CHAPTER 3

THE USE OF TECHNICAL MEASURES IN RESPONSIBLE FISHERIES: AREA AND TIME RESTRICTIONS

by

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1. WHAT ARE AREA AND TIME RESTRICTIONS?

This chapter describes approaches to fisheries management that restrict access by fishers to an area in some way. In some cases restrictions are imposed throughout the year, whereas in others they only apply at a particular time (or times), usually in certain seasons. As noted in Chapter 4, when an area or time restriction is established as a technical conservation measure it is a form of input control. There are, however, many other objectives beyond stock conservation that can be served, particularly by permanent area closures, thereby warranting a separate treatment of this topic.

These more general objectives are articulated under Article 2, Paragraph g of the FAO Code of Conduct for Responsible Fisheries, which states that fisheries should "promote protection of living aquatic resources and their environments and coastal areas".

Area closures (whether temporary, seasonal or permanent) are referred to by a variety of names, each of which may have a particular formal definition, depending on the legislative or cultural context. Of these various terms, however, 'Marine Protected Area' or MPA is, perhaps, the most widely used. The International Union for Conservation of Nature (IUCN) defines an MPA as: *"Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment"*. Kelleher & Kenchington (1992).

Similarly, in the Canadian Oceans Act, a Marine Protected Area is defined as:

an area of the sea...(that) has been designated ... for special protection for one or more of the following reasons:

(a) the conservation and protection of commercial and non commercial fishery resources, including marine mammals, and their habitats;

(b) the conservation and protection of endangered or threatened marine species, and their habitats;

(c) the conservation and protection of unique habitats;

(d) the conservation and protection of marine areas of high biodiversity or biological productivity; and

(e) the conservation and protection of any other marine resource or habitat as is necessary to fulfill the mandate of the Minister (of Fisheries and Oceans).

Section 35(1) Oceans Act, Canada.

Note that both of these definitions leave considerable latitude with respect to the nature of the restrictions on fishers that are imposed and a number of classification schemes have been proposed for categorizing the various levels of area restriction that would fall under the MPA banner. As with most such schemes, however, there are shades of grey at the boundaries between classes and it may be better to think in terms of a continuum between absolute prohibition of access at one extreme (often termed a 'no-take' reserve) and relatively minor restrictions such as limitations on gear that are deemed to be threatening to key environmental or conservation values at the other.

One important distinction that needs to be made, however, is between area closures that are established solely with reference to fishing activity and multiple-use management areas, which allow a range of activities to take place, but with appropriate restrictions on them to protect valued attributes of the area. On coral reefs for example, tourist operators might be restricted to certain mooring locations to limit anchor damage and fishers might have restrictions placed on the types of gear that can be used.

Such multiple-use zones are most likely to be established if a coastal management framework exists that seeks to reconcile the requirements and values of all legitimate interested parties. Thus, the consultative and legislative context in which multiple-use areas are established and managed is likely to be markedly different from that which obtains when an area is established solely within a fisheries management domain. While much of this chapter will deal with the fishery specific issues surrounding closed areas, the reader should bear in mind the wider set of considerations that must be factored in for multiple-use management areas.

2. WHY WOULD YOU ESTABLISH AREA OR TIME RESTRICTIONS?

The importance of clearly identifying the objective(s) for an area or time restriction in any particular instance cannot be over-emphasised (Chapters 1 and 5); unless a clear rationale for the action is developed it will be difficult to make appropriate decisions about how to implement the measure or to communicate and negotiate effectively with the relevant interested parties. As expressed in the definitions of an MPA noted above, a fishery manager might choose to adopt an area or time closure for a variety of reasons. The rationale underlying each of the objectives one might set are described below. Possible objectives have been classified here into three broad categories, the first dealing exclusively with fisheries management issues, the second with broader conservation considerations and the third with equity issues. In reality, the boundary between these categories is rarely clear cut, but it is convenient to make the distinction at this point.

2.1 As a fishery management measure

Paragraph 6.3 of the Code of Conduct articulates the general principle that "states should prevent overfishing and excess fishing capacity and should implement management measures to ensure that fishing effort is commensurate with the productive capacity of the fishery resources and their sustainable utilization". Area and time restrictions can assist fishery managers in achieving these objectives in the following ways.

2.1.1 Limiting harvest of specific life stages

Often it is desirable to prevent fishing on particular stages of a species life-cycle that are especially vulnerable to capture, or are critical to overall production. One example is of species that aggregate in particular areas to spawn; if fishing is allowed on these spawning grounds, it might not only disrupt reproductive activity in that year, but also unduly deplete individuals of reproductive age, leaving too few to contribute in subsequent years. If there are particular characteristics of the spawning habitat that might be affected by fishing on them, a permanent area closure may be required. Alternatively, closure of the area during the spawning season may be sufficient.

There might also be a need to protect areas where juveniles are particularly abundant; if a particular area contains a high proportion of juvenile fish along with adults, allowing a fishery to exploit the adults might lead to undesirably high levels of mortality on juveniles.

While protecting particular life-stages may require continuous closure of an area to fishing, it is often possible to only restrict fishing access during a particular season. The most appropriate measure will depend on the life-history characteristics of the species concerned, with closed seasons often being used for fast growing species with a short recruitment period, such as prawns and shrimps. In fisheries for such species, closing the fishery early in the season allows individuals to grow to larger and more valuable sizes.

2.1.2 Protecting depleted stocks and their habitats during the rebuilding phase of a fishery

If a fishery has collapsed, or is close to collapse, the action that needs to be taken to allow the stock to rebuild is likely to be draconian but essential (Code of Conduct, Paragraph 7.2.2). One option of course is to impose a complete ban on fishing. In some circumstances, however, it may be possible to protect stocks effectively with less stringent measures that allow fishing in some areas but prevent it in those that are critical to the rebuilding process.

2.1.3 Protecting genetic reservoirs

The value of a resource population being genetically diverse is important to appreciate, even though the benefits are often difficult to quantify. Understanding a few basic ideas helps one to appreciate why genetic diversity is important. The first of these is that the mortality fishing imposes often leads to differences in survival for fish with different characteristics. For example, most fishing is size-selective and removes large fish while leaving smaller ones. Fish in the population that start reproducing at small size are, therefore, likely to contribute more offspring to the next generation than those that wait until they are large, because the larger ones are more likely to be caught before they can reproduce. Thus, if the biological characteristic of size at first reproduction is passed on from parent to offspring (i.e. it is inherited), the inevitable consequence of size selective fishing will be that, over time, the average size at first reproduction of individuals in the population will fall. This is the process of natural selection. What does this mean for the fishery? In essence it means that adult fish will generally be smaller, which will usually be undesirable for the fishery. Maintaining a reserve in which larger bodied adults can persist may act as a genetic reservoir to counteract this trend.

Another important idea is that genetic variation provides insurance against changing environmental conditions. For example, some individuals in the population may grow better in warmer years and others when it is cold. If fishing reduces the population to very low levels it is possible that individuals with a genetic trait that may be important for the population in the future will be lost and the capacity for the species to adapt to a new situation compromised. Establishing protected areas to help preserve genetically diverse sub-populations may in some circumstances provide insurance against such possibilities.

2.1.4 Protecting habitat that is critical for the sustainability of harvested resources

Some types of fishing gear can have very large negative effects on benthic habitat that may be important for the sustainability of harvested resources. Often such habitats will be in inshore areas, where juvenile fish often aggregate in areas with high physical structure such as seagrass beds or mangroves. Among other things, the fish are afforded protection from predators in these areas. Paragraph 6.8 of the Code of Conduct makes specific reference to the importance of protecting such critical fisheries habitat as a guiding principle for responsible fisheries.

Although such habitats are more easily identified in shallow water, there may also be environments in deeper water that are important for similar reasons. In particular, structured habitat in deep water may provide refugia for commercially important juvenile fish. Structured benthic habitats are particularly at risk from mobile fishing gears, such as trawls and dredges (see Chapter 2), which can destroy them with only a few passes of the gear. Thus, it may be desirable to prevent access to trawlers and dredgers in such areas, while allowing, for example, pot or trap fishing.

