Coasts of Barbados: Importance, Impacts, Present Status and Management Recommendations. DRAFT. Report to Delcan International/CCPU, Government of Barbados. 81pp. *

In recognition of the enormous importance of nearshore tropical marine communities and also the implications of their deterioration the Barbados Government initiated a feasibility study to examine coastal conservation strategies and develop a long-term Coastal Zone Management Plan to guide further development towards sustainable use of coastal resources. This report attempts to examine the nearshore marine communities of particular importance to Barbados, to summarise what is known about factors responsible for their degradation, to document their present status, and to suggest mitigation and management measures which could be considered in the Coastal Zone Management Plan for the island. The report focuses partly on the west coast identifying the characteristics of the reef, status and also for sea grass beds.

Ratikin, A. 1994. The effect of a marine reserve on the abundance and size of coral reef fishes in Barbados, West Indies. MSc Thesis, Department of Biology, McGill University, 65 pp.

The study used trapping and visual census surveys to assess whether a marine reserve in Barbados effectively protected coral reef fish stocks and whether there was evidence of emigration from the reserve. Fish abundance and sizes were higher in the reserve than in surrounding non-reserve areas. Relative differences in abundance and size between reserve and non-reserve of different taxa were positively correlated to vulnerability to traps (the most common fishing method) but not to mobility of fish. Gradients of abundance across the reserve boundaries (decreasing abundance but not for individual taxa. These patterns suggest that the reserve does protect fish stocks and that emigration is of minor importance.

Rakitin, A. and D.L. Kramer. 1996. The effect of a marine reserve on the distribution of coral reef fishes in Barbados. Mar. Ecol. Prog. Ser. 131: 97-113p.*

High population densities of larger fish within reserves could result in emigration of fish to surrounding non-reserve areas, producing a gradient of abundance and mean size across the reserve boundaries. The difference in fish abundance and size between reserve and non-reserve should be higher for sedentary than for mobile species and for highly catchable than for less catchable species. To test these hypotheses we estimated the abundance and size of fishes by trapping and visual census on fringing reefs in Barbados: 5 reefs within the 2.2 km of the Barbados Marine Reserve (BMR) and 8 reefs in the non-reserve (NR) area within 4 km of the reserve boundaries. The abundance of large, trappable size fish of all species combined was higher in the BMR than in the NR, but abundance of small, nontrappable fish did not differ between BMR and NR. Trap catches decreased gradually with distance from the BMR center, but this gradient of abundance was less evident in visual census counts of trappable size fishes of all species combined and not apparent in trap or visual census estimates of abundance for individual species. Mean size was larger in the BMR than in the NR for 18 out of 24 species. The relative differences in both abundance and size between BMR and NR did not differ between mobile and sedentary fish taxa. However, for sedentary taxa, the relative differences in abundance and size increased with trappability (the vulnerability to traps, which are the most common fishing method). These patterns suggest that the BMR does protect the fish community from fishing mortality and that emigration rates are generally low. Trappability and mobility depend on complex behavioural characteristics of fishes and are potentially important for the functioning of marine reserves.

Renard,Y., N. Brown, T. Geoghegan. 2001. Stakeholder Approaches to natural Resource Management in the Caribbean. 25pp.*

The paper describes a research project, "Synthesizing the Caribbean experience in stakeholder analysis for participatory natural resource management," carried out by the Caribbean Natural Resources Institute (CANARI) in 2000 for the purpose of assessing the growing body of experience in stakeholder approaches in the region. The project received support from the International Development Research Centre under the framework of the project entitled Community-Based Coastal Resource Management in the Caribbean; the University of the West Indies Centre for Environment and Development through its project Caribbean Capacity- Building for Environmental Management; the Environmental Foundation of Jamaica; and the UK Department for International Development as part of its regional programme Capacity-Building for Community Participation in Natural Resource Management, which is implemented by CANARI. The major activities of the project were the preparation of six case studies from around the region documenting examples of stakeholder approaches in a variety of contexts, and the convening of a seminar in April 2000 to review and analyse the case studies for the purpose of deriving lessons and methods for stakeholder approaches that are appropriate for the region. This paper summarises the conclusions of the project, complemented by lessons learnt by CANARI in field activities and training programmes in the region. It also offers a brief summary of the six case studies prepared for the seminar. The paper was prepared by three members of CANARI's staff, Yves Renard, Executive Director; Nicole Brown, former Communication Coordinator; and Tighe Geoghegan, Associate Director. One of these studies included the Case study of the Folkestone Marine Park and Reserve, Barbados.

