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THE NEW ZEALAND EXPERIENCE WITH 'NO-TAKE' MARINE RESERVES.

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SUMMARY

Marine fisheries management is trapped by two assumptions. First, that fishing must be allowed everywhere until demonstrable problems occur. Second, that detailed scientific data on fish stocks can define and then solve these problems in some acceptable way. In fact, there is no convincing factual evidence for either assumption, and the first would prevent the operation of the second, even if the latter was true (no unconfounded controls on which to base valid analysis).

New Zealand's experience with 'no-take' marine reserves suggests a practical way out of these traps, based on the following principles:

- Marine ecosystems must be sustained for a wide range of reasons, including the maintenance of fisheries, but not restricted to this.
- Marine reserves with 'no-take' and minimal disturbance are a practical and effective management tool for sustaining marine ecosystems.
- The benefits of marine reserves depend on full ecological and biogeographical representation and a network design.
- Marine reserves will provide benefits to fisheries, and these principles will maximise the benefits. But specific benefits cannot be accurately predicted, should not be promised, and are not a sensible basis for the design of the reserve system.
- Marine reserves provide a necessary insurance against unpredictable and unpreventable events. Detailed resource management will always be necessary but it is not sufficient. Insurance is based on risk-spreading and an admission of ignorance. We can never assume sufficient knowledge to cover all eventualities.

New Zealand has 18 years of practical experience with 'no-take' marine reserves - areas of the sea in which no one can fish, but where people are encouraged to come and observe the full natural marine life. The first reserves proved socially-popular, scientifically-useful and are widely regarded as a support to fisheries. As a result, more

are being created, and a full system is being planned - representing all marine habitats in each region. The aim is to have a network of reserves that is self-sustaining and provides a wide range of benefits, including the support of fisheries.

The New Zealand experience is extensive in time, covers a wide range of marine habitats, and has tested the principles. This experience supports the recommendations of the PDT 1990 report but strongly suggests that social and political acceptance requires fisheries management to upgrade its aims and responsibilities. The success of 'no-take' marine reserves depends on clear statements of broad principle and hence a good view of the full range of potential benefits.

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1. INTRODUCTION:

During a visit in 1994, I asked everyone I could the simple question -
In North America, is there any piece of freshwater - lake, river or stream - which is not fished on principle?

I never got a quick answer. It was obvious that almost no one (politicians, administrators, resource managers, biologists, teachers, journalists, fishermen or general public) had ever considered the question. This is both remarkable and informative. Common sense and ecological theory suggest there are many advantages in knowing the intrinsic properties and dynamics of any major habitat.

Since no one ever asked themselves the question seriously, it is not surprising the answer was no. Everyone tried to think up a positive response – places too remote to

reach, prohibited defence areas, some eccentric private owners, situations of high pollution, etc., - but essentially the answer was no.

. If this is true for freshwater, where physical separation and specific ownership make it easy to have different management aims, it is not surprising that the idea of 'no-take' areas in the sea has received little serious attention.

Widespread non-events do not necessarily have any particular or precise explanation. Although plausible reasons can be invented, it is more likely that some mind-set prevented the possibility being considered. Trying to provide a simple logical explanation is probably not very helpful. If marine reserves fall in the bracket of 'non-events', we need not waste time on local or specific details. Instead, we can direct our attention to the mind-set, the erroneous or irrelevant assumptions and thought patterns that prevented serious evaluation of the idea (Ballantine, 1995).

2. THE HISTORY OF MARINE RESERVES IN NEW ZEALAND

It is extremely difficult to alter mind-sets. Although the history of marine reserves in New Zealand exceeds 30 years, it is an on-going story, and far from complete. Events to date show that some principles have been clearly established, and that others are slowly but steadily emerging. It is these principles which are important and valid elsewhere, rather than the details of the actual reserves (Ballantine, 1991).

Ideally, each principle should be tested separately and sequentially. The process with marine reserves in New Zealand was more complicated. Simultaneous tests occurred covering the full range of marine resource management including standard fisheries regulations, highly-restricted fishing areas, and 'no-take' marine reserves.

During the past 30 years, many fisheries, including the most important, showed evidence of declining stocks, despite the application of a wide range of management techniques. The establishment of some highly-restricted fishing areas, although initally favoured by management and some fishing interests, produced steadily increasing management problems. Despite difficulties in getting them set up, 'no-take' marine reserves have received a steady increase in public support and a demand for more.

The established principles are:

- Marine reserves are a practical and publically-acceptable management tool.
- Acceptability and practicality are highly dependent on the 'no-take' rule.
- 'No-take' marine reserves have a wide range of important uses in conservation, science, education and recreation, as well as in resource management.
- Most of these uses are 'new' and basically unavailable without 'no-take' reserves.
- Because the benefits are 'new', developing public understanding and support for 'no-take' reserves is a slow process, but it is steady and progressive. It proceeds faster after the actual enactment of some reserves, and when clear statements of principle are provided at all times.

