

PRECIS.

Fully-protected marine reserves: a guide

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1. Preface

Fully-protected marine reserves are areas of the sea completely protected from fishing and other extractive or harmful human uses. Since the first fully-protected reserves were established, more than two decades ago, they have stimulated a wealth of research and intense interest. Recent scientific evidence indicates that reserves are not only powerful tools for conservation, but can also provide much needed support for fisheries. There is an urgent need for more reserves in order to address the developing crisis in the oceans. Worldwide, fisheries are in trouble, and **habitats** and species are being lost at an alarming rate.

However, decision makers need good scientific information on how to make reserves work successfully. Questions such as ‘how do reserves function?’, ‘how many should we have?’, and ‘where should we put them?’ are challenging the minds of scientists, conservationists and managers everywhere.

The case for marine reserve establishment gets stronger with every new study published and scientists are making good headway in developing a detailed theoretical basis for fully-protected reserves, supported by good quality data.

2. Introduction - Key points:

- Less than half a percent of the seas lie within marine protected areas, and most of them are under-resourced, poorly managed and offer little protection.
- Perhaps only one ten thousandth of the oceans are protected from all forms of fishing.
- Fully-protected reserves, areas closed to fishing, extractive or harmful uses, are powerful management tools. There is an urgent need to establish more to reverse species losses and habitat destruction.
- Fully-protected reserves represent a precautionary, ecosystem-based approach to management.

3. Why should reserves be protected from fishing?

Key points:

- Fishing has transformed the seas, leading to widespread depletion of species and the alteration and destruction of habitats.
- Although losses of some species have been highly publicized, such as the great whales, most have gone virtually unnoticed. In many cases this is because habitats were transformed by fishing long ago. Any unfished, undamaged ‘baseline areas’ that could be used for comparison have long since disappeared.

- Few refuges from fishing remain in waters shallower than a kilometre deep. This is due to technological advances in fish finding, navigation and fishing gears, together with a greatly increased human population.

- Some species are so vulnerable to the effects of fishing that they have disappeared from most of their ranges. For some, extinction seems imminent. Fully-protected marine reserves may be the only means of ensuring their survival.

4. Fully-protected reserves in a nutshell

Key points:

Fully-protected reserves can:

- Protect exploited populations, enhancing production of offspring which help restock fishing grounds.
- Supplement fisheries through spillover of adults and juveniles into fishing grounds.
- Provide a refuge from fishing for vulnerable species.
- Prevent habitat damage and promote habitat recovery.
- Maintain biodiversity by promoting development of natural biological communities that are different from those in fishing grounds.
- Facilitate ecosystem recovery after major human or natural disturbances.

5. What is the evidence for recovery of animal populations in marine reserves?

Key points:

- There is compelling, irrefutable evidence that protecting areas from fishing leads to rapid increases in abundance, average body size, and biomass of exploited species. It also leads to increased diversity of species and recovery of habitats from fishing disturbance.

- Reserves are often portrayed as working only on coral reefs. In fact, they have been successful in a wide range of habitats in environments ranging from tropical to cool temperate zones. Reserves are a valuable tool globally.

6. What is the evidence for spillover from marine reserves?

Key points:

- Spillover, the movement of marine animals out of reserves, is one of the two main mechanisms through which reserves can enhance fisheries.

- The rate of spillover varies among species and reserves, and depends on the mobility of animals, degree of compliance with the reserve, time since reserve creation, intensity of fishing around the reserve, the edge to area ratio of the reserve, and whether or not habitat is continuous across reserve boundaries.

- There is circumstantial evidence for spillover from studies of the movements of exploited species, and direct evidence of increased catches close to reserve boundaries from a growing number of studies.

- The most compelling evidence for spillover is 'fishing the line', the change in fishing patterns following reserve creation where fishers preferentially fish close to reserve boundaries.

7. Do reserves increase reproductive output and recruitment of

animal populations?

Key points:

- Well respected, fully-protected marine reserves typically lead to at least a doubling in the biomass of exploited species after three to five years protection. Sometimes biomass can increase by orders of magnitude over levels in fishing grounds.
- Much of that biomass is concentrated into larger individuals than in fished areas, and they usually produce many times more offspring.
- For intensively exploited species, reserves may support the bulk of successful reproduction by a population.
- Most exploited species have an open water dispersal phase and their offspring can be expected to disperse widely into fishing grounds.
- Over time, reserves may come to produce orders of magnitude more offspring per unit area than fishing grounds, and even relatively small reserves could produce regionally-significant replenishment of exploited populations.

