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MARINE RESERVES IN NEW ZEALAND: THE DEVELOPMENT OF THE CONCEPT AND THE PRINCIPLES

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SUMMARY:

This paper reviews 35 years of experience with marine reserves in New Zealand and attempts to distil from this the principles necessary for their successful establishment. Progress in New Zealand was slow but continuous. There are now 16 reserves, many more are planned, and the idea has considerable support with the general public, politicians, scientists, teachers and conservation interests. Plans are being made to create a full system of marine reserves.

Experience in New Zealand and some other countries shows that the broad and vague concept of Marine Protected Areas (MPAs) has little practical value for marine planning and management. In contrast, the clear and simple concept of marine reserves – areas of the sea free from direct disturbance – has proved very useful.

The concept of marine reserves is new and different to standard marine management. It is proactive rather than reactive. Its operation is not dependent on detailed information. Marine reserves are additional to detailed and general marine planning and management, which will continue to operate and develop outside the reserves. Marine reserves provide essential support to these management systems, especially by providing insurance and buffers against ignorance and error.

Marine reserves aim to maintain (or restore) the intrinsic biodiversity and natural processes. No fishing is permitted or any removal of material. No dredging, dumping, construction or any other direct disturbance is allowed. Within these limits, people are encouraged to view the results (directly or vicariously) and hence learn the values of natural biodiversity. The reserves and their rules are permanent.

The known benefits of marine reserves already form a long list and cover a wide range. More are being discovered at a rapid rate. Many direct benefits to science,

education, conservation, and various forms of recreation are now well-established. Indirect benefits - to the fishing industry, to tourism, to resource planning, and to ecosystem health – are steadily becoming clearer, from empirical data and from modelling. The potential benefits of marine reserves are universal in scientific and social terms. They are independent of bio-geographical region and ecological habitat, and also of culture, politics and economics. Marine reserves can work anywhere.

Since marine reserves provide a wide range of benefits, it would be sensible to arrange a system of reserves that would optimise these benefits. No country has yet done this, but several, including New Zealand, have plans in that direction. The principles for such a system are reasonably clear - Representation, Replication, a Network Design and a Self-sustaining Total Area. All regions would be represented in the reserve system and, within each region, all major habitats would be represented. For many reasons, several spatially-separated examples (of each habitat) would be required in each region (replication). A network design would be required so that the decoupling of recruitment from reproduction in most marine populations (via planktonic dispersal of eggs and larvae) is used to sustain the system. The total area of the system needs to be sufficient to make the system permanently self-sustaining.

Some scientists and politicians find it difficult to reorganise their thinking to the level of systems. They keep trying to use detailed analysis to determine the precise locations for each reserve. In fact, once the principles for a *system* are accepted at the appropriate political and public levels (thus preventing any local veto of reserves), it is not necessary to do this. Indeed it is not advisable or sensible. Local and sectional interests can, and should, be used to arrange the precise locations, *within* the guidelines provided by the scientific principles. This involves the existing user groups (and their knowledge) in the positive aspects of the process while reducing opposition based on suspicion of authority or simple parochialism.

The principles for the implementation of marine reserve systems are ‘top-down’ in terms of adopting a general policy designed to optimise the benefits; *and* ‘bottom-up’ for the arrangement of details in terms of local decisions to minimise any temporary problems. This is standard practise in other human affairs once a concept and its purposes are generally accepted and the full benefits of a system are desired.

INTRODUCTION

The label Marine Protected Area (and its acronym MPA) is now in common use, especially by those attempting to plan and manage the sea. However, the definition of Marine Protected Areas is so broad and vague that the term has little value. Indeed, the use of this label merely adds confusion to the situation. Almost any piece of sea that has one or more special rules can be called a Marine Protected Area. This makes the label attractive to politicians and government agencies because they can say that they already have some MPAs and are planning more. They can then imagine that they are acting efficiently to deal with the problems of marine planning and management. However, this is like saying that if we have buildings called ‘schools’ we are dealing with the problems of education.

In sharp contrast to the broad and vague idea of Marine Protected Areas, a number of countries, including New Zealand, have developed the concept of marine reserves – parts of the sea where no disturbance is allowed (Ballantine, 1991). This idea is new, different and additional to the standard methods of marine planning. In marine reserves, all fishing is prohibited, no removal of any material is permitted, and no dumping, dredging or construction is allowed. While the concept is simple, the idea is so new, it appears difficult to those who work with the standard forms of marine planning. Experienced managers find it hard to see how ‘no-take’ and ‘undisturbed’ marine reserves fit into existing methods, protocols and systems. They are correct, because marine reserves are *additions* to such systems. Unless this is clearly understood and accepted, we will be distracted by endless misconceptions.

There are serious problems with nomenclature in this matter. In different parts of the world the same words (marine park, reserve, sanctuary, etc) are used to mean totally different things. In the USA a ‘Marine Sanctuary’ can permit almost any activity except drilling for oil, but in Western Australia ‘Sanctuary Zones’ are the strictly ‘no-take’ areas within large multi-purpose ‘Marine Reserves’. In this paper ‘Marine Reserves’ are defined as ‘no-take’ and undisturbed areas in the sea.

STANDARD FORMS OF MARINE PLANNING AND MANAGEMENT

For many reasons, marine planning and management are at a very early stage compared to the situation on land. Despite the relatively primitive level of management in the sea, two forms of planning have become common. The oldest and commonest can be termed ‘detailed’ planning; the more recently developed system I shall refer to as ‘general’ planning.

Detailed marine planning and management is:

Problem - based
User - orientated
Separated into sectors
Locality - based
Data - based
Detailed and precise

Almost all fisheries planning and management is still at this stage. It is stock-specific and data-based. In order to function effectively it requires a continuous input of high-grade information for each stock. It deals with problems as they arise. It tends to get more and more complex over time, but it is not able to cope well with sudden, large, widespread or unpredicted changes (Ballantine, 1995 and 1996). Other examples of detailed management include authorities for the control of ports, the regulation of pollution, permissions for reclamation, arrangements for erosion control, defence requirements, etc. These authorities are more or less autonomous and produce separate sets of complex regulations for each locality.

Many Marine Protected Areas have been arranged by 'detailed planning'. In California there are 104 MPAs designated by 12 different authorities for a range of reasons (McArdle, 1997). Some of the designations overlap. Each MPA has different rules, stating which activities are permitted or prohibited. The rules are often lengthy and complex. While the purpose of each MPA may have been clear at the time of designation and the rules logical in terms of the local problems, the total situation lacks any clear principle, is very confusing to the public and does not form a sensible system.