- Highly-restricted fishing areas become publically-unacceptable over time, since they fail to support any general principle, while creating new sectional interests. It is very difficult to up-grade such areas later to a 'no-take' status, even when this has strong and widespread public support, because of actual or implied agreements with fishing interests during the imposition of the special restrictions (Department of Conservation, 1994).

The emerging principles are:

- Detailed resource management (e.g. stock-specific fisheries regulations) is necessary but not sufficient.
- Specific, knowledge-based management is always vulnerable to rare, sudden or unpredicable changes in the system - whether natural or human-induced.
- Some additional and differently-based management methods are required as insurance.
- The general public, standing back from the sharp realities of day-to-day use and management, are more likely to be able to appreciate these points than established interest groups, and are more willing to try new approaches.
- The traditional focus on established interest groups (whether users or managers) reduces the chances of adopting additional and different measures.
- 'No-take' marine reserves are essential for valid conclusions in much of marine science and in most marine resource management.
- 'No-take' marine reserves are required for all habitats and all regions.
- This ecological and biogeographic representation must include replication.
- A network design is needed because of remote dispersal in most marine biota.
- The density of the network must be sufficient to ensure self-sustainability.
- The general public tends to be more receptive of these points (and their practical linkage) than those with a long experience in detailed resource management (e.g. stock-specific fisheries).

3. FISHERIES MANAGEMENT IN NEW ZEALAND

The overall status of fisheries in any region is hard to determine, and New Zealand is no exception. However, New Zealand fisheries are isolated in physical, biogeographic, and political terms. They are significant in geographic and economic size; and in social importance, both commercially and as recreation. They are a good case for assessing the general results of fisheries management. However, any such analysis is full of traps for the unwary, and New Zealand situation illustrates these well.

Serious problems do not produce a concensus for action

Virtually any opinion on fisheries management can be supported by reference to some selected stocks. If we select fisheries that are long-established, economically-important, well-studied and of high recreational interest (i.e. the ones where research and management have been concentrated) we are likely to see the system at its best.

The most valuable and best studied inshore fisheries in New Zealand are for:

Snapper or seabream (*Pagurus auratus,* Sparidae)

Crayfish or rock lobster (*Jasus edwardsii*, Palinuridae).

It is generally agreed, by all interested parties (see Annala,1994 and 1995) that:

(a) These fisheries are very important, commercially and recreationally.
(b) The detail and precision of the available data have steadily improved.
(c) The standard and detail of management have been continuously improved.
(d) The stocks of both species are now well below the levels that are sensible in economic or biological terms.
(e) The decline of the stocks has a long and complex history.
(f) Without major management changes, further stock declines are likely.

However, there is no agreement between the scientists, the user groups or the administrators on what changes should be made. Indeed there is no agreement within the various 'user groups'. A careful examination of the literature shows that this state of affairs is common in well-studied and fully-managed fisheries, not just in New Zealand (Horwood, J. 1994; Cochrane, 1995).

The shifting databases - improved methods prevent simple comparisons

A literature search does require great care, however, because it is difficult to obtain properly comparative data. There are many reasons for this. Comparisons can be confounded by differences in the actual biology of the species or stocks; by the use of different data collecting systems (and there is a very large range); by the different statistical and analytical techniques adopted; and simply by the physical differences between geographic locations. Even for a single stock, there are still complications. Methods improve, and these improvements are naturally applied to the collection and analysis of the data. The result is that the basis for comparison shifts.

As we sub-divide fisheries into species, then stocks, breeding areas, year-classes, and other cohorts, the precision of the data improves, but the problems of comparability increase. As we analyse variations in sex-ratios, growth rates, physical factors, etc., strictly comparable baselines recede, and the capacity to make general statements diminishes. Even for undisturbed populations this is a serious problem (which occupies a lot of time in ecology). Fisheries deals with exploited populations, subject to continuous manipulation, and this complicates the matter still further.

Policy changes - political and economic changes prevent rational comparisons

If the manipulation due to fishing was a constant or changed in a linear fashion, it would be possible to make adequate adjustments in the analysis of the dynamics to allow for, and hence predict, the effects. But the manipulations are rarely single, constant or linear in their effects. There are several aspects to this.

First, there is often more than one 'user group' doing the fishing, and they can behave quite differently. Commercial and recreational interests are not the same, and each includes different sub-groups. Large trawlers supplying supermarkets with frozen fish

have little in common with small long-liners providing fresh fish to expensive banquet tables, even when they are catching the same species in the same area. Divers with spear-guns, anglers on boats, and shore-based seiner-netters can react very differently to the same circumstances.

