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**THE CONTRIBUTION OF MARINE PROTECTED AREAS TO SUSTAINABLE
DEVELOPMENT**

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Graeme Kelleher. January 2001..

Introduction.

"How complex and unexpected are the checks and relations between organic beings, which have to struggle together in the same country"(Charles Darwin, 1882)

Charles Darwin was referring to living organisms. I am quoting him here because the complex, interrelated environmental problems which the world is seeing at the end of the 20th Century reveal that his observation is equally applicable to the checks and relations between human political and administrative organisations.

We are at last realising that everything is connected to everything else and that the world operates as a complex process with characteristics which ensure that it will function chaotically. That is to say, precise predictions of events and states a long time ahead will not be possible. This is particularly true of the marine environment, because of the complexity and varying scales of its interconnections and ecological processes. The best reaction to such a situation is to proceed strategically - that is, to adopt policies that will put us in advantageous positions from which to take specific actions which will contribute to us attaining our objective. **Our goal is ecologically sustainable development.**

My aim in this paper is to suggest strategies which might contribute to this goal in relation to the establishment and successful management of marine protected areas (MPAs). In doing so I shall draw on the experiences from the Great Barrier Reef and from around the world that demonstrate which approaches usually work and which ones usually fail. The ubiquity of these lessons in social and natural sciences and management reflect the apparent commonality of human attributes in all societies. These attributes are represented, although obliquely, in economic theory and practice.

I shall start by briefly describing why MPAs are increasingly seen as useful mechanisms for achieving ecologically sustainable development of the sea's resources and follow with a description of the world's largest and most valuable MPA- the Great Barrier Reef Marine Park. An estimation of the value of this MPA will give a sense of scale to the discussion. Then I shall outline the lessons that have been learned globally in developing MPAs in various bio-geographic and socio-economic environments.

What is a MPA?

.A MPA is defined by IUCN, the World Conservation Union, as **“Any area of intertidal or subtidal terrain, together with its overlying waters and associated flora, fauna, historical and cultural features, which has been reserved by legislation or other**

effective means to protect part or all of the enclosed environment." (Kelleher, 1999).

It is widely recognised that MPAs can make a series of potential contributions to human communities. They include :

- Sustaining fisheries;
- Economic benefits from tourism;
- Recreation and improved human health; and
- Aesthetics.

One of the major changes that is occurring globally is the recognition that conventional fisheries management and, indeed, sectoral management generally, are failing to achieve sustainable development. Let us look briefly at the reasons for this.

Background

The concept that development should be ecologically sustainable is not new. It has existed in virtually every group of humans who have lived and depended on the earth's natural bounty. It is my controversial opinion that, one of the factors that has contributed to the erosion of commitment to ecological sustainability in theory and practice in the 20th Century has been the application of micro-economic analysis involving cost-benefit analysis and the calculation of net present worth using discount rates of around 5% p.a. or more. The application of these methods and concepts together tends to lead to decisions which state tacitly or explicitly that anything that happens more than twenty years hence is irrelevant. This factor, which I do recognise contributed significantly to relatively objective decision-making in resource development, came on top of a long history of over-exploitation of common property resources for other reasons.

Marine areas may be particularly vulnerable to the negative impacts of uncontrolled use because they are traditionally considered to be "commons" and development in marine areas is not usually closely controlled, either by effective management or by economic processes. Individuals are normally assumed to act so as to maximise their returns on investments over a fairly short period of time. Private corporations will generally have an obligation to their shareholders to act similarly, within the constraints of socially acceptable behaviour, and government agencies may have equivalent motivations. It follows that such individuals and institutions have a strong incentive to externalise costs and to internalise benefits as much as practicable. That is to say, they have an incentive to maximise utilisation of the "free" or common resources. In the case of the sea these common resources are the water and the air above it, their natural qualities and their pollution assimilative capacity, scenic vistas, wildlife habitat and the wildlife itself, such as corals, fish, whales and birds.

Before and since Garrett Hardin's essay "The Tragedy of the Commons", (Hardin, 1968) there has been sufficient study to demonstrate conclusively that these incentives work. Consequently, the usual long-term effects on the commons of uncontrolled human use is

that the commons are destroyed. General awareness of this fact, even in the absence of a clear perception of the processes involved, has led to demands by the public, particularly in the past three decades, for the right to participate in decisions affecting the commons, and for governments to protect these public properties. While it is true that most marine areas are not absolute commons, in that there are usually some restrictions on access and use, nevertheless they are not subject to individual ownership equivalent to that applying to most land areas. It follows that in relative terms they are commons and are subject to the same human processes as were those considered in Hardin's essay, which were not in fact "ideal" commons themselves.