Detailed planning for Strangford Lough, U.K. has been going on for more than 30 years. At least 7 overlapping MPA designations exist (ranging from ASSI to Ramsar), but even the proponents feel that the whole exercise has failed to achieve the fundamental objectives (Brown,1999).

General marine planning is:

Based on zoning and compatible activities
User - orientated
Attempts to combine sectors
Regional – based
Uses general experience with problems
Attempts to maximise use and minimise conflicts

The earliest examples of general planning were zones for ports and shipping channels, but many countries, including New Zealand, are now extending territorial planning into all coastal waters using this approach. Some very large areas of sea, such as the Australian Great Barrier Reef Marine Park are entirely divided into zones with different rules for each. The aim in each zone is to encourage a range of compatible activities and prohibit any which would conflict.

General marine planning is an advance on detailed planning because it looks at whole regions (rather than just the places where problems have occurred) and because it considers the interaction of various human activities (rather than each separately). Furthermore it can be pro-active to an extent, by using general experience to anticipate some problems. Nevertheless the approach is still user-orientated and assumes that the intrinsic properties and natural processes in the sea will simply continue to exist, except when we deliberately alter them.

The inability of standard management to create marine reserves

It is clear that in either of these approaches, it is unlikely that anyone will consider keeping some pieces of sea free from all human disturbance. In detailed planning, no one is asked even to think about such possibilities. In general planning, the focus is on active uses, and the general aim is to make these efficient. Only in very special circumstances would areas be arranged where all exploitive use was forbidden.

Consequently the idea of marine reserves is rarely contemplated by those responsible for marine planning and management. This, of course, is not their fault. They cannot reasonably be blamed for the situation. However, the situation is very unfortunate. As is explained below, not only do marine reserves have many 'uses' (despite being kept free from all extractive and exploitive activities), they also have many indirect benefits, some of which are extremely important. Indeed, since most of our active uses of the sea rely on the intrinsic properties and processes, it is essential that these processes are maintained. Fishing (the hunting of wild stocks) falls into this category, and many other uses of the sea also depend on its natural properties.

Our existing powers of disruption (over-fishing, pollution, habitat degradation, etc.), tend to hide the simple fact that we have little power of positive control in the sea. Breakwaters do not stop waves from happening, they merely deflect or absorb them. Fisheries management does not grow fish, at best it allows fish to grow themselves. Even the apparent exceptions merely prove this rule. Stock enhancement and aquaculture still depend on the natural processes of the sea, at one or more removes.

I PRINCIPLES OF CONCEPT

Marine reserves are:

1. A new and different concept – independent of 'problems'

Marine reserves help maintain the intrinsic properties and processes of the sea, by keeping some areas free from all potentially disruptive human activity. The concept is proactive, not reactive. There is no need to identify each potential problem, nor to wait for problems to occur. There is no requirement to show that a particular disturbance causes any particular level of damage. Some areas are kept free of all disturbance on principle.

2. Additional to existing systems of marine planning and management

Detailed data-dependent problem-solving management will continue to operate outside marine reserves. General marine planning will also continue and develop. Marine reserves are additional to these methods. Most of the sea will still be managed with the focus on active human uses, their problems and conflicts; but marine reserves will provide areas where none of these features occur.

3. Supportive of standard planning and management systems

Standard management requires good data, appropriate analysis, scientific judgement, social awareness and political acuity, as well as practical and economic methods to remove or reduce any problems. None of these features can be guaranteed, especially the first. Marine reserves provide buffers and insurance against the effects of management ‘error’ from whatever cause. Marine reserves act to maintain natural biodiversity and processes independently of available data or detailed decisions.

4. Necessary for effective marine management

There are many reasons why ‘standard management’ needs the kind of support that marine reserves can provide. For example:

(i) Our existing knowledge about marine biodiversity and the natural processes in the sea is very poor. Major discoveries continue apace – proving there is still much to learn. While we must use the knowledge we have, it is not reasonable to rely on it being adequate to cover all purposes.

(ii) Our technological power continues to increase, so each year there are fewer ‘natural’ refuges, which previously provided some buffers for our actions.

(iii) Human numbers also increase, so the intensity of exploitation increases.

It is necessary to arrange marine reserves to insure against ignorance, provide natural refuges, mitigate the increasing pressures and ensure that the intrinsic processes in the sea are sustained.

THE EARLY HISTORY OF MARINE RESERVES IN NEW ZEALAND

The early history of marine reserves in New Zealand was complicated. At least four inter-related processes occurred simultaneously. During the 25 years from 1965 to 1990 there was a slow, irregular, but continuous development of:

(a) the concept of marine reserves (i.e. discovering the essential rules)
(b) public acceptance of the concept
(c) establishment of actual marine reserves
(d) learning about the many uses, benefits and values of marine reserves

Experience in New Zealand strongly suggests that there is no quick, single or straightforward method for achieving marine reserves. People require time to become accustomed to the idea; they need to see examples that work; they need to discuss the concept from many viewpoints and they require a lot of information about both details and principles.

Many actions can help the development of marine reserves, but success depends on a wide range being used and the effort being maintained over a number of years. It helps if:

1. The authorities provide clear policies for marine reserves, based on principles, with sensible stages for implementation. ‘The authorities’ include not only elected politicians, but also scientists, educators, planners, fisheries managers, conservation experts, etc.

2. Schools and tertiary education organisations are provided with materials that demonstrate - the wonders and complexity of marine life; our low but expanding level of

knowledge of marine biodiversity and its natural processes; and the ways in which marine reserves would help maintain these – in that order. Specially prepared visual aids such as slides, films, videos and CD ROMs are important because few students have much opportunity to examine marine life directly.

3. Actual working examples of marine reserves are established using *any* local or special features that make this easier. In New Zealand, features such as proximity to a marine laboratory, beautiful underwater scenery, remote places with special biodiversity, very high intensity use near a city (preventing much actual fishing), historic significance to indigenous people, very sensitive habitats, local concern about over-fishing, etc. were all used to promote particular reserves. Note, however, that while these special reasons can, and should, be used to make initial progress, the authorities must keep reiterating the *principles* involved so that the initial reserves are seen as general examples and not merely one-off special cases.

4. General public discussion is actively promoted at all levels and by all methods, including not just public meetings to discuss actual proposals, but many ways of spreading information about the concept, the principles and the potential benefits. These include television programs, talk-back session, magazine articles, web sites, support for conservation groups, diver surveys, monitoring programs, etc.

5. The authorities actively pursue the formal designation of marine reserves in areas where fishing is already prohibited or seriously restricted for special local reasons. There are many areas that are *de facto* marine reserves (see Table 1) and many of these could, with little change to the regulations, be formally recognised as such.

