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# ECOLOGICAL GUIDELINES FOR ISLAND DEVELOPMENT

JOHN Mc EACHERN  
and  
EDWARD L. TOWLE

Published with the assistance of the  
Swedish International Development Authority (SIDA)  
and the World Wildlife Fund



International Union  
for Conservation of Nature and Natural Resources  
Morges, Switzerland

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## FOREWORD

The interest of the International Union for Conservation of Nature and Natural Resources in promoting the acceptance of ecological principles as an essential basis for the planning and execution of economic development is of long standing. This led in 1970 to a meeting, co-sponsored by the Conservation Foundation and held at the headquarters of FAO, Rome, Italy, which brought together many representatives of international development agencies to consider this task. As a result of the meeting, and in collaboration with the Conservation Foundation, various studies and consultations were carried out. With the assistance of the Swedish International Development Authority (SIDA), the results of these were published in 1973. The book, Ecological Principles for Economic Development, by Raymond F. Dasmann, John P. Milton and Peter H. Freeman (John Wiley & Sons, Ltd., London) was regarded as the first of a series to be concerned with this subject.

Subsequently, IUCN has sponsored a series of workshops and studies in those regions, or ecological situations, in which the risk of environmental disruption resulting from economic development appeared to be most acute. These will result in short publications presenting ecological guidelines for use in economic development. The following is the first of these publications, and is concerned particularly with those smaller and more isolated islands where development pressures are, or soon will be, severe. It is expected that later publications will be concerned with coastal areas in tropical regions, tropical humid forests in Latin America and in South East Asia, semi-arid lands in Western Asia, and tropical savannas in Africa.

This publication has been written by Dr. Edward L. Towle and Mr. John McEachern of the Island Resources Foundation, Inc., St. Thomas, U.S. Virgin Islands. Dr. Towle has long experience in problems of island development and conservation. He has been president of the Caribbean Conservation Association and is director of the Caribbean Research Institute. Mr. McEachern is an economic geographer with experience in land-use planning in South East Asia, the Canadian Arctic and, particularly, the Caribbean.

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## I. INTRODUCTION

### Preamble

Islands of every kind and however remote are currently experiencing strong development thrusts founded chiefly on tourism, on extractive enterprises, on their use as global air and steamship transportation nodes, and on the increased demands for local resources generated by rapidly growing insular populations. An unwanted by-product of this development has been a dramatic deterioration of island environments, accompanied by a decline in the insular quality of life as measured by welfare indicators other than the traditional economic ones of GNP and per capita income. With islands, as elsewhere, progress has its price.

While the stresses and pressures of high population growth, unrestrained development and modern technology are partly responsible for this decline in island environmental quality, serious shortcomings are also becoming apparent in the matter of resource planning, allocation and management for island systems (McEachern and Towle, 1972).

The principal deficiency has been the omission of environmental values in planning and development strategies. The question of the moment, therefore, is how to incorporate ecological principles to a far greater degree in the modernization of island communities now being shaped by local forces and by development agencies involved in or responsible for island administration and growth.

Attracted by the undeveloped, pristine nature and recreational qualities of previously isolated islands now made accessible by the reduced costs and ease of air transport, a virtual tidal wave of people from urbanized continental areas are invading them and threatening, inadvertently, to alter the very qualities which make them attractive. The anomaly of the situation is that, on the one hand, islands are regarded as idyllic sites for a vacation experience and superior sites for specialized industries and free ports while, on the other, they are expected to develop their resources to service these demands indefinitely with no loss of insular character or unique environmental features (see Dasmann *et al.*, 1973, p. 135).

Islands constitute discrete points of conflict in the world's oceans, where the activities of developers directly confront fragile insular biological systems and circumscribed resources. Evidence is mounting that the impact of this confrontation has upset the precarious biological balances developed on these islands through their previous isolation and lack of exposure to modern technology. In a geographical sense islands are becoming "an endangered species" destined to be rapidly subsumed into a technology-dependent, culturally homogenized, urbanized and polluted copy of larger continental political, social and economic systems (Towle, 1971).

This threat to insular environments carries implications beyond irreversible changes in physical and biological assets. The environment is what obviously defines the quality of life for island peoples and visitors alike. The concept of "quality of life" is gaining favor as the focal point for converging economic, social and environmental development objectives. It expands the narrow measure of progress by the standard economic indices of GNP and per capita income to include other social welfare indicators and environmental indices and amenities which are a vital part of any island's life support system.

#### Objectives and limits of the study

Our aim has been to:

- (a) Identify those adverse impacts that are frequent by-products of contemporary land-use activities on islands as opposed to the impacts with a longer history which have been emphasized in previous studies (see Section V at p. 27);
- (b) Derive a set of guidelines relevant to the identified impacts in order to assist development planners and decision-makers in weighing alternatives and protecting the intrinsic amenities and the biological integrity of an island as a human and natural habitat.

Ecological guidelines are most effectively employed before development projects get under way. They serve in the pre-investment phase of development planning to acquaint the decision-maker with the likely consequences to the environment from allocating specific resources to specific uses. In the case of an undeveloped island, their particular objective is to permit optimum exploitation of the island's limited resource base, consistent with human needs and minimal environmental imbalance. To

be effective, such guidelines must be applied locally in conjunction with adequate inventory and delineation of natural resources and their inter-relationships in island systems. By evaluating the known and projected stress on various environmental zones or features, and combining the result with the types of data usually available, we can effectively upgrade the quality and soundness of resource planning, decision-making and environmental management.

Unfortunately, the ex post facto application of guidelines to already developed insular economies is more difficult and less rewarding for two reasons: (1) future land-use options are often largely foreclosed; (2) present usage patterns are essentially irreversible because large amounts of capital have already been committed and owners with vested interests require compensation. Nevertheless, in developed islands, guidelines can still be useful both in planning future projects and in repairing past damage, so long as one resists the temptation to view past neglect as justification for future carelessness. There is seldom a place within the complex interdependencies of the island system for the concept of a "degradation threshold" or point beyond which even a very limited environmental rehabilitation becomes totally impossible or infeasible, although such thresholds do, of course, exist for the maintenance of specific forms of island life.

The scope of this paper is bound by the obvious constraints of space and by the less obvious lack of precise island-by-island data on development impacts based on detailed case studies. Thus, the ideas put forward are not exclusively phrased in terms of specific island ecosystems. Rather, the paper focuses on the development and conservation problems of the generic "island system", based on a review of the literature and on the authors' personal observation of islands of Micronesia, the Arctic and the Caribbean.

The study has been addressed principally to the smaller oceanic islands of the world, volcanic or coralline, isolated or in groups, rather than to those large island land masses which have been referred to as "mini-continents". Also excluded are coastal islands lying immediately adjacent to continental margins. Such islands tend to be dominated by social and biological links with the proximal continental areas and are best viewed in that association as a special category requiring different management approaches.

One cannot escape the basic question whether islands should be developed at all. It is sometimes maintained

that they should remain frozen in a state of nature, free from the contamination of twentieth century development technology; adherents of this homeostatic view assume that islands encumbered by an over-developed infrastructure and other displays of material progress are "spoiled". It is a viewpoint which may be based on genuine professional concern for the preservation of rare, specialized, biotic communities that are well suited to research in evolution, genetics, population dynamics and the relationships within and between ecosystems. But, in other cases, the motivation may be an individual observer's quest or predilection for a return to a simpler, slower-paced life and reduced responsibilities. Islands have long been cast as paradisiac oases where, through dialogue with nature, man can enjoy a continual rebirth of spirit. Despite the self-contradiction, an element of this vision pervades the tourist development phenomenon with its supporting promotional literature and marketing materials. Some island residents also subscribe to this idyllic "keep things as they are" anti-development position.

Certain isolated, sparsely inhabited or uninhabited islands (e.g. the Galapagos, Aldabra) will of course have their best use if kept in an undeveloped state for scientific, inspirational or recreational purposes. But most inhabited islands cannot be so categorized. To do so would be to accept the simplistic premise that a majority of island peoples share the outsider's enthusiasm for a primitive economic state. Island studies refute this premise, and it is a fair assumption that the stewardship of islands is best vested in the islanders whose livelihood depends on them in the long-term. They alone have most to gain by careful allocation and use of insular resources. They have the most to lose if their resource base is destroyed or diminished. It is their prerogative to influence development patterns. The question is, what means should be chosen to effect that end.

The acceptance of ecological principles is mandatory if environmental integrity is to be maintained in the face of development. The principles articulated here are in response to known adverse development impacts which have already occurred in island systems and threaten to befall others in the future. The guidelines developed from the principles mainly concern local planners and decision-makers, but also outside people involved in development policy and planning for islands, whether they be colonial administrators, multi-national corporations, development planners, consulting firms and staffs associated with international banking groups, or public development agencies at various levels. Nevertheless, it is the particular merit of ecological principles and guidelines,

properly applied, that they can also enhance the islander's perception of the environmental implications of development and facilitate his involvement in the planning and decision-making process.

## II. THE ISLAND SYSTEM

### Definition

Development and its associated impacts should always be considered within the framework of the island system, a concept that applies to individual islands as well as to multi-island groups and to their associated socio-economic and biological systems. From the standpoint of environment, the concept of an island system is relevant in three respects:

- (1) it affirms that an island is not an homogeneous discrete entity, but from its highest point above sea level to the edge of its submarine shelf is in continuous interaction with the surrounding air and water;
- (2) it stresses the interdependence of island ecosystems; impacts on one will have repercussions in another, and although the extent of each will seldom conform to political boundaries or even to such convenient geophysical divisions as "land" or "sea", it is important to have some perception of each individual island's relationship to and within any island group;
- (3) it allows for a biocybernetic view of island growth and development, in which multiple feedback phenomena from effect-to-cause can be considered in addition to the customary cause-to-effect relationships.

### The biocybernetic model

"Biocybernetics" can be defined as the science of feedback relations between living and non-living components of an ecosystem. It makes it easier to see precisely how the output from any part of the system ultimately affects the input to the same part (Van Rensselaer, 1971). Feedback (where the result of an action acts back on its cause) can either reinforce the original process that yielded the result (positive feedback), or it can inhibit the original process by limiting its growth (negative feedback). Complex growth phenomena and associated environmental impacts can be more accurately understood by reference to a biocybernetic model. As a conceptual tool it stresses the importance of interacting links between various

multiple causes and their several impacts. It also indicates how initial actions may spawn consequences that accelerate through the system or, conversely, retard system processes.

Analysis of what attracts tourists to islands provides a good example of feedback effects. As already explained, negative feedback occurs when the result of an action acts back on its cause in a manner that diminishes it. So, a declining tourist market might be explained by a simple model based on the following flow pattern: increasing number of tourists come to an "unspoiled" island → infrastructure develops to service them → assimilative capacity of environment is exceeded by waste loading → natural environment deteriorates → number of tourists decreases → net quality of life is reduced.

However, it is much more likely in practice that a simple feedback loop like the above will be complicated by other positive and negative loops or processes. Herein lies the threat to island conservation. As the character of the tourist island changes from "unspoiled" to "spoiled" (e.g. more urbanized), the influx of tourists does not stop. Due to various stimuli, such as mass advertising and other publicity, it continues and may even accelerate according to a positive feedback loop that reinforces the degree of urbanization and the influx of new tourists with different tastes and interests. The implications are serious, for it means that when the first wave of tourists is attracted to an island by its unique environment and then becomes part of a process that destroys the very asset which was the initial lure, it neither halts the influx nor the process. The first group acting under negative feedback loop will not return, but a second, quite different group of tourists will be attracted by assets equally different from those which the island originally possessed and has now lost. Under the operation of a positive feedback loop, the waves of tourists with more urban tastes will return again and again, compounding their numbers gradually, remaking the face of the entire island. It is a vital function of our biocybernetic model to measure the impact of this phenomenon on island environments, and upon the quality of life for island residents.

The model does, in fact, provide a most useful methodological tool in island systems planning and management. Its use represents a renunciation of narrow sectoral planning in favor of a more comprehensive, integrated development approach. The feedback loop framework induces a planning and decision-making process that is far more responsive to

island values and likely to give due weight to the kind of values -- scientific, aesthetic, cultural, etc. -- which tend to fall by the wayside in traditionally planned development activity.

#### Limitations and fragility of insular resources

A feature of smaller oceanic islands is that they are seldom well endowed with resources: land, minerals and other stores of energy, fresh water, flora and fauna, all tend to be limited in amount and variety. This natural condition of scarcity applies equally to the resources of upland, littoral and sublittoral zones, and even to the outer insular shelf. Because of their finite nature, island resources are particularly liable to over-exploitation, leading to degradation or complete destruction of the resource, a situation inevitably aggravated in such severely confined circumstances by increasing pressure as population grows. Islands have no hinterland except the seabed, and natural regulatory mechanisms have tended to slow down or go out of use in the human species for reasons discussed in the next chapter.