2.1.5 To restrain excess fleet capacity and optimise the value of the catch

The Code of Conduct states that management measures should, among other things, provide that 'excess fishing capacity is avoided and exploitation of the stocks remains economically viable' (Paragraph 7.2.2a). When there is excess fishing capacity, a short appropriately chosen fishing season can optimise the value of the harvest while preventing over-exploitation of the stocks. Although by no means ideal from an economic perspective, in some cases this can lead to seasons that are restricted to a few days, when so-called "fishing derbys" or "the race for fish" takes place. In such cases, consideration needs to be given to how best to optimise the timing of the season. In the Bering Sea pollock fishery, for example, the opening of the season is delayed until late January when the pollock roe commands the highest price at market.

2.2 As a wider conservation measure

Coastal waters in particular are often rich in habitats that are highly valued for their aesthetic or other nature conservation values and some forms of fishing activity will alter such habitats in ways that harm those values. Permanent area closures in particular provide a mechanism for protecting such habitats, and their establishment is understandably a key goal for many sectors of the marine conservation movement. Importantly, MPAs for wider conservation purposes will normally seek to limit other activities in addition to fishing. Often, however, fishing is a primary target for restriction, partly because it is a practical proposition to impose restrictions, but also because, by definition, it directly exploits a biological resource. Other less direct impacts, such as pollution inputs from diffuse sources on land, are more difficult to deal with, especially given the open nature of marine systems and high rates of exchange.

An indication of the value and importance of the MPA as a conservation measure is provided by the fact that the IUCN and others have called upon national and inter-governmental agencies to adopt a series of goals centred upon them. Specifically, they have argued for a global representative system of marine protected areas in accordance with a set of guiding objectives (Table 1) and for national governments to also set up their own systems of marine protected areas; a number of nations have already taken such steps, including Australia, Canada and the USA, with other nations likely to follow suit in the future.

2.2.1 Protecting benthic habitats of high conservation value

As noted above, structural epibenthic communities can be especially vulnerable to towed fishing gears. When such areas have been identified to be of high conservation value, establishing a permanent closed area that prevents fishing by such methods is probably the only measure that will protect them. Such protection is endorsed by the Code of Conduct under Paragraph 7.2.2d, which states that management measures should provide that 'biodiversity of aquatic habitats and ecosystems is conserved and endangered species are protected'.

2.2.2 Limiting bycatch

In some groundfish fisheries, for example off Alaska, closed seasons have been set to minimise bycatch rates or potential interactions with marine mammals.

Table 1: Guiding objectives for the establishment of a representative system of marine protected areas. Extract from the Resolution of the 4th World Wilderness Congress, Colorado, USA, September 1987.

- To protect and manage substantial examples of marine and estuarine systems to ensure their long-term viability and to maintain genetic diversity
- To protect depleted, threatened or endangered species and populations and in particular to preserve habitats considered critical for the survival of such species
- To protect and manage areas of significance to the life cycle of economically important species
- To protect outside activities from detrimentally affecting the Marine Protected Areas
- To provide for the continued welfare of people affected by the creation of marine protected areas; to preserve, protect, and manage natural aesthetic values of marine estuarine areas, and historical and cultural sites for present and future generations.
- To facilitate the interpretation of marine and estuarine systems for the purposes of conservation, education, and tourism.
- To accommodate within appropriate management regimes a broad spectrum of human activities compatible with the primary goal in marine and estuarine settings.
- To provide for research, training and monitoring of the environmental effects of human activities, including the direct and indirect effects of development and adjacent land use practices.

2.2.3 Protecting attributes of the ecosystem that are critical for maintaining ecosystem services

The idea that ecosystems provide services to mankind is one that has only recently emerged (Costanza et al., 1997). In essence, the term 'ecosystem service' connotes the idea that ecosystems serve functions that are of value to mankind and that maintaining the basic structure of the system will ensure that these functions continue to operate. By preventing fishing activity in particular areas, it is argued that ecosystem services will be preserved. These services can be divided into two classes – extractive services (things that provide products, etc.) and existence services (things that you get, just because something exists). Of course, extractive ecosystem services include the provision of fish, oil and mineral resources, the management of which may be served in part by access restrictions to particular areas (see above with respect to fisheries management). Of more relevance to this discussion, however, are the existence services, examples of which include water purification and nutrient regeneration. Unfortunately, for the fisheries manager, while the need to protect ecosystem services is a point that may often be raised in consultation with other interested parties, adequate operational frameworks for defining such services and the protection that is needed will often be lacking.

Despite the above difficulties, however, certain water bodies (e.g. reed beds, wetlands, mangroves or lagoonal areas) might, for example, be shown to be important for protecting coastal environments by removing high nutrient loads from land run-off before entering the sea. In this case, protecting such habitats from fishing activities such as trawling might be justifiably argued for on the basis that it would preserve an important ecosystem function.

Notwithstanding the comments above, a manager should be aware that other justifications for permanent area closures, based on arguments about ecosystem function, may be much more difficult to make. It is often claimed, for example, that high levels of biodiversity are important for ecosystem function. While there are many very valid justifications for protecting biodiversity, the evidence for a positive relation between this attribute of the ecological community and ecosystem function remains a subject of considerable scientific debate. A manager should be wary, therefore, about giving undue weight to justifications for establishing an MPA on biodiversity-function grounds. There may well be other factors that are far more important for preserving function than preserving the number of species an area supports and other much sounder arguments for establishing an MPA that do not depend on such contentious scientific hypotheses.

2.3 To resolve equity issues

2.3.1 Providing a mechanism for resolving conflict over multiple-use of areas or resources

The coastal zone in particular is an area where a multiplicity of users require access. Often, however, uses are incompatible with one another. Trawling in an area where pot fishermen operate, for example, can lead to major conflicts when pots are destroyed. Similarly, combining a submarine practice area with trawling activity would be a bad idea! There are many other possible conflicts of use (e.g. tourism, shipping, recreational fishing), where the only tractable solution is to restrict activities to certain areas by some form of zoning arrangement, either on a permanent or seasonal basis.

2.3.2 Reserving economically vital marine and coastal resources for the preferred use of residents or traditional users

Often indigenous cultures have traditional (and sometimes exclusive) claims on certain lands or resources that can be served by the establishment of some form of area closure or exclusive season. Similarly, local fishermen's cooperatives or communities might benefit from rights protection that is area based. In some cases the fishery manager will also need to incorporate issues of non-governmental management and customary tenure into the equation. The Code of Conduct (Paragraph 6.18) calls on States to "appropriately protect the rights of fishers and fisherworkers, particularly those engaged in subsistence, small-scale and artisanal fisheries..."

3. WHAT ARE THE ADVANTAGES AND DISADVANTAGES OF AREA AND TIME RESTRICTIONS?

3.1 Advantages

3.1.1 Conceptual simplicity

There is no doubt that it is relatively easy to explain and justify to many sectors of the community the reasons for establishing, and the mechanisms for implementing, area or time closures. To use a terrestrial analogy, placing a fence around a piece of land clearly establishes a property right and identifies the basis for its use. Dividing up the fishing season, or fishing grounds, among different fishing sectors is an obvious solution for resolving access issues. In principle at least, it is also a relatively straightforward matter to specify an area or time closure in legislative terms once agreement has been reached among interested parties that the measure is appropriate. With respect to enforcement there are also clear advantages to a reserve system or fishing season when the local fishing community supports the initiative and polices it themselves. For example, control of fishing effort by closed areas or seasons seems to be one of the few options open to managers of marine municipal fisheries in the Philippines (see below).

3.1.2 A good option for protecting bycatch species that cannot be protected by other means

When bycatch species are at serious risk, closed areas or seasons offer a means for protecting them. It is important to recognise, however, that the appropriateness of such approaches critically depends on a clear understanding of the life-history of the species concerned. For example, for highly mobile species that range over an entire region a closed area may be completely ineffective or need to be impracticably large.