Richards, A. and J.B. Bird. 1970. Beach studies on the west coast of Barbados, 1967-1969. McGill University, Department of Geography, Manuscript Report, 83 pp. *

In 1967 an extensive program of cliff and beach measures was commenced. Six beaches were selected as intensive study area: Maycocks, Six Mens, Gibbs, Sandy Lane and Holetown. Information on seasonal variation in wave emergence and refraction patterns were determined.

Sander, F. 1972. Suggestions on marine parks in Barbados. Paper presented at the Carribean Conservation Association AGM, St. Kitts and Nevis.

Not seen.

Scoffin, T.P., C.W Stearn, D. Boucher, P. Frydl, C.M. Hawkins, I.G. Hunter and J.K. MacGeachy. 1980. Calcium carbonate budget of a fringing reef on the west coast of Barbados: Part 2: Erosion, sediments and internal structure. Bull. Mar. Sci. 30:475-508. *

The rates and effects of the erosion of a discrete fringing reef were determined so that when combined with figures for the rates of CaCO, production for the same reef (Steam, Scoffin and Martindale, 1977) a budget for the CaCO3 of the reef could be established (Steam and Scoffin, 1977). Mechanical erosion of the reef edifice is negligible other than during heavy storms. Visual observations suggest that significant movement of grains occurs only during winter. Loose sediments on and around the reef were analyzed for grain size and constituent composition to reveal their origins. These analyses showed that the major portion of the sediment is derived from the breakdown of the primary framework and that bioerosion plays an important role in controlling the grain size, shape and texture of the particulate sediments. Excavation by bivalves, barnacles and worms contribute towards reef degradation, but the boring sponges are markedly the most effective of the boring

organisms. The quantity of CaCO3 removed by borers was determined either by direct measurement with calipers and rulers for the thinly branched corals, *Porites porites*, or by totalling the voids seen in X-radiographs of slices of skeletons for the massive corals. Knowing the growth rates of the corals it is possible to calculate the percentage of their skeletons removed per year. It was concluded that approximately 24.9 ± 4.4 x 106 g CaCO, are excavated from the reef annually by boring animals. The grazing organisms on the reef include worms, gastropods, parrotfish and sea urchins. Erosion by worms and gastropods is insignificant. Of the parrotfish only *Sparisorna viride* occurs in considerable numbers and feeds dominantly on the rocky substrates. The abundance and size of the fish were recorded, their gut contents analyzed and the rate of turnover of gut contents assessed. From these observations a figure of 0.4 ± 0.05 x 10° glyr was deduced for annual removal of CaCO, from the solid reef by parrotfish. Sea urchins, Diadema antillarum, are exceedingly abundant on the reef rocky substrates averaging 23 individuals per m'. The test size distribution of the population was measured and the rate of CaCO, fecal production for each size class was determined. The proportion of the reworked carbonate in the fecal waste was determined after petrographic analyses of the pellets. An annual grazing rate of the reef framework by Diadenia of 97.5 ± 5.7 x 10° g CaCO3fyr was obtained. A quantity of reef sediment is incorporated back into the reef rock which later may be reworked by bioemosion. In order to assess the extent of inorganic incorporation of CaCO, into the reef edifice buried reef rock was excavated and analyzed by SEM to record the extent of diagenetic alteration. These final studies indicated that the CaCO3 reincorporated and inorganically precipitated into the reef amounts to about 17% by weight of the coral skeletal carbonate, i.e. 29.8 ± 3.9 x 10° g)yr. The budget synthesis indicates a CaCO3 production on the reef of 206 ± 10 x 10° g/yr and a removal from the reef of 123 ± 7 x 10° g/yr. The internal structure of the preserved reef is fundamentally shaped by the interaction of the growth and bioerosion processes.