A second endemic feature of oceanic islands is their environmental fragility, of which perhaps one of the more obvious signs is vulnerability to the destructive effects of modern continentally-scaled development technology. This feature is of greater importance than the one discussed in the preceding paragraph, because islands have always been characterized by a condition of underlying scarcity, but it is only very recently that they have been exposed to the formidable growth pressures of the modern world, its machines, mass transport and mass media.

One reason for island vulnerability to these new forces is the historical conditioning of remoteness and isolation. In the past, it served to inhibit development. Now that factor is largely inoperative due to the technological revolution in transport and communications. There are few islands left in the world that cannot be reached in less than six hours by airplane from a city of a half million or more inhabitants. In addition to jets, hundreds of formerly isolated islands are now serviced by seaplane, STOL aircraft, hydrofoil, cruise ships, yachts, and that ubiquitous cultural "tourist", radio and television.

The barrier of isolation has further been transgressed by exogenous factors occurring far beyond the shores of the island itself and which set up wholly unanticipated technological encounters. Remoteness no longer guarantees avoidance of continental pollution, oil spills from wrecks

and on the high seas, ocean dumping of chemical and solid wastes, and the effects of external catastrophes to migrant species that visit islands for part of the year. All have affected oceanic islands in recent times. In the course of Project Carapace, a sea turtle research expedition which took place in the Caribbean in 1972, the authors landed on the remote uninhabited cays of Serrana Bank, 300 miles east of Nicaragua. They found oil on the beaches and a vast flotsam of bottles, cans, plastic containers and rubbish, washed ashore by the tides of the last few years.

An insidious dimension in exogenous influences is the global development phenomenon itself. Decisions that can affect an island and its environmental quality may be made thousands of miles away in the board rooms and bureaus. The tourist industry provides a good example. Corporate hotel interests, international airlines, cruise ship lines, travel agents, the publishing industry and banks wield immense power to create a tourist boom where none existed before. In many cases, islands that experience the impact of this development may not themselves be the target. Rather, they are swept along in a development thrust aimed at a sister island, neighboring archipelago, or even a broad oceanic region. Thus, the stimulus underlying development pressure is often as unpredictable as it is exogenous. Unless there has been some very comprehensive anticipatory planning, an island's vulnerability is exacerbated. The pace of change in many cases is incomprehensible, overwhelming and destructive of an island's entire way of life.

Finally, as to the biological aspects of island ecosystems, which have, of course, received the major share of attention in the scientific and conservation literature, it is well known that isolation, circumscribed space and other environmental factors result in specialized floral-faunal and even human communities. The specific life forms that have evolved in oceanic islands, as a result of sporadic and infrequent natural immigration and the processes of adaptive radiation, tend to be far less tolerant of changes in environmental parameters than those of continental regions. Man's intrusion into an oceanic island, with the concomitant probability of increased introduction of other species, intentionally or otherwise, can therefore even in the short-term be permanently devastating to fragile, long-term, evolutionary interdependencies. Obviously, an understanding of the possible effects on island ecosystems, and not least on the economy and well-being of islanders, calls for fairly intensive and sophisticated research, combined with continuing social

and scientific monitoring. But it is safe to assume that to the extent that any irreversible disruption of the system can be shown to have been avoidable but for unplanned or badly planned development, the developers and decision-makers, even if they cannot be called to account, will stand condemned by the judgment of posterity.

### III. DEVELOPMENT AND ISLAND SYSTEMS

#### Historical and modern development perspectives

Historically, island development has involved discovery and settlement leading up to occupancy based on hunting, fishing, agriculture, animal husbandry and, less frequently, on extractive mining activities and trade. The modern development perspective is founded more on a technological infrastructure which allows island peoples to pursue livelihoods less dependent on the intrinsic resource base. The discussion which follows outlines the qualitative differences between the traditional and modern perspectives and explains why adverse impacts of modern development are fundamentally more threatening to environmental quality.

Traditional land-use activities are by nature environmentally dependent in that a rise or fall in the quality or availability of the resource generates a corresponding change in the fortunes of the islander.

Environmental dependency holds implications for both the use and abuse of natural resources. There is a built-in equilibrium between population and natural resources when the environment is the sine qua non of livelihood and survival. Even if there is at least some degree of technological input from the outside world, an effective response to and regulation of adverse impacts may be maintained over long periods of time. This negative feedback mechanism serves to check serious man-environment dislocations, which is not to say that resources were not and cannot be abused: short-term over-exploitation of coastal fishing resources is a common example. However, basically the traditional course of events acknowledges that the abuse does have limits. Thus, in the case of islanders who rely solely on fish for a living, over-fishing will soon rebound to their disadvantage: as the fish supply is depleted they will be driven to other sources of food, other modes of livelihood or to other islands, if they wish to avoid starvation. The dearth of fish will eventually result in a new equilibrium between man and resource.

Adverse environmental impacts common to fishing, hunting and agricultural subsistence economies, and perhaps even more those which rely on exports, have generally been impacts of resource depletion and land despoliation. Infertility, soil erosion, and pasture degradation

through overgrazing are perhaps the best known and documented of the resulting problems, which on many occasions, especially in the islands of the tropical and subtropical Indian Ocean and Pacific, have rendered continuing human occupancy impossible. Another frequently recorded cause of ecological disruption, involving the extinction of many species of plant and animal, of which the true potential can never be known but must retrospectively and sadly be suspected of having been of a high level, has been the deliberate or accidental introduction of exotic species. But although these impacts and their effects have been and still continue to be of great importance, the emphasis on what follows must switch to some of the often quite dramatically destructive consequences of modern development patterns, which have received too little attention or even been purposely minimized.

#### Present development perspectives

Wherever islands have been catapulted into the twentieth century in a matter of a decade or two, environmental, cultural and economic impacts have been severe. Their experience may well act as a harbinger of what other developing islands can expect in the future.

The seriousness of the technological encounter is manifest in the gross alteration of land-use activities and the concomitant environmental stress and incompatibility factors that these activities produce. Toward the end of this Section, tourism is singled out for special attention because of its potentially pervasive impacts, the widely accepted presumption that it can confer economic benefits on traditional island economies, and the high level of current activity in the field of tourist promotion.

Implications of introduced continental technology: The precipitous introduction of continental technology into island systems has fundamentally altered the patterns of land-use development. As already mentioned, island economies are no longer so tied to the availability of intrinsic resources. For many developed islands, agriculture and fishing are relatively less important than they once were. Some islands that were once self-sufficient in food production, now rely heavily on imports to feed their population, their most productive lands having slipped into non-agricultural uses. The implications of land-use that is independent of intrinsic natural resources are two-fold; first, it allows islands to support high, dense populations and to reach a stage of development unfettered by the constraints of the

natural resource base; secondly, it has created a host of incompatibility problems extending across environment, culture and the economy.

St. Thomas in the U.S. Virgin Islands may be quoted as an example of an oceanic island which through reliance on technology has apparently overcome the traditional development barrier of resource scarcity. Because of poor soil and unreliable rainfall, virtually all foodstuffs to support its burgeoning resident population are imported. Furthermore, scarcity of fresh water makes it necessary either to import it by tanker or make it in costly desalinization plants. Similarly, the scarcity of materials for the manufacture of construction aggregate means that sand has to be imported, as well as dredged (often with adverse effects) from inshore areas. Finally, because of the short supply of land itself, more land is created by dredge and fill operations along the coast, thus further disrupting fisheries, damaging reefs and reducing inshore water quality.

Still, the island appears to flourish, with a high level of tourism and a high per capita income, but at the expense of near total dependence on external capital, alien labor, foreign tourism, imported food and technology, accompanied by a declining quality of physical, natural, social and cultural environment. Progress of this type, as was noted earlier, exacts its price, especially in the absence of sound, anticipatory planning and advance assessment of the environmental implications of development objectives, strategies and tactics.

Incompatibility factors of transplanted technology: Some incompatibility problems derive from growing reliance on artificial, man-contrived or manipulated environments that technology has made possible. Others owe their origin to the irreversible nature of land-use decisions previously reached. The establishment of a petroleum and heavy industry complex in the Krause Lagoon on the south coast of St. Croix in the U.S. Virgin Islands, is an example of environmental manipulation which has resulted in obliteration of vast areas of coastline, at one time one of the most biologically productive sectors in the islands. The complex threatens to induce further decay along the coastal zone through continued dredging, oil spills and complementary industrial development. The Ponce-Guyama area on the south coast of Puerto Rico is experiencing a similar metamorphosis on an even larger scale.

Essentially capital-intensive land-use activities like these are economically irreversible. The extent of land-form alteration and devastation makes them environmentally

irreversible. Both economic and environmental irreversibility are crucial features of modern development schemes which ought to be squarely faced by island planners.

Incompatibility factors prevail in social and political spheres as well. The influx of alien construction workers, executives, technicians, bankers, consultants to government, and "permanent tourists", once set in motion, can quickly make local islanders a minority in their own homeland, which has obviously undesirable implications. The newcomers tend to espouse technically glamorous, environmentally damaging and culturally inappropriate development projects and methods. Their choice of approaches, models, methods and projects will probably be partly influenced by predilection for continental modes of operations and partly by lack of expertise in the special cultural, technical, economic and social requirements of the island under consideration. Perception of the gross differences in scale is notably absent in the thinking of many continental developers, planners and administrative officials who become involved with islands. Many operate on the principle that "what is good for one is good for the other". To the misfortune of far too many island peoples and their environments, that attitude has seldom been challenged.

#### The impact of tourism on islands

As previously stated this has been singled out for amplification by reason of its topicality and because it is having more and more marked effect upon the fabric of island communities. This does not mean that other activities acting alone or in combination may not prove more critical to specific insular environments (deforestation, oil pollution or dredging, for example). Emphasis on tourism simply points to the type of environmental hazard implicit in development, and suggests the internal conflicts and trade-offs involved in any comprehensive development strategy.

In islands that need foreign exchange, better employment opportunities and general modernization, people often regard tourism as a promising solution to economic problems. Few would argue that tourism cannot contribute to higher incomes and long-term development goals of islands. What is open to question is the wholesale acceptance of mass tourism as the economic mainstay of an island, without any proper attempt being made to formulate a strategy to deal with any adverse social and environmental consequences. In effect, concern for the qualitative aspects of tourism development and for an island's capacity to absorb such development, is often sadly lacking.

One of the main reasons why adverse consequences follow from tourist development is a modus operandi based on the belief that any method of enhancing revenue from that development is justified even if it recklessly exploits the social and natural environment. This attitude largely ignores certain inherent structural weaknesses of the tourist industry, which include: potential instability; the low "multiplier effect" of tourist expenditures, sometimes aggravated by tax incentives commonly offered by competing islands; inequities in income distribution; and the erosion of indigenous cultural values arising from a development process managed by outsiders for outsiders. These weaknesses are of sufficient importance to be discussed in some detail.

One risk which particularly affects island tourism and is a fundamental fact of the industry, is the sensitivity to vicissitudes and uncertainties of tourist supply. An increase in air fares, a sudden change in airframe size and technology, a foreign recession, or a change in tastes will dramatically affect the market and are all factors in which the island community is unlikely to have any say.

Other aspects of tourism that invite a critical look are the inequities in income distribution and the low "multiplier effect"--the coefficient that shows how great an increase in income is generated by a given level of tourist expenditure. A total dependence on outside tourist development capital may well lead to exploitation. The societal distribution of the benefit stream may heavily favor outside owners, operators, investors and immigrant labor, to the disadvantage of locals. In the Caribbean, a high percentage of wages paid in the tourist industry goes to labor which is recruited from abroad to serve in the hotels because of local employment values that equate "service" with "servility". To be fair, the income disparity may also reflect low labor productivity of the native islander. The combined effect on the environment of maldistribution of the income from tourism and importation of labor is that a large allocation of public resources must be diverted for social welfare and public services. Given the dearth of public monies and the past low priority awarded to maintaining environmental quality, it can be argued that this situation indirectly exacerbates government neglect of environmental protection as an area of public concern.

A more fundamental challenge to the traditional configuration of the industry than the distribution of benefits is the amount of benefits that accrue to the economy. Is the industry structured to maximize net returns to the island? Figures on annual tourist expenditures can

mislead when presented within the framework of an import-oriented economy characterized by a substantial re-export of currency for the purchase of foreign goods and services.

A study undertaken in the U.S. Virgin Islands (Clapp & Mayne, 1972) has shown that the income multiplier in a tourism-based economy can often be very small, of the order of between 1 and 2. This is again explained by the great amount of leakage that occurs when foreign exchange enters the island economy, the benefits that eventually accrue being less than commonly supposed.

These considerations clearly point to the conclusion that contrary to the belief at the root of the modus operandi of much tourist development, to which reference was made earlier in this Section, total commitment to the promotion of tourism at any environmental cost cannot be justified. In fact, the existence of a low multiplier raises economic questions about the desirability of land-use activities which have adverse environmental ramifications. Environmental quality carries a price. The degree of impact that can be tolerated for a specific land-use activity should be determined in part by the benefits that the activity brings to the economy. For example, the adverse impacts of offshore dredging that recovered a fortune in diamonds every month would be more tolerable than the same type and scale of dredging operation that recovered sand or some other construction aggregate. In short, no realistic view of environmental quality can be divorced from an economic framework. To be credible, ecological guidelines for a specific development project should consider the economic benefits that will accrue to an island from specific land-use activities and balance these against the importance and magnitude of the adverse impacts.