II PRINCIPLES OF DEFINITION: The rules for marine reserves.

The essential regulations for marine reserves are those needed to maintain the full expression of the intrinsic processes in the sea, and hence allow the free development of natural biodiversity at all levels. At first sight these rules seemed very fierce and many people thought they were unnecessarily so. However, when ‘weaker’ versions were tried it became clear that the tough versions were mandatory – for both scientific and practical reasons. The necessary rules for marine reserves are:

1. **No fishing of any kind.**
2. **No removal of any material – living, dead or mineral.**
3. **No active human disturbance – no dredging, dumping, construction or any other human activity that might disrupt natural processes.**
4. **Subject to the above, encouraging people to view, appreciate and study the results of this protection.**
5. **These rules and the reserves are permanent.**

These principles of definition form a consistent, coherent and necessary set. They cannot be separated or diluted without loss of the purpose. It took a long time and much trial and error to see that this was true. Many attempts to weaken these rules were made by various interests for a wide range of reasons. The main arguments that were used can be summarised as follows:

People are part of nature, everything they do is natural (including fishing)

This argument is logical, but is merely semantic. If we choose to define 'natural' in this way, then we have to find other words to describe what fish and marine habitats do in the absence of exploitation by people. Whether fishing is 'natural' or not, it has significant effects, not only for fishermen, but also on the fish and their habitats. This is even more obvious for dredging, dumping, reclamation, etc.

Marine life and habitats have their own dynamics, which will operate in the total absence of people. While we can, and often do, affect these dynamics, we need words for the independent 'natural' dynamics. If someone does not wish to use the term 'natural' for these, they must provide some clear alternative to cover this point. They must not be allowed to deny that there is a difference. If we are to have effective management, we need to know the difference between what we have caused by our activities and what would have happened anyway, or in the absence of these activities.

What's the problem? "If it is not broken, do not try to fix it."

At first sight this argument sounds hard-headed and practical, but it includes so many unreasonable assumptions it is actually dangerous and irresponsible. First the idea assumes that there is some simple 'it', when in fact we are dealing with a very complex set of populations, habitats and ecosystems. Then the argument assumes that we would be able to recognise when and where these systems were 'broken' or damaged. In practise, we have not even described all the parts (species) of any of the systems. We keep discovering more of the processes involved. We have no reliable way of telling whether the essential processes are operating properly, or even, in most cases, what 'properly' would mean. Given these levels of ignorance, it is dangerous to rely entirely on noticing when things 'go wrong'.

What the proponents of this argument are really assuming is that if *they* have not noticed any problem or inconvenience then there is nothing wrong. They are, of course, entitled to think in that way, but the rest of us can recognise that this attitude is narrow-minded, short-sighted and quite inadequate for sensible management.

In New Zealand, for the second marine reserve (around the Poor Knight Is) this argument was initially used to deny the principle of 'no-take'. The authorities (and the majority of interested citizens) felt that some kinds of fishing were doing no harm and could be allowed to continue in the 'reserve'. So the initial regulations permitted a short list of species to be caught within the reserve by a restricted list of methods. For a few years the plan seemed to be working, and those in charge congratulated themselves on a victory for pragmatism.

However problems slowly emerged and steadily became more serious. Enforcement was difficult due to the complex rules. The majority of visitors to the 'reserve', many of whom came long distances to witness the spectacular natural life and underwater scenery, were annoyed to find any fishing going on. Other visitors came specially to fish, under the impression that it must be better there due to the restrictions. Two conflicting groups started to emerge. Explanations about the rules became tedious and confused (Department of Conservation, 1995). After two rounds of public submissions, a court injunction and a great deal of political fuss, it was finally decided (after 16 years!) to make the whole marine reserve 'no-take'.

The lesson was painfully learnt, but was perfectly clear. If we merely wish to reduce some fishing pressure, we should not involve the idea of marine reserves at all – simply apply some extra fishing regulations under standard 'detailed management'. If, however, we want the full range of benefits that a marine reserve can offer (see below) we must have the full set of rules. The messy and lengthy argument over the rules at the Poor Knights taught this lesson to New Zealanders the hard way. All subsequent marine reserves in New Zealand (14 more to date) have been strictly 'no-take'.

Universal fishing is a right, unless there is a clearly defined problem.

Table I shows that fishing 'rights' are often cancelled for various reasons. It is socially and politically practical to close areas of the sea to fishing. Such closures are frequently invoked and can occur in any region or habitat. The reasons for suspending fisheries are usually specific and problem-dependent (i.e to prevent damage to something in that area and/or danger to visitors). The only difference in the case of marine reserves is that the reasons are multiple (rather than single) and that the sites are not precisely fixed (by particular problems).

The prohibition of fishing (and/or access) for any reason can produce *de facto* marine reserves. Johnson et al (1999) describe a case near Cape Canaveral.

TABLE 1 COMMON REASONS FOR PROHIBITING FISHING (and/or normal access).

1. DEFENCE AREAS e.g. sensitive frontiers, firing ranges, naval bases, minefields, etc
2. DUMPING GROUNDS e.g. of munitions, poisons, radio-active material, sewage, etc.
3. AREAS DANGEROUS TO VISITORS (or the visitors endanger the facility) e.g. rocket test sites, pipelines, oil platforms, power cables, off-shore loading facilities, etc.
4. PORTS AND HARBOURS e.g. wharves and docks, turn-around or mooring areas, etc.
5. SHIPPING LANES e.g. port approaches, narrow straits and channels, etc.
6. LITTORAL INDUSTRIES e.g. oil refineries, power stations, ship building yards, etc.
7. AQUACULTURE e.g. shellfish or seaweed racks, rafts or lines, fish cages, etc.

Protection must be absolute, people must be excluded from marine reserves.

This argument, while having some surface logic, is neither sensible nor practical. It concentrates on temporary and relatively trivial matters, while ignoring the major processes. It is true that some of the first reserves became so popular with the public that their large numbers caused some problems. However, these were trivial compared to trawling, sand mining and reclamations. In any case, if marine reserves prove highly popular with the public, it is politically easy to get more (and hence relieve the pressures).

More fundamentally, it is the activities of people that cause damage, not their numbers. Marine reserves form a *process* by which people learn to modify their activities. At first, in a marine reserve they learn that it is pleasant and instructive to have places where no one kills or deliberately damages anything (no fishing). They see more natural levels of marine and notice how abundant these can be. From this they learn about other forms of damage people can inflict (e.g. land-run off, trampling, etc.). This can lead to demands for more effective restrictions (e.g. control of land drainage, removing shoes, etc.), but this *depends* on the first stage.