8. How useful are marine reserves as tools for conservation?

Key points:

- It was once believed that fishing could never cause the extinction of marine species but it is now clear that there are many threatened species in the sea.
- Many species have been seriously depleted by overfishing, and some have been eliminated from large areas of their former ranges. Where source populations still exist, reserves can help promote their recovery.
- Where fishing is intense and widespread, reserves may be the only means of protecting species that are highly vulnerable to depletion by fishing.
- Reserves protect habitats from damage by fishing gears, and foster the recovery of damaged habitats. Reserves may be essential for protecting vulnerable habitats, especially those that are limited in distribution.
- Reserves promote biodiversity by creating conditions that favour the development of communities that are different from those in fishing grounds.

9. Are fully-protected reserves beneficial to migratory species?

Key points:

- Many people believe that fixed location marine reserves will not benefit migratory species because they will move in and out of them and periodically be exposed to fishing. In fact, there are numerous ways in which migratory species can benefit.
- Many migratory species pass through population bottlenecks where they become highly vulnerable to capture, such as spawning aggregations, and fisheries often target such locations.
- Strategically-placed reserves can provide protection at critical places and times.
- Reserves can prevent premature capture of juveniles in nursery grounds.
- Reserves can protect places where by-catch of migratory species is excessive.
- Reserves can promote habitats that provide better conditions for growth, survival and reproduction by migratory species.
- Reserves can provide important protection but most migratory species

will require other forms of management to supplement them.

10. How long will it take before reserves produce benefits?

Key points:

- Working reserves around the world show that benefits of protection can occur very rapidly. Population increases among exploited species can be seen within a year or two.

- Well-protected reserves can be expected to begin supplying fisheries within five years of creation, and benefits are likely to continue to build up for 10 or 20 years.

- Models suggest that the more overexploited a fishery is at the time of establishment, the faster there will be net benefit from reserves. However, recovery will be slow if populations have been so seriously depleted that there is little reproduction to stock reserves in the first place.

- Damaged habitats will recover more slowly than populations, but recovery begins as soon as reserves are created and may continue for many decades.

11. How can fishers be helped through the economic transition following reserve creation?

Key points:

- If fishers are living hand-to-mouth, they may feel they have no alternative but to oppose measures that will reduce income in the short-term.

- Fishers with large economic stakes in a fishery may find it hard to leave without assistance, even if they want to.

- Short-term economic assistance can help gain fishers' support for reserve proposals.

- Economic assistance can be offered in many forms, from cash to loans, vessel buy-backs or re-training.

- Economic assistance can be an extremely effective way of gaining compliance with reserves by those who remain within the fishery.

12. Will redirected fishing effort undermine the benefits of reserve establishment?

Key points:

- Problems caused by redirection of fishing effort following reserve creation are highly unlikely to outweigh the benefits of reserves.

- Problems can be caused if fishing effort is redirected from a place where a population is less vulnerable to capture to one where it is more vulnerable, or from places where habitats are resilient to places where they are vulnerable to damage from fishing gear.

- It is important to protect sites where populations and habitats are highly vulnerable to fishing, and reserves are a valuable means of facilitating such a beneficial redirection of fishing effort.

13. How large should a marine reserve be?

Key points:

- Very small reserves have shown striking benefits from protection. However, while the magnitude of effects is not strongly affected by the size of a reserve, overall effects are dependent on the combined area of reserves.
- Mobile species will gain less protection from small reserves than large. The larger a reserve is, the greater the range of species that will benefit.
- It is important that reserves are large enough to protect areas of habitat that will be viable over the long-term.
- Large reserves will be less susceptible to catastrophic disturbances than small, but networks of small reserves covering the same total area may reduce risks further.
- Large reserves are more difficult to implement than small and may be harder to enforce.
- From the viewpoint of fisheries, networks consisting of many smaller reserves may be better than a few very large protected areas. They will spread benefits more widely over a management area.

14. How much of the sea should be protected from fishing?

Key points:

- The sea receives very different treatment to land in terms of conservation. While most people accept that some terrestrial habitats should be protected, they feel the sea should be open to exploitation. These attitudes are inconsistent and greater protection of the sea is needed to redress the balance.
- More than 1600 international scientists and conservationists have backed a call for 20% of the seas to be protected from fishing by the year 2020.
- Theoretical modeling work suggests that protecting 20 - 50% of the sea from fishing will greatly reduce the risks of overexploitation and fishery collapse.
- Protection of 20 - 40% is likely to substantially increase long-term yields of over-exploited species.
- Protecting significant fractions of the sea from fishing will help sustain biological diversity, ecosystem functioning, and provide resilience against human and natural catastrophes.
- Figures of 20%, or greater protection, represent long-term targets. Reserve protection will begin small and develop over time. Every little counts.