As an example of a situation in which environmental costs could well prove to outweigh the economic benefits, the so-called "condominium" type of development, in which a block of land is alienated for the establishment of a tourist colony, can be quoted. In economic terms these enclaves for the rich contribute very little to island welfare given the high import content of their business operations: continental investors use capital drawn from off-island banks; they purchase the land from a realtor who is probably continental himself; building materials are imported; and profits arising from the condominium development are generally banked abroad. Adverse environmental impacts may be seen, for example, in the intrusion of alien architecture dominating the coastal zone to the obvious detriment of aesthetic values, the curtailment or loss of access by indigenous islanders to the adjacent beaches for recreation or traditional non-consumptive

uses, and the pollution of inshore waters by the overloading of waste disposal facilities. The gains and losses may not always be easy to quantify, but the lesson for the planners is surely that if an adverse imbalance is to be avoided, every possible care must be taken to select and control the land-use activities involved, minimize the leakage of profits abroad, and exclude any careless wastage of aesthetic, ecological and cultural values.

Finally, it is worth repeating that in striking the balance full weight should always be given to the effect on the social fabric of island communities brought about by the promotion of mass tourism. These include impacts associated with a change in the consumption and behavior patterns of islanders through exposure to ideas and life styles of tourists; and secondly, impacts arising from decisions made by outsiders who may have a short-term, selfish, vested interest in rapid development and gross increase in land values through speculation, and may not be over worried by the prospect and possibility that the tourism engendered may be of a quite ephemeral nature.

The first group of impacts originates from the cross-cultural transplant of life styles and consumption patterns modelled after Europe, Asia, North America, Australia and other developed areas. The unmodified superimposition of life styles which are alien to traditional island culture and incongruous with the natural environment, can lead to social unrest and excessive pressure upon natural resources. An instance of the latter can be quoted from Barbados, where some years ago complete internal domestic plumbing facilities were installed in one section of the island in lieu of the customary public standpipe distribution system. This technologically-inspired convenience resulted in an immediate ten-fold increase in household water consumption. There was no change in the number of consumers but only in their perception of the availability of the resource.

Little additional comment is necessary on the second group of impacts, which are characteristically derived from the activities of the outside entrepreneur whose primary objective is short-term profit with no sensitivity or regard for the long-term welfare of islanders. It is obvious that environmental costs will be omitted from economic accounting by someone with this deplorable outlook, but equally certain that they must have an important place in the cost-benefit analysis of every tourist development project affecting an island community.

#### IV. ENVIRONMENTAL VALUES

In this Section a brief look is taken at the environmental values which may be affected by "adverse impacts", as a basis for the more detailed discussion in Section V of the critical land-use activities that pose problems for island development. It is this relationship between activities and effects which must in turn provide the background for the ecological guidelines in Section VI, since the presupposition of any such guidance is that it refers to an explicit set of environmental values.

In order to illustrate the range of values to which reference can be made when working out ways to minimize undesirable effects of development, the categories proposed in a comprehensive planning study published fairly recently (U.S. Water Resources Council, 1971) can be usefully adopted. They are not necessarily mutually exclusive, nor do they claim to mirror the precise viewpoints and priorities which indigenous islanders with cultural perspectives different from our own might be inclined to hold. There is in fact no intention of imposing a set of values, but simply of devising a framework sufficiently broad and flexible to take account of most of the environmental impacts likely to be experienced by island peoples. The three categories in which it is suggested that these may conveniently be grouped are the aesthetic, ecological and cultural.

##### Aesthetic values

These encompass the multiplicity of qualities which invoke in man a sentient response to natural beauty, scenic grandeur and primeval wilderness, or which enable him to be refreshed and recreated by the experience and study of geological features and life forms in their natural setting. Insular landscapes and seascapes tend to be rich in these qualities, which are obviously inherent in their more typical components--beaches, rocky shores and cliffs, reefs and cays--as well as in those which are equally commonly found in mountain, estuarine and other geomorphically remarkable mainland areas. The aesthetic values of island environments are also perhaps more often enhanced by simplicity, quietude and privacy derived from the absence of overcrowding, noise and man-made pollution of grossly intrusive or overwhelming kinds.

Most of the generally held theories of aesthetics declare beauty to be in the eye of the beholder and certainly, of the three categories we have to consider, aesthetic values are the most dependent on subjective interpretation. This means that guidelines for maintaining them will inevitably assume interpretations of what is pleasing which may conflict with those of others and will therefore be most liable to criticism and disagreement. Thus the aesthetic appeal of the animals and plants of remote islands often lies in their exquisite adaptations, but to the ordinary observer they appear drab in color and form and of little interest except when present in vast numbers (e.g., huge seabird colonies). This may be one of the reasons for the notorious misuse and wastage of island species by man and their too frequent replacement by more colorful, familiar or "sporting" introductions.

### Ecological values

These embrace what in this case are the essentially objective qualities of the basic constituents of the planet and of the natural biological systems and processes depending upon them. Their proper evaluation and conservation call for knowledge and understanding of the inter-relationships and balancing mechanisms exhibited, for example, in population and behavior patterns, habitat, food chains and energy requirements. It follows that optimum benefit from this category of values is dependent on effective control of pollution, whether inflicted by waste disposal or deliberate action, and the application of management principles based on accurate measurement of the stress limits of each sector of the system--including human populations. In the special case of island ecosystems the sharply limited extent of terrestrial and aquatic resources make this type of approach even more imperative.

Furthermore, although the initial aim may simply be to meet man's more obvious and immediate material demands, sight must never be lost of an important implication of the ecological value concept. This lies in the fact that, due to the complexity and dynamism of the inter-relationships of its parts, continuing study and monitoring are required for the proper understanding and maintenance of the system. This implies that conservation of all the elements of the system is the only prudent course, and in particular conservation of biological resources, which are more liable to total obliteration and the potentials of which are apt to be less known. Put in another way, the full range of options for future use must if possible be kept open.

### Cultural values

If the first two categories of environmental values are, in essence, concerned respectively with influences of nature on man and of man on nature, this third and very distinctive category derives from the effects of man's creative activities and artifacts upon himself. These are the values embodied in traditions, monuments, buildings, sites and works of art, often of great antiquity, but in islands more usually of fairly recent origin. Like the other categories they contribute to the quality of human life and, perhaps more surprisingly, they too tend to sharpen man's perception of his natural environment (witness the great debt that Art has always owed to observation of Nature). Thus, to study, understand and appreciate the cultural evolution of insular man is the better to comprehend his essential links with his habitat and the environmental requirements for the survival of his life style and culture.

### Implications for resource management

All of the values discussed have the common characteristic that the resources on which they depend are finite not limitless, too easily liable to disruption, wastage and eventual disappearance. This clearly implies that the resources must be used and their values enjoyed with restraint. In no way synonymous, therefore, with "preservation" or "non-development", restraint or due regard for the maintenance of proper balances and interdependences is an intrinsic part of environmental values: its function is simply to warn decision-makers to anticipate the effects of development activities with a view to minimizing those which either in the short- or long-term may be harmful to human interests.

Any resource management in a world of uncertainty involves risks about future outcomes. The danger of making a large-scale, fundamentally wrong allocation decision in the environmental sphere lies in its potential irreversibility. Once seriously depleted or imbalanced, many environmental resources, particularly biological systems, cannot be reclaimed for alternative uses. The value of restraint is the benefit gained from guarding against needless foreclosure of future options and from optimum use of a specific resource at minimum environmental cost.

## V. INSULAR LAND-USE ACTIVITIES AND ADVERSE IMPACTS

The Table which follows lists some of the major land-use activities and subactivities or agents that characterize the development pressures affecting islands. A number of traditional activities which historically have had the greatest impact and are still of importance, such as the introduction of exotic plants and animals, subsistence and plantation agriculture and labor intensive forestry, have been omitted. This is partly because in the past they have received the major share of attention (see Fosberg, 1963, for a comprehensive review) and partly because in the island context many of the more immediate and pressing concerns of those responsible for the future relate to use and development linked to tourism and the technologies of mining, manufacturing, shipping and air transport, all of them normally of continental origin.

The land-use practices that currently cause environmental problems can be identified in the Table by combining selected major activities listed in the left-hand column with relevant subactivities or agents listed in the right-hand column. For example, "H23" refers to oil spills or oil leaks associated with oil refining and storage, and implies that planning of such facilities should incorporate proper provision for dealing with the oil spill contingency, although in the past it has seldom done so. For any given "Major Land-Use Activity", there are generally only a few counterpart subactivities or agents, but these may act together to reinforce environmental problems. It is rare for one activity to cancel out the negative effects of another.

Examples of land-use circumstances that degrade insular environments have been selected from the Table for discussion in the subsections that follow. Their impacts on the three categories of environmental values, aesthetic, ecological and cultural, are summarized in turn.

Defining these impact linkages is only part of the problem, the other being to assess their significance. For this purpose each can be considered to have both a dimension of "magnitude" and of "importance" (see Leopold, 1971), the two together constituting a measure of the impact's severity. The "magnitude" component refers to the degree, extensiveness, or scale of the impact, which is potentially quite capable of quantification. The "importance" component relates to the consequence of an impact. Determination of significance therefore inevitably involves some degree of subjective evaluation, in assigning

TABLE - Major Land-Use Activities and Subactivities or Agents Causing Adverse Impacts in Developing Islands

<u>Major Land-Use Activities</u>	<u>Subactivities or Agents</u>
<b>ENERGY AND NATURAL RESOURCES</b>	
A. Power Generation	1. Excavation and Earth Moving
B. Seawater Desalinization	2. Blasting, Terrestrial and Underwater
C. Mining, Terrestrial	3. Rock Crushing and Ore Treatment
D. Mining, Marine	4. Dredging
E. Made/Reclaimed Land	5. Channels, Cuts and Fills
F. Harvesting Biota	6. Wetland and Submerged Landfill
G. Logging (Capital Intensive)	7. Vegetation Clearing, Mangrove
	8. Vegetation Clearing, Upland
	9. Structures, Hostelries and Residential
<b>INDUSTRIAL, COMMERCIAL, AND RESIDENTIAL</b>	10. Structures, Other
H. Industrial, Oil Refining and Storage	11. Demolition of Structures and Neglected Maintenance
I. Industrial, Other	12. Utilities
J. Commercial	13. Marinas
K. Residential	14. Docks, Piers, Slips, Berths
L. Research	15. Runways and Aprons
	16. Fences and Barriers
<b>TRANSPORTATION INFRASTRUCTURE</b>	17. Landfills, Garbage and Solid Waste
M. Airports and Seaplane Terminals	18. Dumps, Garbage and Solid Waste
N. Ports and Cruiseship Terminals	19. Litter
O. Highways and Roads	20. Sewage, Discharges and Outfalls
P. Pipelines, Terrestrial and Marine	21. Sewage, Septic Tanks
Q. Communication and Energy Corridors	22. Waste Water
	23. Fuel and Oil, Spills and Discharges
<b>RECREATION</b>	24. Stack Emissions and Open Burning
R. Land-Oriented	25. Airplanes and Seaplanes
S. Marine-Oriented	26. Yachts and Boats
	27. Ships and Tankers
<b>WASTE EMPLACEMENT</b>	28. Vehicles
T. Waste Disposal	29. Fishing
U. Ocean Dumping	30. Collecting Marine Flora and Fauna
	31. Collecting Terrestrial Flora and Fauna
	32. Collecting Artistic and Historic Objects

relative weights to the two components by reference to a scale of values.

In order to illustrate the process, the example of a "model" Caribbean island undergoing rapid development through the growth stimulant of mass tourism, has been chosen. An attempt is made to show the severity of various impacts, in terms of magnitude and importance, on aesthetic, ecological and cultural values by classifying them as "low", "moderate" or "high". As previously indicated these judgements are not absolute but involve a subjective element, and the fact that they have to be used in lieu of some more sophisticated formula simply reflects the absence of precise environmental standards on which to base measurements. Although the scheme is, therefore, clearly open to criticism on this score, both in relation to (i) determining what is "adverse" and (ii) determining the degree of magnitude and importance, it nevertheless does serve to separate impacts which have profound environmental implications from those of lesser import, and as such is certainly instructive.