The creation of marine reserves (with restrictive rules) needs active public support. People will support restrictions on their activities if they (their children and friends) can experience something special, different, useful or instructive as a result. The benefits of marine reserves must be *seen* to occur. Of course, this need not be direct experience; it can be vicarious (via glass-bottomed boats, remote cameras, films, books, etc.) but it must be actively encouraged.

Reserves should be opened to fishing on rotation

This argument confuses different aims and methods. If it is helpful, for some stocks, to arrange rotational fishing, this can be carried out under normal fisheries management. It is not necessary to involve marine reserves. Indeed it would not normally be practical. The appropriate rotation intervals are likely to be different for different species of fish and shellfish, so no single cycle for opening and closing areas is sensible.

In any case, most benefits from marine reserves increase over time, so there is no point in cutting them off at intervals. These include benefits to fisheries – such as the maintaining of high quality breeding stocks (see below).

III PRINCIPLES OF BENEFIT : The uses and values of marine reserves

The discovery of the uses, benefits and values of marine reserves is a slow and erratic process. It is still going on. Each year more benefits are recognised as having occurred. This is surprising, since, with hindsight, it is obvious that many of the benefits could have been deduced quite easily. It seems that we are not very good at predicting the benefits of marine reserves and often have to experience them before we can recognise their existence. Even recent attempts to list the benefits (e.g. CALM, 1998) seem inadequate as more and more actual examples are demonstrated and more potential benefits are predicted. It is already clear that:

1. Marine reserves have a very wide range of uses, benefits and values.

These are not restricted to a particular ‘sector’. They include benefits to:

science	tourism
education	planning
conservation	management
health	fisheries
recreation	ecosystem support

This wide range is, of course, a major advantage from any general viewpoint, and does make it much easier to convince the general public that marine reserves are worthwhile and important. However, it also means that many different government agencies are involved. This leads to inter-departmental rivalries and conflicts of authority. In particular there tends to be confusion about aims and methods between those in charge of fisheries and the conservation agencies.

Some scientists and managers assist this confusion by insisting that ‘the’ purpose of each reserve is clearly stated. The scientists are assuming that the establishment of a reserve is like a scientific experiment – where a single clear aim is required to produce an unconfounded result. But marine reserves are not created as scientific experiments – they involve changing the management of large areas of public domain. It is absurd to restrict the aims. The more benefits the better, regardless of whether this makes analysis by scientists more difficult. Managers from particular agencies may find it convenient to restrict the purpose of a reserve to those features within their usual responsibilities (such as just conservation or just benefits to fishing), but the public does not want to run the world for the convenience of managers.

2. Marine reserves provide numerous benefits within each ‘sector’.

Indeed, unless these are categorised, the list seems endless. This is partly because marine reserve benefits are as broad as the rules. For example, in conservation terms, marine reserves do not select the species are protected nor do the rules specify the types of disturbance from which they are protected. All species are protected, including those not yet recorded, and from all forms of disturbance.

Another reason is that the same feature may be a benefit to many interests. For example, if fish, relieved of harvesting pressure, become more numerous in the reserve, this may be a benefit to fisheries, through extra larval supply or adult spill-over; to science, by making it easier to investigate natural dynamics; to education, by giving students better opportunities for study; for conservation, by providing a buffer stock and maintaining genetic diversity; to recreation, by creating more enjoyment for divers, etc.

Furthermore, the detailed effects interact to produce second order benefits. Fish survive longer and grow bigger in a reserve. The larger fish produce more eggs per unit weight (and per unit food). Older fish produce larger eggs with better survival rates

(Trippel et al, 1997). Denser aggregations of fish increase the chances of fertilisation. All these effects interact to produce a natural ‘enhancement project or ‘stud farm’.

3. Many of the benefits of marine reserves are ‘new’ and hard to predict.

We have a poor record of predicting the benefits of marine reserves in almost all categories. For example, the first marine reserve in New Zealand was proposed by my university for the area adjacent to the marine laboratory where I work. The original reason was to help protect and encourage scientific research. During the 12 years of argument and discussion before it was established, although we were trying hard to find additional reasons, I never heard anyone say how important and useful the reserve would be for school-level education. It was not until the school bus visits became routine, that we realised this rather obvious point. At least 10,000 school children a year now visit the site as an organised part of their education, and this aspect is used as a strong argument for further reserves in other regions.

This ‘new, different and hard to predict’ aspect seems to apply to all aspects of marine reserves. None of the most spectacular or successful features of the first reserve were predicted. These included -

- The immense popularity with the general public (200,000 visitors this year – for a typical piece of coast where all fishing is forbidden!)
- The 20 fold increase in large rock lobster (which could easily walk out and we thought would do so).
- The major changes in habitats (including large increases in kelp and primary productivity).

It seems that our general experience with multiple and pervasive uses of the sea is a barrier to understanding any alternative or to predicting the conditions natural forces would produce in the absence of our activities.

4. Some benefits provided by marine reserves are basic and important

It is an ironic fact that, while some precise effects of marine reserves are easy to describe and quantify, the more basic and, hence more important benefits are generally more difficult to identify and measure.

At the first reserve in New Zealand created near Leigh in 1977, it was easily demonstrated that some species quickly became more common and larger within the reserve compared to similar habitats outside. For example, red moki (McCormick and Choat, 1987) and rock lobster (MacDiarmid and Breen, 1993). This effect is commonly observed wherever reserves have been established for a few years, for example in the Phillipines (Russ and Acala, 1996) and Tasmania (Edgar and Barrett, 1999).

However, it took more than 20 years and a great deal of work by many workers to show that major habitat changes had occurred in the Leigh reserve (Babcock et al, 1999). The increase in large predatory fish and rock lobster reduced the density of sea urchins, which allowed an increase in the quantity of large seaweeds. In 1977 around 30% of the subtidal rocky reefs were dominated by sea urchin grazing and devoid of large brown seaweeds. By 1997 only 3% was dominated by sea urchins and primary productivity had increased by more than 50%.

The major changes in the sea due to humans, especially when widespread or long-term, are very difficult to predict and generally impossible to demonstrate unless some areas have been kept free of the disturbances. This is true over a wide range of causes. Whether the changes involve damage by fishing gear (e,g. Dayton et al, 1995), trophic level changes due to serial depletion (e.g. Pauly et al, 1998), cascade effects (e.g Estes and Duggins, 1995), the reduction of keystone species (e.g. Castilla, 1999), or complex interactions (e.g. between coral, algae, sea urchins and fish, McClanahan and Kauunda-Arara, 1996) a clear demonstration that anything has happened depends on comparisons with areas or times where the effect has not occurred.