3.1.3 A tractable approach for stock protection in complex fisheries or when data are poor or absent

The potential for permanent area closures to be a cost-effective means for managing fisheries for coral reef systems has been recognised for some time, but it is also now being widely advocated for some temperate fisheries. In reef systems, the major objective for such reserves is to protect critical spawning stock biomass to ensure recruitment supply to fished areas via larval dispersal, and possibly to maintain or enhance yields in areas adjacent to reserves. If they work, they have the additional advantage of being easier to implement than more conventional fisheries management programs. This aspect makes them especially attractive for coral reef fisheries which are almost always multi-species, with many artisanal or subsistence fishers using a wide variety of gears and landing their catch at many sites over a wide area. These features make it difficult to collect even the most basic information such as catch and effort that are required for conventional management.

3.1.4 A sound approach for protecting sensitive benthic habitats

It is axiomatic that if one wishes to protect sensitive sessile benthic communities, which often have recovery times of 10-15 years following significant impact, some form of area closure will often be the only alternative when fishing activity has been shown to be a threat.

3.1.5 Insurance against uncertainty

A fishery manager is often faced with the problem that the information which scientists can gather and the predictions they are able to make are uncertain. He or she must also be mindful of the need to adopt a precautionary approach as articulated by the FAO in its Technical Paper on the precautionary approach to fisheries (FAO, 1996). Indeed, much of the focus of fisheries science is currently on finding ways to quantify and communicate that uncertainty to managers so that they can make informed decisions (see Chapter 5). Along with uncertainty comes the need for insurance policies that provide some degree of safeguard in the event that decisions are based on overly optimistic predictions.

Closed areas can sometimes be viewed as providing such insurance. For example, a reasonable management goal for demersal fish resources might be that the stock should remain at above 60% of the un-exploited biomass over a given time horizon, say 20 years. Maintaining such levels would put the stock in the region of optimal sustainable yield that many fisheries aspire to. Using this goal, recent theoretical analyses for a large-scale demersal fishery on the continental shelf suggest that establishing an MPA could be an important bet-hedging strategy and could act as an effective insurance policy that would protect both the long-term future of stocks <u>and</u> yield higher average catches (Lauck et al., 1998). It should be stressed, however, that in this theoretical exercise, the MPA had to be very large to be effective. This latter conclusion is supported by independent work undertaken by the International Council for the Exploration of the Sea (ICES) to examine the utility of a closed area in the North Sea to protect cod stocks. Given current understanding of fish movements and the behaviour of fishing fleets, even closing one quarter of the North Sea to fishing would do little or nothing to protect the widely dispersed and mobile cod. It should also be stressed, therefore, that although MPAs can theoretically serve to protect stocks, it is by no means axiomatic that they will do so in all cases (see Section 4 of this Chapter).

3.1.6 A tool for continuous improvement

An important benefit from establishing an area or season closure is that it can provide an area for research to learn more about how a marine system works, or it can be viewed as a form of management experiment to gain information that will lead to better decision-making in the longer term. One could view such benefits as a primary objective for an area or time closure, but more often it will be an ancillary benefit that flows from the establishment of the area for other reasons. Such approaches can sometimes fall in the realm of what has been termed adaptive management, where new measures are tried specifically to test ideas and learn more so that management can be adapted in the light of results. A good example of this approach is provided in Section 4.

3.2 Disadvantages

3.2.1 Inter- Agency negotiation

When the objectives for establishing an area or time closure require restrictions on activities other than fishing, it will be necessary to negotiate with other agencies and interested parties. This can often be an extremely long and drawn-out process that requires considerable negotiating skill and political judgement. Critical to overcoming the difficulties inherent in the process is a clear and agreed set of shared objectives for the measure.

3.2.2 High economic cost in some cases

Although an area or time closure may be effective in conserving a stock, other measures may be more desirable on economic grounds. Displacing fishing effort from areas or times that are economically optimal can be very costly in terms of the economics of the fleet.

3.2.3 Reduced effectiveness of restrictions over time in the absence of complementary measures

In cases where a time or area closure is imposed to limit catches by effectively reducing effort, then without limits on capacity, effort or catches, the effect is to encourage an increase in capacity over time that eventually undermines any short-term benefits of reduced catches. Such responses serve to emphasise that area or time closures will usually need to be combined with other input and output controls to ensure that the stocks are well managed.

3.2.4 Enforcement

Although establishing an area or time restriction might look good on paper, without a convincing enforcement mechanism the measure is clearly pointless (Chapter 8). As noted above, when fishers support the measure there can be a strong incentive for self-policing, which can make enforcement relatively straightforward. In other circumstances, however, particularly when a fishery operates over a large or remote area, the practicalities and costs of enforcement can be prohibitive. It seems likely, however, that in some cases satellite surveillance techniques could be used to good effect – (Section 3.2.6, Chapter 8).

3.2.5 Enthusiasm versus Appropriateness

There is considerable enthusiasm for the establishment of permanently protected areas by many sectors of community. Unfortunately, however, this enthusiasm may lead to un-sound judgement concerning the likely effectiveness of such a measure for achieving specific objectives. This possibility is particularly likely with respect to fishery management, where considerable uncertainties often remain concerning the effectiveness of permanent "no take" zones. Careful quantitative evaluation of the benefits that will flow from the establishment of an MPA is highly desirable when the objective is stock protection. It may well be, for example, that using other input or output controls is more appropriate for managing any particular fishery. For wider conservation purposes, however, the establishment of a permanent area closure may better serve objectives. Indeed, if one wishes to protect sensitive habitats from mobile fishing gears it is difficult to see an alternative. This example serves, once again, to emphasise that clarity of objectives is of paramount importance.

4. CASE STUDIES

4.1 Gulf of Mexico: a mixture of area and time closures

Good examples of seasonal closures can be found in many fisheries, but shrimp fisheries seem especially suited to the approach because juveniles generally develop in coastal estuarine environments and move offshore as they continue their life cycle, which is completed often within about a year. Thus, to prevent growth overfishing, where individuals are harvested at sub-optimal size, the fishery is closed during the early period in the growing season. Authorities in Texas for example, close state and federal waters from mid May to mid July – a measure that protects juvenile shrimp migrating from the bays to the Gulf of Mexico, thereby allowing them to grow to a larger more valuable size.

A good example of a combination of area and time closure to minimise conflict between fishing sectors can also be found in the Gulf of Mexico, where the State of Florida has a closure zone which restricts the trawl fishery for shrimp and trap fishery for stone crab (Figure 1).

4.2 Coral reefs

There are a number of practical examples of the closed area approach in coral reef systems, with a number of authorities imposing temporary or permanent closure to fishing of portions of or, in some cases, whole reefs. Often, this has been done in the hope that it will prevent fish stocks being depleted and maintain or even enhance yields in adjacent areas. Additional benefits might accrue if tourist activity is to be promoted in an area. Unspoilt coral and an abundant fish life are a pre-requisite for attracting visitors. Of course, given the destructive nature of some forms of fishing and tourism activity (especially poisoning and dynamite fishing, which although illegal, still occur) the imposition of closed areas on coral reefs serves a conservation purpose that does not require positive benefits to the fishery. Obtaining these benefits may be justification enough in some cases with no need for additional benefit to tourists or fishers.

In the case of coral reefs, studies have shown that after affording protection, even to relatively small areas, the densities and biomasses of target species generally increase within the reserve area (see Hall, 1999, for review). Perhaps the best demonstration of this effect is from the Philippines, where fish populations were compared in two small areas (Sumilon and Apo) where protection from fishing was variously established and then relaxed over a period of 10 years. Figure 2 summarises the results of this study. For Sumilon densities of large predatory fish decreased significantly when it was opened to fishing in 1985 and 1993, and increased significantly three times following periods of protection. In contrast, at Apo there was a steady increase in densities over an eleven-year period of protection while comparable non-protected areas showed little change.

The above results and other similar results from other areas show that fish populations in both temperate and tropical regions respond, even in relatively small areas, if one protects them from fishing. In Kenya, for example, studies on two reefs - one in a marine park that allowed no fishing and another in a reserve that only allowed artisanal fishing – found that the abundance of commercially important species was ten times greater in the fully protected area. One rather unsettling observation from the Philippines study described above, however, is that it took only 1.5 and 2 years of unregulated access to an area to eliminate density and biomass gains accumulated over 5 and 9 years of marine reserve protection.

Another response that is observed is an increase in the number of species found in protected areas. For example, studies in Kenya have shown that 52 of 110 species that were found on protected Kenyan coral reefs were not found on un-protected reefs – of these, 44 species were unique to the protected coral reefs. Similar responses have been observed in a number of other studies; if the objective is conservation, marine reserves would seem to be very effective.