Impacts affecting the model island are summarized graphically in the form of matrices at the end of subsections 1, 2 and 3 (Figs. 1, 2 and 3). Although matrices designed to show the situation in other islands could be expected to differ in detail, replicas of the Caribbean model at various stages of evolution are to be found in all oceans of the world. To illustrate the kind of information about impact significance which can therefore be drawn from the model matrices, a couple of examples may be helpful. Ocean dumping of oil, usually resulting from casual hold-cleaning by tankers, to which the code number U23 would be allotted in the Table, is shown in the ecological matrix (Fig. 2) to be of low magnitude, based on past experience in the model island; but its importance is adjudged to be high in the light of known adverse effects on littoral and sublittoral biota from oil slicks drifting ashore. By contrast, the equally casual waste disposal through the scattering of litter (T19 in the Table) is shown in the aesthetic matrix (Fig. 1) to be of high magnitude, due to the widespread nature of this careless practice; but, although litter blankets much of the model island, the importance of its impact in an aesthetic sense can only be assessed as low, in the absence of much evidence of the exodus of island residents from their tarnished paradise because they can no longer tolerate its appearance. Such an assessment may not, of course, be valid in the future or in other islands, especially when ecological rather than aesthetic values are being considered. For example, it may well be that the input of polychlorinated-biphenyls derived from plastic wastes can have harmful effects on the living organisms in which PCB residues are increasingly being detected.

## 1. Activities That Affect Aesthetic Values

In this subsection some of the more striking examples of the many activities which have an impact on the aesthetic category of environmental values in islands, are examined. Not all of them are included in the illustrative matrix, based on the model island, at the end of the subsection (Fig. 1), although the reference number in each case is drawn from the Table. This simply indicates that it is fortunately very unlikely that any particular island will experience all the possible impacts.

### C1. Terrestrial mining, excavation and earth moving

Strip or opencast mining and quarrying are perhaps the most obvious of the activities liable to deface the landscape and reduce scenic values. Failure to replant or otherwise rehabilitate surfaces laid bare is exceedingly common and often leads to a process of continuing erosion, long after mining has ceased. Other adverse ecological consequences such as a chronic deterioration of coastal water quality through siltation are discussed under subsection 2, page 34. Typical examples are to be found on Nauru (phosphate mining), Jamaica (bauxite), New Caledonia (nickel) and the innumerable small islands such as Assumption, in the Indian Ocean, which have been laid waste by guano exploitation, when with reasonable care not only the aesthetic values but the resource itself could have been perpetuated.

It is also worth noting, under this heading, that dredging, which may pertain to underwater mining (D4) or to the servicing of transportation or recreation facilities (N4 and S4) and which is discussed more fully under the two following subsections, may also diminish aesthetic values; for example, those on which subaqua sports and the ever more popular marine national parks are largely dependent.

### J9 & K9. Commercial and residential structures

Huge multi-story and multi-unit hotel and housing developments may well be unaesthetic if architecturally inappropriate to island culture and tastes or out of scale with the surroundings. If located in the coastal zone, they run the risk of marring the natural beauty of the shoreline, as well as interfering with access to its enjoyment. Oahu (Hawaii) provides an extreme example of the limitation of aesthetic values which result. A secondary effect, exhibited by housing development on St. Croix, in the U.S. Virgin Islands, which also has an aesthetic element insofar as it inhibits unrestricted enjoyment of the values concerned, occurs where resulting concentrations of population overtax public services.

A10, B10 and H10. Power and desalinization plants, and oil refinery and storage structures

These may represent an unsightly intrusion on the natural landscape in coastal zones, obstructing the view and linking up with subactivities 22-24 by the discharge of noxious fumes and wastes. They are also apt to act as a nodal point for attracting other heavy industry whose operations exacerbate the problem.

All three activities, as well as several others, such as general industrial and airport development (I and M), are commonly associated with a further subactivity, the erection of fences and barriers (16). These can again have secondary effects on aesthetic values by impeding their enjoyment and, incidentally, creating social resentment.

It is also worth stressing that although techniques for mitigating disturbance of aesthetic values by industrial structures have been known for years (see for example, IUCN, 1967), island developers seem to have been particularly lax in applying them.

T18, 19 and 28. Disposal of solid wastes, litter and worn-out vehicles

The volume of these wastes mushrooms in developing islands as personal incomes rise and imported goods claim a greater share of the market. Tourism, foreign exchange earnings and adoption of outside consumer preferences abet the process. The wastes thus generated can rapidly overtax traditional methods of disposal. Landscape defacement is a common consequence.

The temptation in islands is to deal with the problem by offshore dumping. Its effect is to litter shorelines with everything that floats and sublittoral zones with all that sinks. Although submerged junk occasionally serves the useful purpose of giving shelter to marine organisms, the chances are that water quality will be impaired and that the aesthetic values supporting all the variety of seaside recreational activities will be significantly reduced.

The magnitude and importance of casual disposal of litter, in which the dumping of abandoned or derelict vehicles plays an increasing part, were briefly discussed at the end of the introduction to this Section. Side effects, with perhaps a more serious social than aesthetic content, include growing public disregard not only for cleanliness in general (this has become quite apparent in St. Thomas, U.S. Virgin Islands) but also for property rights. Moreover, the cost to public funds of tidying up becomes steadily greater.

\*23. Fuel and oil spills and discharges

Various combinations with this adverse subactivity have already been mentioned, including those arising from risks inherent in the normal operations of the oil industry (H23) and in the flushing out at sea of residues in the holds of oil-tankers (U23). It may also, on occasion, be associated with power generation (A23), desalinization plants (B23), port operation (N23), pipelines (P23) and even, to a small extent, recreation facilities such as marinas (S13). In addition, spills traced to oil storage tanks of almost every conceivable type of commercial and industrial enterprise, and of public buildings and private accommodations, are frequently reported: they are as likely to occur in islands as anywhere else and then almost certainly enter the sea.

Apart from the kinds of destruction of aesthetic values, usually combined with quantitative and qualitative loss of resources, which such incidents as the Santa Barbara spills and the Torrey Canyon disaster have forcibly brought to general attention, it is worth noting a number of secondary and less well known impacts. Thus, chronic oil pollution of one beach or section of coast can put an increased loading on unpolluted beaches elsewhere, which in turn may diminish their value.

Continual small spills may have more insidious and negative effects than a single massive spill. One reason for this is that marine flora and fauna, with their high aesthetic as well as economic values, are much more likely to recover from a catastrophe big enough to alert everyone to the danger and to stimulate effective action against recurrence. On the other hand, if conditions become chronically unsuitable, but not to the extent that much notice or action is taken, molluscs, fish, crustaceans, seafowl, marine mammals and all other life forms which islanders and visitors to islands enjoy, are doomed to disappear.

M25. Airports and aircraft

We noted that in islands aesthetic values are perhaps more often enhanced by tranquillity than in all except the more remote wilderness areas of the continents. Few things are better calculated to destroy this asset than constant exposure to aircraft noise, with the concomitant of heavy traffic and congestion in the airport vicinity. The important point to note is that because of the inherently extensive nature of this type of impact, its effect may be disproportionately greater in small islands than in large islands or continents.

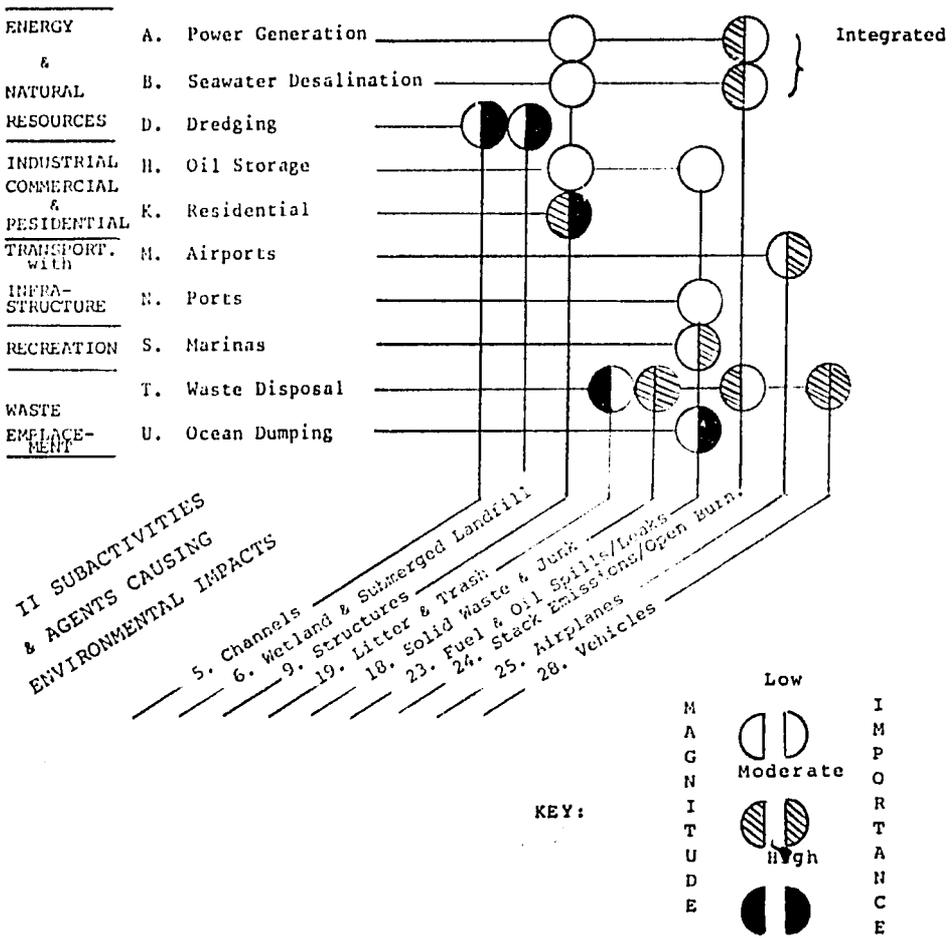
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\* The asterisk designates subactivities or agents as set out in the Table in this Section.

- FIGURE 1

IMPACTS ON AESTHETIC VALUES - WITHIN THE MODEL TOURIST ISLAND

1. MAJOR LAND-USE ACTIVITIES



### Illustrative matrix

Figure 1 summarizes most of the land-use activities and subactivities discussed in this Section and evaluates their impact on aesthetic values within the model island.

This matrix and the two that follow (Figs. 2 and 3) are general in scope and, because of their gross scale, have a utility more conceptual than functional. However, functional matrices can readily be derived from them to cover specific insular resource use situations, serving as useful tools for decision-making in early stages of program development. For example, assume there are plans to establish a tropical marine (coral reef) park. When, or preferably before, a site is selected, reference to a "Potential Impact Matrix", such as the three presented here, should immediately alert those responsible for the project to the likely effects (e.g., sedimentation, freshwater inflow, nutrient enrichment, pollution, etc.) of environmentally critical activities that can degrade or destroy the aesthetic, ecological and in special cases, cultural attributes of the park and its vicinity. Although the matrix necessarily draws quite generally upon analogous insular experience, it is quite capable of being modified to suit local conditions.

Acknowledgement is made to previous matrices developed by J.C. Sorensen (1971). His pioneering work suggested many of the activities and their correlated subactivities and agents which have been adopted in designing our matrices for the model island.

## 2. Activities That Affect Ecological Values

As in subsection 1 only some selected activities liable to cause major problems are listed. Activity combinations are taken from the Table in this Section.

### \*1. Excavation and earth moving

Associated, for example, with Road Building (O1), Residential Site Development (K1), Airport Construction (M1) and Terrestrial Mining (C1), this subactivity shares with forest destruction and careless cultivation on steeper slopes, the prime responsibility for erosion. Since the soil tends to be disturbed to a much greater depth, particularly in the case of mining and road building in hilly terrain (New Caledonia provides some striking examples), the mass displacement of material downslope can exceed that brought about by any other form of land disturbance. The consequences, such as silting of low altitude dams and fishponds and of coastal saltworks and lagoons, the profound habitat alterations brought about by

turbidity in reef and tidal waters, and others discussed below under the "Dredging" subheading, all tend to be more marked.

Quantity and rate of siltation are a function of the nature and degree of development, the time period over which it occurs, the climatic regime, amount and distribution of rainfall, soil type, and relief. High volcanic islands of the tropics experiencing rapid development, such as Puerto Rico, are especially prone to impacts derived from erosion.

Arctic islands, at the other climatic extreme, are also vulnerable though fewer variables are operative. Excavation and removal of the tundra vegetation, which insulates the permafrost from solar radiation, can cause the surface to turn into a quagmire. Its unstable nature resists recolonization by tundra plants and leads to rapid rill and stream erosion, which may perpetuate the traces of excavation for years to come, or maybe for ever. Gas and oil explorations underway in the Canadian Arctic archipelago (Banks Island and the Parry and Sverdrup groups) are presently creating this type of geomorphic disequilibrium in localized areas.

#### \*2. Blasting, terrestrial and underwater

This may accompany the building of structures within the littoral, sublittoral and outer shelf zones. It most commonly occurs in the construction of coastal oil drilling rigs, refineries, storage depots and transshipment terminals (H2), marine pipelines (P2), ports (N2), often in association with the cutting of channels (\*5). A highly undesirable and increasingly prohibited combination is the use of explosives for fishing in reef areas (F2) and for mining of coral rock (D2). In addition to direct destruction of biota by the shock waves of underwater blasting, the secondary effects on living coral colonies can drastically alter the evolution of an entire reef complex.