Second, economic and practical considerations often shift the aims, methods, locations and intensity of a fishery, even for a single stock. These can produce major changes in a fishery without any prior change in the stock itself. Oil prices, new markets for fish, and the fashion in tourist destinations are examples of the huge range of potentially-important factors.

Third, policy changes in fisheries management, or at higher levels of government, can at any time shift the entire basis of a fishery. Although policy changes may relate to changes in fish stocks, they are often quite independent of this. The introduction of ITQs (individual transferable quotas, i.e.saleable or leasable quotas) in New Zealand across all stocks, virtually doubled the costs of long-line snapper fishing in a few years. Tax provisions, licencing, and port development subsidies are other examples which are not necesssarily stock-specific, while there is huge range of regulatory methods that are usually species or stock related (e.g. closed seasons, minimum size limits, total allowable catches, etc.).

One important result of all these changes is that there is no clear or rational basis for comparison. Not only is it impossible to make accurate predictions for a fishery, it is not even possible to get any agreement on the reasons for observed events (Ludwig et al, 1993). Given this degree of uncertainty, it is not surprising that political and social conerns actually determine policy, despite all the data and analysis of the the scientists and managers.

The illusion of the average

At any one time a region's fisheries consist of a mixture of:

some known but unexploited species and stocks
starting-up fisheries, still small and/or underdeveloped
well-fished stocks that seem in reasonable condition
hard-pressed species and stocks, perhaps holding but vulnerable
declining stocks, in serious trouble
defunct fisheries, just historical memories

The majority of species and stocks fall in the middle groups. If the situation is re-examined a decade or so later, it seems the same. But is it? The overall picture obscures the processes involved by focusing attention at the median. In fact potentially-fishable species or stocks are being discovered all the time, and in each period the final demise of a few remnants occurs. Different stocks and species move at different speeds but the tendency is one way. New Zealand's fisheries now catch much more than they did 30 or even 10 years ago. But most of the stocks and species caught previously have declined and the 'increase' is in new species, some stocks of which have already sharply declined. The serial depletion of stocks within one species is routinely recorded in fisheries, and

'fishing down the food chain' - the reduction high-order predators first - is often mentioned. In fact, these points seem just part of the process, serial depletion is a general feature of fisheries.

The total effect of these features of fisheries management is that it becomes almost impossible to produce an informative overall critique. Unless someone properly appreciates the highly technical data and complex scientific analysis involved, any criticism they offer can be set aside as being ignorant. But almost the only way this detailed knowledge can be obtained is by training for professional fisheries management, and anyone doing so is then constrained by the economic consequences. Employment and grants are naturally controlled by those who believe in the professional methods. It is difficult to have a knowledgeable but independent opinion.

Even expert *general* views of fisheries management are rendered questionable by the other problems. The data are never strictly comparable between species or stocks. Locations, collecting methods, systems of analysis and actual biology vary significantly. Even if this can be sorted out, or approximated to a reasonable degree, the shifts of economic and political policy over time cloud any general conclusions.
The only general conclusion that can be made about fisheries management (and its scientific basis) is that no simple, easy-to-use, general conclusion is possible.

This idea was stated by fisheries experts in a recent viewpoint (Ludwig *et al*, 1993) and is strongly supported by the first worldwide review of marine biological management, edited by Norse (1993). We should not be surprised or upset by all this, indeed the only worry is that it took so long to see that it applied to fisheries. Science is an important and powerful system for gaining knowledge, but it has real limitations, as well as temporary frontiers. As Medewar (1984) pointed out some time ago, it is necessary to recognise the limitations of science, and to state them in clear terms to the public and decision-makers. If this is not done, expectations are unreasonably inflated and science then falls in disrupute. Good management also recognises that it is not perfect and can never be so. Mature management systems carefully define their own limitations and develop proceedures that cope sensibly with the resulting problems, without pretending these will *solve* them.

4. BASIC ASSUMPTIONS IN MARINE FISHERIES MANAGEMENT

The basic assumptions of marine fisheries management, worldwide, are:
(i) that fishing must be allowed (by anyone, at any place, and any time) unless or until serious and demonstrable problems occur ('universal fishing rights').
(ii) that the use of detailed scientific data on fish species and stocks can define, and then solve these problems in some acceptable way ('stock-specific problem solving').

Although these assumptions are widely held, and often considered to be unchallengable, they are:

(a) merely the result of historical accidents

(b) unjustified by any coherent theory (scientific, economic or social)

(c) unsupported by any persuasive body of factual data
(d) inconsistent as an operational set
(e) subject to the problem of infinite regression

Individual fisheries scientists or managers may not hold these assumptions personally, but since they believe that politicians and the public do, the effects on policy are much the same.