Let us now look at the effect of human behaviour modes on fisheries management.

The Problems with Conventional Fisheries Management.

Traditional fishery management has demonstrably failed in most of the world's fisheries to prevent overfishing and stock collapse. The United Nations Food and Agriculture Organisation (FAO) estimated in 1995 that 69% of the world's marine fisheries were "either fully to heavily exploited, overexploited, depleted... and therefore in need of urgent conservation and management measures". (FAO.1995). Events since 1995 have shown that this trend is continuing.

The literature is replete with examples of disastrous collapses of apparently well-managed fisheries. One of the most dramatic has been the collapse of the groundfish fishery on the Grand Banks of Newfoundland, and the subsequent failure to recover over a period of years even though a complete moratorium was placed on harvest. (Lauck et al. 1998). There are many other examples of stock collapse throughout the world's seas, even in the presence of scientifically based stock assessments and apparently sound management regimes based on those assessments.

Many scientists believe that the primary cause of such failures is inherent uncertainty. The development of chaos theory by Lorenz and, independently, by May, shows that cause-effect relationships which contain non-linear elements are likely to be characterised by dramatically different outcomes from small changes in initial conditions. The behaviour of fish populations over time, especially multi-species stocks, is indeed often non-linear. It follows that predictions of future fish stocks are in many cases likely to be highly uncertain.

This problem is exacerbated by other factors. A major one is that the ability of scientists to assess accurately even present stocks is often very limited, not only in terms of total biomass, but in age structure. The cost of making accurate assessments in all but very simple fisheries is likely to remain prohibitive. Minor errors are likely to lead to massive errors in predicting stocks.

Another problem emanates from the difficulty management agencies encounter in applying conservative effort and take restrictions. Naturally, fishers demand that actions by management agencies which are likely to adversely affect their livelihoods in the short

term are supported by unequivocal scientific evidence. The burden of proof is placed on the management agency. Inevitably, management agencies are forced by political pressure to err on the side of overestimates of fish stocks and their ability to recruit.

It is clear from the fundamental nature of these problems that they are unlikely to be solved merely by expenditure of more effort and resources on fishery research and management by controlling effort and take. These methods need to be supplemented by other approaches which do not suffer from the same systems problems. MPAs are seen by many to be the appropriate response, because they protect habitat and ecological processes, even when those processes are not fully understood.

Contributions of MPAs to Fishery Management and Other Human Interests..

The primary reasons for creating MPAs have been identified as:

- . to maintain essential ecological processes and life support systems;
- . to ensure the sustainable utilization of species and ecosystems; and
- . to preserve biotic diversity. (Kelleher, 1999).

Each of these three interconnected reasons is likely to be relevant to fishery management, because even if the primary purpose is sustainable harvesting of fish, this aim is unlikely to be achieved without simultaneously achieving the other two. That is to say, the fishery is unlikely to be ecologically sustainable.

The major problems which stand in the way of achieving these aims are :

- . stress from pollution;
- . degradation and depletion of resources, including over-harvesting of species;
- . conflicting uses of resources; and
- . damage and destruction of habitat.

MPAs, in association with other management methods, can address all these problems. Particularly, they can significantly reduce the incentives and opportunities to over-exploit resources and to externalise costs. However, in considering their potential efficacy, it is necessary to specify the kind of MPA and its relationship to surrounding areas which can impinge on it. There are two approaches to addressing this issue.

The first approach involves the creation of small marine protected areas which provide special protection for particularly valuable areas (such as spawning sites) within broad areas which are subject to sectoral regulation or, in some cases, to no regulation. Protection may be permanent or seasonal. This is the most common application of the concept of marine protected areas. It is usually the first stage in marine conservation initiatives which go beyond fisheries restrictions which limit gear, catches and effort.