Although increases in abundance (and perhaps of species richness) within reserves is a general rule, the establishment of an MPA for fisheries management purposes will generally need to be justified on the grounds that the higher spawning stock biomass inside the reserve will contribute recruits to the adjacent fishery. Since adult fish that inhabit reef systems tend to be fairly immobile this is often a realistic proposition.

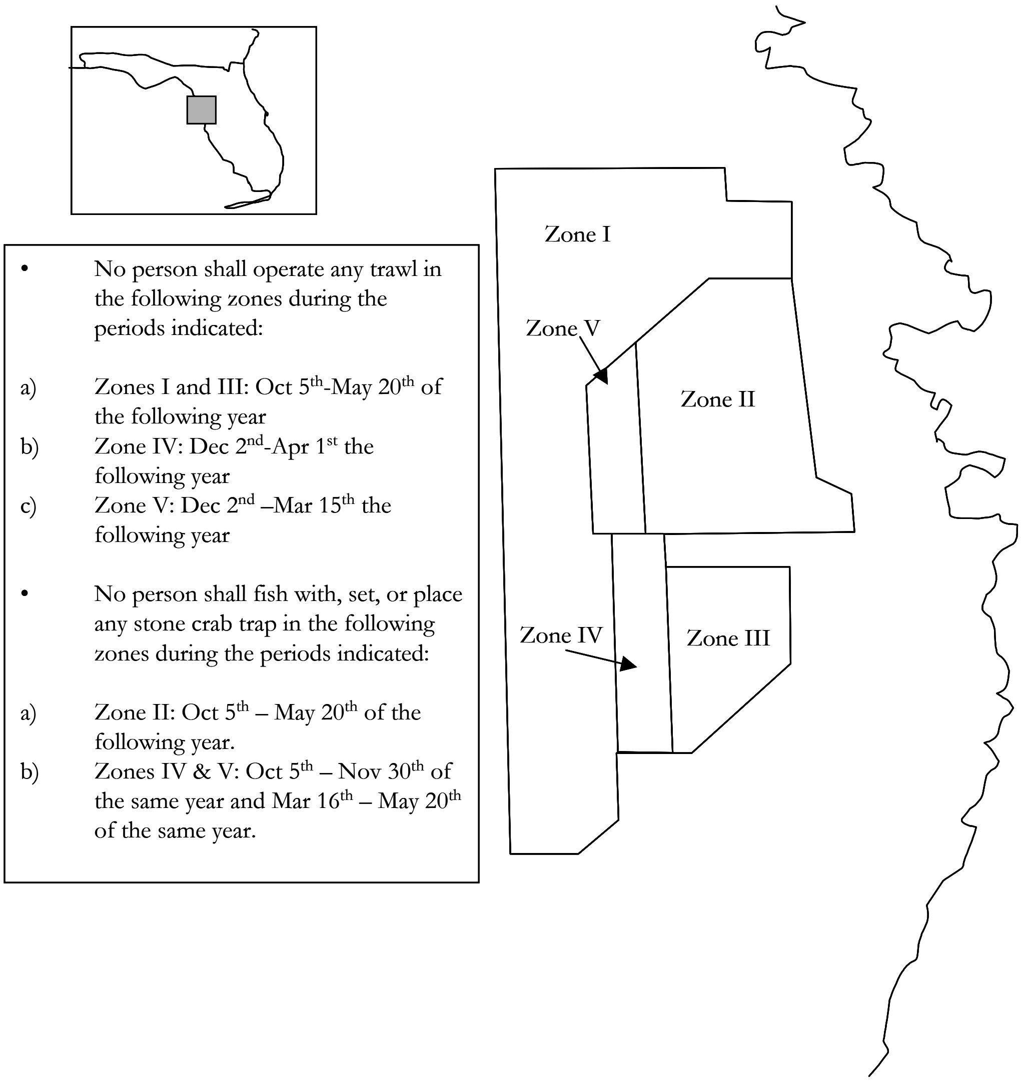

Figure1: The State of Florida Citrus-Hernando Shrimp/Stone Crab closure zone, a 144,000 acre closure area, which restricts access by each fishery to designated areas of seabed for defined periods each year.

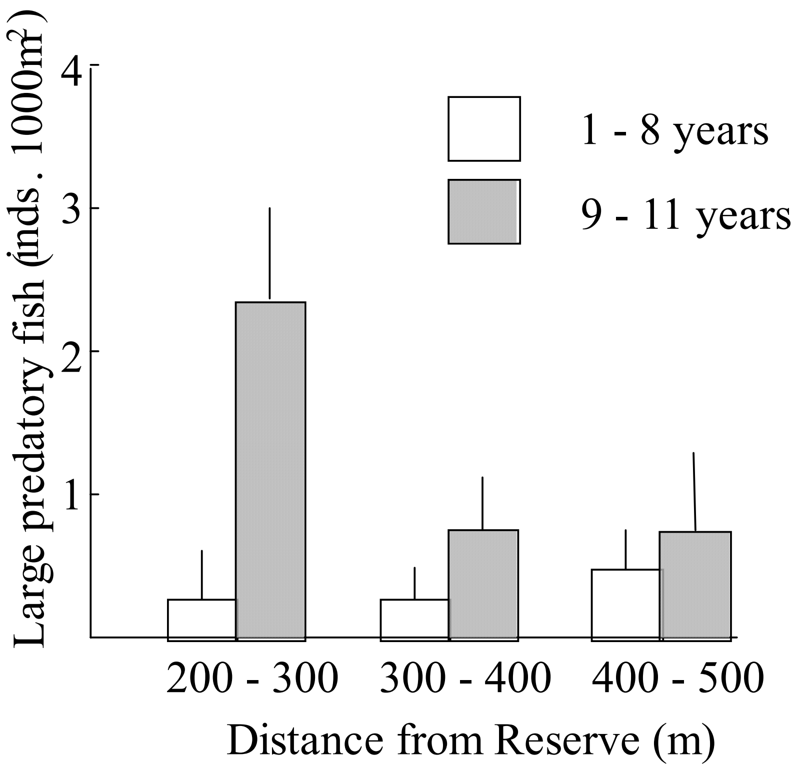

Figure 2: The densities of large predatory fish at different distances from the Apo reserve boundary during the first 8 years of reserve protection and from years 9 to 11. Data are means ± 1 standard error of the mean. Redrawn from Fig. 3 of Russ & Alcala (1996) and reproduced from Fig. 9.1 in Hall (1999).

4.3 Surf zone fisheries

One other tropical example, where there is good evidence that a marine reserve increases yields in adjacent areas fished comes from the De Hoop Marine Reserve on the southern African coast (Attwood and Bennett, 1994). Here, tagging studies over a five-year period showed that Galjoen (*Coracinus capensis*), a species exploited by anglers, showed two distinct behaviours. Part of the population was relatively sedentary with home ranges within the reserve, while the other part was nomadic. Estimates of the numbers dispersing strongly suggest that the reserve, which spans a 50 km stretch of coastline, was contributing to the fishery by providing a supply of mature fish to both nearby and distant exploited areas.

4.4 Georges Bank

On Georges Bank, off the northeast coast of the United States, as with many other temperate demersal systems, controls on mesh sizes, minimum fish sizes and seasonal areal closures failed to conserve stocks because there was no direct control on fishing effort. Changes in fish community structure occurred largely as a consequence of highly species-specific harvesting patterns driven by market considerations. In response, the authorities set up long-term areal closures in 1994 to try and improve the fisheries of the region (Fogarty & Murawski, 1998). These areas encompass areas of traditionally high catch-per-unit-effort (i.e. good fishing grounds), including part of the scallop grounds of the region and important spawning grounds for cod, haddock and yellowtail flounder. Sand/gravel areas that may be important for, among other things, juvenile survivorship are also protected. The effect of this closed area was described recently by Murawski *et al* (2000), who showed that, although whitefish stocks have increased during the period of closure, other management measures had also changed over the period. This has made determining the cause of the increase difficult. For scallops, however, the size of stock increased considerably, which was almost certainly in response to the closure.

