ISLAND RESOURCES FOUNDATION

Caribbean Headquarters
6296 ESTATE NAZARETH NO. 11, ST. THOMAS
U.S. VIRGIN ISLANDS 00802-1104
TEL: (809) 775-6225 • FAX: (809) 779-2022

Washington, D.C. Office
1718 P STREET, N.W., SUITE T4
WASHINGTON, D.C. 20036
(202) 265-9712

THE ISLAND MICROCOSM

BY
EDWARD L. TOWLE
PRESIDENT
ISLAND RESOURCES FOUNDATION

Prepared Under Contract To
The U.S. National Park Service
(For the U.S. Agency for International Development)

Contract No. CX-0001-3-0048
Order No. PX-0001-3-0499

April 1984

EXTRACT

"THE ISLAND MICROCOSM"

By:
Dr. Edward L. Towle, President
Island Resources Foundation
6296 Estate Nazareth No. 11
St. Thomas, U.S. Virgin Islands 00802-1104

Originally Published In:

COASTAL RESOURCES MANAGEMENT: DEVELOPMENT CASE STUDIES

Renewable Resources Information Series
Coastal Management Publication No. 3

John R. Clark, Editor

Prepared By:

Research Planning Institute, Inc.
Columbia, South Carolina

For:

U.S. National Park Service
and
U.S. Agency for International Development

March 1985

ISLANDS: FUTURE AND PAST

In the event of a nuclear Armageddon,
islands may well be mankind's only hope
for a future as the continents
will be uninhabitable.
(Anonymous, 1984)

The sea has long dominated the history of the Virgin Islands. It has, until the advent of the air age, been the only route to the outside. It has also been a constant source of food and recreation. The threshold to the sea that surrounds us is the shoreline. The shorelines of the Virgin Islands have in the past been used freely by all residents and visitors alike. The seashore has been a place of recreation, of meditation, of physical therapy and of rest to Virgin Islanders, past and present. To fishermen the sea and its shores are a way of life. The second half of the twentieth century has brought adverse changes to the Virgin Islands shorelines. There has been uncontrolled and uncoordinated development of this area.

(Open Shorelines Act, Title 12 of the U.S. Virgin Islands Code, 1972)

The tidal wave devours the shore
There are no islands any more.

(Edna St. Vincent Millay, 1940)

In everything, respect the genius of the place.

(Alexander Pope, Essays on Man, 1733)

CONTENTS

SUMMARY

This study is concerned with the coastal resources of smaller, offshore developing island systems. Perspectives on the nature, constraints, and implications of "insularity" are interwoven within an analysis of the extensive literature on islands of all types. Classification strategies regarding the island universe are reviewed, as is the possible instructional use of detailed studies of "island microcosms" as models for comprehension of larger, more complex continental ecosystems. A major conclusion is that smaller oceanic islands are sufficiently different from continental areas to require customized, carefully adapted, and more participatory kinds of resource assessment, planning, development and management strategies, especially since islands tend to be far more dependent on coastal and marine resources than continental countries. Examples of island system gains and losses from the environmental impacts of poorly planned, externally initiated development projects are presented. Summaries are given of successful "model" approaches to island coastal resource assessment, planning and management.

The analysis examines the vulnerability, dependency, stability, and ecological integrity of islands, principally within the context of externally induced, rapidly implemented, and sometimes inappropriately scaled and designed development initiatives that are often stimulated by outside interests and factors. The significance of island coastal zones and the use of their marine resources, along with the evolving theories and practices of resource management, are reviewed. An attempt is made to analyze and document the way in which insular systems respond to stress and their customarily very short list of true options.

Study findings suggest the need for serious modifications of standard continental approaches to coastal resource management if they are to be applied to tropical islands.

CONTENTS

1. INTRODUCTION

1.1 Continental Perspectives on Islands

In man's imagination, islands have always been lands of promise--promises of escape from the mundane to high adventure or an unknown delight. Sir Thomas More located Utopia on an island in mythical seas. For those who live on continents, the greatest attraction of the world's oceanic islands is their detachment, both from the mainland and from mainland routines. Crossing water to reach an island becomes a symbolic act of leaving behind too familiar activities and unsolved problems.

Islands can be fun. They tickle the imagination; they conjure up fantasies and dreams. They are wonderful places to visit, to study, to poke about, and to write about. They are also fun to read about (remember Defoe's Robinson Crusoe, The Swiss Family Robinson by Wyss, Goldings' Lord of the Flies, Hemingway's Islands in the Stream and Melville's Typee, among others). Tourists by the tens of millions search for them and artists and writers retreat to them, while ocean-going yachtsmen and cruise ship passengers collect them as log or diary entries, and natural scientists and anthropologists find them ideal "mini-laboratories"--neat, clean, comprehensible and Eden-like, with endemic, symbolic "apples" ripe for academic picking from the insular tree of knowledge! A genuine discovery perhaps awaits the intrepid island investigator.

However, not everyone cares for islands. There are at least two that Napoleon was not happy with (recall his: "...able was I ere I saw Elba"!), and Papillon could have done without his private room on that special green island in the sun off the coast of South America. Columbus, too, was displeased when he found that islands had an annoying habit of getting in his way en route to Cathay.

Similarly, larger, continental nations do not really appreciate them because they are so small and "clutter up" the United Nations and other international fora; the UN, in turn, has often found islands a troublesome lot, pleading special case circumstances, isolation factors, and smallness as a disadvantage and arguing they are "different".

Nevertheless, with a few exceptions, islands remain a source of enjoyment available to everyone, especially since there are so many of them --500,000 "islands, isles and islets" according to the U.S. Department of State (Hodgson, 1973)--seemingly enough to go around to meet everyone's fantasies and dreams of paradise, for exploration, study, or escape. But things are not quite that simple--ask any islander about these continental perspectives on his or her insular home for a contrary point of view!

The flippancy of the above paragraphs is deliberate because it reflects the often equally flippant, if not frivolous and wrong-headed perspective of many continental people regarding the nature of islands. How, they question in a condescending manner, can a small vacation spot in the middle of the ocean or even along a coastline be a "country"? A Club Med, yes; exotic, idyllic, nostalgic, backward, traditional, remote, yes. But a real country, a full-fledged nation--impossible!

To a large degree, smaller oceanic and coastal islands have been traditionally perceived by continental peoples as interesting but only satellite appendages, frontier outposts, or recreational sites. Whether colonial, territorial, or even politically independent, most smaller islands are viewed by continental powers as marginally valuable and marginally viable--as difficult, but exploitable geographical hybrids. Islands of all types (coastal, oceanic or grouped as an archipelago) have, therefore, historically been treated in a cavalier, even callous, manner and have frequently been administered with general disregard for the "niceties" of prevalent democratic theory, political morality, social ethics, and--more recently--environmental principles or standards.

There is, unfortunately, in the mind's eye of many "mainlanders" only a fuzzy, artificial island construct--part metaphor, part myth, part fiction, part caricature that obscures, distorts and even, on occasion, blinds the observer about what an island (or insularity) really is and how it "fits" into the rest of the world.

For this reason alone, islanders are always at risk. The continental's skewed perception or island expectation model constitutes a one-sided, conceptual barrier which further skews any transactional process linking or involving the island system and the larger continental system.

There are other dysfunctional imbalances that characterize the large vs. small or continental vs. insular relationship (which will be discussed later in this study). Yet this particular problem is sufficiently pervasive and on occasion pernicious enough, when development planning and resource management are addressed, to require an early cautionary note for the reader. It may account for why island systems literature and documentation, in the aggregate, is so diverse and inconsistent and lacks both a unified theoretical and empirical base. There has been little consensus.

1.2 Contemporary Pressures on Island Systems: An Overview

At the present time, thousands of islands are experiencing strong development thrusts based chiefly on tourism, on extractive enterprises, on their use as nodes for international air transportation and satellite tracking networks, and on the increased demands for and upon local resources generated by rising affluence and expectations among rapidly growing island populations. Additional driving forces include continentally based initiatives seeking waste disposal sites, deep-water petroleum transhipment sites, cruise ship ports, offshore banking centers, low-cost labor for materials processing and assembly, and expanded supplies of harvestable high-value marine species (like tuna, lobster, conch, and certain seaweeds). The availability of multinational and bilateral aid programs has also contributed to accelerated development activities.

One by-product of this current development phenomenon has been a dramatic deterioration of island coastal environments, accompanied by a decline in the quality of life on islands, as measured by means other than such traditional economic indicators as gross national product (GNP) and average per capita income. On islands, as elsewhere, progress has its price. As insular smallness confronts continental bigness in its various manifestations, what are the prospects for islands and island people? The pessimist well may say there is no hope, for island cultures, environments, and ecosystems will be overwhelmed and fundamentally changed if not destroyed. But for those who can say of an island (as once did Rupert Brooke), "This is my home, my native land," the values of smallness, isolation, self-sufficiency, and the insular condition have a special meaning and promise. If islanders are uneasy, it is understandable. And if the process of change is to be managed and sustainable island ecodevelopment is to become a reality, then the skills, expertise and accrued learning of islanders, continental scholars and development specialists need to be applied in the search for island growth, resource management and survival strategies.

How urgent is the task? "Maybe you can afford to make a mistake on a continent," warned Ray Fosberg. "The thing you damage or destroy probably exists in two or three other places but almost every island has something unique on it. Anything you do on an island makes a difference. You just can't always tell what the difference is going to be" (Gosnell, 1976). Aldo Leopold once reflected, "One of the penalities of an ecological education is that one lives alone in a world of wounds. Much of the damage inflicted on land is invisible to laymen." Unfortunately, in the special case of the world's oceanic and coastal islands, much of the damage being inflicted is invisible to almost everybody involved--except the islanders themselves. As in the case of the old saying, "out of sight, out of mind," insular remoteness obscures from all but a few persons the burgeoning impact of contemporary continental pressures and well-meaning but often ill-designed international development strategies on small insular systems, their associated terrestrial and coastal environments and their human production systems.

Twelve years ago, an island biogeographer, Sherwin Carlquist, observed (1972), "Access to islands is far easier than it has ever been, and island biotas, many relatively intact now, are going to be devastated soon to the point where all we will have to study are shreds of the marvelous fabrics of evolution that inspired Darwin and Wallace...." "There is plenty of evidence," according to Bill Newman, Professor of Oceanography at Scripps, "that almost anything we do on islands makes them worse" (Gosnell, 1976).

The stresses and pressures of rapid population growth, unrestrained development, and modern technology are partly responsible for the decline of the environmental quality of island systems and their littoral zones and for coastal zone competition and conflict among traditional and prospective users. Another increasingly apparent cause of the decline is a serious methodological failure in the omission of environmental resource values in planning and development strategies. The principal question now is how to incorporate environmental criteria to a far greater degree in the modernization of island communities, as they are shaped by local forces, transnational corporations, external market factors and by development agencies involved in or responsible for external financial and technical assistance in islands. A derivative of this has been the procedural and technical failure of the development planning process to comprehend or deal specifically with island coastal zone or marine resources, use opportunities, conflicts, trade-offs, and externalities (see Section 6.3).

1.3 Study Objectives

The primary objectives of this extended case study are to address the questions of the verifiability and utility of the island microcosm concept, to explore the theoretical and empirical underpinnings to the concept of both island ecosystems and an island model or paradigm, and to develop from the extensive literature and from several site specific analyses an updated set of rules for the design and implementation of development projects in small island systems.

1.4 Antecedent Methodological Considerations

A "microcosm" is a diminutive representative world or system analogous to a much larger system. It is not so much dwarf-like as it is a miniaturized replicate in substance, structure, and process. Assuming for the sake of argument that islands are in fact a microcosm, a number of questions arise. The most important one is, microcosms of what? Are they microcosms of continents? Of man-environment interaction on continents? Can a smaller island be seen as a microcosm of other larger islands? Are they microcosms of closed systems or open systems (most islands are viewed as closed systems but are they in fact open systems)? Are they only microcosms of smaller, continental microstates, as Dommen

(1980b) and Jones-Hendrickson (1979) have argued? Or are they microcosm models of the development and resource management process and therefore to be seen as artificial or genuinely real laboratories of one or both processes? Is the whole idea of microcosm simply an analog, a way to describe the target area, a vehicle for analysis and evaluation, or is it the result of a standard (perhaps naive) continental view of islands as smaller, discrete systems that are more manageable for the resource planner, the conservationist, or the development change agent? Alternatively, are islands a true archetypal form of global real estate that is only artificially and perhaps inaccurately assumed to be a microcosm of other systems, whatever those systems might be?

If one assumes that, for whatever definitional, hypothetical or strategic reason, some kinds of islands are a microcosm of something larger (insular or continental), then one also has to address the question of how then to classify islands as microcosms. This immediately raises the issue of an island taxonomy; and matters of size, of levels of development, of economic structure, culture, ethnicity, dependency, complexity (a single island vs. a multiple island grouping), linkages to adjacent islands, archipelagic status, population, GNP, and other parameters become important in some yet to be determined fashion.

This in turn raises other questions. Are islands really different? What makes them so? Are the differences significant or secondary constraints regarding model transfer? Does the existing literature which suggests they are scientifically and ecologically "different" (especially when considered within that portion of the ecological framework called biogeography) constitute a sufficient differentiation to require different approaches in development strategies, different approaches in conservation strategies and different approaches in coastal resource management within such island systems?

If there is an argument for substantive differences, then how does one conceptualize the development paradigm for islands? Do we have one --or more? Should it focus on structural factors, on process, or on intervention strategies to address the problems that have arisen from the applications of continental development paradigms (like the market system, central planning, free trade, or protectionism) to island areas? Are the larger continental systems development models and practices truly applicable to the insular microcosm? Is the relationship symmetrical or not? If not, can we assume that the assymetry is disadvantageous to islands (for example, through the one-way "brain drain" factor or tilted terms of trade in commodities, technology transfer or economies of scale and capital-intensive resource development, which all tend to favor the more developed and/or larger system or country)?

Regarding islands' vulnerability or victimization, are these derived solely from insular status? Is there a way to document (as per Hamnett et al., 1981) a unique insular system vulnerability factor and to document island victimization, dependency, and exogenously imposed limits on options?

The island "coastal" model is obviously unlike all continental "coastal" models (considered holistically). All islands have circumferential (surrounding) sea-land boundaries or coastal zones, whereas continental microstates do not. Is this "surrounding sea" an important or vital variable? What does a surrounding sea or marine environment do to an insular microstate model that it cannot do to a continental coastal model? Lastly, how does the microstate model for an island affect the treatment of satellite mini-islands on the periphery?

This litany of queries is not a checklist of what follows but illustrates some of the complexities of what appears to be a simple assumption--that islands are microcosms (of something) and that, by implication, some lessons learned in one or more islands are transferable to someplace else. Since paradigms as approaches are less rigid than models (and therefore less island-type specific), we put forward the a priori assumption that the microcosm concept may lead to more effective customized models (for analysis or management), but that only the currently emerging, more holistic, still transitional island paradigm can put the "microcosm" hypothesis to a proper test regarding both its validity and utility.

1.5 Case Study Methodological Design

Behind the title of this case study, "The Island Microcosm," there are two hidden assumptions. The first is that islands are microcosms of some larger system (whether insular or continental is neither explicit or proven). The second assumption is that any "microcosm" studied in detail might offer some lessons that could be applied to islands, presumably larger, or part or all of a continental system. There is some question about whether or not islands can be models, in a microcosmic sense, for continental areas (at least it has not been proven yet and is only an hypothesis). It seems more likely that small islands might be microcosms of larger islands. These in turn might be microcosms of continental areas.

We have elected to focus on islands that exhibit characteristics of true insularity in the form of isolation and smallness: smaller oceanic islands. We choose this focus, recognizing that if the hypothesis that islands are microcosms of continents proves invalid, there may still be a high probability that the findings from the smaller island microcosm universe could provide a model for larger island systems that are, in turn, closely linked to continental systems. We have elected to study the problem from the bottom up since medium to large size islands could only be microcosms of continents, but small islands could be microcosms of both larger islands and continents. Our principal focus is on developing oceanic islands smaller than about 10,000 km^2, approximately 4,000 mi^2 (the size of Jamaica). We have excluded all the developed coastal islands, like Great Britain or Japan, all very large islands like New Guinea and Cuba and the larger conglomerates of multi-island systems, like Indonesia and the Philippines.

A second rationale for selecting smaller islands is that the perceived environment is totally insular, since there is no "interior." In an island of approximately 10,000 km^2 there is no point that is more than approximately an hour's drive from the sea. The entire island and the sea are closely linked under these conditions.

There are four separate elements involved in the following case study analysis and report, the first of which is an historical overview that examines the universe of islands, their characteristics, attempts to classify them and conceptual problems in studying them. The second element is to extract from site-specific examples what has been learned from experience. The third is an overview of technical problems and advances in insular resource assessment and coastal zone management. The final element explores and evaluates the evolving experimental approaches that have emerged over the past decade, leading toward a new island paradigm (or a theory of insular systems development) that could be empirically tested in the future.

This case study utilizes a variety of data sets: the existing published literature on islands and island systems, only a small portion of which has been cited and included in the bibliography; reports and counsel from various expert consultants; direct site visits to St. Lucia, the Virgin Islands and Fiji; and the extensive island reference files (documents, reports, correspondence, maps, photos) maintained by the Island Resources Foundation.

The principal sources for literature reviewed were the U.S. Virgin Islands (Island Resources Foundation Library), St. Lucia (the St. Lucia National Trust and the St. Lucia Central Planning Unit), Hawaii (the East-West Center), Fiji (the University of the South Pacific, UNDP/CCOP/SOPAC, and the National Trust), and Washington, D.C. (the Library of Congress and the headquarters of the U.S. Man and the Biosphere Program). It should be noted that although the literature available on islands, published and unpublished, is rather voluminous, it is heavily biased on the side of science and natural history material, and is more or less deficient in areas of the social sciences.

The author would like to take this opportunity to make special acknowledgment of contributions made by the following persons: Mr. Robert Devaux of the St. Lucia National Trust (an engineer), Mr. Steven Koester (an anthropologist), Dr. Jerome McElroy, (an economist from St. Mary's College, formerly of the College of the Virgin Islands and the Department of Commerce, U.S. Virgin Islands), Dr. Michael Hamnett from the East-West Center, Mr. William Beller (engineer and chairman of the U.S. Man and the Biosphere Directorate on "Islands and the Rational Use of Island Ecosystems"), Mr. Cruz Matos (engineer and present director of the CCOP/SOPAC group based in Fiji), Dr. Uday Raj (director of the Marine Resources Institute, the University of the South Pacific, Fji), Mr. Birendra Singh (environmental planner, Fiji National Trust), Mr. Allen D. Putney (principal investigator of the Eastern Caribbean Natural Area Management Program, St. Croix,), Ms. Judith Towle (public administration specialist on international development, Island Resources Foundation), Ms. Fran Roberts (who handled the onerous task of manipulating the word processor to produce this report), and the World Wildlife Fund-U.S. for its logistic support.

2. STATEMENT OF THE PROBLEM

2.1 Dimensional Considerations: The Universe of Islands

In the normal scheme of world politics, islands--especially small islands--have traditionally lacked sufficient area, population, resources and geopolitical leverage to count for very much. Although all of the world's islands taken together have a combined land area of about three million square miles (not including Greenland with 840,000 square miles), they constitute only about five percent of the earth's total land area. However, forty three, or approximately one-quarter, of the world's independent states (with membership in the United Nations and other international bodies) are wholly insular. Most of these (Table 1) are developing countries, with thirteen concentrated in the Caribbean, ten in the Pacific, and seven in the Indian Ocean/Persian Gulf.

Table 1. Independent island countries.

1. Antigua-Barbuda	16. Iceland	30. Sao Tome and Principe
2. Bahamas	17. Indonesia	31. Seychelles
3. Bahrain	18. Ireland	32. Singapore
4. Barbados	19. Jamaica	33. Solomon Islands
5. Brunei	20. Japan	34. Sri Lanka
6. Cape Verde	21. Kiribati	35. St. Christopher & Nevis
7. China, Republic of	22. Madagascar	36. St. Lucia
8. Comoros	23. Maldives	37. St. Vincent
9. Cuba	24. Malta	38. Tonga
10. Cyprus	25. Mauritius	39. Trinidad and Tobago
11. Dominica	26. Nauru	40. Tuvalu
12. Dominican Republic	27. New Zealand	41. United Kingdom
13. Fiji	28. Papua New Guinea	42. Vanuatu
14. Grenada	29. Philippines	43. Western Samoa
15. Haiti		

There are sixty two islands with areas greater than 4,000 square miles, and 126 islands with areal dimensions larger than 1,000 square miles. However, some very important islands are much, much smaller, and many of these smaller, formerly colonial island territories and associated states have over the past decade or so opted for independence or are moving in this direction and thus represent new factors on the international scene.

There are very few island countries that are essentially single islands like Barbados, Sri Lanka, St. Lucia and Nauru. Some come in major pairs like Trinidad and Tobago, St. Kitts and Nevis, Antigua and Barbuda. Some occur in single country clusters or arcs or archipelagos like Fiji with 322 islands or Tonga with 150. Others, as in the case of the Lesser Antilles in the Eastern Caribbean, represent a multi-state cluster with eight independent island nations in an area about the same size and with the same number of individual islands as Fiji. The Seychelles in the Indian Ocean has a hundred volcanic and coralline islands spread over a distance of 1,000 km. The Maldives has a thousand islands, sub-clusters of 19 atolls spanning an arc of 800 km, while Kiribati has 33 islands but they are spread over five million square miles of the Central Pacific. The Marshall Islands in the Pacific Trust Territories, with 1,156 islets, have a combined land area of only 70 square miles (smaller than St. Croix in the U.S. Virgin Islands), each averaging only 39 acres. By way of comparison, some continental countries also have extensive insular resources. The United States has 29,000 islands, of which 6,000 are in Alaska and 2,000 in the Pacific Trust Territories. Panama has 700 (about the same number as the Bahamas); New Zealand has 500.

But for all of these and others, this is a time of change and transition. Within just the past two decades, the advent of jet air service, containerized cargo technologies, mass tourism, satellite communication links, television, multinational corporations, and geopolitical considerations have each contributed to a rising level of interest in islands among continental business circles, bilateral and international development agencies.

2.2 Definitional and Conceptual Considerations

The dictionary definition of an island as being a body of land entirely surrounded by water is not of much use. Australia and Funafuti in Tuvalu both meet the definitional requirement. As a consequence, island groupings originated for convenience' sake by the user lack precision (for example, wet, dry, high, low, tropical, arctic, small, poor, French, Aegean, remote, atoll). In addition, there is a similar lack of precision which derives from a conceptual dualism; Fiji, for example, is both a discrete point on a map and a country with 322 distinct islands spread over 600 miles of ocean. The "point" approach is convenient but obscures the reality not only of internal distances separating sub-units but cultural and economic "distance" or differences as well. Secondly, the discrete-point perspective tends to emphasize the center or core island and downplay the periphery or satellite islands and how things are seen from the "out island" vantage points. In effect, the "view" of the city from the suburbs is very different from the reverse view. Two very different perspectives are involved.

Another conceptual problem arises out of the natural scientist's tendency to construct a more or less closed system model for isolated islands because of the sea barrier. Unfortunately, from the perspective of economists, planners, humanists, and other social scientists, islands are highly open systems (Brookfield, 1980; Hamnett, 1981; McElroy, 1978b; MAB, 1977; Villamil, 1971) and therefore vulnerable to numerous external factors which limit and often override internal preferences, decisions, traditional resource use practices, and strategic planning assumptions, rendering facile projections invalid.

As early as 1971 it was noted that insular open systems planning should be structured around the concept of contingency planning (Villamil, 1971). Demas (1965) in The Economics of Development in Small Countries, now considered a classic, noted the importance of modifying development planning every year to consider changes in the external sector or in the sytem's environment. This practice of course rarely happens, and there is a tendency on many small islands to consider development plans as static entities to be modified every five to ten years -whenever external aid funding is available.

The strong identity or sense of insular place which most islanders have for their homeland, surrounded by water as it is, tends to produce a collective inclination to see the island as a "closed" and secure system like the scientist's insular ecosystem, but the realities of developing islands as open systems induces an internal conceptual conflict often reflected in island politics and life.

2.3 The "Island System" Concept

Although some islands are more "open" than others, all are bounded by the sea, and the smaller they are, the shorter the time frame for interactions between human and natural ecosystems (and component terrestrial and marine ecosystems), especially when external forces induce change.

For this study, development and its associated impacts are considered within the framework of an "island system" construct, a flexible label that applies principally to islands or island groups and their associated natural, social, economic, and political systems. The "island system" concept calls attention to the following facts.

- It affirms that an island, even though it is small, is not an homogenous, discrete entity, but rather an assemblage of diverse subaerial and subaqueous ecosystems in upland, littoral, sublittoral, and outer-shelf zones; most of these, in the case of small islands, are included in the coastal zone.
- It stresses the importance of the interdependent linkages among island ecosystems: impacts in one ecosystem will have repercussions in another. Further, their areal extent will not conform to convenient geographical or political boundaries, like "land" or "sea". The concept also requires perception of each island's relationship to and within associated island groups, wherein artificial international boundaries and the downstream pollution effect create resource management problems.
- It suggests the need for a "biocybernetic" view of island growth and development, wherein multiple feedback, effect-to-cause "transformational" phenomena can be added to the more linear, more "transactional" cause-to-effect phenomena usually considered, especially in the linkages between the human and natural ecosystems.
- While technically interchangeable with the more flexible term "ecosystem," it suggests the value of seeing an island as an assemblage of ecosystems, preferring to consider multiple

island groups as clusters of island systems with a central core and peripheral satellite islands, which may differ appreciably within the cluster.

2.4 Understanding the Difference

Failure to understand distinctive differences between island and continental systems has often had unanticipated and undesireable results for both private developers and public sector funding agencies engaged in island development activities. Evidence of mistaken, ill-advised, inappropriate, sometimes naive development schemes abound in the island world. Most failed, even though similar approaches had worked well in continental systems, because of insufficient adaptation to insular conditions and constraints, and reflect an antecedent conceptual failure to see islands as different--and then to define those differences. Several examples are illustrative of this point.

- Costly groin, pier, dock and jetty facilities have been literally washed away by "unanticipated" seasonal storms (not even hurricanes). They were simply sited or designed wrong for an island environment.
- Costly sewage treatment plants, desalination plants, and diesel/electric power plants not designed for island environments have deteriorated and failed prematurely.
- Costly enclave-type tourism efforts, especially those designed as sequestered, centralized, high-rise, "Miami Beach-style" facilities, have failed to meet island development needs. They overlook local employment, ownership, cultural exchange and integration with other island economic development possibilities, and many are under increasing pressure to "decentralize" and become more integrated into island development planning strategies.
- Costly coastal zone management programs extrapolated from continental models have simply not measured up to island expectations or requirements.
- Costly beach improvement/nourishment strategies have failed

for design reasons, based on an assumption that what worked elsewhere would work in islands.

- Standard sand and coral mining efforts have seriously damaged adjacent beaches, coral reefs, and coastal environments and adversely affected other sectors like fisheries and tourism.
- Natural disaster relief activities, because of poor planning and inappropriate scales and styles of intervention vis a vis island areas, have often had a greater negative long-term impact on the island system and its capacity for survival than the cyclone, hurricane, flood or drought itself.

Most of these "failures" will resurface in more detail in later sections of this report.

3. INSULAR SYSTEMS: CLASSIFICATION AND CHARACTERISTICS

3.1 The Taxonomy Problem

The literature on islands abounds with partially completed or failed attemps to classify islands. The simpler approaches which distinguish between continental and oceanic islands, or between developed and undeveloped islands, or between wet and dry, or high and low, or large and small tend to be essentially academic exercises that are of little use to a development planner. More sophisticated approaches, which have generally dealt experimentally with island regional groupings or types focusing on various small sets of characteristics like rainfall levels, soil types, floral and faunal diversity and endemicity, population levels or densities, and ethnicity, have not been of much help either and tend to be equally academic. However, although they differ considerably, they do perhaps represent the first step in the development of a full-fledged taxonomy or classification system for islands as a unique geomorphic type and a unique resource development and management problem.

Any attempt to classify the characteristics of small developing island countries is not without its problems, especially in view of their heterogeneity and the serious shortcomings in many of the more basic statistics. But even leaving aside the statistical and descriptive information availability problems regarding islands, there still remains the separate issue of how to classify existing information about islands into some taxonomic or even tabular format that will have utilitarian value to the resource planner/manager.

As early as 1973, a thoughtful UNESCO document dealing with islands as an element in the Man and the Biosphere Program (MAB) suggested that "an elaborate land classification (evaluating fluvial and coastal geomorphology, soil and water resources, etc.) would contribute to ... planning future development of islands ... with a view to rational land use ...." (UNESCO/MAB, 1973). The report, entitled "Islands and the Rational Use of Island Ecosystems," went on to suggest four options for classification:

1) Structural types
   a) Continental islands (geologically defined)
   b) Volcanic islands
   c) Elevated coral/limestone islands
   d) Low coralline islands and reefs

2) Climatic types by temperature zones, precipitation, wind effects

3) Geomorphic types
   a) The degree of preservation of flat structural or erosional surfaces on the divides
   b) The formation of foothills and foot slopes as well as coastal lowlands
   c) The existence of reef and lagoonal systems (in tropical zones)

4) Biological types
   a) Islands situated on a continental shelf (with biota similar to the adjacent continent)
   b) High oceanic islands with unique ecological communities usually limited and vulnerable
   c) Atolls and raised limestone islands.

In the same UNESCO/MAB document (1973), an attempt was made to use a three-tier breakdown of more developed, less developed, and uninhabitated islands, but this was of limited use.

Best (1968), of the University of the West Indies, separates islands into "metropolitan and hinterland (marginal) economies"; the United Nations distinguishes between less developed and more developed island areas; some scholars separate the "core" or central islands from "peripheral" islands; and the United States government in an inventory of its 29,000 islands makes a fuzzy distinction between coastal, barrier and offshore islands (U.S. Department of Interior, 1970).

For the development planner, there is no master list or inventory of islands displaying and categorizing the comparative characteristics of island systems. There is, in effect, no universal system of classifying islands -- no taxonomy of islands. Only the 1974 UNCTAD document on "Developing Island Countries" is useful in this regard but it has not been kept up to date.

3.2 Classification Approaches

Since there is no general island paradigm, i.e., a theory embracing the nature of all insular systems, this has left the field wide open for experimentation with classification frameworks.

Natural scientists (Fosberg, 1963; Dorst, 1972; Douglas, 1969; MacArthur and Wilson, 1967; Wace, 1978; and Simberloff, 1974) generally are in agreement that all true islands, as ecosystems, are characterized by the following:

- relative isolation
- limitation in size
- restricted natural resources
- limitation in organic biological diversity
- reduced interspecies competition
- natural protection from external competition and consequent preservation of numerous bizarre endemic species
- tendency toward climatic standardization
- high vulnerability and a tendency toward equally high instability when isolation is broken down
- ecological fragility.

Similar investigations by social scientists (mostly economists and geographers) (Dommen, 1980b; Dolman, 1982; Wace, 1980; UNESCO/MAB, 1973; UNCTAD, 1974) collectively suggests the following socio-economic characteristics of smaller island countries:

- more dependent on foreign trade than large countries and have less influence on the terms in which that trade is carried on
- a narrow range of resources and, hence, specialized economies
- heavily dependent on one or more large foreign company;
- dependent for key services on external institutions such as universities, regional training facilities, banking and marketing arrangements
- a narrow range of local skills and specific difficulty in matching local skills with jobs

- difficulty in providing some infrastructure services as there may be costly diseconomies of scale in the provision of such services
- a small Gross Domestic Product and, hence, import substitution industries may face special difficulties.

All small countries face most of these problems, but they appear in an extreme form on small islands. Collectively, the characteristics can be best summarized as economic dependence, whereby external circumstances and decisions have a far greater impact on the internal system than do internal circumstances and decisions on the external system.

Little attention has been given to the following important and unique characteristics of islands--as compared to continental countries:

(1) Islands (and only islands) have a completely circumferential coastal zone and, therefore, a sea frontier and Exclusive Economic Zone (EEZ) which totally surround the entire country or territory and no land frontier. The only exceptions to this rule are occasional islands divided into political units such as Hispaniola, Borneo, St. Martin, or New Guinea. In this special case, the coastal zone perimeter boundary is always longer than the inland land boundary or frontier (the reverse being generally true for continental countries). Islands also have a disproportionate ratio--favorable to islands--of the size of the Exclusive Economic Zone (EEZ) to the island land mass itself (as compared to continental countries).

(2) Island clusters (not continents) have no internal land transport option to link the parts of the country and are restricted to sea transport and air links.

(3) Small islands (unlike continental countries) do not have an interior hinterland or central terrestrial core area that is essentially distant from the sea. Therefore, for island states, coastal resource planning and management is essentially synonymous with national resource planning and management. (See Sections 3 and 8 of the Coastal Management Case Study.)

In the above examples, islands are different in kind, not just degree, from all continental countries. Furthermore, the facts that island ecology differs from continental ecology and ecological principles derived from continental ecosystems are insufficient to explain the ecological relationships in islands have been well described by Fosberg (1963), Carlquist (1965 and 1974), MacArthur and Wilson (1967), Dorst (1972), and Mueller-Dombois (1973). Three important factors--insular isolation, size and age (geologically islands are relatively recent in origin)--<u>in combination</u> have biological consequences that are most clearly developed on islands because they result in many unique ecological relationships.

One unanswered question, however, is whether the island characteristics discussed above diminish or limit the prospective utility of the microcosm model. This remains to be tested.

3.3 <u>Classifying Islands as Laboratories: The Ecosystem Model</u>

In the world of the natural scientist, islands have long been considered ideal laboratories--microcosms of larger continental situations or systems. Within the framework of an island, "the parameters of variables can be readily defined, the behavior of variables measured, and externalities either controlled or disregarded" (Brookfield, 1980). It was the more remote islands in the Pacific and Indian Oceans that, in the 19th century, had an enormous and fateful impact on the minds of Charles Darwin and Alfred Wallace, the fathers of modern evolutionary theory. For nearly a hundred years after Darwin, however, investigations of islands remained a descriptive science, accumulating a "wealth of information on patterns of species distributions, on the composition of island floras and faunas, on the taxonomic description of insular species and subspecies and on the adaptations, often bizarre, of island creatures" (Gorman, 1979). During the decade of the 1960's, however, island studies underwent a transformation, perhaps triggered by the role islands played in World War II but more likely the result of emerging paradigms for ecosystem analysis within the natural science disciplines.

Institutionalized cooperative island study projects were mounted by UNESCO (Natural Science Division), the U.S. National Academy of Sciences and the Smithsonian Institution. In 1961, F. Ray Fosberg took the first step in generating a new synthesis by organizing a Pacific Science Congress symposium on "Man's Place in the Island Ecosystem" and, in 1963, by publishing the papers in book form under the same title. This seminal symposium and book (reprinted in 1965 and again in 1967) launched a whole new way of looking at islands, not only as "ecosystems" but as ecosystems perceived, studied, used and modified by man. It was the first step in the direction of seeing the island ecosystem as a laboratory, serving both science and man.

Island ecology was transformed into a predictive science by the publication of MacArthur and Wilson's Theory of Island Biogeography (1979), which argued that the number of species on an island is distinctly correlated and is a direct function of the island area and its distance from the nearest island or continent and that on very small islands the process of natural extinction is accelerated. More relevant to this study is their assertion that "by studying clusters of islands, biologists view a simpler microcosm of the seemingly infinite complexity of continental and oceanic biogeography. Islands offer an additional advantage of being more numerous than continents and oceans. By their very multiplicity, and variation in shape, size, degree of isolation, and ecology, islands provide the necessary replications and natural 'experiments' by which evolutionary hypotheses can be tested."