The second approach is a more recent development. It consists of the establishment of a large, multiple use protected area with an integrated management system providing levels of protection varying throughout the area, from total exclusion of human activity other than research and monitoring in relatively small areas, to usually larger areas where many non-destructive activities are allowed or encouraged. Ideally, this integration should extend to co-ordinated management of marine and terrestrial areas in the coastal zone and beyond, with special emphasis on controlling land based sources of marine pollution. Experience has shown that the presence of a downstream MPA can be a powerful argument for changing polluting land activities. The Great Barrier Reef Marine Park is still the best example of this approach, even though it was fully established as long ago as 1988.

Both approaches allow for the protection of habitat. This is considered essential if the three major aims described above are to be achieved, because the ecological interdependencies and variabilities in most fisheries are unlikely to be so simple as to allow protection of a species merely by controlling fishing effort and take.

I do not intend in this paper to go into the contributions of MPAs to tourism and other human interests, partly because the reasons for their effectiveness are relatively obvious. For instance, it would be surprising if people were interested in touring degraded marine areas. Let us now look in some detail at the world's largest MPA as an example of the application of the management principles sketched above.

The Great Barrier Reef Marine Park.

The Great Barrier Reef Marine Park Act, 1975 was one of the first pieces of legislation in the world to apply the concept of ecologically sustainable development to the management of a large natural area. Real public involvement in all areas of management and decision-making is at the centre of the strategic approach that has been adopted to ensure that human use of the Great Barrier Reef is ecologically sustainable. So far, the approach has been successful - over-exploitation of the Great Barrier Reef has largely been prevented.

We are entering a new and more difficult phase. Direct use of the Marine Park is increasing; government expenditure as a proportion of Gross Domestic Product is decreasing; there are proportionately fewer resources for management; management agencies are being forced to recover costs from users who are reluctant to pay; and there is evidence that nutrient levels in the waters of some parts of the Marine Park are at times above those at which some corals can thrive.

The Great Barrier Reef.

The Great Barrier Reef (the Reef) is the largest system of corals and associated life forms anywhere in the world. It is encompassed in a Marine Park within the Great Barrier Reef Region (the Region - fig. 1) covering an area of about 350,000 sq km on the Australian continental shelf - larger than the United Kingdom. The Reef

stretches for almost 2000 km along the north-eastern coast of Queensland in a complex maze of approximately 2900 individual reefs, ranging in area from less than 1 hectare to more than 100 sq km. In the north, the Reef is narrow and its eastern edge is marked by a series of narrow 'ribbon' reefs but in southern areas it broadens out and presents a vast wilderness of 'patch' reefs.

The Reef is diverse not only in the form and size of its individual reefs and islands, but in its inhabitants. Six species of turtle occur in the Region and it is believed that there are more than 1500 species of fishes. The Reef may be the last place on earth in which dugong (Dugong dugon - an endangered species) are still common and are not in jeopardy. About 350 species of reef-building coral have been identified on the Reef and the islands are inhabited or visited by more than 240 species of birds.

Human Use of the Great Barrier Reef

It has been estimated that the value of Reef-dependent activities (on the Reef and on the adjacent mainland) approximates AUD\$1,300 million per annum.

The following table summaries the initial, flow-on and total impacts for output and employment associated with the nominated economic activities that utilise the GBRMP, for the year 1994/95. (GBRMPA, 1997)

Summary of Output Effects GBRMP- Based Activities, Queensland, 1994/95						
Activity	Output Effects			Employment Effects		
	Initial Output (\$m)	Flow-on (\$m)	Total Impact (\$m)	Initial Employ. (no.)	Flow-on (no)	Total Impact (\$m)
Commercial Tourism	436.5	407.9	844.4	7,421	5,467	12,888
Commercial Fishing	120.6	73.3	193.9	1,568	1,152	2,720
Recreational Fishing & Boating	120.2	134.7	254.9	N/A	2,008	2,008
Total	677.3	615.9	1,293.2	8,989	8,627	17,616
Source: KPMG Consulting						

Commercial fishing and tourism, recreational pursuits including fishing, diving and camping, traditional fishing, scientific research and shipping all occur within the Great Barrier Reef Region. The only activity which is prohibited throughout the

Region is oil drilling. Mining is prohibited in the Great Barrier Reef Marine Park which covers 98.4% of the Region.

Resort tourism is the largest commercial activity in economic terms

There is conflict between the various users of the Reef and between some users and those who wish to see the Reef maintained in its pristine state forever. Some uses of parts of the Reef have already reached levels which fully or over exploit the productive capacity of the system. Bottom trawling for prawns is an example. Run-off from islands and the mainland contains suspended solids, herbicides, pesticides, nutrients and other materials.