The preferred uses of islands for nuclear bomb testing can be classified as research blasting (L2). In the past, Eniwetok and Bikini Atolls (Marshall Islands) have been used by the U.S., Christmas Island (Line Islands) by the British, and Novaya Zemlya by the Soviet Union. French tests on Mururoa in the Tuamotus have continued into 1974, as has underground testing by the U.S. and U.S.S.R. in some northern island sites, although here the long-term effects are uncertain. This is certainly not the case with the direct impacts of aboveground nuclear explosions. Moreover, gene pool damage through radiation may extend beyond the test islands to other islands and surrounding waters, and could represent a more serious long-term ecological impact than catastrophic obliteration of a single island and its biota.

#### \*4. Dredging

This may be associated with marine mining (D4), making and reclaiming land (E4), construction of ports (N4), marine pipelines (P4) and the development of marinas (S13), as well as several other subactivities involving underwater operations (\*5, \*6, \*14, etc.).

Inshore dredging may seriously disrupt, degrade or destroy complex, diverse and highly productive biotic communities of the littoral and sublittoral zones of island ecosystems. The best-known examples are to be found in tropical atolls and islands with fringe, patch or barrier reefs, all of which tend to be especially vulnerable. Adverse ecological effects can result from direct substrate removal, increased water turbidity, reduced light penetration and intensity, siltation and a change in sediment dynamics (Johannes, 1972). Repercussions of dredging extend to benthic communities of the lagoons that the reef protects. An indirect impact is the curtailment of the natural supply of sand, which in tropical oceanic islands is largely of biological origin, to beaches, cays and barrier formation. In the absence of new deposits, beaches can soon deteriorate through continual erosion by wind, tide and wave.

#### E6. Land "reclamation" through filling of wetland and submerged land

This activity is often combined with mangrove clearing (E7) and the dumping of solid wastes (E17).

The immediate impact is of course to bury productive littoral and sublittoral habitats and associated biota. However, reclamation by infilling has the further counter-productive results of interfering with watermass and nutrient exchange of coastal ecosystems; and of aggravating sublittoral siltation by eliminating natural sediment traps, such as the marshland and saltponds often found between higher ground and the sea. In projects involving the filling in of embayments, there is an irreversible loss of land potentially suitable for mariculture, and an absolute reduction in linear measure of the coastal zone, which especially for smaller islands means losing a major public resource.

This activity has always had a powerful attraction for development planners because of the physical and economic advantages of the flat land surfaces produced; in the form of the "polder" system it has long been the foundation of Dutch land-use policy, which on the whole has been remarkably successful, although even there voices are beginning to question the real long-term benefits of gigantic new projects such as the reclamation of the Waddensee.

However, in tropical and insular situations, a popular target is the coastal mangrove belt which, despite a long tradition of sustained pole production (notably in the Indian Ocean region) and despite the protection against wind and wave which it gives to the land, has generally been rated as mosquito-ridden and useless: mangrove clearing as a prelude to reclamation (E7) was therefore until recently regarded as wholly beneficial. It is now well established that clearance causes outright destruction of one of the most biologically productive of all ecosystems. It removes the main fish breeding and nursery areas, and terminates the processes (set in motion by mangrove leaf-fall) of the nutrient production on which reef and outer shelf biota all ultimately depend. Among the many other side effects can be the loss of economically and aesthetically valuable bird populations through elimination of nesting and feeding areas.

#### G8. Logging and upland vegetation clearing

Capital intensive logging that contravenes sustainable yield (long-term investment-return criteria) and severely diminishes or in some cases eliminates the forest resource, can result in catastrophic ecological changes. Although the best examples are to be found in continental areas and the "mini-continental islands", such as Madagascar and New Guinea, they can still occur in smaller islands and not necessarily in the tropics (some of the islands of the Alexander Archipelago, off the southeastern Alaska coast, being a recent case in point). The secondary effects of the changes such as soil erosion and deterioration of water supplies, due to accelerated run-off and compaction, are well documented, but it is worth stressing that these in turn lead to the adverse impacts of siltation and turbidity already discussed under the "Dredging" subheading.

#### T20 and 21. Waste disposal, sewage outfalls and septic tank seepages

Discharge of raw or partially treated effluent into the sea can sometimes cause mortality in the environs of the outfall by modifying the habitat of species which have a high oxygen requirement. Sewage-tolerant species, on the other hand, especially noxious algae and the gull family, tend to proliferate. Other effects are bacterial contamination of water, introduction of disease vectors, and seabed sludge accumulation, all of which may kill benthic biota and reduce water quality. The build-up of organic pollution in the harbors of Kingston, Jamaica, and of St. Thomas, U.S. Virgin Islands, and in Keahi Lagoon, Hawaii, gives some indication of a problem with worldwide dimensions. It is also worth remembering that the comparatively safe disposal of wastes by septic tank treatment can cause problems when seepage or overflow contaminates ground water resources and percolates to coastal waters. Considerably worse and

similar in its effects to the piping of sewage directly into the sea is, of course, the deliberate dumping or discharge into streams and rivers of untreated or insufficiently treated sewage. Hazard to human health is a well established consequence.

#### B22 and I22. Waste water from desalinization plants and industry

The ecological impact of waste water, which is either very saline or heated above the ambient temperature may well favor some species (for example, by providing ice-free areas during severe weather conditions), but will repel or eliminate those with a narrow range of tolerance. A more generally adverse factor is the high metallic uptake of brine or water that has been used for cooling, which may result in the absorption of trace elements, possibly accumulating as they pass through the food chain to toxic concentrations at high trophic levels.

The water-borne wastes of many other industrial operations can inject high chemical and organic loads into coastal waters with similar effects to those already noted for the discharge of untreated sewage (T20): eutrophication, algal blooms and oxygen depletion, all of which, in severe cases, can cause major fish kills. This stems from the fact that organic pollution originates from waste accumulation having a high biochemical oxygen demand (BOD): the resultant oxygen deficiency puts a stress on the benthic biota and may even create an anaerobic environment in which life is virtually impossible.

#### \*23. Oil spills and discharges

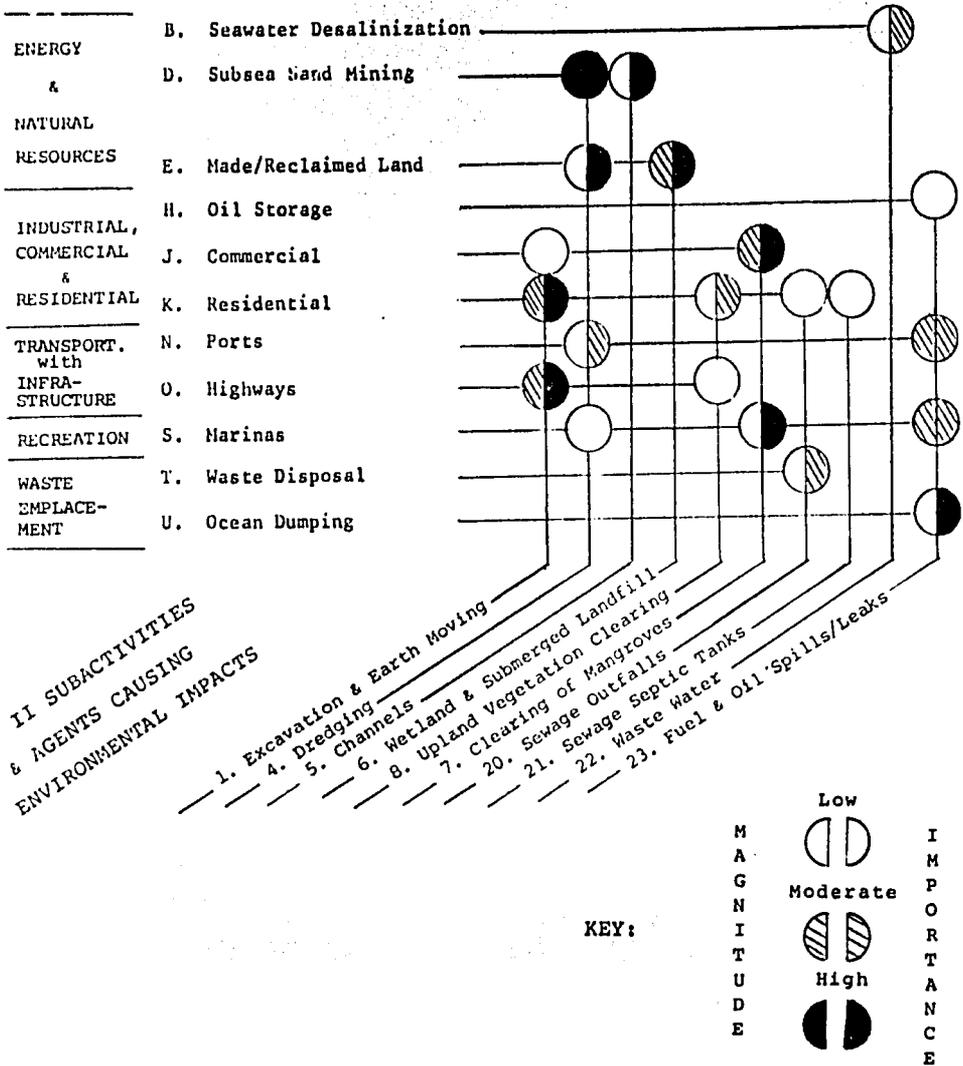
The associated activities have already been listed among those affecting aesthetic values (p. 32) and need not be repeated. The main impact on ecological values derives from the pressures exerted by the toxic hydrocarbons of oil spill residues concentrated on the sea bottom or deposited on nearby reefs and shores. Ingestion of these by animal life can result in direct mortality; oiling of plumage or fur of seabirds and marine mammals, which also involves some ingestion in their efforts to clean themselves, is apt to be equally fatal unless individually treated by difficult and expensive human intervention.

Adverse secondary effects of oil pollution relate to the chemicals and detergents used in cleanup operations which may themselves be highly toxic or, by making oil miscible with water, enhance the danger of ingestion by certain marine fauna, especially filter feeding invertebrates such as oysters and clams.

- FIGURE 2 -

IMPACTS ON ECOLOGICAL VALUES - WITHIN THE MODEL TOURIST ISLAND

1. MAJOR LAND-USE ACTIVITIES



### F29 and 30. Harvesting marine flora and fauna by fishing and collecting

Any fishing or collection beyond sustainable yield levels is bound to lead to depletion of the resource, but the chances are greatly aggravated by the use of sophisticated modern gear. Still more injurious is the use of dynamite (already mentioned under "Blasting" activities F2) and poison to harvest reef fish, because of its non-selective, uncontrollable, persistent and widespread impacts on the marine biota. Side effects of intensive methods of exploitation include the impoverishment of the fauna by the often more or less accidental extinction of rarer species, the ecological effects of which on common food species may prove to be much more serious than expected.

Excessive collection of living corals for curios, and of molluscs for food, curios, pearls, or the manufacture of industrial "pearl" (from Trochus species), all have a similarly destructive or at least impoverishing impact on reef systems. A comparatively recent development, which although largely practiced for allegedly sporting purposes, has ruined many reefs, is spear-fishing. The difficulties of effective control are such that in a few islands it has already been deemed advisable to prohibit it altogether.

Numerous examples could in fact be quoted of marine faunal depletion. Perhaps the paradigm of the exploitation of these resources, which to some degree can be regarded as the common property of mankind, is to be found in the plight of the marine turtles. The wholesale capture of such species as the Hawksbill Eretmochelys imbricata for their carapace, skin and calipee, and of the Green Turtle Chelonia mydas, in particular, for food, and the equally seldom regulated collection of turtle eggs, have contributed to the near extinction of a half dozen species of sea turtles in former strongholds ranging from the Caribbean (Caymans, Dry Tortugas and the Nicaraguan Miskito Cays) to the Indian Ocean (Aldabra, Assumption and the Mascarenes). In the process a prime source of high protein food for island peoples, if properly husbanded, has been recklessly decimated.

### Illustrative Matrix

Figure 2 summarizes most of the land-use activities and subactivities discussed in this Section and evaluates their impact on ecological values within the model island.

### 3. Activities That Affect Cultural Values

The most powerful impact on the indigenous culture of island peoples is undoubtedly that derived from exposure to foreign life styles and customs. As a psychological one this falls

outside the scope of our basic Table (p. 28). The present subsection is therefore concerned with a few physical activities which play a relatively secondary role and the impacts on which on cultural values are in fact mainly limited to effacement of the material cultural record. The part of that record liable to be affected is assumed to comprise the archaeological and other traces of the prehistory and early human history of the island, historical buildings and monuments, and artifacts of local design and materials. It should, however, always be remembered that the attitude of mind that can permit the serious disturbance or destruction of these cultural assets may be engendered by involvement in almost every one of the major land-use activities listed in Column 1 of the Table, if it is conducted in ignorance or disregard of environmental values.