The existing literature is heavily biased in two ways. Most reports are about specific and local changes that are relatively easy to quantify. In addition, they mostly refer to short-term comparisons (see reviews by Roberts and Polunin, 1991; Dugan and Davis, 1993; and Rowley, 1994). Only a very few workers have managed to maintain broader interests and long-term data. Their conclusions are necessarily less precise, but are very disturbing. Pauly and others draw attention to sliding base-lines (e.g. Pauly, 1995) and the ecosystem shifts produced by intensive fisheries (Pauly et al, 1998), while Dayton and co-workers show how some ecosystems have become ‘ghosts’ i.e. lacking so many of their original features that the natural dynamics can scarcely be determined (Dayton et al, 1998).

Faced with problems at these levels, it is important that marine reserves are established systematically and urgently. We must retain at least examples of the full natural biodiversity and processes in the sea. Unless we do so, we may never be able to understand the dynamics of the ecosystems which we are attempting to plan and manage.

Despite the obvious urgency and importance of establishing marine reserves, progress has been very slow. One of the reasons is that ‘old habits die hard’. Many scientists and managers find it difficult to give up attitudes and assumptions gained during earlier experience in solving particular problems. These assumptions are frequently stated as if they were self-evident axioms – i.e. with no supporting argument or evidence – which makes it hard even to start the argument. But it is necessary to do so. The following examples are chosen to illustrate some of the commonest assumptions:

The precise purpose of each reserve must be clearly stated.

This assumption is especially common amongst scientists, but is not supported by the rules of science. It implies that the establishment of a reserve is the manipulative part of a scientific experiment. While a politician could argue that creating a marine reserve is a *social* experiment, in scientific terms it would be a ‘control’, the un-manipulated part of an experimental design. This means that quite different scientific rules apply. An ‘experimental manipulation’ in science does require a single precise reason (hypothesis), but this is not true for the ‘control’. The same ‘control’ can be used for any number of ‘experiments’. All that is necessary is that it remains un-manipulated.

By definition, marine reserves are free from all preventable disturbances, so they can act as controls for any comparisons involving human disturbance in the sea. The marine reserve at Leigh has already been used for many comparisons – including the abundance, size structure, fecundity or behaviour of various species, many habitat comparisons, etc. It does not make any scientific sense to ask which of these was ‘the’ purpose of the reserve. This point extends to other aspects. If a reserve provides for the protection of apparatus, for education, for conservation and for stock support, while still providing for valid scientific comparisons, these are added benefits.

We must state the primary purpose of each reserve.

This argument is frequently used by managers who work for particular agencies. They wish to avoid conflicts of interest produced by multiple aims. They can easily imagine that detailed ‘conservation’ aims might conflict with specific ‘fishery’ aims. They want to know who is in charge and will make the final decisions. All this is quite understandable, but it misses the point. The primary purpose of *all* marine reserves is to maintain (or restore) the full natural biodiversity and processes, whether or not this helps solve the currently-recognised problems of any agency.

At the Leigh reserve, the numbers and sizes of rock lobster increased while those of sea urchins decreased. Both results appear to be more ‘natural’ than the previous situation. Whether these features suit the current detailed aims of ‘fisheries’ or ‘conservation’ is irrelevant.

There are other and better ways of tackling the problems

There are two main versions of this argument. One is that detailed or general management can solve all the problems, and will do so when we have made some further adjustments, so marine reserves are not needed. Dedicated and hard-working managers can perceive pressure for marine reserves as criticism of their efforts. However, this is not the case. No single management system is perfect and never will be. Good managers understand this and welcome additional systems that work in different ways.

The other version of this argument maintains that active interference is a better way of dealing with the problems, especially in fisheries. The proponents want to install ‘fish aggregation devices’ (FADS), construct artificial reefs, develop stock enhancement schemes (rearing and releasing juveniles) or go over to completely controlled systems (aquaculture). They view marine reserves as feeble – just leaving some places alone – and prefer action. This argument is very popular and frequently attracts political support and large amounts of funding. However the record of results does not match the popularity.

FADS may make fish easier to catch but they are unlikely to produce any more fish (see Bohnsack, 1996). Artificial reefs can create different habitats (e.g. when dumping wrecks in generally sandy areas), but this new and artificial diversity merely supports one set of interests (often tourists with money to spend) at the expense of those that were using the existing habitats. When artificial reefs are created in areas with existing reefs, this is just 'going the long way round'. Having made a new reef, and developed a set of fish, those in charge generally wish to protect it from being over-fished. They end up arguing for the kind of special rules for 'their' reef that they refused to accept for any of the natural reefs all about them!

At a recent conference on stock enhancement, Hilbron (1999) analysed the economics. He showed that few, if any, of the projects were cost effective, and gave as his opinion that most schemes were driven by political forces quite independent of the actual effects.

Marine aquaculture can be ecologically sensible, as well as commercially profitable, when the arrangement is simply to put organisms in situations where they can feed themselves efficiently (such as mussel farming. However, a great deal of aquaculture makes no ecological sense at all, since it involves the destruction of food. When caged salmon are fed with pellets made from fish meal obtained by industrial fishing elsewhere, it may be profitable, if the fish pellets are cheap enough and the salmon expensive, but it means less fish. Where large scale habitat destruction is involved (most shrimp farms are created out of mangrove areas) the resulting total loss of edible biomass is even worse. While marine aquaculture may be economic, it is not a better alternative to fishing for the production of food.

There are more important problems that must be tackled first

This argument is commonly used to suggest that any attention to marine reserves detracts from more urgent and important business. It is generally linked to problems where marine reserves provide no direct help. Invasive species, land run-off, and water-borne pollutants are examples. These are, of course, important problems, but the suggestion that we have to choose an order for action is not intelligent. Even individuals can do more than one thing at once, and societies can handle many problems simultaneously. It is not sensible to restrict action to one problem at a time.

THE RECENT DEVELOPMENT OF MARINE RESERVES IN NEW ZEALAND

New Zealand created a Department of Conservation in 1987, which took over responsibility for marine reserves. Since then the development of marine reserves has accelerated. There are now 16 reserves, 6 more formal applications await final decision and at least 20 more proposals are under active public discussion and investigation.

All the major political parties support the idea of more marine reserves, and in November 1999 the newly-elected government announced its aim to arrange 10% of the coastline in marine reserves by 2010.

