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CRITICAL MARINE HABITATS

The attached document, which was prepared by G. Carleton Ray for the International Union for the Conservation of Nature and Natural Resources with support from the World Wildlife Fund, the United Nations Educational, Scientific and Cultural Organization (UNESCO), and UNEP, is distributed to participants for their information.

CRITICAL MARINE HABITATS

Definition, Description, Criteria and Guidelines for Identification and Management

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FOREWORD

Many marine and marine-related ecosystems are now in serious jeopardy and action to protect and manage habitats of critical importance to the survival of marine species is urgently needed.

IUCN has asked Dr. G. Carleton Ray at The Johns Hopkins University, Baltimore, Maryland 21205, U.S.A., to undertake a study on the conservation of critical marine habitats which involves the identification and description of such areas and preparation of plans for their conservation. The work is being carried out under a grant from the World Wildlife Fund with additional support from UNESCO and the United Nations Environment Programme.

One of the objectives of the study is to provide criteria for the selection of areas to be set aside as marine parks or reserves and to prepare guidelines for their management. Dr. Ray has drawn extensively on material available to him from many quarters, particularly through his association with the Conservation of Ecosystems Program which was carried out until late 1974 as part of the U.S. contribution to the International Biological Programme (Darnell *et al.*, 1974). The "National Workshop on Sanctuaries" (Lynch, Laird, and Smolen, *Eds.*, 1974) provides a background on marine sanctuaries relative to important new U.S. legislation, the Coastal Zone Management Act of 1972 and the Marine Protection, Research and Sanctuaries Act of 1972, and this is also referred to in this study. However, the point of view expressed here is more general, in recognition of the fact that problems and solutions differ in various regions and areas.

Action has already been taken in various parts of the world for the establishment of marine parks and reserves. The recommendations of international meetings, including the First and Second World Conferences on National Parks (Adams, 1964; Elliott, 1974) have been important in leading to action. Nevertheless, there is only a small number of such reserves and, unfortunately, due to the nature of the coastal and marine environment, it is probable that few of them are self-sustaining. Therefore, a broad ecosystem-oriented point of view is presented here, particularly with regard to the value of parks and reserves in ecological research and in monitoring the impact of man.

The present paper has been prepared as a working document for those engaged in marine conservation in general or in the creation and management of marine parks and reserves in particular. It is a preliminary essay and is being circulated to attract critical comment with a view to its revision and expansion.

The paper is to be read in conjunction with IUCN Occasional Paper No. 14, "A Preliminary Classification of Coastal and Marine Environments" by G. Carleton Ray (Morges, 1975).

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PREFACE

Marine conservation has an ultimate goal to incorporate the knowledge derived from marine ecology into the fabric and practices of all societies so as to assure the maintenance of the health and productivity of marine ecosystems and the diversity of life within them. To work toward this goal, we must greatly amplify our efforts to identify habitats which are critical to the survival of marine species and biotic communities, and evolve methods for their conservation so as to exemplify how the broader aim may be reached.

The term "critical marine habitat" is here taken to mean those identifiable areas which are vital to the survival of a marine species, at some phase in its life cycle, or of a marine habitat, community or ecosystem, because of the ecological processes that occur within it. These may be extensive communities, such as mangrove-sea grass-coral reef systems, or small areas, such as rookeries for seals, or unique areas, such as lagoons which are important as whale breeding grounds, or even terrestrial areas, such as watersheds which nourish an estuary.

It is recognized that in the long run there is only one critical marine habitat, the sea itself. The "marine revolution" in which mankind is now involved, requires recognition that civilization as we know it, or an improved life style towards which we strive, is dependent upon the health, diversity and stability of marine systems. Terrestrial areas alone cannot provide sufficient food and other materials for the survival of mankind. Our objective must be no less than the comprehension and preservation of marine systems and the cessation of man's deleterious impacts upon them.

Such an objective is simple to state and has been stated in various forms many times in the past. The simple truth is that it is not being met -- notwithstanding many meetings and conferences with their recommendations, and the clear warnings which marine ecology provides. The establishment of a few parks and reserves is a hopeful sign, but is also only a partial approach. There is no alternative to a massive, integrated effort of scientists, social scientists, lawyers, politicians, and public relations personnel in a regional, world-wide attack on the problem. Ecological science must take a lead since the primary need is to modify man's life style to the realities of ecosystems which he is far from understanding or controlling in the sea and coastal zone, but which he is presently destroying. The reverse approach -- i.e. modifying the sea to man or what has been called the "engineering mentality" -- clearly will not work in the light of our present knowledge or for the foreseeable future.

How man handles the coastal zone and the ocean commons is perhaps the most critical issue of la problématique (cf. the Club of Rome), since these areas are currently viewed as a placebo to the overuse of the land.

Permanent solutions do not lie in drawing lines about what areas or species are to be exploited and what are not, nor do they lie in expansion of state's rights, nor in preservation of tradition. They lie in new directions, particularly in ecologically-oriented, regional applications of system theory, in readjustments of life styles, and in alterations of prejudicial lines of thought.

One such prejudice is that which exists between industrialized and non-industrialized nations or areas. The contrasts between them are real, but each is destructive in its own way to marine resources. Industrialized nations have already destroyed resources and have exploited much ocean space -- their own as well as others -- in their short-term interests. However, there is evidence that this trend is being reversed in some quarters. Conservation practice and theory have advanced and, most significantly, these nations have at least addressed the need to curb population and per capita consumption. Non-industrialized nations have destroyed more of their marine resources than would at first seem apparent. A few have taken some marine conservation action, such as the establishment of parks and reserves, but these often are gestures toward the development of tourism. Many have laws on the books for conservation of habitats and species, but these largely go unenforced due to short-term resource or economic needs. Most dangerous is the lack both of technology for marine conservation and of population planning. With the notable exception of a very few "ecosystem peoples", the non-industrialized nations may face a worse and even more immediate crisis than the industrialized ones, should present trends continue.

So far, man's approach to "critical habitats" has been largely to identify rare, threatened, or endangered areas or species and to make efforts to set them aside or protect them. Western man, mostly, has reacted emotionally to loss of aesthetic values or scientifically to loss of genetic resources while at the same time eating, breathing, buying, selling, and therefore destroying, what is common or taken for granted. The "protectionist" approach emphasizes a drawing of legal or geographic boundaries, which do not really exist ecologically, around what is considered, usually on a highly selective basis, exploitable and what is not. Such an approach may save the rare, threatened, or endangered, for a time at least, but only so long as ecological support systems and processes are also maintained. What such an approach cannot do is prevent the common from becoming rare or the clean from becoming dirty. Therefore, systems applications are required and this is especially true and difficult in the gigantic "sink" we call the sea, or the tortuous ecotone we call the coastal zone. In this coastal zone the majority of the world's people live, and the greatest diversity of life on earth exists; from it man extracts about half of the protein he consumes, as well as a large portion of his recreation.

Should present trends continue, that is, should population continue to grow, should per capita consumption continue to increase, should conservation continue to be piecemeal, and should man's activities have the effect of creating leaky, non-viable ecosystems, then there will soon remain but one endangered marine habitat -- the sea itself.

I suggest that we take the approach that this "long-range" danger may now be upon us even though we perfectly well know that the sea is far from dead, that abundance and good environmental health remain in many quarters and that restoration of many perturbed areas is clearly possible. Some areas need to be set aside as parks and reserves. But the overwhelming need is to meet the long-range goal stated above. The short-range objective of protection of certain critical habitats is the route towards this end.

How long is "long-range"? I would guess that if concerted and dynamic action does not proceed immediately, some now alive will live to see it.

G. Carleton Ray
Morges, December 1975.

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Mrs. Mary A. Mix, my secretary, has had to put up with my handwriting and many alterations in order to transfer the manuscript to legible form. I have also received help from many of the secretarial staff at IUCN, for which I am very grateful.

If the fishes, corals, mangroves, and waters of the sea had a voice - and who is to say they do not - I would also say thanks to them for life itself. And I do!

INTRODUCTION

Threats and Solutions

It is generally acknowledged, on the basis of both fact and intuition, that the seas are in jeopardy. Pollution abounds, overfishing is prevalent, coastal development remains excessive, and there continue to be losses in the productivity of many regions. Further we sense feedbacks which imply loss of stability in whole systems. There can be no doubt that the total impact of man's activities on the coasts and seas is impressive - and frightening in a world which still deludes itself that the seas are a panacea to our overuse of the land.

The literature is extensive on this subject. Hood, Ed., (1971) reviews the pervasive perturbations of man on the sea, and Clark (1974) summarizes problems of coastal ecosystem conservation. Edwards and Garrod, Eds., (1972) take an ecosystem-oriented approach to conservation which reveals many possible new approaches from fisheries management to radioecology in grappling with the many problems before us. Ketchum, Ed., (1972) points out that natural coastal systems may no longer exist, that "optimum human use" must be developed by means of models, and that a major effort must be devoted to this task. The U.S. National Academy of Sciences (1973) examined water quality criteria and found that major emphases needed shifting, for instance, from lethal to chronic effects and from diversity-stability indices to the determination of "most sensitive organisms" for monitoring purposes. Both of the latter studies made a strong case for the reserve concept, a concept largely devoted to both preservation and research and which has evolved far beyond early thoughts on marine conservation as implied by "parks". Lynch, Laird and Smolen, Eds., (1974) review the application of marine "sanctuaries" for purposes of mitigating impact, research, and monitoring.

Specific studies on the precise nature of man's impact, from geological to biological, abound. In a brilliant, concise paper, Inman and Brush (1973) cite impressive facts; for instance, "If everyone in the world decided to spend some time along the 440,000 km of world shoreline, each person would have less than 13 cm of shoreline". Although only 5% of the world's area is the productive continental shelf, about two-thirds of the world's population lives there. These same areas receive the bulk of man's impact in terms of waste discharge, thermal discharge, dredging, mining, poaching, and coastal destruction. Further, they point out that coastal waters have limited flushing capacity which contrasts strongly with the mentality which states: "the solution to pollution is dilution".

Turning to estuaries, which rank as among the most productive areas on earth as well as among the most threatened, Darnell (1967) reviews the many perturbations which occur there and also states: "The dreadful problem that we face is that there does not now exist in scientific literature sufficient information to guide ecologists in predicting the detailed effects of major environmental modifications...". A sample scenario of the sorts of problems encountered begins with a study of Likens and Bormann (1974) which showed approximately a 1500-fold difference in sediment yield between a clearcut forest converted to farm and pastureland, and a stream running through mature forest. The differences between that same stream and a construction site in Baltimore was about 20,000-fold! This represents vast differences in the inputs of nutrients and pollutants between these three site types as well. Loftus, Subba Rao, and Seliger (1972) studied responses of phytoplankton to alterations in the physical and chemical parameters of Chesapeake Bay and found that relative species compositions changed drastically. The conclusion raised by these two studies is: whereas we cannot predict the exact impact of clearing and construction on estuarine systems, we can say that we are drastically affecting the life support systems of essential resources to man through ecologically non-conforming development. Is such development, or the experiment which could prove the final result, worth the risk?

Two further scenarios are worth mentioning. The first concerns one of the most aesthetically and scientifically valued, and highly productive biomes of all - that of coral reefs. Johannes (1972) lists the many serious perturbations of man on coral reefs; the total effect is staggering. They include a variety of activities from souvenir collecting to siltation and pollution, the latter of which reduce the clarity of water and have a serious effect on coral. We are aware, for instance, of the symbiosis between corals and included algal "zooxanthellae" and of the cleansing rates of corals, both of which mean that silty, dark water, as is caused by some forms of pollution and dredging, is inimical to reefs (Goreau, 1964; Lang, 1974). Even when coral reefs are included in parks, their protection is not assured. For instance, Voss (1973) has reported the "death" of patch reefs of the John Pennekamp Coral Reef State Park in Florida because of outside, as yet unidentified, influences. Strong possibilities are pollution and dredge-and-fill activities.

The last scenario is a reminder that the perils of pollution continue unabated in many areas. Here, the literature is huge, but among the most astonishing cases, to my knowledge, concerns damage to a whale which merely swam through the "boues rouges" (red muds) emanating from an industrial site in Italy. Pichod-Viale (1974) reports that the whale died because of deep skin corrosion and heavy metal impregnation through the damaged skin. Though this is an extreme case, it calls our attention dramatically to the pollution problem, and also to the fact that waters in many parts of the world are closed not only to the extraction of human food, but even to human contact.

These are but samples of the problem of perturbation by man. It is clear that the valuable resources of the sea will not survive without deliberate managerial intervention on their behalf. However, it appears unfortunate that to date national and international agencies have been only partially able to cope with problems of perturbation. So long as civilization's pattern of growth is sustained, the road to ecocatastrophe and the collapse of many cultures as we know them is assured. Nevertheless, whereas it is clear that our uses of coastal and marine systems must be altered so as to preserve their productivity, it remains to be seen how extensively ecological concepts will be incorporated into actual practice. It has been said that if history teaches us anything it is that man does not learn from history! Civilizations from Mesopotamian to Mayan have collapsed due to environmental abuse and there is no assurance that any present civilization is immune. For example we no doubt recognize problems, but it is astonishing how readily we reach for the quick technological "fix". Forbes Magazine (January, 1975) carried an article describing an underwater bulldozer, developed in Japan, 47 tons in weight and costing about $70,000, which some coastal city mayors see as a solution to their beach erosion and restoration problems! There is little doubt that there is insufficient appreciation of the value of solid ecological solutions (some of them free) for the already very widespread damage suffered by marine systems, nor that environmental damage threatens the support base of man himself at a time when his population is still explosively expanding and his per capita consumption is increasing.