The "laboratory" notion and the "microcosm" concept, wherein islands are seen as models of a wider complexity (continents, oceans, and even the whole biosphere), are implicit or explicit in the work of MacArthur and Wilson and became recurring themes in following years. Carlquist (1974) observed that islands were both "great museums for the biologist and remain the marvelous laboratories of evolution that Darwin and Wallace found them to be more than a century ago. These laboratories, however, have hardly been used, in comparison to what they offer." When a UNESCO project on islands emerged the following year it presumed that "islands could have an important laboratory function as places where different theories of resource management are developed and tested for subsequent application elsewhere" (UNESCO/MAB, 1973). By the early 1980's, the "continentally perceived" purpose of the laboratory had changed somewhat, but Dolman (1982) suggested that small islands, for all the problems and constraints which confront them, could become the laboratory in which alternative development strategies, shaped by the notion of self-reliance, first see the light of day. The longevity of this island "laboratory" notion confirms the point made above about how many outsiders have and continue to view islands.

3.4 Changes in Focus: Islands As A "Special Case"

International concern regarding developing island countries, as a kind of "special case" of the development process, also first surfaced in a serious way in the mid-1960's when a number of international institutions began a search for a theory and a prescription for certain types of "special circumstances" (within the international organizational framework) to improve technical assistance programs to various kinds of "special problem areas." For example, international organizations began to separate out least developed or land-locked countries as needing special attention, and strategic distinctions began to appear regarding least developed, less developed and more developed countries. The concept of Third World countries came into vogue as a classification, and eventually some attention was paid to islands as a special case.

Only within the past two decades or so have most of the world's island populations begun to emerge as subjects of specialized, systematic resource analysis and of planning and management strategies, rather than adaptations of traditional, continentally focused models (Fosberg, 1963). This has involved an evolutionary process. As early as 1966 scientists working with the International Biological Program (IBP), the International Union for Conservation of Nature and Natural Resources (IUCN), and the Pacific Science Congress articulated a concern for the conservation of certain Pacific islands through a series of conferences, symposia, and resolutions which launched the "islands for science" program (Nicholson and Douglas, 1970). Subsequent IUCN initiatives at a "Symposium on Conservation of Nature--Reefs and Lagoons," held in Noumea, New Caledonia (August 1971), stressed the need for specialized ecological guidelines in island development project planning, and noted the vulnerability of island ecosystems to disturbances arising out of human activities. The specific environmental impacts of tourism development on the resources of coastal zones of certain Pacific islands were also given attention.

Shortly thereafter, one of the priority study projects listed by UNESCO's International Coordinating Council for the Man and the Biosphere Program (a follow-up to the IBP) was designated "ecology and rational use of island ecosystems" and resulted in publication of the MAB "Green Book No. 11 on Islands," published by UNESCO in 1973. About the same time a special "Group of Experts" was assembled by the Secretary-General of UNCTAD (United Nations Conference on Trade and Development) to "identify and study the particular problems of the developing island countries and to make recommendations thereon" (UNCTAD, 1974). This was the first full-scale attempt to examine the economic problems of developing island countries within an international forum. Islands surveyed ranged in size from a large archipelago like Indonesia, with about 100 million inhabitants, to very small islands with only a few thousand inhabitants. An attempt was made to classify the island countries and territories according to various significant characteristics, and a further attempt was made to identify certain key problems and the implications for development policy.

The report from the group of experts was published by UNCTAD in 1974 "Developing Island Countries" and was followed shortly by a UNDP sponsored study of coastal development problems in the Caribbean (Towle and McEachern, 1974) and by two IUCN initiatives, first a booklet on "Ecological Guidelines for Island Development" (McEachern and Towle, 1974a) and then an environmental management case study of the British Virgin Islands (Howell and Towle, 1976).

Since 1974 the available specialized literature on island resource development and management has expanded rapidly as is reflected in the bibliography section of this study. Of particular note is a UNESCO/MAB/UNFPA sponsored carrying capacity case study of the Lau sub-island group in Fiji (MAB, 1977). The study's multidisciplinary team was headed by Dr. Harold Brookfield, formerly of McGill University, and included such eminent scholars as R.D. Bedford, T.P. Bayliss-Smith, Bernard Salvat, Anne Whyte, J.B. Hardaker, R.F. McLean and other island specialists. The seven volumes of reports from this project, dealing with population-environment relations, resources, and development, were published between 1977 and 1980 (the last as MAB Technical Notes No. 13; see Brookfield, 1980). They constitute a major point of departure for any proposed insular resource management strategy in the future.

4. THE CARIBBEAN REGION: EXAMPLES AND LESSONS

Development projects, resource planning efforts and environmental management strategies have, in recent decades, had an uneven history in island systems, with fewer real successes than disappointments. The reasons behind this pattern of development and technical assistance failures lie buried in the experiences of those involved and in the historical web of changing circumstances, options, constraints, events, choices, and impacts. Post-audits can be helpful.

Two examples of coastal resource management problems have been selected from St. Lucia and from St. Thomas in the U.S. Virgin Islands group for detailed investigation. Each covers about the same span of time--1960 to 1983. One (Rodney Bay, St. Lucia) involves a large-scale development project and the effects of its induced environmental changes on people. The other (the Mangrove Lagoon, St. Thomas) involves the effects of incremental growth and people on an ecosystem. A non-governmental, regional approach to Eastern Caribbean resource "eco-develoment" is also reviewed in some detail. All three offer instructive lessons within the Caribbean context.

Stretching between the atypical, oil-rich coastal island of Trinidad (adjacent to the Venezuelan coastline) and the island of Puerto Rico (the easternmost and smallest of the Greater Antilles group), there exists an extended chain of smaller islands known generally as the Leeward and Windward Islands or, collectively, as the Lesser Antilles. Within this 600-mile arcuate-shaped linear assemblage of islands, islets, and cays, there are approximately 300 insular entities of varying types, dimensions, shapes, and levels of development. The largest is Guadeloupe at 710 square miles, but most are much smaller. Some are emergent volcanic, high and wet; and some are raised carbonate, low and dry. A few are combinations of both geomorphic types, and many are simply cays or rocks.

Within the archipelago, there are seven independent island countries (Antigua-Barbuda, Barbados, Dominica, Grenada, St. Christopher-Nevis, St. Lucia, and St. Vincent). Most of these have significant satellite or peripheral islands and cays, some of which are habited but most are not, at least on a permanent basis. Interspersed among the seven island nations are eight other non-independent islands or clusters politically linked to France, the Netherlands, the United Kingdom, and the United States.

Taken together, their cultural, linguistic, historical, ecological, developmental, and human and natural resource endowment characteristics vary enormously. All of the Lesser Antillean islands, however, are small, have lost a disproportionate share of endemic species, and most have been greatly modified by external influences (i.e., the colonial experience, the plantation system, contemporary tourism, and imported technologies).

As vestigial colonial ties began to weaken in the 1950's and island political systems gradually became more self-governing, local governmental bodies were faced with the difficult task of balancing competing pressures for change. On the one hand, expanding populations, growing unemployment, and rising social, economic, and nationalistic expectations created demands for development, employment, and services. On the other hand, a marginal natural resource base, weak monocultural export earnings, and a primitive infrastructure suggested other forms of intervention and growth were needed. Some islands, like Barbados, sought a way out of the dilemma by opting early on for independence. Others waited, seeking time and external multilateral and bilateral assistance as a "holding action." Still others took the opposite route altogether by strengthening ties with parent countries in order to obtain needed investment capital, grants-in-aid and technical assistance.

Regardless of the strategy selected, when the pace of development activity quickened markedly in the 1960's, critical land and coastal resource allocation questions arose regarding the landscape -- what and where to develop or to preserve (and how), what constraints to apply, and how to optimize growth in employment, income, exports, and earnings using the indigenous resource base in company with external involvement and capital, both public and private.

As a result, the period from 1960 to 1984 has been one of dynamic change in the Lesser Antilles--witnessing several new oil refineries and transshipment terminals, a dozen new seaports and airports, scores of new marinas, hundreds of new hotels, thousands of new cruise ship calls, hoards of tourists in the millions, tourism receipts in hundreds of millions of dollars, and petroleum production, refining, and transshipment of roughly a billion dollars. Since these are all coastal water-dependent activities and all island cities and urban centers are seaports, it is obvious that the coastal zone is the primary nexus of economic growth in the Lesser Antilles. Less obvious is the environmental price being externalized or deferred.

4.1 Rodney Bay Development, St. Lucia (1968-1984)

4.1.1 The Setting

An independent island state since 1977, St. Lucia is situated in the Windward Islands of the Lesser Antilles (between Martinique and St. Vincent). It has a total land area of 238 square miles (616 km^2), a population of approximately 124,000 persons, and in 1980 it had a gross domestic product of US\$80 million or \$210 million Eastern Caribbean currency (EC\$2.6 = US\$1). Over 30 percent of these revenues were derived from the marine sector (sand mining, fishing, transportation, and tourism) (Mitchell and Gold, 1982). It is a rugged, lush island with steep mountains, mainly volcanic in origin. Relief is broken only by a small plain in the south, eroded hills in the north, and several deep embayments and harbors on the central leeward (westerly) coast. A new international jet airport occupies the extreme southern tip at Vieux Fort and a second older, lesser air facility is located at Vigie, adjacent to the capital city of Castries.

The island possesses a relatively narrow nearshore, submerged shelf area and several coastal islets. Maria Island (12 ha), a nature reserve on the southern coast, and the former Pigeon Island (20 ha) off the northwestern coast opposite the Village of Gros Islet, some seven miles north of the capital, are especially noteworthy.

Since St. Lucia was formerly settled by the French and was captured, lost and recaptured several times by the British during the eighteenth and early nineteenth century colonial period, a French "patois" is spoken widely (although the official language is English), and customary place names are mostly French.

Traditionally, the people of St. Lucia have depended heavily upon agriculture (mostly bananas), forestry and fisheries for a livelihood. In more recent times there has been rapid growth in other sectors which draw heavily upon various marine resources, especially port-related industry, sand mining, shipping, and tourism. Growth in tourism since about 1970 has brought it from a relatively non-existent sector to one contributing approximately 18 percent of the Gross Domestic Product. St. Lucia has approximately 2,000 fishermen, although some are only part-time participants, with over 400 boats producing an artisanal catch valued at EC$45 million in 1981 and virtually all of which is consumed locally. Village units of artisanal fishermen are common along the leeward and southerly, more protected coastlines (Figure 1).

In the early 1960's, when the Government of St. Lucia sought to define a share of the Eastern Caribbean tourism traffic for itself, one of the areas selected for resort hotel development was the Bay of Gros Islet on the northwestern coast opposite Pigeon Island. At the time, the islet and its associated shallow reef at the northern end of the Bay created a superior, semi-enclosed and protected anchorage of considerable ecological diversity, historical significance, and importance as a net, lobster and conch fishing area used by fishermen of the nearby Village of Gros Islet. Pigeon Island, the namesake of the village, was studded with historical forts, batteries, and buildings dating back to the era of Admiral George Rodney.

Reduit Beach, approximately one mile long, forms the southern half of the Gros Islet Bay coastline with the fishing village of Gros Islet located at the northern beach limit. North of the village, the rugged coastline is formed by low cliffs and pebble beaches. Between Reduit Beach and the volcanic peaks well to the east, a flat swampy area of about 250 acres was maintained by surface water drainage from the surrounding hills. Natural drainage to the sea was restricted by Reduit Beach and its associated berm (Figure 2).

During World War II the United States leased and occupied the area as a seaplane base for anti-submarine patrols, and some construction and

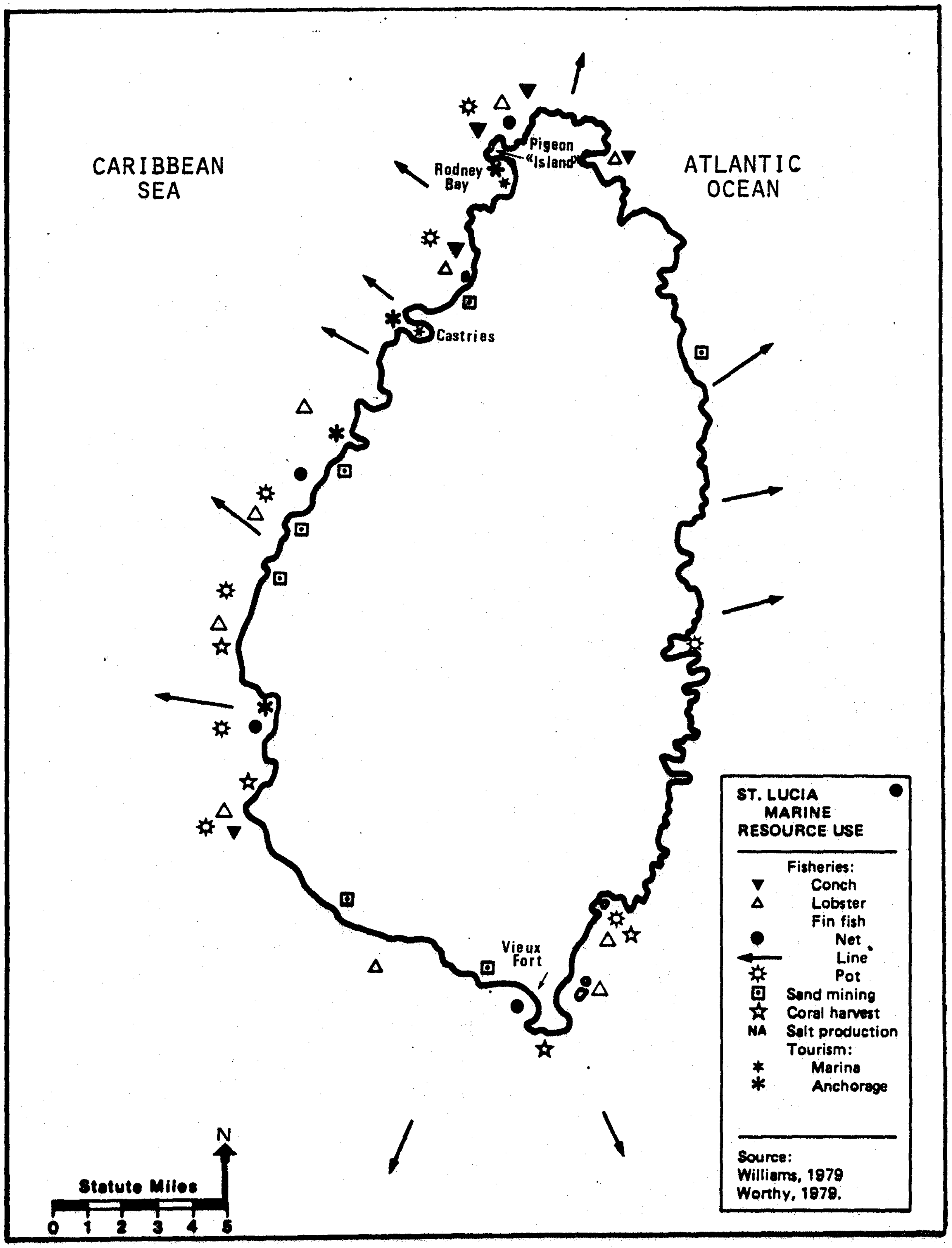


Figure 1. St. Lucia marine resource use. (Adapted from Eastern Caribbean Natural Area Management Program Resource Data Maps, 1980.)

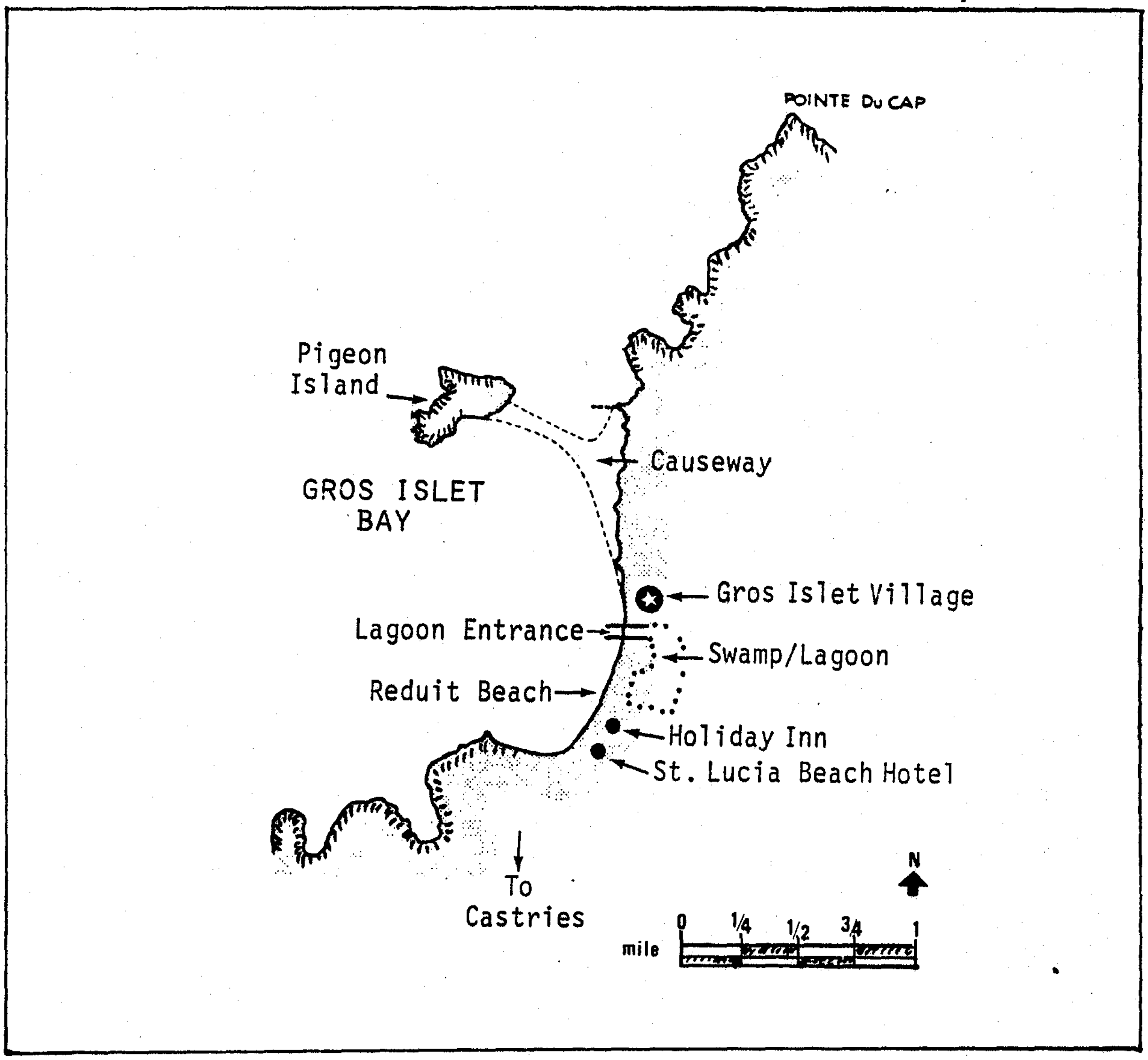


Figure 2. Location map: Rodney Bay development project at Gros Islet Bay/Pigeon Island area, St. Lucia.

considerable dredging were carried out at the site. The U.S. Navy attempted to fill the swamp with about 200,000 cubic yards of sand hydraulically dredged from an area immediately offshore at the southern end of Reduit Beach. The deep borrow pits are still visible forty years later. Because of the amount of soft silt that had built up over the years in the swamp bed, the dredging strategy did not work as the heavy sandy fill material compressed the underlying silt and gradually sank. By 1960, the area was once again a swamp.

4.1.2 The Rodney Bay Development Project

The attractiveness and development potential of Gros Islet Bay (later unofficially renamed Rodney Bay) captured the attention of a group of Canadian investors. In 1961, with government blessing, they commenced construction of the St. Lucia Beach Hotel on the palm fringed extreme southern end of Reduit Beach, as far from the Village of Gros Islet and as near to Castries and the airport as possible. The new facility was ready to open by 1962. Six years later a second Canadian-owned resort hotel (Holiday Inn) was planned for Reduit Beach--even larger than the first--just north of the existing St. Lucia Beach Hotel (Figure 2).

However, there was a problem that delayed construction of this second facility: tiny but bothersome, bloodfeeding insects known locally as sand flies or "no-see-ums." Both the St. Lucia Beach Hotel management and the prospective Holiday Inn developers complained to Government that something had to be done about the swamp to the east, thought to be the source of the sand flies. Their bites plagued visiting tourists in the early morning and late afternoon to early evening hours, causing occupancy rates to suffer. Insecticide fogging and spraying had not worked. The option of draining the swamp was raised in order to eliminate the breeding habitat of the pesty "no-see-ums" (Island Resources Foundation files; Devaux, 1983).

The Government gave firm assurance to the hoteliers that something would be done to alleviate the problem. But what and how and who would pay for it remained to be established.

Nature may abhor a vacuum, but so, apparently, do engineering contractors. By a mysterious process akin to osmosis a well-known Jamaican entrepreneur, who owned a large marine dredging and construction firm, appeared on the scene with an offer that "could not be refused." He proposed a private sector solution to the government's "bug" problem at Reduit Beach, one that would generate profits but only if his grandiose scheme was accepted in its totality (Devaux, personal communication, 1983). That plan evolved as the Rodney Bay Development Corporation with a projected investment capital requirement of EC$17,089,000. It included the following development components:

- To dredge the core of the swamp, filling border areas with sea sand and open up the new "lagoon" to the sea with a channel for yachts through Reduit Beach.
- To create 88 acres of new flat land with a new mile-long beach for additional tourist facilities by dredging seabed sand from Gros Islet Bay and emplacing it as a "causeway" on top of the shallow reef between Pigeon Island and the main island, thereby doubling the linear dimensions of Reduit Beach available for "development."
- To create and sell or lease marinas, residential and condominium units on the newly filled "waterfront" lots on the filled areas in the new lagoon (i.e., ex-swamp).
- To accomplish the above through a three-way partnership between the Government of St. Lucia, the [British] Commonwealth Development Corporation (which would cover the up-front capital costs as an "investment"), and the Jamaican entrepreneur, who would provide the expertise and dredging, road building, and other services (for which he would be paid).
- The project would comprise 1,311 acres (1,243 of which had to be purchased), consisting of 650 acres of single residential vacation/retirement housing units, 52 acres of hotels, 80 acres of condominium/apartment units,

7 acres of commercial tourist "boutiques," 10 acres of yacht club/marina facilities, 440 acres of green land, lagoon, public beaches and roads, and 72 acres for "extension" of the Village of Gros Islet.

- The project would require two years of site modification and five to seven years of lot sales and development.

The Government of St. Lucia accepted the proposed scheme; engineering studies and plans were completed by June of 1969; shortly thereafter work commenced, i.e., temporarily surcharging or covering the swamp with sea sand to compress the silty bottom, installing a rock/boulder barrier from the mainland to Pigeon Island (behind which dredged sand could later be safely deposited), opening up the swamp/lagoon by a channel cut through Reduit Beach and re-routing the existing north-south road system. But not everything went according to plan.

In 1970, as part of the attempt to create access from the sea to the swamp behind the beach berm at Reduit, an effort was made to excavate the entrance channel between the former St. Lucia Beach Hotel and the new Holiday Inn. This, however, had to be abandoned when it was discovered a ridge of hard rock extended underneath the beach berm. Blasting was unfortunately ruled out, and in 1971 an alternative strategy was selected which involved the dredging of a channel immediately south of the Gros Islet Village. The siting of the channel south of the Village ended up requiring the elimination of the bridge over the old swamp drainage outlet between the Village and its cemetery, thereby cutting the Village off from both its traditional burial ground and from direct access to the existing hotels and the new "development area." The initial rock barrier placed between Pigeon Island and the mainland, as an antecedent protective mechanism for the causeway dredge and fill activity, caused the beachfront at the Village to collapse, thus requiring "nourishment" with additional dredged material--a remedial strategy which, it will be demonstrated below, failed over time (Stevenson and Hardtke Associates, 1973; Devaux, 1983).

However, the final phases of the site preparation, including the dredging of over 2.5 million cubic yards of Gros Islet (Rodney) Bay sea-bed coral sand to construct the 88-acre causeway, were completed by the end of 1972. All that remained for the project to succeed was to sell or lease the newly created or "enhanced" waterfront properties to amortize the investment and generate new revenue. But, some fourteen years later, this has not yet occurred. Not one sale, lease or option has been finalized for the causeway area. Not one new hotel has been built. There has been no deluge of buyers or leaseholders for the residential sites in the new "lagoon", which is fairly attractive. Additional capital investment (for further site improvement and remedial environmental interventions), development, and marketing costs have mounted, and the total is close to three times the original estimate. There has been no appreciable return on invested capital, and carrying costs are estimated at about US$2,000 *per day*.

There were other recurring costs of a different nature accruing to the project and its environs. From an environmental impact perspective, the development scheme for Rodney Bay is a rather classic case of both good intentions gone astray and of "Murphy's Law" ("If anything can go wrong, it will"). The following section summarizes a sequence of unanticipated environmental impacts that help explain the failure.

4.1.3 The Short-Term Impacts

As part of a larger series of Eastern Caribbean investigations focusing on coastal processes, erosion, sand mining, and regional beach control, Deane et al. (1973) undertook a detailed study of the Reduit Beach area in St. Lucia from 1970-1973. In the subsequent report documents, Deane reported that the most signficant event that had occurred in this area was the closure of the Pigeon Island passage which had resulted in the following major changes in the littoral climate: 1) almost no new sediment is supplied to Reduit Beach; 2) there has been a significant reduction in the wave climate along the stretch of coastline between St. Lucia Beach Hotel and the lagoon entrance near Gros Islet Village; and 3) waves now approach the beach at almost right angles and consequently southerly littoral transport, formerly driven by waves passing through the Pigeon Island passage, has ceased. "One result of the first change is that in the long term, erosion will be experienced over the entire stretch of beach. As a result of significant changes in the direction of wave approach in the medium term major losses will be experienced in the southern half of the beach during periods of severe wave attack" (Deane et al., 1973).

In 1973 the consulting firm which had prepared the original engineering and design study for the Rodney Bay project was employed by Rodney Bay, Ltd., of St. Lucia to examine the post-construction beach stability situation at Rodney Bay. The study was prompted by various complaints about modifications that were occurring to beaches and other marine features in the area. The report by Stevenson and Hardtke Associates (1973) noted that the causeway beach will "tend to change to some degree over the next five to ten years, but this is not likely to create a problem, provided the change is allowed for in planning." Concurrently, they indicated that "regular surveys of <u>all</u> Rodney Bay beaches are recommended in order to insure that <u>unexpected changes</u> are noticed." Shore erosion problems at the southern end of Reduit Beach, according to the consultants, were solely the result of the offshore dredging carried out in 1941 and the mining of sand from the beach during the 1960's for aggregate and the removal of the sheet piling (installed by the U.S. Navy in 1941) from in front of the southern part of the Holiday Inn in 1970. The report concluded that any existing erosional problems were "not caused by the Rodney Bay construction, ... <u>although it has markedly influenced conditions in the area</u>" (Stevenson and Hardtke Associates, 1973, emphasis added).

What the consultants were saying, in effect, was that the previous extraction of perhaps a total of 200-400,000 cubic yards of sand and the removal of a forty-year-old sheet pile wall had more influence than the closure of the Bay entrance, the removal of 2.5 million cubic yards of sand for the causeway fill, plus the removal of more than a million cubic yards for the surcharge and fill strategies for the swamp area.

The most interesting part of the study is its endorsement of the need for costly remedial actions, involving the installation of a gabion blanket near the St. Lucia Beach Hotel costing EC$100,000, the installation of an offshore breakwater near the southern end of the Bay costing EC$300,000, possible installation of two stone groins at the point where the causeway beach and Pigeon Island connect in order to attempt the restoration of the former Pigeon Island natural beach. The study also supported the need (given the modifications in Bay circulation caused by the installation of the causeway) for any new sewer outfall serving future tourist facilities to extend at least 2,000 feet from the nearest shoreline. The outfall recommendation was deemed necessary to take account of the new flow conditions, new bathymetry, and new wave regime--yet no cost estimates were cited (Stevenson and Hardtke Associates, 1973).

By 1975 the beach at the Village of Gros Islet had deteriorated, causing the village council to protest to the Town and Country Planning Unit, suggesting that the existing lagoon entrance south of the Village was "an eyesore." The Council complained that the encroachment of the sea on the bay front created a hazard, and that the sandy beach which was expected had not materialized. In the opinion of the council, these problems were a <u>direct result</u> of the works carried out in the creation of the causeway (Devaux, 1983).

Changes were not limited to the main island. For more than three hundred years the westerly side of Pigeon Island had a rather beautiful 1,000-foot-long, 40-foot-wide yellow sand beach. The foundations for a rock pier constructed by military engineers in 1782 still survive and, until the causeway was built, produced a minor widening of the beach area at the point where the 1782 stone dock was constructed. In 1969, two years after a new timber-pile jetty was constructed on the eastern side of Pigeon Island as a dock for visiting boats, the rapid build-up of sand to the south rendered the jetty more or less unuseable. Rapid shoaling occurred at the extreme outer edge, indicating a sand deposition phenomenon and slow littoral sand transport from south to north in the area. By 1970 when construction activity began for the causeway, Reduit Beach began experiencing serious erosion problems. Pigeon Island was not affected by these events until the closure of the gap. However, when the gap was closed in 1971, the sand on Pigeon Island beach began to shift noticeably toward the east. At that time, accurate measurement profiles of the Pigeon Island beach were taken for the first time (Devaux, 1983). By 1972, when the causeway was completed (almost a year later), a yellow sand strip or streak began to appear along the white coral sand on the artificial causeway beach, matching the color of the sand at Pigeon Island. Within six months it had traveled 1,000 feet along the causeway toward the mainland; Pigeon Island was apparently losing its only beach to the causeway beach.

The St. Lucia National Trust, a quasi-governmental body responsible for developing Pigeon Island as an historic site and national park, was properly concerned. By 1976, however, the beach had virtually disappeared and, despite sequential protective and remedial engineering strategies (e.g., gabion baskets, groins, and armor stone emplacements), all at great expense to the National Trust, only the northerly segment of the former beach had stabilized (Devaux, 1983).

In the meanwhile, the causeway itself has been "stabilizing" (to use the consultant's term)--or eroding (to use the disinterested observer's term)--at a loss rate of 14 feet per year since 1974. The original 88 acres are now down to perhaps 75 acres. When and if it will truly "stabilize" is an unknown. Whether investors can be attracted to build hotels or condominiums on a dynamic, not yet stabilized, artificial tropical island beach is also an unknown. What has happened as a result of the causeway and associated Rodney Bay dredging activity to the adjacent artisanal fishing Village of Gros Islet, however, is not an unknown. It is a matter of record and a cause for concern.

4.1.4 Impacts on the Coastal Fishing Community at Rodney Bay

Gros Islet, St. Lucia, is a small fishing village for which there are dozens of replicates within St. Lucia and hundreds in the Caribbean region. Before the Rodney Bay project, Gros Islet bore a resemblance to coastal fishing villages on all inhabited oceanic islands, such as those in the Lau group of Fiji described in detail by Brookfield and others (MAB, 1977). To illustrate how this has all been changed, we have elected to explore in some detail the metamorphosis of the village-based fishery at Gros Islet.

Prior to the Rodney Bay project, Gros Islet had three seine nets exploiting the resources of the nearby reef and coastal environment. Each seine had a full-time crew of four to six men responsible for casting the net and maintaining it. In addition, between 15 and 20 people regularly accompanied the crew to pull. Another shifting group of approximately 15 to 20 villagers would pull on a given day in exchange for at least a substantial portion of their families' daily food requirements. A crew member's share served as his daily wage, and the shares distributed to the regular pullers were also essential sources of income. In theory, the distribution of a day's catch was: 1/4 to 1/3 to the net owner, 1/4 to 1/3 to the permanent crew and 1/2 to 1/3 distributed among those who pulled. In all, each net had between 40 to 50 people working on it daily in exchange for varying amounts of income and subsistence. The size of the work force fluctuated with the seasons, the quality of the previous day's catch, and weather and sea conditions (principally wind and swell).

With the advent of Rodney Bay Development, this fairly stable system was undermined and destabilized. Dredging the Bay, digging the lagoon channel, and building the causeway destroyed the usefulness of the seine fishermen's two principal beaches. The causeway cut the Gros Islet Beach area in half. The dredging left borrow pit edges or underwater cliffs that would snare large beach seines when cast. It also released mud and sediments into the water, destroying sea grass and coral fish habitats. The causeway also blocked off the current and, according to the fishermen, a main "path" for schools of jacks and mackerel which they previously caught.

All three seine owners abandoned fishing as a result of this drastic environmental alteration, and their cotton nets all spoiled. Eventually, one of the three experienced seine fishermen bought a nylon net and began casting at the Cariblue Beach some distance to the south. He was followed by two net owners from Anse La Raye (south of Castries) who also began fishing there.

This new arrangement left three nets (from two villages) sharing one beach and resulted in a reduced daily catch from the seines and a reduced demand for labor. Instead of three separate groups of people pulling each seine daily, only one group was needed. In addition, because the Cariblue Beach is located outside the village, a large portion of the catch no longer comes through Gros Islet but is instead shipped directly to Castries by van. Before, with three nets being used close to the village, fish were more plentiful and, with over 100 people (sometimes 150) getting a share daily, the catch was efficiently and widely distributed to meet local needs.

Gros Islet's seine fishing was also an important source of fresh bait for fishermen trolling the banks northeast of the island, especially during the bottom fishing seasons, July to November. It was common before the development to sell bait to over 20 canoes a day during the bottom season. As seine fishing has diminished in Gros Islet, these fishermen had to find more direct alternative sources for bait.

A still unfolding further development illustrates the current predicament of Gros Islet's seine industry. Until recently, one local fishermen with a "ti-seine," (small [pe<u>ti</u>te] seine) had been casting his net on beaches that the larger seines cannot use, including the remaining part of the Gros Islet Beach and along part of the causeway. But even he has emphasized that net fishing was much better before. "Before we were a fishing village, everyday we were taking kawang (carang) and jacks especially in this season now but the barricade blocks off the fish" (Koester, 1983).

Rodney Bay development destroyed or eliminated the most productive parts of the seine fishermen's environment, cutting their daily production by two-thirds and diminishing the daily work force requirements by about the same amount. According to one of the net owners, "From the time of the causeway I haven't had a really good year. Before if I had a son I would encourage him to come and help me with my seine. Now I wouldn't do that. There is no future in it" (Koester, 1983).

The use of both wire and the more traditional bamboo fish pots was the second major fishing method employed by Gros Islet fishermen at the time of the Rodney Bay Development project. Some men specialized in this single technique, others combined it with additional methods and others (like farmers, craftsmen and day laborers) set fishpots as a part-time occupational pursuit. Before the development about 30 Gros Islet fishermen relied principally on setting pots inside Reduit Bay, in the area of the causeway and north of the causeway up to Cap. Setting pots on the nearby reef area and in the bay provided all fishermen with a secure inshore component to their overall strategy, thereby spreading the risk. It involved the least effort and provided sustenance and income when the sea was too rough or the weather too bad for other kinds of fishing.