4.5 The Plaice Box

The Plaice Box is an area of about 38,000 km^2, along the Danish, German and Dutch coasts that was established in 1989 to protect juvenile flatfish (plaice and sole) by preventing large vessels from fishing in the region in the second and third quarter of the year. In 1994 an analysis of the plaice box was undertaken, which explored the benefits of various management options by comparing expected long-term landings and spawning stock biomass (SSB) of plaice and sole, compared to the *status quo*. This analysis indicated that, if the box were removed, long-term landings and SSB would decline by 8-9%, but if the prohibition were to be extended to the entire year, landings and stock biomass would increase by 24-29% (Table 2). The main reason for these substantial benefits stemmed from the fact that previous discarding rates inside the box averaged 83%. In the light of these analyses, new regulations were established which extended restrictions to all year, but which permitted selected vessels to continue fishing, particularly those targeting shrimps.

Table 2: Percentage increase in long-term landings and spawning stock biomass (SSB) for the North Sea fleet relative to the 1994 *status quo* quarter 2 and quarter 3 closure of the Plaice Box (From Horwood, 2000).

Management option	Landings (%)	SSB (%)
Remove Box	-8	-9
Extend to quarter 4	+11	+14
Extend to entire year	+14	+17
All year + no discarding fleets	+24	+29

4.6 Adaptive management using the closed area approach: an example for NW Australia

As noted in Section 3.1.6, one of the advantages of implementing closed areas is that they provide an opportunity to learn more about the marine environment and progressively improve management decisions. Perhaps the best example of such an approach comes from the northwest shelf of Australia, which also illustrates the importance of including the possible effects of fishing on fish habitat into decision-making.

Research survey data available from 1960 onward showed that, while the total biomass of fish had not changed as the fisheries of the region had developed, the composition of the fish community had altered, with *Lethrinids* and *Lutjanids* declining and *Saurids* and *Nemipterids* increasing (Fig. 3).

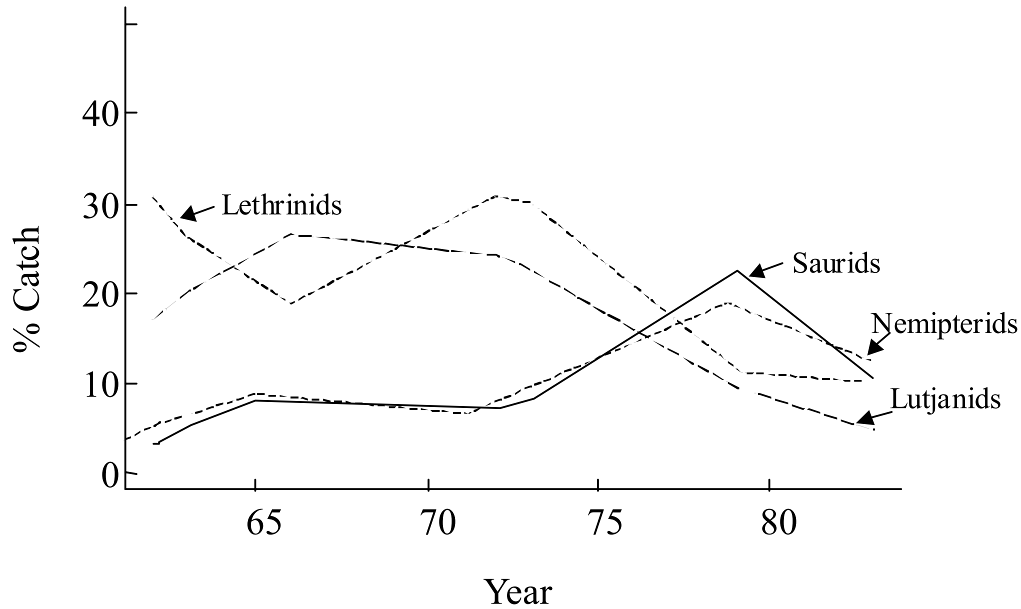

Figure. 3: Trends in abundance of the four major exploited fish taxa on the Australian Northwest shelf. Adapted from Fig 14.2 in Sainsbury (1988) and reproduced from Fig. 3.7 in Hall (1999).

The available data also indicated that the benthic environment had altered over the same period. In particular, the quantity of epibenthic fauna caught in trawls (mainly sponges, alcyonarians and gorgonians) is now considerably lower than it was prior to the development of the trawl fishery (Sainsbury, 1987). Underwater video data indicated four habitat types in the region on the basis of dominant benthic fauna, and fish catch data indicated that *Lethrinids* and *Lutjanids* were almost exclusively associated with habitats supporting large epibenthos. In contrast, the lower value *Saurids* and *Nemipterids* were only found on open sand.

This information gave rise to important management questions for the region: 1. Could the change in fish and benthic community composition be reversed? 2. If changes were reversible, was it worth attempting to do so given the uncertainties of the outcome and the time frame over which the change would occur? 3. If an attempt was to be made, what management measures were most appropriate to achieve the goal?

The key to resolving these issues lies with understanding the mechanisms responsible for the changes in the first place; four alternative hypotheses were formulated:

1. *intra-specific dynamics*: the observed changes result from independent responses of each species;
2. *competitive release due to fishing*: there is a negative influence of *Lethrinus* and *Lutjanus* on the population growth rate of *Saurida* and *Nemipterus* so that when the *Lethrinids* and *Lutjanids* were removed by fishing the latter experienced a release from competition and increased in abundance;
3. *competitive depression: Saurida* and *Nemipterus* have a negative influence on the population growth rate of *Lethrinids* and *Lutjanids* and the abundance of these species declined because the former increased for reasons independent of the fishery;
4. *habitat modification:* habitat characteristics determine the carrying capacity of each genus separately so that trawl-induced modification of the abundance of the habitat type alters the carrying capacity of the different genera.

All four hypotheses are ecologically reasonable and were consistent with the available data. It is important to recognize, however, that each has markedly different management implications. Hypotheses 1 and 2 imply a relatively low productivity of *Lethrinids* and *Lutjanids* with reductions in the biomass of these taxa being viewed as a consequence of fishing. Accordingly, even if stocks could be rebuilt, the sustainable yield from the fishery would need to be low to prevent the same decline happening again. In contrast, hypotheses 3 and 4 imply a relatively high productivity for *Lethrinids* and *Lutjanids* under some circumstances. Selective harvesting of these taxa under hypothesis 3 and harvesting without damage to benthic habitat structure under hypothesis 4 would result in comparatively high sustainable catches. These differing implications make determining which mechanism operates much more than an academic exercise.

To address these issues, a formal evaluation procedure was initiated by stating the above hypotheses as explicit mathematical models. Establishing such models is very worthwhile because they permit one to formally evaluate which hypothesis is most likely to be true given the available data.

The statistical analysis suggested that there was a relatively low expected present value from continuing the existing licensed trawl fishery and the additional information that could be gained from monitoring the outcome of continued trawling would not help make future decisions about what to do for the best. In fact, even though the probabilities that could be assigned to the various models at the time were relatively low, there appeared to be clear benefits from an immediate switch to a domestic trap fishery. However, it was also shown that some experimental management regimes, involving cessation of trawling in some areas and the introduction of trap fishing in some of the areas closed to trawling, could provide a higher expected present return from the resource.

Partly on the basis of this work, the management agencies for the northwest shelf agreed to conduct an experiment by subdividing the area into three zones. One part of the area was left open to trawlers, a second part was closed to trawlers in 1985 and a third was closed in 1987. Trap fishing was permitted throughout. It was hoped that closing part of the area to trawls would allow this fishery to develop to exploit species which are found in less disturbed habitats.

Despite some difficulties, an adapted experiment is still continuing and sufficient data have been collected to allow the four hypotheses to be evaluated (Sainsbury *et al*., 1997). Figure 4 shows how the area closed to trawling experienced an increase in the density of *Lethrinus* and *Lutjanus* and in the abundance of small benthos. The abundance of larger epibenthos stayed the same or perhaps increased slightly. In the area open to trawling, the abundance of fish declined along with the small and large epibenthos.