Inevitabl rotection of coastal and marine s stems will interlock with the Law of the Sea. I have spo en of man's dependency upon the sea as the "marine revolution", in analogy with the previous, and still continuing, agricultural and industrial revolutions (Ray, 1970). The point was made that traditional legal systems for the sea are not in accord with what we know of marine systems and although that paper is out of date, one still finds only a modicum of ecosystem thought in the LOS discussions. There is still an over-riding concern for "yields" and "products" and a weakness in the formulation of long-term objectives. And there is very little planning which identifies systems as the proper units for management. These matters were examined at a recent Workshop on the Conservation of Wild Living Resources (Anon, 1975) which stressed the failure of international management of ocean fisheries. World catches have increased, but the rate has slowed despite an increase in effort and some marine resource populations have not proved able to withstand fishing pressure. The Workshop redefined some principles of the 1958 Geneva Convention by the addition of several emergent ecological principles. Most significantly, it defined resources as parts of their ecosystems and called for conservation of ecosystem and population stability. Peculiarly, neither the Workshop nor LOS discussions seem to have considered in much detail the relationships between coastal and open ocean jurisdictions and management, nor the role of critical marine habitat identification and protection.

Clearly, systems cannot be divided on the bases of legalistic proclamations about territorial limits any more than they can be separated by what is a "product" and what is not. The first is a largely economic spatial decision, the second a value judgement, and both are ecologically unsound. A current example concerns the role of the Waddensee. The value of this area as a nursery ground for international fisheries is well known biologically. Living resources, that is renewable ones, are clearly of greater value than non-renewable ones, as there is no theoretical limit on the time during which they may be exploited. Yet the decision by some coastal states which have jurisdiction over the Waddensee, or which influence it by pollution, is reverse - its value is seen as more important as real estate, as a dump, or for extraction of various non-renewable resources. What responsibilities do coastal states bear for stewardship of this critical habitat which clearly influences an entire ecosystem beyond their jurisdiction? What is the ecological unit, how can it be legally described and how can it be managed? One hopes that the UN Conference on LOS will come to terms with such questions.

Law of the Sea discussions and sub-discussions go on, seemingly ad infinitum (and often ad nauseam), but in the meanwhile, part of the answer to marine conservation is national and regional efforts to set aside parks and reserves. Genetic and ecological systems are valuable national and international resources which are theoretically perpetually renewable, but which are fragile. When they are gone, they are gone with finality. Mankind must protect samples of each major and minor type of habitat and community in order that ecosystems themselves will be made known and protected. In the history of conservation, early efforts towards the establishment of reserves dealt largely with species protection, mostly those that were endangered or of interest to sportsmen or commerce. Associated with this was the protection of areas of scenic or historic value; still, the intent was to preserve what was conceived "endangered" and the objectives were not truly ecologic. How could they have been? The science of ecology did not truly exist at that time. Later, habitat protection came to be entrained in these objectives, but it has been all too recently that we have realized that in very few cases indeed are "protected" habitats large enough to preserve the elements necessary for their continuity or the species they contain. A reason for this is that the natural communities which we seek to protect are not stable in time or space nor are they independent of their ecosystems. Migratory species, as many fish and marine mammals, are only protected in part by reserves set up for them. Further, the limited size of reserves implies that there will be loss of species and genetic diversity and control over the fate of the reserve is not possible within the reserve itself. What we will be left with in the end are a series of fragile, simplified habitats in an otherwise altered land or seascape, that is, "islands" which are highly unstable and which can hardly be called "natural" at all. These statements rest on the theoretical work of MacArthur and Wilson (1967) and upon such analyses as those of Diamond (1975) and Terborgh (1974). These have important implications in conservation.

Thus, very recently and largely through the rise of ecosystem science, we have come to know that what is really vital is the preservation of processes - evolutionary, genetic, and ecological. This is something we do not sufficiently understand, but it is not altogether intuitive. For example, we know of nutritional processes involved in the detritus food chain which makes mandatory the preservation of coastal productivity (Darnell, 1967; Odum and Heald, 1972). We know of nutrient "short circuits" in the sea whereby organisms moving through ocean boundaries transfer nutrients in ways that current structure cannot explain (Walsh, 1972). We also have begun to understand the important role of predators. In large fresh water systems the crocodilians have been shown by Fittkau (1973) to be important in nutrient cycling and pooling, and the loss of these predators may result in a decline in local fisheries. How extensively this may apply to marine systems is not known, but analogously, Estes and Palmisano (1974) have indicated the importance of sea otters, Enhydra, in maintaining the complexity and productivity of their inshore habitat through their dietary habits, alterations in herbivore populations, and resultant changes in aquatic vegetation. These results are exactly opposite to the widespread feeling that getting rid of predators will leave more for man's harvest or has little ecosystem effect! They also serve to remind the oceanographic community of the importance of predators in maintaining oceanic ecosystem stability, a feature which has been regrettably too little considered in their overwhelming emphasis on primary productivity. The role of large predators in nutrient transfer, nutrient pooling, and the maintenance of prey diversity ("predator effect") has been established for terrestrial systems and there is increasing evidence that this applies for aquatic systems too. Paine (1966, 1969) has identified "keystone" species as those which have a major environmental effect. The identification of such species is of profound importance.

All components of ecosystems, large and small, play a part in the maintenance of ecosystem structure. Woodwell (1974) warns about the consequences of loss of this structure. He issues a clear warning about the exploitation of the "assimilative capacity" of living systems, a bit of jargon that has come to be a standard of dangerous compromise; indeed "assimilative capacity" is a bit like "no significant effect" in that neither may exist for many of man's perturbations. Woodwell further states: "Clearly 'stability' at the level of the biosphere is of advantage to man" and he cites a lawyer's maxim in a plea for an international "no release" policy for pollutants: Sic utere tuo ut alienum non laedas or "use your own property so as not injure another's".

In a related sense, Holdren and Ehrlich (1974) call to our attention the "natural services" of natural systems: food production, conversion of wastes, control of the majority of pests and diseases, and storage of genetic information. No technology of man, now or in the foreseeable future, can perform these services to the extent necessary for our present civilization's continued support on this planet. They also point to a vastly important fact of life, that man emphasizes the productivity of systems, whereas nature emphasizes stability. No more pertinent example can be found for the man-nature conflict. Thus,

ecosystem evolution progresses towards no net community productivity because mature natural systems recycle nutrients efficiently. Man's "systems", such as farms, are simplified and recycling is minimal. Further, we cannot depend on the oceans to solve the conflict. Holdren and Ehrlich point out that its vast bulk is deceiving; 99% of oceanic productivity takes place under 10% of its area and half of that is in the 0.1% where coastal upwellings predominate. According to late FAO figures, we are already harvesting over half of the potential protein of the sea; at the same time, we are destroying the sea's production potential. What the result has been on stability is not known, but clearly there is conflict with natural processes and services.

I have previously attempted to emphasize the ecosystem approach to marine parks and reserves (Ray, 1972 and 1974). Ray and Norris (1972) have emphasized the "regional management" approach to marine resource management. This means that we must place our efforts on two levels, the first of which involves systems concepts and the second of which involves implementation; put another way, we must evolve a strategy for marine habitat protection and, flowing from this, a technique for procedure. We must employ multidisciplinary efforts and effective information transfer so that our efforts will not be isolated. And we must do these things rapidly.

These are complex issues, but we must not await the accumulation of complete knowledge - an impossibility, anyway - before taking significant action. Wallis (1971) was among the first to review the marine parks of the world. He laments that "past conservation action has stopped, to a great extent, at the edge of the sea; resources beyond were 'out of sight, out of mind'". As far as parks were concerned, he was absolutely correct. Björklund (1974) gives the most recent review of marine parks and we see that even now these protected areas are pitifully few. Even more notable, there are few nations which have taken the ecosystem approach to marine conservation and none which have truly implemented it. That is, the park/reserve/sanctuary concept ranks high, but what has not been considered in nearly enough detail is how their establishment will make enough of an impact on man's perturbations so that present trends may be reversed or at least intelligently monitored. This clearly involves considering the long-range biological health of protected areas, their relationships to the marine and terrestrial ecosystems on which they are dependent, and their utilization for research and monitoring. Utilization for recreation, as implied by "parks", is certainly important, but remains subsidiary to these broader ecological objectives.

Other aspects of this problem are that "parks" and "reserves" are set aside by boundaries which are almost always ecologically "leaky" and the very action of "setting aside" raises conflicts with those who often would benefit most from marine conservation. Most notably, sport and commercial fishermen need more, not less, conservation action in order that the natural productivity on which they depend may be preserved. However, fishermen often stand against reserves in fear

of losing "rights". Similarly, hotel and property owners fear losing property value. Strangest of all, some who purport to appreciate the beauties of the sea (shell and coral collectors, for example) do not wish favourite areas to be put off bounds, but continue to exact a stupendous toll from the sea. Therefore, park and reserve establishment is seen by many to be in competition with their interests, when actually it is precisely the opposite.

Another aspect concerns the setting aside of "research natural areas". Many short-sightedly object to the removal of areas from full utilization by the present generation. On the other hand, Moir (1972) points out that to some, conservation requires development; they object to large areas being devoted to narrow scientific and educational purposes. Is not knowledge of how systems work at the heart of the matter? That is to say that even though we overcome obstacles, our vistory may be Pyrrhic. It is not sufficiently appreciated that such action will result in only limited ecosystem-process preservation. The most vital use of such areas may lie in the monitoring of man's actions, in research, and in the use of these efforts to mitigate those actions through modification of them. Research and monitoring in natural areas must determine which of man's actions are compatible, which prohibited, and which to be modified. The standard must clearly be ecological, not socio-economic, and these determinations must be made on a site-specific basis (McCormick, 1975).

There is a great difference between developed and lesser developed nations in their approach to these issues. The former tend to be "preservationist" and the latter seek "development". But with regard to monitoring of man's actions, their needs converge. The Man and the Biosphere Project 8 on "Conservation of Natural Areas and the Genetic Material They Contain" clearly recognizes this and has made an effort to define "biosphere reserves" (UNESCO, 1974) which we find to be the closest present approximation between reserve purpose, ecological reality and the desire of many nations to monitor and control development. But it must also be emphasized that these reserves do not replace the older "park" and "reserve" definitions; rather they augment the park concept.

> "The concept of biosphere reserves involves a broad philosophy of conservation. The great changes in the world in the last decades have made it clear that a new dimension in conservation action is required, to provide both for the perpetuation of the earth's living resources in all their variety, and for the proper study and understanding of the change affecting them - for the future use and enjoyment of mankind. The international network of biosphere reserves is intended to provide this new dimension by the maintenance of ecological processes on an appropriate scale. The concept of biosphere reserves may be viewed as an approach to maintaining the integrity of biological support systems for man and nature throughout the whole biosphere. As such, it involves conservation, restoration, and the acquisition of knowledge for improving man's stewardship of both the domesticated and wild countryside". (Emphasis supplied).

I have underlined what I believe to be the most salient thoughts which, if understood on an ecosystem level, describe the magnitude of the task before us. Indeed, the emphasis on processes and stewardship is no small matter. No longer can the "setting aside" of marine areas for their amenities alone, as "parks" imply, be our isolated purpose, for the ecological health of such encompassed areas cannot be guaranteed by this means alone. We must also learn to think in terms of the health of the system within which reserves are located. No longer may we delude ourselves by calling park establishment "ecosystem protection". Further, the surveys we undertake for the establishment of marine parks and reserves must incorporate a new level of sophistication far beyond the level of platitudinous recommendation.

It is widely recognized that a classification scheme for biotic provinces and habitats is a necessary first strategic step to guide an inclusive selection of reserves. It should also serve to build redundancy into the reserve system to circumvent loss from natural catastrophes or the inadvertent activities of man. It is not possible to define marine biogeography in detail at present, but it is possible to erect a pragmatic schema. Therefore a tentative classification has been provided in the form of a companion paper to this one (Ray, 1975). This is, necessarily, a brief summary and is to be taken as a possible point of departure only. Dasmann (1972, 1973a) and the IUCN (1974) have suggested classifications for terrestrial biotic provinces, emphasizing vegetation. It would be facile to say that a vegetational classification of marine biotic provinces is impossible, yet there are some habitats for which it is essential, namely sea grass beds where the nature of nutrient recycling closely approximates the terrestrial condition and where vegetational characteristics predominate. Unfortunately, no comprehensive vegetational or floristic classification for the sea exists. Presently, water mass characteristics, in combination with benthic structure and zoogeography, dominate marine classification schemes, placing a level of complexity and dynamism on them with which those who deal with terrestrial systems are not usually familiar.

A second sort of classification is that for protected areas, and it crosses both technique and strategy. That of Dasmann (1973b) poses some difficulties when applied to aquatic systems as there is probably no such thing as a "strict nature reserve" anywhere in the sea. Downstream effects and the mobility of the living and non-living constituents of the hydrosphere mean that only a very loose definition of this term in coastal or marine environments is possible. Nevertheless, we do not propose to argue such points in detail here. Dasmann's terms are quite sufficient for present purposes, though this paper attempts to redefine and simplify them explicitly or implicitly.

The Lamb misus'd breeds Public strife
And yet forgives the Butcher's Knife

Auguries of Innocence

William Blake

But who are those that see no such dichotomy, who depend upon, love, worship, cajole, fear, use, or misuse their environment directly, and who have neither "public" nor "butchers"? Conservation is an activity required because of the impact of industrialized, "biosphere man", whereas "ecosystem man" had no need of it. These terms are used by Dasmann (1975a) to highlight the difference between "all of the members of indigenous traditional cultures and some who have seceded from, or have been pushed out of, technological society" and "those who are tied in with the global technological civilization". Dasmann draws on the term "future primitive" of Gorsline and House (1974) for a new direction in both life styles and conservation: "This does not mean the rejection of the best of modern technology, but it does mean the avoidance of the worst. It does mean using the tools and energy that are still available to create something permanent, to create a way of life that can be sustained. In such a way of life, nature conservation would necessarily be taken for granted, since people will recognize that their future depends on the health and diversity of the natural world." Dasmann (1975b) enlarges on this issue, calling attention to the need to push responsibility and authority back to a more local level, reminiscent of Schumacher's (1975) marvellous title: "Small is Beautiful. Economics as if people mattered".

Recently, I have queried: "How can tradition, utilization, and conservation be made compatible in the sea?" (Ray, 1975), also pointing out the many conflicting traditional uses of the sea and the rapidity with which new traditions become incorporated into culture's fabric. What is not traditional is an ecological basis for human behaviour. It would be a great error to equate traditional, subsistence cultures or ecosystem peoples as "right" and industrialized peoples as "wrong". The above definition of Dasmann avoids doing so.