A frontal attack on these assumptions is unlikely to be immediately successful, but *practical* ways to weaken confidence in such ideas should be sought. 'No-take' marine reserves occupy a key position in this. The creation of any useful marine reserve denies both assumptions, or at least suspends their local operation. So each established 'no-take' marine reserve demonstrates that the assumptions are unnecessary, and introduces the idea that they are actually counter-productive.

(a) UNIVERSAL FISHING RIGHTS

Arose by accident

No one ever planned, or really wanted, 'universal fishing rights'. The situation arose because of a breakdown in 'local' control before the development of 'central' control (i.e. at national or international levels). This changeover was complicated by simultaneous increases in technology, the development of distant markets, increases in the mobility of people and capital, and a wide range of other factors. The details of this can be debated at length, but should not be allowed to obscure the basic point. During the development of the idea of 'universal fishing rights' no one was in full and continuing control of the situation. The idea developed by default.

They have no theoretical justification

No one has ever put forward a plausible theory which said that **given** full and continuous control of the situation, it would be **generally** advantagous to arrange fishing everywhere until problems arose. A particular fishery might be encouraged to operate over the whole available stock area, for a time and for special reasons; but there is no economic, social or biological suggestion that this need apply everywhere, all the time, for all stocks. Many theories have been proposed on fisheries management but they all relate to some compromise between the actual power of control (or its cost) and the desirable amount of regulation.

They are not supported by the facts

There may be some advantage to the authorities (at particular times and places) in **not** trying to control some marine exploitation, especially when no 'problems' have been perceived; but no one has produced any factual evidence that this leads to the best **long-term** result.

On the contrary, the list of situations where control was too little or too late to avert serious damage to a fishery is depressingly long. Scientific reviews of the subject

(e.g.Ludwig *et al*, 1993) have suggested that such disasters are actually the norm. Long-term success in fisheries management may be rare. Appearances to the contrary are often temporary (e.g. for a new stock or after some recruitment pulses), accidents (e.g. technological or market 'inefficiency'), or simply insufficient data to realise what is happening.

They are irrelevant to the real issue

The important point is not where fishing is permitted, but what can be achieved when fishing is carried out. Fishing at a location is only a means to an end. The catch (plus profit or fun) is the end. 'Restrictions' on fishing location are not, in fact, restrictions on fishing, although at present they are commonly perceived as such.

The right to travel 'without let or hindrance' on the public highway is an extremely important right. Laws that require traffic to drive one side of the road and prevent driving over median strips are not generally seen as 'restrictions', but as protection and support for the essential right of travel.

(B) PROBLEM SOLVING WITH SCIENTIFIC DATA

Science requires unconfounded controls

The idea that detailed scientific data on stocks could define any problems that might arise in a fishery, and hence suggest specific methods of solving these, is at least a plausible notion. However, the application of science requires a 'control' - an unconfounded situation of the same type, that is compared to the manipulated one. If this is not available, due to universal fishing rights, then while a mass of data can still be acquired, there is no strictly scientific way of assessing it. Many scientists would also require 'replication', both for the manipulation and the controls, before they would accept the results as proper science.

Even if these rules are dismissed as too pedantic, common sense strongly suggests that if the whole stock is continuously manipulated in various ways by different people, the probability of being able to predict the result of further changes is not good. Informed or expert opinion is likely to be better than pure guesswork, but such opinions are not scientific statements.

Detailed prediction is not possible

In situations under rigorous experimental control, it is possible to improve prediction by limiting the range of considerations. This method, the reductionist approach in science, is very powerful in improving our understanding about mechanisms and controlling factors, but its ability to predict in real world situations is limited. Biologists used to accept this, even if it implied a 'lower' status than the more 'precise sciences'.

Recently, however, some biologists (including some fisheries scientists) have become confident they can evade the effects of biological complexity. This is ironic,

because over the same period, the physicists whom they wished to emulate, showed that complex systems predominate in the real world, even in physics (Davies, 1987).

Away from the laboratory bench, 'complex systems' - i.e. non-linear systems involving feed-back and sensitivity to initial conditions - are the rule, especially in biology which is concerned with open systems operating far from physical equilibium. One characteristic of complex systems is that while 'broad brush' prediction may be possible, more detailed knowledge does not lead to more precise prediction. Ordinary people always knew this, now it can be rigorously demonstrated (Cohen and Stewart, 1994).

Social acceptability is not based on precision prediction

Although politicians like to pretend that they only act when the outcomes can be predicted, this is generally recognised as a polite fiction designed to encourage rational discussion. While the public is often gullible or cynical, their instinctive distrust of detailed promises is sensible and wise. This is not just because factual knowledge is unlikely to be sufficient for the purpose. Human behavioural reactions are particularly susceptible to infinite regression.