These results provide a valuable perspective on fishery effects, but it is in the formal evaluation of the four mechanistic hypotheses mentioned above that the real strength of this study lies. This is because the data from the experimental period allowed the probabilities assigned to each of the four hypotheses to be further updated. These updated results indicate that a high value *Lethrinus* and *Lutjanus* fishery could be established on the northwest shelf if the habitat could be protected and that changes in fish community structure can probably be attributed in large part to habitat modification by trawling. Managers who are able to draw on such quantitative and systematic scientific evaluations will be in a much better position to make informed decisions.

The northwest shelf is a good example of where an interaction between fisheries and the structure of benthic communities may lead to both an enhanced fishery and a less disturbed benthic community. Such mechanisms may not happen everywhere, indeed, the habitats in which they operate might be quite restricted, but one should be alert to the possibility. Such effects need to be considered when determining suitable technical measures to use in a management strategy (Chapter 2).

Unfortunately, however, in the case of the northwest shelf, it is apparent that the time scales for recovery for epifaunal benthos are slower than previously thought. Rather than taking 6-10 years for sponges to grow to 25 cm, it now appears that at least 15 years are required. Moreover, video analysis of the effects of the trawl ground rope indicated that about 89% of encounters lead to dislodgement of sponges and almost certainly subsequent death. This slow recovery dynamic and the apparently high probability that large benthos will be removed by a trawl mean that measures to protect the habitat would need to be very effective to maintain the habitat structure required to support this high value fishery.

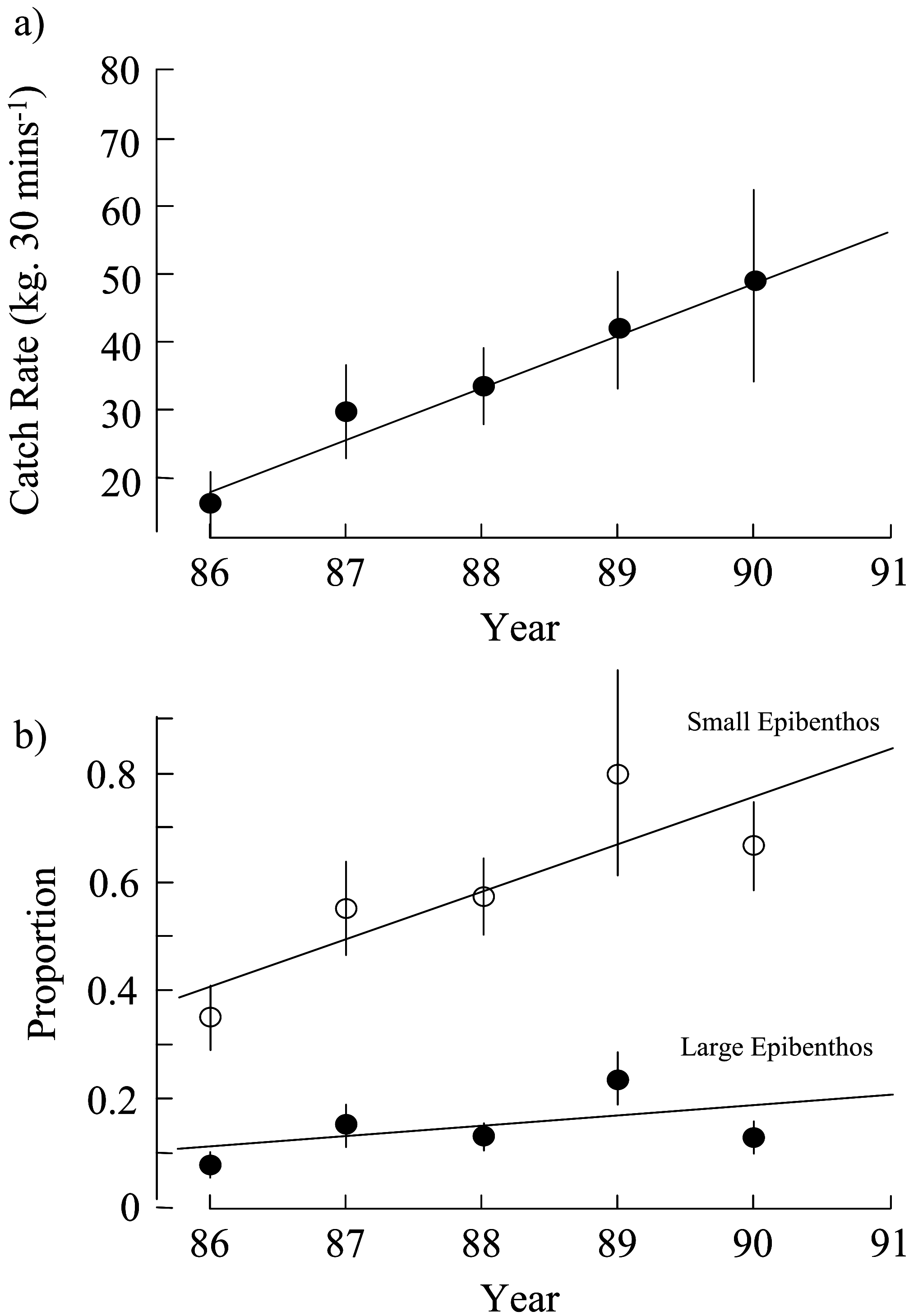

Figure: 4. a) Changes in the abundance of fish (*Lethrinus* and *Lutjanus*) b) Changes in the proportion of large and small epibenthos in areas closed to fishing. Adapted from Fig. 2 of Sainsbury *et al.* (1997) and reproduced from Fig. 3.8 in Hall (1999).

5. WHAT ARE THE PRACTICAL STEPS TOWARDS ESTABLISHING TIME AND AREA RESTRICTIONS?

A brief summary of the steps involved in the implementation process, for fisheries management or conservation purposes is given in Figure 5. Further commentary on aspects of the process are given below.

5.1 Set your goal

The importance of being explicit about the goals for area or time restrictions has been continually emphasised throughout this chapter and is throughout this Guidebook. To re-iterate, it is essential that the manager selects from among the justifications presented in Section 2 or identifies an alternative goal. There may, of course, be multiple justifications for the measure, in which case it is important to try and specify them in order of priority. While there can be no hard and fast rules about how detailed the specification of objectives for a measure should be, its establishment will be greatly facilitated by including as much detail as possible about what you seek to achieve at the earliest opportunity. This will require translating the broad goals into detailed operational objectives (Chapter 5).

5.2 Specify criteria for selection

5.2.1 Criteria for stock management

Once the objectives for establishing an area or time restriction have been established, the criteria for the selection of candidate sites or time periods should follow logically. For many time and area restrictions, the choice will often be driven by the life-history of the species involved and the dynamics of the various fishing sectors that the measure is designed to serve. Adequate biological data to support the decision will often be available - the location of nursery grounds and spawning seasons or areas are often relatively well known. Similarly, fishers are acutely aware of where and when conflicts between sectors occur. With respect to the justification of permanent no-take zones in the adult habitat, however, data will often be less comprehensive and the potential benefits more open to debate. Lauck *et al*. (1998) note the following as "desirable" features for a no-take reserve, established to fulfil fisheries management objectives.

1. It should be large enough to protect the resource in the event of overfishing in the unprotected area.
2. The reserve should serve as a source capable of replenishing the exploited stock in the event of its depletion. In particular, reserves should protect spawning grounds and any other areas critical to the viability of the population.
3. The reserve must be completely protected, since the almost certain build up of biomass inside the reserve will be very attractive to poachers.

In my view these features are not just desirable, but essential if an MPA is going to work to protect stocks.