Stearn, C.W. and T.P. Scoffin. 1977. Carbonate budget of fringing reef, Barbados. Proc. 3rd Int'l Coral Reef Symposium, Miami, Florida. 2:471-476.

The rate of calcium carbonate production by corals was determined by measuring the annual growth increments revealed by X-rays in the species determined by areal surveys of the reef to be important in building the framework. The rate of growth of coralline algae was measured from artificial substrates and staining experiments. The co2als and algae fix about 160 metric tons per year of CaCO3 over a planimetric area of about 10,800 m of rocky substrate. Studies of the extent of boring by sponges, barnacles, and bivalves in the corals suggest that about 1.5 metric tons are removed by these organisms per year. These same borers are estimated to remove 23.5 metric tons from the algal encrusted dead coral surface. The effect on the reef structure of grazing by parrotfish is calculated to be about 1 metric ton per year but the urchin Diadema antillarum scrapes up to 163 tons per year of the substrate from the reef in grazing on algae. Although not all factors of construction or destruction have been taken into account, these figures suggest a considerable deficit in the carbonate budget of the reef.

Stearn, C.W., T.P. Scoffin, W. Martindale. 1977. Calcium carbonate budget of a fringing reef on the west coast of Barbados: Part 1. Zonation and productivity. Bulletin of Marine Science, 27:479-510p.

Not seen.

St. Hill, Y. 1985. You and Your Marine Environmental: An Introduction to the Folkestone Underwater Park. Produced by the Ministry of Tourism and the Environment of Barbados. Funded under the Caribbean Environmental Education

Programme, a project funded by the USA for International Development and directed by RARE in cooperation with CCA. 20pp.*

The booklet was written for several audiences particularly visitors to the Folkestone Underwater Park and Marine Museum, general public and schools. The information will give visitors an understanding if what they see and how not to damage it. The booklet will provide visitors to the park with a wide appreciation of the underwater world. It can also be used as a teacher's guide.

St. Hill, Y. 1987a. Brief on Barbados Marine Reserve. Rationale for the Establishment of the Marine Reserve. 5pp.

Not seen.

St. Hill, Y. 1987b. Management Plan for the Barbados Marine Reserve. Environment Unit. Ministry of Employment, Labour Relations and Community Development, Barbados.

Not seen.

St. Hill, Y. 1987c. The protected areas of Barbados, Report no. 2, Management plan for the Barbados Marine Reserve. Environmental Unit, Ministry of Employment, Labour and Community Development, Bridgetown, Barbados.

Not seen.

Tupper, M. and F. Juanes. 1999. Effects of a marine reserve on recruitment of grunts (Pisces: Haemulidae) at Barbados, West Indies. Environ. Biol. Fish. 55: 53-63pp.*

The effects of a non-extractive marine reserve on the recruitment dynamics of haemulid fishes and their predators on Barbados coral reefs were studied using visual census and mark-recapture methods. Size and abundance of piscivores (including large adult grunts) known to prey on grunts were greater within the reserve than on adjacent reefs, whereas size and abundance of older juvenile grunts did not differ between protected and exploited reefs. Recruitment and early juvenile abundance were lower within the reserve and were inversely related to predator density (including adult conspecifics). Patterns in density of new recruits may also have been influenced by oceanographic patterns of supply of larvae. Thus, although protection has a significant positive effect on the size and abundance of large carnivorous fishes, higher predation pressure within a reserve may serve to reduce juvenile recruitment within the reserve. At some size/age, cumulative recruitment due to lower size-specific predation mortality results in higher density within the reserve. This increased density is maintained by the absence of fishing mortality within the reserve. Despite maintaining high spawning biomass of several large, commercially exploited species that may export larvae to downstream areas, the Barbados Marine Reserve appears to be a local sink for juvenile grunts.