However logical people are on larger issues or principles, they tend to become much less so as the cases becomes smaller and more particular. This is quite reasonable, since the perceived risks tend to be smaller. The important point is that, socially, people are less logical in detail, not more. The idea that, if detailed effects could be demonstrated in advance, restrictions would be more acceptable, has no basis in politics or social affairs.

Fisheries management must be based on broad principles because there is no actual alternative. All other approaches are based on unwarranted assumptions based on historical accidents or complex forms of wishful thinking. Even if all this was accepted, practical people, especially fisheries managers could still argue that the assumptions, however nonsensical, are so deeply entrenched and widely held that we have no option but go along with them and to tinker within the existing system.

Being a pragmatist myself, I have great sympathy with this point, and would not have raised any of the above if there was no practical alternative. But there is. It will not be the answer to everything, but it does point in the right direction. It will not overturn all the assumptions at once, but it will start the process. It will not make a large difference quickly, but this means it is politically and socially viable. And it is specifically what is needed for this symposium.

The bad news is that those most experienced in detailed resource management will find it hardest to shift their perspective. The good news is that the voting public will, for once, tend to be more receptive than the experts.

5. Principles before particulars - avoiding regression

The organisers of this symposium are professional, careful and modest. But virtues can be misapplied. Consider the original title of this symposium and its implicit assumptions – *"Predicting the value of marine reserves for managing reef fisheries"*. The organisers are trying to keep the discussion within bounds of our professional expertise. This is understandable, but may not be appropriate when discussing a major change in the overall use of a large area of public domain.

"...the value of marine reserves ....for ***managing****... fisheries"*
The unstated implication is that if marine reserves do not provide useful advantages to the management, we would lose interest in the matter. This could be true, but there seems no advantage in saying so, or implying it. The average citizen believes that the convenience of management is not the main, or even a particularly relevant point when discussing what should be done with an important system. We could omit the word "*managing*".

"....the value of marine reserves for ... ***fisheries****"*
The underlying assumption is that if marine reserves provided no advantage to one class of existing users, we would not bother with them. Again this could be true, but the wisdom of implying it is doubtful. An increasing number of citizens feel that the marine ecosystems do not actually belong to the present users, and that management should not be controlled or limited by the present interests of any particular class of user. Why risk alienating those who potentially control the political decisions? Are we really so confident that no other interest counts to any significant degree? Why not omit the word "*fisheries*"?

"*the value of marine reserves for ...* ***reef****...*"
Here the implication is that reefs are the important part of the ecosystem and any others do not really matter. The public does think reefs are much more interesting and important than sediments flats or plankton, but this is part of the problem, not a step to a solution. The idea has no scientific basis, and is unhelpful in a scientific sysmposium. As scientists we must begin by affirming that marine ecosystems include more than top predators or reef systems, and that any sensible management will have to include a wider viewpoint. I would simply omit the word "*reef*".

*"****Predicting*** *the value of marine reserves....."*
This suggests that if we were unable to predict what marine reserves would do, in some specific sense, then we would not recommend action. I emphatically deny this, and insist that there is no point in implying it. Most political decisions are made in terms of some kind of perceived principles, rather than detailed predictions. Furthermore, the public is understandably wary of detailed predictions, but can react positively to suggestions that we need effective insurance against error and ignorance.

What would be wrong with a title that read -

"The value of marine reserves for the southeastern United States."

To some extent my point has already been recognised. The organisers of the sysmposium invited " economists, sociologists, ecologists and conservationists" as well as fisheries experts. This is certainly a good idea, but it should be carried further. We don't just need their views on "*predicting the value.... to reef fisheries management*" - we need their views on "*the value of marine reserves*".

Suppose we found that marine reserves provided no *predictable* benefit to the *management* of *reef fisheries*, indeed the probability was more work for the managers. Would this decide the matter, or would we take in account the probability of major improvements to

conservation at all levels (genetic, species, habitat and ecosystem)
marine science (provision of unconfounded controls)
marine education and training (from public awareness to professional levels)
non-destructive recreation and tourism
monitoring (and separation) of natural and human-induced effects
marine resource management
support and insurance for all extractive uses (including all fisheries).

Government and the voting public are interested in reef fisheries management, but they also have much wider ranging and more important interests. When advising government, professionalism requires care in two directions. We must base our advice on evidence and professional knowledge, but we must avoid restrictions based on departmental boundaries or accidents of employment.