\*1. Excavation and earth moving

This subactivity which may be involved, during the construction phase, in most of the major activities just referred to, is quite capable of effacing the in situ cultural record, especially when this has been buried by the dust of centuries, unless there is at least some degree of awareness on the part of those carrying out the work, or very careful supervision. Excavation may physically displace or destroy the asset, but almost as adverse are the secondary effects, which may range from the loss of something that could have contributed to the sense of origin and purpose of the island-er to waste of what might have been a further attraction and interest for the visitor and tourist.

\*4 and \*6. Dredging and landfill

Whether conducted in connection with mining, construction or simply reclamation, these subactivities bear much the same relationship to submerged sites, including shipwrecked or otherwise drowned works of art or historical interest, as do excavation and earth moving to terrestrial sites. In this case, however, it is perhaps rather more likely that the major earth moving activities may exercise the more positive and beneficial impact of discovery, since, despite the recent growth of interest in underwater exploration, submerged sites and wrecks are only too easy to miss, especially if there is no clue to their precise location. This is, for example, often the case with the pre-Columbian remains of the Carib and Arawak Amerindian cultures, which are commonly located along coasts and therefore most likely to come to light through the large-scale and extensive activities of dredging and reclamation.

As in the case of terrestrial excavation the recognition and safeguarding of the cultural values of what is discovered depends on the awareness and care of operators and supervisors. Due to the publicity and romance attached to sunken

treasure, this may be less applicable to the discovery of shipwrecks, such as that of H.M.S. Nymph stumbled upon in 1970, 186 years after its loss, during dredging operations off Tortola (British Virgin Islands). Nevertheless, in the absence of adequate perception of the value for the cultural record and heritage of such finds, there is always a risk that they will largely be wasted or misappropriated.

\*11. Demolition or neglected maintenance of existing structures

This is a subactivity which often precedes construction of new facilities for every conceivable kind of industrial, commercial, recreational and private activity; its best known impacts on cultural values are doubtless to be found in the normal processes of urban redevelopment. The cultural values sacrificed may pertain to monuments of religious, historical or artistic significance, and may include public and private buildings and the whole panoply of ecclesiastical structures from cathedrals, mosques and temples to shrines, catacombs, tombs and cemeteries. Evaluation of these and subsequent development decisions pose a difficult problem, complicated by the fact that individual structures not in themselves at all exceptional or historically notable may nevertheless collectively represent a vernacular architecture which merits a high preservation rating from the cultural, traditional, not to mention aesthetic, points of view.

By contrast, the loss of the cultural values of buildings and sites located in rural or wilderness areas, normally stems from simple neglect, which strictly speaking is a non-activity. Its immediate causes are often economic, but basically rest on the failure to appreciate the value of surviving memorials to past human endeavor, let alone their touristic potential.

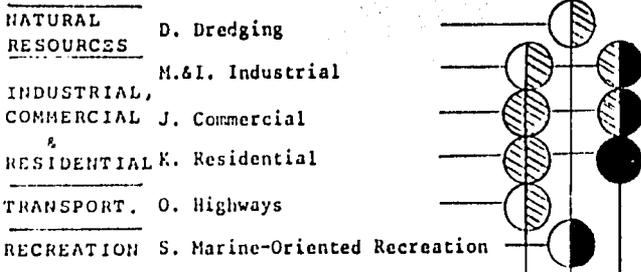
J32, S32 and T32. Commercial and recreational collection of artistic and historic objects

The pilfering of all manner of artifacts from archaeological and historic sites, at one time usually in the form of souvenir hunting by individuals, has tended to have an increasingly adverse impact on cultural values, because of the high prices that can now be realized from the sale of such objects and the consequent commercialization of the activity. In most developed and some developing countries it is now quite illegal, but nevertheless remains difficult to control. In the particular case of islands, especially those located on historic routes of early exploration and trade, a common manifestation is the unauthorized removal of objects from sunken ships.

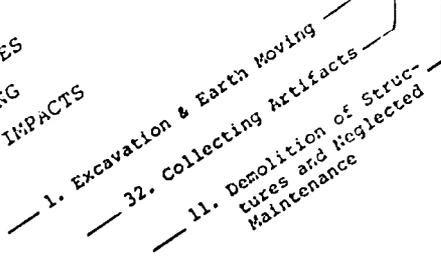
- FIGURE 3 -

IMPACTS ON CULTURAL VALUES - WITHIN THE MODEL TOURIST ISLAND

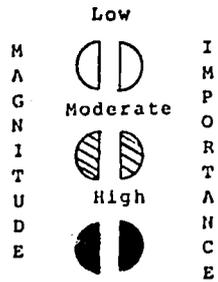
1. MAJOR LAND-USE ACTIVITIES



II SUBACTIVITIES & AGENTS CAUSING ENVIRONMENTAL IMPACTS



KEY:



The effects are in some ways comparable to those exercised on ecological values by excessive or uncontrolled exploitation of fauna and flora in undermining, and inhibiting a better understanding of the inter-relationships of the objects of exploitation. The main difference is, however, that, since artifacts cannot perpetuate themselves except by spurious imitation, the activity, however limited, is bound to obscure or disrupt the cultural record and thus foreclose on the opportunity of establishing and enhancing the cultural identity of an island society.

#### Illustrative Matrix

Figure 3 summarizes land-use activities and subactivities discussed in this Section and evaluates their impact on cultural values within the model island.

## VI. GUIDELINES FOR MINIMIZING SOME ADVERSE DEVELOPMENT IMPACTS AND ENHANCING CERTAIN RESOURCES

In keeping with the previous discussion, the aim in this final Section is to facilitate the incorporation of ecological principles, derived from the study of environmental impacts, into the planning and management of island development. As we have seen, the impacts under consideration are exerted by a limited range of physical activities, selected because of their current rather than historical (and more often emphasized) importance in the shaping of island ecosystems. In general, the guidelines which emerge are justified by the need to redress imbalances that arise from economically viable, but environmentally damaging, aspects of these activities. The price of progress in one sector may have to be a declining quality of life in another sector, but the business of guidelines is to ensure that gains and losses are correctly evaluated and that decisions leading to an adverse balance sheet are avoided.

Public and private bodies customarily treat the environment as a free resource, with no account of the adverse costs which their exploitation of it may generate. For this reason, it is necessary and appropriate for decision-makers to guide development activities in such a way as to minimize these costs and protect the limited stock of environmental capital from being exhausted. Guidelines can help this purpose by alerting decision-makers to problem areas. They also provide a basis for broadening the criteria of project analysis to include environmental impact considerations, which is very much what was called for by Recommendation 63 of the U.N. Conference on the Human Environment (Stockholm, 1972).

It is important, however, to appreciate from the outset that within the limited scope of our study of the "generic island system", it would be impossible to develop prescriptive and detailed guidelines on specific development projects or land use. For example, to translate the guiding principles referred to under one of the headings discussed below, namely, "Amenity and Aesthetic Resources" into specific measures for a given coastal development plan, a complete subset of standards and procedural guidelines would have to be devised to cover all the tasks and responsibilities involved: this could include--defining shoreline structures, their height, location and density; land uses compatible with the aesthetic, ecological and cultural values of the coastal zone and, where necessary, the areas to be reserved because of their

special suitability for maintaining these values; any other zoning or land-use regulations required; and appropriate policies for the promotion and guaranty of public use rights to coastal resources.

However, the most that can reasonably be attempted within the compass of the present paper is to give more general guidance, based on the principles identified in the previous discussion of environmental problem areas or "stress points" of the island system, from which the inter-disciplinary nature of the development planning challenge can be properly appreciated and the scope and content of guidelines for specific situations and projects can readily be deduced.

### 1. Tourism

The introduction of tourism to islands has too often resulted from a series of unrelated single project allocation decisions, made by outsiders insensitive to an island's distinctive characteristics. These projects individually and collectively ill-serve the basic needs of the society concerned, their unplanned, spontaneous development bringing more vexations than visitors and more problems than profits. Moreover, the common experience has been that the tourist industry is rarely charged the true cost of the additional public services its development entails: its growth always generates increased loading of such essential services as water supply, sewage and solid waste disposal, power generation and communications, resulting in their quantitative and qualitative deterioration for ordinary residents and a precipitous increase in their cost.

An intrinsic weakness in most island tourism development planning has been the lack of any explicit statement, included as an integral feature of the plan, of the level at which further growth of tourism would be limited and how this would be done. Maintenance of the quality of life in any small island requires the fixing of carrying capacity ceilings. Examples of the kind of control already in operation include limitations on the number of cruise-ships allowed to call per day and on the size and number of motor vehicles that may be imported; but it is doubtful if such piecemeal regulations can be of much real value in the long run, in the absence of overall density regulations.

These considerations may be summarized in the following guidelines:

1. *Because of its interaction with other land-use activities commonly pursued in islands under development, the planning and promotion of tourism should be undertaken at the highest governmental levels and viewed as a component part of an integrated, comprehensive,*

*resource management plan founded on sound ecological principles.*

2. *The infrastructure of the industry involves a high risk of diminishing and eventually destroying the natural balance of island resources. The precise type of tourism desired and the strategy to be employed in fostering its growth, must therefore be carefully considered and decided in advance, in the light of an assessment of the impacts on the tripartite range of environmental values and on alternative resource development. Where expansion of the tourist sector is planned, a commensurate expansion of public services should be mandatory.*
3. *In the matter of design, it is almost always desirable, especially in smaller islands, to lay down standards for resort developments. These should cover the style and location of structures (specifying, for example, density and height limits, and the extent to which encroachment on the coastal zone is permitted), the treatment of sewage and the control of litter, the preservation of open spaces, and public use of and access to beaches. Resort projects likely to affect the marine environment would require special permits in which the conditions laid down are related to the contribution of the project to the totality of impacts on the resources concerned.*
4. *Finally, comprehensive regulations for limiting tourist densities to the carrying capacity of the island as a whole and the resort development areas should be included in the plan.*

## 2. Dredging

In the discussion of ecological impacts it was emphasized (p. 36) that dredging operations are frequently involved in a wide range of developmental activities now affecting small oceanic islands as, for a much longer period of time, they have affected continental coastlines. We have also seen that islands, with their comparatively closed and fragile ecosystems, are more likely to suffer from adverse consequences of these operations. It might therefore be expected that to avoid such impacts the relevant guidelines should begin with a general proscription on dredging, but while this may on occasion be warranted it will usually be unrealistic and unenforceable. Sensible limitations and above all continual monitoring are therefore the keynote of the guidelines which follow.

1. *Unless planned and controlled with extreme care, dredging, together with such aggravations as underwater blasting, can result not only in direct physical damage*

*to productive and protective marine communities such as coral reefs, but also, indirectly, in harmful effects over a far wider area, by triggering turbidity, silting and interference with water flow and natural sedimentation. An additional and immediate effect may be to reduce the primary production of the nutrients on which all marine life depends.*

2. *Dredging operations beyond the 15-fathom line should almost always be prohibited and any within that limit which are more than of a very minor nature, should be subjected to permit regulation and environmental monitoring, in which some or all of the following points will be of importance:*
  - (a) *Inventory of offshore sand resources, including a review of past insular supply and demand, in order to assess alternative sites and to anticipate future needs.*
  - (b) *Consideration of dredging methods and selection of the one likely to cause the least environmental disturbance (e.g., hydraulic suction may be preferable to the use of draglines, bucket ladders or cutterheads).*
  - (c) *Evaluation of excavation sites prior to dredging, which as Thompson (1973) has pointed out, should properly include: investigation of substrate composition, distribution, stability and relationship to the overlying water column in terms of nutrient exchange, elements and minerals; data on currents and tide; benthic geomorphology; and a study of the composition and inter-relationships with one another and with the total environment of the existing biotic communities.*
  - (d) *Monitoring of the dredging activity prior to, during, and after the completion of, operations. In the latter phase, this will be directed to such problems as the levelling of excavated areas (where the dredging is not concerned with the opening up of channels) and the rehabilitation of biota.*
  - (e) *Where dredging involves the disposal of unwanted spoil, appropriate provision for placing and containing this in such a way as to minimize damage to ecological and aesthetic values.*
  - (f) *The possibility of helping to finance monitoring, research and effective planning and control of*

*coastal development by charging royalties not only on products or materials dredged out for consumptive purposes, but also at a flat rate per unit volume on dumped spoil which cannot be shown to confer a positive and quantifiable benefit.*

### 3. Oil pollution

The impacts which can be conveniently placed under this heading are implicit in the observed mortality of seabirds, marine mammals and other marine organisms, the aesthetic losses represented by beach, port and marina contamination, and, most importantly, in the still not fully understood repercussions on ecosystems as indicated by major alteration of habitats and various food chain disruptions. One reason, apart from their obvious vulnerability to sea-borne pollution, why islands stand in special need of guidelines in this matter, is that they are seldom technologically well-equipped or in a strong position to meet or prevent the hazards accompanying the production, storage and shipment of oil. Apart perhaps from a few high risk continental areas such as the region of Cape Agulhas and the coasts of the English Channel, islands are also more prone to spillage by shipwreck (e.g., in the last five years at, Wake Island, 1967, 143,000 gallons spilled from the R.C. Stoner; Bahamas, 1968, 1,260,000 gals., General Colocotronis; Puerto Rico, 1968, 3,400,000 gals., Ocean Eagle, and again in 1973, 2,000,000 gals., from the grounding of the Zoe Colocotronis).