Yupiktak Bista (1974), a publication of an Alaskan Eskimo corporation, asks the fundamental question: "Does one way of life have to die so another can live?" It reminds us: "When the balance or circle of life as it has been called is broken, birds and fish and animals begin disappearing from the land. When they are gone, so are the people who depended on them...Poverty has only recently been introduced to native communities. Up until a hundred years ago people were living a finely balanced economic relationship with the land." This is a moving statement, but does it still represent a useful position for traditional culture and if so which ones and to what extent? Surely there are places where "cultural impact statements" need to be made as much as "environmental" ones, in the face of "development"!

There is a mandate that conservation, no less than exploitation, recognize traditional and substence rights. This not only cultivates good will but is part of the fabric of simple justice. Nevertheless, "traditional" activities do not long remain compatible with either their own origins nor with the dynamics of ecosystems. They are subject to external influences and changing technology in exceedingly subtle ways which often escape the attention even of social anthropologists. They also change through the increase in populations of peoples recognized as "traditional" or "aboriginal" or "subsistence-oriented".

How will it be possible to reconcile these problems? Perhaps "ecodevelopment" is an answer. The Government of Papua New Guinea has tentatively defined a set of guidelines, quoted here from IUCN (1975):

"1. All our people have the right to a safe, healthy, productive and culturally satisfying environment which permits a life of dignity and well-being.

2. We are the trustees of the environment for future generations and our approach to development must reflect this.

3. Pollution of land, air and water in quantities which cause the degradation of the environment must be controlled.

4. Habitat and wildlife management must receive consideration in planning our development.

5. Protection and enhancement of the environment requires education directed toward living with our environment."

These guidelines recognize the people's rights to be involved in decisions about acceptable patterns of development. They recognize cultural and environmental values together and the danger in sacrificing these for short-term economic gains. They are close to the concept of the "future primitive", i.e., the achievement of a world-wide ecologically and culturally sustainable way of life. The true meaning of "ecology" is brought back for "ecodevelopment" unites man and nature.

It is particularly important to develop means by which marine conservation may be integrated into patterns of ecodevelopment, building from local knowledge and customs, and taking into account traditional uses of the sea. Such an approach would link conservation with increasing the economic welfare of people in ways that are ecologically sustainable and can therefore be enduring. This will not be accomplished by the same means everywhere. There is no more a social common denominator than an economic one for describing "value". As McCormick (1975) points out: "A written document organizes and presents alternatives, but the same policy cannot always be applied effectively everywhere. Local accommodation to specific needs and problems is the best means of safeguarding the critical habitats to be protected." This does not imply a dilution in effort, but rather the gaining of strength from parallels

between culture, ecosystem, and the aspirations of people. Ecodevelopment needs to be explored as a means to that end. The nature of parks and reserves will be dramatically different in various parts of the world as a result.

Man is forced, pending much greater ecological know-how, still to place as his highest priority the protection of ecosystems and to interfere with them as little as possible. He is far from control by means of knowledgeable manipulation. Therefore he cannot place socio-economic values before ecological ones. Yet, to imply a sharp line be drawn between the two would be a great mistake. Unfortunately, conservation is yet in its infancy in uniting the two.

The Nature of Marine Ecosystems

Before we proceed, it is useful to consider the nature of the seas in general and the transitional/dynamic nature of the coastal zone. Three considerations are paramount. First, no-one owns most of the sea and this vast area of res nullius or res communis, whichever the approach to resources, impinges in important ways upon areas of national jurisdiction. Second, our knowledge of marine environments lags far behind that for terrestrial environments. Third, ecosystems are the largest functional units of the natural world, characterized by recycling of materials and properties of homeostasis.

The following salient points on the nature of marine and coastal systems are adapted from Ray and Norris (1972), Cronin, ed., (1974), and Darnell (in litt.):

1. Size and Mobility. The scale of marine systems confounds thinking based on terrestrial models. The largest ecosystems by far are marine and we cannot aspire to include them, in toto, in parks and reserves. Certain exceptions to this statement exist, of course, but this is a general pattern with which we must cope. Whereas large-scale mobility or migration of major ecosystem biomass is more the exception terrestrially, it is the rule at sea. Whole fractions of ecosystems move great distances, limited only by behavioural and physiological tolerances, or by the sessile or sedentary habit of some species.

2. Predominance of Water Current Among Environmental Factors. Of all the factors of the aquatic environment, water current is probably most important in the lives of marine organisms, and an understanding of water currents is basic to aquatic system management. Currents provide transport for many marine organisms and their development stages. They transport chemical nutrients and particulate food. They bring in oxygen and remove wastes. Their force determines, in large measure, which species may exist in an area. Currents also determine the quantity of freshwater and saltwater which enter an estuary and the overall

circulation patterns may determine the temperature of a protected body of water. They also trigger events. Management of a coastal or marine area rests on maintaining the normal current patterns as well as their seasonal volumes and regularities. Management must also be based on an understanding of currents in order to control upstream events which might reduce the quality of the water bathing in area.

3. Ecotones and Transition Zone. The shore and coastal zone do not separate land and sea, but unite them. Neither geologically nor biologically can the coastal zone be defined as a complete ecosystem; it is the interface between two systems and, characteristic of such ecotones or transition zones, is immensely productive as a result. For this reason, marine reserves should not end on the shoreline, but should incorporate adjacent land areas, either within their boundaries or in their management plan.

4. Boundaries. The sea is not a continuum, though the boundaries can be subtle. The sea's texture varies with eddies, circulation cells, currents, upwelling, salinity, and temperature, and any of these may form boundaries in addition to physiographic boundaries by which terrestrial environments are largely separated.

5. Dimensionality and the Living Hydrosphere. Life exists on land as a thin surface skin surrounded by an atmosphere which is uninhabited on a permanent basis; thus, terrestrial systems are largely two-dimensional. The sea is a "bouillabaisse" of organisms, nutrients, degradation products, inorganic chemicals, and pollutants. This "living" quality of the hydrosphere, in contrast with the "abiotic" atmosphere, adds a third dimension of large scale to marine systems.

6. Physiological Continuity. Most aquatic animals are not "sealed off" by virtue of a relatively impervious skin, as land animals largely are. Most aquatic organisms are in physiologic continuity with water and are generally very susceptible to foreign substances, pollutants, or nutrients, which enter their bodies with facility, then quickly are incorporated into the trophic structure. Exceptions, of course, are the air-breathing "re-entrants", i.e. the aquatic reptiles, birds, and mammals.

7. Inverted Pyramid of Biomass. Terrestrially, the greatest biomass is found in primary producers; much is locked into the "bottleneck of ecosystems", cellulose, which is slowly degraded and recycled. Aquatic systems, with the notable exception of algal beds, sea grass beds, and some reefs which are dominated by algae, do not have the greatest biomass at the lowest trophic level. Rather, phytoplankton productivity compensates for the lack of biomass so that production on an annual basis is very great, but the amount of plant material present at any one time is usually far less in weight per unit volume of habitat than that of the consumer levels.

8. The "Sink", "Downstream Effect", and "Short-Circuits". Ultimately, rainfall and land drainage carry terrestrial and atmospheric nutrients, pollutants, and silt to the sea. Thus, the sea has been called a "sink". Forests, estuaries, and marshes are natural "filters" which retard the process of passage of products, either harmful or beneficial, to the sea. The "downstream effect", as the name implies, refers to the mobility of silt, pollutants, nutrients, and organisms over great distances and to the effects in their wake. Organisms and their food chains move through oceanic features both laterally and vertically, often against currents, and provide "short-circuits" (Walsh, 1972) to nutrient and pollutant transfer, the magnitude of which we have only begun to suspect. These are among the features which make the protection of marine environments so very difficult.

9. Eutrophy. Oxygen supply is taken for granted in terrestrial environments, but it can be critical in the sea. Eutrophy refers to the over-enrichment of a body of water so that it becomes so productive that the biological oxygen demand may reach levels beyond the oxygen supply, thus depleting this vital substance and causing anoxic conditions. Large-scale die-offs of oxygen-dependent organisms may result. Particularly vulnerable are estuaries, lagoons, and the relatively stagnant bottom waters of fjords, enclosed seas, and oceanic trenches. The danger to trenches may be a surprise to some, but the suspicion grows among marine scientists that the life of trenches is presently endangered by the degree of dumping that occurs in some of them. Should organic wastes be dumped there in sufficient quantity, those poorly circulated waters could become anoxic and much of their characteristic biota would perish.

10. Dynamism. Spatial and seasonal alterations of inshore features reflect some of the most dynamic of all natural processes, exceeded only by earthquakes, floods, violent storms, and vulcanism. Shorelines, dunes, banks, and shoals move to change the faces, even the boundaries, of whole marine systems. Dredging, bulkheading, channelization, damming of rivers, and other attempts to contain or alter natural geomorphological processes are usually doomed to failure and are creating great problems (Inman and Brush, 1973). It is difficult to establish reserve boundaries which encompass such natural alterations as the movement of inlets, banks, and beaches. It is also sometimes forgotten that natural geomorphological change creates new habitats critical to the existence of certain organisms; for instance, certain shore-birds depend on new or recently storm-scoured sand beaches. Such "sterile" beaches are not solely the habitat of the beach buggy!

Summation

Perhaps the point is now clear that the strategy for environmental conservation falls within the realm of ecosystem science, that it is an immensely difficult ecological-social problem, that the descriptive phase may begin systematically with the aid of a classification scheme, and that techniques of description and implementation should flow from this base. A lengthy discussion of conceptual approaches to marine

ecosystem preservation is not appropriate here; some thoughts on the nature of marine systems have been expressed and hopefully will suffice. The bulk of this paper is more related to establishing an approach than to theory; some aspects of this are difficult enough in themselves. For instance, for required detail, we will have eventually to employ workshops to elucidate such questions as: "What jurisdictional methods shall we employ to resolve conflicts between recreation, fishing, conservation, and mineral exploitation adjacent to or within marine reserves?" "What traditional values are ecosystem-compatible and which are not?" "What are the interfaces between land-oriented and marine-oriented conservation practices?" "How do geomorphological processes affect jurisdictions involved in marine habitat conservation?" "What are the indicator species which we wish to employ in the monitoring of reserves?" "What is the nature and extent of the buffer zone in protecting the core reserve?" "How will the many national and international agencies responsible for (or interested in) marine conservation coordinate their diverse (or conflicting) efforts?" These are among the many emerging matters which are dependent upon a sophisticated comprehension of marine systems. Most are already receiving some attention in various quarters, but integration of interests is not yet sufficiently strong.

In conclusion, there are two concurrent considerations. First, we must work towards the identification of "critical" areas and the "buffer" zones upon which the integrity of the critical areas depends. The selection and description of critical areas must be done in such a way that many national and regional efforts are compatible and comparative. The selection of what is "critical" must be according to a set of agreed criteria. Some specific reserve function or set of functions for selected areas must be identified from the start. Second, we must work to evolve a context for operation, based upon a classification scheme and a format for information gathering for marine and estuarine habitats. These two aspects should evolve together, not necessarily sequentially, and guidelines for conservation management will evolve directly from the level of our understanding on all levels, ecological to social.

The rationale is: given we do not understand ecological processes well enough to be able to predict the effects of man's perturbations; given our desire to protect the integrity of nature; given that marine and estuarine systems are too large to protect by means of reserves in their entirety; given that the existence of a diversity of biotic provinces, habitats, species, and cultures of man is probably reflective of ecosystem processes in all their complexity; therefore, let us set about assuring that diversity in all its aspects is represented in protected areas for the principal reason of understanding those processes and formulating procedures for man's actions which will neither jeopardize them nor - in the long run - man himself. As a corollary, we must see our efforts not merely directed towards the protection of pristine remnants of man or nature, but also towards the restoration of habitats within already devastated, despoiled, or

perturbed areas (New York Bight, Florida's coast, the Baltic and Mediterranean Seas, the seas about industrialized Japan, some reefs of East Africa, Hawaii, etc.). We must allow that man will soon have within his grasp the improvement of many areas as, for instance, is indicated by our stated desire to develop mariculture and to maintain the productivity of wetlands.

There are clearly ecological, life-style and philosophical matters to be considered in our endeavours. Not all people or places are the same, nor should they be. The study of history, archaeology, and palaeontology give us a sense of the past and the fact of evolutionary change. The science of ecosystem ecology, with man as an integral part of nature, can aid in the development of the ethic that the only "reserve" is the Earth itself. The preservation of bits and pieces, as "parks" or "biosphere reserves", is an essential interim measure which will be necessary so long as man cannot police himself and remains ignorant of - or ignores - natural processes. Ecosystem science, in our view, is thus essential, both in the reduction of ignorance and the evolution of ethical values.

BACKGROUND ON DEFINITIONS AND PRINCIPLES

Terminology

Definitions are important, but must be interpreted with flexibility. It is not useful to quarrel over semantics though it is obvious that terms have quite different meanings according to language and local customs. The vital matters are that habitats be preserved, that the purpose of protected areas be well-defined, and that they be managed according to ecological knowledge and a set of enforceable and realistic guidelines, not that names merely be applied to areas for which there is no real management or stated purpose.

Nomenclature falls into two categories, title and function. By "title" is meant simply what we call the area. Function is considered below. Dasmann (1973a) considers aspects of both for terrestrial protected areas, but it is my belief that we can make a simpler effort here. Belying this is the summary given by Björklund (1974) in which 52 marine reserve names are now in use! Nevertheless, a few examples may suffice to clarify. Blumberg (1974) describes "sanctuaries" in the Commonwealth of Massachusetts; these actually describe administrative zones for control or prevention of activities on the sea bed, such as construction, removal of sand or gravel, incineration, dumping, and the discharge of coolant water. Thus, such a "sanctuary" is hardly complete, but serves critical control purposes. The U.S. Department of the Interior (1973 a, b, c) takes a broad view in defining an "ecological range" as encompassing entire or nearly entire biotic units or ecosystems substantially unaltered by the actions of man and "areas of ecological concern" as those which "contain resources that are part of the total ecosystem; and which if compromised, could endanger resources within the proposal". Clark (1974) identifies "vital areas", "areas of environmental concern", and "areas of normal concern" which he notes are analogous to the "preservation", "conservation", and "development" zones established by the State of Florida (see also Johnson, 1974). Last, "research natural areas" describes both title and function and is a name extensively used in the U.S. It is even incorporated into the Federal Committee for Research Natural Areas which is currently attempting to identify such places where study can be made of gene pools and the structure and function of natural communities to provide baseline data for long-term monitoring of environmental quality.