This description applies also to other reef systems throughout the world's tropical seas. The need for and the difficulties of managing uses so that they are ecologically sustainable forever are also common. The system of management which has been developed on the Great Barrier Reef could be applied elsewhere, although the social acceptability of any management system is likely to be diminished where there are very high levels of usage and economic dependence on reef areas, for instance in many parts of Asia.

The Goal of the Authority

The Great Barrier Reef Marine Park Authority has derived a primary goal and a set of aims from the provisions of the Act and recognition of the political, legal, economic, sociological and ecological environment in which it operates.

The Authority believes that any use of the Reef or associated areas should not threaten the Reef's essential ecological characteristics and processes. Activities depending on the Reef's renewable resources should generally be held at or below maximum sustainable intensities indefinitely. This belief has led the Authority to adopt the following primary goal:

"To provide for the protection, wise use, understanding and enjoyment of the Great Barrier Reef in perpetuity through the development and care of the Great Barrier Reef Marine Park".

However, not only the physical aspects of the Reef need to survive. If the Reef is to be protected, administrative arrangements also must be durable.

Failure of the Authority would not necessarily or even probably be followed by the creation of new, more effective arrangements.

In Australia the major determinant of administrative survivability of organisations like the Authority is public support. In the long run, government support flows from it. Recognising that the Authority and the Marine Park concept already have a degree of public support, the Authority must act in ways which sustain or increase

that support. What are those ways? It seems clear that the ground work has been well established in the Act through the formal requirements for public participation, the provisions for a Consultative Committee, the composition of the Authority itself and its functions, as well as the ability to perform those functions in association with Queensland or its agencies.

Generally speaking the public is likely to continue to support the Marine Park and the Authority if the primary goal is seen to be being achieved efficiently. For this to occur, the public will have to be aware of what the Authority and its day-to-day management agencies are doing and the way they are doing it, the effectiveness and costs of their programs and the reasons for them, and to the extent practicable, to be involved in the establishment and management of the Marine Park. A set of aims has been derived from this and related observations. One that should be of particular interest to economists is "to minimise regulation, consistent with meeting the goal and other aims of the Authority."

The Marine Park and its Zoning System

The Great Barrier Reef Marine Park is not a National Park. It is a multiple-use protected area, fitting the definition of Category VI of the classification system used by IUCN, the World Conservation Union (IUCN). It also meets the criteria for selection and management as a Biosphere Reserve), although it has not been formally proposed or established as one. The Reef was inscribed on the World Heritage List in 1981 as a natural site.

Through the use of zoning, conflicting activities are separated, areas are provided which are suitable for particular activities and some areas are protected from use. Levels of protection within the Park vary from almost complete absence of restriction on activity in some zones to zones within which almost no human activities are permitted. The only activities which are prohibited throughout the Park are oil exploration, mining (other than for approved research purposes), littering, spearfishing with SCUBA and the taking of large specimens of certain species of fish.

In the zoning plans which have been developed so far, there are three major categories of zones. They are:

- | | |
|---|--|
| 1.Preservation and/or Scientific Research zones | Equivalent to IUCN Category I-
Strict Nature Reserve / Wilderness Area: protected area managed mainly for science or wilderness protection |
| 2.Marine National Park zones | Equivalent to IUCN Category II-
National Park: protected area managed mainly for ecosystem protection and recreation. |

3. General Use zones

Equivalent to IUCN Category VI-
Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems.

Nature Reserve VI, Resources Reserves. Uses are held at levels which do not jeopardize the ecosystem or its major elements. Commercial and recreational fishing are generally permitted, although bottom trawling is prohibited in one of these two zones.

The zones are fixed during the life of a zoning plan (generally five to seven years). They are complemented by subordinate areal management plans that give special protection to animal breeding or nesting sites, to sites in general use and other areas which are required to be protected to allow appreciation of nature free from fishing, collecting or major development and to sites suitable for scientific research.

Linkage with the Land

It has always been the philosophy of the Authority that the Great Barrier Reef should be managed as a single ecosystem including all the waters of the Great Barrier Reef Region and the 900 islands within its outer boundaries.

