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MARINE RESERVES

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Introduction

This paper is about fully-protected marine reserves. It does not refer to so-called marine protected areas (MPAs). The reason is simple. Every part of the sea already has *some* forms of protection, and regulations and restrictions continue to develop everywhere. Although the actual restrictions vary considerably in different countries and regions, so many places can already be classed as 'Marine Protected Areas', and the number is increasing so rapidly, the title is of little value.

Many attempts have been made to classify MPAs into grades of protection (including the IUCN) but none of them are of much practical value. One reason is that 'protection' is multi-factor and does not produce any simple hierarchy. Another reason is that marine planning is rapidly expanding (from a low base). Most 'categories' of protection change with time (extra regulations, subdivisions, etc.) and every year many new areas of sea are put in some category.

We should recognise clearly that MPAs are NOT primarily a form of conservation or protection, they are simply a misleading label for general marine planning.

Marine reserves reverse the usual philosophy of management in the sea. In general terms marine management assumes that human activities should be permitted everywhere unless or until there is evidence of some significant impact or conflict. In marine reserves the aim is maintain the full range of intrinsic properties. To ensure this, the burden of proof is reversed. Potentially-disturbing activities are banned in reserves on principle. No evidence of actual damage is required, still less that any damage is significant in some way.

Achieving complete 'naturalness' in marine reserves is, of course, an impossible ideal, especially if we encourage people to see and study the results. However, making this the aim and focus of management is entirely practical and has many precedents both in science and everyday life. Physicists aim for 'accurate' instruments, chemists aim for 'clean' apparatus, physiologists aim for 'healthy' experimental animals. None of these aims are completely achievable. Engineers and architects aim for 'safe' roads and buildings, and keep doing so, despite the impossibility of complete success. It is perfectly sensible and practical to aim to maintain (or restore) the full range of natural content and process within marine reserves.

Positive attitudes for systems of marine reserves

Action on marine reserves to date has been mostly local, analytical, and problem-based. Despite the successful establishment of fully-protected marine reserves in many regions, there is no agreement about how we can move to effective, efficient and worthwhile systems of such reserves.

This section focuses on the meta-principles that will encourage positive thinking about the establishment of *systems* of marine reserves. This will enable us to put in proper perspective the almost endless list of excuses for delay and inaction.

There are three key ideas - uncertainty, complexity and synthesis. They are closely related. In order to create systems of fully-protected marine reserves, we must learn to:

1. Confront the uncertainties in available information, and then use these to build effective systems.
2. Recognise the scales of space, time and complexity in the sea, and then use these to create efficient systems.
3. Appreciate the range and multiplicity of benefits of marine reserves and then use these to synthesise worthwhile systems.

Uncertainty

There is rarely, if ever, really good data on the present content and processes of the sea. Even in the best-studied locations, the best-known groups and the most investigated processes, discoveries continue at a rapid rate. Even if we assume we have 'sufficient' data, the analysis is equally problematical. For the foreseeable future, it is very unlikely that we will be able to calculate the 'right' places for marine reserves in any precise way, or even to be sure that this is the appropriate method.

Scientists spend most of their time obtaining precise data, analysing these to produce clear conclusions and then using these to make predictions. The best short definition of science is 'Science is prediction'. It is surprising then that I should begin by stressing how science can help when the data are inadequate, few conclusions can be drawn and little detailed prediction is possible. However, we need to remind ourselves of two basic points.

First, science does not, and cannot, tell us how to behave. It can predict the constraints (what is possible) and it can predict consequences (if you do this, then that will happen – or has some degree of probability), but it does not tell us what to do. This is true even within science. As Karl Popper himself said –There is no logical procedure that will tell you whether a hypothesis is *worth* testing. This is even more true when applied to the real world. Actual decisions always depend on value judgements and value judgements depend on assumptions, many of which *cannot* be scientifically tested.

Despite all this, science can help make decisions. Although scientists spend most of their time in precise forms of data collection and analysis, this is not the *purpose* of the exercise. The real aim is to deduce *principles*, forms of prediction that are *independent* of many of the detailed facts.

Some principles (Laws, Rules, Theories, etc.) can be expressed as equations or short logical statements, but others, especially some of the more basic ones, emerge as guidelines or 'rules of thumb'.

In their short but timeless essay '*Uncertainty, resource exploitation and conservation: Lessons from history*', Ludwig *et al* (1993) point out, "most principles of decision-making under uncertainties are simply common sense." Furthermore, all of us are accustomed to using such principles in everyday life. We rarely have all the necessary data to clearly demonstrate the 'right' decision, but, despite this, we often manage to make sensible and effective decisions.

Unfortunately when decisions are being made on large matters of general public interest such principles are often ignored or forgotten. The history of marine reserves so far is a classic illustration of this. It is understandable that users, scientists or politicians will want more information before any action is taken to limit existing activities, but it is not sensible to wait for their complete satisfaction. In public affairs it is frequently necessary to act before clear proof is available or precise prediction is possible.