TABLE 2 Established marine reserves in New Zealand

Title and region	Date	Area km^2
Cape Rodney to Okakari Point, near Leigh)	1977	5.5
Poor Knights Islands, Northland	1981	24.1
Kermadec Islands, North of NZ	1990	748.3
Kapiti Is., nr Wellington	1992	21.7
Whanganui a hei, Coromandel	1992	8.4
Tuhua (Mayor Island), Bay of Plenty	1992	10.6
Long Is., Marlborough Sounds	1993	6.2
Tonga Is, Nelson	1993	18.4
Milford Sound, Fiordland	1993	6.9
The Gut, Doubtful Sound, Fiordland	1993	0.9
Westhaven, Nelson	1994	5.4
Pollen Is, Auckland	1995	5.0
Long Bay, Auckland	1995	9.8
Te Angiangi, S. Hawke Bay.	1997	4.5
Pohata, Banks Peninsula	1999	2.2
Te Tapuwae o Rongokako, near Gisborne	1999	24.5

Formal applications awaiting final approval:

Kaikoura	N. Taranaki
Nugget Point, Otago	NW Nelson
Paterson Inlet, Stewart.	Te Matuku, Waiheke Is.

IV PRINCIPLES OF UNIVERSALITY: SCIENTIFIC AND SOCIO-POLITICAL

1. Marine reserves are appropriate in all biogeographic regions.

Under a variety of names, successful 'no-take' marine reserves already exist in all climate zones – tropical, sub-tropical, warm and cool temperate and polar – and in many biogeographic regions of the world, including the Mediterranean, the Caribbean, East Africa, South Africa, the Indo-Pacific, Australia and New Zealand. There is every reason to believe that they would function equally well in all regions, and provide the same potential benefits.

2. Marine reserves are appropriate for all marine habitats

The range of habitats already included in successful 'no-take' marine is very large. Even within New Zealand the range includes habitats in fiords, rias, estuaries, sheltered coastal waters, open continental shelves and in deep oceanic waters round isolated islands. In other countries the list includes mangrove forests, coral reefs, sea mounts, etc. There is every reason to suppose that marine reserves would be successful in all marine habitats and provide the full benefits available in those habitats.

3. Marine reserves are successful over a wide range of socio-political features

While the actual establishment of marine reserves is clearly subject to political factors, their successful operation does not depend on any of the usually important socio-political features. Established reserves exist in remote and uninhabited areas (e.g. Kermadec Islands, 700 km from any permanent habitation) or in densely populated places (e.g Pollen Is. in the middle of the metropolis of Auckland). They operate successfully in a range of cultures, economies and government systems including U.S.A., Spain, Egypt, Israel, Kenya, South Africa, the Philippines, Barbados, Belize and Chile.

These principles may seem rather obvious, but it should be remembered that 'no-take' marine reserves are still rare. Many countries, even developed countries with large numbers of 'Marine Protected Areas', have no undisturbed marine reserves or any plans to arrange them (e.g. U.K. and Japan). Even in the countries that do have some real marine reserves, these are often few in number, small, and recent. The first planned and publicly-discussed 'no-take' marine reserves in the U.S.A. were created within the Florida Keys 'Marine Sanctuary' in 1997 and occupy only 0.5% of the area of the 'Sanctuary' (Schmidt, 1997).

V PRINCIPLES FOR SYSTEMS

Once it is accepted that marine reserves can provide a wide range of benefits, it is sensible to investigate systematic ways of optimising the benefits. The scientific principles for a system of marine reserves are relatively simple, but the ways these would operate to maximise the benefits are subtle and complex.

1. Representation

This principle can be considered to operate at two levels - biogeographical and ecological. By definition, different marine biogeographic regions have major differences in their biota. Consequently, to optimise scientific and conservation benefits a system of marine reserves must represent all the regions. Similarly, within regions, different ecosystems and habitats have (again by definition) different species and/or arrangements of their biota, so within each region each major ecosystem and biota must be represented. The reserve system must therefore have at least one marine reserve in each region, and within each region each ecosystem and habitat must be represented in at least one reserve.

2. Replication

There are many reasons for including more than one spatially-separated examples of each ecosystem and habitat (within each region). For example:

(a) Basic precaution requires that important benefits are not lost due to single accidents (whether natural, such as a exceptional storm or human induced, such as an oil spill). Several separate examples are the best way to ensure this.

(b) Science requires several instances to exclude chance, describe the set, to record the variety within it and to increase the precision of any measurements.
(c) Many uses are assisted by easier access (e.g. educational use is helped if reserves are available near the schools).
(d) Management problems such as crowding are relieved by more reserves of that type. Replicates also allow comparative tests of various management options.

3. Network design

Most marine species have small dispersive stages in their life history –spores, eggs or larvae – that drift in the currents for days or weeks before becoming adults. The reproduction of many populations is thus decoupled from recruitment. For the design of single marine reserves, this is a serious problem, since a single reserve is unlikely to be self-sustaining, unless it is very large indeed. However, for the design of a system of marine reserves, the feature of remote dispersal becomes an advantage.

A network of reserves, which allows the drift of larvae from one reserve to reach others is potentially self-sustaining. The purpose of a network is to maximise the variety of ‘connections’ (distances and directions between reserves) as well as their number. Since we rarely know the ‘sources and sinks’ of the larvae for a species, we need this precaution. But even if we could provide the optimum design for one species, other species would have quite different requirements, so to optimise the benefits a network design is necessary (see Roberts, 1997).

4. Large enough to be self-sustaining

While a network design for a system of marine reserves is necessary for sustainability, a series of tiny reserves would not be sufficient. To keep providing the benefits, a system of marine reserves must be large enough to sustain indefinitely all its natural processes (and hence its full biodiversity), even when our management of the rest of the sea is imperfect.

The key point is not the size of particular reserves (or their number) but the size of the whole system. This size is measured as a proportion of the whole sea – as a percentage of area. This percentage is maintained at all scales – regional, ecological, etc., i.e. it feeds back to representation.

The aim is clear, but we do not know with any precision how much is required to achieve it. General experience suggests that it will be more than 10% and less than 50%. Even this very broad range is informative. Since some of the clearest benefits (e.g. to science and education) would require at least 10%, and provision at that level would greatly assist in gaining more information, the first stage should aim for least 10%.

5. Maximum diversity for the arrangements

The above principles do nothing to specify the sizes or detailed spatial arrangements of the actual reserves. This is not accidental. Indeed the absence of any detailed prescription is necessary and important. We do not know the ‘right’ way to make detailed arrangements and we are not likely to get the appropriate data in the foreseeable future. This alone would require us to vary the arrangements – under general precautionary principles. But there is a more compelling argument.

> Everything we do know about complex systems suggests that variety is the key feature. It is highly unlikely that any single way of making the detailed arrangements would optimise the benefits. The appropriate aim is to ensure as much diversity as possible in the detailed arrangements. We should prevent the application of *any* theory that restricts this diversity.