In short, names are important, but they should not cloud the major issues of ecosystem preservation through the establishment of a series of reserves. For purposes of this paper, four terms (titles) are paramount:

1. Reserve. An inclusive term for any area which is set aside for special purposes and for which management guidelines are established. Most of Dasmann's (1973b) terms apply. Thus, a marine

"reserve" may incorporate only the single purpose of a moratorium against such exploitation for a region within which few other restrictions exist or of setting aside an area to protect breeding grounds for which there has been no previous protection. Other reserves prescribe against certain deleterious extractive use, for example oil, gas, sand, or gravel. Still other reserves may emphasize scientific research (i.e., research natural areas) or sporting activities. "Strict" nature reserves may forbid all trespass except under permit (Antarctica's Specially Protected Areas). "Sanctuary" is a kind of strict reserve, but with widely varying application (cf. Lynch, Laird, and Smolen, 1974).

2. Park. A kind of reserve in which recreation and/or public education are emphasized.

3. Core. The park or reserve itself which incorporates the "critical marine habitat". In many cases, more than one "habitat" is included. In others, historical or archaeological sites comprise the central feature.

4. Buffer. An area adjacent to or surrounding the core and upon which the core depends, or vice versa, in the ecosystem sense; i.e., an "area of ecological concern" as it is sometimes called. This is the hardest term to define. What is "critical" may not be known. Once a core area is acquired, it may prove not to be the critical one or, in the case of geomorphological change, it may move. The difficulty lies in the identification and prediction of natural processes.

Reserve Function

Protected areas or those managed along sound ecological principles serve a number of highly relevant purposes. First, they tell of natural processes and serve as areas in which to measure man's perturbations. Jenkins and Bedford (1973) emphasize the importance of environmental baseline data. As Moir (1972) puts it: "A greatly augmented, purposeful, national and global natural area system can provide an invaluable biological basis for measuring man's impact, and his future security, on this planet". Ecosystem research, especially that which is process-oriented, is central to this task and reserves must be set up in some of the most productive and desirable places, in terms of value for exploitation, so that we may do research towards the development of predictive capability. Second, reserves serve to protect species and habitats which are endangered by man and which embody unique processes and/or genetic materials. Obvious candidate species are large vertebrates such as birds, marine mammals, turtles, and crocodilians. Obvious candidate areas are productive estuaries, mangroves and coral reefs. There are several other functions, but what parks and reserves cannot do is survive intact outside the context of the ecosystems of which they are only a part. Thus, buffer areas must be established to include the support systems which usually derive largely from outside the core areas.

The preceding relates to the identification of natural ecological units, such as habitats or communities or ecosystems. There is another rather different, but no less important, use relating to education, the preservation of cultural values or of traditional use, and the continued appreciation of nature's amenities by mankind in general. The two might be contrasted by saying that the former is ecological, the latter cultural, but a false dichotomy between man and nature must not be erected. Eco-preservation and eco-development enmesh the two inseparably.

We must now relate terminology (which is less important) with function (which is all-important). The former simply describes a three-dimensional space. The later describes our philosophy and use with regard to that space. Surely, the two are difficult to separate, or inevitably semantics suggest both; the point is not to let semantics interfere with our intent. To that end, I offer a condensation of functional definitions which have been widely used heretofore:

1. Habitat preservation. These areas are primarily for protection, and management of essential or specialized area components of marine systems. The management emphasis is on preservation so that representation of the diversity of habitats in the coastal zone and adjacent waters shall be maintained. Preservation of endangered species and habitats must, by definition, involve unique areas either because man has eliminated a component of the area (the endangered species) or because similar areas no longer exist. Long term research is essential for the continuation of these species or habitats, including natural population studies, reproductive biology and recruitment rates, energy flow and nutrient recycling, carrying capacity, husbandry and pathology, impact of perturbation and the extent of the buffer zone, and alternate areas for propagation of endangered species. However, studies should be on a "not-to-interfere" basis, so are primarily observational with a minimum of sampling. A notable exception to the latter point is: what to do about preservation of subclimax conditions? This will require careful management, especially in small reserves where limits of space interfere with creation of new habitat.

2. Species preservation or conservation of genetic resources. In order to maintain species populations there must be a diversity of areas for protection of migratory pathways, spawning grounds, nursery grounds, and feeding areas. In some cases this involves the preservation of existing conditions, in others the re-establishment of former inhabitants. In all cases, research will be mandatory for the clarification of environmental correlates with the particular species' presence or abundance. In other words, why is the species there, with what does it compete, and why are there as many (or as few) as there are? The same statement with regard to subclimax stages applies here as above.

3. Research. These areas are for scientific research, monitoring, and to establish ecological baselines against which to compare and predict the effect of man's activities. Most important,

they are necessary to develop an understanding of natural processes, without which neither reserves nor man himself can survive. Two basic subdivisions are possible: (a) "natural history" in which observation and a minimum of manipulation are involved. This, contrary to some opinion, may involve extremely sophisticated methodology, such as remote sensing and telemetry. The emphasis is observational which is the only type of research to be permitted within a strict natural area; (b) "manipulative" in which some disturbance is essential in order to comprehend ecological processes. A particularly important example requiring manipulation involves successional stages, emphasized above. Cronin, ed., (1974) considers research in greater detail. Randall (1969) emphasizes the importance of natural area preservation near marine laboratories: "More than one marine station has all but lost its raison d'être because of pollution, shore alteration by dredging or filling, or by excessive collecting of marine organisms in the vicinity".

4. Recreation education and aesthetics. Such areas protect scenic beauty and/or complement and enhance areas for enjoyment and education of the public. Education and training should be on at least three levels: public education, training and education of park specialists and environmental managers, and higher education and research. There are several types of educational and recreational activities from those having a close relationship with sport to those which appeal to the artist -- or both. The latter is a highly personal matter and no strict definitions are possible, or should even be attempted. However, an essence to be emphasized is that interpretation may take many levels. An imaginative and creative interpretative programme is one of the key elements or potentials in marine parks. Films, displays etc., will be important to inform possibly unfamiliar groups about the marine environment.

5. Special or cultural purposes. Unique areas may be necessary to protect geologic or oceanographic features, for instance the Phosphorescent Bay in Puerto Rico, a habitat type which is rare elsewhere, and even degraded there. They may also protect a cultural heritage. The latter point is important. Auburn (1974) states that: "Over extensive areas of coastal seas, skin divers have already looted and destroyed a considerable number of ancient wrecks in shallow waters". Protection of such sites is a difficult, often controversial, matter. "Wreck-hunters" have been a dominant feature in the scuba-world and, whereas many discoveries of value have been made, many sites have also been destroyed by those of selfish or greedy motivation.

6. Multiple use. Cronin, ed., (1974) examines this term from a largely ecological standpoint. All that is really intended is an expression that several purposes may be carried out continuously or contiguously in a reserve. This requires careful management, but is not to be taken to mean a dilution of one value to the advantage of another.

such as has occurred in some forest reserves which also purportedly have broad scientific and wildlife value, but in which the latter are clearly secondary. A current example of multiple use in the sea is the oil and gas industry's acceptance of "sanctuary", but only insofar as the industry is not excluded (Hay, 1974).

Now we have two sets of terms, area descriptive and area functional. A combination is necessary for full description: i.e., "a reserve for multiple use", "a park for education", "a core area for the preservation of a coral reef", "a buffer zone for research, education, and for natural successional change", etc. In any case, the two sorts of titles should be clearly defined.

In conclusion, I cannot emphasize too strongly the need for incorporation of research and education within all reserves. The threat of man's activities to natural ecosystem health and stability pose critical problems for civilization's survival. Systems of national and international marine and estuarine ecological reserves, embodying genetic and ecological diversity, should be subject to investigations on the scientific basis of preservation. Reserves should be "reservoirs of biological species, physical phenomena, naturally functioning communities, and existing habitats" (Lynch, Laird, and Smolen, Eds., 1974). Not only must rare and endangered species and habitats be studied under a variety of conditions so as to evolve procedures for their continuity, but the structure and function of natural ecosystems must be studied, as opposed to those stressed by man's activities. From such study will emerge baseline data for long-range monitoring and a cadre of trained personnel to do the work. By means of educational programs, a better-informed public may prove able to make better and less costly environmental decisions.

Thus, the function of reserves is primarily preservation, but also incorporates education, recreation, and especially the potential for research in its fabric.

Management Principles

The following suggest a basic philosophical and practical approach to critical habitat management and are a condensation of much of what has already been stated.

1. Ecocentrism. Strong arguments for socio-economic (i.e., homocentric) decisions on land use persist. There should be no man versus nature dichotomy in resource decisions. On the other hand, socio-economic issues should be secondary to ecocentric ones in the decision-making process. The nature of ecosystems is our paramount concern, not to be diluted by overriding concern for monetary value, non-conforming social custom, or "needs" and "desires" which may result in deleterious environmental impact. The education of social scientists, lawyers, businessmen, engineers, politicians, and economists in the essences of ecosystem dynamics is a goal worthy of pursuit.

2. Conforming use and controlled growth. When numbers of peoples are small, use may be less important to control. However, the concentration of populations on the coastal zone requires careful control of man's actions there. Also, although no human populations actually live permanently on or under the sea, traditional and encodified Law of the Sea has promoted laissez-faire attitudes and common property uses there, most of which have not led to ecologically conforming use, in the sense that the objectives of man and ecosystem processes conflict. This implies controlled growth which may mean positive growth, negative growth, or no growth, depending on the area in question. Reserves serve important functions in the control of growth as well as in preservation, and one of their greatest values lies in the monitoring of growth as it affects ecological processes so that the biological support systems of the sea for man and other organisms will not be allowed to collapse as a result of man's perturbations.

3. Zonation, research and monitoring. The aim should not be only the identification and setting aside of critical areas; it is the zonation of the coastal zone and contiguous seas in the recognition of ecosystem structure and function, and of man's conforming use that is essential. Research and monitoring will lead to principles by which zonation can be applied. It will also lead to a flexible approach as is indicated by geological, cultural, or other alterations; i.e., zones will change in accordance with their use and ecologic health.

4. "Assimilative capacity" of receiving waters. This is a term of convenience used in the "engineering" of the environment. Surely, natural substances are assimilated, but the analogy should not be drawn that foreign substances and pollutants have a threshold concentration below which there is no "significant" effect on the ecosystem. It is probable that this concept is a myth, that we have simply not learned to recognize insidious, chronic effects. Odum (1970) mentions some of these with respect to estuaries. A "no release" goal for pollutants is to be highly recommended, even though difficult to achieve.

5. Site specificity. It is difficult to generalize management to cover all cases, from areas where maintenance of water quality is paramount for the maintenance of productivity, to areas where parks are established for tourism or where sanctuaries are established for species preservation. It is also difficult to extrapolate between the preservation of small representative or unique habitats and the large, systems-oriented Biosphere Reserves proposed by MAB and it is difficult to establish guidelines for the management of biologically similar areas which are subject to quite different political systems. Reserves should usually be set aside in perpetuity, but it is also desirable to establish reserves of a short-term nature where, for example, restoration and later use are contemplated. Reserves may be exclusive of any use by man or merely be areas wherein certain administrative guidelines are employed, for example, the prohibition of shell and coral collecting in Kenya's marine reserves. So it is

essential that the function of the reserves be made absolutely clear and that management proceed accordingly within both general principles and site-specific requirements.

6. Stewardship. Beaches move according to coastal currents and the impact of storms, and mangrove and marshes are highly transitory interfaces. In both cases, changes occur within human lifetimes such that serious jurisdictional and legal problems arise when the protected areas themselves move and undergo successional changes. How does one protect such dynamic processes in a world which seeks to stabilize habitats and boundaries? Purchase may prove so difficult and costly that perhaps it is useful to consider not the geographic boundaries involved in "ownership" or precise jurisdictional delegation, as reserves imply, but to turn our attention to "stewardship". This involves a highly imaginative approach to "reserves" and the solution of jurisdictional conflicts in unique new ways. The Coastal Zone Workshop (Ketchum, ed., 1973) identified some of these in the following categories:

   (a) Alternative means for regulation of coastal development besides the taking of private property (easements and the like).

   (b) Improvement of statutes and administrative regulation.

   (c) Increased access of all to administrative and judicial proceedings.

   (d) Establishment of local review boards for review of decisions.

   (e) Establishment within the judiciary of an Environmental Court with broad jurisdiction.

7. Public disclosure. This is, in most circumstances, to be highly recommended in all cases involving coastal development. However, some areas are so isolated, with difficult accessibility, as to qualify as "natural reserves" without protective measures being taken. Advertisement of their existence can, in some cases, precipitate exploitation, and care must be taken in disclosure of some of the best areas, especially reefs, in advance of their protection and specification of enforcement procedures.

8. Regional agreements. For a majority of marine and coastal areas, downstream effects involve the necessity for regional, international approaches to conservation. Such should be incorporated from the start, particularly with regard to pollution control and resource exploitation, but in areas where this is presently impossible, it remains an eventual goal.

9. Cultural and traditional values. This exceedingly difficult matter has been discussed above under Ecodevelopment (p. 19). The incorporation of such values into habitat preservation in a changing world involves the most careful, detailed, and sensitive consideration which must, however, be interpreted so as to avoid ecological compromise.

ECOLOGICAL APPROACH TO PLANNING

Marine and coastal conservation must proceed from a knowledge of marine ecosystems and their interfaces with the land. Such knowledge must derive from studies of processes under the controlled conditions possible mostly in reserves established for the purpose. There is simply no substitute, either in conservation or "enlightened" exploitation, for the comprehension of ecosystem processes if man wishes to maintain the productivity and integrity of the seas while he uses them. Thus, marine reserves should, wherever possible, incorporate research as a major objective. In addition, "planners" must incorporate a broader ecological base into their work.