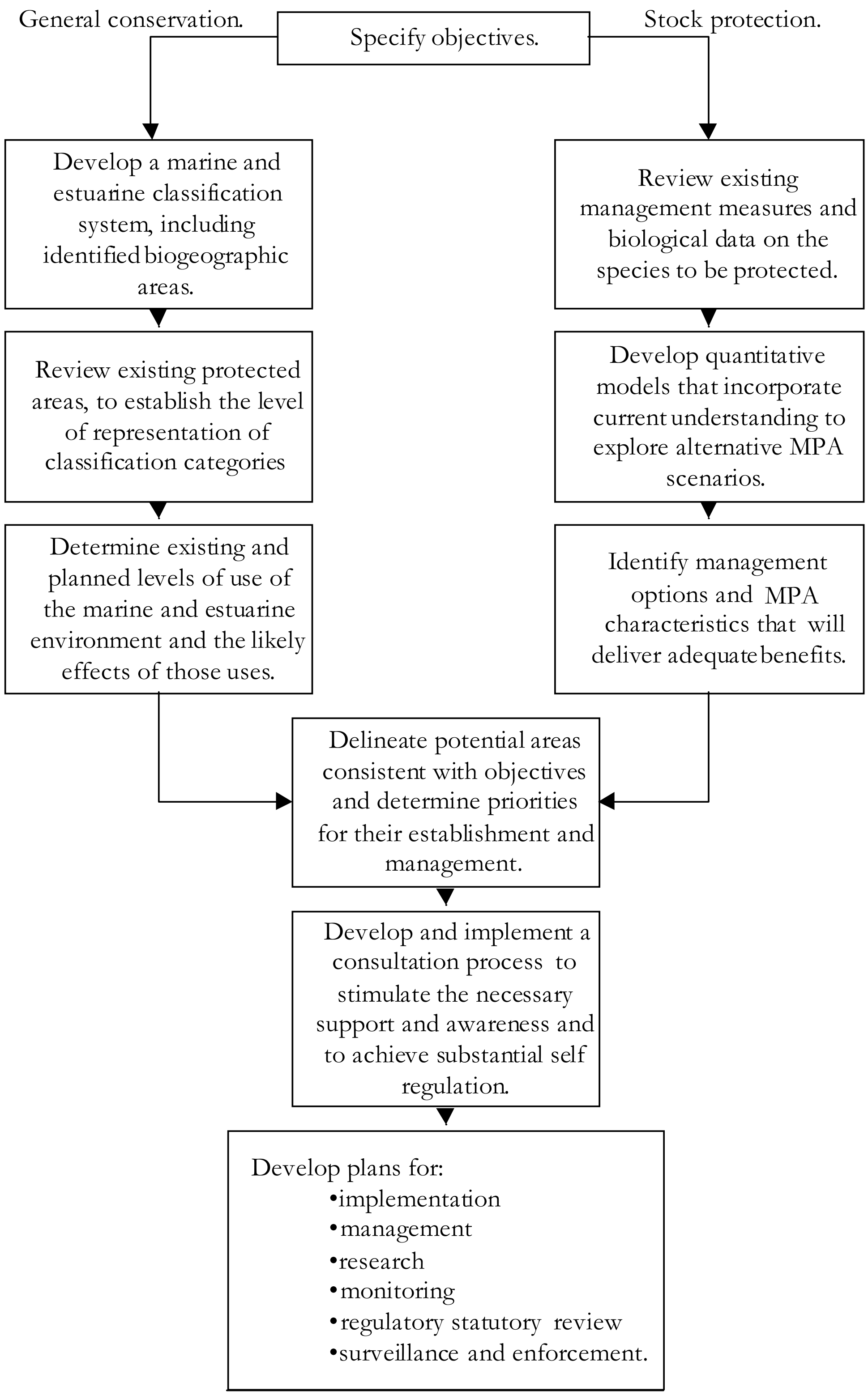

Figure 5: A diagrammatic summary of the steps involved in the specification and implementation of a MPA for either fisheries management or other conservation purposes. Adapted in part from Kelleher & Kenchington (1992).

With respect to point 3, there should be relatively little difficulty in working out what is required – it is simply a matter of establishing the political will to meet the costs. In contrast, points 1 and 2 are a major challenge for ecologists. Identifying appropriate sizes and locations for closed areas requires consideration of the relative proportions of the populations and communities of interest within the protected region, their potential to serve as source populations for unprotected areas, and the location of any sensitive habitat types, which need to be included in the protected area to maximise the benefits of the approach.

The preferred model for area and time restrictions for more general conservation purposes is for legislation that is based upon sustainable multiple-use managed areas. Isolated highly protected pockets in an area that is otherwise unmanaged or subject to piecemeal regulation is much less desirable because piecemeal protection of small marine areas alongside conventional fisheries management often leads to over-exploitation of fish stocks and progressive deterioration of the protected area. Thus, most conservationists favour larger multiple-use protected areas that provide for a number of levels of access and of fishing and collecting in different zones, with continued sustainable harvest of food materials in the majority of a country's marine area. A summary of the IUCN criteria for the inclusion of an area as an MPA are given in Table 3.

Table 3: The factors or criteria that have been proposed for deciding whether an area should be included in an MPA or for determining the boundaries of an MPA. Adapted from Kelleher & Kenchington (1992).

Criteria	Description
Naturalness	The extent to which the area has been protected from, or has not been subject to, human induced change.
Biogeographic importance	Either contains rare biogeographic qualities or is representative of a biogeographic "type" or types. Contains unique or unusual geological features.
Ecological importance	Contributes to maintenance of essential ecological processes or life support systems. The degree to which the area either by itself or in association with other protected areas encompasses a complete ecosystem. Contains some or all of the following: • a variety of habitats; • habitat for rare or endangered species; • nursery or juvenile areas; • feeding, breeding or rest areas; • rare or unique habitat for any species; • high genetic diversity i.e. diverse or abundant in species terms.
Economic importance	Existing or potential contribution to economic value by virtue of its protection. Economic contribution could be delivered through: • recreation; • subsistence; • used by traditional users; • appreciation of tourists; • important habitat for economic importance species.
Social importance	Has existing or potential value to the local, national or international community owing to its heritage, historical, cultural, traditional, aesthetic, educational or recreational qualities.
Scientific importance	Value for research and monitoring
International or national significance	Has the potential to be listed on the World or National Heritage list or declared as a Biosphere reserve, of other national or international significance, or subject of a national or international conservation agreement.
Practicality/feasibility	• Degree of isolation from external destructive influences • Social and political acceptability, degree of community support • Accessibility for education, tourism, recreation • Compatibility with existing uses, particularly by locals • Ease of management, compatibility with existing management regimes.

5.3 Assemble information and conduct a preliminary evaluation

Clearly, to address the criteria described in the previous section a considerable amount of economic, social, biological and ecological information is required before informed decisions can be made. As noted above for many of the objectives one might set for area and time restrictions, biological and fishery data will be adequate. For some forms, particularly of permanent area closures in adult fish habitat, the information for basing a decision about a closed area will, in many cases, be poor or unavailable. Whatever, the available data, a manager must seek to learn from past experience in other systems and, if possible, from scientifically defensible quantitative models that predict the likely consequences of different management scenarios (Chapter 5). Questions that it may be important to ask include the following.

5.3.1 Will my restriction protect fish stocks?

In the limit, of course, where the vast majority of an area is closed to fishing, the answer has to be yes (unless the small piece that was left open happened to be the only spawning ground for the resource). A more appropriate question, however, is under what range of circumstances is area or time restriction likely to succeed in this objective and by what mechanisms? This is a complex and difficult question, for which no simple answers can be offered, especially for permanent area closures in adult fish habitat. It is perhaps notable, for example, that the Organization for Economic Cooperation and Development (OECD) recently reviewed the benefits to fisheries of 52 restricted areas and found that in 32 cases stocks declined or showed major oscillations and in only 16 had stocks increased or remained the same (Anon 1997). Importantly, in all of the successful cases limited entry or TACs were also used along with other input controls such as size or sex selectivity so the contribution made by the area closures alone to the outcome was impossible to determine.

Despite this somewhat pessimistic OECD analysis, however, there is, good evidence that for many purposes area and time restrictions have been highly successful. Indeed, as noted above, there is also growing evidence for successful MPAs in adult habitat for fish stock conservation in coral reef and other tropical systems, where the biology of the fish is favourable and management is through effort control. One might expect similar positive benefits in temperate systems where the fish species of interest have similar life history characteristics to their tropical counterparts. At present, however, the case for permanent closures is rather less convincing for temperate continental shelf fisheries, although seasonal closures such as the Plaice Box described above certainly appear to confer benefits.