Not so long ago, fisheries science and management was equated in the public mind with all marine life and all the habitats. This was mostly a mixture of ignorance and indifference, but it did have great practical value. When any question of policy arose that involved marine life, the politicians knew who to consult and the public felt they were getting, if not the right answers, at least the best available information.

Since then we have progressed in logic, but regressed in practise. Fisheries science and management has become much more precisely defined and, hence, more professional and knowledgable in this narrower bracket. However, the broader issues have been cast adrift. If you now want advice on policy for marine ecosystems, there is no clear source. Large numbers of agencies are involved in many different ways, but there is no focus, no simple hierarchy and, hence, no principles.

I spend a lot of time apparently criticising fisheries scientists and managers, but I am not antagonistic. Quite the opposite, I am trying to persuade them to upgrade their status. There are good practical reasons for this and marine reserves provide a straightforward route to do it. Simply by recognising the traps inevitably formed by detailed management and the opportunities offered by 'no-take' marine reserves, fisheries science and management could become much more effective.

The public at large would welcome the change. They want to believe that someone is looking after their sea , its life and habitats. Indeed they get very cross if you carefully explain that, at present, the 'responsible professionals' are fully occupied in sorting out conflicts amongst the user groups. The politicians will (sooner or later) take their cue

from the voting public, which has a built-in majority of 'non-users' for each locality. The 'user groups' in each case will not be directly converted. They will continue to demand all kinds of impossible things. But these demands will be seen a new perspective. Instead of being the only point of interest, as at present, they will become simply one of a range of issues to be considered.

This may sound impossibly idealistic, but it has already started to happen to 'fisheries' in New Zealand, and is well-developed in other branches of resource management in the U.S.A.

6. THE HISTORY OF NATURAL RESOURCE MANAGEMENT

It is very difficult to predict precisely when and where new mind-sets will develop in natural resource management, but it is quite simple to see the trend. All branches of exploitive resource management are following the same route, some much faster than others. Whether we look at mining, forestry or waste disposal, the story is very similar. Some nations or regions are farther down the track, but there is very little variation in the route. The stages have even been labelled and defined as principles (Landner, 1995).

Hodges (1995) writing about mining in the USA, states quite firmly that the days are gone when the profitable extraction of a useful mineral from public lands was automatically regarded as the 'highest and best use". Bill Bentley, the executive director of the 7th American Forest Congress, is reported in New Zealand newspapers (N.Z. Herald, 28th July 1995) saying "the congress is seeking an environmental and economical policy acceptable to all Americans". A multi-national oil company and the British government was recently forced by public opinion to reverse a plan to dump a redundant oil storage platform in the deep waters of the North Atlantic.

All these matters involve a change in mind-sets. They all move in the same direction. These paradigm shifts are not a matter of new information. They do not depend on detailed data or accurate predictions. This aspect annoys many scientists and managers. An editorial in *Nature* (29th June 1995) claimed the "decision not to sink a used oil rig at sea is a needless deriliction of rationality". This simply misses the point. It is true that dumping at sea was perfectly feasible. It was the cheapest option and there was no real evidence that it would harm any particular marine life to any significant degree. But large numbers of the public said they did not want that junk in their ocean. Whether this is more or less 'rational' than just dumping things until problems arise (and are scientifically verified) is a matter of opinion. The fact is the public increasingly rejects the idea that user-group cost-benefit calculations and provable damage should be the *only* way of deciding how ecosystems are used.

Slowly but steadily the public is starting to say - We don't *have* to chop *all* the trees that could profitably be made into useful things. We don't *have* to mine *all* the land

that contains worthwhile minerals. We don't *have* to dump rubbish in *all* the available spaces, because it would be cheaper. Very soon they will be saying -
We don't *have* to fish *all* the sea, just because it would be fun or profitable. They already are saying so in New Zealand, and the idea is likely to spread. It would be very unfortunate if this spread was slowed down by the misapplication of scientific ideas. This could occur in at least four ways.

First, although science is prediction, it is not social judgement. It is scientifically improper to imply opposition to marine reserves on the grounds that we cannot predict their outcome to any particular level of detail. Science can and should provide factual background to political decisions, discuss the possible outcomes, indicate the likely variables, etc. but, even if it can accurately the detailed results, its practictioners are in the same class as other citizens when decision time comes - they are entitled to their opinion. If the other citizens wish to give knowledgeable opinion a higher value that is their perogative, but they are not obliged to do so, and probably should not if the knowledge is only being used in a very narrow frame.

Second many scientists are (like this panel) engaged in reviewing marine reserves and their effects (e.g. Dugan and Davis, 1993; Rowley, 1994) . This is reasonable up to a point. But the implications are disturbing. Science does not consist of reviewing the pre-existing evidence, it consists of determining the facts directly. If we want to know the effects of marine reserves in the USA (or anywhere else) the scientific method requires us to run some trials. Discussing previous trials elsewhere is only useful if it results in some actual tests.