The magnitude and extent of an oil pollution incident is determined by the massiveness of the spill, the toxicity of the distillate, the sensitivity of the biota, and the rate of oil removal either by human intervention or through natural means. As noted on p. 38 the use of detergents (emulsifiers) in cleaning up oilslicks in coastal areas can prove ecologically more hazardous than the slick itself. The incidence of oil pollution is greatest at islands with shorebased oil installations. Although deliberate spills from tanker cleaning are still globally more pervasive, despite the fact that the "load-on-top" technique has shown them to be totally avoidable, they are invariably eclipsed locally by repeated mishaps occurring in the process of oil transfer, storage and refining.

Certain islands conveniently located in relation to high demand markets are likely to experience an increased risk of pollution due to a transformation now underway in the oil industry. This stems from the gradual replacement of 70,000 ton or smaller tankers by VLCCs (Very Large Crude Carriers) of 90-foot draught and 150 million gallon capacity. Offloading of these supertankers always has an

element of risk in shallow continental shelf areas and therefore tends to be switched to ports or SPMs (Single Point Moorings) with direct access to deep water. Islands located near continental markets but on the edge of or beyond the shelf, have obvious advantages from this point of view: the incoming oil from major production areas having been stored and refined can readily be shuttled in smaller tankers when and where required. There has been, for example, in the Caribbean area increasing pressure to acquire insular sites for this purpose, aggravated by soaring demand for oil (only for the first time partially brought to its senses by the energy crisis, which broke in the second half of 1973) and the emerging environmental resistance to coastal oil development projects in the U.S.. New or expanded facilities have thus been proposed or scheduled for Jamaica, Haiti (Fort Liberté), Puerto Rico (Mona Island), the Caymans, St. Croix, Turks and Caicos (West Caicos), the Bahamas and Guadelupe.

In this complex situation the following guidelines have to be somewhat loosely framed but hopefully adaptable to local needs.

1. *It may be appropriate to combat oil pollution in the island context by blanket rejection of exploration, storage or refining activities or, alternatively, to concentrate such facilities in a particular island in the calculated belief that the economic benefits will outweigh associated costs.*
2. *In the latter case, the location of offshore SPMs, storage terminals, refineries and dockside loading terminals should be very carefully selected to insure minimal disturbance of environmental values, and the necessary structures equally carefully designed with that end in view.*
3. *A wide range of experts such as meteorologists, oceanographers, marine and terrestrial biologists, industrial designers and of course oilmen themselves, will need to be consulted. As a general principal, however, installations should be prohibited in areas of high natural biological productivity, such as estuaries, mangroves, coral reefs and oceanic upwells; in other areas, strict operational regulations, inspections and enforcement, coupled with contingency planning, can do much to reduce the risk of oil leaks or spills.*
4. *Elements to be included in such planning, which should be supported by a governmental policy statement and organizational directives, are: discovery and notification procedures; methods for containing or enclosing*

a spill (by prompt placement of booms, etc.), which from the ecological and, where there is a chance of salvage, economic points of view have the highest priority; cleanup, disposal or destruction where salvage is impracticable; restoration of damaged sites or biota, whether above or below water; and enforcement (cf. U.S. Coast Guard, 1970).

5. In the last-mentioned connection, high priority should, where possible, be given to investigating methods of assigning liability and recovering costs of damage, control and cleanup operations, if necessary, supported by the enactment by island authorities of new or better legislation.
6. The latter could provide for (a) the licensing of operators; (b) proof of financial responsibility and capability of reimbursing aggrieved parties in the event of a spill (such proof may be required to be supported by the posting of a bond, in the light of the poor accident record of vessels sailing under certain so-called Flags of Convenience, as compared with those operated by well-managed and more adequately capitalized multi-national companies); and (c) everything else necessary for the recognition and enforcement of strict liability (see the draft environmental impact statement published by the U.S. Maritime Administration in 1973).
7. Whether covered by legislation or otherwise guaranteed by international agreement, a further necessary provision is the setting up of an insurance fund. This could be financed from oil revenues, at a national, regional or ultimately worldwide basis, and act as a revolving fund to underwrite the prevention, detection and cure of oil pollution, and the assessment and restoration of lost or diminished environmental values.

#### 4. Soil disturbance

Guidelines on development activities involving large-scale excavation and earth moving will naturally seek ways of guarding against soil loss, erosion, sediment and silt, the ecological effects of which are the equivalent at the terrestrial level of those which occur in the marine environment as the result of dredging (p. 36). They therefore need little introduction.

1. Land-use limits based on the geophysical character of the area--soil type, slope, rainfall, nature of the vegetation--should be prescribed and can be

applied by provisions, such as those used in St. Thomas (U.S. Virgin Islands), for regulating earth moving by permits which lay down detailed conditions. These focus on where the activity is carried out, how it is done, and the time period in which it must be completed.

2. *Environments that, perhaps at first sight rather surprisingly, stand to benefit most from effective control of soil disturbance are tundra areas in the arctic, wetlands in temperate regions, and coral reefs in the tropics. This is because, in rather different ways, they react badly to erosion and instability brought about by such activities as road construction, housing development, mining and logging. For example, strip mining, especially in hilly terrain, which is often preceded by logging or more wasteful forms of deforestation and accompanied by roads and buildings, is very liable to lead to wetland and reef destruction through erosion, silting and interference with the natural flow and quality of water. Re-establishment of topsoil and vegetative cover in such cases should therefore be mandatory, always included in the direct costs of a project and budgeted for accordingly.*
3. *Another form of mining, of beach and marine sand deposits, usually for the purpose of mixing with cement, merits special attention, since sand deposits are often, for practical purposes, non-renewable, their rate of natural replenishment being closely balanced by natural attrition. Mining sand from beaches and inshore banks will usually need to be prohibited because of the risk of erosion and destruction of protective functions and of amenity and biological values (e.g., as turtle-nesting ground). The possible alternative of off-shore excavation is worth investigation (subject to the initial warning in the guidelines on Dredging, No. 2 above): if it can be achieved without serious ecological disruption, it could compensate for and help to secure shoreline restrictions.*

#### 5. Wetland drainage or landfill

Wetlands, including tidal zones and saltings, have a crucial role in maintaining physical stability and productivity of the land/sea interface and in conserving freshwater resources. In islands, they will in fact frequently accommodate the most biologically productive communities and are represented by a wide variety of habitats, the lagoons and depressions behind the seaward banks (including man-made fishponds), mangroves and, less commonly, freshwater marsh and estuarine flats. Development activities

which threaten to interfere with the natural water regime, flow rates, water body and water volume exchange, and water quality, can be expected to result in imbalance in the geomorphological features of the coastal zone and to have adverse secondary repercussions on shallow water communities.

Wetlands and tidal lands have traditionally attracted development because of their suitability for certain uses (e.g., estuaries and lagoons for harbors and yacht anchorages), low cost of land preparation, and proximity to existing development which has usually been concentrated along the coast. A contributory factor is the prevailing belief, reflected in the market place, that marshes, mangroves and similar wetlands are of low value. On islands, perhaps more than elsewhere, pressure is exacerbated by the omission of environmental accounting from the investment analysis of projects. Accordingly, private and public enterprise has long tended to pick on wetland areas, without heed of possible adverse impacts on the environment. In effect, wetland "development", usually of course starting with its total drainage, has had an artificially low price attached to it. A ramification of this situation worth noting is that development projects sited in coastal wetland quite often fail to take any initial advantage of the access to the sea afforded by draining and infilling. Sites are chosen in response to cheap land rather than to that access; the development activity, in short, has no bearing on the physical attributes of the site, an extreme case being the disposal of solid waste in wetlands though this is usually only an interim stage in their conversion to building sites. Nevertheless, the fact that so much of the coastal zone is taken up for these "non-dependent" purposes has the result of increasing demand to use any areas that are still untouched--often mangroves or other difficult ground--for activities which do depend on the coast: desalinization plants, harbors, marinas and similar recreation facilities, etc.. By the time scarcity drives the price of coastal land up sufficiently to exclude non-dependent uses, little land may remain undeveloped and, to make matters worse, land previously developed may have been so irreversibly changed as to be incapable of redevelopment for more appropriate uses or reversion to its original productive status.

1. *Reservation of wetlands of high productivity (mangroves and estuaries) and, at least on a temporary basis and until the relative merits and potential economic benefits of alternative uses have been fully explored and assessed, of the kind of large bay or inlet clearly suited to the development of fish or shellfish resources or other forms of mariculture, is of the greatest importance. Where on balance, as in areas of*

*low productivity potential, it is finally decided that infilling could be of greater benefit, great care must be taken to choose materials and to design enclosing bulkheads in such a way as to exclude damage to neighboring biota through turbidity and sedimentation.*

2. *Control of wetlands and tidal areas will require regulatory legislation and a system of user permits to allow for pre-evaluation by decision-makers of anticipated development impacts. It has been the common experience in islands as in continental areas that the value of wetlands has only been realized after their disappearance and the loss incurred from a major reduction in the length of coastline has only been appreciated after the completion of the infilling and drainage of a bay or lagoon. The planner and decision-maker therefore should give priority attention to ensuring that any user whose losses exceed his gains can be adequately compensated and, more important, that inventory and other ecological evaluation techniques are always employed, before any development commitments are entered into, thereby excluding or greatly reducing the risk of unpleasant surprises and unforeseen economic disbenefits.*

## 6. Waste disposal

Although the ecological effects of this activity were dealt with rather summarily and, in the case of solid wastes, largely from the aesthetic and social points of view (p. 31), the point was made earlier (p. 25) that ecological values are under increasing stress from pollution derived from these products. Certainly experience indicates that traditional methods of disposing of solid wastes tend to be outmoded: in small islands the problem increases dramatically as a function of population (tourist and residents), rising incomes, substitution of synthetic goods and materials for organic, and the trend towards urbanized living. Guidelines must therefore be mainly concerned with recommending ways of safeguarding environmental quality by a much less casual and disruptive approach to the management problems involved in waste disposal. Compatibility with environmental values is a function of disposal methods, site location and the extent to which recycling is a practical possibility. In particular, the coastal wetlands of islands, which as previously stressed are often the areas of maximum biological productivity and by no means "wastelands", are not at all suitable as dumping sites.

1. *The essential elements in systematic management of solid wastes are: (a) preliminary inventory of solid*

waste generation, including long-term projections based on all the relevant factors (population, incomes, etc.); (b) investigation of public and private disposal practices; (c) definition of criteria for disposal sites and their selection; and (d) a strategy for debiting the waste producer for costs of collection, handling and disposal.

2. Every effort must be made to find solutions appropriate to the island circumstance. One of these is the identification of alternative sites where emplacement of consolidated wastes may be positively beneficial, such as badly eroded areas and worked out quarries. Once located they must be guaranteed against re-allocation for other purposes until the landfill is completed.
3. Another problem arises from the accumulation of litter and abandonment of derelict vehicles which cannot economically be recycled. Possible solutions which are worth considering include anti-litter legislation and proscription of disposable beverage containers; incorporation by statute, or agreement with the companies concerned, of a disposal fee in the purchase price of a motor vehicle, refundable at least in part when the vehicle is surrendered at the end of its operating life; and the use of such derelicts, under careful control and selection of suitable sites, for the construction of breakwaters and artificial reefs.
4. Islands have the option of using both land and sea as the final repository of waste. But until environmentally safe methods of oceanic disposal are devised--deep ocean dumping of baled refuse may prove feasible in future--the selective use of terrestrial sites, as advocated above, that is, with strict avoidance of the areas of high biological productivity or aesthetic value, is certainly to be preferred.

Turning to sewage or liquid waste discharge, the ecological impacts that have been discussed (pp. 37-38) turn mainly on interference with water quality through contamination, eutrophication and oxygen depletion. It follows that guidelines should primarily require that sewage be treated. The alternative, which is sometimes advocated, is to install an ocean outfall that will transport effluent far offshore to areas where favorable current patterns are calculated to be capable of dispersing any haline, thermal or toxic pollutants. Thus, the latest plans for the Sand Island outfall in Oahu, Hawaii, call for construction of an 84" outfall pipe, 9000 ft. in length, that will terminate in a 3350 ft. diffuser located in a water depth of 220-240 ft.

The effluent to be discharged through this pipe will originate from a 85 mgd. advanced primary sewage treatment plant (Dugan and Young, 1973). The validity of this approach and the extent to which it may be accepted as a guideline must, however, depend entirely on the efficacy of the initial treatment.