The list of principles provided by Ludwig *et al* can be applied to the business of creating systems of fully-protected marine reserves:

(a) consider a variety of plausible hypotheses and a variety of possible strategies
Marine reserves automatically do this in relation to the planning and management assumptions that generally apply in the sea. For example, management tries to arrange for fishing of a particular stock to be sustainable. This requires complex data, analysis and prediction. It is always plausible that the result will not be what was intended. Excluding a portion of the stock from fishing is a different and possible strategy. The same argument applies to management of any human activity in the sea. Whatever we assume in standard management, marine reserves offer a way of introducing other plausible hypotheses and strategies based on these.

(b) favour actions that are informative
Scientific investigations need data which allow unconfounded conclusions. Areas in the sea which are not being actively disturbed by humans will make it much easier to understand the intrinsic processes and the effects of human disturbance. Unless we have places that are not fished, dredged, dumped on etc., it is very difficult to form sound conclusions about what would happen in their absence. Marine reserves will provide 'controls' for any reasonably preventable human disturbance. Although this is rather obvious, scientists have been very slow to state the point and even slower to ask for something to be done about it.

(c) favour actions that are robust to uncertainties
This extends the second point from scientific research into education, conservation and resource management generally. While it is rarely clear, in advance, precisely how a particular reserve would aid in education, conservation, etc., we know that undisturbed areas would be helpful in many ways in these fields.

(d) hedge
This single word encapsulates the proverb –'Do not put all your eggs in one basket'. If any feature is important, we must prevent its value being destroyed by a single accident, or a degree of ignorance. The simple way to guard against such accidents or ignorance is not to rely on a single system – either of management or location.

(e) probe and experiment (e.g. sizes and arrangements)

If we do not know the 'right' size or arrangement for marine reserves it is sensible to create a range, rather than try to calculate the 'best'. In any case, it is unlikely that there is a single best arrangement for the great variety of species and processes we are trying to maintain.

(f) monitor results

For marine reserves, this is much more difficult than it sounds. In most management arrangements there are clear objectives, but in marine reserves we do not know the result(s) we want. We want 'more natural' conditions, but we rarely know what they are in advance. Despite this problem, it is especially important to monitor results, because this is the only reliable way to separate natural from human induced variation. Without an understanding of this, management of any human activity is likely to be inefficient.

(g) update assessments and modify policy accordingly

While this is obvious, the ramifications of it are many and complex. We should note that most of the larger modifications would be to policies outside the reserves. The main exception to this would be indications that more or larger reserves would be useful.

(h) favour actions that are reversible

Marine reserves fit this feature almost perfectly. It is always possible to restart fishing, dumping or dredging at a location, whereas it is often impossible to reverse a fishieries collapse or replace dredgings.

(i) equitable

A point not mentioned by Ludwig *et al*, is worth including here. Since there is no allocation of any of the usual 'resources' in marine reserves, such reserves are equitable, meaning they apply equally to all sectors of the community. This point is often denied by existing users of particular locations, usually in an attempt to extract compensation, but it is seen as fair and reasonable to all others.

Complexity

There is only one sea. It is very large, covering more than 70% of the surface of the planet. It has many regions, which are very different in their physical conditions and life. Each region contains a wide range of ecosystems and habitats, and each of these contains an array of species. There are innumerable interactions between these species and with their physical environment. The time scales that govern the important processes range from seconds to millennia. If we attempt to calculate precisely what is necessary to protect the biological content and its processes, we are overwhelmed by the complexity.

Furthermore the scales involved effectively prohibit precise analytical science in the usual sense. We are not dealing with test-tubes on a bench or small quadrats, we are talking about square kilometres of public domain. It is not possible for scientists to have a free choice of experimental design.

Yet in a fundamental sense, the nature of these difficulties provides the answer. Since it is impossible, for the foreseeable future, to use precise analytical science to cover more than a few relatively trivial cases of protection, it is necessary to use the other attributes of science. It is practical and sensible to use general principles to create systems of protection which do not depend on detailed or precise knowledge. For example, it is clear that a representative network of fully-protected marine reserves will serve to protect species that have not even been discovered, still less described, quantified and assigned to some category of danger.

Provided we are prepared to act on principle, complexity and our low levels of knowledge are not barriers to effective action. Indeed, on land, we do often act in this way. Representative reserves on land are now widely supported and promoted, regardless of whether all the species have been enumerated or all the ecological processes involved have been evaluated. Far from being a radical idea, as soon as it is considered at all, the notion of fully protecting some of everything *until* we understand them better, seems simple common sense, and the alternative (exploiting *all* parts of the sea until we notice problems) seems grossly irresponsible. The general public and politicians are able and willing to appreciate these points, but need scientists to bring them to their attention.