The Rodney Bay Development Project adversely affected pot fishing by destroying nearby areas previously used by fishermen and by impeding their access to more distant areas they previously used and continue to use, but now at a greater cost. Dredging destroyed fish habitats where men had set pots, and the mud and fine sand particles released while dredging the bay and swamp continue to hinder the efforts of pot fishermen. The causeway itself obstructed their access to fishing areas north of the village. "The causeway kept me back a lot, I used to set pots there. Before I rowed my boat and used a sail, now I have to buy a machine to go around Pigeon Island. And its not just me, its kept back a lot of fishermen," reports one village resident (Koester, 1983).

The Rodney Bay project has therefore raised the cost and effort required for Gros Islet pot fishermen, and many pot fishermen have left fishing altogether. Some sold their boats to Frenchmen, a lot left the sea and went on shore for a job. Another concludes, "Before the causeway, I never left the sea but after that I can't depend on the sea alone."

The Rodney Bay project occurred at a time when several new fishing technologies were being introduced in St. Lucia. At Gros Islet only two men had engines; the rest were still rowing and sailing. The three seines were all cotton. There were only two bottom gill nets and no trammel nets. Only one man was diving with a tank, and the use of dynamite was infrequent. Since the completion of Rodney Bay the old technologies have given way to more modern ones. Engines are used on both canoes and chaloupes, the seines are nylon, there are more bottom nets, and diving with tanks is widespread (Koester, 1983).

When the Rodney Bay project began, some Gros Islet fishermen were able to secure jobs in its construction. For example, it was reported, "A lot of fishermen quit to work on the causeway, the whole area was white with mud, there were no fish so there was nothing else to do." This alternative, however, was short-lived. Before the Rodney Bay project over 100 Gros Islet men earned their living from the sea. Estimates of the number of active fishermen now range from 30 to 50 (and many of these are part-time). The adverse effects of Rodney Bay Development for fishing, combined with the options it offered in construction, changed the occupational focus of many Gros Islet men.

Up until the time of the development project, lobster and conch were both present in the area of the causeway and also around Pigeon Island. The Bay itself had extensive sea grass beds. The fishermen of Gros Islet and the St. Lucia fisheries office agree on this. But all three--lobster, conch, and sea grasses--have now virtually "disappeared."

Before the Rodney Bay project, tourism seems to have played a more visible and reliable role in the livelihoods of Gros Islet fishermen. Tourists were able to walk from the Reduit Beach hotels to the Village and arrange for boat tours. Somewhat nostalgically, one fisherman recalled, "We used to take tourists to Pigeon Island. We didn't have engines then so we'd row them or take them by sail. We could always make a few dollars from it. Now the tourists catch big transports [tourist buses] and drive right around us" (Koester, 1983).

Fishermen also claimed it was possible, before the project, to catch lobster nearby and sell directly to the St. Lucia Beach Hotel and the Holiday Inn. Since the development, the nearby hotels buy from all over the island because the local supply is now "unreliable."

Frequently, when discussing the causeway, the fishermen of Gros Islet Village will use the term "barricade." One fisherman reports, "Gros Islet was the net fishing center. Since after they put up the barricade the place is dead." From the perspective of the village, its cemetery has been destroyed and the channel was made in order to separate the people of Gros Islet from the tourists. "I believe they didn't want much black people to meddle with the white people. Now we can walk to Pigeon Island but before we could walk over the bridge to the cemetery but now they've built the marina there. They didn't want the people in the midst of the whites" (Koester, 1983).

4.1.5 Retrospective Conclusions

The central idea of developing the Rodney Bay area as a multi-purpose (hotel, condominium, marina) site had merit. But the development plan was fundamentally flawed and produced serious problems when implemented. The project scheme did attract external investment capital, expand the tourism industry's infrastructure base in St. Lucia, provide some new employment opportunities (although primarily short-term), and is probably economically viable for the owners or investors over time. But as designed and implemented, and in the absence of any serious impact assessment or mitigation planning (even by 1970 standards), it produced a number of serious negative effects. Far too many unanticipated social, economic, and environmental costs resulted, and the project, in retrospect, was a failure, especially since the full accounting of environmental disbenefits (losses) is not yet finished. Three fairly obvious categories of failures overwhelmed the original scheme and placed it at risk. These failures are summarized below, not to be retroactively critical but because experience is still the best teacher and there are positive lessons to be learned.

1) Conceptual Failures. There was a general conceptual failure to appreciate the magnitude and complexity of the project and its aggregate consequences if done in one "fell swoop" instead of in stages. The evidence now suggests (after the fact) that the Rodney Bay tourist facility and land development project could have been accomplished without installation of the causeway and would have produced a better outcome. The causeway "component" of the scheme was costly, has returned no revenue and has induced numerous unanticipated, negative environmental effects on the natural and human ecosystems. The Gros Islet bay, beach, swamp, and village "system" was subjected to several sequential devastating modifications, almost simultaneously, with no

attempt to assess the impact of the first stage before moving ahead on later stages.

Three distinct and major ecosystem disruptions were involved:

- conversion of the fresh water swamp to a saline system by cutting a deep channel (it would have been better to cut not one but two) for enhanced flushing and to reduce the sand flies
- dredging of Gros Islet Bay sand for surcharging the swamp and then converting the core of the swamp to a lagoon marina system with filled shoreline areas and road access for residential and commercial use
- closure of the Pigeon Island passage and massive dredging in Gros Islet Bay for causeway fill emplacement which has had (and could have been predicted to have) fairly dramatic oceanographic, biological, and socio-economic impacts--mostly negative--on the ecosystem.

Had the swamp/lagoon modifications been followed by an even brief period to allow the system to stabilize and to allow for an assessment of impacts (providing feedback), it is likely that a decision would have been made to abandon the final "causeway stage". New market conditions and problems, community concerns, and environmental lessons learned in the first phases would have been evident, arguing against proceeding as planned with the causeway. Grand and complex schemes, hurriedly modifying equally complex island coastal ecosystems, are often pre-programmed routes to an economic failure, if not an environmental disaster.

The rule of thumb should be "when in doubt, stretch it out," even though this involves resisting the "can do" inclination of getting the job finished, producing immediate results, and moving the money--all very efficient and legitimate concerns under smaller, less risky coastal resource development circumstances.

A second conceptual failure by those who originated and sanctioned the project was their inability to perceive the marine biological system at Gros Islet Bay, the artisanal fishery, and the Village itself as "resources" which were unofficially committed to the project and which would be modified by it. The traditional users of the area became involuntary, reluctant partners in the venture because they fell within the "natural boundaries" of the project, although not within its official or legal boundaries as shown on planning documents.

In the absence of any integrated development planning protocol, this narrow perception of the project led to a failure to assess the nature and value of the resources being allocated--perhaps inadvertently and irrevocably--as an investment in the Rodney Bay development scheme. For example, the former coral reef at the Pigeon Island passage, now buried under the causeway, was taken out of the St. Lucia natural resource "bank" and invested in the project. It can only be recovered in kind, and even that prospect of re-payment is in doubt -- in part, because, after the fact, one can only infer what it was worth in terms of pounds of fish, lobster, or conch, in employment, and in natural shoreline protection (i.e., as an annually renewable free input to the economy of the Village of Gros Islet and of St. Lucia).

There were also a variety of other failures, some systemic (and those can be avoided in the future only by external compensatory actions) and some technical (that can be eliminated by modifying or applying higher or different standards or using alternative methods).

2) Systemic Failures. The political decision-making process, i.e., the political system, as an ongoing process of interactions between electorates, institutions, and leaders, is inexorably inclined to optimize short-term, sectoral development aimed at generating employment, investment and income in a problem solving mode within the shortest possible time frame. This is a simple fact of life, but especially risky when the developmental "quick fix" involves the allocation of small island coastal resources, usually involving complex, closely coupled dynamic natural ecosystems with an overlay of an equally closely coupled human ecosystem, constrained by both the insular vulnerability and limited option factors characteristic of smaller islands.

There is, however, another aspect of this systemic failure of the governance process. Insular dependency on externalities, like investment capital, technical assistance, grants-in-aid, and specialized engineering expertise (particularly marine) means that political leadership must also listen to a variety of different, exogenous drummers. The conjuries of development planning schemes and tempos (generally faster in the private sector, slower to funereal in the public) resulted in a Janus syndrome of trying to look inward and outward at the same time for signals or guidelines. In the process, coastal ecosystem development planning gets short shrift--project boundaries are too constrained, planning is both hasty and narrow, schedules are too tight to allow for feedback adjustments, resources are damaged, and costly surprises are endemic. Rodney Bay presents a classic example of this particular dilemma of "getting on with it" vs. "getting it right" (i.e., minimizing losses and optimizing gains); it is a problem that can only be ameliorated, not eliminated.

3) Technical Failures. Relying on engineers and economists to design a project like Rodney Bay was akin to planning a hospital without consulting with either the medical staff or user groups. In effect, a narrow engineering/marketing solution was sought and applied to a development task that had other equally important, non-engineering dimensions, namely, severe modifications to the natural and human ecosystems. Missing was the design perspective and technical expertise of natural and social scientists who, collectively, could and should have dealt with the unfortunately unaddressed matters of natural and human resource assessment. Issues deserving attention included documentation of traditional local uses and their economic and social significance, ecosystem characteristics, and project environmental impacts.

Other technical failures or omissions included cutting the Village off from its cemetery and its customers for tours and boat trips, dredging too close to the shoreline, not fairing the edges of the dredge borrow pits, not maintaining a beach profile monitoring program (although the engineering consultant recommended one in 1973), not working out an employment strategy for the Gros Islet villagers (who were prevented from fishing during the project), not including a proper sanitary waste water sewage outfall disposal strategy for projected tourism facilities in the planning, not anticipating the causeway erosion phenomenon, and not being responsive to obvious negative feedback signals from the disturbed ecosystem. These all were project design failures more than performance failures.

The final failure, perhaps the most significant, is really a by-product of all the conceptual, systemic and technical lacunae discussed above.

Over historical time, the Gros Islet community had struck a balance with nature. It had learned how to survive the vicissitudes of isolated island living, not just by fishing (which it did well) but also by learning to spread risk and adjust to seasonal catch cycles for various species. The community had developed ways to reduce vulnerability by internal diversification (mixing farming and fishing) and to limit dependencies on external markets by "substitution." It had developed an unwritten but proven and practical "optimum sustainable yield" resource management strategy for harvesting living marine species, which were within economic range. It embodied two or more centuries of experientially derived, collective information about the dynamics and stock of nearby coastal resources. As a West Indian community, it had come to terms with insular constraints, natural hazards (especially hurricanes and drought), and the vagaries of exogenous factors such as fish hook and net pricing, energy costs, spare parts availability, and "outside" markets for fish catch. When the St. Lucia Beach Hotel was built on the southern end of Gros Islet Bay, the community (wholly without assistance from tourism planners or commercial operators) adapted what it knew well to develop a new economic activity requiring no new capital investment, i.e., transporting tourists to historic Pigeon Island or to visit other local marine "things" within the area like the adjacent reef. Fishermen built their own boats and wove their own fish pots out of local material. In short, the Gros Islet community was a viable, fairly self-sufficient, productive fishing unit with low-level requirements for input from the state and from the external cash/market economy of St. Lucia and beyond.

Villagers had few requirements for energy, capital, and technological imports from off the island; their "dependency index" was low.

It is clear that Gros Islet was a village community which possessed its own technically autonomous culture while maintaining itself as a marine-oriented coastal society with a fairly "complex" production system. This is true, even though in a classical sense, Gros Islet was and still is a marginal and "peripheral" community vis a vis the more advanced dominant core systems in Castries or beyond. Even as a marginal or peripheral (albeit archaic) social unit, the Village was economically important (like other villages along St. Lucia's coastline) both to the national center and to other marginal units and production systems. It knew how to produce, to nourish, to sustain, to survive, and even to grow. It had established its own definition of the "rational use" of insular resources.

What the people of Gros Islet had not learned and did not know was how to deal with a Rodney Bay development intrusion. Not that they saw it as intrinsically "bad" or "good"--only that it represented a totally new threat and opportunity, frightening and promising all at once.

Island villages like Gros Islet, even in the face of development schemes like the Rodney Bay project, are not, of course, totally helpless. They may survive on their own adaptive terms as villages and as "less" productive, less efficient (more marginal) communities within the terms of national planning and development activity, but in either case they and we confront the same two questions: what of value is there already that could be lost in the process of modernization and growth, and how can the production system be sustained and losses minimized?

Failure to address these questions more often than not leads to later costly losses requiring remedial strategies and interventions. In this instance, there is no known remedial action that will recover what was lost. What was will never be again; no engineer can "fix it" or make it right. St. Lucia inadvertently sacrificed a living coastal village on the altar of tourism to exorcise a small, pesty bug. Unfortunately, there are still sand flies lurking in the bush at Rodney Bay, and the causeway remains an empty, unused expanse of sand.

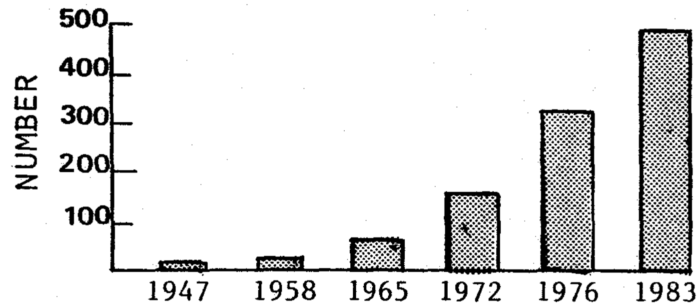
4.2 Virgin Islands Mangrove Lagoon (1967-1984)

4.2.1 Introduction

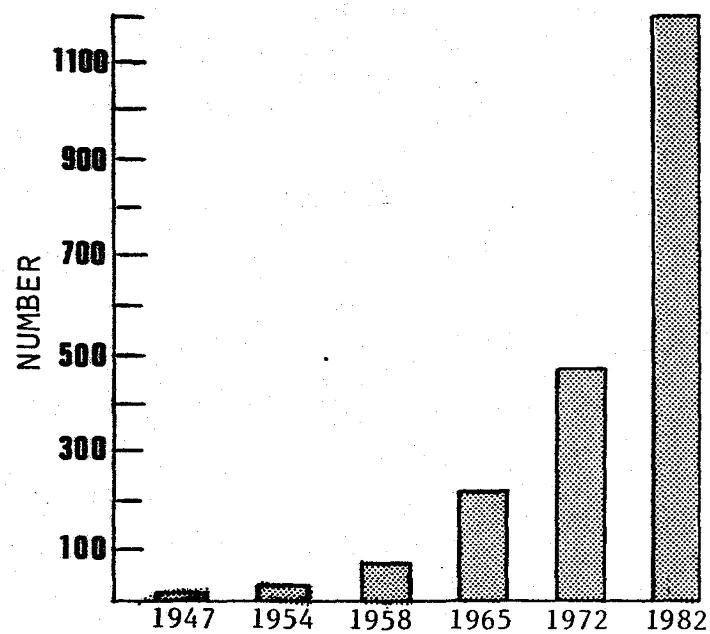
The southeastern coast of St. Thomas is endowed with a large, singularly attractive mangrove lagoon and bay of exceptional natural value. Its water, mangrove and grass bed systems traditionally provided a rich nursery area for fish and a productive habitat for benthic biota. Its mangrove fringed shores are a natural buffer against shore erosion, floods and hurricane waves. The coast's configuration provides a protective anchorage for boats and its adjoining hillsides are popular residential areas for Virgin Islanders. The area is filled with scenic contrasts, manglar islands, rocky cliffs, ponds and panoramic ridgelines. Its diverse complex of natural communities provides a recreational opportunity for Virgin Islanders. Yet these very attributes have attracted so many people in recent years that the same elements which first attracted them to the area are now being degraded.

Traditional uses of the "Mangrove Lagoon" (its official and generic names are the same) have included fishing, crabbing, clamming, the cutting of mangrove wood for charcoal and boat timbers, and serving as a protected anchorage for local boats, particularly as a hurricane refuge. Since the 1960's, however, development of the watershed and shores has proceeded virtually unchecked. Upland slopes, valleys and flood plains were bulldozed for two shopping centers, thousands of residential sites, and roads. Mangroves were cut and buried by backfill to create marinas, docks, a sewage treatment plant, roads and a racetrack. Coastal salt ponds were also filled. More people and more boats (Figure 3) created a need for new service facilities, i.e., more fresh water, more power, more roads, more parking, more docks, sewage treatment plants, and septic tanks. These, in turn, have reduced hillside vegetation and created higher residential and commercial densities resulting in more runoff, erosion and pollution. As pressures for development mounted, a series of environmental problems were created, and the Lagoon's traditional ecological values and functions were threatened.

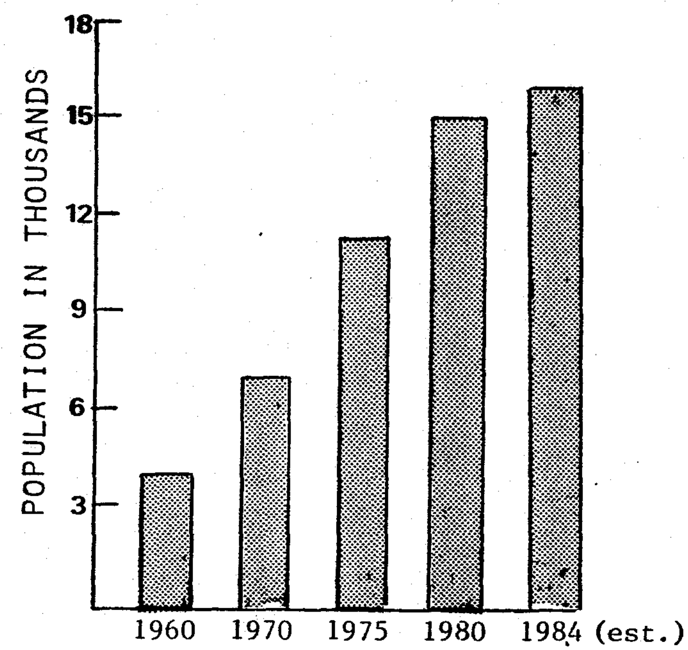
The following are some of the stresses and impacts currently impinging on or present in the "Mangrove Lagoon."



a. Boats in Mangrove Lagoon-Benner Bay.



b. Residential units in Mangrove Lagoon-Benner Bay.



c. Population in the Mangrove Lagoon, Benner Bay and watershed.

Figure 3. Trends in number of boats, residential units, and population in the Mangrove Lagoon-Benner Bay area. (Modified from Nichols and Towle, 1977b.)

- sewage pollution from anchored boats, sewage treatment plants, local septic tanks and shore establishments

- release of toxic trace metals from a municipal dump and boat yards, and local debris scattered around lagoon margins and watershed

- discharge of petroleum products, i.e., oil, gasoline and grease from boats, shore spillage, bilge discharge

- declining water quality, i.e., high turbidity, low transparency and low oxygen content, and rising indices of coliform bacteria

- growths of filamentous algae associated with high nutrient pollution loads

- sedimentation associated with storm runoff from the watershed and shoaling of the lagoon floor with formation of a black mud blanket

- disturbance of vital mangrove habitats by bulkheads, dumping and landfill to create dock space, berthing facilities and useable land

- loss of productive inshore clam and fishing grounds and reduction in vitality and diversity of bottom biota

- restriction of drainage with loss of flushing capacity and stagnation of backwaters favorable to mosquito breeding

- shoaling in the entrance channel which limits boat traffic and, in turn, marina use and economic viability.

Figure 4 schematically displays these current stresses and impacts in relation to contemporary lagoonal uses.

What is most notable, however, is not that the Mangrove Lagoon has deteriorated in an accelerated fashion but that this has happened within the context of a full spectrum of well-funded, well-intentioned, regulatory and control mechanisms, of planning, zoning, permitting, research and environmental assessment procedures, and after 1978 a formal Virgin Islands coastal zone management program designed and funded by the U.S. federal government.

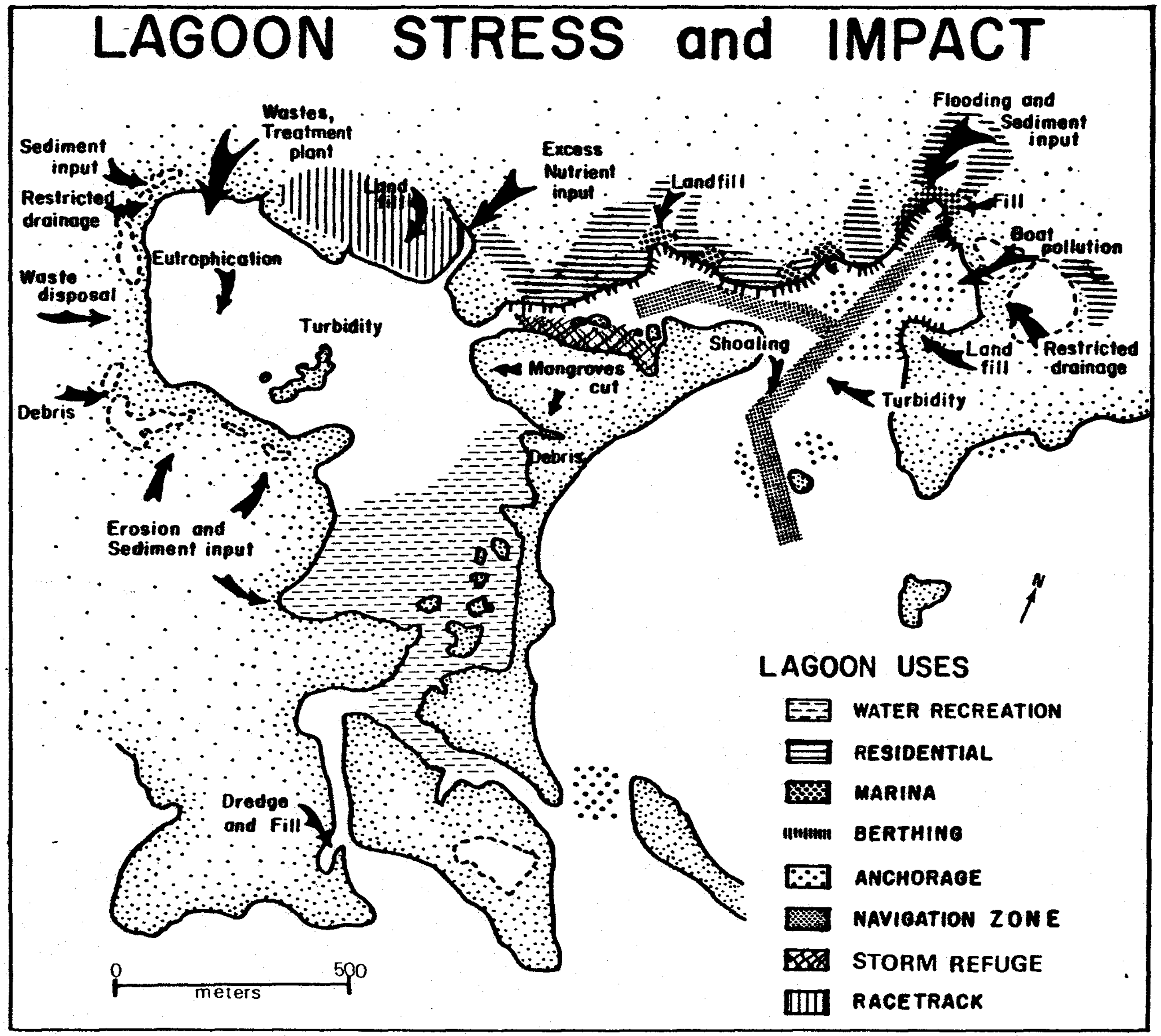


Figure 4. Schematic summary of stresses and impacts on the Mangrove Lagoon and Jersey Bay area, St. Thomas, 1983. (Modified from Nichols and Towle, 1977b.)

What went wrong? What can be learned from the labyrinth of emerging interactions between the users, the planners, the managers, the off-island exogenous factors and forces, and the natural ecosystem? It would appear that the management system was overwhelmed. Was it for internal or external reasons?

What follows is a fairly detailed description of the metamorphosis of an island lagoon/watershed system undergoing rapid change. It suggests that we can learn from experience, and it demonstrates that good intentions and local legislation, research and planning are not always enough to prevent the degradation of an island ecosystem in the face of externally generated and funded development pressures. It also stands as a kind of biography of an insular ecosystem that has inadvertently been pushed beyond its natural carrying capacity threshold into a new behavioral mode of a highly stressed, man-modified system requiring continous human management inputs of a costly and remedial nature.

4.2.2 Description of the Lagoon System

The Mangrove Lagoon with its contiguous passages, bays and backwaters forms a triangular estuarine system 2 km (1.2 miles) long and about 1.3 km (0.6 miles) wide overall. Because the shores are very irregular the average width is less than 0.5 km. The system lies in a northeast-southeast trending fault zone of sedimentary fill at the mouth of Turpentine Run, the largest perennial stream on St. Thomas. Mangrove fringed islands and shallow waters form an embayment in the coast which contrasts with the pattern of steep, rocky headlands and narrow sand or cobble beaches along the rest of the south coast of St. Thomas.

Together with Cas Cay and Patricia Cay, Bovoni Cay separates the Lagoon from Jersey Bay and the sea creating the quiet water necessary for extensive mangrove growth and the development of a safe harbor for small boats. Table 2 summarizes the geographic and hydrographic dimensions of the Mangrove Lagoon and Benner Bay.

Since the Lagoon is linked to the sea and to the watershed, contiguous upland drainage basins or "watersheds" and the waters of Jersey Bay are also considered. The standard geographic element is the ecosystem,

Table 2. Summary of geographic and hydrographic dimensions for the Mangrove Lagoon and Benner Bay systems. (Source: Nichols and Towle, 1977b.)

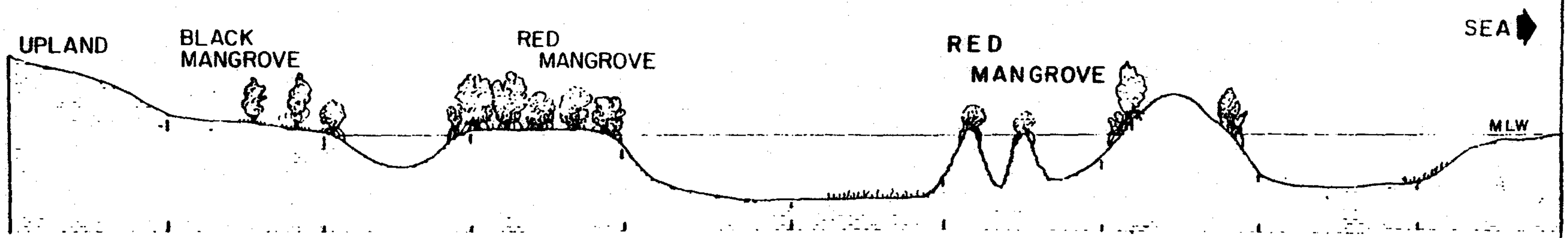
Parameter	Mangrove Lagoon (including passages)	Benner Bay
Length	1.6 km	0.4 km
Width	0.35 - 1.0 km	0.15 - 0.30 km
Water Area (Mean Low Water)	614,339 m^2	128,891 m^2
Water Area (Mean High Water)	809,471 m^2	135,607 m^2
Water Volume (below MLW)	805,675 m^3	160,394 m^3
Mean Depth Overall	1.3 m	1.3 m
Maximum Depth	3.2 m	2.2 m
Mean Tide Range	0.27 m	0.27 m
Tidal Prism	191,238 m^3	35,713 m^3
Shoreline Length (MLW)	1,374,641 m	13,201 m
Watersheds (total surface)	12.7 km^2	0.8 km^2

embracing all the biologic and physical components in the Lagoon which act together as an ecological unit; no single part of the system operates independently. The concept of a "coastal ecosystem" employed herein is that defined by Clark (1977) as including "... (1) a defined water basin (or series of interconnected basins), (2) all marginal (shoreline transition areas, and (3) all shoreland watersheds that drain into the coastal basin."

The lagoonal complex involves a series of ten ecological zones or units. These units are all linked by the flow of water and other human use. Table 3 summarizes attributes of these zones and their relative position with respect to each other, to water depth, and to distance seaward. Proceeding from greatest elevation, they are: the upland Tutu Valley area, a primary drainage basin called Turpentine Run with cactus and secondary scrub growth, the high tidal flats and salterns which are dominated by the black mangrove, the several ponds and inner lagoons which are edged by the red mangrove forest and swamp. There is also an open-water lagoon which contains turtle grass flats and manglar (barrier) cays. Between Bovoni Cay and Patricia Cay and between Patricia Cay and

Table 3. Ecological zones of the Mangrove Lagoon (from Nichols and Towle, 1977b).

ECOLOGICAL ZONES



ATTRIBUTES	DRAINAGE BASIN	HIGH TIDAL FLATS "SALTERNS"	PONDS & INNER LAGOONS	MANGROVE FOREST & SWAMP	OPEN WATER, LAGOON & BENNER BAY	GRASS BEDS (LAGOON) THALASSIA	MANGLAR CAYS	BARRIER ISLAND	PASSAGES, ENTRANCE CHANNELS	BACK REEF FLATS
AREA IN ACRES	3,334	10.7	14.34	49.9	183.0	11.0	4.5	15.3	14.8	10.4
WATER DEPTH OR **ELEVATION**	Range 0 to 260	Range 0.2 to 0.4	Range 0.1 to 0.3	Range 0 to 0.3	Mean 1.3	Mean 0.8	Range 0 to 0.3	Range 0.3 to 2.6	Range 0.2 to 3.2	Range 0.1 to 0.3
DRAINAGE OR FLUSHING	Intermittent	Partly Covered on Spring & Storm Tide	Slow	Red Mangrove. Covered with water most of year	Slow to Moderate	Slow to Moderate	Covered by Normal Tides	Rapid Drainage	Moderate	Rapid
SUBSTRATE OR BED SEDIMENT	Gravelly Clay Loam	Clay & Silt	Organic Muck	Peat	Mud, Sandy Mud, Muddy Sand	Muddy Sand Sandy Mud	Peat, Sandy Mud	Sand	Sand	Rubble, Sand
DISTINCTIVE ECOLOGICAL CHARACTER & FUNCTION	Dry Forest with Cactus, Secondary Snrub growth	Barren or Algal Covered	Bird and Wildlife Habitat	Forest Cover, Nutrient Production, Shore Stabilization	Plankton Habitat, Feeding and Nursery Area	Confinement, Nursery Habitat, Production, Nutrient Storage	Nutrient Production, Shore Stabilization, Sediment Trap	Storm Barrier, Sand Storage	Water Exchange, Feeding Area	Storm Barrier, Sediment Trap, Feeding Area

the mainland are entrance passages that lead to the back reef flats at the several "false entrances" (open but too shallow for boat traffic due to coral reefs). Much of the circulation for the Lagoon comes across these shallow reef systems in the form of wind driven currents.

The lagoon system acquires some of its water and much of its sediment from the upland watershed or drainage basin. Because the Lagoon is linked to the watershed, changes in topographic and flow characteristics of the watershed affect many functions in the Lagoon itself. Fresh water inflow governs the salinity of lagoon water which, in turn, affects the types of organisms in the Lagoon, their distribution and abundance. Additionally, the amount of sediment, nutrients, organic debris and some pollutants carried into the Lagoon is determined by stream runoff. These materials affect lagoon water quality, sedimentation rates, and plant production.

The drainage basin receives an average of about 40 inches of rainfall annually, but as much as eight inches has been recorded from a single 24 hour storm. Annually runoff amounts to only two to eight percent of the rainfall. The drainage system of the Mangrove Lagoon and Benner Bay consists of four sub-basins (Figure 5). Most stream channels are dry and carry only intermittent storm runoff. The Lagoon receives drainage conveyed through small guts or washes, through local culverts, and through a major stream channel--Turpentine Run. Most runoff in Turpentine Run infiltrates the soil and alluvium (Jordan and Cosner, 1973). Only major storm runoff, resulting from infrequent rainfalls totaling more than four inches, reaches the Lagoon as surface flow.

Intense development in the upper drainage basin of Turpentine Run (the Tutu area) has increased the potential for flash flooding into the Lagoon. By destroying the naturally absorptive soil and vegetation cover with construction of roadways, parking lots and roofs, and by lining stream beds with concrete, flood water from torrential rains is delivered to the Lagoon quickly (Nichols et al., 1979a). Most watershed sediment so supplied to the Bay is fine-grained silt and clay, and by remaining suspended in Bay waters the fines degrade water transparency.

Prior to 1968, flood drainage from Turpentine Run entered the La-

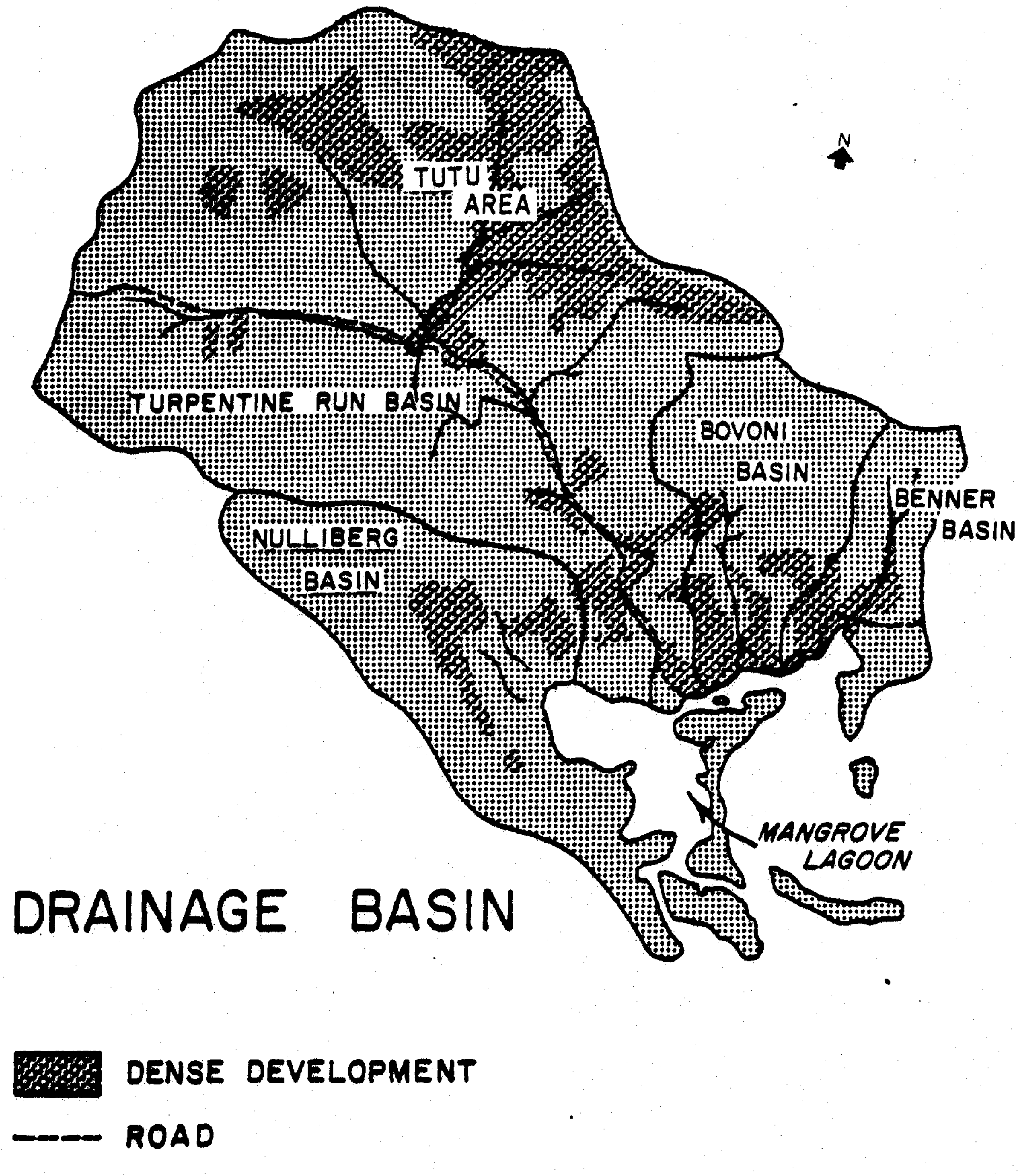


Figure 5. Drainage basins of the Mangrove Lagoon and Benner Bay, with areas of dense residence. (Source: Nichols and Towle, 1977b.)

goon through two or more vegetated distributary channels across an alluvia delta with mangroves. These shallow channels and the mangroves acted like a filter to cleanse the runoff of sediments and debris. When fill for a potential horse racetrack was dumped on the delta in 1968, drainage was short-circuited through a single channel directly to the Lagoon (Figure 6). Thus, the cleansing action of the distributaries was lost.