Strategy

We cannot await detailed study before taking strong and definitive action! Therefore, the following suggests a series of practical steps, not necessarily to be taken in the precise order given, for the initiation of coastal and marine conservation, emphasizing biosphere reserves, on national and international levels. Steps 1-5 should be taken quickly. Step 6 is long-term.

1. Survey. The Classification Scheme (Ray, 1975) may be used as a background on the basis that habitat survey is reflective of ecosystem processes. The initial survey thus should include a summary of habitats and community structure within the survey area. It also should include a catalogue of perturbations so that it may serve to prioritize conservation action. This survey is to be a relatively brief collection of existing and/or easily acquired information. It should be as comprehensive of whole coastal systems as possible and should attempt to identify natural units irrespective of political or legal boundaries. It should also identify people and logistics essential to the following steps.

2. Selection. Critical areas inclusive of all habitat types may now be designated according to agreed criteria (see below). Priorities must be worked out, designating the most critical areas, i.e. those which are not negotiable in ecological terms. Also to be included are cultural and educational criteria, as their application will identify areas possibly not "critical" in the ecological sense, but also worthy of protection.

3. Description. Selected critical areas should be described in a computer-compatible form (see Area Description below). Area purposes should be identified, at least preliminarily.

4. Management Recommendations. The above steps should result in a concise and implementable report delineating both critical habitats and recommendations for coastal system conservation and management.

The Guidelines below may serve as an outline of subjects to be covered. A zonation scheme for use of the coastal and marine environment should be included.

5. Implementation. Authorities must put a coastal and marine conservation plan into action, either by executive action or enabling legislation. Both approaches usually are required as, for instance, executive action for the immediate protection of certain most critical areas or to cause cessation of harmful practices, followed by more detailed, programmatic national legislation.

6. Detailed Research and Management Refinement. An implementation programme will lead to the necessity to evolve detailed site specific guidelines and a research and monitoring programme. Research must be dedicated to the mitigation of man's perturbations, to restoration, and to the development and management of parks and reserves. Such a study must not omit socio-economic issues, but the major thrust still must be ecocentric. Thus, the investigation of the scientific basis for natural area and ecosystem preservation must include man, but it must not tread in fear of socio-economic and traditional policies and practices which clearly pose threats. The practical side of this question concerns the high priority effort towards the discovery of the legal and financial means by which preservation may be achieved. Research and management should be carried out so that feed-backs are generated leading to: (a) the formulation of new management policy based on the latest research results, and (b) the posing of new questions to the research community. The long-term nature of research and management, directed towards social adjustments, is to be emphasized!

Criteria for Selection

The Classification Scheme (Ray, 1975) should be used as a primary reference for the development of a system of reserves which shall be inclusive of habitat types and reflective of ecosystem processes. Included in this effort, we ask: "How inclusive of habitat types are existing reserves; what are existing management practices; how effective is present protection; and what among those habitats not already protected are suitable for preservation?". This leads immediately to the need for detailed criteria for further selection and for determination of reserve function.

Criteria may be used in at least two ways. First, they may be used to judge the quality or applicability of areas to fit the requirements and functions of reserves and, second, they may be used to determine priorities for the most suitable sites within a series of candidates. In either case, we should be careful not to pick only the single most qualified or few top candidates for at least two reasons. Foremost, we must incorporate considerable redundancy in a reserve system and, secondly, no two areas are precisely alike. The latter point involves a distinction between what is "representative" and what is "unique".

The various criteria should not be applied with equal priority to all candidate areas for the simple reason that area characteristics and functions will be quite different. It should also be obvious that the priorities will shift according to the purposes for which a reserve is to be used. A good deal of judgement in their application is necessary. The following is a list of criteria mostly derived from several sources (cf. Cronin, ed., 1974; UNESCO, 1974; James Dobbin, pers. comm.). The criteria are here arranged in three sets. Significant in its absence is a set of criteria pertaining to ecosystem man and eco-development, a set which possibly could be drawn from the three sets presented.

A. Set 1 - Ecological criteria

1. Criticalness. The degree to which important life stages or entire life histories of species are dependent on an area is an important criterion. Obvious cases are areas where rare or endangered species are present. Others include the feeding, resting, or breeding areas essential to marine reptiles, birds, or mammals. Examples are: Laguna Ojo de Liebre (Scammon's Lagoon), Mexico, for calving of Gray whales, Eschrictius robustus; Round Island, Alaska, as summer habitat of walrus, Odobenus rosmarus; the many essential feeding areas for shore birds and Sirenia; the many nursery areas used by fishes. In emphasizing these critical areas, we must not forget those of a different sort, i.e., those which are critical in terms of production or other processes. Thus, sea grass beds and mangrove swamps are critical areas for detritus production and for nutrient conversion to other production such as fisheries and coral reefs. That is, not only must the endangered, rare, aesthetically important species be considered, but we must also give increased attention to species of trophic significance, areas where processes are best exemplified, and upstream and downstream areas.

2. Representativeness and/or uniqueness. These two terms can be the extremes of a spectrum. A "unique" area is one that is rare, whereas areas which are representative fit well into the classification scheme, i.e., they are typical of biome or habitat types as they may exemplify processes, transition zones, ecotones, or subclimax situations of either undisturbed nature, or of interactions between man and nature such that some comparability between example areas is evident. On the other hand, unique areas (as the Puerto Rico Trench) can also be representative (oceanic trenches). In either case, unique areas, i.e., rare habitat or process examples, naturally rank high in priority as they are "one-of-a-kind". However, exemplary areas, i.e., the "best" sample areas among many representatives, rank equally high. In either case, extrapolation of the nature of ecosystem properties and processes to other areas should be attempted.

3. Diversity. This criterion often influences the size of the area to be preserved. It means the inclusion of several habitat types, successional stages, and biotic associations, such as lagoons, estuaries, various benthic types, associated river drainages, etc., within a single reserve. Whereas diversity shall have high priority, its lack should not mitigate against inclusion as certain areas are by their nature (mangroves, sea grass flats, etc.) not as diverse as others.

4. Naturalness. This is related to the degree of perturbation by man and, again, loss of naturalness should not mitigate against inclusion so long as some degree of restoration is possible. Care should be taken to include subclimax and transition zones and other areas which undergo natural change subsequent to natural disasters or perturbation. Care must be taken that "naturalness" does not exclude man's use. Semi-"natural" systems which have become stable under long established use practices may be included. Naturalness should not come to mean "degraded", however.

5. Natural Unit: Size and buffer zone compatibility. Areas to be preserved should be sufficiently large or buffered to allow natural dynamic change, biological or physical; that is, in so far as possible, "natural units" should have high priority. In case a buffer area is involved to incorporate this objective, its use and properties must be compatible with the core reserve area. In effect, size or extent shall be such than an effective conservation unit, biologically speaking, is created; i.e., what has been called the viability, defensibility, or integrity of the reserve may be maintained. In the case of marine and estuarine systems, this inevitably involves the difficult problem of mitigating upstream effects, whether generated from land, river, or sea. Hence buffer zone compatibility ranks especially high in these environments.

6. Inclusiveness. The lack of a habitat type in a reserve system is a strong argument for finding one or more to include. In some cases, undisturbed habitat types will not be available for protection or such sites will no longer be extant. Potential sites for restoration should be sought so that the reserve system shall be inclusive of all present or potential habitat types.

B. Set 2 - Cultural, Recreational, and Educational Criteria

1. Diversity and abundance. These relate to qualities of the species and/or habitats within the area. Values are interchangeable; for example, the great diversity of life of a coral reef ranks as a prime criterion, but the abundance of few species of schooling fishes in channels, estuaries, or swamps may rank just as high in other areas. When both abundance and diversity occur together, the area will have a very high priority from the point of view of the public.

2. Physiography and topography. Just as for terrestrial areas, these are important criteria. The scope and grandeur of a scenic area, especially in coastal or reef locations, contribute greatly to its value to the public. Scope and grandeur should, however, not be confused with size. Small areas have a grandeur of their own. This is obviously a matter involved with personal taste.

3. Uniqueness and rarity. The public is much attracted to one-of-a-kind locations and high priority should be attached to them.

4. Climate, weather and oceanographic conditions. Especially in marine areas, access is greatly influenced by these factors. Some areas, in fact, are rendered of relatively low use to the public because of difficult tidal or current conditions, low water visibility, frequent storms, high sea state, and low water or air temperatures. However, these features all fall into the category of "amenities". Such difficulties should not necessarily mitigate against inclusion, but they do often involve certain stringent safety regulations being imposed.

5. Cultural value. Sites of obvious aesthetic, historical, archaeological, anthropological, traditional, subsistence, or folklore value rank very high. These range in size from small areas wherein a shipwreck is protected, to a village or city now covered by the sea, to very large areas where traditional and/or subsistence activities of a whole people are currently carried out.

6. Scientific value. There are scientific values which bear little present relationship to pragmatism, but which are among the most important of all human values, as they relate to man's essential being. Asking "what good is science?" is like asking "what good is art?". Areas of scientific value, in terms of basic research, should rank very high, from the obvious cases of the Galapagos Islands and Aldabra, with their surrounding waters, to research or other localities of more local interest.

C. Set 3 - Pragmatic criteria

1. Value for research or monitoring. Reserves are an important source for study related to direct human use and high priority should be given to scientists' use now and in the future. This will depend on at least three factors; high scientific interest, past history of scientific research, and proximity to a user group of scientists which will monitor the area, use it for education, and transfer the information gained to the community at large as well as to management agencies. Lack of present use by scientists should not mitigate against this value.

2. Degree of threat or fragility. Remote environments will not rank as high in priority as those close to possible perturbations of man. Also, areas which are highly fragile should be considered first.

3. Feasibility. Is the site available? Can it be properly financed, managed, and brought under the jurisdiction of a stable agency with proper organic powers? If the site is potentially valuable, can it be restored? Such questions are central to the suitability of areas as reserves.

4. Redundancy. Care must be exercised not to exclude areas with the statement: "We already have one of those!" Redundancy is important in the establishment of a reserve system and is essential from the genetic and ecological points of view.

5. National or international value. The Galapagos Islands is an example of an area of obvious international importance. Aldabra and the Bering Sea and Laguna Ojo de Liebre (Scammon's Lagoon) are others. Marine and estuarine areas should rank high in priority as reserve candidates because of their contribution to international fisheries production and as habitat for migratory waterfowl, for instance.

6. Educational, recreational and economic value. Tourist value is often extremely important in economic terms. However, recreation is not always in accord with the "conforming use" principle. Deleterious effects often result to stress reserves beyond their carrying capacity (Second World Conference on National Parks, 1972) when purely recreational values are placed above ecological ones, i.e., when such areas are "developed" rather than properly managed. Education also emphasizes the public as a user group, but generally more care is taken to preserve natural values than when emphasis is purely on tourism. Both tourism and education require facility development, requiring usually land-based access, and precise knowledge of costs and how development may alter the habitats preserved.

Area Description

There are several stages in this process from the most preliminary and short-range to the long-range, scientifically detailed matrix of data necessary to develop precise guidelines for management and monitoring. Obviously, the first step is the simple process of listing candidate areas. The next step is that which we shall consider here, that is, the assembly of available information in a computer-compatible format which allows concise information transfer on a world scale and which allows planning of later detailed survey necessary for protection and management.

Very often, reserves of large size, especially "natural" ones, will not be in proximity to "experts" who will be able to develop management guidelines, much less to maintain a long-range scientific programme. It is part of the educational process to train such personnel and to develop such programmes for this purpose. Therefore, after an area has been identified as having value or interest, facts of a very basic nature must be gathered as a prelude to the relatively detailed survey which will produce further information necessary for the recommendations that the area be set up as a reserve, and if so, when and how. It is suggested that this fact sheet include the following information:

1. Name of area.
2. Geographical location (nation, province, state, district, etc.).
3. Latitude, longitude (supply map or chart).
4. Surface area (in square kilometres or hectares).
5. Type (from Classification Scheme code, i.e., zoogeographic and biotic, with habitats and relationship to coastal, terrestrial province specified).
6. Description should note:
   (a) Physical features - including water depths.
   (b) Dominant biota (ecologically).
   (c) Special scientific, recreational or other interest.
7. Conservation status, degree of naturalness, degree and nature of threat (if any) and present jurisdiction(s) or ownership.
8. Character and use of contiguous land or sea areas emphasizing effectiveness as buffer areas.
9. Proposed purpose or present use of area, including suggested zoning, if any.
10. Knowledgeable contacts.
11. References to literature, both scientific and popular.

This description list is closely in accord with IUCN's World Directory of National Parks and Other Protected Areas (IUCN, 1975).
It is essential that there be compatibility of descriptions so that computerization of data be possible. Darnell et al. (1974) give a model for such a system and point out the advantages that accrue through computer query. Answers to the following sorts of questions are obtainable.

1. What habitats are in any geographic area?
2. What areas are protected for a certain biotic province or habitat?
3. What is the state of research for a particular habitat type - i.e., printed publications or work in progress?
4. Search for key words: i.e., algal reef, manatee, detritus, organochlorine, etc.
5. Which areas are in ownership, stewardship, or controlled by administrative authority only?
6. What areas are most endangered?

Thus, a purpose for description is to enable the integration of a world-wide system. In no other way can marine ecosystems be comprehensively treated.

SUMMARY GUIDELINES FOR PROTECTION

The remainder of this paper summarizes specific matters which should be considered in marine habitat conservation. They may be used in at least two ways; first, to guide surveys and studies; second, to guide implementation. Each of the topics summarily treated below is complex in itself. Therefore, it is to be hoped that the following will be recognized as a matrix only and that site-specific flexibility will be required. Indeed, this is a "bare-bones" outline; each topic could - and should - become the topic of a detailed workshop related to site-specific issues and realities. Also, the guidelines represent a goal which may take some time to achieve.

These guidelines have been drawn from many sources, some of which have already been cited. More references of major importance to what follows are given in the Additional Bibliography (not included are references to the many survey reports directed towards marine parks). The structure below is from the general to the specific, not to imply a rigidity of approach. Thus, enabling legislation is considered first, parks and reserves last, but it could just as well be approached the other way around.