VERMEER, L.A. 1993. A compilation and summary of marine benthic studies conducted in Barbados between 1960 and 1990. For Delcan International Ltd. and the Government of Barbados, 271pp.

The report summaries the results of significant surveys of nearshore benthic marine communities around Barbados conducted over the period of 1960 to 1990. It reviews 45 different studies and provides information on benthic communities at 77 different sites around Barbados. The material is presented on a site by site basis with each study providing information on a particular site being summarised in a series of brief text statements with

accompanying relevant citation tables, figures. It is intended that this document will serve as a concise reference source for information on the characteristics of nearshore benthic marine communities around Barbados over the period 1960-1990. Noteworthy is the information on the sites Sandy Lane, Bellairs and Holetown which lie in the current marine reserve.

UNEP/IUCN. 1988. Coral Reefs of the World Volume 1: Atlantic and Eastern Pacific. UNEP Regional Seas Directories and Bibliographies. IUCN, Gland Switzerland and Cambridge, U.K./UNEP, Nairobi, Kenya. 373pp.

Patrick Cotter, a US Peace Corps Volunteer, compiled details about the Barbados Marine Reserve. The report briefly looks at physical features of the reef structures/coral. The fauna and flora have been identified along with economic value, social benefit, disturbance deficiencies e.g. Holetown River at the Reserve. The reserve was officially established on the 29 November, 1980 and relevant legislation and management is controlled by the National Conservation Commission.

Wittenberg, M. and H.A. Oxenford. 1994. Nearshore Marine Water Quality of the West and Southwest Coasts of Barbados: Present Status and Management Recommendations. DRAFT. 86pp.*

The quality of nearshore marine water is of great importance to the overall maintenance and functioning of the coastal ecosystem. Anthropogenic activities continue to deteriorate nearshore water quality which will cause serious economic consequences for commercial shelf fisheries, the stability of breaches, tourism and public health. In recognition of these facts, the Barbados Government has initiated a feasibility study to examine conservation strategies, and to develop a comprehensive long-term coastal zone management plan (CZMP), to guide further development towards sustainable use of its coastal resources. The report attempts to outline the nearshore marine water pollutants of concern to Barbados; to examine the present status of nearshore marine water quality on the west and south coasts; to recommend water quality threshold levels for benthic marine communities and for recreational bathing; and to suggest mitigation and management measures for consideration in the CZMP for the island.

Wong, P.P., 1971. Beach changes and sand movement in low energy environments, West Coast, Barbados. McGill University, Department of Geography, Manuscript Report, 108 pp. *

The report examines the physical characteristics of beaches, beach gradient, transport of sediment and sediment size.

Internet resources

These references are internet resources of information relating to the Folkestone Marine Reserve.

**Axys Environmental Consulting Ltd. 2000e. Feasibility studies for Carlisle Bay and Folkestone Marine Reserve, Barbados.2pp. *
http://www.axys.net/clients/casestudies/diversified/barbadoscoastal.pdf.Last accessed, 9th May 2008.**

Feasibility studies assessed the long-term sustainability of tourism development in two coastal parks on the island of Barbados. AXYS managed a team of Barbadian, Canadian and other consultants to complete the assessment and planning studies. The team also worked closely with staff of the Environmental Special Projects Unit and the Coastal Zone Management Unit (Ministry of Environment) throughout the project.

CERMES. 2008. Community-based Coral Reef Monitoring and Management project website. http://cavehill.uwi.edu/cermes/folkestone.html. Last accessed, 9th May 2008.