5.3.2 How big would my MPA have to be or how long should restrictions run for?

As noted earlier, for fishery management in temperate demersal systems, area closures in adult habitat may need to be especially (and perhaps unfeasibly) large to be effective. This may be especially true in fisheries that are managed through controls on total allowable catch, where effort may be diverted to other areas and negate potential benefits (Horwood, 2000). Horwood argues convincingly, for example, that claims for benefits to fish stocks using closures of the order of 10-20% of fishing grounds are overly optimistic for such systems in Europe. However, seasonal or other closures to protect juveniles certainly appear to be effective. With respect to coral reef systems, McClanahan & Kaunda-Arara (1996) suggest that many small reserves may be preferred from a fisheries perspective. These authors found that small reserves increased the total catch in adjacent areas, but a larger park did not. This effect may be due to the lower ratio of edge to park area in a large reserve. Data or experiences for tropical demersal trawl fisheries appear to be lacking and there is little analysis available to guide decision-making for these circumstances.

For more general marine conservation, the concept of a park or reserve in a marine system is somewhat different to that which obtains on land. In terrestrial systems one generally thinks of a protected area as being separate from the rest of the system, with surrounding unprotected areas having little influence within the park. In contrast, marine systems are usually extremely open with considerable exchange across the legislative boundaries defined by lines on a map. It follows that the minimum size required to meet the objectives for an MPA is often likely to be many times larger than that required for a terrestrial system. In particular, there is general agreement that, in order to protect productive marine ecosystems and areas of high biodiversity, an MPA needs to encompass as many of the ecosystem components as possible and give full consideration to the many factors and influences affecting productivity and diversity.

5.3.3 Who are the interested parties that will be impacted by the measures and what are the legislative issues associated with its implementation?

Decisions about closed seasons will usually fall exclusively within the domain of the fisheries manager, with little need to involve agencies or interested parties other than those with a direct interest in fishing. In contrast establishing permanent MPAs will almost certainly require inter-agency agreements and negotiations. An important goal for a fisheries manager will be to acquire the knowledge required to support the planning and management process. Indeed the general principles outlined in Paragraph 6 of the Code of Conduct make a number of references to the importance of consultation and negotiation. In particular, the implementation of an MPA is more likely to be successful if:

- the foundation for planning is based on real biological and physical data;
- this foundation includes data on cultural aspirations and the socio-economic position of interested parties;
- the facts are available in a readily understandable format to explain and, where necessary, justify concerns and actions;
- there is a clear consultative process established (Chapter 7).

With regard to legislation, it is clearly the case that management success is more likely when the area under consideration for protection (and preferably the adjacent land in coastal waters) is under the same agency's jurisdiction. In most cases, however, this is unlikely, and in cases where this situation does not obtain, it has been strongly argued that legislation and management arrangements should grow from existing institutions unless there is overwhelming public or political support for completely new administrative agencies. Of course, the precise legislative environment in which an MPA is to be established will differ from country to country. Thus, no general guidance can be provided here beyond emphasising the value to a manager of being fully acquainted with the legislative issues for their own situation.

5.3.4 How would the measure be enforced?

As with all fisheries management measures, the ease with which compliance can be monitored and enforced is likely to be a critically important determinant of feasibility. Unfortunately, for area and time restrictions, there is no straightforward answer to how easy enforcement will be. An analysis by the OECD (Anon, 1997), for example, showed that increased enforcement costs or problems were reported for six fisheries, while five fisheries reported no difficulties. One could imagine a situation, for example, where a short fishing season for boats from a limited number of ports could easily be policed. In contrast, permanent closure of a large and remote area would be almost impossible to control without technological support such as satellite tracking of vessels, or air surveillance. Without doubt seasonal or area closures are likely to be most effective where the fishers themselves agree wholeheartedly with the measure and are prepared to police it themselves (Chapters 7 and 8).

5.3.5 Would there be a need for adjustment funding?

An important consideration when access to fishing grounds is to be restricted is the extent to which effort is likely to be displaced elsewhere and what the consequences of such displacement are likely to be. If effort displacement is a concern, the possibility of providing funding for structural adjustments to reduce capacity and compensate fishers for loss of access may need to be considered.

5.4 Implement the process of negotiation

After undertaking a comprehensive evaluation of the options and becoming familiar with the scope of the problems for a given situation, the fisheries manager should be in a position to decide whether an area or time restriction is likely to be appropriate. Assuming that it is, however, it must be recognised that there are no simple standard procedures for establishing restrictions. What works for one nation or group of nations can rarely be adopted without modification for a new situation. Nevertheless, one universal truth probably applies - local people must be directly involved in the selection, establishment and management of measures if the chance of success is to be maximised (see Chapter 7). This is also emphasized in the Code of Conduct (see Paragraphs 10.1.2 and 10.1.3).

5.5 Evaluate the need for underpinning research

It is difficult not to be sceptical of some of the bolder claims that are made for the success of area and time restrictions. In particular, with respect to permanent area closures in adult fish habitat, it is certainly not axiomatic that they must enhance fisheries. This is not to suggest, however, that uncertainty about their value as a management tool should be used as a reason not to establish them. On the contrary, the case for trying the permanent reserve approach is rather compelling. However, a manager ought to ensure that we learn from the process, by making efforts to understand the underlying mechanisms that determine success or failure. A program of research that is closely allied with the implementation of the management measure is a pre-requisite for doing this. There are also perhaps more politically compelling reasons for mounting research programs in association with area restrictions. Consider the following scenario.

A marine reserve is set up using arguments that benthic habitats will be conserved and fish stocks will be enhanced. This reserve was established in the face of great resistance by fishers, who perceived the measure as an unnecessary constraint on their trade. In the end the fishing industry accepted the measure, albeit grudgingly. Imagine now that after 5 years, there were no detectable improvements in catches. One could imagine at least four reasons why this might be:

1. the reserve was not big enough;
2. the area had not been closed for long enough;
3. the reserve was in the wrong place;
4. reserves don't work in this system.

Reasons 1 and 2 argue for even stricter constraints, and acting on reason 3 is likely to be politically very difficult. Fishermen of course are likely to argue for reason 4 and for a re-opening of the region. The point is that in the absence of information about the mechanisms that operate in the region, there is no basis for saying which of these explanations is the most likely. Thus, one is unable to decide whether to make the reserve bigger, continue with it as it is, move it, or abandon reserves altogether. Of course, even with a directed research program the information will not be perfect, but adopting the kind of Bayesian approaches described earlier (Section 4.3) seems to be a sensible route towards a sensible decision. Without efforts to monitor the effectiveness of any area or time restriction and understand why they succeed or fail, I fear the goal of protecting fish stocks and the marine system in general will be compromised.

Despite the above comments, it should be recognised that it will often be difficult to demonstrate the benefits offered by an area or time closure for fishery management over reasonable time scales. It has been estimated, for example, that using the standard 5% statistical significance level, it would take over 30 years before one could obtain a 90% probability of recognising a 20% improvement in mean flatfish recruitment after establishing the plaice box described earlier. In many circumstances, therefore the benefit of a closed area is unlikely to be clearly demonstrated in less than a decade (Horwood, 2000).

6. CONCLUDING COMMENTS

There are many compelling reasons why a fisheries manager should seriously consider closed areas and/or time restrictions, either as a complement to other measures or as the primary facet of the management strategy.

Time restrictions have been shown to be effective in many fisheries and are an important tool in the management armoury. In many respects justifications for their use (i.e. the benefits that will flow to fishers) and the process of implementation are likely to be relatively straightforward compared to permanent area closures. The political gulf between a temporary loss of access each year and a loss in perpetuity is enormous.

From a fisheries management perspective, the benefits that flow from permanent area closures are usually less easy to predict than for seasonal closures. Moreover, even if one accepts that implementation of a permanent reserve will provide higher production levels in adjacent fished areas, the potential benefits may often be in danger of being largely dissipated. If, for example, the fishery remains open access, the increased production is likely to attract new entrants into the fishery, thereby driving it back towards bioeconomic equilibrium. From a wider conservation perspective, however, closed areas have an important and clearly defensible role to play and some form of zoning arrangement will often effectively serve conservation values. Given the increasing trend towards the establishment of national networks of marine protected areas, it seems likely that fisheries managers throughout the world will need to ensure that they are familiar with the issues surrounding these approaches.

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