The following points should be noted very carefully:

The order of the principles is important in their practical application.

The first three principles form a spatial hierarchy. Applying them in spatial order allows sequential fine-tuning *without* having**:**

general agreement on boundaries or classification
large amounts of detailed data
full understanding of the naturally controlling processes

For example, if it is not clear whether a particular area is really a separate biogeographic region or is merely a major ecological division within a larger region, the point does not have to be settled. It will be represented in either case, so everyone can agree to proceed. Similarly, if there are insufficient data to determine whether a particular ecosystem should be sub-divided or not, it is not necessary to get agreement on the matter. If it is sub-divided, representation will ensure that the range will be included in reserves, but if it is not, the range can still be included under 'replication'.

There is an important feedback.

The last principle (about total amount) feeds back to all the others and hence affects the actual sizes and arrangement of particular reserves. For example, if the aim for the total amount of the system is 10% by area (of everything), this will affect which estuaries in a region could be included in their entirety and still have some replication. For very large harbours only partial reservations would be possible. These details would alter if the aim for total size was for 20%. Because even initial sizes, spacings and selection depend on the final aim it is important that the principles be treated as single set and not adopted piecemeal or subjected to reduction analysis. Any political problems this might cause can be reduced to manageable proportions by stating the whole set as the *final* aim while providing *stages* for implementation.

The interests of fisheries

Until recently it was assumed that the principal objectors to marine reserves would be fishing interests who felt that they would suffer from not being able to fish in some areas previously open to them. This is no longer true. Many studies, both of actual reserves and of mathematical models strongly suggest that total fishing will benefit from the provision of quite large amounts of 'no-take' area. This was first formally proposed for coral fisheries (PDT, 1990) but has since been argued more generally (e.g. Roberts, 1997, Bohnsack, 1999). Indeed, it is has been shown (Guenette *et al*, 1998) that the general decision to control fishing by restricting effort (size limits, licences, quotas, etc.) rather than by restricting the area fished, was originally made on pragmatic grounds (it was thought to be easier) and not for any scientific reason. It is now clear that marine reserves not only provide many benefits to fisheries management, but also directly to fishermen. Most models suggest that closing substantial proportions of a stock area to fishing produces higher and more stable yields than when the whole area is open to fishing.

The necessary and effective principles for *systems* of marine reserves have only recently been considered (e.g. Ballantine, 1995; Bohnsack, 1999). Although these principles are reasonably clear, they are often implicitly denied by those still caught up in the considerations for *single* reserves or simply forget the scale involved.

Reserves must be located in the 'right places'.

This argument assumes that there will only be a few reserves and that they will have a primary purpose. If this were true the analytical approach would probably be appropriate. But if we are aiming for a system, with multiple reserves providing numerous benefits then the analytical approach is not suitable. For a *single* purpose we might be able determine *the* optimum arrangement (e.g. the best way to sustain one species or the most convenient locations for school visits), although even then there are likely to many practical and useful alternatives. However, if there are many purposes and potential benefits, the idea of a 'best' arrangement has no scientific meaning.

Furthermore one of the main reasons for a system of marine reserves is to protect us from any detrimental effects of ignorance. It is therefore counterproductive to rely on detailed existing knowledge to design the system. This would be a reversion to 'detailed planning'. Of course, if there are known and compelling reasons for particular locations these can be *added* to the system, but such instances should not be the basis for the design of the system.

Surveys and data are needed to locate the 'right places'.

At best this is premature. If we already had a large number of marine reserves, it would sensible, before adding any more, to obtain data on new proposals and carefully analyse them. None of this is relevant at the beginning. No amount of data will tell us where the first reserve for a system *should* be (systems can be started in many ways) nor is it helpful to keep making surveys to establish priorities for habitats if the first principle is that *all* habitats must be represented in the system. Replication, by definition, means that there are many equivalent choices. Networks, by definition, do not depend on any single part. It is *not* scientific to design a representative, replicated, network system by selecting precise locations.

Monitoring is necessary to show 'success'.

This is logically true, but it is not necessary to *show* success, nor is this the important point. The important point is to *achieve* success. Monitoring is expensive and difficult even when the objectives are agreed (see below) and, if it is required for each and every reserve, this expense may severely limit the number and speed of establishment.

This argument is a carry-over from normal science. Almost by definition, it is necessary to measure the results of a scientific experiment, otherwise the exercise is essentially futile. However there are several reasons why this simple and logical idea is not appropriate or even practical when applied to marine reserves.

Marine reserves have multiple purposes and it is not practical to measure whether more than a few are being achieved. One of the important purposes is to make things 'more natural'. Since we do not know what that is until after it has happened, while we can keep watch over events, standard monitoring (which needs to define measurements from the beginning) is not applicable.

Success is when there is 'more and better' inside than out.

This idea confuses the immediate desire for a 'nice story' (or in scientific terms a 'clear experimental result') with the fundamental aims. It is pleasant to report that a marine reserve has a much higher fish density than surrounding areas and that the reserve fish are larger (and hence more fecund). We can then imagine that the reserve is acting as a kind of stud farm and perhaps also providing a spill-over of adults. However we must be careful not to carry this simple idea too far. The general public (and anyone thinking straight) does not want marine reserves to be bursting with life while the rest of the sea is a desert, although this would provide the biggest difference.

On the contrary, the most desirable outcome would be sufficient marine reserves to maintain rich stocks inside and out, despite a high but sustainable take outside. This is quite possible – as every stock farmer knows. We may not be able to arrange this in the sea just yet, but it is clearly the real aim. No good purpose is served by allowing some sectional interests to define success in the opposite way. Very large differences between reserve biota and outside are, for concerned citizens, a sign of failure of our general management of the sea. This can be used as an argument for more reserves, but cannot be labelled 'success'.

VI PRINCIPLES FOR IMPLEMENTATION

Current role-reversal

Many of the presently perceived problems in creating marine reserves will be sharply reduced when scientists and politicians revert to their proper roles. The scientist's role is to determine the relevant principles of marine reserves, explain the potential benefits, and show how these two aspects are related and constrained. It is not their role to decide where to start, how fast to go or how far, those are social and political judgements. At present, in most countries, scientists are being asked to select marine reserve sites, define boundaries and predict the benefits that would result. This is not good science and its social morality is questionable, but even more to the point is the fact that it rarely produces any marine reserves (see below).