Enabling Legislation and Structure

The larger goal of legislation should be to encodify a zonation of the entire coastal zone, including land areas, drainage systems, estuaries, lagoons, and continental shelf. It should follow the initial survey and establish a policy for coastal development and preservation on an interdisciplinary and interdepartmental basis. Rarely can this derive from existing governmental bodies, i.e., tourism, fisheries, educational or parks departments, which are not generally mandated to manage the large problems involved, but which all have major interests. Enabling legislation must establish baselines for long-term financial and administrative control with an administration sensitive to the needs of land and water management as well as to those of educational, research, and public institutions.

A. Policy includes:

1. Wise use of marine, estuarine, wetland and upland areas;
2. Maintenance of natural ecosystems;
3. Provision of resources for the people;
4. Increasing the carrying capacity of the coastal zone through technical and managerial means;
5. Restoration of damaged environments; and
6. Clear evaluation of the burden of proof of deleterious actions, with identifiable liability.

B. "Central Authority":

A "central authority" should carry out the policy. It is essential that this authority coordinate the activities of all government and non-government agencies with important interests, most notably departments involved with fisheries, coastal zone development, conservation, national parks, tourism, and enforcement. Educational institutions and fisheries or conservation departments should cooperate on research. Public and private conservation or other interest groups should be included in an "advisory panel" (see C below) to contribute their expertise to an integrated policy. Policy should be subject to constant review and deliberations should be made public. The Central Authority may be a single government agency or coordinate several agencies. It should be empowered to:

1. Review existing information and activities in order to take immediate action on: selected areas having unique ecological character; wetlands and estuaries containing highly productive habitats, spawning areas or nurseries, or rare and endangered species; and coastal activities that will affect diversity and productivity of the ecosystem;
2. Initiate computer-compatible descriptionsof areas, with the aid of a data-retrieval system;
3. Set up appropriate management guidelines;
4. Certify activities, by means of permits, licences, or authorizations and ascertain that activities are consistent with the purposes of the permit;
5. Initiate and administer research grants or contracts;
6. Record use and monitor system changes;
7. Maintain a consultative process to coordinate the interests of various departments and agencies, including management of fisheries resources, cultural resources, education and research, and those having responsibility for national security, transportation, and exploitation of mineral resources;
8. Establish public relations and increase public awareness by means of audio-visual or other materials, such as: illustrated pamphlet with boundaries and regulations for reserves noted; guidebooks; file and slide series of sample habitats and of man's use of these systems;
9. Provide for ranger and guide training; and
10. Recommend international agreements as necessary for protection of water quality or non-resident species.

C. "Advisory Panel":

Should be structured as a "scientific committee" and comprised mostly of, but not dominated by, ecologically-oriented scientists. Thus, it must include public interest groups (not special-interest groups, i.e., lobbyists) and, especially, environmental lawyers and land-use planners. The panel has the following functions:

1. Consults on long-term goals and policies;
2. Evolves model guidelines;
3. Determines research needs and reviews research proposals;
4. Provides for scientific evaluation, surveillance and enforcement;
5. Recommends an interpretative programme for public understanding;
6. Recommends specific functions for each reserve;
7. Recommends a management programme;
8. Helps government design the national programme;
9. Advises on regional problems; and
10. Aids in the development of innovative approaches, including new scientific, legal, and social methods and institutions.

D. Permits:

A permit or licence system for coastal activities should be put into effect and subject to periodic review. One should always carefully examine the need for paper work, but man's effects are so numerous that there is probably no alternative other than to consider most of his actions subject to review and permit procedures which may require both environmental and cultural impact statements. Statements and permits include:

1. Established need for proposed action;
2. The effect on human health and welfare, ecologically, economically, aesthetically, and recreationally;
3. The impact on traditional or subsistence-oriented life styles;
4. The effect of the action on fisheries, research activities, resources, plankton, fish, shellfish, other wildlife, shorelines, beaches, and marine ecosystems;
5. The persistence of the effect on the marine environment;
6. The most appropriate location for the action;
7. Special provisions, as monitoring the action and surveillance of the action; and
8. Fees.

E. Enforcement:

Enforcement will usually already exist in a multiplicity of agencies. The purpose is to coordinate and amplify these functions and it may also prove advantageous to set up a separate enforcement body under the "Authority". The nature of enforcement and the character and extent of punishment will vary according to local law and tradition.

Some of the problems to be faced are:

1. Jurisdictional:

   a. Conduct of citizens outside the country's territorial limits should be the same as that regulated by national law within national boundaries;

   b. Law of the sea, wherein many problems are currently unresolved, two of the most difficult being the protection of fisheries on the ocean "commons", and the implications of coastal development and pollution on oceanic productivity;

   c. Common property resource policy vs. resources subject to claim and ownership; and

   d. The confused legal situation with regard to delineation of agency duties and authorities in the coastal zone and territorial waters.

2. Public hearing and testimony:

   It is expected that the "Authority" will conduct hearings leading to recommendation of enforcement and penalties.

3. Penalties:

   These must be substantial to be a real deterrent to violation. Close cooperation of the courts, notices of violation, and sufficient penalties are mandatory. Each violation must be treated separately. A highly recommended penalty is confiscation of boat or other equipment and/or suspension of licences. Nature of the penalty will vary according to, among other things:

   a. whether the offence is civil or criminal;

   b. whether the offender is commercial or private;

   c. whether the offender is utilizing subsistence or traditional methods; and

   d. the income level and capital investment of the offender.

Zonation, Research and Monitoring

Research is not a luxury, but is at the heart of any programme, whether for preservation or development, as it is essential to the development of a workable zonation scheme and to management and planning efforts. We have stressed the roles of a classification scheme and predictive models to aid in understanding the effect of man's activities upon the coastal and marine environment. A survey of coastal resources is essential to long-range ecological stability and must elucidate demographic patterns, ownership and land-use, and socio-economic data. These contribute to baselines of knowledge and lead to environmental and cultural impact statements for development schemes, such as the siting, construction and operation of industrial plants, harbour development, and the dredging and deposition of spoil.

A. Evolution of a plan for zonation and ecosystem protection. Initial surveys should establish land and water use practices in accordance with the nature of coastal systems, taking cognizance of socio-economic and other current practices, but also identifying those practices in need of cessation and/or modification. Research and monitoring will undoubtedly make alterations in this initial plan mandatory, and probably more restrictive. Randall (1969) emphasizes that prime research areas in the vicinity of coastal research stations should be protected. The nature of dynamic aquatic systems dictates that zonation be equally dynamic. Generally the following types of zones will initially be necessary:

1. Developed zones are those which are already developed to such an extent that they are almost completely man-dominated and have lost most semblance to the natural state, for example, cities, airports, industrial complexes, etc. The major emphasis should be on pollution abatement and restoration.

2. Conservation zones are those intermediate between 1 and 3, that is where careful planning can guide development within environmental guidelines.

3. Protection zones are "natural areas" such as:

   a. critical areas in need of immediate protection;

   b. formerly productive areas in need of restoration;

   c. research areas;

   d. recreational areas; and

   e. buffer zones.

Boundaries between these zones are highly artificial and ideally the goal should be compatibility between environmental processes and man's activities throughout the entire coastal zone and adjacent sea. Research and monitoring, in any case, must play the primary role in determining this course of events.

Results of research must be capable of altering the course of man's actions and this capability should be clearly stated in the enabling legislation. This may be one of the most difficult of matters as most governments have shown little ability to plan for crisis, no matter how predictable, and society shows little desire to alter its ways, no matter how deleterious. In these regards, a systems model is useful in the following ways as Ketchum, Ed., (1972) states: first, it brings orderly criteria evaluation into management practice; second, it develops common concepts, measures, and languages; third, it brings to authorities a knowledge of natural environmental processes, institutions, and activities for complex decisions; and, fourth, it trains professionals and others to higher scientific awareness for greater competence in management.

B. Research needs

These must be long range. A primary need is to identify functional groups of organisms, that is those which process organic matter or which are important in the recycling process. Research should include such important topics as:

1. Ecological factors:

   a. Role of nutrients and trace elements in ecosystem function and their recycling;

   b. The relationship between nutrients, pollutant loads, and primary productivity to recreational and aesthetic use of water;

   c. Information on the chemical characteristics of the systems involved;

   d. Information on the physical characteristics of systems involved, especially hydrology, current structure, and geomorphological shore processes;

   e. Information on the distribution and abundance of species at all trophic levels and their normal variations, emphasizing endangered species and those critical to the system;

   f. Description of community structure with emphasis on natural rates of recovery from perturbation and natural successional change;

   g. Studies on the nature of diversity and stability, especially the effects of predation in maintaining stability and the relationships between stability and successional change;

   h. Studies on successional change;

   i. Studies on processes of restoration;

   j. Natural history of endangered species;

k. Nature of food chains and webs;

l. Horizontal and vertical migrations of constituent organisms;

m. The influence of climate and weather on living and non-living components;

n. Indicator species for water quality or environmental monitoring; and

o. "Assimilative capacity" (see p. 31) for wastes, i.e., in which organisms or physically where pollutants are accumulated and how they may be recycled.

2. Social factors:
These are essential and should lead to development of cultural impact assessments. Complex issues are involved which will not be considered here in greater detail (see Ecodevelopment, pp. 19-21).

3. Factors important for public health:

a. Surveillance of contamination input levels;

b. Effects of solid waste disposal;

c. Effects of contaminants on organisms and ecosystems;

d. Epidemiologic and virologic studies;

e. Accumulated effect on organisms of sublethal pollutant levels;

f. Effects on man and other "top" carnivores from eating these organisms; and

g. Water quality as it relates to ear, nose, and throat infections, or other public health considerations.

4. Techniques for increasing productivity and production:

a. Restoration of damaged environments;

b. Environmental enhancement, that is, increased carrying capacity of the environment for certain species under natural conditions;

c. Aquaculture and increased production of certain species for commercial utilization; and

d. Artificial reefs to increase the habitat of reef-dwelling species.

5. Factors related to industrial activities:

a. Bioassay methods for potential toxicants, including both lethal and chronic effects;

b. Identification of biological productivity inhibitors;

c. Released nutrients and/or pollutants from resuspension of bottom sediments;

d. Causes of nuisance algae and aquatic weed growth;

e. Flushing times of receiving waters;

f. Predicting fate and extent of warm water plumes;

g. Long term rate evaluation of biological, chemical and geological modifications;

h. Effects of sea water on organic and inorganic chemicals; and

i. Possible synergistic effects between wastes, as that between oil and oil-soluble organochlorines.

6. Factors related to the carrying capacity of reserves for human activity:

a. Environmental quality vs. recreational use, i.e., effects of recreation on biota or communities;

b. Impact of multiple recreational use on the environment;

c. Determination of probabilities of transmission of disease through recreational water contact; and

d. Influence of climate, weather and accessibility on numbers of human visitors.

C. Methods of analysis

Very often it is both instructive and practical to use a modelling approach which expresses the matrix of flows between man and his environment, producer and consumer, donor and receiver, and receiver and user. Models may be heuristic, stochastic, or deterministic and are especially useful in analyses of more than one variable or as a research tool, i.e., as a matter for validation and subsequent improvement. Rarely, however, is it wise to derive precision from models of entire marine systems. It is best to use models for:

1. Methods of analysis of environmental variables;

2. Information storage and retrieval;

3. Prediction of productivity and energy flow, nutrient cycling, diversity, recovery of ecosystems, and other process studies;

4. Establishing the periodicity of water quality analysis tests or other survey methods;

5. Evaluating user impact and use;

6. Evaluating consequences of pollution or other alterations to the environment; and

7. Analysing the dynamics of populations.

D. Monitoring

This must be on a systems level. The most important tool is the predictive ecological model in which data acquired from monitoring lead to its continual validation and improvement. Previous indices of diversity, involving analyses of single groups such as algae or diatoms to determine health of systems are no longer ecologically acceptable as there is no proven relationship between such diversity and stability. For example, natural successional change and the relative youth of some ecosystems strongly influence diversity and stability. Monitoring involves long term endeavours such as baseline surveys for the continuous collection of chemical, physical, and biological data. Great care must be taken to select "critical" or "indicator" factors, i.e., those "most sensitive species" and/or processes which relate directly to the predictive ecological model. Selection of such species and/or processes is a most difficult matter, however.

Tests of effects of various chemicals, natural or manmade, on organisms must not consider only lethal effects. Sublethal or chronic effects are ecologically more meaningful and must be determined and monitored.

Monitoring must take place both within controlled areas such as reserves and areas where perturbation is taking place in order that baseline data and data of perturbation be gathered and compared. It must involve:

1. Use of the most up-to-date methods, such as remote sensing of environments and telemetry and radio-tracking of large organisms;
2. Uniform sampling procedures;
3. Methods for long term effects on community structure and productivity;
4. Methods for quantitative description of biomass;
5. Methods for monitoring biostimulants;
6. Identifying criteria for waste discharges;
7. Development of methods for location, quantification and classification of heavy metals and other materials of acute or chronic toxicity;
8. Quantification and classification of persistent organisms;
9. Review of methods for detecting foreign materials; and
10. Quantification of floatable matter and films.

Maintenance of Environmental Quality

Coastal development and man's other activities need not be in conflict with the maintenance of environmental quality. However, it has been the practice to externalize the costs of these activities, often based upon acceptance of estimates of the "assimilative capacity" of the environment or what a "significant effect" may be (see p. 31).

A. Ocean dumping

The eventual goal should be an end to this practice and research and management criteria are needed towards that goal. Current international agreements prohibit dumping of such dangerous materials as high level radioactive wastes and agents for chemical or biological warfare. We are now aware that some "remote" areas such as oceanic trenches, fjords, and the abyssal ocean are biologically of great interest and value and the threat to them by dumping should be removed. It is necessary to establish more detailed baselines for:

1. The types of material to be dumped and the amount;
2. The location with stated alternatives;
3. The length of time dumping will be carried out; and
4. International complications.