Some lagoonal circulation is wave driven. As waves enter Jersey Bay, they "feel bottom" and are refracted into gently curved patterns with crests more or less parallel to the bottom contours (Figure 7). Because of the narrowness of the west entrance channel and protection provided by Manglar Island and adjacent shoals, waves do not enter Benner Bay under normal conditions. Bovoni Cay excludes waves from the Mangrove Lagoon proper.

Although tidal forces are small compared to wind and wave transport over the reef, they are the most persistent force over the long term. They are also the main force during periods of light weather, a time when "worst case" conditions for exchange and flushing of pollutants develop.

4.2.3 Historical Development

The narrative begins in 1961 when the territory of the U.S. Virgin Islands entered into a dynamic period of rapid expansion and economic growth (stimulated almost exclusively by external factors) in three sectors--government operations, light manufacturing (assembly) exports, and tourism. In the case of tourism, growth rates were exponential, measured in tourist arrivals and accommodations. Massive U.S. government funding was also made available for public housing, roads, educational facilities, sewage treatment plants, health care and other human services. Additionally, U.S. tax incentives favored external investment in the Virgin Islands.

As a result, between 1960 and 1980 the population of the Virgin Islands doubled, and the employed labor force tripled. Electricity demand increased at an average of 20 percent per year. Thousands of new individual housing units were built. Public housing for 20,000 residents was constructed utilizing federal funding. A new 750 thousand barrel a

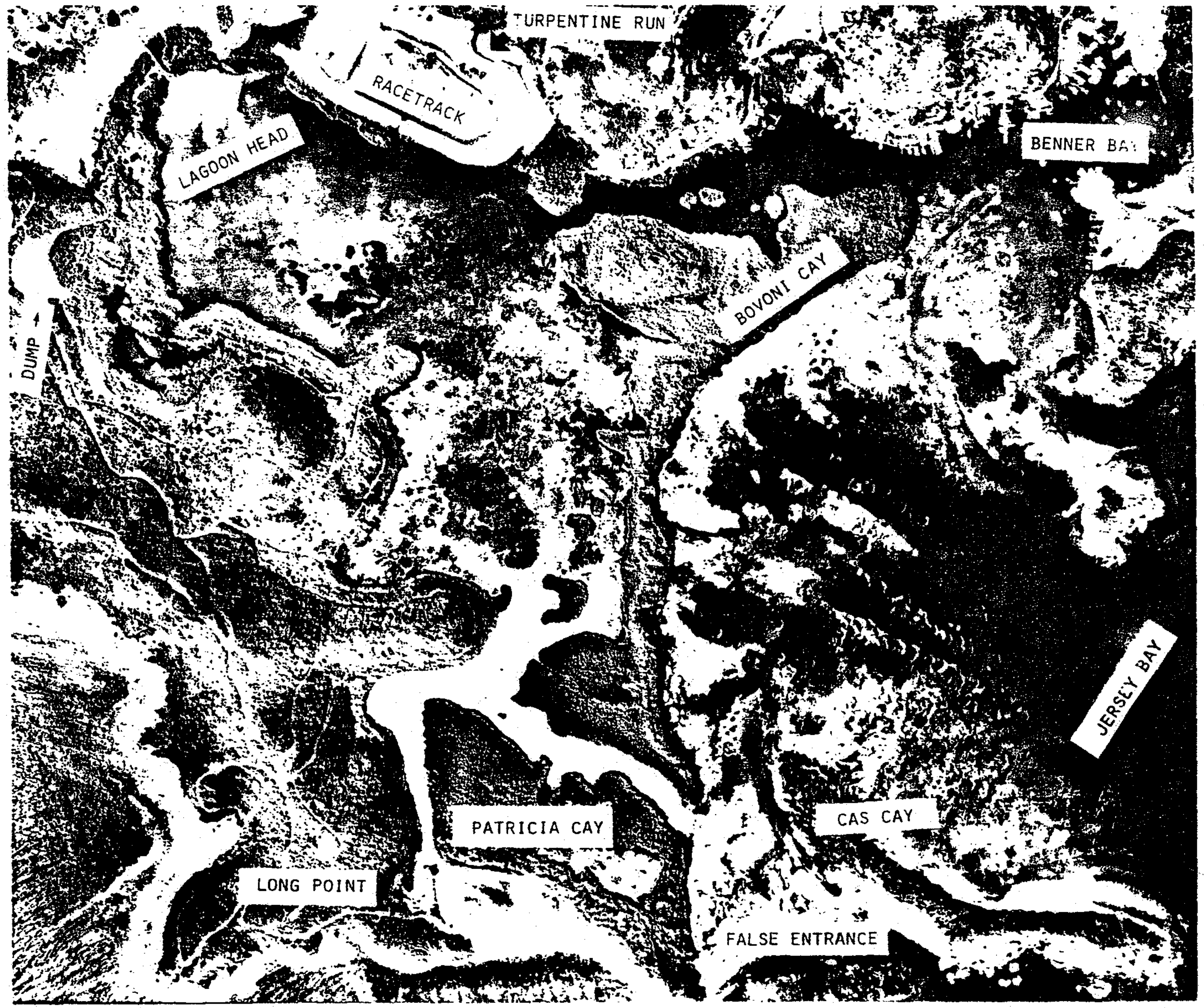


Figure 6. Aerial photograph of the Mangrove Lagoon and Benner Bay taken by the National Ocean Survey, November 23, 1972. (Source: Nichols and Towle, 1977b.)

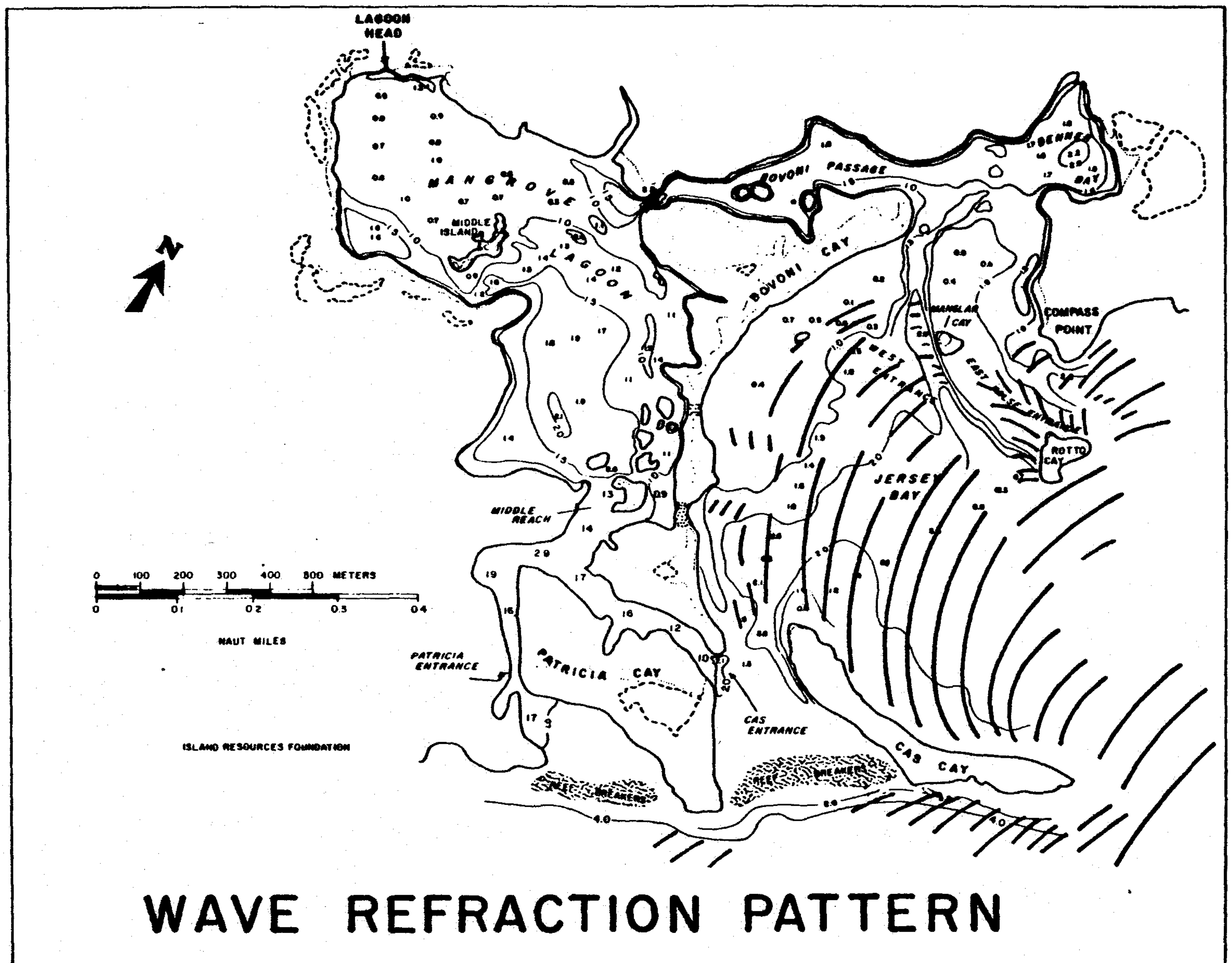


Figure 7. Wave refraction pattern for easterly swells reproduced from NOS aerial photographs of 1958 and 1974 (from Nichols and Towle, 1977b).

day oil refinery was sited on St. Croix (one of the three major islands within the territory of the U.S. Virgin Islands), adjacent to a new bauxite processing plant. Most standard indices for the Virgin Islands' economy had literally taken off, and the territory became increasingly dependent upon the mainland. As McElroy and Albuquerque (1983) have noted, "... the tourism base became pervasive ..., new ties were forged with national travel, financial, and transport interests..., federal social service and regulatory programs were institutionalized... [and] manufacturing activity (petroleum and aluminum refining) tied the territory inextricably into the global energy and raw materials markets." Although attenuated by the mild world-wide economic recession of the early 1970's, the process of accelerated growth has been sustained at only a slightly reduced level through the present time.

Sometime in 1967 the Governor of the Virgin Islands determined that the existing St. Thomas airport at Lindbergh Bay, on the island's southern coast near to the capital of Charlotte Amalie but removed from most major beaches and resort hotels, was unsafe and unsatisfactory and that a new international airport that could accommodate larger jet aircraft should be constructed at some alternative location. Engineering studies by off-island firms recommended that a new airport be constructed on the south shore of the Mangrove Lagoon on the easterly end of St. Thomas' shoreline. This would be accomplished by leveling Patricia and Cas Cays and Long Point and filling in intermediate reefs and the false entrances to build a runway which would have a more or less east-west axis, extending into 50 feet of water in Stalley Bay (Figure 8). It was a major engineering undertaking.

At the time no attempt had been made to assess the environmental impact of the proposed jet airport construction, and a bitter controversy in the community emerged which lasted the better part of two years. The resulting public debate evolved into rancorous polarization between the so-called growth vs. no-growth factions, between the environmental purists and the developers concerned with jobs, the economy, and human resource development.

Local opposition to the proposed airport resulted in the letting of

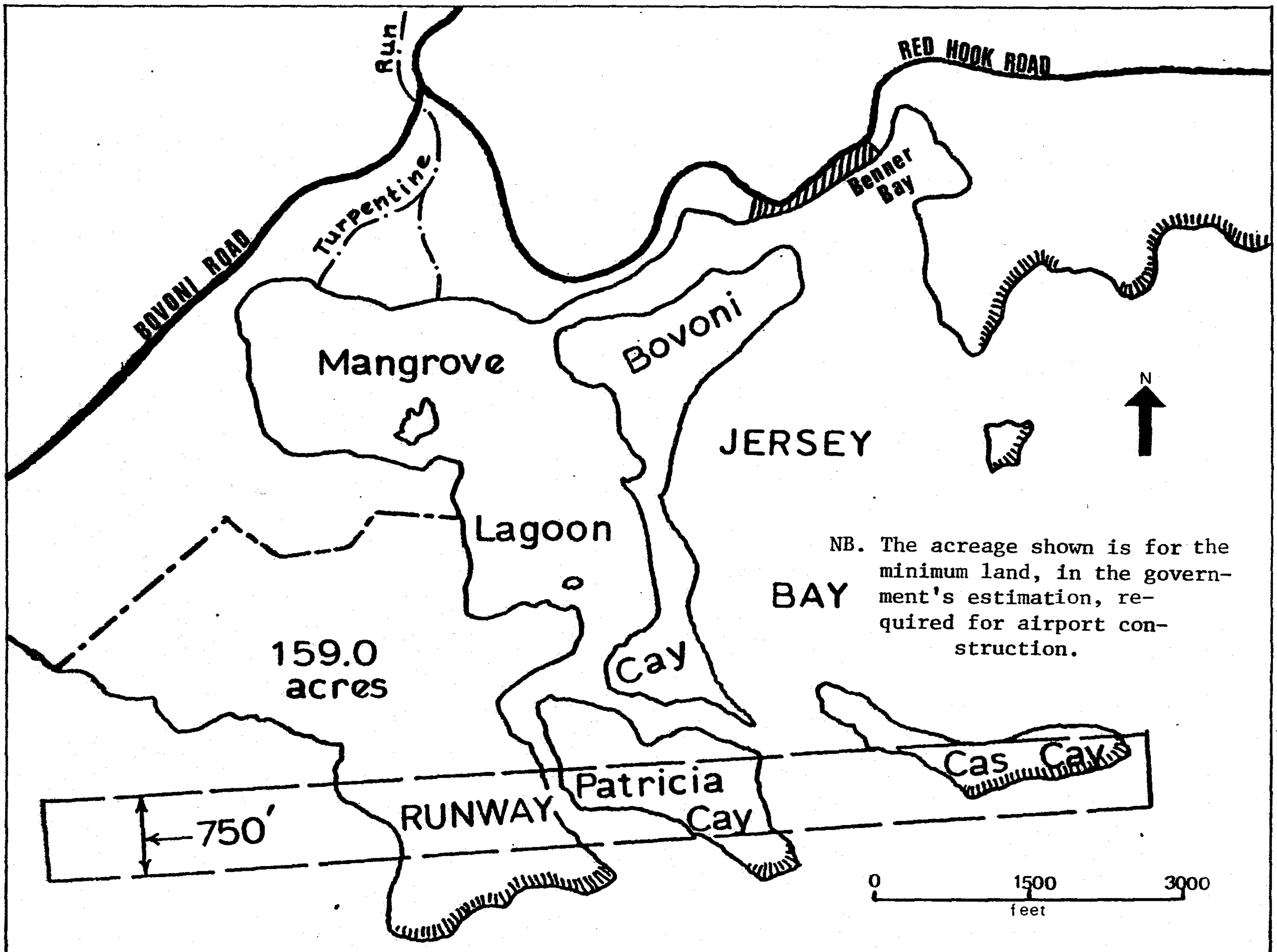


Figure 8. Mangrove Lagoon runway orientation for proposed St. Thomas jet airport, 1968. (Source: Tabb and Michel, 1968.)

a contract by the Governor's Office to the University of Miami in February of 1968 for a preliminary environmental assessment which resulted in a survey of the floral, faunal and hydrographic features of the Mangrove Lagoon. The consultants' report (Tabb and Michel, 1968) can be summarized as follows.

1) Turbidity from the silty clay component in the hill masses scheduled to be excavated and used for runway site fill would affect the entire bay area and, if prolonged, could have serious ecological consequences.

2) The construction of the airport would require paving over massive portions of the adjacent hillside areas, resulting in accelerated freshwater runoff in times of heavy rainfall, which would further aggravate pollution problems and result in nutrient enrichment (including sewage).

3) High water clarity and the natural seawater circulation were absolutely vital to the continued biological well-being of the Bay.

4) To conclude that conditions within the Bays might be improved by the addition of nutrient materials such as sewage was an unwise assumption.

5) The circulation pattern of the Mangrove Lagoon and the western part of Jersey Bay was dominated by the water transport induced by breakers on the shoals between the mainland and Patricia Cay and Patricia and Cas Cays. Transport from these breakers flows into Jersey Bay and the Mangrove Lagoon, overcoming the normal tidal flows and owing its existence to a rare combination of topography and wave characteristics coupled with a diurnal tide of a very small amplitude.

It is understandable that the Virgin Islands Governor's Office was unhappy with this report. An effort was made to seek a technological solution to the problem posed by the closure of circulation along Patricia and Cas Cays by the proposed airport project. An engineering consultant suggested the possibility of establishing an artificial wave run-up ramp and empondment on the seaward side of the projected runway, with a tunnel or sluiceway to be constructed under the airport runway itself. Such a scheme would <u>theoretically</u> maintain the pattern of water flow into the Lagoon and thereby maintain the normal circulation regime within the Lagoon itself (Michel, 1970).

At the same time, as the public debate continued, a worried voice was heard from a new direction, namely, from the island of St. John which lies immediately to the east of St. Thomas and directly under the path of the projected take-off patterns for the larger jets which would use any new airport at the Mangrove Lagoon. The U.S. National Park on St. John and a luxury resort hotel at Caneel Bay, St. John, were uneasy and quietly requested a U.S. Department of Interior, Fish and Wildlife Service study team to visit the Lagoon to provide further documentation on its ecological value.

The study team reported that "the Mangrove Lagoon is easily the most significant [mangrove] area remaining and is, in fact, very near the only stand of appreciable size that remains in the American Virgin Islands." They also found that "the Mangrove Lagoon is in fact the major remaining habitat in the northern U.S. Virgin Islands for about twenty species of herons, egrets, and other waterbirds and an equal number of wintering and migratory species." The U.S. Fish and Wildlife Survey experts expressed concern for the loss of habitat for waterbirds that live on Cas Cay and the adjoining waters of the Mangrove Lagoon, noting that encroachment on their habitat had already brought the population of many of these birds to extremely low levels (McNulty et al., 1968).

The administration was sufficiently confident with its position on building an airport in the Mangrove Lagoon that it purchased the land at Long Point, the focal point of the proposed facility. It also established a Port Authority so that it would be in a position to build and manage the new airport. However, the Governor was to discover that it was easier to decide to build a new airport than to find the money to construct it. During the ensuing, rather extended, delay yet another study of the Mangrove Lagoon, involving nine months of field work, was carried out by the research arm of the local college, the Caribbean Research Institute. The final report from this survey (Grigg et al., 1971) more or less coincided with a year long down-turn in tourist air arrivals and with acknowledgment by the administration that it had not been able to identify the necessary funds for airport construction.

The environmentalists and most residents of the Lagoon area were elated, assuming the Mangrove Lagoon was now out of "danger" since no new airport would be located there. But the government purchase of a key parcel of land at the Lagoon was a harbinger of other things to come --other incremental kinds of change and new pressures to "use" the now government-owned land in the Lagoon, if not for an airport then for whatever was convenient. Further, the territory-wide accelerated growth pattern, especially for the island of St. Thomas, was rapidly subsuming the Mangrove Lagoon and its watershed. Local planning, resource management, and environmental protection agencies were simply overwhelmed by the process of change. They were unable to deal with the pace and magnitude of growth, landscape alteration, and resultant environmental impacts generated by outside, off-island factors and funding.

Between 1970 and 1971 the number of boats in the Lagoon had doubled, and a new full service marina (Antilles Yachting Services) and three new bare-boat chartering operations had started up in the Benner Bay area, with construction just beginning at another marina at Compass Point. At the northern end of the Lagoon, a fair-sized residential community was developing, serviced by a 70,000 gallon-per-day sewage treatment plant operated by the Virgin Islands Public Works Department, with its allegedly treated effluent draining into "polishing" ponds near the Lagoon's edge. At the other end of the watershed, in the Tutu Valley area, a massive residential and commercial building boom was under way. The population of the drainage basin, which had been about 4,000 in 1960, had doubled by 1971. No one foresaw that it would almost double again by 1980, reaching 15,000 persons (nearly one-third the population of St. Thomas). This substantial growth would also eventually spur demand for several new sewage treatment plants (funded largely by the U.S. government) and thousands of septic tank installations in both the coastal and more remote watershed housing units and smaller commercial establishments.

Local environmental agencies had been concerned for some time about the problem of how to handle domestic and commercial sewage and waste water from burgeoning new "point sources" in the Lagoon watershed area.

Signals from the Washington-based federal agency concerned with territorial "sewage problems" favored a "treatment" instead of a "disposal" strategy. Unfortunately, the former strategy was inappropriate for island systems. Therefore, instead of opting for a low-cost ocean outfall disposal strategy (appropriate for offshore islands) for raw macerated sewage, local government authorities were forced to accept the federally "approved," standard continentally based approach of a fairly sophisticated system of complex aerobic/ mechanical sewage treatment plants, which are costly and energy intensive. Unfortunately, isolated, upland units require polishing ponds which use up limited land area, and larger "downstream" coastal treatment facilities still require short ocean outfalls for final disposal of the partially treated effluent.

Most of the subsequently built sewage treatment plant systems were not designed for tropical environments, rarely performing to design specifications and with a fairly high rate of breakdown. Furthermore, they require a high degree of operator skill if they are to be maintained and remain functional. As a consequence of periodic, often extended electrical power outages, a not uncommon phenomenon in island areas, raw untreated sewage often passes directly into associated polishing ponds or the coastal littoral environment.

Many of these problems were anticipated locally, but because the external funding sources pressed for use of standard continental criteria and preferred technology, the island got what it did not need --a high cost, high technology, breakdown prone, decentralized management nightmare of a system. The Virgin Islands could and probably should have opted for the World Health Organization (WHO) strategy which encourages island areas to avoid elaborate treatment systems and use well designed, long ocean outfalls for disposing of macerated and chlorinated raw sewage, preferably below the coastal thermocline (as, for example, in the case of the Cook Islands [Raratonga], Western Samoa [Apia], and Papua New Guinea [Lae]).

The Virgin Islands did not, however, choose to reject the "inappropriate" sewage treatment strategies imposed from outside (to do so would have reduced funding levels), and the Mangrove Lagoon watershed was to eventually have a total of five government operated systems--all disaster prone and difficult, if not impossible, to run efficiently.

In the meanwhile, within the Mangrove Lagoon itself (more than half of which was bounded by privately owned land), development activities were expanding, stimulated by various U.S. (off-island) tax policies favoring "charter boat" operations. By 1975, Antilles Yachting Services, a large marina operation based in the Lagoon at Benner Bay, applied for a permit for expanded facilities. The environmental assessment report accompanying the permit application emphasized that because there were so many other large-scale pollutants entering the Lagoon area from the watershed runoff and from the malfunctional, government-operated sewage treatment plant at Bovoni and from the government's solid waste disposal facility at Long Point, the pollution contribution from their own modest proposal of a few docks and a little bulkheading was very small by comparison and would not make a substantial difference (Insular Environments, 1975b). They were in fact saying, "Why single us out?" The implication was that the larger pollution sources in the area, resulting from ongoing government activity, should be dealt with first in coping with the general deterioration of the ecosystem.

But even as these events were occurring, there seemed to be new hope for the Lagoon from a different direction. Stimulated by the passage of the federal Coastal Zone Management Act of 1972, the local territorial government elected in 1974 to apply for the necessary planning grants to implement a Virgin Islands Coastal Zone Management Program. Under the aegis of the local Planning Office, a team was assembled and contracts let for specialized planning studies. The first of these, completed in 1975 (Towle, Grigg, Rainey et al., 1976), suggested that the "Mangrove Lagoon" be considered as an "area of particular concern" (APC).

By June of 1977 the Virgin Islands had completed its preliminary Coastal Zone Management Program Plan (VI Government Planning Office, 1977) which, after extensive public hearings and extended legislative debate, was approved in October 1978. The program consolidated and centralized the local permitting process for development projects, officially identified so-called "areas of particular concern" (including the Mangrove Lagoon), laid out the requirements for more elaborate environmental impact review documents to accompany permit applications for development activities, and provided criteria for restricting development in the coastal zone to water-dependent uses. Once the planning phase was completed, the administration of the program was turned over to the Virgin Islands' environmental agency, the Department of Conservation and Cultural Affairs (DCCA).

Many observers believed that with the advent of the Coastal Zone Management (CZM) Program, piecemeal development and mismanagement of the Lagoon watershed would be a thing of the past. The future of the ecosystem, however, remained at risk without remedial action to reduce pollution loading.

The U.S. Environmental Protection Agency (EPA) (through the Virgin Islands Department of Conservation and Cultural Affairs) funded two studies to address the problem of pollution loading (Nichols et al., 1979a and 1979b), but neither had any observable effect on either the expanding operation of the solid waste disposal facility or on the increasing volume of sewage and nutrients discharged into the watershed by the government-operated sewage treatment plants. These plants continued to be hydraulically overloaded and to malfunction and, in some cases, to not function at all for extended periods.

Finally, the Department of Public Works, which was officially charged with responsibility for managing both the solid waste disposal site at the Lagoon head and the five sewage treatment plants in the watershed (at that time), continued to have problems. The Department was hard pressed to find man-power, funds, and facilities to address the dramatic increase in solid waste generated on St. Thomas. Volumes rose from 100 tons per day in 1971 to over 150 tons per day in 1981 and up to 200 tons per day by 1984. The burdens imposed by the continual operation of sewage plants running at 120 to 150 percent capacity and by the frequent power outages due to mechanical failures at the power plant also proved difficult. Furthermore, because local hotels were required under the Virgin Islands Environmental Protection Act to install package sewage treatment plants, the Public Works Department was continually training sewage plant operators, only to lose them to the private sector.

Lastly, it must be remembered that the Mangrove Lagoon was only one of many stressed areas in the Virgin Islands through this entire rapid growth period, causing the agencies involved to divide their interests, forces, and finances between the three major islands of St. Thomas, St. Croix, and St. John.

The foregoing discussion presents the context for the next series of impacts on the Lagoon which brings the current case study to what we call the remedial phase. In the early 1980's, the territorial government obtained funding for a new hospital to be located on the outskirts of the capital city of Charlotte Amalie, St. Thomas. The site was then occupied by the island's only horse racetrack, a very popular, heavily used facility for local racing enthusiasts. Because time was of the essence in commencing construction of the hospital, a quick decision was made by government to move the racetrack to the Lagoon. The reasons appeared sound: the government owned the land (which made it convenient) and, further, there was a partially completed racetrack there already. It had been started by the Department of Public Works in 1968 in the mangrove wetlands at the lower end of Turpentine Run, but terminated because the local government had failed to secure necessary federal permits.

The government's hastily assembled environmental assessment report, accompanying its coastal zone permit application in late 1980 for siting the racetrack in the Lagoon area, argued that it was Public Works Department's sewage treatment plant, immediately to the west of the racetrack site, that was causing all the problems in the Lagoon. The only irreversible environmental effect of the racetrack would be to diminish the area available for nesting birds. The Coastal Zone Commission granted the permit in early 1981. Public confidence in the efficacy of the Virgin Islands CZM permitting process was not enhanced.

It is ironic that just two months after the Coastal Zone Commission permit was issued for the racetrack, the senior planner of the Division of Coastal Zone Management completed and circulated for review his very detailed "management plan for the St. Thomas Mangrove Lagoon area of particular concern" (Teytaud, 1981). The plan was too late to have any effect, too complex for efficient application, and too removed from prevailing uses and management requirements to enjoy acceptance as a workable plan of action or for controls.

As water quality continued to decline and shoaling accelerated, DCCA came under increasing pressure from a newly formed, private sector Benner Bay/Lagoon Marine Industry Association and others to take more direct action to reduce Lagoon pollution loading and also to permit a deepening of the access channel by dredging. DCCA turned to the U.S. Army Corps of Engineers District in Jacksonville, Florida, with a request to study the feasibility of improving the flushing of the Lagoon. Proposed modifications included widening and deepening the Lagoon channel to Benner Bay and dredging a turning basin at the end of the Bay. The Corps responded favorably and promptly launched a preliminary reconnaissance survey. Their September 1982 report (U.S. Army Corps of Engineers, 1982) documented approximately 400 boats docked in the Bay, the majority of them in excess of 28 feet in length. To quote the report:

> Benner Bay is one of the three major harbors in St. Thomas. It provides docking and anchorage for a large portion of the charter sailboats in the islands and, in times of severe weather, serves as a vital harbor of refuge for many additional boats. The bay also houses five commercial marinas and one of the few boat-hauling and complete service repair facilities in the Virgin Islands. Since a large percent of the boats in the islands have drafts in excess of five feet, shoaling in the bay has greatly curtailed its usefulness as an anchorage both in emergencies and on a long-term basis. In addition, economic growth of the existing marine-related businesses in the area has suffered from the inability of deeper draft vessels to enter the bay.... Shoaling in the bay is also suspected to have contributed to the environmental degradation of the area by decreasing the flushing rate of the bay and the adjacent mangrove lagoon.

The Corps estimated that 45,000 cubic yards of material would need to be excavated, costing $160,000 for final planning and engineering studies plus an additional $495,000 for dredging and construction costs, plus incidentals, for a total of $655,000. It would take two years, however, just to complete the detailed project plan. The "remedial action" phase of Lagoon management was fast approaching.

The local marina operators found two years to be somewhat long for simply a planning phase and opted to do it themselves. The idea was, however, expanded to include an additional dredged area for ninety new boat slips, but the permit application to the Government was rejected, in part because of rising concern within DCCA about the number of moored and docked live-aboard boats used as residences. The agency believed that live-aboard boats were contributing significantly to the growing pollution problem in the Lagoon. Concern was laid to rest, however, in 1983, when an EPA funded study of vessel wastes in the territory demonstrated that while the Lagoon's boat population had risen in one year from 400 to 481 vessels, only 81 were live-aboards. Furthermore, the aggregate Biological Oxygen Demand (BOD) loading from all boats was only 8.6 lb/day, while at the Lagoon head, the combined loading of the sewage treatment plant and Turpentine Run effluents was 455 lb/day, or 98 percent of the problem (Wernicke and Towle, 1983).

With few options left open, and with public pressure mounting concerning both the public "dump" and sewage pollution at the Lagoon head, the government was forced to take action. It elected (with U.S. federal funding) to "eliminate" the dump by building a "high-tech" 350 tons per day solid waste incinerator/energy recovery plant (to make fresh water by seawater desalination) and elected to eliminate the "sewage" problem by building yet another high technology, centralized sewage treatment system (replacing all existing smaller plants which would be abandoned). The total estimated cost is 25 million dollars. The two proposed facilities are to be located at the Lagoon head shoreline (the old "dump site"), on the land previously purchased by the government for the aborted jet airport (Virgin Islands Planning Office, 1983).

As for the Mangrove Lagoon, its days are clearly numbered, and in one--perhaps two--decades it will have more facilities than fish, more boats than birds, and more modifications than mangroves, requiring ever more costly pollution control and continuing remedial measures (like dredging) to do what nature once did for free.

4.2.4 Retrospective Conclusions

In the first place, there was a conceptual failure by almost everyone to perceive the Lagoon and its associated watershed as a system of connected and related parts (some more critical than others). This resulted in a sequence of structural design failures in virtually every management sector or agency concerned with the Lagoon "sink" at the lower end of the watershed.

For example, the natural scientists who produced the approximately 20 research reports, monitoring documents, and development impact assessment studies between 1968 and 1983, with only two partial exceptions, failed to address the totality of the ecosystem, focusing only on the "effects" manifested in the Lagoon. The Mangrove Lagoon without its watershed may have been a useful and convenient study framework but it was not a satisfactory resource management model.

As a consequence, there was a tendency to measure and count the wrong things and not to quantify others. In studies of the Mangrove Lagoon there were elaborate scientific measurements and quantification of waves, currents and fisheries, of fecal coliform and other water quality parameters, and of the distribution of benthic and pelagic organisms, sea grasses, algae, and mangroves. But it might have been more useful to count fewer fish and algae, and to allocate more time and effort to count the number of site development permits, septic tanks, and housing units, and to measure periodically the devegetated areas in the uplands, as well as look at things like commercial effluents, stream flow and sediment loads in Turpentine Run. An assessment of the driving variables and trends in the whole system would have been more useful than just measuring their impacts on the aquatic system at the lower end of the watershed.

Even with this expanded focus, the task of data analysis leading to a determination of significance and to implications for management would have remained at risk because natural scientists are not accustomed to, skilled at, or comfortable interpreting these kinds of data. A team effort involving planners, resource management technicans, and natural and social scientists was required, but the terms of reference for most studies rarely encouraged or even permitted such an approach.

Both the planning and management systems failed to conceptualize the ecosystem as a "watershed unit" and therefore proceeded over the years to look at the phenomenon of growth in the area through an artificial framework of "census enumeration districts" and zoning districts and codes designed in 1970 but never modified in the face of emerging concentration and density factors in the "Turpentine Run/Mangrove Lagoon ecosystem."

In any event, just the existence of a central, physical or town planning unit (whatever it is called) can give all concerned a false sense of security. This problem is especially awkward when dealing with coastal and marine matters in developing island areas, largely because planning units seldom have staff competent to adddress the complex question of coastal resource planning. This situation is especially bothersome for insular areas undertaking more intensive strategies to develop coastal and marine resources.

As in the case of Rodney Bay in St. Lucia (see Section 4.1), there were also systemic failures in the transition of the Virgin Islands Mangrove Lagoon and its watershed from a low-cost viable natural system to a pollution prone area requiring high-cost engineering interventions to maintain its "utility" to residents and users. Units of the local resource management system (planning, zoning, environmental control, waste disposal, land use, and coastal zone management) were completely overwhelmed by the magnitude of the tasks required in the face of externally generated and accelerated development activity. They never seemed to "catch up" as their functions required more lead time and expertise than were available locally, even though external funding support was ostensibly provided for some elements of their resource management functions.

For example, the establishment of a Virgin Islands environmental management agency, the Department of Conservation and Cultural Affairs (DCCA) in 1968 tended to encourage a false sense of environmental security. It was simply too new and too complex an undertaking to be effective in its early years. The institutionalization of any new, broadly focused and "technically" based government department (or its ministerial equivalent) takes time, is fraught with organizational, funding and staffing problems and is destined for a difficult first decade of trial and error learning, with some successes and many failures. The Mangrove Lagoon was, unfortunately, one of the latter.