Synthesis

Surprisingly, uncertainty (lack of prediction) and complexity extend to the uses benefits and values of marine reserves. Although, once discovered, most of the benefits seem fairly clear, indeed almost obvious, few of them were foreseen. Many now recognised benefits were not considered at all before they became obvious, or, it was thought they would not develop. The educational benefits were never mentioned until the appearance of school buses at Leigh became a frequent event. The large increases in snapper and rock lobster numbers in the reserve were a surprise to those most knowledgeable about their mobility.

This unpredictability is still operating and seems to be fundamental. Each year the list of known and potential benefits of marine reserves increases, and there is no slackening of the rate of discovery. It appears that fishing and other human disturbances in the sea are so widespread, and have been pervasive for so long, that we find it very difficult to imagine the consequences of them ceasing, and still more difficult to perceive the benefits this might produce.

Benefits affect many sectors

One feature of the benefits from fully-protected marine reserves is the wide range of sectors affected. We are still expanding this range and it is impressive. However, many people, including some scientists, continue to act as if only a few of these are significant (such as the benefits to fisheries or to endangered species). It is therefore important to stress the range:

- Science
- Education
- Recreation and health
- Conservation in the stricter senses (genetic, species, and habitats)
- Ecosystem health (the wider aspects of conservation)
- Management support – natural baselines and measurement of natural variation
- Management evaluation – reserves as ‘controls’ for impact assessment
- Fisheries support at three levels
  - (a) insurance against collapse
  - (b) support for aspects such as increased spawning biomass
  - (c) actual improvement in yields

Economic aspects – not just things like ecotourism but also much improved value for money in all sectors. For example, easier data collection, savings in impact controls, earlier recognition of unpredicted effects (or natural variation), etc.

Multiple benefits within sectors

Within science the list of benefits is very long, including the protection of apparatus or marked organisms, the ability to investigate natural densities and behaviour, and other basic aspects. Indeed, it can be argued that many branches of marine science cannot be effectively carried out if all parts of the sea are subject to the confounding effects of various forms of human disturbance.

The potential benefits of fully-protected areas for fisheries support have been listed (e.g. Ward et al, 200 and NRC report, 2001). The lists are extensive and include several aspects that cannot generally be achieved by stock-specific management.

The general point is that in any sector there is a long list of known benefits, an even longer list of potential benefits, and that additions to both these lists continue to be made. Many of the uses, benefits and values are important and fundamental. In the past we have assumed that there were undisturbed areas in the sea that would provide these. But in for many habitats in many regions this is no longer true. The geographic spread, frequency and intensity of human disturbances continues to develop and positive action to provide undisturbed areas is now necessary.

Cross-linkage of benefits

Classification of the uses, benefits and values of fully-protected reserves is not strictly possible. Many results of marine reserves – the more natural conditions – are benefits across many sectors. For example the increased density of fish within a reserve can be a benefit to:

Science	Tourism
Education	Conservation
Recreation	Fisheries support

As larger and older fish develop within a reserve, this can assist with

Conserving genetic variation
Providing increased fecundity
Producing more viable gametes
Allowing more variation in other behaviour – such as mobility and feeding

The need for synthesis

The ‘number’ of known or likely benefits is already so large, listing them becomes tedious, and then counter-productive. However, it is important to prevent any sectional interest from capturing the process by pretending that their benefit(s) are the only important factor. This commonly occurs. Many design systems for marine reserves simply assume that fisheries support is the only significant benefit (despite paying lip service to the others), and, some even base their design on the effects on single species. This must be exposed as nonsense. If restrictions on fishing can be shown to benefit a particular species or stock, this can and should be arranged under standard fisheries management. Such arrangements must not be allowed to subvert the much larger purposes of marine reserves.

Urgency and priority

Once the above points are fully appreciated, attitudes to the appropriate speed of action and the nature of priority are completely altered – in fact more or less reversed. When we were considering *single* reserves as *special* cases that might assist with *particular* problems, the focus was on evidence that the precise benefits would develop if a particular reserve was created. Where good evidence was lacking, which was often the case, nothing happened. However, once we consider developing a *system* to provide a *range* of important benefits in *all* regions, the focus moves to providing *sufficient* reserves to ensure that this happens and moving as *quickly* as possible to obtain all the benefits.

The principles required for a system of fully-protected marine reserves are rarely considered, but turn out to be relatively simple. Many of the 'problems' commonly stated are due to confusing the need for *full* protection in *some* areas with the need for *more careful* management *everywhere*. Other 'problems' are due to confusing the selection and justification of *particular* reserves with the principles that govern an effective *system*.