15. Where should reserves be located?

Social and economic criteria used to select the locations of marine protected areas

Economic Value

- > Number of fishers dependent on the area
- > Value for tourism
- > Potential contribution of protection to enhancing or maintaining economic value

Social Value

- > Ease of access
- > Maintenance of traditional fishing methods
- > Presence of cultural artefacts/wrecks
- > Heritage value

- > Recreational value
- > Educational value
- > Aesthetic appeal

Scientific Value

- > Amount of previous scientific work undertaken
- > Regularity of survey or monitoring work done
- > Presence of current research projects
- > Educational value

Feasibility/Practicality

- > Social/political acceptability
- > Access for education/tourism
- > Compatible with existing uses
- > Ease of management
- > Ease of enforcement

Key points:

- Selection processes must be practical, working with the limited data available on marine communities, ecological processes and human uses of the sea. If threats are serious, don't delay reserve selection due to lack of information but do use the full range of information available.

- We need to put biology up front in selecting reserves, but with a process that leaves flexibility for socio-economic considerations to be taken into account. Reserves that are inadequate biologically will fail to meet conservation or fishery management objectives.

- Reserves should be designed to fulfil many objectives. In particular, it is critical to marry fishery and conservation goals as far as possible. Previous separation of these objectives has been counter-productive, leading to the creation of complex masses of overlapping, often conflicting measures that offer the impression of protection, but not the reality. Design principles which favour conservation are almost always compatible with those for fishery management.

- Isolated reserves will be insufficient to conserve marine ecosystems over the long-term. We must adopt approaches that can be used to help design interactive networks of reserves.

- Select the best sites available for pilot reserves, but it is also worth including places where populations have been seriously depleted in pilot reserve networks. Such areas could show the most dramatic improvements following protection.

16. Why is it important to network reserves?

Key points:

- Isolated reserves have many benefits but will only be able to protect a limited fraction of marine biodiversity.

- Large numbers of marine species have open water dispersal phases and can potentially be transported long distances from where they were spawned.

- Individual reserves may be able to sustain self-recruiting populations of species that disperse short distances, but networks will be necessary to protect many of the species that disperse long-distances.

- Reserves in networks need to be close enough for protected populations to interact through dispersal, ideally being closer together than a few tens of kilometres.

17. Should marine reserves be temporary, rotated or permanent?

Key points:

- Agricultural systems on land benefit from crop rotation and fallowing because this frees up nutrients on which crops depend. Marine reserves function differently, and fertility builds up only as animal populations expand and individuals survive long enough to grow large.
- Reopening a reserve to fishing will create a short-term benefit to catches but will squander the productivity that the reserve sustains.
- Reserves should be viewed as permanent fixtures in which capital stocks accumulate that can feed their 'interest' into fishing grounds.
- Habitat recovery is typically slow while damage is swift. Rotating reserves will regularly undo benefits of protection, thereby reducing their conservation value.
- Reserves are difficult and expensive to establish and take time for users to become accustomed to. It makes little sense to make these investments for temporary measures that offer little long-term benefit either to fisheries or conservation. Reserves are a permanent commitment.

18. Will fully-protected reserves work in temperate waters?

Key points:

- Countries with industrialized fisheries have been slow to implement fully-protected reserves, believing (without evidence) that they will not work as well as in the tropics. This view is commonly expressed by those whose remit is to manage exploited species.
- Fully-protected marine reserves have been established in many temperate regions and have performed well.
- Temperate regions have been heavily altered by decades or centuries of intensive fishing. Their habitats and species desperately need the protection that reserves could offer.

19. Tourism and marine reserves

Key points:

- Fully-protected marine reserves can be highly attractive to tourists. Protection leads to the development of more interesting and spectacular biological communities than exist in unprotected areas.
- Tourism can be a major asset to reserves, helping finance their management, offering alternative employment for fishers and others, so easing pressure on exploited resources.
- Excessive visitation of reserves, and the development that accompanies tourism, can be damaging. It is important to monitor and manage reserves to ensure that sustainable levels of tourism are not exceeded.

20. What other activities can be permitted in fully-protected reserves?

Key points:

- Fishing is not the only activity that affects marine ecosystems. It is important to protect reserves from other extractive uses and sources of harm.
- Many recreational, educational and scientific uses of reserves are compatible with full-protection. However, it is important to monitor reserves to ensure such uses are not causing harm.

- Strict protection, the exclusion of all human uses except observational science, is sensible for some zones if reserves are large enough. Such zones offer refuge for species that are easily damaged or disturbed by people and will help in assessing the impacts of use elsewhere in reserves.
- Science should never be completely excluded from reserves, since nothing will be learned from them if it is.