DCCA's agenda from 1970 onward was too full to allow the agency to pay much attention to the Mangrove Lagoon (although it did, with off-island funds, support several studies focused on the Lagoon but not properly aimed at the right issues). Therefore, when the new, externally funded Virgin Islands Coastal Zone Management Program was approved in 1978 by the local legislature (based on a three-year planning effort) and assigned to DCCA to administer, those within the agency and those outside concerned with coastal resources somewhat naively assumed that a balance could be struck between developmental pressure and environmental imperatives in coastal areas. Hope may spring eternal, but unfortunately reality creeps in, and in the case of the Mangrove Lagoon, the Virgin Islands' CZM program was fundamentally flawed. Using an external (federal U.S.) model, it split out a relatively narrow "coastal zone" along the land/sea interface into a two-tier demarcation, a) ignoring the fact that, in small islands, the <u>entire</u> island is a coastal zone and b) excluding from the CZM program's purview and permitting jurisdiction the entire inner core of the island and thus most upland "watershed" areas (for example, the most heavily populated segments of the Turpentine Run-Mangrove Lagoon drainage basin).

There was also a technical failure of researchers, planners, and managers to address the full spectrum of driving variables within the system. The numerous studies of the natural system and its changing characteristics produced mostly negative management recommendations of the "don't do this anymore" character, with little concern for how to effect needed changes in user behavior, management structures and policy. At no time was there a systematic investigation of the social system and its characteristics, limits, changes, and driving variables--which were continually interacting with the natural parameters of the Mangrove

Lagoon and its watershed.

Between 1960 and 1984, the Mangrove Lagoon watershed experienced the emergence of a variety of new social units of direct and indirect users of the Lagoon. In 1960 there were only farmers, fishermen and a sprinkling of residents and small commercial establishments (served by septic tanks). By 1984 there were nearly 500 vessel owners, an active marine industry, thousands of low-income public housing residents, thousands of middle-income single family dwellings, thousands of apartment dwellers and owners, and hundreds of commercial businesses. To some, this was progress. But there were numerous deferred or hidden costs, not the least of which was the degradation of the Mangrove Lagoon.

Finally, the Virgin Islands Mangrove Lagoon example illustrates several additional technical problems worthy of mention.

- There was a general failure to recognize the fact that the aggregate effect of degradation in an ecosystem like the Mangrove Lagoon can be worse than the sum. Initially, incremental changes are minimized and considered acceptable because the natural ecosytem is "working" and can handle the changes. But in later stages, larger incremental changes are justified as inconsequential (in the presence of the aggregate pollution effect). The argument is made that by concentrating polluting activities in one location, the use of other still pristine areas for those same activities will be avoided.
- There was a failure of government to abide by its own established rules and to apply the same environmental standards to itself as it requires of the private sector. Permit systems involving subjective judgments by the permitting agency only work well when everyone assumes the procedure is "fair" and "reasonable." When, for example, government agencies subvert this system by manipulating the process through subterfuge, or by applying higher "anti-pollution" or environmental quality standards to others than they are willing to

honor, then the permit system will break down--not in form but in function.

- There was a tendency on the part of all off-island, external development funding agencies involved in Lagoon watershed development to ignore the environmental impact of their lending or grant input. It is almost as if there were a separate set of less stringent rules for "offshore" areas, but, as O'Riordan (1981) and others have noted, it is unrealistic to assume that external (off-island) funding sources and institutions will voluntarily seek to establish the full spectrum of environmental costs or be willing to internalize them, within discrete project budgets. However, until such costs (representing a draw-down on the natural and social systems' capital stock) are identified and quantified, development planning and growth management will continue to generate unanticipated environmental crises, disbenefits and ecosystem losses, leaving islands at risk.
- The Virgin Islands' experience demonstrates that the impact of inappropriate capital-intensive technologies on fragile insular ecosystems will tend to reduce long-term resource flexibility because of the virtually irreversible alterations to specialized and highly complex land/sea ecosystems caused by such intrusions. This dysfunctionality results from the incompatibility of grafting high-volume technologies onto small closed environments with a very limited capacity to absorb the residuals (McElroy, 1978b). As McElroy has noted, "The result is the substitution of man-made inputs for irreplaceable natural ones, and in the long run development options are restricted and perverse feedbacks reduce the viability of environmentally sensitive industries like tourism. Such technological dependence chronically limits future local options" (McElroy, 1978b).

4.3 ECNAMP: A Regional NGO/PVO Participatory Planning Approach

Over the past eight years, the Eastern Caribbean Natural Area Management Program (ECNAMP) has developed as an effective regional approach to island resource assessment, environmental management, and ecodevelopment. It is a private sector initiative supported by the Rockefeller Brothers Fund, World Wildlife Fund, International Union for the Conservation of Nature, UNEP, and others.

ECNAMP was based on an hypothesis (derived from prior experimental activity in Latin America) that, given the pace of Caribbean tourism development and landscape change, a systematic national park and wildlands program was needed in island countries. Such an approach would serve a dual purpose of analysis and action: the process of identification, justification, selection, planning and protecting "critical natural areas" also provided a mechanism for introducing multiple-use resource assessment, strategic planning, and management techniques. Each would be addressed through a non-formal, hands-on, learning-by-doing process. By linking conservationists, local users and institutions, development planners, and unique ecosystem features in a kind of "non-Faustian bargain," both the development and conservation ethics could be honorably addressed in a well choreographed framework of human and natural ecosystem interactions. The whole, it was assumed, would be greater than the sum of its parts.

Essential to ECNAMP's development was acceptance of a long-term approach: a small "force for change" over an extended period of time (three to ten years) would be more effective than a larger force over a short span of time (one to three years). Further, ECNAMP has been structured so that, except in rare cases, a less "qualified" indigenous expert, consultant, or participant was preferable to a more qualified "continental" expert from the outside. Additionally, a locally designed and produced plan (perhaps using external counsel), however simple or imprecise, was preferable to an externally produced, more sophisticated plan or scheme. The entire concept was, in the language of educators, an experiential learning strategy for <u>both</u> the teacher and the learner. Best of all, it has worked!

ECNAMP was originally launched in 1976 by a grant from the Rockefeller Brothers Fund (under the auspices of the Caribbean Conservation Association and the University of Michigan's School of Natural Resources) as the Eastern Caribbean Wildlands Program. It took as its thematic approach the need to define strategic planning programs for natural areas in the Eastern Caribbean. The initial effort embraced a strong conservation theme, with an emphasis on the region's needs and best options for insular park, preserve, and natural area protection and preservation.

By the end of 1980, through the gradual evolution of a rather low-key, "bottom-up" strategy emphasizing participatory components, ECNAMP had emerged more as a process than as a discrete program. It was less of a natural-area protagonist and more an attempt "to stimulate ... creative development ... through the definition and use of socially prudent approaches designed to match the environment's potential" (Putney, 1981). The resultant emphasis has been on the human and social components of the natural resource ecosystem, on the interaction of the human resource base and the natural resource base, and on the development of a sustainable "ecodevelopment" process. In effect, the "island experience" of the early years generated a quasi-reversal of emphasis from wildland protection to ecodevelopment and sustained resource utilization strategies. Even more significant was the shift in focus from terrestrial to marine environments and resources.

ECNAMP's long-term potential as an agent of insular change is based on the premise that strengthening local institutional capabilities will enhance the capacity of an island area to effectively manage its natural resource base. As a catalytic, skills-building effort, the program has developed an integrated series of mutually reinforcing activities. Major program components include research, training, education, mapping, planning and field projects, each designed to strengthen the capabilities of island resource managers (such as fisheries officers and planners) in the Eastern Caribbean. The goal is to foster management strategies sensitive to human needs and economic imperatives which do not exceed ecological constraints.

One of its earliest program components was an inventory and mapping effort, combining locally collected and collated natural resource systems data (for each of 25 island areas in the Eastern Caribbean) with data on established resource users and the human resource base. The resulting output of this survey and mapping project was a series of island data atlases (18 maps per island). Atlases were designed to provide a broad spectrum of information for local and regional policy makers, planners, and resource managers (especially those who had collated and analyzed the data as a training process). The information compiled illustrates the inter-relatedness of both the biological and socio-economic aspects of development activity and encourages a systematic approach to decision making and resource utilization (Putney, 1982).

More recently, ECNAMP program efforts have included non-formal, community-based coastal zone management and environmental education in St. Lucia; assistance to a forestry products crafts industry in Dominica; and a marine parks program for the British Virgin Islands which emphasizes traditional use, economic activities, recreation, education, and research as well as protection of the natural environment. Other projects are an integrated, multi-island, intra-governmental strategy for resource planning and development for Anguilla, St. Barthelemy, and St. Martin/St. Maarten, and a multiple-use development planning effort for the Cabrits Peninsula in Dominica. This last project incorporates an ecodevelopment approach for utilizing the resources of a local fishing community and developing a nearby historic site located within the Dominica National Park.

ECNAMP activities are structured to support a process which is holistic rather than segmented into smaller parts. Its integrated approach to natural resource management emphasizes coordination, with a series of linked program elements carried out within a highly flexible, decentralized management framework to encourage integrated learning and transferability. Dispersed offices and personnel located on several islands in the Eastern Caribbean (Barbados, St. Croix, St. Lucia, Antigua, British Virgin Islands) participate in the program, and affiliated associates can be found in most of the other larger islands of the Eastern Caribbean. Since its inception in 1978, the ECNAMP operation has evolved as a network of collaborating individuals and institutions from the region who cooperate in the ECNAMP framework when appropriate. It uses a talent pool of individuals already in place in the islands of the Lesser Antilles, thus enhancing ECNAMP's ability to be responsive to changing local requirements and to adjust requirements in response to ongoing community-based assessments.

The importance of participatory strategies to all facets of program planning and implementation has been consistently stressed by ECNAMP personnel. ECNAMP strategists recognize that communities, together with government planners, must be an integral part of the decision making process for natural resource utilization. Emphasis has been placed on the use of local community expertise, assessments, and solutions to meet local problems and define local needs. The linking mechanism is a regional networking of indigenous institutions and consultants, responding to community-level needs in designing and implementing program activities in the small decentralized islands of the Eastern Caribbean (Putney, 1981; Towle, J., 1982).

The change process fundamental to development can perhaps best be accomplished within an organizational framework which acknowledges the uncertainty associated with the task of development. An appropriate response to such a risk-bearing environment is a process of ongoing creative adaptation. This is the working model of ECNAMP. Its funding and executing agencies have permitted core personnel to work within an environment relatively free of institutional constraints or plan-specific approaches to resource management. Rather, an experiential, action-based, capacity-building program style has been encouraged. The ensuing climate of innovation and flexibility has permitted ECNAMP to adapt the process en route which has been, in effect, goal enhancing.

ECNAMP is a catalytic development process for natural resource management with increasing emphasis on coastal areas. It is not an organization in and of itself, but it manifests a capacity building framework which is being "institutionalized" as a learning model by a network of collaborating program participants in island areas throughout the Eastern

Caribbean. It is as much a learning process as a doing process and, as such, is a unique program, with replication possibilities, for developing island areas (Towle, J., 1982).

Its most recent publication, "Guidelines for Integrated Marine Resource Management in the Eastern Caribbean," provides a useful model demonstrating what can be done at the local and regional level by employing a "participatory" strategy, limited funds, unlimited patience, and a willingness to listen to the non-professional resource managers--i.e., the traditional users of the resource. It is recommended reading and a working handbook for anyone addressing island coastal zones and marine resource development and management (Geoghegan, 1983).

5. THE PACIFIC ISLAND REALM: EXAMPLES AND LESSONS

5.1 Regional Overview

Embracing some 64 million square miles and covering nearly one-third of the earth's surface, the Pacific Ocean is the largest, most prominent feature of the globe. It also contains the world's largest collection of islands--some "continental," most "oceanic." It includes the world's second and third largest islands (New Guinea and Borneo), the world's two largest independent archipelagic states (Indonesia and the Philippines) and perhaps twenty or so island groups encompassing more than a hundred thousand islands, atolls and islets. There are twenty separate smaller political entities of which ten are independent "developing" island countries.

If the reader can conceive of a line drawn along the great circle route (the shortest distance) from Japan, eastward across the Pacific Ocean to central Chile and then back to Australia's south coast, the wedge-shaped enclosed area or "triangle" contains nearly all of the island groups of the Pacific, encompassing the islands of Melanesia, Micronesia and Polynesia, and some five million people (three-fifths in New Guinea). This wedge-shaped Pacific Ocean "island" subregion, even though only about one-fourth of the larger Pacific Basin, covers a vast oceanic area nearly 9,600 km (6,000 miles) long measured on the east-west axis and averaging about 4,800 km (3,000 miles) on the northsouth axis. For every 500 square miles of ocean there is an average of about one square mile of island "land." Under the framework of the emerging "Exclusive Economic Zone" concept (200-mile-wide extensions to the territorial sea boundary), land-to-sea area ratios vary widely, with New Guinea at 1:10, Fiji at 1:60, the Cook Islands at 1:3,000 and Kiribati at 1:6,000 (all figures rounded).

Some island groups, like Fiji, are true "clusters," while most are spread out in curvilinear arcs over great distances like the Solomons, the Cook Islands, Tonga and especially Kiribati (the former Gilberts) which extends over 4,000 km (2,400 miles) of ocean space but has only 567 km^2 (215 square miles) of land area.

In 1979 the Pacific island area received about three percent of the world-wide total of overseas development assistance (concessionary grants) mainly from Australia, New Zealand, the United Kingdom, France and the UN. By way of comparison, the Caribbean region received about five percent and the five island states in the Indian Ocean area received two and one-half percent. Donor/recipient funding relationships in the Pacific vary widely, some highly dependent on a few bilateral sources and others with a broader, more multilateral external funding base.

5.2 Fiji: The Regional Center

Fiji is made up of about 322 islands which are strategically located in the center of the South Pacific island area. The total land area of Fiji is 18,272 km^2 (7,000 square miles). There are two rather large islands, Viti Levu with 10,429 km^2 and Vanua Levu with 5,556 km^2, and ninety-five other inhabitated islands like Taveuni (470 km^2). Approximately 95 percent of the population of Fiji lives on the two main islands of Viti Levu and Vanua Levu. Population is concentrated in Suva, Latoka, and Nadi areas of Viti Levu (Figure 9).

The economy of Fiji is primarily agrarian. Sugar is the primary export. Tourism in Fiji is second to sugar as a foreign exchange-earning sector. Other major exports are gold, copra, fish and coconut oil. The population of Fiji is approximately 635,000, of which forty percent work in the agriculture sector. Bilateral overseas development assistance to Fiji in 1980 was 31 million dollars (total overseas development assistance was 33 million dollars), less than ten percent of total Fijian goverment expenditures which in 1980 were US$360 million. According to Hamnett et al. (1981), "Just after independence in 1970, Fiji relied on the United Kingdom, Australia, and New Zealand for a majority of its aid. Since that time, Fiji has successfully captured aid funds...[but] has also built up its own ability to generate development funds internally." Fiji is therefore less vulnerable to major changes in foreign aid allocations." Food imports per capita in 1978 were only US$114, and the government has a fairly elaborate diversification strategy designed to reduce even this relatively low level of dependency on external food supplies. The government of Fiji, unlike most Caribbean countries, has

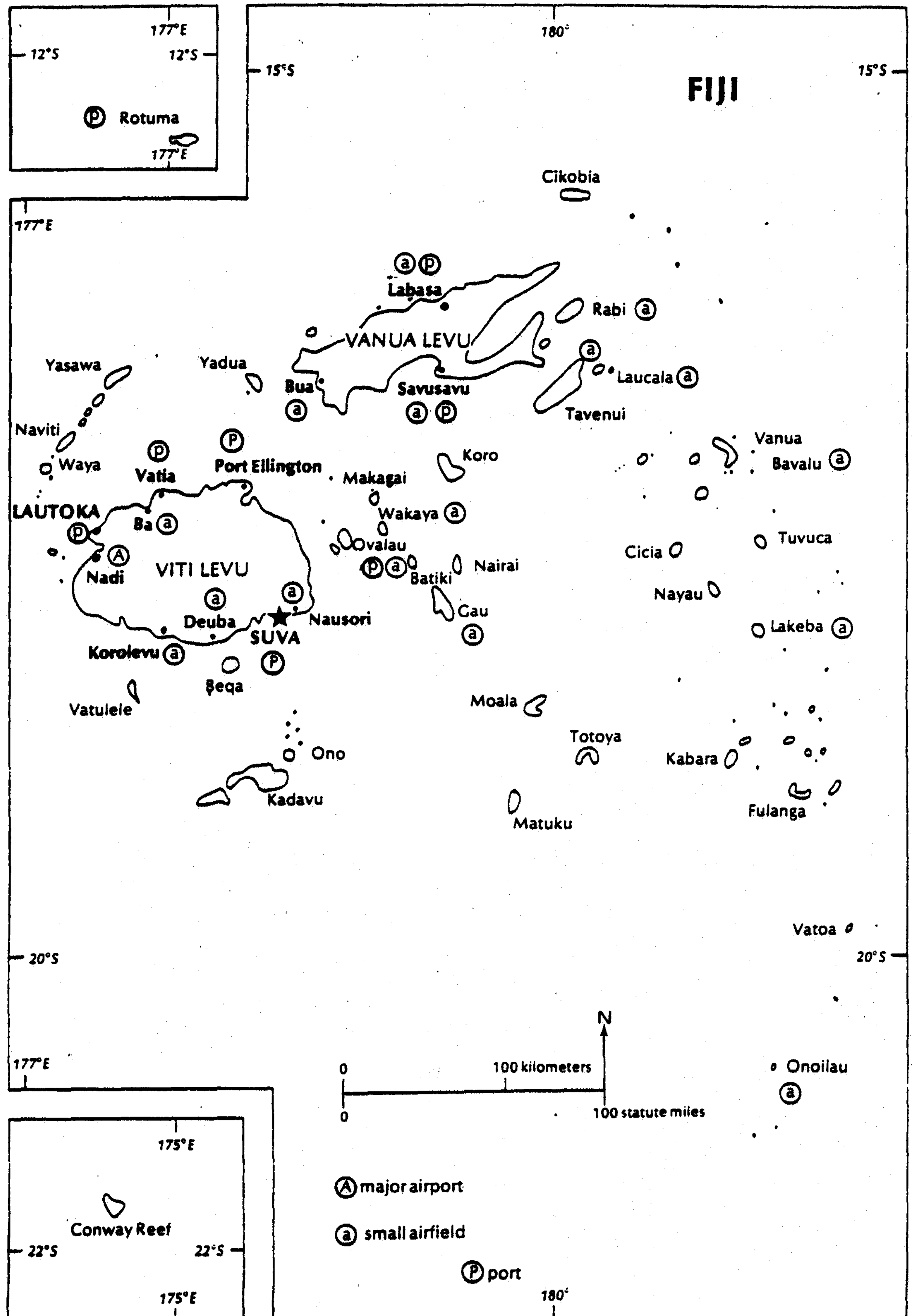


Figure 9. Fiji Islands. (Adapted from East-West Center, 1982.)

a well developed structure of divisional and local government units.

Fiji is also the site of the regionally supported University of the South Pacific and various other regional programs and projects supported by international agencies. This centralization of research stands in contrast to the Caribbean where regional agency and service headquarters are based in a variety of places (like Barbados, Trinidad, Jamaica, St. Lucia and Guyana).

Fiji has a very professional planning division, which has produced top quality national development planning documents (Fiji, 1980). In the fourteen years since independence, it has made significant progress in addressing both growth strategies and environmental management issues, though the format differs from island counterparts outside the Pacific area. Overall long-range planning objectives are designed to promote self-sufficiency, in part through rural sector and peripheral island development programs with the aim of encouraging Fijian citizens to expand primary production and to own and manage domestic and international business ventures serving domestic needs in order to make Fiji less dependent on external help. Fiji's expanding interest in using coastal and marine resources to accelerate this process is reviewed in the following sections.

5.3 Fiji and the Coastal Zone

For many oceanic islands there appears to be a class of marine resources that are in excess of local subsistence requirements. In most smaller island countries, it is not clear to what extent it is practical to exploit these resources in a more extensive, intensive, or commercial way for local use, for supplying urban areas or for export, without jeopardizing subsistence use levels and encouraging food imports at high costs.

We have taken for our case study in this instance certain prototypic examples from the island group of Fiji. There the indigenous population's perception of man and his natural resource base takes the form of an all-embracing, unifying concept of interdependence between humans, land, and sea. The concept is implicit in the Fijian word "vanua" (whereby it is impossible to separate out any single component) and forms the basis of traditional Fijian resource rights (Baines, 1979). For Fijians who use and draw subsistence from coastal areas, the land itself as well as adjacent lagoons, coastal reefs and other marine components are seen as part of an integrated whole, inseparable from other portions of village land regardless of boundaries that might artificially separate marine and terrestrial ecosystems or divide or designate them by such distinctions as "high-water mark" or "the beach" or even the "coastline." As Baines (1982) has noted, "In Fiji this enlightened perception of resources persists even in the externally influenced Fijian culture of today."

This perception is, of course, at odds with British Admiralty Law and land title law, imposed upon and common to Fiji for more than a hundred years. It is possible for private individuals and corporations to own some land above the high-water mark. It is also possible, in the case of traditional or native land above the high-water mark, for it to be owned on a kind of village-rooted communal basis. However, anything below the mean high-water mark and extending seaward to the island's outer-reef edge is legally defined as the property of the nation but is also subject to a traditionally derived, now codified (under a national Native Lands Trust Commission) set of practices based on "communal use rights," all of which, in turn, constitutes a rather remarkable, integrated, grass-roots coastal resource management strategy.

It is, in effect, a bottom-up coastal zone management program, to the extent that it is an internalized equilibrating process for adjusting to the carrying capacity of the system. Change is absorbed or resisted and risk is spread, by limiting use of the marine "commons" (which is important to island peoples in the face of seasonal changes, natural disasters and unpredictable outside influences). It is solidly based on locally derived, traditional technology and on an awareness of the limits of the system (Hardin, 1968).

In both the Caribbean and the Pacific, larger as opposed to smaller islands and especially island groups display significant differences in both the perception and the use of coastal resources. For example, smaller islands or islands with very small shelf areas in the Caribbean and also atoll communities in the Pacific have developed fairly diverse technologies and not inconsiderable skill for going "offshore" to exploit fish on adjacent or even distant deep-water outer-reef slope areas. Larger islands or islands with larger coastal shelves, as in the case of islands on the Virgin Islands platform or as in the Fijian case, have tended to venture not quite so far offshore for fishing purposes. Barbados, in the Lesser Antilles, is an interesting case in point here because the Barbadian fisherman, lacking both an extensive shelf and protecting satellite islets and therefore working in more exposed open sea area, especially when loaded after fishing, cannot easily exploit the shelf areas of the more westerly islands to leeward, just over the horizon. He has, therefore, evolved a very special kind of boat, quite different from other Lesser Antillean watercraft, enabling him to fish in the more exposed waters on the deep shelf off Barbados.

A different situation has emerged in Fiji. Baines (1982) has noted that in the case of traditional Fijian communities, which have access to an extensive shelf area, there are "no Fijian names for the high-quality snapper now being fished in Fiji from the deep-water outer-reef slope." Fijians simply did not venture into or attempt to harvest fish from the outer deep-water reef slopes, for such coastal villagers had access to inshore marine resources.

Additionally, traditional "territorial" limitations have also defined the particular areas which community or village groups were to exploit. Such traditionally defined "fishing rights" areas continue to be important in Fiji today and are delimited by boundaries which generally are seaward extensions of the land boundaries to which a particular group has legal rights (Baines, 1982). This approach is, in modern terms, a "limited entry system" serving as an internal mechanism to maintain a sustainable-yield strategy for use of marine resources.

Any given fishing village might have exclusive rights to use an area immediately offshore. Its dimensions were determined customarily by historical shifts of power and influence and, to a degree, reflected the local sequence of village establishment. A given village would also customarily possess shared use rights with some limited number of additional villages in other demarcated areas (with seasonal limitations or for an occasional "harvest"). Thus, there tended to exist a kind of equilibration process whereby each village defined a basic subsistence area plus several kinds of fall-back, emergency use or seasonal use areas shared with others that combined the coastal, lagoonal, and offshore reef system in a fairly complex pattern of demarcated use rights. In more recent times these traditional use rights (in part because they have been nationally codified) have been seen by some as a constraint upon more modern kinds of development activity, such as marinas, hotels, or other tourist operations, because to use such traditionally demarcated fisheries areas the developer is required to negotiate for any new "use" of the area. Since use rights are not customarily sold but only leased, the end result is an informal permitting system whereby the new user pays a recurring annual fee which, in turn, becomes a limiting device on the use of the resource.

For example, the author learned on a recent site visit to Fiji (1983) of a large tourist operation on the western coast of Viti Levu which was desirous of using various nearshore, uninhabited islets for a "deserted island beach experience" for its clients (who would be delivered to the areas by boat). The operation had to "negotiate" with the "controlling" village for such access. In addition, the tour operators had to specify intended use patterns and sites, establish nonconflicting schedules, and also pay a "use" fee. They could not, therefore, treat the islets as "commons" and knew full well that their activities (and any negative environmental impacts) would be monitored by the traditional users. Similar examples have surfaced relative to marine sand mining/dredging projects which have been required to negotiate a fee-payment with traditional use-rights holders, not for the sand (which belongs to the "crown") but for "diminished fishing opportunities", i.e., presumed temporary environmental impacts. Even coastal mangroves have come under these arrangements, for during disputes over shoreline reclamation efforts, traditional users (who seasonally harvest crabs, etc., for food from the mangroves) have brought complaints to the Native Fisheries Commission, asserting that they had been deprived of a traditional harvesting option and sought to recover the value of that loss. In such cases, the local litigants have been awarded between \$258/acre/year and \$384/acre/year for lost use rights (Baines, 1979).

Such a system of checks and balances reduces the indiscriminate, irrevocable allocation or destructive use of any coastal resource in favor of a sustained, non-destructive use. It has a "free," built-in monitoring system (because the users jointly share the resource), establishes a cost for utilization of the "commons," and represents an internalized and informal, multiple-use, participatory, sustainable-yield coastal resource management strategy which favors the maintenance of local subsistence use and national self-reliance, with cost figures attached to commercial exploitation schemes (Hardin, 1968; Gilles and Jamtgaard, 1982-1983). Any attempt to install a highly formalized top-down "coastal zone management system" in place of or casually superimposed upon this preexisting and traditional island system would undoubtedly be a mistake. While not every island has quite such an effective, codified, and workable coastal resource "management" mechanism already in place as does Fiji, most islands have locally evolved, village-based, uncodified counterparts (see the Rodney Bay example in Section 4.1).

Since Fiji emerged as an independent nation in 1970, increasing attention has been paid to coastal resource development potential. One result is an expanding and profitable offshore fisheries focus on the skipjack tuna. Exploitation of this fishery has, in turn, involved international development of commercial joint venture and licensing arrangements with the Japanese as well as various domestic horizontal and vertical integration arrangements for new local businesses. Elements of the new economic strategy include the successful development of local can manufacturing, fish processing, vegetable oil supply, marketing companies, and ship building enterprises. Other experiments, focusing on the commercial expansion of nearshore artisanal (traditional, small boat, low-technology, mostly subsistence) fishery resources have not been quite so successful.

It is useful to review two prototypic examples of well-meaning attempts to "develop" traditionally used coastal fishery resources on a commercial basis while still maintaining an artisanal base. They have each been analyzed in some detail by Baines. Both projects were planned on the premise that artisanal fishermen and their respective villages had some understanding of the concept of surplus production and of marketing for cash. It was assumed that there was a link between the sale of fish for cash and the possibility of exchanging services and cash for a variety of other goods that would benefit the individual or the village.

A simple two-phase model for commercial development of a coastal fisheries resource (based on a single offshore insular village unit but assuming some cooperation between neighboring villages) was designed by the local Fisheries Division to exploit local reef and lagoon resources. The effort was to require only shallow draft, small traditional boats and nylon seine nets. It had been assumed that after the village repaid initial capital loans, surplus income would be invested in a later phase for larger boats and better gear to enable trolling and possibly pole-and-line fishing activity outside the reef. The overall scheme required the government to provide some additional shipping service for ice transport to be used in outer island fish storage facilities and for the return trip by sea to the main urban center of Suva (Figure 9). The only uncertainty in the model was the renewable-yield potential of the area to be fished. At the time there were no simple guidelines to assess the fisheries potential of coral reef and adjacent shallow-water environments, although this shortcoming has since been remedied (Baines, 1982).

Shortly after the project was launched, technical and climatic circumstances introduced additional uncertainties in the logistical support side of the endeavor. Engine breakdowns and bad weather prevented some scheduled ice deliveries and fish collection trips by the government's boat, resulting in a general decline of enthusiasm on the part of the participating fishermen. But the most significant problem was not technical but social. The ice delivery and fish pick-up by the inter-island service boat, when it worked, involved a fixed schedule. The fourteen-day cycle of catching fish, preparing and icing the catch and then loading it for shipment to market imposed a regular concentrated pattern of activity which conflicted with other village activities. These behavior patterns had been more traditionally based on seasonal changes and on planting and harvesting cycles for both terrestrial food crops and for the optimal time required for achieving the best harvest of marine species. Most fishermen, accustomed to the normal "feast or famine" cycles of fishing, limited by both biological and climatological considerations, had spread the risk of economic survival over a variety of additional pursuits. Maintenance of small-scale farming plots was an important secondary occupation. Villagers found it very difficult, under these circumstances, to adapt to the fourteen-day project cycle which seemed so reasonable from the perspective of the project planner in Suva (Baines, 1982).

Fortunately, the project was not abandoned. By shifting to more appropriate fish processing techniques, ice supply and shipment problems were essentially eliminated. Fish was dried and smoked and dried sea cucumber (beche-de-mer) was added as an exploitable resource, all of which could be safely stored until transport. The solution represented an adjustment of the project design to the more traditional, local activity pattern which had long combined both agriculture and fisheries. Adaptation to this strategy essentially guaranteed the project's success (Baines, 1982).

A second project in Fiji involved an enterprising effort to encourage coastal villagers to exploit beche-de-mer (dried sea cucumber). In this case the fisheries' project planners determined, in advance, "customary" or traditional fishing areas of target villages, the availability of adequate beche-de-mer stocks, the basis of community support for the project, and the presence of the required labor supply. A sincere and effective effort was undertaken to train selected persons from the various target villages as both harvesters and processors to guarantee a supply. This strategy also ensured the application of techniques necessary to produce a high-quality dried product that could be stored for shipment and be acceptable for the export market. The initial effort produced a good product which was processed with enthusiasm and brought a good price in Suva. Villagers were more or less satisfied, although they expressed some unhappiness about the long interval between the collection and processing work and the cash proceeds which ultimately resulted from sales. In time, this unhappiness resulted in a gradual waning of community enthusiasm, and the only alternative that seemed acceptable was for the villagers to harvest but not process beche-de-mer, even though they would be paid a much lower price for the unprocessed animals. They clearly were more interested in the immediacy of cash return, and thus the beche-de-mer industry developed through an intermediary (not a villager) who purchased the raw material and then processed it for shipment to Suva and ultimate export (Baines, 1982).

However, as harvesting continued and stocks declined, fishermen began looking to the stocks in areas controlled by other villages not involved in the scheme. The search for additional stocks resulted in an unfortunate confrontation over fishing rights and in failure of the project because the carrying capacity of the target area had been exceeded. This outcome suggests that fishing rights for domestic consumption are not easily merged with commercial exploitation of the resource for export. As Baines concludes, "...successful coastal resource development projects require that the chosen technology be consistent with the social organization of the communities involved in its application" (Baines, 1982).

Promising and effective new strategies for small island coastal resource development are possible, but only if environmental perceptions of coastal communities are better identified and appreciated, and local understanding of the ecosystem and its management requirements can somehow be tapped. Central planners, and external development change agents need to be responsive to this information source and imaginative enough to incorporate such data into economic and development models for small island areas. Anything less than this will, if the island experience is any guide to the future, diminish the resource base, encourage island "openness" and demands which exceed ecosystem capacity, create internal user conflicts and new dependencies for the island, and subvert future attempts to develop more self-reliant, national coastal resource use, management plans and practices.

If small coastal resource development projects require midstream re-design (based on feedback from the participants), then larger schemes are even more at risk if they are not sufficiently flexible to make such adjustments. Current international and bilateral development project design formats--at least for island areas--are more often inappropriately structured and rarely permit truly flexible readjustment of program elements, and objectives in response to changing circumstances. As a result, in the larger search for effective, workable "leverage" points to provide for basic needs, many projects brought to islands from the outside fail to establish and put in place an institutionalized living mechanism (people, structures, and technology) for growth that enhances national or insular self-sufficiency, reduces dependency, minimizes vulnerability, and is economically viable. This problem is endemic to islands; the view from inside (looking out) bears little resemblance to the view from outside looking in. Bridging this conceptual gap has nothing to do with funding levels or more foreign aid--it is solely a question of how to address technical assistance for and to island areas in a more constructive, creative, and appropriate way, one that is sensitive to unexpected events and to the island's requirements for self-reliance and survival, not as a microstate but as an island system. There is a difference.

5.4 Center-Periphery Questions (The UNESCO/MAB Fiji Project)

Between 1972 and 1980 Fiji and small satellite islands to the east of Viti Levu and Vanua Levu, particularly the Lau group, became a kind of test site for what may be the most significant, detailed and instructive study carried forward in the last several decades on man/environment relationships in island areas. The study comes to grips with island carrying capacity, small island dependency, productivity, and vulnerability, and related development options for insular areas.

In 1972, the UNESCO Program on Man and the Biosphere (MAB) launched a special study project on "the ecology and the rational use of island ecosystems." Humans were the focal point of the study, with an emphasis on the problems of island populations within their environmental context. The island ecosystem project was to offer exceptional opportunity to study, under relatively controlled conditions, the entire spectrum of ecological, economic and social factors influencing man's relationship with the biosphere. Its objectives were to pursue three themes: (1) management of environmental resources by island populations, (2) impact of external forces on islands and (3) impact of alien plants and animals on island ecosytems.

The study assumed that island ecosystems, because of their small size and isolation, were intrinsically susceptible to environmental degradation resulting from external influences, and that islands would also "provide unusually favorable conditions for scientists to study ecological, social and cultural models of human carrying capacity." Additionally, although among islands there is tremendous variability (which offers opportunity for comparative studies), the program designers also assumed that "islands constitute discrete units of manageable size in which scientific measurement might be facilitated" (UNESCO/MAB, 1973).

As a working hypothesis, the project sought to explore the concept of carrying capacity of various types of islands along a continuum of subsistence-based, self-sufficient island systems and more developed islands which had lost their internal capacity to prevent or control environmental degradation.

It was also presumed that research work on the less developed islands would (in a kind of preservationist mode) look to strategies for maintaining traditional forms of stability. In the case of islands already substantially integrated into wider economic and technical systems, research emphasis would be placed on remedial strategies for emergent <u>environmental</u> problems caused by over-population, unbalanced land use, misuse of resources and the negative impacts of tourism (UNESCO/MAB, 1974).

As part of its overall world-wide strategy, the UNESCO/MAB planning group began to search for an island test site in which to examine man/environment equilibria. Outlying islands in the Pacific area were considered to be good examples of a situation common to many tropical islands: mono-cultural use of land for export crops, subsistence food production, and inter-island exchange of produce (taking advantage of ecological diversity) between primary and secondary island areas, in combination with the use of coastal marine and reef resources. It was assumed at the time that many island areas and particularly the peripheral islands of larger island groups were experiencing a process of disintegration of the normal network or flow of materials, goods and people. At the same time they also remained marginal to national growth centers. As a result, peripheral islands were increasingly under-utilized and under-populated, while the "core" island areas were experiencing urbanization and losing their former self-sufficiency in food production. As urban core islands were growing and in a sense becoming more centralized and marginal to external systems (because of their openness), the outer islands or peripheral areas were increasingly more vulnerable, dependent and less diversified. Outlying areas were, therefore, less able to contribute to any national strategy for self-reliance and internally based economic development.