B. Pollution and waste treatment

This differs from dumping mainly in that the site is usually close to the shore and that some alteration of material usually occurs before it is discarded. Effluents may be released continuously or "pulsed". The goal should be the cessation of all effluents containing known or suspected deleterious materials, either because of their toxicity or their nutritive (eutrophic) potential. Research is needed to design systems of treatment which are tailored to preserve the specific receiving waters. Design of systems should be by cooperation between ecologists and engineers, a feature usually sadly lacking! Detailed attention needs to be paid to the chemistry of the effluent, its physical and biological dispersion in the environment and physical or biological effects. For instance, more consideration must be given to:

1. "Point" or site-specific effects vs. dilution;
2. Synergistic effects;
3. Nutrient chemistry and biochemical changes;
4. The chemistry of receiving waters;
5. Current dynamics and basin topography of receiving water;
6. Prohibition of any material that combines the properties of mobility, chemical stability, low solubility in water, and high solubility in lipids;
7. Elimination of pesticides and heavy metals;
8. Trace elements in water and sediment;

9. Concentration of trace elements in organisms, especially amplification through food chains and food webs;
10. Control of thermal plumes;
11. Multiple jet diffusers;
12. Lateral spreading of wastes; and
13. Flows of suddenly released sinking sludge.

Continuous monitoring of the effluent within biotic communities should lead to modification of the nature and amount of released materials. For example, sewage systems might have to be altered for use of saline water. Vessels and small boats should not be exempt from restrictions on the dumping of sewage and other wastes, and the use of holding tanks with shore facilities for waste and oil disposal should be required.

C. Mineral extraction and dredging

Mineral extraction is in many cases equivalent to strip mining on land as it destroys the benthic surface, that is, the area where organisms are concentrated. Dredging usually occurs close inshore or in waters especially subject to siltation. Disturbance to the benthos has many severe effects. Excessive siltation kills coral reefs and can also reduce light needed by rooted aquatic vegetation. Exploitation for oil and gas may be much less deleterious in that only a small portion of the benthos is disturbed (nevertheless the possibility of oil pollution poses perhaps the most severe threat to shallow water environments).

A particularly severe effect of dredging, or mineral extraction in polluted areas, is the sudden release of pollutants from the sediments. Dangerous materials such as pesticides and heavy metals commonly accumulate in the anoxic sediments which lie beneath a thin surface of silt. Their sudden release can result in fish kills or other severe consequences.

D. Coastal development

This is among the most insidious and damaging activities of man, amplified by the fact of the extreme attractiveness of coasts for human habitation.

Shoreline, particularly, is subject to damage due to its extreme dynamism. Attempts at shoreline stabilization usually fail and lead to destruction of aesthetic qualities and to high maintenance costs. Inman and Brush (1973) eloquently describe "the coastal challenge", pointing to the futility of man's attempts to stabilize shore processes. Only one of their facts need be repeated here, that a wave 3m high transmits energy at the rate of 100 kw/m of the crest line, equivalent to a solid line of 270 Hp automobiles moving at full throttle! Such a fact points to a reason for failure of engineers and shore developers to "control" shore processes. Dolan and Hayden (1974) state the new U.S. Park Service policy of adjusting to, not controlling, shore processes. Previous control attempts have swallowed

$20 million in Cape Hatteras National Seashore alone since the 1930s. The foregoing has led to the adoption of new procedures. "Set back lines" should be established, seaward of which no construction should occur. Jetties should be of open construction so as not appreciably to slow longshore currents. Groins are to be avoided. Damming of rivers and streams severely slows the deposition of both minerals and nutrients in the coastal zone and care must be taken that this is not excessive. Forestry, mining, and agriculture should not be practised near streams and rivers so that rates of flooding and siltation are not increased (for a history of the siltation of San Francisco Bay, see Pestrong, 1974, and for a description of the effect of land clearing on estuaries, see p. 12. Existing channels should be utilized for access to harbours rather than opening new ones. Cognizance must be taken of coastal circulation cells in planning for development which involves either alteration of shoreline or waste outfalls. Estuaries, marshes, and lagoons are "filters" (for both nutrients and pollutants) between land and sea, and if access through them is necessary, an offshore barrier of rooted vegetation should be provided beyond the channel.

In coastal development, the following should also be noted:

1. Adequate circulation in waterways, such as canals and marinas, with short residence time for water is mandatory;
2. One method of protecting the water line back of a "set back line" is a "coastal interceptor waterway" (Tabb and Heald, 1973) which preserves surface water sheet flow across coastal marshes and shores;
3. Development should emphasize highlands, not low coastal marshy areas, or low energy shores; and
4. Clark (1974) identifies many other effects, such as runoff as a consequence of development and agriculture, the effects of construction site preparation, pest and mosquito control, and residential development. Great care must be taken to thoroughly examine the inter-relationships of these actions in the preservation of our coasts and associated ecosystems.

Fisheries Research and Management

This is a large and complex, as well as highly controversial, subject of which only a few relevant features will be treated here. Below are mentioned matters of broader policy. The next section on Marine Reserves considers some additional fisheries matters (p. 55).

The essential point is the sharp contrast between freshwater and saltwater fishing as far as management is concerned. The former is sharply controlled and the latter hardly controlled at all, despite clear evidence of need in many quarters (most notably, high seas sport fishing for marlin, other billfish, and tuna, and the very destructive inshore reef fisheries of many nations). There is probably no

fundamental difference between fresh and saltwater fishing other than a matter of scale. In any case, research and management must emphasize sustainable yield and should be dedicated to the following:

a. Licensing of all fishermen, the fees to be returned to research, management, and enforcement;

b. Establishment of game and non-game species in which only game species are allowed to be taken;

c. Establishment of season, bag, and possession limits on game species;

d. Establishment of zonation for various fishing activities;

e. Resolution of conflicts between fisheries, tourism, and parks;

f. Environmental enhancement, especially artificial reefs; and

g. The merits of limited entry to fishermen.

Management should also recognize fundamental differences between underwater (spear) fishing and surface (hook-and-line) fishing (cf. Barada, 1974). The former is more analogous to hunting and has three deleterious effects: (1) the inducement of fear of man, (2) the reduction in numbers of resident species, and (3) the hazards involved when swimmers, viewers, and hunters cohabit the same environment. Therefore, spear-fishing is completely incompatible with underwater viewing, recreational swimming, and photography. Surface fishing is capable of reducing some fish populations to an equal extent as spear-fishing and can be hazardous to swimmers, but does not induce fish to fear man.

Management of Marine Reserves

This section covers all "reserve" areas (see p. 26-30). Access by people to parks and reserves should be in accordance with conforming use in which protection is paramount. In some cases, human presence must be forbidden, for instance in a colony of animals where human activity would interrupt breeding. In other cases human activity is encouraged, for instance at national seashores emphasizing recreation. In either case, preservation and/or manipulative management (where natural succession might lead to habitat elimination) is paramount in "core" areas.

A. Core vs. buffer

In general, the core is to be left undisturbed and research is to be non-manipulative. Education, research, and recreation are not to alter the values for which the core area is established. Buffer zones are created to protect the core, to provide space for wide-ranging movements of animals, to provide space for the existence of rare or endangered species or for manipulative research. In some important cases, the buffer may be primarily dedicated towards restoration, protection of naturalness, or understanding of natural processes. Most importantly, buffers must accommodate the shift of the core in cases of biological,

ecological, or geomorphological change, for example, the growth of reefs or the movement of beaches. Buffers are usually of the same biome as the core and can usually accommodate manipulative research which should not be carried out in the core. Buffer zones may differ fundamentally from the core by not being under the direct ownership or jurisdiction of the agency which manages the core area. Therefore, control of human activity within the buffer may be through administrative action, easements, or by other means, emphasizing proper stewardship (p. 32).

B. Land and sea inclusion

Deriving from the above, and the fact that the coastal zone is an ecotone, is the requirement that portions of land, especially watershed and drainage areas, be included in marine reserves. This can be accomplished by a variety of management or legal procedures which will not be detailed here.

C. Boundaries

Boundaries for core areas should encompass entire ecological units (habitats and communities) in so far as possible, including adjacent terrestrial areas. However, for whole ecosystems this will be difficult. Seaward boundaries should include the outermost reef or, for sandy shores, to at least the 20-metre contour line or the territorial limit, especially in areas where deep water is close to the shore. Buffer zones should encompass upstream effects and contiguous ocean water. The buffer area should be large enough to incorporate geomorphological changes which alter shore boundaries. Marking of boundaries should be by means of shore posts and buoys or natural marks, when these are available, and clearly visible. When it is impractical to establish such markers, various distance or depth delineation is required. In such cases problems will arise with regard to policing, requiring that these "invisible lines" be set with as much flexibility as possible. In any case, boundaries must be clearly delineated on all charts, maps, tourism brochures, etc.

D. Legal mechanisms

These will depend upon the enabling legislation. The uses of the coastal zone may fall under a multiplicity of agencies. However, regulation and enforcement within the core should be the responsibility of the "Authority" established under the enabling legislation. The buffer should also fall, if possible, under that "Authority". Obviously, legal mechanisms fall within at least two jurisdictions, the coastal state and law of the sea. The distinction between the two is presently undergoing rapid change, through both multinational and unilateral actions.

E. Multiple use

This may be permitted if no interference with the purpose of the park or reserve is contemplated. Severe threats to core areas may be through mining, dredging, oil and gas exploration or exploitation, and coastal development. In some nations dynamiting of reefs and shell and coral collecting also pose severe threats.

non-excessive
However, rights of innocent passage and/fishing or hunting for migratory species in general pose little threat to core areas.

F. Regulations for protection within marine parks and reserves
These regulations mostly emphasize a series of restrictions which serve to protect living and cultural values. They are applicable in areas emphasizing protection (as National Parks):

1. The taking of any living creature is prohibited;
2. Non-living flotsam and jetsam may be taken from the beach;
3. There should be an admission fee, proceeds going to park research and management. Seasonal tickets should be provided for residents and tourists staying longer than one day;
4. No anchoring should be permitted on reefs. Buoys should be established for this purpose;
5. No person should cut, carve, injure, mutilate, remove, displace or break off any underwater growth or formation;
6. No person should dig in the bottom or in any other way injure or impair the natural beauty of the underwater scene;
7. No person should destroy, molest, remove, deface, displace, or tamper with wrecked and abandoned airborne or water craft or any of its cargo. An exception is dangerous cargo which requires removal and safe disposal;
8. No person should molest, kill, wound, capture, frighten, or attempt to molest, kill, wound, capture, or frighten any animal within park boundaries; and
9. Removal of shells from coastal areas of parks in order to build roads or other industrial uses should not be permitted.

G. Regulations for specific recreational use within marine parks and reserves
These regulations will address several activities for which more specific guidelines for management are necessary. They are applicable variably for areas set aside (zoned) for specific uses or regulated in other ways. In either case, approaches to these activities are extremely subject to local needs, law and tradition.

1. Water skiing, underwater viewing and swimming:
Specific zones should be set aside for these activities. Snorkelling and swimming are compatible with each other, but neither is compatible with water skiing.

2. Boating:
Private pleasure boats to be used in parks or reserves should be authorized for seaworthiness. Anchoring on reefs should be prohibited and buoys for anchorage be provided in parks and reserves. All boats operating within park boundaries should be licensed, temporarily or permanently, or an entry fee charged.

Sportfishing and spear-fishing (see p. 51-2)

The taking of fish within Parks should not be allowed, but taking in Reserves may be permitted under controlled conditions. The number of individual fish taken by these activities is usually small, with some notable exceptions. However, neither should be conducted in the presence of the other nor in the vicinity of commercial operations, due to the hazards involved. Spear-guns should not be permitted, that is, those operated by means of a trigger mechanism with the aid of elastic springs, or compressed gas. The only allowable spears should be the straight spear or Hawaiian sling, powered by a single elastic, at the most. There exist rare exceptions to this, either more restrictive or more lenient, but such exceptions deserve critical examination.

The taking of fish should not be permitted by the use of underwater breathing apparatus.

Particularly in the case of spear-fishing, regulations on permitted areas, species, season, and possession limits should be established, similarly to terrestrial hunting.

4. SCUBA (Self-Contained Underwater Breathing Apparatus) diving:

These regulations are largely oriented towards the establishment of a safety programme. They may be applied nation-wide, if this is suitable.

a. Only certified divers should be permitted to dive in parks and reserves or those not certified should be required to take a checkout dive;

b. Divers should be registered when in the park or reserve;

c. Diving should take place from registered diving or private boats, and/or within certain areas so zoned for the purpose;

d. Diving should be distant from areas of heavy boating use;

e. Special areas should be set aside for SCUBA-diving, off-limits to other use when the former activity is being conducted;

f. Chartered dive boats should be licensed to operate in parks and reserves. They should fly the diver's flag throughout trips and file a dive plan before departure. They should maintain radio contact with park headquarters throughout their trip. Special docking areas are advantageous;

g. The diver's flag should be exhibited during all dives and divers should stay within 50 m of the flag when at the surface;

h. Other boats should stay beyond 100 yards of a diver's flag;

i. Literature should be made available describing dive sites;

j. If at all possible safety equipment should be accessible, such as both fixed and portable hyperbaric chambers; and

k. An emergency system for search, rescue, and treatment should be established. Coordination of park or reserve managers, police, and medical and rescue personnel is required.

H. Other activities within marine parks and reserves

The following apply to areas outside reserves as well, but must be given special attention within protected areas:

1. Coral, shell and fish collecting for souvenirs or pets:

Theoretically, these activities are permissible on "sustained yield basis". However, they should never be permitted in core areas. Practically speaking, knowledge of sustained yield and enforcement are both inadequate to regulate these potentially extremely harmful activities. Therefore, collection of coral and shells should be prohibited, even on a nation-wide basis, except in case of permit holders whose activities should be carefully regulated. No living shells, with rare exceptions, should be allowed to be taken and any living coral collection should be permitted only after a review of permit application by the Advisory Panel. The collection of fishes for the aquarium trade should also be subject to review by the Advisory Panel and in no case should collecting methods involve poisoning or destruction of the reefs.

2. Commercial fishing and collection of bait:

Bait gathering on reefs should either be prohibited or carefully controlled on a rotating zone basis, but never allowed in core areas. Commercial fishing must not involve uses of dynamiting or poisoning. Commercial fishing need not be prohibited in channels within reserves where migratory fish are caught, and commercial fishing for resident species should be allowed in reserves only after critical examination of need. The latter falls within general fisheries policy (see p. 51-2).