This has largely been achieved through the following mechanisms:

- . coordination of policy and action between the Federal Government and the State (Queensland) Government in a 4-person Ministerial Council;
- . the State Government being represented by one member on the 4-person Authority (the Chairman represents the Federal Government, one represents Aboriginal and Torres Strait communities and a fourth member is independent);
- . day-to-day management of the waters and islands is carried out by a single management group, with costs shared by the two governments;
- . the application of the policies embedded in the goal and aims of the Authority (described previously); and
- . very strong commitment of the Authority and Queensland agencies to work together.

The problem of the effects on the Great Barrier Reef of human activities on the mainland are more intractable. Probably the major issue is run-off from farm land of nutrient enriched water. However, even in this case high levels of cooperation in research have been achieved between the Authority, farmers' organisations and state Government agencies responsible for primary industry. Our experience has been that if cooperation is achieved in carrying out research into a problem then that cooperation is likely to extend into defining and applying ways of curing the problem.

Sustainable Fishing

In common with nearly every major world fishery, the Great Barrier Reef prawn fishery is over-capitalised. It is going through the now familiar process of declining catch-effort ratios. This problem is being addressed in two ways.

Through the zoning system, some areas of the Marine Park are closed to trawling. These amount to about 30% of the total area. They act as reference areas, so that the long term effects of trawling can be determined. They also ensure that the species that occupy them are fully protected.

The second approach is being taken by the fishing industry itself and the agencies directly responsible for its management. It consists of traditional fisheries practices including seasonal closures, the protection of nursery areas and attempts at limiting the total effort expended in the fishery.

We are fairly confident that these two complementary approaches will together ensure that any damage to the Great Barrier Reef system from fishing can be repaired. Additionally, the Authority has worked with the commercial fishing industry in a scientific study of the effects of all kinds of fishing on the reef ecosystem.

On the basis of the results of this research, the Authority and fisheries agencies are modifying their management programs to ensure that the use of the Great Barrier Reef for fishing is ecologically sustainable

Lessons from experience.

Several lessons shine out from the experience of my colleagues and me in establishing MPAs around the world. First, the involvement of local people is essential. It must begin at the earliest stage but must not be forgotten once the planning phase is over. Lack of participation by local people is the most common cause of failure, for no government can manage effectively a MPA without community support. Effective participation calls for restraint on the part of MPA managers, who must ensure that the local communities "own" the MPA intellectually and emotionally. (PARKS, 1998)

The specific lessons that follow are related to this observation. They appear to me to be universal in their applicability- to virtually all social groups and to different bio-geographic and socio-economic circumstances.

1. **The most important attribute of an MPA manager is integrity.** Many managers have made the mistake of believing that they can fool some of the people some, or even all, of the time. The consequence of this is that the manager appears to win a series of battles, but he or she loses the war because of the accumulation of loss of trust. This eventually leads to failure.
2. **Time spent in preparation is an essential investment that will be repaid many times over.** Proponents of MPAs have to show demonstrable benefits for stakeholders, and this takes time and diplomacy.
3. **Financial sustainability needs to be built in from the beginning.** In many countries government budgets for conservation are declining, and protected area managers are having to be increasingly creative in finding ways of paying for protected areas once the initial grants and aid support run out. Alternative income generating activities should be planned from the beginning, not when the grants run out.
4. **Almost all MPAs contribute to the maintenance or restitution of both biological diversity and abundance, both of which are relevant to sustainable fisheries.** One of the problems commonly encountered in setting up MPAs is conflict between those who wish them to be established purely for the sake of biological diversity and those who emphasise their contribution to human welfare. This conflict is not only unnecessary, it is destructive of both objectives. There are always opponents to the development and establishment of MPAs and it is essential that those in favour of them collaborate. Ecologically, MPAs inevitably contribute to the maintenance and restoration of biological diversity and also to biological productivity. This has been demonstrated particularly in relation to coral reef MPAs as described in numerous papers by Russ and Alcala. (e.g. Alcala and Russ, 1990.).
5. **It is not feasible in today's marine environment to divorce the questions of resource use and conservation, because marine natural resources and their living space are all sought now by many different users for many different purposes.** Many of us remember the halcyon days when many developed countries and some developing countries had the luxury of natural marine resources which were not fully utilised. In those days it was possible to create MPAs purely for the sake of biodiversity without regard for the effects of the MPAs on local communities. Those days are long gone in nearly all parts of the world.
6. **The tendency in some areas to oppose the recognition of fishery reserves as MPAs seems to be counter-productive, inhibiting cooperation between fishers and environmentalists in creating and managing MPAs.** Coastal communities who depend for subsistence or for profit on coral reefs will never support MPAs if they are thought to incur more costs than benefits for those communities. It follows that proponents of MPAs should ensure in their design that they overtly provide for local community benefits, as well as contributing to biodiversity.
7. **There has been a long history in almost all areas of the world of conflict and lack of cooperation between environmental and fisheries management agencies. This**