Changing gear

Moving up to the level of systems will make it much easier to create marine reserves. Single proposals for marine reserves with specified boundaries maximise opposition. Anyone who feels they will be inconvenienced by the proposal starts shouting. But single proposals attract little support from the public at large, since nothing major will be achieved. Once we upgrade our thinking to systems, both these points change. General support is massively increased, since most citizens would approve a program likely to provide a wide range of benefits in all regions. But opposition is likely to be reduced (and will certainly lose focus), because 'the system' is first expressed as principles not as a set of actual proposals. At this stage no one can be sure they will be inconvenienced. Indeed many people will support the principles even if they later object to some precise proposals.

The two approaches

Two methods have been used to establish marine reserves (worldwide and within New Zealand). These can be labelled 'bottom-up' and 'top-down'. In the 'bottom-up' approach some local people, for special reasons, decide that a 'no-take' reserve in their area would be beneficial and then persuade their fellow citizens to create one. Government agencies may approve the result and make it official, but they take no active part. While this approach can work, the formation of such activist groups is not common and they often fail to gain sufficient support.

In the 'top-down' approach, employees of a government agency have the idea that a marine reserve would have some general public benefit and persuade the politicians to make this official policy. They then decide the precise site and boundaries of the reserve to suit the purpose and try to push it through. If the country concerned is very small (e.g. Barbados), the region of the reserve is uninhabited (e.g. Kermadecs, Tasmanian sea mounts) or the regime is authoritarian (e.g. S. Africa during apartheid) this approach may succeed in producing working reserves. Usually however, the result is either a descent into endless surveys and habitat classifications with no actual recommendations (e.g. U.K.) or a fierce rejection by local interests of what they perceive as heavy-handed interference in their affairs (e.g. eastern Canada).

Combination

A sensible solution to these problems is fairly obvious – combine the two approaches in a way that retains the advantages of both while reducing the difficulties of either. Combined approaches are rarely used. Claims of 'extensive local consultation' are usually smoke screens for an effectively 'top-down' approach, and claims of 'extensive government assistance' are usually attempts to claim some of the credit after all the hard work was done by a 'bottom-up' approach. Nevertheless some partial examples can be found and they do appear to be successful roughly in proportion to the amount of 'combination'.

The formal application for the most recent marine reserve in New Zealand was made jointly by the 'tangata whenua' (local Maori) and the 'Director General of the Department of Conservation' (DoC, 1998). Many of the earlier reserves were initially proposed by local groups after extensive public education efforts by staff of the Department of Conservation. I took an active part in this process from 1987 onwards, either as a supporter of some local group or by assisting the Department staff, or both. This involved several hundred school talks, public meetings, discussions with special interest groups, etc. all over New Zealand. It became clear, with hindsight, that when the government staff confined themselves to promoting the *idea* and potential benefits of marine reserves, but were persistent in that process, this often resulted in the establishment of sensible and successful marine reserves. When, however, the locals were left to struggle on their own without any help or guidance on the principles, nothing much happened or the proposals were absurdly small. Equally, if the offical staff got too enthusiastic and tried to push particular sites, local opposition generally increased and there was rarely any sensible outcome.

This experience makes it reasonably clear how to proceed if we wish to create a system of marine reserves that provides maximum benefits. We should use both the 'top-down' and the 'bottom-up' approach simultaneously. The 'top-down' approach should confine itself to principles and policy. The 'bottom-up' approach should be used to arrange as much of the detail as possible. These conclusions are not very remarkable, indeed the only surprise is that we took so long to reach them. In democracies most important and useful systems are created with this combined approach. For example, in the provision of a school system, educational experts determine the necessary *principles* (e.g. school sites should be level, sunny, close to where the children live, etc.); the government decides the *policy* (e.g. all children of certain ages must have full-time education); but the actual selection of school sites (*the detail*) is left as far as possible to local knowledge and interest.

Applying these ideas to the establishment of a marine reserve system is fairly straightforward:

1. The adoption of a policy based on principles by the authorities

Once the idea of marine reserves is considered to be of some interest, it helps if the authorities state a clear policy, based on principles. It greatly helps if the *long-term aims* are made as explicit as possible. Note the adoption of all the principles as *policy* would not commit the authorities to any particular reserves, expenditure or action. It would however enormously improve the support. All government scientists would now know they could speak and act in support, whereas before they were left to guess. Citizens who already want marine reserves are transformed from cranks into people speaking in the public interest. Teachers can now encourage discussion of the topic and include the subject in the formal curriculum.

2. Stages for implementation of the policy are announced

These should be framed in terms of the principles, have time limits, but refrain from specific recommendations. For example the very first stage could be: "At least one marine reserve in each region in the next 3 years" A later stage might be "At least three replicates of each major habitat in the region by some fixed date", or "10% by area of all regions and habitats in marine reserves by some fixed date".

3. Local and sectional interests are encouraged to arrange the details

This feature is two-edged. Local and sectional interests are *prevented* from vetoing marine reserves or causing unreasonable delays by the policy and stages, but they are *encouraged* to take an active interest in arranging the details within the principles of the policy. Government agencies should assist the discussions and may even initiate them. They should also ensure that information on the policy and the principles is available and understood, but they do not propose the actual sites or boundaries for the reserves. Of course, if local and sectional interests do not avail themselves of this opportunity, government agencies will *then* decide actual reserves and boundaries and ignore any subsequent protests (except those that point out deficiencies in principle). However, if it is known that this will happen, it is very unlikely to be necessary. Those in favour of reserves will naturally want to be involved, but those *not* in favour for some reason will be even more likely to try and influence the details to their advantage.

CONCLUSIONS: The future in New Zealand and other countries

New Zealand has moved further than most countries on marine reserves and is now poised to move to a full system of reserves based on principle (Ballantine, 1998). However it took 35 years to reach this stage, progress was slow and involved a great deal of trial and error. If other countries wish to move more rapidly to a system of marine reserves the New Zealand experience offers some useful lessons:

Marine reserves aim to maintain (or restore) the natural biodiversity and intrinsic processes in the sea

- Marine reserves are additional to and supportive of standard management systems
- Marine reserves must be 'no-take' and prohibit all direct disturbance
- The benefits from such reserves are numerous, wide-ranging and important
- It is desirable to establish a system of marine reserves that optimises these benefits
- The benefits will occur in all regions and habitats and their occurrence is not dependent on the economic or socio-political conditions (their expression may be)
- The system must therefore represent all regions and habitats
- The system will require replicates, a network design and must be self-sustaining
- There is no simple quick or single method of creating a marine reserve system
- People require time to appreciate the concept of marine reserves
- Active public education is required at all levels
- The most effective education comes from direct experience, so the provision of initial examples of marine reserves by *any* practical method is worthwhile.
- The most effective method for general implementation uses a 'top down' adoption of principles and policy while encouraging local and sectional interests to be involved in arranging the details.

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