5. *Prohibition of the discharge of raw or partially treated effluent into sublittoral zones is usually essential if coastal environmental quality is to be maintained. Housing, hotels and urban areas must therefore be designed with appropriate standards for treatment. For example, septic tank location should be related to soil conditions to prevent overflow and contamination of groundwater. Primary or partial treatment before discharge is no more than a stop-gap measure, utterly inadequate in the long-term. There can be no substitute for the removal, by secondary treatment, of all potentially harmful substances or toxic materials prior to ocean dumping. Even when this is assured, the utmost care needs to be taken with the preliminary oceanographic and ecological investigations in order to confirm that calculations as to the dispersal and impact of the effluent are well founded.*

## 7. Conservation of natural areas

Within the limits adopted for this study (p. 27) it has only been possible to offer advice on ways of minimizing adverse impacts on small oceanic islands arising from half a dozen activities selected as being very influential at the present time. However, hopefully, the sample should have been sufficient to show the method and value of working out guidelines for any activity or combination of activities, which may be picked out of the Table on page 28, as affecting or likely to affect a particular island. In this and the two other concluding subsections, a brief look is taken at the kind of guidance which can be given on the positive aspect of enhancing island resources. Guidelines on any systematic program for conserving, that is to say making sustainable use of, natural areas--the complex of everything that contributes to the ecological values discussed in Sections IV and V--can be classified under the three headings of inventory, selection and management.

1. *Inventory: Identification of the natural assets of an island may be accomplished as part of a general natural resources inventory, or conducted as a single purpose program. The former approach is preferable as it enables subsequent allocation decisions to be made within the framework of competing resource demands*

(agriculture, fishing, mining, scientific research, recreation, education...). The survey, which may well be partly presented in map form, should of course include islets, reefs, shoals, inshore waters and the marine periphery to at least the 30-fathom line. Although in discussion of values, the aesthetic and cultural have been distinguished from the ecological, all three are integral elements in the island ecosystem. It is therefore essential that the survey include, in addition to the physical data commonly recorded (geomorphic features, terrestrial and marine biota, details of the range, movements and abundance of species, etc.), an indication of all assets of artistic, historical and in the broadest sense recreational significance. Fortunately, the necessary groundwork for and models of the kind of inventory required have been completed in connection with the World Heritage Trust (IUCN, 1973) and the Check-Sheet Survey of the International Biological Program's Section on Conservation of Terrestrial Communities (IBP/CT) (Peterken, 1967).

2. *Selection:* Once natural assets have been identified, catalogued and mapped, the way is open not only for soundly-based development planning and resource allocation, but also for the selection of areas which in the light of recognized criteria deserve special protection and management. The criteria will of course vary with the immediate objective, whether it be admission to an international listing, the establishment of an "island for science", the provision of a recreation area for an island conurbation, or any of the other conservation purposes recently reviewed in the two sets of Conference papers and proceedings published by IUCN and the S.P.C. (1973) and edited by Costin & Groves (1973).
3. Two points may be picked out for emphasis: first, the criteria should not be limited to those that can be quantified in purely economic terms; and secondly, in the process of evaluation, local as well as international expertise should always be consulted. Both these provisos in fact reflect the subjective element in selection, which as indicated in Section IV is particularly associated with aesthetic values, but is also a factor in the estimation of cultural and ecological values. The indigenous islander's preferences or scale of values are often peculiar, but as quite properly claimed at the IBP/CT Technical Meeting at Palau in 1968, may be derived from a long tradition of conservation practices (Nicholson & Douglas, 1970). They therefore need to be taken fully into consideration, even though they may be modified,

*in making the final selection, by the outsider's advice on the degree to which particular island assets are unique, rare or endangered in global terms.*

4. *Management: The basis for effective natural areas conservation and management (see Dasmann, 1973) rests with the design of a flexible and relevant program addressed to the specific conservation tasks at hand. As already noted (see 2 above), the task or objective can vary enormously, at its simplest perhaps merely calling for the protection of a single endemic species. But it is important to appreciate that even that will undoubtedly require the protection of the nesting, breeding or growing place, which in turn can only be secured by the maintenance of the habitat or entire biotic community of which the species is part. A high proportion of the island species which have become extinct (themselves accounting for the majority of global extinctions in the past 200 years) have done so because of habitat destruction.*
5. *Attention to the point just mentioned is far more important than, for example, attempting to set lower limits on the size of conservation areas; witness, for example, the survival of the really unique flora and fauna of the 151 hectare Round Island, off Mauritius, which can be attributed to resistance to introduced goats and rabbits of a single key tree species. In short, allocation of land for conservation should be determined by the specific project objective and ignore preconceived ideas about minimum acceptable size.*
6. *Flexibility should also extend to the management of the resources of the ocean. Thus, ideally and not infrequently in practice (well over a dozen protected areas in the Japanese islands are a mixture of land and sea), a marine park should be supported by a contiguous terrestrial sector, extending from the tide-line to the proximate watershed. Erosion set up by a variety of landward or upland activities can be just as destructive to marine biota as dredging and underwater blasting (see pp. 35, 36 and 37).*

*In conclusion of this subsection, mention should perhaps be made of potential problems in fixing the seaward boundaries of marine conservation areas. They should if possible enclose the entire ecosystem concerned within the management unit (see Carleton Ray, 1972). But the difficulty, as he goes on to explain, is that marine ecosystems are large, often shared in or claimed by several countries, and despite the many attempts made in recent years to*

extend the limits of national sovereignty, their resources are still in many cases treated as common property--used by all, safeguarded by none. It follows that success or failure to conserve marine areas may, in many cases, ultimately hinge on the degree of international cooperation achieved.

#### 8. Amenity and aesthetic resources

On several occasions in early Sections of this paper, with particular reference to the growing impact of tourism (pp. 7, 13, 24 and 25), the principle has been invoked that islands are exceptionally well endowed with aesthetic and recreational assets, which are just as susceptible and vulnerable to excessive pressure as the physical and biological resources with which they are often closely related. Because of their exceptional value, the protection of these assets is clearly a public interest and responsibility, made all the more important by the possibility that demand for recreational facilities in islands will exceed current projections based on population growth. It is, in short, essential to forestall a situation in which overloaded and badly sited facilities lead to a rapid deterioration of the very values they were designed to make available.

1. *Maintenance of recreational and aesthetic values may best be achieved by promulgation of permitted land uses in specific areas, encouragement of buffer zones in which the land use is reasonably compatible with that of the more closely controlled zones they are designed to protect, and even outright proscription of certain uses that cannot be reconciled with these values or are bound to foreclose recreational opportunities. Fortunately, the majority of land-use activities which seriously conflict with this category of values, are not site-specific to the extent that it is likely to be impossible to find suitable alternative sites elsewhere.*
2. *Other methods which may have to be employed by planners to maintain these values range from tax concessions and the purchase of access rights and scenic easements, to zoning and, as suggested in Guideline 7(2), attaching special importance to criteria, including the values now under consideration, which cannot easily be quantified in monetary terms. It should be noted that the term "zoning" can cover a variety of regulations which can be applied severally or together, such as those governing residential and visitor densities, or the height of buildings (which, as in the Seychelles, can even with advantage be restricted to the height of*

surrounding trees) and the distance they must be set back from the beach or waterfront. Typical minor examples could relate to the control of bill-posting and outdoor advertising or insistence that the car parking facilities for a coastal resort be located well inland of the beach zone.

3. A more fundamental method, which should be considered and for which there is already a useful precedent in the National Environmental Policy Act in the U.S. (see Delogu, 1974) would impose a legal obligation that any public or private development projects which appear to involve a significant risk of destroying or degrading amenity and aesthetic resources, should always be accompanied at the planning stage by detailed and specific environmental impact assessments.

### 9. Cultural Resources

As indicated in our review of the physical impacts on cultural values (pp. 40-44), many islands, but especially those which have had a historical role as stepping stones for migrant peoples, trade and exploration, are rich in cultural records, the loss of which would result in social and artistic impoverishment. As a first step towards conservation and restoration of historic monuments and protection of archaeological sites, terrestrial or marine, the place of cultural resources within the overall development strategy needs to be established and provided for on the following lines.

1. A country's policy on the conservation of cultural resources should be based on the contribution these assets can make to inculcating in island peoples a sense of identity, a better understanding of their place in history and relationship with their environment. Secondly, it should evaluate the resource as a tourist attraction and as a reference point for all students of the evolution of man's artistic heritage. Elements in such an evaluation would be:
  - (a) inventory of cultural resources and priority rating for their conservation;
  - (b) estimate of financial and legal implications;
  - (c) enactment of conservation legislation and initial budgetary provision;
  - (d) setting up an appropriate governmental or non-governmental body (e.g. National Trust, Museum Boards, Arts Councils) to advise upon or manage the resource;

- (e) establishment or expansion of museum facilities to house collections which cannot be suitably maintained or displayed on site, and to promote the relevant artistic and historical research;
  - (f) preparation and publication of interpretative materials (history and guidebooks, reproductions, etc.) and recruitment and training of interpretative staff.
2. It is worth underlining the suggestion contained in item (e) above that wherever possible the physical integrity of a monument or site should be safeguarded. This can greatly enhance the enjoyment and hence beneficial impact of cultural values, although admittedly more expensive and possibly less convenient for research than the removal of artifacts to a central repository. The management of cultural assets within the context of their physical environment does, of course, also call for additional vigilance to ensure that ancillary or competing land-use activities are not allowed to detract from that environment and ipso facto from the cultural assets themselves.

### Conclusion

The highly selective treatment of activity categories imposed by the confines of this little book (the Table on p. 28, although in itself very selective, could readily suggest well over a hundred combinations of activities and subactivities of relevance to islands) may leave the impression that maintenance of environmental quality can be achieved by piecemeal treatment of each problem area. In fact such an approach may buy time, but is unlikely to confer any lasting benefits. This conclusion can be drawn from a study of the three illustrative matrices based on our model island (pp. 33, 39, 43): they make it clear that the causes underlying environmental deterioration do not reduce to single activities, operating independently and in isolation. Rather, they result from cumulative impacts of numerous activities. This implies that if the environmental values of islands are to be effectively maintained, guidelines must point the way to a program that will,

- (1) deal with land-use activities comprehensively, and,
- (2) form an integral part of overall development planning.

The difficulty in achieving this arises from the simple fact that nowadays even the small oceanic island is a continent in miniature in respect of the array or disarray of development activities and impacts occurring within its circumscribed territory. In contrast with the continental situation, however, the abundance and diversity of its resources are likely to be limited, so that neither the

manpower nor the funds will be available to effect the necessary coordination. A recent suggestion by H.J. Coolidge (1973) offers a possible method of alleviating the problem. He advocates that in every island or closely associated group of islands, steps be taken to set up a "conservation council", composed of governmental agencies in the resource and conservation field, legislators, concerned private individuals, and landowners who would be affected by environmental programs. The advantages of this approach are threefold: (1) it allows for maximum use of available environmental expertise; (2) it confers a degree of independence on the conduct of environmental affairs by opening the council to private participation; and (3) it permits direct feedback to decision-makers on the environmental development issues facing the island. Whether the functions of such a council are executive or advisory, it is certain that its effective operation will depend on the formulation of and constant reference to ecological guidelines as envisioned here, namely the lessons to be learned from observed impacts on environmental values.

Postscript: A population guideline

Ecological guidelines can help in finding ways of mitigating the adverse effects of development. But despite anything that can be recommended within this field and however rational the allocation and use of resources achieved by a comprehensive plan, one factor can ultimately compromise environmental quality in all respects--aesthetic, ecological and cultural--namely, excessive human population densities. It follows that, assuming a social desire to maintain environmental quality over the long-term, acceptance of and allegiance to a demographic policy is inescapable. What is involved and must be at the root of all planning, is the placing of an effective ceiling on the permanent and transient human populations deriving their livelihood or recreation from the island system.

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The International Union for Conservation of Nature and Natural Resources (IUCN) is an independent international body, formed in 1948, which has its headquarters in Morges, Switzerland. It is a Union of sovereign states, government agencies and non-governmental organizations concerned with the initiation and promotion of scientifically-based action that will ensure perpetuation of the living world - man's natural environment - and the natural resources on which all living things depend, not only for their intrinsic cultural or scientific values but also for the long-term economic and social welfare of mankind.

This objective can be achieved through active conservation programmes for the wise use of natural resources in areas where the flora and fauna are of particular importance and where the landscape is especially beautiful or striking, or of historical, cultural or scientific significance. IUCN believes that its aims can be achieved most effectively by international effort in co-operation with other international agencies, such as Unesco and FAO.

The World Wildlife Fund (WWF) is an international charitable organization dedicated to saving the world's wildlife and wild places, carrying out the wide variety of programmes and actions that this entails. WWF was established in 1961 under Swiss law, with headquarters also in Morges.

Since 1961, IUCN has enjoyed a symbiotic relationship with its sister organization, the World Wildlife Fund, with which it works closely throughout the world on projects of mutual interest. IUCN and WWF now jointly operate the various projects originated by, or submitted to them.

The projects cover a very wide range, from education, ecological studies and surveys, to the establishment and management of areas as national parks and reserves and emergency programmes for the safeguarding of animal and plant species threatened with extinction as well as support for certain key international conservation bodies.

WWF fund-raising and publicity activities are mainly carried out by National Appeals in a number of countries, and its international governing body is made up of prominent personalities in many fields.