With the financial assistance of the United Nations Fund for Population Activities, the UNESCO/MAB program in 1973 designed and mounted a pilot research project with field studies to be undertaken principally in the small eastern island group of Fiji, concentrating on the systems relationships among (a) human population dynamics, (b) the use of natural resources from a set of previously interlinked ecosystems (marine, coastal and terrestrial) and (c) the function of the outer islands in relation to national and global economic development structures. This multidisciplinary project was headed by Dr. Harold Brookfield, a geographer affiliated with the University of Melbourne in Australia and later the University of West Indies in Barbados. Topical areas covered in the subsequent research effort were reef systems, soil and vegetation, land use and land holding, nutrition, work input, demographic considerations, migration and the larger question of center-periphery relationships. More complex questions of island carrying capacity, vulnerability, dependency, and development planning were also considered. During the course of the project the interdisciplinary study team also become very much enmeshed in Fijian efforts to design improved long-range development strategies for Fiji and in a search for development guidelines appropriate to the Fijian insular system (diCastri and Glaser, 1979).

The MAB Fiji project was far too complex and its products too extensive to adequately summarize or even review here. The seven volumes of documentation constitute perhaps the best available analysis of what makes islands systems "tick" (MAB, 1977, and Brookfield, 1977, 1978a, 1978b, 1979, 1980). It is instructive to note what happened in Fiji for it is a microcosm of what happens generally to oceanic island systems.

Until the twentieth century, ecological variety in the outer islands of Fiji gave rise to specialized, localized production which supported an active, although informal, system of direct inter-island trade. Some exchange of goods extended to nearby islands in Tonga outside of the boundaries of Fiji. With development in the core or center (essentially Suva on Viti Levu), there was a change in the terms of the relationship between the center of Fiji and the very productive and diverse satellite island areas. As the center of the Fiji island system enlarged, the smaller outer island systems were absorbed into the structure and framework determined by the center. As a result, the outer island group tended to lose its own diversity, productivity and independence of judgment as to what and when to produce in order to survive.

Adjustments to the needs of the larger system diminished the capacity of the outer island group to serve the larger task of national self-reliance and self-sufficiency. In Fiji's case, the outer or easternmost islands are increasingly marginal to and dependent upon the centralized decision making and resource use systems, which continue to be mono-cultural and export oriented and over which they have little control.

Brookfield's own retrospective overview of the Fiji project is instructive (1980). He was perhaps the first to suggest, based on field work in Fiji, that despite the good intentions of the UNESCO/MAB program the research study had suggested "the need for a new integrating paradigm, in which the relative roles of the social and natural science contributions might be clarified within a unified framework."

Brookfield was concerned as early as 1972 with the MAB program notion that the "rational use of island ecosystems" could be defined because this involved a behavioral assumption regarding the existence of "rational ecological man." Who was to define what was "rational"? It ignored the fact that an islander's own perception and set of values did not necessarily seem to find any clear place within the framework (i.e., that there were differing versions of rationality). Furthermore, even at the outset of the project, Brookfield expressed some concern about the conception of islands as "laboratories" for the study of population/environment relations and about the assumption that a high degree of closure existed in island/environment systems which made them useful objects of study. "This assumption," according to Brookfield, "is not tenable for the majority of the world's island communities and is not tenable for any island in which externally generated development efforts are being made." Colonial and mercantile expansion had subsumed previously independent systems within larger hierarchical systems of spatial integration, to the detriment of both (Brookfield, 1980).

The Fiji carrying capacity project began when the entire MAB program philosophy was shifting. By 1974 a major stumbling block was removed by introduction of the concept of "the human use system" as defined in a UNESCO/MAB (1974) document. The perspective of MAB shifted in less than a year to incorporate a new kind of social science dimension into its approach, one which defined the human use system as "organizations through and by which resources are managed. They vary in size and composition from the household or village to the nation state or multinational corporation. In their spatial expression they are rarely, if ever, congruent with ecosystems" (UNESCO/MAB, 1974).

In Brookfield's opinion, the importance of the concept of "human use systems" lay in freeing the Man and the Biosphere Program from its original insistence on the concept of man <u>within</u> the ecosystem. He notes somewhat plaintively, however, that as the MAB program regarding islands has evolved, human use systems (although acknowledged after 1974) have generally been examined <u>separately</u> from the natural ecosystems which they manage and exploit, and the problem of integration has not yet been resolved. His project in Fiji is one of the few MAB initiatives that has avoided this problem.

A few of Brookfield's conclusions drawn from the empirical field work of interdisciplinary research teams in Eastern Fiji deserve a brief summary here. They bear directly on the design of effective and appropriate development intervention for island coastal ecosystems and resources. When the project was conceived by the UNESCO/MAB task force in 1974, the basic concern in man/environment interactions focused on growth implications and the impacts of the increasing scale and volume of human activity. Enlargements in the structure of human use and resource management systems were presumed to result in the incorporation of smaller systems as effective working sub-systems of the new enlarged structures. Life would go on as before with the addition of a few new rules. For example, an island government could quite logically design a "rational" coastal zone management framework, using a scaled-down external model, which would simply incorporate more traditional, smaller human use systems and structures without injurious change. At the same time, the central hierarchy of human use systems would expand its sphere of influence. The planning and decision making processes for those more universal (centrally perceived), more critical resource management issues would provide the controls to improve or guarantee the quality of life. This would protect the environment and optimize coastal resource allocation and use. The evidence from the Fiji field work, however, suggested that this assumption simply was not true.

The historical process of change for Fiji's peripheral islands was not transactional, but rather transformational. Smaller human use systems on the periphery were not simply subsumed or affected in a benign fashion; they were structurally transformed by the transition process into something else. A lessening of resource use differentiation and a loss of an internal capacity to manage those environmental and other variables it had traditionally managed successfully were the results. This loss of management capacity and diminished differentiation of use appeared to be a greater problem on the peripheral/marginal areas than it was in the populated core areas which were presumably more stressed. For these reasons, among others, Brookfield concluded (1980) that one had to reject any notion that small islands, as man/environment systems, were microcosms of conditions in the world or continents as a whole. They were, however, representative of those parts of the world that have been rendered peripheral by spatial structuring forces within the larger world system.

In other words, islands are representative of peripheral regions of Third World countries that are themselves peripheral within the international system. Brookfield is positing the outline of a peripheral or marginal systems paradigm to supplement or replace the island ecosystem paradigm (see Section 7).

In the Fiji case, as local peripheral human use systems were absorbed and transformed by larger systems in the process of development, local decision making structures were "transformed" into a kind of "client" status within larger decision making structures. The division of labor ended up being reallocated from the center, viewed in terms of the demands of the larger absorbing system. The interdependence of the smaller, diverse "satellite" islands' collectively self-reliant economies were essentially destroyed and replaced by dependence on the center and the world system which lies beyond it. The consequence was that the fine mesh of "rational" resource allocation that had evolved out of the man/environment relationship in the peripheral islands was, in effect, removed.

The result is not, as noted earlier, a simple transactional process of "change by consensus," but involves a "transformation" process for the social, economic, and resource management systems in the outisland areas. Therefore, any a priori presumption that the center is more "rational" than the periphery in its resource allocation strategies and priorities is, at best, risky. All too often, technical assistance strategies do exactly this.

5.5 The CCOP/SOPAC Regional Coastal Zone Strategy for Islands

The Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC) is an intergovernmental body established under the sponsorship of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). Its mission is to develop and promote investigation of the mineral potential (including petroleum) of shelves, platforms and the ocean floor in the South Pacific Ocean. The present Committee, comprising ten island members, had its origins in various planning sessions carried forward by ESCAP's predecessor and others in late 1970 and early 1971. Considerable interest had been expressed in the petroleum potential of the submerged shelf areas of South Pacific islands after the 1968 discovery of seepages of crude oil in the Kingdom of Tonga. Increasing attention was paid to the possibility of finding economic deposits of both petroleum and detrital heavy minerals (placers) in the beach and nearshore areas of several island countries. This coincided with rising interest in prospects of mining manganese nodules from the Pacific Ocean floor for their metallic content. The inaugural session of CCOP/SOPAC was held in Suva, Fiji, in 1972, and annual meetings have been held in various member countries since that date.

In 1974, the United Nations Development Program (UNDP) commenced support of various planning and operational phases of the CCOP/SOPAC regional program. In 1979 the terms of reference for the overall project were expanded to include additional inshore "coastal" activities and marine studies. Since that date, CCOP/SOPAC has responded to increased requests from member countries for "inshore" baseline studies and technical assistance dealing with seabed sand dredging, sewage outfall siting, beach erosion and other coastal marine problems (Table 4). The primary objective of the ancillary "inshore" program was to obtain and make available to planners and engineers the environmental baseline data needed to determine design criteria for ongoing or proposed development activities in the coastal areas of member countries. A secondary objective was to encourage the development of a small group of trained nationals capable of carrying out investigations, baseline measurements

Table 4. Examples of South Pacific Island Coastal and Inshore Marine Resource Development Program Requests (1981). (Source: Towle, E., 1981.)

Categories	Ocean Outfalls	Ports and Harbors	Sand Supply, Dredging	Lagoons and Estuaries	Fisheries Support	Shoreline Erosion	Impact Assessment	Misc.
Tasks/Needs / Country	Siting, Impact, Design	Siting, Impact, Design	Supply, Impact, Risks	Resource Management Criteria	Baseline Data, FAD Siting	Dimensions Methods, Mitigation	Baseline, Methods, Training	Training, Mapping, Education
Cook Islands	X		X	X		X	X	
Fiji	X	X	X		X	X	X	X
Kiribati		X	X	X		X	X	
Papua New Guinea	X	X						X
Solomon Islands	X	X			X		X	X
Tonga		X	X	X	X	X	X	X
Vanuatu		X		X	X		X	X
Western Samoa	X	X	X	X	X	X	X	X
TOTALS	5	7	5	5	5	5	7	6

and similar activities in the inshore marine environment with minimal outside assistance. The overall inshore program has been designed to address these two priorities and to be responsive to the marine resource development initiatives of the member countries.

Carried forward since 1979 within the larger framework of the ESCAP/ UNDP offshore mineral prospecting project, CCOP/SOPAC's inshore program has been extremely successful. Implementation has proceeded on a modest scale amid the press of previously scheduled, larger scale offshore and nearshore geophysical and geological program elements. The expansion of the project's original terms of reference in 1979 to include nearshore studies, training, and technical assistance was motivated by growing awareness of the need to provide South Pacific island governments with access to the technical expertise and data base. This information was required by their planners and decision makers who were, on the one hand, involved in the development of coastal resources, but, on the other, sought to avoid adverse environmental impacts resulting from their decisions and actions. It was a well conceived strategy to reduce local risks and costs by improving project and facilities design and siting, while utilizing local raw materials extracted from the coastal zone and incorporating at the same time a local skills training and data base building program component.

The CCOP/SOPAC inshore coastal resource program to date encompasses major efforts in Fiji, Western Samoa, Tonga, the Cook Islands, New Guinea, the Solomons, Vanuatu and Kiribati. Additionally, a series of prototypic inshore/nearshore training workshops have been held in cooperation with the University of the South Pacific (Institute of Marine Resources), the United Nations University and the University of Hawaii (International Sea Grant Program).

The inshore program is compatible with CCOP/SOPAC's basic mission of supporting marine geophysical and geological surveys and data analyses and marine mineral prospecting. It responds in a timely and relevant fashion to member country requests for practical, short-term technical assistance for inshore marine resource development projects, for baseline data, and for site surveys. Further, it makes cost-effective use of complex scientific equipment acquired by the project for esoteric, long term, less visible offshore seabed hydrographic, oceanographic, and geophysical investigations.

It also incorporates a reinforcing combination of (a) practical short-term training on site; (b) extended, paraprofessional attachment training at Suva project headquarters and on various survey vessels; (c) problem-focused, short-term workshop training; and (d) formal, thematically focused, earth science courses offered by the University of the South Pacific.

Taken together, these four training elements of the CCOP/SOPAC inshore program constitute an effective "marine literacy" strategy for younger technicians from member island countries confronted with an unfamiliar nearshore and deep-water environment. The CCOP/SOPAC inshore initiative is a practical and regional marine resource development and coastal zone management program in embryo. As such it adjusts its participatory strategy to reflect country differences, local priorities, available skills and institutions. It is problem-oriented and seeks to use and improve existing human and institutional resources currently engaged, although often inexpertly, in the marine resource development process. The program has developed and maintains an effective network of active in-country participants and advisors which provides informational feedback loops and enhances a two-way flow of operational and technical data and counsel critical to the success of the overall program (the CCOP/SOPAC telex network linking the participants is an important technical element, but the "network" process is only facilitated by, not dependent upon, the telex system).

There are some lessons to be learned from the CCOP/SOPAC experience. Without a cadre of bottom and mid-level technicians in each island country who are reasonably skilled in and conversant with the sampling, numeration and mapping processes used in marine inshore areas, national or regional environmental management programs for islands are at risk, if not scheduled to fail. A cadre of skilled para-scientists is a sine qua non of effective inshore project design, impact mitigation, monitoring, and evaluation. The ECNAMP project (Section 4.3) in the

Caribbean addresses this problem to a degree. The CCOP/SOPAC training program in the Pacific, as designed and implemented, is even more responsive to this requirement. The existing technical skills training curriculum for island country nationals is on target. Training is offerred in bathymetry, cartography, field measurements, position fixing, seabed and sub-seabed seismic profiling, side scan sonar mapping, precious coral stock surveys, current measurements (by dye, drogue and meter methods), water quality indicators, sediments, and data recording, reduction and reporting techniques.

The CCOP/SOPAC approach, like that of ECNAMP in the Caribbean, has been successful and cost-effective for a variety of reasons. It is flexible, open-ended, not too highly structured, relies principally on existing in-country persons and institutions, and maintains a closely coupled network (horizontal and vertical) of users and cooperating local agencies and institutions. It also has developed a management information system, along with good communication linkages. Islands participate in establishing priorities, levels of effort, and, to a degree, levels of precision. These islands are partners, not targets.

Both ECNAMP and CCOP/SOPAC make use of regional university-based persons with expertise (but not so much the institutions themselves which have a different agenda and more rigid calendars). Both emphasize function rather than form, service rather than structure, building skills rather than academic credits, and the long as opposed to the short term. Mr. Cruz Matos, head of CCOP/SOPAC, and Mr. Allen Putney, principal investigator of ECNAMP, have been successful because they, quite simply, understand islands better than most and have therefore been able to develop workable programs (which are both pragmatic and non-formal) for expanding local capacities to utilize and manage coastal resources.

6. TECHNICAL CONSIDERATIONS

6.1 Island Vulnerability: The Search for a Model

6.1.1 An Overview

Both natural and social scientists tend to agree on one important characteristic of islands: their vulnerability to interference from outside. Ironically, oceanic islands are increasingly vulnerable due to their very isolation. In the past, this characteristic inhibited development; now, however, remoteness is largely immaterial because of the revolution in transportation and communications. The barrier of remoteness has been overcome by factors far removed from the shores of the islands themselves -- factors that set up wholly unanticipated technological encounters. Remoteness no longer guarantees freedom from pollution, offshore oil spills, inappropriate coastal architecture, tourism, ocean dumping of chemical wastes, or the destruction of habitats and indigenous species (some endemic) by introduced exotic species. All have affected oceanic islands in recent years.

The anomaly of the island situation is twofold. On the one hand, increasing numbers of continentals regard islands as both idyllic sites for vacation experiences and as superior sites for offshore banking centers, free ports, and specialized industries (some seeking to escape formal environmental controls). On the other hand, they often expect islanders to develop their resources to service these demands indefinitely, yet with no loss of the unique character of the insular situation.

Additionally, isolation, circumscribed space, and other environmental factors affecting islands have resulted in specialized biotic and human communities. The indigenous life forms of an oceanic island tend to be less tolerant of changes in environmental conditions than those on the margins of continents (Wood and Johannes, 1975). Man's intrusion on some oceanic islands has been permanently devastating to fragile, long-term, evolutionary interdependencies (Carlquist, 1965, 1972; Wace, 1978; Gorman, 1979; Mueller-Dombois, 1973). Obviously, intensive and sophisticated scientific research is indispensible for understanding the dimensions of the problem. But as Fosberg noted twenty years ago:

> It is clear enough that the arrival of man has invariably increased, to some extent, the degree of instability in these systems. With the advent of modern man this increase has frequently assumed catastrophic proportions. The losses in organic diversity, soil development, water retention capacity, and biotic community organization all amount to an increase in entropy; and in cases of extreme degradation this increase has brought about a high entropy level. It is suggested that this is bad from any conceivable viewpoint.

One objective of the UNESCO Man and the Biosphere Program, launched in 1973, was to assess the vulnerability of islands to exotic species introduction. Another objective was to explore cultural, social, and technological introductions as well, for these raise dependency levels. It was hypothesized that most inhabited islands lie somewhere on a continuum between two extremes. At one end, the least vulnerable are those islands where external agents have had little impact on formerly closed, self-equilibrating, self-sufficient systems. At the other end of the continuum are islands with institutionalized openness, so heavily affected by the impact of the outside world that the island system has lost its internal capacity to manage the environment, prevent decay and satisfy requirements for food, water, shelter, and other basic needs. As a result, such islands have a high degree of vulnerability and dependency.

It was assumed at the time that the island microcosm could model both man's destruction of his own habitat and his success or failure in achieving a steady-state adaptation to modified habitats. The microcosm model would reflect his learning to live with the problems he had created, thereby reducing his vulnerability over time. But the positive (reinforcing) feedback loop from initial vulnerability to openness to new dependencies back to increased vulnerability is difficult to control in the face of new kinds of unanticipated external and internal driving variables or factors. For example, in some cases, islands have been catapulted, figuratively speaking, into the technological world of the twentieth century within a decade or two. The environmental, cultural, and economic impacts of these changes have been severe. The experiences of these islands (with "high-tech" sewage treatment systems, desalinization plants, agro-business enterprises, mining technologies, high-rise hotel structures, jet airports, and pesticides) serve as harbingers of what other developing islands may expect in the future.

The seriousness of the "technological encounter" is reflected in widespread changes in uses of coastal land and in concomitant environmental stresses and incompatibilities that the new activities create. Exploring and drilling for oil and natural gas, tourism, and offshore dredging are especially noteworthy in this regard because of their potentially pervasive impacts on coastal areas, their presumed economic benefits to traditional island economies, and the intensity with which they are being pursued at present.

St. Thomas in the U.S. Virgin Islands, with 50,000 persons on 28 square miles (1,786 persons/square mile) serves as a useful case. It is an oceanic island that has relied on technology and accepted dependency status to overcome traditional barriers to development due to resource scarcity. Because of its mountainous terrain, poor soil and unreliable rainfall, more and more food for its burgeoning resident population must be imported. Furthermore, fresh water, also scarce, must either be imported by tanker or manufactured in costly desalinization plants. Owing to the scarcity of construction aggregate, sand must be imported and dredged from inshore areas, often with adverse effects. Finally, because flat, developable land itself is in short supply, it is "created" by dredge-and-fill operations along the coast, disrupting fisheries, damaging reefs, and degrading the quality of inshore water (Frankenhoff, 1974; McElroy and Albuquerque, 1983).

An insidious aspect of the exogenous off-island influence factor is the global-development phenomenon itself. Decisions that can affect an island and its coastal zone may be made thousands of miles away, for example, in the boardrooms of multinational corporations. The tourism industry provides a good example: corporate hotel interests, international airlines, cruise ship lines, travel agents, the publishing industry, banks, metropolitan newspapers and television advertisements, and even direct mail outlets have immense power to create tourism "booms" for islands. In many cases, the insular areas which experience the full impact of this development may not themselves be the chosen target islands. Rather, they may be swept along in a development thrust aimed at a sister island, a neighboring archipelago, or even a broad oceanic region. Without advance notice and in the absence of contingency planning, the vulnerability of adjacent islands is exacerbated. In many cases, the pace of change is incomprehensible and overwhelming.

This secondary transfer or "wake-effect" is most easily demonstrated by the impact that the growth frenzy of the 1960's and 1970's in the U.S. Virgin Islands had on the neighboring British Virgin Islands and on even more distant islands in the Eastern Caribbean (Jackson, 1981; Howell and Towle, 1976; Towle, Howell, and Rainey, 1976). The advent of regular international jet air service between the United States, Australia and New Zealand has had significant repercussions on South Pacific island stop-over/refueling points such as Raratonga in the Cook Islands, Viti Levu in Fiji, and even Pago Pago in American Samoa.

6.1.2 Indexing Insular Vulnerability

It has been suggested that a ranking system for vulnerability, reflecting an island's position on a undeveloped/degradation/dependency continuum, would provide a useful reference point. Such a ranking system could benefit both development assistance planning by "outsiders" and design of national self-sufficiency strategies from "inside." However, there are different sources, kinds, and levels of "vulnerability." For convenience, these are approached here within three artifically separated categories or groups: the environmental system, the human system, and the economic system. Each will be summarized separately.

First, the basic island ecosystem and its intrinsic environmental characteristics and associated ecological vulnerabilities must be considered. Despite numerous prior attempts to classify these environmental characteristics (see Section 3 above), no vulnerability ranking index has been attempted as a component of other classification efforts by scientists (Douglas, 1969; Pierre Gourou in Fosberg, 1963; UNCTAD, 1974).

However, the recent, subregional ecosystem assessment efforts of Putney (1982) in the Caribbean and Dahl (1980) in the Pacific are useful prototypes. In concert with UNEP's country environmental profiles, IUCN/WWF's World Conservation Strategy, and the rather extensive literature base on insular flora and fauna, the subregional assessments are sufficient to permit formulation of a vulnerability ranking system for island ecosystems.

Secondly, there is an insular "human system" (societal) vulnerability factor which may be unique to island microcosms. With few exceptions, societal vulnerability has only recently been the subject of preliminary investigations (Rappaport in Fosberg, 1963; Brookfield, 1977-1980; UNESCO/MAB, 1974; MAB, 1977; and Stinner et al., 1982). An indexing/ranking system for this aspect of island system vulnerability is a long way off as the social scientists have lagged behind their natural science counterparts in building a generic island system data base.

Thirdly, there is the matter of insular economic vulnerability, by far the most dynamic and least subtle of the three. This more quantifiable factor is quite possibly the most important in the short run because it is the most amenable to modification from inside through domestic national development planning and policy reorientation.

6.1.3 The "Unbalanced Books" Model: Islands At Risk

One clue to economic vulnerability is the level of island dependency induced by external driving variables such as multinational initiatives, bilateral and multilateral foreign aid, satellite communications and international energy and commodity pricing programs. Numerous studies have been completed on the economic dependency characteristics of smaller island systems. Some focus on commodity trade and exports (UNCTAD, 1974 and Dommen, 1980a and 1983), some on production, diversity, and environmental limits (for internal or external trade) (Brookfield, 1977-1980), and still others on the openness of island economies (McElroy, 1978b and 1983). In 1981, Michael Hamnett and three colleagues of the East-West Center's Pacific Island Development Program in Hawaii put together an effective ranking strategy to establish an index of island economic vulnerability. Based on a sample of fourteen Pacific island countries and territories, the model provides a framework and simple formula to assess six separate indicators of economic vulnerability (or per contra, resiliency). In short, the model provides a format for establishing a composite island vulnerability index and ranking number. A summary of the results was recently published by the East-West Center (Hamnett et al., 1981).

Hamnett and his colleagues observed that, although numerous oceanic island areas had achieved political independence in the past twenty years (nine in the Pacific and eight in the Caribbean), all remained economically dependent on external capital, commodity export markets, and outside sources of costly energy and development assistance. This dependency persisted despite efforts to achieve a respectable measure of economic self-reliance. Some appeared more successful than others, and strategies varied. For example, the head of Papua New Guinea's National Emergency Service declined a million dollars in foreign aid disaster relief funds in 1981, offered by the United Nations. This decision was based on the grounds that such outside aid might make the recipients, and the Melanesian nation itself, too dependent on outsiders in the future.

By way of contrast, in 1979 only about four percent of the revenues of the Trust Territory of the Pacific Islands were generated by economic activity within the territory. The 100 million dollars (U.S.) being provided to Micronesia suggests an index of emerging, irreversible dependency. Western Samoa, which obtained nearly half of its foreign assistance from various multilateral sources, may be slightly better off and less vulnerable to the vicissitudes of outside policy changes. Surely there was a way to assemble a useful "picture" of dependency levels and types, based on this kind of information.

It was assumed by the Hamnett team (1981) that six major constraints contributed to the economic dependence and vulnerability of island nations and territories in the Pacific basin:

- the need for some states, still not fully independent, to gear their economies to the needs of a colonial power rather than their own needs

- the strain of trying to internally finance extensive government programs
- the high cost of energy coupled with the region's almost complete dependence on imported fuels
- an overreliance on imported food supplies
- a lack of diversity in exports
- an overdependence on foreign aid.

Using only readily available, standard statistical data and information for 14 selected Pacific island areas, Hamnett and his associates then converted these six constraints into the six sub-components of an economic vulnerability index, namely, (1) foreign aid dependency, (2) diversity of exports, (3) food substitutability (could the island feed itself if it had to), (4) dependency upon imported fuel, (5) fiscal integrity (cost of government operations compared to Gross Domestic Product), and (6) political constraints (types of external ties affecting internal decision making). Very simple, hand-calculation formulas were employed to generate the six indices. The indices were then combined into a composite index of economic vulnerability, shown in Table 5.

The last three entries in the table suggest that standard U.S. domestic policies for its island territories may have produced some adverse effects. They further suggest that current U.S. technical assistance strategies for non-domestic developing islands may need readjustment to ensure that increased local self-reliance is a targeted objective, rather than an assumed by-product. The mere transfer of funds to offshore island areas to address development problems is not a final solution as it may unintentionally generate increased dependency and, therefore, vulnerability. By skewing the allocation and development of local resources in favor of imports and external control factors, such practices too often leave the island with even fewer options and more dependent than before. It also appears that the planning and design phases of island technical assistance projects should incorporate "an assessment of vulnerability," perhaps as a new component of the standard impact assessment.

Table 5. Composite index of economic vulnerability (Source: Hamnett et al., 1981).

	Ranking (least to most vulnerable)
Tonga	(1)
Solomons	(2)
Papua New Guinea	(3)
Fiji	(4)
Western Samoa	(4)
Vanuatu	(5)
Kiribati	(6)
Cooks	(7)
Tuvalu	(8)
New Caledonia	(9)
Niue	(10)
French Polynesia	(11)
Trust Terr. of the Pacific Is. (U.S.)	(12)
Guam (U.S.)	(13)
American Samoa (U.S.)	(14)

For this to succeed, however, Hamnett's prototype "island economic vulnerability model" needs both refinement and regular updates. Additionally, a similar composite economic vulnerability index would be an instructive development planning tool for the Caribbean and Indian Ocean island areas. What is ultimately needed, however, is an island economic vulnerability index for all developing islands regardless of their location or political status. Similar vulnerability indices could also be developed for specific island ecosystems (as natural but modified or stressed systems) and possibly of insular coastal zones.

But for development planning, the numbers are not as important as the interrelationships among the six constraints. Even island systems are complex, and the trade-offs between various constraints and options need to be recognized, ranked, evaluated, and employed as inputs to the strategic planning process for development, if insular vulnerability is to be kept within lower risk ranges and manageable bounds.

One Pacific islander summed it all up rather nicely when he said, "For independent small island states the real issue is the nature and degree of dependence because they really only have independence of limited choice within a dependent system" (Kavaliku, 1980).

The implications of all of the above for island coastal zones, for Exclusive Economic Zones (EEZ's) and for marine resource development strategies lie far beyond the scope of this study and are a task for yet another day. But foreign aid and technical assistance programs are an ongoing present day phenomena. Therefore, the following section explores the linkage between island coastal and marine resource development, on the one hand, and island vulnerability mitigation on the other.

6.2 Coastal and Marine Resources: An Island Dilemma

6.2.1 The Risks of Development

Developing island countries, especially the smaller systems, are particularly dependent upon their surrounding marine environments and coastal zone. Populations, ports, marinas, mangrove lagoons, major cities, artisanal fisheries critical to local food supplies, occasionally a commercial pelagic fisheries industry, some agriculture, all watershed drainage, and most industrial, commercial, and energy supply activity are clustered in this highly complex, circumferential area where the island meets the sea.

The greater the pace of island development, the greater the stress placed upon this high-energy, pollution prone interface of interacting terrestrial and marine ecosystems. These pressures create a need to devise workable and appropriate management strategies and practices for the resource base to achieve sustainable development goals. But this is not easy to accomplish because most proven continental and temperate zone approaches, procedures and models are inappropriate for tropical and subtropical seas, where the majority of developing islands are situated. The greater the degree of island openness (and therefore vulnerability), the greater the risk of imported, irreversible, potentially destructive schemes, technologies, and capital investments.

Fortunately, the miniscule size of oceanic island areas tends to rule out most of the spectacular strategies and technological options for achieving a new kind of power over nature because the resources are simply not generally available to carry out this conquest. Nevertheless, islands should not allow themselves to be inveigled or importuned by multinational corporations and aid programs "peddling" high technologies to accept a kind of Faustian bargain to conquer nature in their own island ecosystem. This is one of the few cases where the "economy of scale" principle benefits islands. Some things are just too big to fit!

For example, most islands are too small to provide a sufficient market for the alleged minimum bottom-end/break-even point for "super-tech" energy systems--like nuclear power generation (500 to 1,000 megawatts) or ocean thermal energy conversion (OTEC) strategies (200 to 500 megawatts) (Cohen and Dunning, 1978). But their isolation and strategic locations, not their market potential, open them up to other coastal dependent high-technology uses such as oil refinery sites, super tanker deep-water transshipment terminals, rented military bases (US$200 million/year to the Phillipines) and test sites, and ever larger destination sites for tourists.

On a less dramatic, but more extensive, scale, island coastal areas have been and continue to be victimized by carelessly planned marine sand mining schemes; mariculture ventures; municipal and industrial wastewater discharge outfalls; port terminal, breakwater and causeway construction; coral harvesting; solid waste disposal activity (with associated leachates); and the discharge of cannery wastes.

Once again, it is a case of good intentions gone astray because of systemic deficiencies on the part of both island leadership (tending to look outward for assistance) and development institutions (which often assume existing program and project planning, review, and evaluation mechanisms will weed out the unworkable or non-productive, environmentally objectionable development schemes). Most of these activities are carried forward with externally provided bilateral and multilateral development assistance funding. In theory, negative impacts can be anticipated and eliminated, or reduced to acceptable levels, by the funding agency's requirement of an environmental impact assessment (EIA) and by applying standard "island specific" criteria, conformance tests and project post-audits. However, the last three are rarely completed.

These steps plus programs to train islanders and provide assistance in building island institutions to address "environmental issues" help to insure that environmental constraints in the development process are locally defined and applied. The emphasis here, however, is not about applying constraints on development. Rather, the concern is to understand generic constraints on island strategies for development and undesireable constraints on future options caused inadvertedly by ill-conceived development schemes. There are several very specific constraints or problems which affect the design quality, effectiveness and the implicit element of risk in most island development projects.

Tropical marine and coastal ecosystems pose an especially difficult environmental management problem. Their chemical and physical characteristics, their community structure, and their biological functions differ or behave differently from their better known temperate zone counterparts. Tropical island systems tend to have lower tolerances to various kinds of abnormal stress resulting from excessive and recurring concentrations of waste discharges in any particular location, principally but not entirely because of their smaller size and reduced ecological diversity. A detailed tabular summary of how tropical systems differ from temperate continental coastal systems is provided by Johannes and Betzer (1975), a very useful document for coastal resource development planners. The dispersal, breakdown, uptake and impact of water pollutants (including sediment discharge) also differ quantitatively in the tropics. An appreciation and understanding of how they differ are essential for proper marine resource planning, structural design, environmental monitoring, and impact mitigation strategies in tropical waters.

In the meanwhile, tropical island coastal "zones" remain at risk because of their contemporary uses, because they are more sensitive to stress (than continental, temperate systems), and because we are slow in applying what we already know about pollution loading limits, thresholds, standards, and appropriate practices under insular circumstances.

6.2.2 The Promise of Development

While island coastal zones and marine resources are ecologically vulnerable and are the target of not inconsiderable contemporary development activity, they also constitute the best hope for islands to recover a degree of self-reliance, thereby reducing some types of less desireable dependencies. The logic of our emphasis on coastal and marine resource development within the smaller island context is straightforward. The practice of exchanging traditional, precarious, export-based, plantation-type mono-culture (sugar, copra, bananas, nutmeg) for new export-based industries such as more diversified agriculture and mini-agro-business, enclave tourism, and manufacturing has not really worked well. It has worked only when supported by massive foreign aid which props up the economy to compensate for export revenue failures and provide funds for expanding social programs (McElroy, 1978a). One style of dependency has simply been traded for another, leaving the local economy with essentially undeveloped, internal linkages (especially in clustered, multi-island systems) and a weak economic base for self-sustaining growth both essentially unchanged (Brookfield, 1977, 1980). And still the question remains of how an island breaks out of this expanding framework of constraints, dependencies, and vulnerability, especially when "land resources" are still heavily influenced by surviving remnants of the "plantation system," even in newly independent islands.

Our purpose in focusing on the development potential of coastal resources is to address the matter of historical dependencies and recurring cyclic instability, induced principally by external forces. Devising an island coastal resource development management strategy then can be seen as essentially an "... orderly attempt to gain a degree of internal control over one area of the domestic domain that is still amenable to public intervention, namely the vital resources of the coastal zone" (emphasis added) (McElroy, 1978a).

Given the recent addition of the 200-mile "exclusive economic zone" (EEZ) concept to the traditional coastal zone, Dolman (1982) is probably correct in observing that "ocean space and marine resources may be the comparative advantage of island states which can be exploited to the benefit of both people and as a source of foreign exchange." He is certainly correct in deploring the fact, again specifically referring to island systems, that "the seas and their resources have been forgotten in development thinking and planning, in part as a consequence of colonialism and preoccupation of colonial managers with cash crops and the exploitation of land based resources."

Dolman fails, however, to convey a feeling for both the magnitude of the "coastal/marine space/EEZ" resource assessment task and the dimensions of coastal and offshore resource management responsibilities for smaller island areas with underdeveloped institutional and technical capabilities for such tasks (see Section 6.3).

Villamil (1974) may have been ahead of his time when, in discussing open-system planning, he noted that "...the survival of small island systems depends on the adoption of development paths which are responsive to their characteristics and aspirations." The surrounding, encompassing, ever present sea-context of an insular system may force just such a reorientation in resource development perspectives. Islands, by definition, have far more "coastal zone" per unit of land area or population than continental systems. It is one of their unique characteristics, and it holds a relatively undeveloped set of resources, especially if one considers the EEZ as a part of the coastal zone.

Obviously, in each island country, a long-range coastal zone-marine space management strategy is needed to serve locally defined objectives. At a minimum, such a strategic planning effort should assure orderly development of more familiar, more accessible inshore and coastal resources, and to protect (conserve) the offshore EEZ resources until such time as the island has the technical capacity to design and implement appropriate resource development activities. In sum, if island coastal zones are as important to island futures as we argue (on the basis of the literature, our examples, and our experience), then it behooves bilateral and multilateral technical assistance agencies aiding in the process of island development to pay more attention to expanding the capacity of island systems to optimize the uses of their coastal resources and to conceptualize new uses for their newly demarcated EEZ marine space.