lack of joint action inhibits progress in establishing MPAs and managing them wherever it is manifest. Individual MPAs and systems plans should be designed to serve both sustainable use and environmental protection objectives, and relevant agencies should work together in planning and management. Anyone who is familiar with government in any democratic country (and perhaps in non-democratic ones) will have encountered the natural human tendency for officers of one agency to compete with officers of other agencies. This occurs particularly where, as in the case of fisheries and environment agencies, the objectives will overlap or be in conflict.

If this natural human tendency is to be overcome, it will require deliberate action by the agencies concerned to identify the problem and to set up systems to overcome it. Perhaps the most effective system is the establishment of joint working parties to deal with the development of strategies and action plans that address the primary objectives of both agencies.

8. **Local people must be deeply involved from the earliest possible stage in any MPA that is to succeed. This involvement should extend to them receiving clearly identifiable benefits from the MPA.** An important attribute of human behaviour is to be suspicious of proposals by others, in the development of which they have not been involved from the start. This suspicion is often justified. All of us have had experiences where proposals have been deliberately held secret so as to minimise the ability of those who will be adversely affected by the proposals to oppose them. I believe that this human attribute may be so fundamental to survival that it is genetically programmed.

The work involved in converting a person full of suspicion to an ally is immense. Sometimes it is impossible. While the early involvement of potential opponents in the process of developing and establishing a MPA takes a lot of time and effort, the global experience is that this investment is essential. It will produce dividends of much greater magnitude later on in the development phase. Conversely, haste in the development phase, often in order to remove opportunities for opposition, will usually result in future costs many times greater than the apparent savings.

9. **Socio-economic considerations usually determine the success or failure of MPAs. In addition to biophysical factors, these considerations should be addressed from the outset in identifying sites for, selecting and managing MPAs.** It is essential that ecological considerations are central in the process of identifying potential sites for successful MPAs. However, world-wide experience has shown that no MPA will be successfully established without general community support – especially support from local communities. This experience applies equally in developing and developed countries. No country can afford to establish and manage an MPA successfully using enforcement methods alone. The ease of avoiding restrictions on use in the sea are so numerous that voluntary compliance is essential, reinforced by enforcement that reassures the voluntary compliers that the minority non-compliers will not get all the benefits.
10. **It is better to have an MPA that is not ideal in an ecological sense but which meets the primary objective than to strive vainly to create the “perfect MPA”.** We all have seen dedicated scientists and others spending their lives attempting to convince governments to establish MPAs in areas which are ideal from the viewpoint

of biological diversity but which are not appropriate from a socio-political viewpoint. However, it is usually possible to find potential sites for MPAs which are satisfactory from a biodiversity (ecological) viewpoint and which can be seen to contribute to the welfare of local communities. The establishment of MPAs in these sites will immediately begin contributing to the maintenance of biodiversity. In contrast, environmental degradation will proceed as long as proponents of MPAs expend their energies in futile attempts to establish MPAs where socio-political forces will ensure their failure.

11. It is usually a mistake to postpone action on the establishment of a MPA because biophysical information is incomplete. There will usually be sufficient existing information to indicate whether the MPA is justified ecologically and to set reasonable boundaries. In nearly every country, human populations continue to increase in coastal areas. Their demands on local marine environments escalate accordingly. In these circumstances, unnecessary delay in establishing a MPA places the whole program in jeopardy. In most countries and locations sufficient ecological knowledge exists to permit a high degree of confidence in identifying suitable sites for MPAs. This information may not be held in a central database but is more likely to reside in various information centres and parts of the community. The involvement of local users in identifying ecological attributes can serve two functions – first, the efficient collection of information gathered over many years by people highly familiar with the target area; second, the generation of support from these local users for the proposed MPA. A person is much more likely to support a proposal if he or she has been involved in information collection and in decision-making in relation to that proposal.