This website provides project information relating to the Community-based Coral Reef Monitoring and Management Project which was initiated by Caribbean Conservation Association in collaboration with the National Conservation Commission and also the Centre for Resource Management and Environmental Studies, focusing on the Folkestone Marine Reserve on the west coast of Barbados. The project's programmes and resulting reports can be obtained via the website. A number of project documents will be produced by this project.

CZMU. 2008. Marine Protect Areas: Folkestone Marine Park and Reserve. http://www.coastal.gov.bb/pageselect.cfm?page=17. Last accessed, 9th May 2008.

This briefly describes the establishment of the Reserve in 1981 and provides details about the four designated zones.

DECLAN. 1991. Barbados Coastal Zone Management Program. http://www.delcan.com/pdfs/PDS-Water-Infrastructure/PDS-Barbados.pdf. Last accessed, 22nd May 2008.*

An integrated management program to protect and enhance the marine and terrestrial environment.

Horrocks, J.A. 1992. WIDECAST Sea turtle Recovery Action Plan for Barbados (K.L. Eckert, Editor). CEP Technical Report 12. UNEP Caribbean Environment Program, Kingston, Jamaica. 61pp. Also available online at: http://www.cep.unep.org/pubs/Techreports/tr12en/content.html. Last accessed, 9th May 2008.

The WIDECAST Sea Turtle Recovery Action Plan for Barbados strongly supports ongoing efforts at improving sea turtle conservation legislation, enhancing the effectiveness of law enforcement and coastal zone management, and allocating financial and personnel resources more efficiently by consolidating coastal zone responsibilities. The Plan also supports ongoing field research and public awareness campaigns and proposes several activities to enhance and expand sea turtle conservation in Barbados. The report makes reference to the Barbados Marine Reserve that protects sea turtles from pollution and harvest within the boundaries of the Reserve.

National Conservation Commission. no date. Folkestone Marine Park. http://www.nccbarbados.gov.bb/ .Last accessed, 9th May 2008.

Briefly discusses the establishment of the reserve and the designated zones. The park has prohibited activities and it is protected under the Marine Areas (Preservation & Enhancement) Act CAP 232A.

Parker, C. and H.A. Oxenford. 1998. CARICOMP Caribbean coral reef, seagrass and mangrove sites: Barbados. Bellairs Research Institute, McGill University, Holetown, St. James, Barbados Marine Resource and Environmental Management Programme, University of the West Indies, Cave Hill, Barbados. http://www.unesco.org/csi/pub/papers/parker.htm#Fig.%204 .Last accessed, 9th May 2008. *

The CARICOMP sites on Barbados include a reef site near Holetown on the west coast and, 25 km away on the south coast, a seagrass site (St. Lawrence Lagoon) and a mangrove site (Graeme Hall Swamp). The 32 ha Graeme Hall Swamp is fringed by red and white mangroves and is greatly impacted by a large population and several channel-dredging projects. The seagrass site is located in a shallow lagoon that is protected from high energy waves by a reef rubble bank; turtle and manatee grasses dominate. Shallow fringing reefs are fairly extensive along the west coast of Barbados. The reef site, the Bellairs fringing reef, extends 300 m seaward from the shoreline and is very shallow, with the base of the reef at a depth of 6 m. *Agaricia agaricites* is the dominant coral species, but *Porites porites* was dominant before Hurricane Allen in 1980.

UNEP/CEP/Sida/CaMPAM. 2008 Caribbean MPA-A database of the Wider Caribbean's Marine Protected Areas.
http://cep.unep.org/caribbeanmpa//recently_modified .Last accessed, 28th May 2008.

This database is part of the Caribbean Marine Protected Area Management (CaMPAM) Network and Forum activities and aims at providing detailed and standardized information of the protected areas located in the coastal areas of the 34 countries and territories that are part of the Wider Caribbean or Tropical Northwestern Atlantic Coastal Biogeographic Province. This activity includes not only the compilation and dissemination of information, but also the generation of analytical products that can assist the management and academic communities to better understand the MPA scenario in the Wider Caribbean. The Barbados (Folkestone Marine Reserve) is listed in the database. Information on the geographic location and size, physical description, legal aspects and management is provided.