Third, a considerable amount of scientific effort is being expended to try and determine whether marine reserves 'work', without applying basic scientific rules to the question itself. Even when this question is posed in scientific reviews (e.g. Roberts and Polunin, 1991), it can miss the point. While a scientist may be pleased to find a significant difference between population densities or size structures between a marine reserve and its surrounds, this should not be confused with managerial or social success. Ordinary citzens do not feel happier when the marine reserves are bursting with life and the rest of the ocean is a desert. On the contrary, they hope that the existence of reserves will *reduce* any difference between the 'exploited' and 'natural' levels in marine life. It is not helpful to define 'success' scientifically in an opposing sense.

Fourth, marine reserves are social experiments but they are not in fact scientific experiments at all. Socially, politically and in management terms, they are experiments in the simple sense of being new and different from previous practise. However, they are not experiments in the proper scientific sense. Marine reserves are controls - the unmanipulated pieces, the 'blanks', the references for comparison. They may be part of an experimental design - involving manipulation(s) and control - but they are not the manipulation. This affects the scientific rules quite markedly. A properly-designed experiment is expected to ask one clear question - to test some strictly-defined hypothesis i.e. you should be able to say what is *the* purpose of *this* experiment. But controls are not like that. The same 'unmanipulated' part of the design can be a control

for any number of other and different experiments, it simply has to remain 'unmanipulated'. So it does not make scientific sense to ask 'what is *the* purpose of this marine reserve'. Furthermore, while in a social or managerial senses a marine reserve can be measured for 'success' in many ways; scientifically 'success' simply means remaining unmanipulated and available for further comparisons.

7. Management principles and insurance

Detailed management cannot take into account changes that are relatively rare, large, sudden or unpredicable. The responsible and professional management reaction to such phenomena is take out some form of insurance. Effective insurance is deliberately different from normal management both in its basic assumptions and its actual design. This is clearly recognised in well-studied situations - such as fire risks to buildings.

Normal detailed management is concerned with fire exits, smoke detectors, hose reels, staff-training, storage of inflammable materials, etc., all of which are highly specific to the particular building, its purpose and locality. This is generally effective, but there it leaves out a range of relatively rare and unpredictable 'accidents' (e.g. lightning strikes, riots, mechanical breakdowns, personal vendettas, etc.) that are capable of causing severe fires. Insurance against these **is** feasible, without detailed knowledge or prediction, provided the arrangements are **not** closely related to the particular building, its purpose or precise location.

Effective fire brigades cover whole districts and, moreover, are networked to provide highly flexible (but rarely used) backups. Effective monetary fire insurance depends on widespread risk-spreading. The principle is that it is worthwhile to pay continuous small amounts to cover unknown, relatively rare, but potentially severe risks. We should note that while (for fire risks in buildings) the need for fire brigades and monetary insurance is generally accepted, deductive principles cannot be proved.

Insurance systems are rooted in general probabilities and background information on possibilities. While actual premiums or effort can be argued in detail, the assumption that **any** cost or effort in these directions is worthwhile depends on a mind-frame. The relevant mind-frame focuses on the areas of ignorance rather than the areas of knowledge and is more concerned with the severity of possible effects than determining actual causes.

Although insurance is essentially a hedge against ignorance, effective insurance systems are largely restricted to well-studied and relatively stable situations. To date fisheries management has been preoccupied with data collection and coping with change - technological, economic, sociological changes as well as biological changes to stocks. When this is coupled with the practical necessity to investigate stocks separately, it is not very surprising that the mind-frame required for broad insurance systems rarely occurred.

None of the discussion above involves criticism or blame for any individual, it is just a flat statement that fisheries management, like all other management systems, cannot be perfected by attention to detail, and hence needs forms of broad insurance.

Inter-year variations: an example of the need for insurance

My own research interests cover a wide range - which is criticised by some - but the common thread is natural variation with time, epecially non-periodic inter-year variations. At all space scales, from biogeographic regions down to small pieces of reef habitat, there exist biologically-important variations between years, which can easily be missed by specialists or dismissed as rare accidents.

Most marine studies are short-term (less than 5 years). Most of the variation found is relatively small and/or regular (e.g. seasonal). Any exceptions cannot be properly investigated within the limited time-frame and tend to be ignored as 'noise' or explained away be special circumstances. Most long term-studies (including most fisheries data) are confounded by changes in methods, observers, aims, or other human-induced effects. However all the reliable long-term data sets we have show major, irregular interannual variations. Some of the changes are widespread and may be correlated with climate patterns like El Nino episodes, others are local and may reflect chaotic dynamics. This is true for all factors (physical and biotic) and all space scales. The available evidence strongly suggests that important but unpredictable interyear variations are the rule, not the exception.