12. Design and management of MPAs must be both top-down and bottom-up.

A common feature of western thought, which many Asians find amusing, is the “either-or” mentality. This is demonstrated in the adversarial legal systems which prevail in many western countries and by the tendency to think in black and white terms.

The debate about the relative merits of top-down and bottom-up approaches exemplifies this problem. Except in mythical perfect dictatorships, pure top-down methods will never work. Equally, attempts by local communities to establish protective measures without the support of appropriate levels of government will end in their rules being broken by outsiders. Therefore, in developing MPAs, it is necessary to obtain the formal support of both local communities and government.

13. An MPA must have clearly defined objectives against which its performance is regularly checked, and a monitoring program to assess management effectiveness. Management should be adaptive, meaning that it is periodically reviewed and revised as dictated by the results of monitoring. Modern management recognises that it is not possible to assess performance without identifying measurable objectives and overtly measuring the attainment of those objectives.

It follows that, before a MPA is established, its general and specific objectives should be defined; the physical, chemical, biological, social and economic attributes that define those objectives should be identified; and a monitoring program should be

carried out that measures those attributes as a foundation against which to measure later changes.

- 14. There is a global debate about the relative merits of small, highly protected MPAs and large, multiple use MPAs. Much of this dispute appears to arise from the misconception that it must be one or the other. In fact, nearly all large, multiple use MPAs encapsulate highly protected zones that have been formally established by legislation or other effective means. These zones can function in the same way as individual highly protected MPAs. Conversely, a small, highly protected MPA in a larger area subject to integrated management, can be as effective as a large, multiple use MPA.**

This debate is another example of the either/or arguments in which we Westerners seem to excel. I have seen eminent western scientists criticise very large, multiple-use MPAs on the grounds that they do not provide sufficient levels of protection, even though they do contain very substantial areas formally zoned as Category I or II in the IUCN Protected Area categories and even though it would be inconceivable that society would ever contemplate closing the whole multiple-use area to human activity.

These debates are destructive. They fail to recognise that the ideal form of management is variously labelled integrated ecosystem management, bio-regional planning etc. This ideal constitutes an integrated system which includes highly protected areas as well as a suite of controls in other areas that ensure ecologically sustainable development. Large, multiple-use MPAs which incorporate Categories I and II zones are a major step towards such country-wide integrated management regimes. The following conclusion emphasises the physical reason why integrated ecosystem approaches are essential and why they should be applied to the development and establishment of coral reef MPAs.

- 15. Because of the highly connected nature of the sea, which efficiently transmits substances and forcing factors, an MPA will rarely succeed unless it is embedded in, or is so large that it constitutes, an integrated ecosystem management regime.**

Conclusion.

The increasing failure of sectoral management of marine resources is now widely recognised. Failure is clearly due to a combination of bio-physical processes in the sea and human attributes. The biophysical processes include the high degree of connectivity that exists in marine environments (which effectively transmits substances and processes long distances) and the chaotic nature of the effects of fishing pressure on fish populations. Critical human attributes include the desire to internalise benefits and to externalise costs- exemplified by the common statement of fishers; "If I don't take them, others will".

MPAs have been shown to be able to contribute to the attainment of ecologically sustainable development of marine resources by complementing other management approaches. They can overcome sectoral management deficiencies, decrease incentives for over-exploitation of natural resources, maintain essential ecological processes and life-support systems and maintain biological diversity and productivity.

The over-riding conclusion from case studies of various MPAs around the world is that success or failure is not usually determined by complex factors unique to that particular MPA. On the contrary, they result from failure to apply fairly simple strategic principles. And it is usually the socio-economic rather than the biological factors that determine success or failure.

Why do managers fail to apply these simple, well-proven approaches? My conclusion is that it derives from the natural tendency of humans to prefer immediate gratification to long-term benefits. It takes a lot of self-control for a manager to refrain from responding in-kind to insults, or to deliberately raise difficult issues with possible opponents in order to resolve them. It is much easier, and perhaps more “natural”, to avoid difficult matters and hope that they go away, or to apply the dictum of “an eye for an eye”.

Nevertheless, experience shows that there are strategic principles which are applicable virtually everywhere. I have attempted to set these out in this paper.

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