UNEP/WCMC and IUCN-WCPA. 2008. World database of protected areas.
http://www.unep-wcmc.org/wdpa/sitedetails.cfm?siteid=27&level=nat.Last accessed, 9th May 2008.

This database houses information about all of the protected areas worldwide. It provides details about the local designation, date of designation, IUCN Management category, geographic location, altitude, size of the reserve. It also provides a brief list of the flora and fauna species existing in the reserve.

3 Subject Index

3.1 Coral reef communities and related species

Bateson et al., (no date);); Bellairs Research Institute (1984); Bellairs Research Institute (1989a); Bellairs Research Institute (1989b); Bellairs Research Institute (1996); Bellairs Research Institute (1997);Chapman (1997); Chapman (1999); Chapman and Kramer (2000); Horrocks (1992); Hunte et al (1986); Hunte et al., (1994a); Hunte et al., (1994b); Hunte et al., (1998); Lewis (1984); Lewis (2002); Lewis and Oxenford (1996); Kramer and Chapman (1999); Mahon and Mascia (2003); Mah (1984); Mah and Stearn (1985); Mah and Stearn (1986); Mascia (1999); MacIntyre (1967a); MacIntyre (1967b); MacIntyre (1968); Parker and Oxenford (1998); Ott (1975); Oxenford et al., (1993); Rakitin (1994); Rakitin and Kramer (1996); Renard et al., (2001); Tupper and Juanes (1999); Scoffin et al., (1980); Stearn and Scoffin (1977); Stearn et al., (1977), St. Hill (1985), Vermeer (1993), UNEP/IUCN (1988); Wittenberg and Oxenford (1994).

3.2 Coastal ecology and dynamics

Bird (no date); Bird et al., (1979); Richards and Bird (1970); Wong (1971).

3.3 Marine Reserve management

Axys Environmental Consulting (Barbados) et al. (1998a); Axys Environmental Consulting (Barbados) et al. (1998b); Axys Environmental Consulting (Barbados) et al. (1998c); Axys Environmental Consulting (Barbados) et al. (2000a); Axys Environmental Consulting (Barbados) et al. (2000b); Axys Environmental Consulting (Barbados) et al. (2000c); Axys Environmental Consulting (Barbados) et al. (2000d); Axys Environmental Consulting Ltd (2000e); Axys Environmental Consulting (Barbados) et al. (2001a); Axys Environmental Consulting (Barbados) et al. (2001b); Axys Environmental Consulting (Barbados) et al. (2001c); Axys Environmental Consulting (Barbados) et al. (2006a); Axys Environmental Consulting (Barbados) et al. (2000b); CERMES (2008) Cotter (1981); Cotter (1982); Cumberbatch (2001); CZMU (1998); CZMU (1999); CZMU (2008); DECLAN International Corporation (1991); DECLAN International Corporation (1995a); DECLAN International Corporation (1995b); DECLAN International Corporation (1995c); Edwards (1994); ECNAMP (1980); Horrocks (1992); Geohegan et al., (2001); Grindal et al., (1998); Inniss (1992); National Conservation Commission (no date); National Conservation Commission (1997); Olsen (1990); Sander (1972); St. Hill (1987a); St. Hill (1987b); St. Hill (1987c); Nicholls (1995); UNEP/CEP/Sida/CaMPAM (2008), UNEP/WCMC and IUCN-WCPA (2008).

3.4 Laws and regulations

Government of Barbados (1981); Government of Barbados (1985a); Government of Barbados (1985b); Government of Barbados (1995); Government of Barbados (1998a); Government of Barbados (1998b); Government of Barbados (1998c); Government of Barbados (2000); Fisheries Division (1997); Fisheries Division (2001).