The principles set out on the next two pages are mostly common sense, once there has been some actual experience with fully-protected reserves and the matter is considered at the system level. Unfortunately, neither of these points are yet widely applicable. It took more than 10 years of argument to get the first fully-protected marine reserve in New Zealand and 20 more years of experience before we began to consider systems. So it is not surprising that many places still have no fully-protected reserves and that few people are considering the establishment of systems.

Although progress has been very slow and sporadic, it has been continuous and is accelerating. In the past year several major reports have appeared that focus on fully-protected areas in the sea (see references) and several places, including New Zealand, Victoria (Australia) and Channel Is (California, USA) are making formal moves towards systems of fully-protected reserves.

REFERENCES

Environmental Conservation Council 2000 *Marine Coastal and Estuarine Investigation*. Final Report. 154 pages + appendicies. ECC, Melbourne, Victoria.
National Research Council 2000 Marine protected areas: Tools for sustaining ocean ecosytems. 181 pages + appendicies. National Academy Press, Washington D.C.
Roberts, C. and Hawkins, J. 2000 *Fully-protected Marine Reserves – A guide*. 131 pages. WWF Endangered Seas Campaign, Washington D.C.
Ward, T.J., Heinemann, D. and Evans, N. *2000 The role of marine reserves as fisheries management tools : a review of concepts, evidence and international experience*. Final Report. 165 pages. Department of Agriculture and Fisheries, Canberra, Australia.

Twelve further papers on this topic by W.J. Ballantine are available (as pdf files) at www.marine-reserves.org.nz

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Principles for a system of fully-protected marine reserves

I Principles of aim and concept

1. The aim is to maintain (or restore as far as possible) the full natural biological diversity of the sea and its complete set of processes and interactions.
2. Some areas of the sea will be kept free of preventable human disturbance.
3. Such natural areas have many uses and setting aside such areas is a legitimate use.
4. These marine reserves are a new and different approach from standard marine management (which is focused on users and depends in actual data).
5. Marine reserves are additional to standard management, support such management and are necessary for effective management in the sea.

II Principles of definition

1. Marine reserves and their basic rules are permanent.
2. Marine reserves are the priority in any zoning scheme for the sea.
3. In each marine reserves all reasonably-preventable human impacts are prohibited
   (a) no fishing or the removal of any material (living, dead or mineral)
   (b) no dumping or additions of any material
   (c) no constructions or reclamations
   (d) no potentially-disturbing activities
4. Subject to the above, people are encouraged to appreciate the natural conditions (by actual visits and research, and the provision of information)
5. Marine reserves are large enough to be ecologically viable (This is not the same as self-sustainable – see V 6.)

III Principles of benefit

1. The main benefit (maintaining natural content and processes) occurs independently of our actual knowledge.
2. Many uses, benefits and values of marine reserves are already known and more are being discovered each year.
3. Most of these benefits are 'new', were not predicted and may not be predictable.
4. Known benefits cover a wide range of sectors (science, education, recreation, conservation, management assistance, fisheries support, etc.)
5. There are numerous benefits within each sector and many cross sectors.
6. Some of the benefits are fundamental and important – e.g maintaining ecosystem health and enabling us to understand ecosystem functions.

IV Principles of universality

1. Marine reserves are useful and worthwhile in all climatic and biogeographic regions and all marine habitats.
2. Marine reserves are useful to, and compatible with, the full range of human cultures, socio-political systems and population densities.

3. Political and administrative boundaries do not affect the major uses, benefits and values of marine reserves and should not influence their boundaries.
4. Since allocations of all normal 'resources' in marine reserves are zero, such reserves are equitable across all sectors of society and between countries.
5. Because marine processes do not recognise political boundaries, special effort should be made to share and disseminate knowledge gained from marine reserves.

V Principles of systems

1. All biogeographic and climate regions are represented in the system of reserves.
2. Within each region all major habitats are represented.
3. The habitats in each region are replicated by several spatially-separate areas.
4. Conservative and widely-accepted definitions are used for regions and habitats.
5. A network design is used for each region to maximise the potential connections.
6. The total area of the system is sufficient to achieve self-sustainability of the natural content and processes.
7. The variety of arrangements (in spacing, sizes, etc.) is maximised.
8. Proportionality of area is maintained at all levels – between regions and habitats.
9. Special or unique areas are additions.

VI Principles for implementation

1. Science is used to demonstrate the principles, and show the constraints on their application.
2. Governments state the policy based on these principles and set the stages (timing and amounts).
3. Local and sectional interests are encouraged to participate in arranging the detail.

VII Principles for management

1. Management is adaptive but precautionary. Detailed rules to achieve the principles of definition (II above) cannot be stated in advance since many human impacts depend on frequency or intensity.
2. Effective compliance is arranged
3. Informing the public at large and formal education at all levels of the natural life and processes in the reserves is the most important function of management.
4. Monitoring will be required to support all of the above.