6.2.3 Developing Marine and Coastal Resources: Early Initiatives

For most continental countries, concern with the ocean, marine resources and even coastal matters is a rather small part of their larger national interest. This is also true for many newly independent island states struggling with basic problems of nationhood, divestiture of colonial ties, encouraging a sense of national identity and creating a viable economic system out of traditional plantation-based agriculture and other land-based enterprises within a volatile world economy. Therefore, an appreciation for the development potential of insular marine and coastal resources is a relatively new phenomena and experimental attempts to inventory and evaluate the components, assess their economic potential and devise an integrated framework or model for their development and management are even now just beginning to surface in a serious and productive way.

Exactly ten years ago a United Nations' study on the special characteristics and problems of "Developing Island Countries" devoted only two paragraphs (out of 44 pages) to the exploitation and control of marine resources (UNCTAD, 1974). The following year another arm of the United Nations also devoted only two paragraphs in a 26-page brief on coastal area management and development to the special coastal problems of developing island countries (UN/ECOSOC, 1975a), while a second 60-page UN paper on "Marine Questions: Uses of the Sea" does not discuss islands at all (UN/ECOSOC, 1975b). During the 1970's the UN Ocean Economics and Technology Office and UNESCO's separate Marine Science Division and its Man and the Biosphere program did a little better by islands and developed special initiatives to adapt emerging continental coastal zone management, environmental education, marine science training, and man-environment research perspectives to islands and island groups in the Caribbean, the South Pacific and elsewhere (UNESCO, 1973, 1974, 1981; Valencia, 1981).

Since about 1978, other regionally focused, internationally sponsored attempts to develop island-specific "coastal resource" initiatives have emerged under the aegis of CCOP/SOPAC (see Section 5.5), the United Nations Development Advisory Team (Baines, 1981), UNEP's

Caribbean and South Pacific regional environmental planning strategies (UNEP, 1980; Dahl, 1980), the University of the South Pacific in Fiji (which established an Institute of Marine Resources under the directorship of Dr. Uday Raj), and the East-West Center at the University of Hawaii (Hamnett et al., 1981 and Valencia, 1981). Each of these represents continuing program efforts.

In the non-government sector (which has greater freedom to experiment) parallel but different approaches to island coastal and marine resource development and management problems have emerged since the mid-1970's. Useful initiatives have been undertaken by the following:

- Dalhhousie University of Nova Scotia (Caribbean - see Mitchell and Gold, 1982 and Gold et al., 1982)
- The RIO Foundation (Caribbean, Pacific, and Indian Ocean - see Dolman et al., 1982)
- The German Foundation for International Development (Caribbean and Pacific - see Szekielda and Breuer, 1976)
- The Eastern Caribbean Natural Area Management Program (ECNAMP) (under the aegis of the University of Michigan and the Caribbean Conservation Association, with primary funding from Rockfeller Brothers Fund, International Union for Conservation of Nature [IUCN] and World Wildlife Fund [WWF] - see Geoghegan, 1983; Putney, 1981 and 1982)
- Environmental Research Projects (Caribbean - see Goodwin and Taylor, 1981; Goodwin and Cambers, 1983)
- Island Resources Foundation (Caribbean and Pacific - see Towle, 1978, 1979a, 1979b, 1981).

Some of these experimental private sector strategies by non-profit organizations have potential as model components of larger more comprehensive governmental coastal resource management schemes. Others offer alternative approaches altogether.

Each of these "experiments," involving island governments but initiated by non-government organizations, has been a learning experience for the sponsoring institution and for island governments, planners and managers. Some approaches (ECNAMP, CCOP/SOPAC, and Dalhousie) have had longer time frames and been more effective than others; all remain functional, and none should be overlooked in the near future as "how-to-do-it" models by those designing and planning, within larger frameworks, bilateral or multilateral technical assistance strategies addressing island coastal zones and marine resource management. The nucleus of a new "integrated" approach is beginning to take shape, but there is no one preferred model as yet.

6.2.4 The "Resource Management Community"

One recent private approach to marine resource management in the Eastern Caribbean (see Section 4.3) has demonstrated the value of emphasizing local participation, communication, and consensus-building strategies through carefully established networks of resource users, technicians, scientists, planners and managers. Taken together, in the smaller island context, this heterogeneous grouping can be conceived of as a "resource management community"--a concept which lends itself to using a consensus strategy for both planning and management. This can be illustrated as follows.

In continental societies, as even in some larger islands, a marine or coastal resource manager is generally assumed to be a professional-level government official charged with the guidance and control of resource usage operating within an established framework of plans, policies, rules, regulations, buttressed by legislation. One should not assume, however, that the absence of professionals in any given island means that no resource management takes place. In most traditional island societies, especially those with extensive subsistence-level coastal villages, an alternative resource management system has evolved over time among the resource users. By custom they apply management techniques learned through experience to sustain the resources upon which they depend. Sometimes a whole village or groups of users in a cooperative format develop strategies to protect the resource base which they understand and identify as vital to their future. As in the case of the fishing village of Gros Islet in St. Lucia (Section 4.1) or the coastal villages in Fiji (Section 5.3), collectively learned "wisdom" about the nature and limits of the resource base resulted in different but similar "limited entry" strategies. As Geoghagen (1983) has recently reported, there are many other instances of island fishing communities "... voluntarily closing off certain fishing areas where overfishing has reduced yield, until the stock is replenished...." These actions select the "option that will be of greatest benefit to them in the long run. This kind of self-regulation allows the resource users to retain control of their own lives and of the resources upon which they depend."

Furthermore, the use of consensus-building networks as a management tool should not be underestimated. By improving communication channels between user groups, planners and government managers, various existing traditional, community-based management mechanisms, not normally recognized or used by government, can be identified and utilized effectively in a more holistic coastal resource management strategy.

6.3 The Economic Significance of Island Coastal/Marine Resources

Insular countries have two things in common with continental countries. First, both have a "national interest" in oceans (Alexander, 1973), as evidenced by the bitter debates over EEZ boundaries at UN Law of the Sea III and continuing bilateral negotiations to define shared boundaries. Second, neither insular or continental states have made significant progress in quantifying the economic significance or contribution of coastal and marine resources to the national economy as a whole or in establishing the dimensions of forward and backward linkages and multipliers for ocean-related industry. National accounts simply are not kept in a way that makes it easy to separate ocean-related economic activity. The principal problem is that national income accounts are maintained on a production, industry or activity sector basis (e.g., forestry, manufacturing, etc.) with no spatial breakdown. For example, there are gross tourism industry figures but no separation of land-dependent from sea-dependent tourism.

A way to solve this problem, however, has been recently developed by four enterprising economists from Columbia University's Graduate School of Business, who designed a conceptual and statistical methodology for extracting the needed ocean-related economic figures from available census data and the national income accounting system. In 1980, they published their findings in a significant article entitled "Contribution of the Ocean Sector to the United States Economy" (Pontecorvo et al., 1980). Based on their model, the aggregate value of the U.S. ocean sector for 1972, the most recent year at the time for which data was available, was $30.6 billion, comparable to agriculture at $35.4 and communications at $29.4, but significantly larger than mining, oil, and gas at $18.9. Note, however, that since the total U.S. GNP for 1972 was $1,171.1 billion, the ocean sector contributed only 2.6 percent of this--not a terribly impressive figure.

In islands, however, as we will demonstrate in a moment, the situation is markedly different. The Pontecorvo model had been circulated in 1979 as a research working paper and caught the attention of an equally enterprising group of researchers at the Dalhousie University Ocean Studies Program (DOSP) in Canada interested in the EEZ question as it relates to insular systems. The DOSP group had previously been investigating certain marine law and policy questions in the Eastern Caribbean where island countries are close together and conflicts over use of the sea were emerging. When the Foundation for Reshaping the International Order (RIO) of the Hague, Netherlands, cast about looking for an institution to carry out two case studies (Grenada and St. Lucia) dealing with the capability of smaller island states to deal with EEZ's, marine space and economic development, the Dalhousie group was selected and supplementary funding support obtained from the Canadian International Development Agency (CIDA). Under the direction of Dr. Edgar Gold, the project research team of ten persons (including three West Indians) commenced work in 1980 and by 1982 had completed two significant reports, one dealing with development and ocean management in the Eastern Caribbean (Gold et al., 1982) and the other entitled "The Integration of Marine Space in National Development Strategies of Small Island States" (Mitchell and Gold, 1982). Taken together, they represent a truly new approach, in part because they adapted the Pontecorvo methodology to island situations (St. Lucia and Grenada).

The approach used was simple and straightforward enough to apply to any island state, using available data without computers or sophisticated economic procedures. While the procedure needs refinement, it does offer the opportunity of establishing an economic rationale for placing greater emphasis on developing improved island coastal and marine resource assessment, planning, development, and management efforts.

Ocean- and coastal-related industries and uses are first identified and sorted into two categories, depending on whether they directly utilize an "ocean/coastal" resource in a harvesting or productive process (supply side, as in the case of fisheries or a marina or resort hotel) or exist because the demand for the establishment's "product or service" is due in part to some attribute of the ocean or coastal zone (demand side, as a contractor who builds a dock for a marina, a store that sells boat engines, or a wholesaler or farmer providing provisions to coastal hotels). The next step involved attempts to measure linkage effects between various industries involved on both "sides" and then effects on the island economy as a whole. Linkages were split out as follows:

- backward, where growth and development in ocean/coastal industries induce investment and development in other sectors, providing inputs to ocean/coastal industries such as boat and ship building, port facilities, engine repair and other service activity
- forward, where ocean/coastal industries exert an influence on industries using "products" from the coastal/marine zone as an input such as coral sand and block for construction use, fish processing
- demand, where incomes generated by marine/coastal related industries stimulate increased demands for consumer goods and services.

Using this approach, the DOSP team then developed an ecodevelopment framework for applying a simple model for an integrated marine system to enhance island development and economic self-sufficiency. Despite implicit weaknesses (for example, it leaves out local village-based subsistence marine protein production values), the DSOP project established one very important fact--islands' coastal and marine resources are far more significant than previously realized by most development planners.

The reader will recall that only 2.6 percent of the 1972 GNP for the United States was attributed to "ocean-related activity." By way of contrast, that figure based on DSOP findings for St. Lucia (1978) was 33 percent of GNP, for Antigua-Barbuda 32 percent of GNP (1981), and for Grenada (1978) over 30 percent (Mitchell and Gold, 1982). <u>These islands were at least ten times more dependent on coastal and marine resources than the United States</u>--a rather compelling argument for paying more attention to devising appropriate management strategies for island coastal zones and associated marine resources and for carrying out a similar coastal/marine economic assessment for other developing islands.

One barrier to getting on with these tasks is the "land" orientation of most island planners and the absence of marine resource professionals in most island planning units--a matter addressed in the next section.

6.4 Island Coastal Resource Planning

6.4.1 Conceptual Problems

Over the past two decades, developing island countries in the Caribbean, the Pacific and the Indian Ocean area have consistently acknowledged the need, embraced the principles, and, largely with the technical assistance of the United Nations Development Programme (UNDP), established the basic framework for physical and economic planning (UNDP, 1977). All island countries have planning units, some more centralized and comprehensive than others, some still partially staffed by expatriate professionals, but most staffed by islanders trained in universities abroad or regionally by continental instructors with continental perspectives and a fundamental preoccupation with land-based physical planning. Geoghegan is partially correct when she observes that "... smaller islands have often tried importing the planning techniques of industrialized nations, even though limited size and financial resources make those techniques unworkable" (1983). The central problem is the ignorance of most planners about marine ecosystems, resources, industries, uses, and such things as ships, ports, fisheries, and how to map corresponding data.

Why is this the case, even though islands have a larger stake in the proper planning of coastal and marine resource use than their continental counterparts? The root of the difficulty, in the author's opinion, lies in the land-focused planning models transplanted by the UNDP and others into the island context. As a result, the existing central planning offices, natural resource ministries and statistical agencies of the smaller island states involved in the CCOP/SOPAC inshore program do not, at the present time, collect, store, analyze or report most of the kinds of marine and coastal baseline environmental data needed for coastal resource development planning and for the optimal engineering design of marine structures and facilities. The same is true for the independent island states in the Eastern Caribbean.

Out of the 16 island government planning units visited by the author over the past five years, not one could provide a "sea-use map" comparable to readily available detailed and continually updated land use maps. Soil but not sea "capability" maps were available. Not one had a detailed map of coastal erosion sites, of former dredging sites, of pollution prone/stressed coastal environments, of vessel traffic, or of anchorage/mooring patterns for boats comparable to their detailed vehicular traffic and parking plans. Not one had thought about sea area "zoning" controls comparable to land zoning. In all sixteen cases, data were available on land but not sea mining sites, on hotel but not charter yacht bed nights, on agricultural input but not marine sector input to GNP, on taxi drivers but not boat operators, on potential geothermal or hydro-power generation sites on land but not on nearshore cold water upwelling zones with thermal energy conversion potential.

6.4.2 Information Problems

Not only is site-specific coastal resource user data (quantitative, spatial, or qualitative) generally unavailable, but routine environmental data is also hard to obtain. At a UN/ESCAP (Economic and Social Commission for Asia and the Pacific)-sponsored workshop on environmental statistics held at the East-West Center in Hawaii (October 1980), it was concluded that "a major handicap for the inclusion of ... environmental considerations in development planning is the lack of environmental data on which environmental agencies may base their judgments within the context of planning efforts" (UN/ESCAP, 1980). Additionally, it was also found that "... environmental statistics per se are not collected" by government statistical offices.

Even in U.S. offshore island areas like the Virgin Islands, Puerto Rico, Guam and Samoa, which already have developed coastal zone management plans and programs as part of a larger national strategy, the problem persists because of a structural failure in the design concept. The basic framework was designed for coastal states of the United States, many of which already had elaborate information collection, storage, and retrieval systems, extensive baseline data, numerous cooperating institutions, overlapping agency jurisdictions and, to a degree, a tradition of data sharing, exchange and transfer. But when the concept was transplanted to offshore insular systems, with only some minor modifications, the absence of a data base, storage, retrieval and management information system (as a program component) became a serious limiting factor.

These planning and information "failures" are not, however, so much the island's fault as the result of inappropriate approaches imposed from outside--models derived from continental areas with less at stake in the "coastal zone." Further, on the basis of three quite different experiments, two in the Caribbean (ECNAMP and Dalhousie) and one in the South Pacific (CCOP/SOPAC/Inshore Program), reviewed elsewhere in this document, it is clear that there are ways to temporarily circumvent these problems and get on with effective insular coastal resource development and management efforts.

In the ECNAMP (Caribbean) case, the ongoing resource data inventory, mapping and analysis effort has emphasized local participation in the collection of existing, best available data, downplays research/field work, while emphasizing training and use of mid-level prototypic resource managers (both government and non-government) supplemented by in-region generalists, all within a closely coupled network of participants exchanging, reviewing, storing, and using data on both a single island and a regional level. Formats are kept simple, data distribution is wide, and feedback loops are carefully cultivated for updating the data base. The ECNAMP program has been strong on qualitative resource and user assessment and weak on quantitative resource and user data.

By way of contrast, the CCOP/SOPAC/Coastal Resource Program has tended to emphasize mid to lower level technicians (in geology, oceanography, marine science, fisheries, etc.); training in more precise cartographic, oceanographic, resource assessment skills; technical agency and university networking; and on-site applied quantitative research and measurement, with less emphasis on generating qualitative coastal resource and user information, more on improving local quasi-professional skills and performance capabilities, and on island specific problem solving (e.g., where and how to site an outfall or a sand mining effort).

The Dalhousie approach (Section 6.3), while less participatory, nonetheless addresses both the planning and informational lacunae, with an emphasis on the latter. All three approaches offer guidelines for a more effective comprehensive approach.

The nucleus of a conceptual management-information framework for combining these three different but promising efforts is provided by Wilimovsky (1979) in his paper on minimal data requirements for aquatic resource management in developing countries. Wilimovsky notes that decision making is generally based on readily "available data," appropriately processed, interpreted and communicated; and "the manner in which such information is conveyed to the user essentially and effectively controls the degree to which one receives, understands, and accepts the information as knowledge" upon which to base decisions. There is considerable evidence to support Wilimovsky's charge that many resource data collection programs overemphasize precision, even though at the management/decision level the very precise data is combined with imprecise guesses. Although the data base for coastal resource managers in small islands is marginal, it is still accessible, useable, and improveable if a management information system sensitive to local conditions, practices, sources and users is designed, put in place and made to work.

Lastly, a word about non-formal information sources is important. Data collection and marine resource management efforts should not only incorporate but reflect "local lore" drawn from traditional island fishermen, ship captains, divers, and other long-standing local subsistence and small-scale commercial users of the marine and coastal environment. Such persons need to be encouraged to participate in the information network (Baines, 1982; Johannes, 1978; Putney, 1981; Geoghegan, 1983). Regular consultation with such individuals for data collection purposes becomes the entry point for their direct participation in the planning and implementation of the management strategy itself.

7. SYNTHESIS: FROM THEORY TO PRACTICE

7.1 The Island Puzzle

Luigi Pirandello's famous play "Six Characters In Search of An Author" provides the inspiration for this summary section wherein we explore the progress being made toward developing a new framework or paradigm for perceiving and understanding the "genius" or nature of small island places and the driving forces which both sustain and change them. The search for a new island paradigm has been years in the making, and we--islanders and continentals alike--are still in a transition period regarding the theory of the island circumstance. For those practical persons seeking to identify leverage points and appropriate mechanisms to assist in the complex process of aiding "sustainable" island development (or ecodevelopment), the insular coastal zone management and environmental planning strategies currently being refined offer some hope of defining more holistic perspectives on "rational resource use" and more effective intervention strategies appropriate to island systems.

But there are problems. The very diversity, ubiquity, heterogeneity, and remoteness of islands induces enormous variations in how they are perceived--conceptually, metaphorically, analytically, descriptively. At one and the same time they are closed, self-sufficient, idyllic, isolated and, alternatively, open, dependent, parasitic, linked. They are both prisons of the mind and places of renewal of the human spirit. While they are living laboratories, metaphorical models and museums of evolution, they are also spatially unique microcosms of some external human ecosystems <u>and</u> a viable home to islanders who have traditionally faced and adjusted to the insular condition with all its vicissitudes and variations.

Perhaps islands and islanders, in all their global diversity, demonstrate an anthropomorphic version of Werner von Heisenberg's principle of uncertainty--even the act of observing (or using) them induces change in the thing being examined. Hence, the result is a kaleidoscope of images reflecting the insular condition.

In any event, attempts to classify, categorize, enumerate, and label islands have, to date, been far from successful. There is still no really useful taxonomy (or classification framework) of island systems. Neither is there a comprehensive or even partial assessment of the "global resource" (as we have, for example, in the case of mangrove systems, coral reefs, forests, marine mammals, or endangered species). What we do have is a vast spectrum of diverse islands and an evolving set of "island tested" or island specific models or methodologies which sequentially and cumulatively are effecting a shift in the way "islands" and insularity are perceived.

7.2 The Island Ecosystem Paradigm

There has been a long tradition of systematic investigation of islands by natural scientists. For all of the natural science disciplines, islands have provided a kind of living microcosmic laboratory of great value. Within the past half century, the flexible concept of the "ecosystem" has become the dominant "framework" for island research to define study area boundaries and sets of factors (variables) to be included or excluded. Best articulated by Fosberg (1963) but replicated by dozens of other theoreticians and employed by thousands of scientific practitioners, the island ecosystem and its varying assemblages of lesser sub-unit ecosystems became the standardized and accepted way of looking at islands. And, in the absence of any appropriate paradigm except for the Darwinian evolution theory and the MacArthur and Wilson "spatial isolation" theory of island biogeography (which were both derived from island observations), the "ecosystem" model became in effect a surrogate paradigm.

Under the post-World War II impacts of internationalized decolonization and development assistance initiatives, in combination with dramatic shifts in air transport and electronic communication technologies, islands everywhere began to experience new kinds of pressure on their environments. These threats to the insular environment (ecosystems to some) carried implications beyond irreversible changes in physical and biological assets. The environment is an integral part of the total island matrix that defines the quality of life for island peoples and visitors alike. The somewhat vague concept of "quality of life" has slowly gained favor as the framework for merging economic, social, and environmental development objectives. It expanded the narrow measure of progress by standard economic indices such as GNP and per capita income, incorporating other social-welfare indicators, environmental factors, traditional resource uses, and amenities which constitute a vital part of any island's life-support system.

The decade of the 1970's, however, saw a more fundamental redefinition of the island ecosystem model with an increasing emphasis placed on island people, socio-economic vulnerability, system complexity, and the importance of traditional resource management approaches, all reflecting the uncertainties of island life due to natural hazards, historical dependency factors, isolation, independence (for some) and expanding social, economic, and technological pressures from outside.

Beginning in 1973, the UNESCO Man and the Biosphere Program launched a rather significant long-term research project focusing on "Islands and the Rational Use of Island Ecosystems," which is still ongoing although its approaches are very different from those of 1973. The island-man-island ecosystem transactional model is slowly being modified by the addition of both center-periphery considerations in multi-island systems and human system transformation theory for "outer islands" (Brookfield, 1977, 1978a,b, 1979, 1980), and more recently by the addition of the "vulnerability" model of Hamnett et al. (1981) and the experimental island marine economy model of the Dalhousie University research team in the Eastern Caribbean (Gold et al., 1982, and Mitchell and Gold, 1982).

7.3 Towards A New Paradigm

Environmental problems generated by island development are neither incidental or ephemeral, especially because they add new limits to already naturally constrained future options. As island habitats are reshaped, the environmental transformation induced by development is resulting in significant cultural reorientations and changes in the institutional structure whereby humans address the environment. Systematic investigations into these processes is called human ecology. It represents an approach which seeks to bridge the gap between the natural and social sciences and is based on the premise that human social systems and natural ecosystems each influence the other and changes in one system are quite likely to generate compensatory changes in the other.

But for human ecology to be useful in optimizing development choices and minimizing man/environment conflict, the natural and social sciences need to work together as equal partners, a circumstance which rarely occurs. Social scientists seldom participate in resource management and environmental planning activities, and such programs are customarily developed largely by the natural and physical scientists. When social scientists do become involved, it is usually to provide some incidental, peripheral commentary on an already defined program; they are brought in long after the design phase to provide a "token" social science input. In one recent coastal zone planning format prepared specifically for Third World country use, "legal, political, financial, and cultural factors" are not scheduled "inputs" until two-thirds of the way through the process and then only to help evaluate previously determined alternatives (Neuman in Valencia, 1981).

The lack of social science participation in the design phases of resource assessment and coastal zone management endeavors means that the definition of problem areas for study falls entirely within the hands of the natural scientists who tend to assume that the physical and biological aspects are empirically primary. They tend to use natural ecosystems (or sub-units thereof) to define the boundaries of the study, whether it is a tropical river basin, mangrove lagoon, endemic species habitat, a beach, or a coastal zone. Only after the natural scientists have defined the "proper" unit of study are the social scientists invited in to provide counsel on how human systems affect the operation of the natural system.

Unfortunately, this approach generally does not work because as Rambo (1981) has noted, "... social scientists work in terms of their own special unit of analysis. This unit is not people as such but an altogether different conceptual unit which is seldom fully isomorphic with the ecosystems defined by the natural scientists." Social scientists each focus on a slightly different aspect of human use systems (for example, the anthropologist addresses cultural systems, the sociologist looks at systems of social organization, the economist explores the market system, the administrative analyst and the planner or manager deal with information systems). These components make up the totality of the social system which interacts with the equally complex natural system.

Although the social scientists, seeking to understand the structure and dynamics of social systems, have made significant progress in recent decades, the availability of socio-economic management strategies for application in island environmental and coastal resource management efforts remains outside the purview of most natural scientists and resource managers with science-oriented backgrounds. As a result, natural scientists often fail to appreciate the value of human social system paradigms for addressing man/environment interactions. Natural scientists continue to be presumptive about the primacy of the physical and biological sciences, while social scientists continue to be diffident about coming forward with viable alternative approaches to an analysis of human interaction with the environment. Both groups would benefit from more frequent, more direct (even forced) kinds of interaction.

However, while social scientists may contribute new ways of "perceiving" the problem and may be especially useful in projecting social impacts and looking at patterns, institutions, options and constraints at various hierarchical levels, a local "participation" strategy (especially at the village level) is essential to document how the existing human use system functions and to establish and evaluate objectives (potential futures). Adding the social scientist to the coastal resource management planning process is, to a degree, only a means to an end, improving and accelerating the data gathering and analysis activity. To a degree, using a participatory strategy compensates for the absence of more rigorous or more elaborate social science input and also functions as a "ground truth" or corroborating mechanism when more formal kinds of social science inputs are available.

The implications of all of this for islands are quite clear and relevant to those whose work involves island conservation and development, especially coastal and marine resource management. There is no one simple paradigm for islands or island microcosms yet--only a series of models (which have served as surrogate paradigms), such as the ecosystem model, the man-biosphere interaction transactional model, and variations on these (like the microcosm model), all moving in the same general direction, namely, an integration of natural and social science knowledge about island processes (derived from different disciplines and interdisciplinary models) within a new framework or paradigm.

In any event, the island ecosystem model or "surrogate paradigm" has served its purpose (and is still relevant to some disciplines). Over past decades it has been pushed and massaged and modified by alternative ways of looking at the insular condition. The feedback loop has not yet been closed and will not be until insular marine environments and marine resources, not just ecosystems, are addressed more systematically as a key element for a more holistic framework for analysis, management, and development of island systems. Some preliminary experimental models and methodologies have proven very promising--opening up new ways to address insular vulnerability (Hamnett et al., 1981), marginality (Brookfield, 1980, and Geoghegan, 1983), dependency (McElroy, 1978b) coastal resource opportunity (Gold et al., 1982), and planning, education and management considerations (Putney, 1982).

No one is, of course, simply waiting for a new paradigm to emerge before proceeding with action strategies. To a degree, only the island "scientist" or specialist is concerned with the paradigm question of "how do island systems work?" Most island resource development practitioners are far more concerned with (1) technology (management, concepts, and strategies as a kind of existing paradigm "software") and (2) institutions (delivery systems for management in a particular insular setting), and are not generally concerned with the theory of why this or that does or does not work in the island context.

Even this case study, despite occasional lapses into more paradigm related theoretical discussions, has sought to focus principally on the technologies of island resource management and on workable island specific institutional arrangements. However, the evolution of a new paradigm, island resource management technologies, and institutional delivery systems are not disconnected entities. All "experimental" or experientially derived perspectives are relevant to the task of improving island system management and the way "managers" perceive and establish a consensus about what they are doing and where they are going.

At the present time, the best hope for combining various experimental approaches to coastal resources in island areas and in accelerating the formulation of a new paradigm for (and general theory of) islands lies in focusing on a conceptual integration of islands and their habitat--"the sea and all that is therein." Insular coastal zones (or marine environments), therefore, offer the prospect of being not just a vehicle for economic revitalization (see Section 6), but also, as the process of management and development proceeds, could provide the missing elements needed for shaping a new conceptual paradigm for island systems.

Therefore, island planners and leaders and the designers of bilateral and multilateral technical assistance strategies for island "coastal zones" will over the next decade or so--whether willingly, consciously, inadvertantly, or perhaps reluctantly--be participants in this process. The island world (within the world island) is close to a paradigm shift. In the meanwhile, useful tentative models, conceptual tools and technical components are available. What is done with them to ensure the survival of island systems is the question.

8. LESSONS LEARNED

8.1 Islands As Unique

Oceanic island states are different in kind, not just in matters of scale, from continental systems and states, a circumstance which suggests the need for caution in extrapolating from continental marine resource development planning strategies and coastal zone management models.

All oceanic islands by definition are surrounded by the sea and have circumferential (not linear) coastal and exclusive economic zones which are always larger than total associated land areas. Island cluster states have no other option except to use costly sea and air transport modes to link-up separate parts of the country which often are dispersed over expansive ocean areas. Most island states (unlike continental countries) have no land frontiers or central terrestrial core distant from the sea, and, therefore, coastal resource planning and management is largely synonymous with national resource planning and management. There is an implied risk, however, in this approach because to a degree it is more holistic and comprehensive than traditional land-oriented physical and economic planning as currently practiced in island states.

All islands are microstates, but not all microstates are islands. Despite its widespread use by the United Nations and some academicians, the term "microstate" is not therefore very appropriate to island systems as it overemphasizes the common constraint of smallness at the expense of the more fundamental constraints of true insularity (isolation, circumferential sea boundaries, dependence on coastal and marine resources, storm risks, limited species diversity, ecological fragility and high levels of biotic endemism).

8.2 Limitations to the Island Microcosm Concept

Islands are not intrinsically microcosms of continents, but smaller oceanic islands (or groups) tend to be microcosms of other larger islands (or groups) or of islands considered generically. Larger oceanic archipelagic or cluster islands may be "microcosms" of marginal, peripheral coastal areas or systems on the edges of continents, to the extent that they help define or demonstrate generic center-periphery or core-margin relationships. The island microcosm concept appears, therefore, to have more academic metaphorical value than applied methodological utility. To the degree that it implies (or the reader infers) that island microcosms are dwarf-like miniatures of continents, it is misleading, falling somewhere between the perception of islands as "satellites" and islands as laboratories.

8.3 Limitations to the Insular Coastal Zone Concept

Island coastal zones are analogous to a topological Moebius strip with no real inside and outside--the sea and the island are truly one identity and in this study are called the "island system." Most islanders innately sense this fusion which goes beyond linear interrelationships or interdependencies of man-land-sea. Perhaps because it is part of the insular mystique, the concept is easily given up by islanders confronting allegedly more acceptable, more rational, but narrower planning, management, and development models when they travel "off-island" for technical and professional training at continental institutions.

In any event, most ongoing island resource planning activity is essentially land-oriented (i.e., inside looking out) which neglects coastal and marine factors, the reasons for which have been previously addressed. But to effect the needed conceptual and structural shift to a more holistic "island system," or island-man-sea framework for resource assessment, development and management planning, one has to first address the implicit land vs. sea asymmetry of the data base, available technical and professional skills, environmental and development control legislation, and institutional capabilities. Secondly, there is a need to develop a more integrated island-man-sea resource management framework by combining the perspective (and respective expertise) of the <u>islander</u> (institutionalized or interpreted by the island core or political center), the <u>out-islander</u> (the margin or periphery), the <u>sister islander</u> (neighboring/regional considerations), and the <u>non-islander</u> (continental/international). Both approaches can be pursued simultaneously. There are two options.

On the one hand, the "coastal zone management concept" (essentially a continental notion) could, with the "insular" adaptations previously suggested, serve as the land-sea linking device and the vehicle for upgrading insular utilization of coastal and marine resources, reducing vulnerability and external dependency, and achieving a greater degree of self-reliance as an insular system.

On the other hand, the standard "coastal zone concept" when applied to islands presents three basic difficulties: (1) when looking inward, because of the "smallness" of the land area, it becomes not a "zone" but an entire matrix of all island watersheds (technically subsuming all planning); (2) when looking outward, because of the vast expanse of the EEZ in comparison to the island itself, the coastal zone concept and label become inappropriate; and (3) when single country island clusters or multiple island systems with closely coupled core and satellite "islands" (as in the case of Fiji, Tonga, Grenada, and St. Vincent) try to use the "coastal zone" format, how do they handle the spatial and jurisdictional problem of what is and what is not "coastal zone." In these cases, the "coastal zone" is not a very useful term, as least for management purposes.

It is suggested, therefore, that for smaller oceanic island systems, the "coastal zone concept" (as a vehicle for change and management) be incorporated within an integrated "marine resource management" concept or its equivalent. In effect, "coastal zones" mean more to continents than to islands; marine resources (which subsume insular coastal zones) mean more to islands than to continents.

8.4 Technical Limits and Options

The reader might assume from this study that extremely isolated, traditionally self-sufficient, more marginal, and less developed islands and peripheral systems represent the ideal, to be encouraged because of their inherently greater stability and sustainability. Their impact on unique, exotic or endangered island habitats and species is seemingly less destructive than larger scale, more intrusive, externally generated activity. This is not the intended lesson.

These "out" island areas (whether undeveloped smaller satellite islands--however ecologically unique--or less developed peripheral outlying coastal areas) are far more important to the core or center than has been previously recognized (not in a preservation mode but as efficient production units that happen to create fewer negative environmental impacts). One task is to incorporate these peripheral areas and their proven "potential" within the larger island national development planning process without detracting from their character as self-sufficient island system sub-units. This requirement and the larger task of devising appropriate coastal resource management strategies for island systems can best be accomplished by paying attention to the following operational considerations.

- Even a simple development project, if its ecological, sociological, and economic consequences have not been carefully thought through, may have strong adverse impacts on the resource in question, on community relations and on the success of other, apparently unrelated development projects.
- A cultural orientation is necessary not only in the choice of a coastal resource development technology but in the case of all research, planning and management activities maintaining active linkages with established practices in the communities involved.
- Technical assistance planning efforts based on continental models by off-island entities dealing with insular coastal resources will be more effective if they are focused on local development opportunities, are integrated with existing human use systems, are less regulatory and constraining than presently available continental models, and place greater emphasis on consensus-building strategies which combine users and managers.
- In small islands rapid, incremental growth or large-scale projects often overwhelm local institutional resource management capabilities. Compensatory training, education and institution building strategies have tended to

lag behind, suggesting the need for more emphasis on strengthening local institutions and their capacities to anticipate and assess the potential environmental impacts of development activities. This can best be accomplished through participatory, interdisciplinary planning and management initiatives (both governmental and nongovernmental) at the local level, rather than through more formal, off-island approaches.

9. GUIDELINES

(1) Continental models and practices for pre-project environmental impact assessment, while useful, need substantial re-design to serve a practical purpose when applied to island systems.

In project planning, design and development for islands, the absence of an antecedent or parallel comprehensive resource assessment can, as in the Rodney Bay, St. Lucia, example (Section 4.1), lead to unanticipated, adverse environmental and social effects. However, the presence of environmental profiles and environmental impact assessment documentation is no guarantee of success and can induce a false sense of security (as in the Mangrove Lagoon, Virgin Islands, example in Section 4.2) unless the framework for the impact assessment is broadened to reflect insular human use conditions (such as descriptions of man-land-sea, non-cash subsistence economic factors), constraints (such as national vulnerability/dependency indices), and the bias or skew factor resulting from a marginal marine data base and historically land-oriented planning practices.

For island areas, environmental impact assessment procedures should be further expanded to incorporate the design of a follow-up project monitoring and evaluation strategy (with clear delineation of assigned responsibilities, schedules, reporting and funding options). Some attention should also be paid to scheduling a post-audit activity. In other words, the impact assessment approach, if used, should be a less static vignette and more concerned with process, feedback and verification of both external and domestic assumptions. A three-stage effort is required --before, during and after--the latter two preferably by an independent entity.

Additionally, the natural ecosystem concept, as employed by many scientists carrying out environmental impact and resource assessment efforts, results in an incomplete definition of project boundaries. The concept must be expanded to include human use systems and related linkages, with appropriate "boundaries" for analyzing project impacts on human ecology.

(2) Guidelines for coastal resources management should be enforceable and equitably applied. Unenforceable environmental management legislation for coastal and marine resources and/or regulations and permitting procedures which the government itself is not willing to honor are worse than no rules at all because they compromise government credibility among resource users.