3. Legal resident recreation, fishing, and bait collection:

Legal residents should have a right to recreation or to earn a livelihood by fishing within designated boundaries of reserves, but not in core areas. However, they too are subject to rules and regulations set up by the "authority" or within fisheries policy. Spear-fishing should not generally be allowed, though traditional, conforming, and non-deleterious spear-fishing may be an exception.

Special recognition must be given to traditional or subsistence privileges. This does not include commercial fishing. Difficult site-specific problems arise over the definitions of "traditional" and "subsistence". From an ecological point of view, in no case should the employment of any method or its expansion because of population increase, threaten habitats or populations, since this is harmful to their own longer-term interests.

4. Charter boat tours:

These should be licensed to operate in parks and reserves. Anchorage sites should be specified, as should the routes for access. A policy of limited entry should be made within the confines of carrying capacity (see p. 47). Anchorage should not be on fragile reef areas and buoys should be provided for this purpose. Boat operators may be designated as rangers or wardens so as best to take advantage of their own interest in preservation of the area.

5. Underwater structures and vehicles:

There is a great range of technology, either existent or in planning, which enables an increased number of persons, such as non-swimmers and tour groups, quickly and easily to view underwater life. However, in many cases, this involves serious perturbation to and destruction of underwater habitat. All such plans should be carefully examined for impact and the ability of the environment to withstand the technology and to recuperate.

6. Aquaculture:

This activity is heavily dependent upon maintenance of good water quality. It has vast potential in lesser developed and industrialized nations alike, but pollution poses serious problems for the latter. It is not generally recognized that aquaculture has potential pollution and other adverse effects itself. Odum (1974) points some out. They include: organic effluents from hatcheries, sedimentation from raft culture, toxic chemicals and to control algae or disease, physical alterations of the environment, removal of naturally productive estuaries from the ecosystem, introduction of exotics, eutrophic effects, and alterations of temperature or water flow patterns. The creation of artificial habitat is related to this subject and has been reviewed by Carlisle, Turner and Ebert (1964).

It is appropriate to create reserves for aquaculture, but this activity should not be permitted in most core areas.

LITERATURE CITED

ADAMS, A.B. (1964) First World Conference on National Parks, Seattle, Washington, June 30-July 7, 1962. U.S. National Park Service, Washington, D.C.: xxxiv + 471.

ANON. (1975) Report of the Workshop on the Conservation of Wild Living Resources, Airlie, Virginia, February 7-14 and April 4-7, 1975. Appendix 2, The Law of the Sea, draft, pp. 1-22. U.S. World Wildlife Fund, Washington, D.C.

AUBURN, F.M. (1974) Convention for the preservation of man's cultural heritage in the oceans. Science, 185 (4153): 763-764.

BARADA, B. (1974) Logical fallacies of the spearfishing controversy. Skin Diver Magazine, 23 (9): 60-63.

BJÖRKLUND, M. (1974) Achievements in marine conservation, I. marine parks. Environmental Conservation, 1 (3): 205-223.

BLUMBERG, R.C. (1974) Massachusetts ocean sanctuaries. Marine and Estuarine Sanctuaries, M.P. Lynch, B.L. Laird, T.F. Smolen, eds., Special Report No. 70, VIMS: 77-82.

CARLISLE, J.G., C.H. TURNER and E.E. EBERT (1964) Artificial habitat in the marine environment. Calif. Fish and Game, Fish Bull., No. 124: 1-93.

CLARK, J. (1974) Coastal Ecosystem: Ecological Consideration for Management of the Coastal Zone. The Conservation Foundation, Washington, D.C.: vii-178.

CRONIN, L.E., ed., (1974) Scientific group summary. Marine and Estuarine Sanctuaries, M.P. Lynch, B.L. Laird, T.F. Smolen, eds., Special Report No. 70, VIMS: 165-185.

DARNELL, R. (1967) Organic detritus in relation to the estuarine ecosystem. Estuaries, George H. Lauff, ed., AAAS, Washington, D.C.: 376-382.

DARNELL, R.M. and R.C. LEMON and J.M. NEUHOLD and G.C. RAY (1974) Natural Areas and their Role in Land and Water Resource Preservation. (Final Report to N.S.F.) AIBS, Washington, D.C.: 1-286.

DASMANN, R.F. (1972) Towards a system for classifying natural regions of the world and their representation by national parks and reserves. Biological Conservation, 4 (4): 247-255.

DASMANN, R.F. (1973a) A System for Defining and Classifying Natural Regions for Purposes of Conservation. IUCN Occasional Paper No. 7, Switzerland: iii-47.

DASMANN, R.F. (1973b) Classification and Use of Protected Natural and Cultural Areas. IUCN Occasional Paper No. 4, Switzerland: 5-25.

DASMANN, R.F. (1975a) National parks, nature conservation, and "future primitive". Keynote address given at South Pacific Conference on National Parks and Reserves, 24-27 February 1975, Christchurch, New Zealand. pp. 89-96 in: Proceedings of the South Pacific Conference on National Parks and Reserves, published by the Department of Lands and Survey, Wellington, 1975.

DASMANN, R.F. (1975b) Toward a dynamic balance of man and nature. In: Papers and Proceedings of IUCN 13th Technical Meeting, Kinshasa, Zaïre, 7-19 September 1975. IUCN Publications, New Series (in press).

DEPARTMENT OF INTERIOR (1973)
(a) Draft Environmental Statement. Proposed Noatak Ecological Range, Alaska. Alaska Planning Group, December.
(b) Draft Environmental Statement. Proposed Aniakchak Caldera National Monument and Aniakchak Wild River, Alaska. Alaska Planning Group, National Park Service, December.
(c) Draft Environmental Statement. Proposed Iliamna National Resource Range, Alaska. Bureau of Sport Fisheries and Wildlife, December.

DIAMOND, J.M. (1975) The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. Biological Conservation, 7 (2): 129-146.

DOLAN, R. and B. HAYDEN (1974) Adjusting to nature in our national seashores. National Parks and Conservation Magazine, 48 (6): 9-14.

EDWARDS, R.W. and D.J. GARROD, eds. (1972) Conservation and Productivity of Natural Waters. Academic Press, New York: xv + 318.

ELLIOTT, H.F.I., ed. (1974) Second World Conference on National Parks. IUCN, Morges: 1-504.

ESTES, J.A. and J.F. PALMISANO (1974) Sea otters: their role in structuring nearshore communities. Science, 185 (4156): 1058-1060.

FITTKAU, E.J. (1973) Crocodiles and the nutrient metabolism of Amazonian waters. Amazoniana IV (1): 103-133.

GOREAU, T.F. (1964) Mass expulsion of zooxanthellae from Jamaican reef communities after Hurricane Flora. Science, 145 (3630): 383-386.

GORSLINE, J. and L. HOUSE (1974) Future primitive. Planet Drum, San Francisco, Issue 3.

HAY, K. (1974) The oil industry attitude towards marine and estuarine sanctuaries. In: Marine and Estuarine Sanctuaries, M.P. Lynch, B.L. Laird, T.F. Smolen, eds., Special Scientific Report No. 70, VIMS: 141-143.

HOLDREN, J.P. and P.R. EHRLICH (1974) Human population and the global environment. American Scientist, 62 (3): 282-292.

HOOD, D.W., ed. (1971) Impingement of Man on the Oceans. Wiley-Interscience, New York: 1-738.

INMAN, D.L. and B.M. BRUSH (1973) The coastal challenge. Science, 181 (4094): 20-32.

IUCN (1974) Biotic Provinces of the World. IUCN Occasional Paper No. 9, Switzerland: 7-58.

IUCN (1975) Papua New Guinea: independence and environmental concern. IUCN Bulletin, New Series, 6 (9): 33.

IUCN (1975) World Directory of National Parks and Other Protected Areas. IUCN, Morges.

JENKINS, R.E. and W.B. BEDFORD (1973) The use of natural areas to establish environmental baselines. Biological Conservation, 5 (3): 168-174.

JOHANNES, R.E. (1972) Coral reefs and pollution. Marine Pollution and Sea Life, M. Ruivo, ed., Fishing News Ltd.: 364-375.

JOHNSON, B. (1974) Florida's planning for sanctuaries. In: Marine and Estuarine Sanctuaries, M.P. Lynch, B.L. Laird, T.F. Smolen, eds., Special Report No. 70, VIMS: 95-97.

KETCHUM, B.H., ed. (1972) The Water's Edge: Critical Problems of the Coastal Zone. MIT, Mass.: xi-393.

LANG, J.C. (1974) Biological zonation at the base of a reef. American Scientist, 62 (3): 272-281.

LIKENS, G.E. and F.H. BORMANN (1974) Linkages between terrestrial and aquatic ecosystems. BioScience, 24 (8): 447-456.

LOFTUS, M.E., D.V. SUBBA RAO and H.H. SELIGER (1972) Growth and dissipation of phytoplankton in Chesapeake Bay. 1. Response to a large pulse of rainfall. Chesapeake Science, 13 (4): 282-299.

LYNCH, M.P., B.L. LAIRD and T.F. SMOLEN, eds. (1974) Marine and Estuarine Sanctuaries. Special Report No. 70, VIMS: 1-212.

MacARTHUR, R.H. and E.O. WILSON (1967) The Theory of Island Biogeography. Princeton University Press, Princeton, N.J.: xi + 203.

McCORMICK, M. Geraldine (1975) Some site-specific problems in marine conservation. In: Papers and Proceedings of IUCN 13th Technical Meeting, Kinshasa, Zaire, 7-19 September 1975. IUCN Publications, New Series (in press).

MOIR, W.H. (1972) Natural areas. Science, 177 (4047): 396-400.

NATIONAL ACADEMY OF SCIENCES and NATIONAL ACADEMY OF ENGINEERING (1973) Water Quality Criteria 1972. Washington, D.C.: 1-594.

ODUM, W.E. (1970) Insidious alteration of the estuarine environment. Trans. Amer. Fish. Soc., 99 (4): 836-846.

ODUM, W.E. (1974) Potential effects of aquaculture on inshore coastal waters. Environmental Conservation, 1 (3): 225-230.

ODUM, W.E. and E.J. HEALD (1972) Trophic analyses of an estuarine mangrove community. Bulletin of Marine Science, 22 (3): 671-738.

PAINE, R.T. (1966) Food web complexity and community stability. American Naturalist, 100 (1): 65-75.

PAINE, R.T. (1969) The Pisaster-Tegula interaction: prey patches, predator food preference, and intertidal food structure. Ecology, 50 (6): 950-961.

PESTRONG, R. (1974) Unnatural shoreline: how to develop a bay. Environment, 18 (9): 27-35.

PICHOD-VIALE, D. (1974) Etude histologique et analyse d'un cétacé tué près de la zone de déversement des boues rouges. Bull. de la Société des Sciences Historiques et Naturelles de la Corse, Fasc. 612: 21-40.

RANDALL, J. (1969) Conservation in the sea: a survey of marine parks. Oryx, 10 (1): 31-38.

RAY, G.C. (1970) Ecology, law and the "marine revolution". Biological Conservation, 3 (1): 7-17.

RAY, G.C. (1972) The problem of marine parks. World National Parks: Progress and Opportunities, Richard van Osten, ed., Hayez, Brussels: 47-50.

RAY, G.C. (1974) An ecosystem approach to marine parks. Second World Conference on National Parks, H.F.I. Elliott, ed., IUCN Paper No. 22, Session IX: 260-266.

RAY, G.C. (1975) A Preliminary Classification of Coastal and Marine Environments. IUCN Occasional Paper No. 14, Morges.

RAY, G.C. (1975) Conservation of marine biota with particular reference to the role of marine parks and reserves. In: Papers and Proceedings of IUCN 13th Technical Meeting, Kinshasa, Zaïre, 7-19 September 1975. IUCN Publications, New Series (in press).

RAY, G.C. and K. NORRIS (1972) Managing marine environments. In: Transactions of the 37th North American Wildlife and Natural Resources Conference, J.E. Trefethen, ed., Wildlife Management Institute, Washington, D.C.: 190-200.

SCHUMACHER, E.F. (1973) Small is Beautiful. Economics as if People Mattered. Blond and Briggs, Ltd., London.

TABB, D.C. and E.J. HEALD (1973) The coastal interceptor waterway. Coastal Zone Management Series, Bull. No. 4., Univ. of Miami Sea Grant Program: 1-10.

TERBORGH, J. (1974) Preservation of natural diversity: the problem of extinction prone species. BioScience, 24 (12): 715-722.

UNESCO (1974) Programme on Man and the Biosphere (MAB) Task Force on: Criteria and Guidelines for the Choice and Establishment of Biosphere Reserves. Final Report. MAB Report Series No. 22, pp. 1-61.

VOSS, G.L. (1973) Sickness and death in Florida's coral reefs. Natural History, 82 (7): 41-47.

WALLIS, D.L. (1971) Establishing underwater parks worldwide. In: Transactions of the Thirty-Sixth North American Wildlife and Natural Resources Conference, J.E. Trefethen, ed., Wildlife Management Institute, Washington, D.C.: 97-117.

WALSH, J. (1972) Implications of a systems approach to oceanography. Science, 176 (4038): 969-975.

WOODWELL, G. (1974) Ecosystems and world politics. Bull. Ecol. Soc. Amer., 55 (1): 2-4.

YUPIKTAK BISTA (1974) Does One Way of Live Have to Die so Another Can Live? Yukon-Kuskokwim Delta, Alaska: 1-80.

ADDITIONAL BIBLIOGRAPHY ON GUIDELINES

GOODE, D.A. Criteria Used in the Selection of National Nature Reserves in Britain. Unpublished manuscript.

NATIONAL ACADEMY OF SCIENCES NATIONAL ACADEMY OF ENGINEERING (1970) Wastes Management Concepts for Coastal Zone: Requirements for Research and Investigation. Washington, D.C.

NATURAL ENVIRONMENT RESEARCH COUNCIL (1973) Marine Wildlife Conservation, an Assessment of Evidence of a Threat to Marine Wildlife and the Need for Conservation Measures. Publication Series B, No. 5. NERC, London: 1-39.

(March 1976)