Detailed, stock-specific, data-dependent, fisheries management is not equipped to cope with this type of variation. In the New Zealand snapper fishery, considerable work over the past 15 years established a strong correlation between sea temperatures and recruitment, which for a few years was successfully used to predict some of the dynamics. But the last 4 *successive* years have been cold to very cold (bad for recruitment). Snapper reach reproductive maturity and legally-takable size in about 4 years. No one can predict the *cummulative* effects of the recruitment losses. Even a doubling of the database (in time series or precision) would not have made any real difference. Four successive cold years have not occurred in the past 50 years. How much would you cut the quota? Would you have been less worried if 20% of the stock area was in 'no-take' reserves?

Postscript: Invented problems

After insisting that fisheries management should consider some new and wider issues, it is pleasant to close on a different note. Some problems now being posed are not worth any effort. One example is 'displaced fishing'. The idea is that something must be done to cope with the fishing that will be displaced from 'no-take' marine reserves. This is a classic invented problem. It assumes that fishing is a 'given', that displacement will occur, that this will cause problems, and that these need solving.
Well, maybe, but first consider the other side of the coin.

The creation of 'no-take' marine reserves, will encourage divers, naturalists, students, tourists, photographers, scientists and families to visit these sites. The displacement of this educational /tourist/ recreational activity into the reserves could cause all sorts of problems within the reserves and deprive existing locations of their custom. What should be done about these problems? I submit that the only way to win

these games is not to play. Fishing 'displaces' all the time, and in many ways. We have no real measure of this, still less any good evidence for the reasons. People displace their recreation and education too, for at least as many reasons and in even more directions. It is absurd to suppose that either of these possible sources of potential problems could be handled by detailed analysis, prediction and specific remedies.

The only viable approach is by principle:

If a few small marine reserves were located in selected places, these would probably maximise fishing displacement problems outside and tourist damage within, while minimising any chance of enhancement.

However, a network of marine reserves that represented all habitats and had sufficient total cover to ensure ecosystem support, would probably create better fishing along the boundaries, displace some into non-extractive recreation, minimise the chance of tourist pressure damage, and maximise the probability of restoration.

These principles and probabilities clearly indicate the way to go, but do not depend on any detailed specific predictions.

The assumption of the PDT report that " heavily populated areas" should be avoided when locating marine reserves (page A3) is understandable, but is not bourne out by New Zealand experience. The two most recent marine reserves established there are within the city limits of Auckland (population 1 million).

8. Conclusions and recommendations

The New Zealand experience with 'no-take' marine is relevant to the south-eastern USA. In socio-political terms, New Zealand is reasonably similar. A 'western', democratic country with a pioneering tradition, moderate affluence, and a medium population density, where fishing is very important both in commercial and recreational terms, and the freedom to fish is generally regarded as a 'right'.

In New Zealand the first 'no-take' marine reserves were created only after lengthy campaigns by some sectional interests (scientists, divers and conservationists). The values of 'no-take' marine reserves were discovered by the general public and other sectional interests from experience with the first reserves. This, and comparisons with other marine resource management systems, has led to an increasing demand for more. The authorities are steadily moving to do this. All the major political parties now endorse the creation of further reserves and some are committed to 10%.

The history of New Zealand marine reserves is a story of slowly developing principles. In particular, it shows that fisheries science and management was trapped by assumptions about fishing rights and stock-related, data-based regulations. These assumptions are now unnecessary and are frequently counter-productive. While detailed management will always be needed, we also require non-specific insurance based systems - including a network of representative 'no-take' marine reserves.

The New Zealand experience supports the recommendations of the 1990 report by the Plan Development Team on the Marine Fisheries Reserves for Reef Fish Management, but strongly suggests that in order to achieve the public and political acceptance of 'no-take' marine reserves, it will be necessary to do two things:

Widen the appeal.
Talk about the sea, its range of life and its ecosystems, not just about catching fish. Argue that the natural properties of the sea have many values other than extraction.
Insist that maintaining this system is essential and has many benefits.
Address the general public, especially the youngest, not just 'user-groups'.
Show that 'fisheries' is only one of many important issues in managing marine life.

Focus the discussion on principles
Avoid details. Make it clear that we are very ignorant about the sea, its life and processes, hence we need insurance.
Show that science, education, conservation, and recreation need undisturbed reserves.
Demonstrate that common sense and ordinary business practise require the provision of unexploited marine areas.
Admit that management has been too narrow in its aims. Upgrade 'managing fisheries' to 'managing marine ecosystems'.
Indicate potential benefits to various user groups, but insist that we cannot predict these in detail.

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