Encouraging the hasty drafting of coastal zone or marine resource management legislation should be avoided. Legislation should be drafted when based on solid (not necessarily precise) scientific and socioeconomic information--including information about how traditional uses, users, and resource management practices will be affected, or what industries need incentives or restrictions to enhance development and increase local self-reliance.

Enabling legislation for coastal zone management programs that require massive off-island hiring of expatriate professionals does not meet these standards and should be avoided as premature.

(3) Training and education strategies should be integral components of resource assessment, impact assessment, or marine/coastal resource management planning efforts.

Training and education strategies in marine and coastal resource assessment and management for and in island areas should focus primarily on mid-level technician skills-building and on upgrading the marine literacy of local economic and physical planners and marine resource users, primarily using sequential, participatory, problem focussed workshops and in situ informal short courses designed to cut across disciplinary or ministerial (sectoral) boundaries.

The relative smallness of the population base in most small islands makes it very difficult to identify and provide manpower requirements in addressing technical areas like marine resource development. Unfortunately, as the Minister of Education for Tonga (former Chancellor of the University of the South Pacific in Fiji) has noted, "... training provided overseas is expensive and disrupting" (Kavaliku, 1980).

Prospective skills-training workshops or programs might focus separately or collectively on establishing management objectives and guidelines on coastal zone or marine resource assessment, on community participation, non-formal data collection, resource mapping (by type and by "objective"), impact assessment methodologies, ecodevelopment principles, and alternative management devices such as marine parks or artificial reefs for fisheries enhancement. As appropriate to the island or island group a workshop format could address preparation of resource planning guidelines for specific issues such as docks and piers, harbors and boat channels, causeways and jetties, baseline data gathering, small boat harbor development, beach and shoreline erosion control, beach nourishment/enhancement, lagoonal systems, waves, swells, tides and currents, and risk analysis. Such topics should be approached as simply and in as practical a fashion as possible. In each case the workshop should emphasize what could be done using locally available skills and materials, equipment and instruments. As a second concern, workshops should address what other management goals could be addressed given a modest additional increment of expanded skills training, a few basic research tools, instruments and measuring devices, along with standard data recording forms and "how-to-do-it" handbooks. The reinforcing incentive of being part of both a national and regional network and baseline data/information management system could enhance the strategy further.

(4) Large-scale development projects in smaller islands should be spread over the longest possible time frame and should be designed to be carried forward in stages, to reduce temporally concentrated impacts and encourage mid-project re-design if necessary.

Major coastal/marine resource development projects on smaller islands affecting complex inter-related ecosystems, whenever possible, should be designed for phased implementation, thus allowing time "breaks" between phases to assess impacts and to make appropriate compensatory adjustments. This is especially crucial when the natural resource base provides input to a local and traditional subsistence economy.

The irreversible "transformational" effects of major development schemes on traditional human use systems and the equally irreversible environmental effects of major projects suggest the need for both careful monitoring and retention of the option for mid-project re-design if required.

(5) <u>At a minimum, continentally derived coastal zone management models require major reformulation if they are to be employed in small island circumstances, and in some cases continentally derived models will be inappropriate</u>.

Scaling down existing continental approaches to coastal and marine resource management is not enough. The focus, boundaries, structure, planning, staffing, and funding elements of a coastal zone management approach all require re-thinking and re-design within an island context to incorporate the following:

- an emphasis on <u>local</u> development opportunities integrated with existing human use systems
- fewer top-down regulatory constraints than in continental models
- targeted emphasis on marine literacy and locally required management information systems (formal and informal)
- reformulation of the concept of "public participation" to place more emphasis on concensus and less on formalized ex post facto responses
- provisions to enhance insular self-sufficiency (which means appropriate, locally sustainable technological transfer and ecodevelopment approaches)
- an emphasis on "production" diversity, decentralization (the peripheral system), and the expansion of internalized markets, even at the expense of (a) exports, (b) alleged economies of scale, and (c) foregone outside investment or foreign aid funds for high-tech schemes
- greater incorporation of existing institutions
- emphasis on inter-island regional linkages and opportunities for shared training, management and enforcement.

(6) <u>The existing informal network of island coastal and marine resource planning and development practitioners (institutional, governmental, individual), who have developed the new approaches and models reviewed herein, collectively constitute a unique "insular resource"</u>

which should be tapped for island coastal and marine resources management.

Numerous innovative and experimental approaches to island coastal resource management have already been developed and are accessible. Their diversity reflects both the complexity of the problem and the universe of island types. Current initiatives to structure more formalized coastal zone management programs need to find ways to utilize these proven island specific strategies. The primary task at hand, therefore, is not fundamentally a basic research problem so much as it is a technical application problem. It is, therefore, appropriate to devise mechanisms to apply what has been learned. This is seldom done by development agencies working within an island context, however, being left primarily as a task for an academician's post-audit, years after the fact.

LITERATURE CITED

Alexander, L., 1973. Indices of national interest in the oceans. Ocean Devel. and Internat. Law J., I(1):21-49.

Baines, G. B. K., 1979. Mangroves for national development: A report on the mangrove resources of Fiji. Institute of Applied Social Research, School of Australian Environmental Studies, Griffith Univ., Nathan, Australia.

________________, 1981. Environmental management for development in the Pacific. United Nations Development Advisory Team for the Pacific (UNDAT)/Economic and Social Commission for Asia and the Pacific, Suva, Fiji.

________________, 1982. Pacific islands: development of coastal resources of selected islands. In: C. H. Soysa, et al. (Editors), Man, land and sea: Coastal resource use and management in Asia and the Pacific. The Agricultural Development Council, Bangkok.

Beller, W. S. (Editor), 1970. The U.S. Virgin Islands and the sea. Office of the Lt. Gov., Government of the U.S. Virgin Islands, St. Thomas, U.S. Virgin Islands.

______________________, 1979. Environmental management and economic growth in the smaller Caribbean islands, proceedings of conference. U.S. Department of State, Washington, D.C. Publication 8996.

Best, L., 1968. Outlines of a model of a pure plantation economy. Social and Economic Studies (September). Univ. of the West Indies, Mona, Jamaica.

Bonnet, J. and Towle, E., 1981. Energy/environment management: A broad perspective for the islands of the Caribbean. Carib. Ed. Bull., VIII(3):13-33.

Bowden, M., 1974. Hurricanes in paradise: Perception and reality of the hurricane hazard in the Virgin Islands. Island Resources Foundation, St. Thomas, U.S. Virgin Islands.

Bowman, J. S ., 1971. A book of islands. Doubleday and Co., Garden City, New York.

Brookfield, H. C., 1973. The Pacific realm. In: Mikesell, M. (Editor), Geographers abroad, essays on the problems and prospects of research in foreign areas. Univ. of Chicago Press.

________________, 1975. Gain and loss of system independence: The problem of accelerating change. Conf. paper at 13th Pacific Science Congress (Symposium: "man's place in the island ecosystem, revisted"), Vancouver, B.C.

Brookfield, H. C. (Editor), 1977. Koro in the 1970's: Prosperity through diversity? Island reps. no. 2, UNESCO/UNFPA Population and Environment Project in Eastern Islands of Fiji, sponsored by Man and the Biosphere (MAB) Programme, Project 7: Ecology and Rational Use of Island Ecosystems. Australian National Univ., Development Studies Center, Canberra, Australia.

_______________ (Editor), 1978a. Taveuni: Land, population and production. Island reps. no. 3, UNESCO/UNFPA Population and Environment Project in Eastern Islands of Fiji, sponsored by Man and the Biosphere (MAB) Programme, Project 7: Ecology and Rational Use of Island Ecosystems. Australian National Univ., Development Studies Center, Canberra, Australia.

_______________ (Editor), 1978b. The small islands and the reefs. Island reps. no. 4, UNESCO/UNFPA Population and Environment Project in the Eastern Islands of Fiji, sponsored by Man and the Biosphere (MAB) Programme, Project 7: Ecology and Rational Use of Island Ecosystems. Australian National Univ., Development Studies Centre, Canberra, Australia.

_______________ (Editor), 1979. Lakeba: Environmental change, population dynamics and resource use. Island reps. no. 5, UNESCO/UNFPA Population and Environment Project in the Eastern Island of Fiji, sponsored by Man and the Biosphere (MAB) Programme, Project 7: Ecology and Rational Use of Island Ecosystems. Australian National Univ., Development Studies Centre, Canberra, Australia.

_______________________, 1980. Population-environment relations in tropical islands: The case of Eastern Fiji. UNESCO/Man and the Biosphere Program. Technical notes, no. 13.

_______________ and Glaser, G., 1975. Population and environment in the eastern islands of Fiji. Nature and Resources, XI(2):2-8.

Carlquist, S., 1965. Island life: A natural history of the islands of the world. The Natural History Press, Garden City, New York.

Carlquist, S., 1972. Island biology: We've only just begun. Bioscience, 22(4):221-225.

____________, 1974. Island biology. Columbia Univ. Press, New York.

Clark, J., 1977. Coastal ecosystem management. John Wiley and Sons, New York.

Cohen, R. and Dunning, F. S., 1978. An island strategy for OTEC commercialization. Paper for Solar Energy and Conservation Symposium-Workshop, Miami, Florida, Dec.

Coulianos, K. E., 1980. Concepts for eco-developmental tourism for small Caribbean islands. Master's thesis, University of Michigan.

Dahl, A. L., 1980. Regional ecosystems survey of the South Pacific area. South Pacific Commission, Noumea, New Caledonia. Technical paper no. 179.

Deane, C., Thom, M., and Edmunds, H., 1973. Eastern Caribbean coastal investigations, 1970-73. British Development Division in the Caribbean, Trinidad. 5 vol.

Demas, W. G., 1965. The economics of development in small countries with special reference to the Caribbean. McGill Univ. Press, Montreal.

Devaux, R., 1983. Report on Rodney Bay Development. Consulting report submitted to Island Resources Foundation, St. Thomas, U.S. Virgin Islands.

diCastri, F. and Glaser, G., 1979. Ecology and the development of mountains and islands. Nature and Resource, XV(3):8-16.

Dolman, A. J., et al., 1982. Small island countries, regional cooperation and the management of marine resources. Foundation Reshaping the International Order (RIO), The Hague, The Netherlands.

Dommen, E., 1980a. External trade problems of small island states in the Pacific and Indian Oceans. UN Conference on Trade and Development, Geneva, Switzerland. Reprint series no. 17.

__________, 1980b. Some distinguishing characteristics of islands. World Development, 8 (12).

__________, 1983. Invisible exports from islands. UN Conference on Trade and Development, Geneva, Switzerland. No. 9.

Dorst, J., 1972. Parks and reserves on islands. Background paper for second World Conference on National Parks, Yellowstone and Grand Teton National Parks, Sept. 1972.

Douglas, G., 1969. Check list of Pacific oceanic islands. Micronesica, 5(2):327-463.

East-West Center, 1982. Energy mission report, Fiji. Pacific Islands Development Program and Resource Systems Institute, Honolulu, Hawaii.

Eastern Caribbean Natural Area Management Program (ECNAMP), 1980. Preliminary data atlas. University of Michigan/UNEP. Series of resource data maps for Anegada, Anguilla, Antigua, Aruba, Barbados, Barbuda, Bonaire, Curacao, Dominica, Grenada, Guadeloupe, Martinique, Montserrat, Nevis, Saba, St. Barthelemy, St. Euastatius, St. Kitts, St. Lucia, St. Martin, Sint Maarten, St. Vincent, Tortola, and Virgin Gorda.

Eastern Caribbean Natural Area Management Program (ECNAMP) and the Government of the British Virgin Islands, 1981. A system of marine parks and protected areas for the British Virgin Islands. Tortola, British Virgin Islands.

Fiji, Parliament of, 1980. Fiji's eighth development plan, 1981-85. Parliamentary paper no. 35 of 1980. Prepared by Central Planning Office, Suva.

Fosberg, F. R. (Editor), 1963. Man's place in the island ecosystem, a symposium. Bishop Museum Press, Honolulu, Hawaii.

Franco, A. B., et al., 1982. Country Profiles (Cook Island, Fiji, Kiribati, Nauru, Niue, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu, Western Samoa). Pacific Islands Development Program, East-West Center, Honolulu, Hawaii.

Francois, P. and Brown, V., 1975. Report on water quality, U.S.V.I., 1970-1975. Prepared by Div. of Natural Resources Management, Dept. of Conservation and Cultural Affairs, Government of the U.S. Virgin Islands, St. Thomas.

Frankenhoff, C. A., et al., 1974. Environmental planning and development in the Caribbean. Graduate School of Planning, Univ. of Puerto Rico.

Geoghegan, T., 1983. Guidelines for integrated marine resource management in the Eastern Caribbean. Caribbean Conservation Association, Eastern Caribbean Natural Area Management Program (ECNAMP), St. Croix, U.S. Virgin Islands. Caribbean environment technical paper no. 2.

Gilles, J. L. and Jamtgaard, K., 1982-1983. The commons reconsidered. Renewable Resources J., I(2 and 3):24-29.

Gold, E., Letalik, N., and Mitchell, C. (Editors), 1982. Problems of development and ocean management in the eastern Caribbean: Economic, legal, environmental and planning aspects. Proceedings of an International seminar held in Kingstown, St. Vincent, May 11-13, 1981. Dalhousie Ocean Studies Progtram, Halifax, Nova Scotia.

Goodwin, M. H. and Cambers, G., 1983. Artificial reefs, a handbook for the Eastern Caribbean. Prepared by Environmental Research Projects for the Caribbean Conservation Association.

__________ and Taylor, S. E., 1981. A survey of the current status of marine resource management in the Eastern Caribbean. Prepared by Environmental Research Projects for the Rockefeller Brothers Fund and the Caribbean Conservation Association.

Gorman, M., 1979. Island ecology (outline series in ecology). Halstead Press (Division of John Wiley & Sons), New York.

Gosnell, M., 1976. The island dilemma. Internat. Wildlife, 6(5):24-35.

Grigg, D. and vanEepoel, R., 1972. Status report on bays of St. Thomas and St. John. Carib. Research Institute, College of Virgin Islands St. Thomas, U.S. Virgin Islands. Water pollution rep. no. 19.

Grigg, D., vanEepoel, R., and Brody, R., 1971. Water quality and environmental status of Benner Bay-Mangrove Lagoon, St. Thomas. Caribbean Research Institute, College of the Virgin Islands, St. Thomas, U.S. Virgin Islands. Water pollution rep. no. 10.

Hamnett, M., Surber, R. J., Surber, D. E., and Denoncour, M. T., 1981. Unbalanced books: Economic vulnerability in the Pacific. East-West Perspectives, 2(3):6-12.

Hardin, G., 1968. The tragedy of the commons. Science, 162:1243-1248.

Hodgson, R.D., 1973. Islands: Normal and special circumstances. Bureau of Intelligence and Research, U.S. Department of State, Washington, D.C. Research study, RGES-3.

Holling, C. S. (Editors), 1978. Adaptive environmental assessment and management. Vol. 3 in international series on applied systems analysis. John Wiley and Sons, New York.

Howell, C. and Towle, E., 1976. Island environments and development: a case study of the British Virgin Islands. Prepared by the Island Resources Foundation for the Government of the British Virgin Islands. St. Thomas, U.S. Virgin Islands.

Institute of Social and Economic Research, Univ. of the West Indies, 1980. Studies on population, develoment and the environment in the Eastern Caribbean. Bridgetown, Barbados. Newsletter no. 1.

Insular Environments, Inc., 1975a. Environmental reconnaissance surveys of selected bays. Prepared for Govt. of the U.S. Virgin Islands, Department of Conservation and Cultural Affairs, St. Thomas.

Insular Environments, Inc., 1975b. Environmental study report for proposed docks, bulkhead and walkway at Benner Bay on the south coast of St. Thomas, U.S.V.I. Prepared for Antilles Yachting Service, St. Thomas, U.S. Virgin Islands.

Jackson, I., 1981. Study of the pleasure boat industry in the British Virgin Islands with emphasis on charter boats. Prepared for the Government of the British Virgin Islands under contract to the World Tourism Organization.

Johannes, R. E., 1975. Pollution and degradation of coral reef communities. In: Wood, E. J., and Johannes, R. E., (Editors), Tropical marine pollution. Elsevier Scientific Publishing Co., New York.

______________, 1978. Reproductive strategies of coastal marine fishes in the tropics. Environmental Biol. of Fishes: 3:65-84

______________ and Betzer, S. B., 1975. Introduction: Marine communities respond differently to pollution in the tropics than at higher latitudes. In: Wood, E. J. and Johannes, R. E., (Editors), Tropical marine pollution. Elsevier Scientific Publishing Co., New York.

Jones-Hendrickson, S. B., 1979. Factors constraining growth of micostate economies. Paper prepared for a conference on environmental management and economic growth in the smaller Caribbean islands, Bridgetown, Barbados, Sept. 1979. Reprinted by Caribbran Research Institute, College of the Virgin Island, St. Thomas, U.S. Virgin Islands.

Jordan, D. G. and Cosner, O. J., 1973. A survey of the water resources of St. Thomas, Virgin Islands. U.S. Geological Survey, Caribbean District, San Juan, Puerto Rico. Open file report.

Kavaliku, L., 1980. A strategy for Pacific islands development. Pacific Perspective, 9(2):62-76. South Pacific Social Science Association, Suva, Fiji.

Koester, S., 1983. The effects of the Rodney Bay development on Gros Islet Fishermen. Consulting report prepared for Island Resources Foundation, St. Thomas, U.S. Virgin Islands.

Lal, P. N., 1981. Institutional aspects of the management of mangrove resources. In: Lal, P. N. (Editor), 1983. Mangrove resource management. Fisheries Division, Ministry of Agriculture and Fisheries, Suva, Fiji. Technical rep. no. 5 (June).

Lewsey, C. D., 1978. Assessing the environmental effects of tourism development on the carrying capacity of small island systems: The case for Barbados. Ph.D. thesis, Cornell University.

MacArthur, R. H. and Wilson, E. O., 1967. The theory of island biogeography. Princeton Univ. Press, Princeton, New Jersey.

Man and the Biosphere (MAB) Programme, Project 7: Ecology and Rational Use of Island Ecosystems, 1977. Population, resources and development in the eastern islands of Fiji: Information for decision making. General report no. 1 of the UNESCO/UNFPA Population and Environment Project in the Eastern Islands of Fiji.

McClymont, R. B., 1982. Environmental assessment procedures for Fiji. South Pacific Regional Environment Programme. 1327/82.

McComb, W. F., Engineering, 1982. Environmental and planning assessment rep., Compass Point Marina, Benner Bay, St. Thomas, U.S.V.I., St. Thomas, U.S. Virgin Islands.

McEachern, J. and Towle, E., 1974a. Ecological guidelines for island development. International Union for Conservation of Nature and Natural Resources, Gland, Switzerland.

______________________________, 1974b. Resource management programs for oceanic islands. In: Environmental planning and development in the Caribbean. Univ. of Puerto Rico.

McElroy, J. L., 1978a. Economic and social impacts of the Virgin Islands coastal zone management program. U.S. Virgin Islands Planning Office, St. Thomas, U.S. Virgin Islands. Technical supplement no. 4.

_______________, 1978b. Internal and external policy constraints in the small island context. Paper prepared for Conference on Economic Development of the Small State, sponsored by Institute of International Law and Economic Development, San Juan, Puerto Rico.

_________________ and de Albuquerque, K., 1983. Federal perceptions and policy versus Virgin Islands reality. Paper presented to ICLAS/MALAS Conference on Ro~~le~~ of Caribbean in Latin America, Univ. of Illinois, Urbana-Champaign, Nov.

McNulty, K., et al., 1968. Departmental study team report and recommendations on proposed new jet airport, St. Thomas. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Michel, J., 1970. A study of the hydrodynamic effects of the proposed airport at Long Beach Point, St. Thomas, Virgin Islands. Final rep. to Virgin Island Port Authority. Rosenstiel School of Marine and Atmospheric Science, Univ. of Miami, Miami, Florida.

Mitchell, C. and Gold, E., 1982. The integration of marine space in national development strategies of small island states: The case of the Caribbean states of Grenada and St. Lucia. Dalhousie Ocean Studies Program, Halifax, Nova Scotia.

Mueller-Dombois, D., 1973. Some aspects of island ecosystems analysis (a preliminary conceptual synthesis). U.S. International Biological Program, Island Ecosystems Integrated Research Program. Department of Botany, Univ. of Hawaii. Technical report no. 19.

Nichols, M., et al., 1979a. Impact of storm flooding in the mangrove lagoon, St. Thomas. Prepared by Island Resources Foundation for the Government of the U.S. Virgin Islands, Department of Conservation and Cultural Affairs. St. Thomas, U.S. Virgin Islands.

__________________, 1979b. Virgin-Islands bays: Modeling of water quality and pollution susceptibility. Prepared by Island Resources Foundation for the Government of the U.S. Virgin Islands, Department of Conservation and Cultural Affairs, St. Thomas.

Nichols, M., Towle, E., et al., 1977a. Circulation, water quality and environmental resources of Perseverance Bay, St. Thomas. Prepared by Island Resources Foundation for the Government of the U.S. Virgin Islands, Department of of Conservation and Cultural Affairs, St. Thomas.

____________________________, 1977b. Water sediments and ecology of the mangrove lagoon and Benner Bay, St. Thomas. Prepared by Island Resources Foundation for the Government of the U.S. Virgin Islands, Department of Conservation and Cultural Affairs, St. Thomas

Nicholson, E. M. and Douglas, G. L., 1970. Conservation of oceanic islands. Papers and proceedings, IUCN eleventh technical meeting, New Delhi, India. International Union for the Conservation of Nature and Natural Resources, Morges, Switzerland.

O'Riordan, T., 1981. Problems encountered when linking environmental management to development. The Environmentalist, 1:15-24.

Parker, J. E., 1971. Accounting and ecology: A perspective. J. Accountancy, Dec., p.41-46.

Penn, N., 1980. The environmental consequences and management of coral sand dredging in the Suva region. Interim report. Institute of Natural Resources, Univ. of the South Pacific, Suva, Fiji.

Pontecorvo, G., et al., 1980. Contribution of the ocean sector to the United States economy. Science, 208:1000-1006.

Posner, B., Cuthbertson, C., et al., 1981. Economic impact analysis for the Virgin Islands National Park. Prepared by the Island Resources Foundation for the U.S. National Park Service, Southeast Regional Office. St. Thomas, U.S. Virgin Islands.

Potter, B., Tyson, G., et al., 1980. Water Island study: Economic development options. Prepared by the Island Resources Foundation for the Government of the U.S. Virgin Islands, Department of Commerce, St. Thomas.

Putney, A., 1981. Annual report, Eastern Caribbean Natural Area Management Program. ECNAMP, St. Croix, U.S. Virgin Islands.

__________, 1982. Survey of conservation priorities in the Lesser Antilles, final report. Caribbean Conservation Association, ECNAMP, St. Croix, U.S. Virgin Islands. Caribbean environment technical rep. no. 1.

Rambo, A. T., 1981. Environment and development: The place of human ecology in Southeast Asian studies programmes. East-West Center, Honolulu, Hawaii. East-West Environment and Policy Institute, reprint no. 32.

Robinson, A. H., 1973. Natural vs. visitor-related damage to shallow water corals: Recommendations for visitor management and the design of underwater natural trails in the Virgin Islands. Virgin Islands National Park, St. John, U.S. Virgin Islands.

Simberloff, D. S., 1974. Equilibrium theory of island biogeograpy and ecology: the biological importance of islands. In: Annual Review of Ecology and Systematics, 5:161-182.

South Pacific Bureau for Economic Co-operation, 1982. Regional conference of senior development planners, SPEC headquarters, Suva, 7-11 June 1982, vol. I and II. SPEC (82)12, Suva, Fiji.

South Pacific Commission, 1981. South Pacific regional environment programme: Report of the technical meetings, Noumea, New Caledonia, 22-26 June, 1981.

South Pacific Regional Environment Programme, 1980. Second co-ordinating group meeting. Fiji country report. SPREP/co-ordinating group meeting 2/W.P. 6, Suva, Fiji, 12-13 Nov., 1980.

Soysa, C. H., Sien, C. L., and Collier, W. L. (Editors), 1982. Man, land and sea: Coastal resource use and management in Asia and the Pacific. The Agricultural Development Council, Bangkok.

Stevenson and Hardtke Associates, Ltd., 1969. Development study, Gros Islet Bay, St. Lucia, W.I. Don Mills, Canada.

________________________________, 1973. Post construction beach stability investigation, Rodney Bay. Don Mills, Canada.

Stinner, W. F., et al. (Editors), 1982. Return migration and remittances: Developing a Caribbean perspective. Research Institute on Immigration and Ethnic Studies, Smithsonian Institution, Washington, D.C.

Szekielda, K. H. and Breuer, B. (Editors), 1976. Interregional seminar on development and management of resources in coastal areas. German Foundation for International Development/UN.

Tabb, D. and Michel, J., 1968. A study of the biological and coastal engineering aspects of the proposed jet airstrip at Jersey Bay, St. Thomas, U.S. Virgin Islands. Report to the Office of the Governor, U.S. Virgin Islands. Institute of Marine Science, Univ. of Miami, Florida.

Teytaud, A. R., 1981. A management plan for the St. Thomas mangrove lagoon area of particular concern. Government of the U.S. Virgin Islands, Department of Conservation and Cultural Affairs, Division of Coastal Zone Management. St. Thomas.

Towle, E., 1975. National parks in the Caribbean area. In: Publicaciones Biologicas, Instituto de Investigaciones Cientificas, Universidad Autonoma de Nuevo Leon, 1(7):195-208. July 1, 1975.

__________, 1978. The coastal zone development dilemma of island systems. In: Earthcare: Global protection of natural areas. Proc. fourteenth biennial wilderness conference. Westview Press, Boulder, Colorado.

__________, 1979a. Caribbean marine resources management characteristics, problems and prospects. Prepared for the Eastern Caribbean Natural Area Management Program and presented at its workshop on natural area planning, Tobago, May 1979.

__________, 1979b. Characteristics of island resources. Prepared for the Eastern Caribbean Natural Area Management Program and presented at its workshop on natural area planning, Tobago, May 1979.

__________, 1981. CCOP/SOPAC inshore programme review (UNDP project RAS/79/074). Consulting report prepared for Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas/UN Economic and Social Commission for Asia and the Pacific. Suva, Fiji.

__________, 1982. Solid waste management in the Lesser Antilles, a status report and planning study for a solid waste management workshop. Prepared by the Island Resources Foundation for the U.S. Man and the Biosphere Program. St. Thomas, U.S. Virgin Islands.

__________, Grigg, D., Rainey, W., et al., 1976. Marine environments of the Virgin Islands. Prepared by the Island Resources Foundation for the U.S. Virgin Islands Planning Office, St. Thomas. Technical supplement no. 1.

__________, Howell, C., and Rainey, W., 1976. Virgin Gorda natural resources survey: economic development possibilities and environmental elements. Island Resources Foundation, St. Thomas, U.S. Virgin Islands.

__________ and McEachern, J., 1974. Environmental survey and status report of selected Caribbean islands. Prepared by the Island Resources Foundation for the United National Development Programme, Physical Planning Project, St. Lucia, West Indies.

Towle, J., 1982. Management analysis of the Eastern Caribbean Natural Area Management Program. Paper prepared for a course in development administration at American Univ., Washington, D.C.

UNESCO, Division of Marine Sciences, 1981. Marine and coastal processes in the Pacific: Ecological aspects of coastal zone management. Report of a UNESCO seminar held at Motupore Island Research Station, Univ. of Papua New Guinea, July 1980.

UNESCO/Programme on Man and the Biosphere (MAB), 1973. Expert panel on project 7: ecology and rational use of island ecosystems. Paris. MAB report series no. 11.

UNESCO/Programme on Man and the Biosphere (MAB), 1974. Task force on the contribution of the social sciences to the MAB programme: Final report. Paris. MAB report series no. 17.

United Nations Conference on Trade and Development (UNCTAD), 1974. Developing island countries. Report of the panel of experts. New York.

United Nations Development Programme (UNDP), 1977. Assistance in physical planning, Caribbean: Multi-island country project: Project findings and recommendations. New York. DP/UN/CAR-75-001/1.

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 1980. Development of environment statistics: Areas of environmental concern in the South Pacific subregion. Pacific workshop on environment statistics, Honolulu, Hawaii, Oct., 1980.

United Nations Economic and Social Council (ECOSOC), 1975a. Marine questions: Coastal area management and development. E/5648 (8 May, 1975).

________________________, 1975b. Marine questions: Uses of the sea. E/5650 (30 April, 1975).

________________________, 1975c. Special economic problems and development needs of geographically more disadvantaged developing island countries. E/5647 (27 March, 1975).

United Nations Environment Programme (UNEP), 1980. A strategy for the conservation of living marine resources and processes in the Caribbena region. UNEP/CEPAL/WG.48/INF.17 (1 November, 1980).

United States Army Corps of Engineers, 1982. Section 107, reconnaissance report, Benner Bay, St. Thomas, Virgin Islands. U.S. Army Engineers Dist., Jacksonville, Florida.

United States Department of Interior, 1970. Islands of America. Washington, D.C.

United States Environmental Protection Agency, 1983. EPA studies options to improve wastewater disposal in Mangrove Lagoon/Turpentine Run area. In: Region II, proj. newsletter (Dec.). New York.

Valencia, M. J. (Editor), 1981. Proceedings of the workshop on coastal area development and management in Asia and the Pacific, Manila, Dec. 1979. East-West Environment and Policy Institute, East-West Center, Honolulu, Hawaii.

Villamil, J., 1974. Size and survival: Planning on small island systems. Lecture, College of the Virgin Islands, Caribbean Research Institute, Feb. 27-28, 1974. St. Thomas, U.S. Virgin Islands.

Villamil, J., et al., 1971. Open systems planning: Preliminary analysis. Northeast Regional Science Review, 1.

Virgin Islands (VI) Government, Department of Conservation and Cultural Affairs, 1979. Environmental laws and regulations of the Virgin Islands. St. Thomas.

______________________________, 1980. U.S. Virgin Islands water quality management plan. St. Thomas.

______________________________, 1981. Environmental assessment report: Bovoni horse racetrack. St. Thomas.

Virgin Islands (VI) Government Planning Office, 1977. Preliminary program: Virgin Islands coastal zone management. St. Thomas.

____, 1983. Virgin Islands comprehensive policy plan. St. Thomas.

Wace, N., 1978. The character of oceanic island resources and the problem of their rational use and conservation. In: The use of high mountains of the world. New Zealand Department of Lands and Survey, Canterbury.

________, 1980. Exploitation of the advantages of remoteness and isolation in the economic development of Pacific islands. In: Shand, R. (Editor), The island states of the Pacific and Indian oceans: Anatomy of development. Development Studies Centre Monograph No. 23.

Wernicke, W. and Towle, E. L., 1983. Vessel waste control plan for the U.S. Virgin Islands. Contract study prepared by Island Resources Foundation for the Virgin Islands Department of Conservation and Cultural Affairs. St. Thomas.

Wilimovsky, N.J., 1979. Perspectives on minimal data requirements for aquatic resource management in development countries. Working paper for workshop on tropical small-scale fish stock assessment, International Center for Marine Research and Development, Univ. of Rhode Island, Sept. 1979.

Wood, E. J. and Johannes, R. E. (Editors), 1975. Tropical marine pollution. Elsevier oceanography series, 12. Elsevier Scientific Publishing Co., New York.

UNESCO, Division of Marine Sciences, 1981. Marine and coastal processes in the Pacific: Ecological aspects of coastal zone management. Report of a UNESCO seminar held at Motupore Island Research Station, Univ. of Papua New Guinea, July 1980.

UNESCO/Programme on Man and the Biosphere (MAB), 1973. Expert panel on project 7: ecology and rational use of island ecosystems. Paris. MAB report series no. 11.

UNESCO/Programme on Man and the Biosphere (MAB), 1974. Task force on the contribution of the social sciences to the MAB programme: Final report. Paris. MAB report series no. 17.

United Nations Conference on Trade and Development (UNCTAD), 1974. Developing island countries. Report of the panel of experts. New York.

United Nations Development Programme (UNDP), 1977. Assistance in physical planning, Caribbean: Multi-island country project: Project findings and recommendations. New York. DP/UN/CAR-75-001/1.

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 1980. Development of environment statistics: Areas of environmental concern in the South Pacific subregion. Pacific workshop on environment statistics, Honolulu, Hawaii, Oct., 1980.

United Nations Economic and Social Council (ECOSOC), 1975a. Marine questions: Coastal area management and development. E/5648 (8 May, 1975).

______________________________, 1975b. Marine questions: Uses of the sea. E/5650 (30 April, 1975).

______________________________, 1975c. Special economic problems and development needs of geographically more disadvantaged developing island countries. E/5647 (27 March, 1975).

United Nations Environment Programme (UNEP), 1980. A strategy for the conservation of living marine resources and processes in the Caribbena region. UNEP/CEPAL/WG.48/INF.17 (1 November, 1980).

United States Army Corps of Engineers, 1982. Section 107, reconnaissance report, Benner Bay, St. Thomas, Virgin Islands. U.S. Army Engineers Dist., Jacksonville, Florida.

United States Department of Interior, 1970. Islands of America. Washington, D.C.

United States Environmental Protection Agency, 1983. EPA studies options to improve wastewater disposal in Mangrove Lagoon/Turpentine Run area. In: Region II, proj. newsletter (Dec.). New York.

Valencia, M. J. (Editor), 1981. Proceedings of the workshop on coastal area development and management in Asia and the Pacific, Manila, Dec. 1979. East-West Environment and Policy Institute, East-West Center, Honolulu, Hawaii.

Villamil, J., 1974. Size and survival: Planning on small island systems. Lecture, College of the Virgin Islands, Caribbean Research Institute, Feb. 27-28, 1974. St. Thomas, U.S. Virgin Islands.

Villamil, J., et al., 1971. Open systems planning: Preliminary analysis. Northeast Regional Science Review, 1.

Virgin Islands (VI) Government, Department of Conservation and Cultural Affairs, 1979. Environmental laws and regulations of the Virgin Islands. St. Thomas.

______________________________, 1980. U.S. Virgin Islands water quality management plan. St. Thomas.

______________________________, 1981. Environmental assessment report: Bovoni horse racetrack. St. Thomas.

Virgin Islands (VI) Government Planning Office, 1977. Preliminary program: Virgin Islands coastal zone management. St. Thomas.

____, 1983. Virgin Islands comprehensive policy plan. St. Thomas.

Wace, N., 1978. The character of oceanic island resources and the problem of their rational use and conservation. In: The use of high mountains of the world. New Zealand Department of Lands and Survey, Canterbury.

________, 1980. Exploitation of the advantages of remoteness and isolation in the economic development of Pacific islands. In: Shand, R. (Editor), The island states of the Pacific and Indian oceans: Anatomy of development. Development Studies Centre Monograph No. 23.

Wernicke, W. and Towle, E. L., 1983. Vessel waste control plan for the U.S. Virgin Islands. Contract study prepared by Island Resources Foundation for the Virgin Islands Department of Conservation and Cultural Affairs. St. Thomas.

Wilimovsky, N.J., 1979. Perspectives on minimal data requirements for aquatic resource management in development countries. Working paper for workshop on tropical small-scale fish stock assessment, International Center for Marine Research and Development, Univ. of Rhode Island, Sept. 1979.

Wood, E. J. and Johannes, R. E. (Editors), 1975. Tropical marine pollution. Elsevier oceanography series, 12. Elsevier Scientific Publishing Co., New York.