21. How do you assess if reserves are effective?

Key points:

- It is essential to monitor the performance of reserves, but few management bodies have sufficient resources to do this properly. Lack of resources can often be overcome by teaming up with university researchers, but this will not provide a complete solution. Reserve managers must also develop a local monitoring capability.
- Monitoring should be broadly based and able to detect expected as well as unexpected outcomes of protection.
- Monitoring should encompass both environmental and human responses to protection, and should be done inside and outside reserves.
- Monitoring provides important data to inform management and provides feedback to local communities that can help reinforce their support for reserves.
- We need to use the opportunity offered by every reserve to learn more about how they function and how to improve performance.

22. Will reserves simplify fishery management?

Key points:

- Fisheries operate with 'irreducible uncertainties', errors in estimates of target species population size, catch, fishing effort and fish mortality that cannot be reduced given the resources available.
- Given such uncertainties, fishery managers need to 'buy' insurance, and reserves can provide it. Reserves could virtually eliminate the possibility of complete fishery stock collapse.
- Theoretical work suggests that reserves could reduce year-to-year variability in catches, so making fisheries easier to manage.
- Reserves can help reduce conflicts among different fishery sectors by preventing damaging by-catch.

23. How can you best gain support for reserves?

Key points:

- Reserves are never easy to set up and require broad support for proposals to get off the ground.
- Natural allies of reserves include the wider public, tourism operators and conservation organizations. However, the public are often poorly represented in discussions and need to be actively engaged to mobilize their support.
- Fishers often oppose reserve proposals to begin with, fearing that they will impose further costs upon them. However, once they understand how reserves work, and have seen examples from elsewhere, they often become firm supporters.
- Fishery scientists often oppose reserves, although they offer many

advantages over conventional management approaches. However, the current flood of information on reserves is likely to soften their reluctance to use this new tool.

24. How can you reach agreement to establish reserves?

Key points:

- Reserves are unlikely to be successful unless they are established with active involvement of stakeholders.
- There are many ways to obtain stakeholder input to negotiations, and a variety of approaches should be taken. However, participatory management groups made up of stakeholder representatives have proved very successful.
- Particular care must be taken in developing participatory management groups to ensure that representatives have the trust of the groups they represent.
- The process of participatory management has many social benefits as well as providing consensus on how to manage resources.
- Meaningful stakeholder involvement slows the process of reserve establishment but will lead to more cost effective, long-term protection.

25. Who should manage reserves?

Key points:

- Governmental agencies are often ineffective as reserve managers. They usually lack sufficient resources to properly implement protection, and locals are often suspicious of top-down control over their resources.
- Community-based management offers an alternative to government control. To be effective it requires a strong sense of community and strong institutions capable of implementing regulations.
- Co-management has also proven successful. Here management of reserves is sanctioned by government and implemented by local communities with their support.
- Reserves are often best managed by locally-based NGOs, sometimes established specifically for the purpose. They combine close involvement with the community and government approved legal authority. They provide a good vehicle for channeling financial support to the reserve.

26. How should reserves be enforced?

Key points:

- Benefits from reserves depend closely on the efficacy of protection.
- The more users respect reserves, the more successful reserves will be. Education and community involvement help build support.
- Protection is achieved through a combination of compliance and enforcement. In their early stages, reserves are likely to need strong enforcement. After a time, communities may start to police reserves themselves and compliance will grow. Long-established reserves may once again need strong enforcement since the potential gains from poaching may be considerable.
- Modern technology offers growing opportunities for remote surveillance at reasonable cost.

27. How can reserves be financed?

Key points:

- One of the most common causes for failure of marine protected areas is a lack of resources to implement protection.
- Start up costs for reserves can often be obtained through co-financing between government and private sources.
- User fees, environmental taxes on tourists, or environmental trust funds can help to provide long-term sustainable income to cover running costs.
- There is no single formula that can be applied everywhere and funding mechanisms must be developed that are appropriate for each reserve. Variety and ingenuity are the keys!

28. Conclusions

The sea was once considered a vast and seemingly endless resource to be used freely by all. But human impacts on the oceans are growing faster than ever and we must now move rapidly to protect them or risk losing precious assets. Marine protected areas provide the most powerful tool but they currently cover a trivial fraction of the sea, and the majority that do exist are poorly managed. Most people think that pollution is the greatest threat to marine ecosystems, whereas the most dramatic agent of change is fishing. Fishing has transformed the seas. We have become victims of our own success in exploiting marine life. Technology allows us to fish virtually everywhere up to depths of more than a kilometre deep. In this new millennium, the only refuges for marine life will be those we deliberately create.

Protecting areas of the sea from fishing has shown dramatic benefits, leading to swift and spectacular increases in abundance, biomass and average size of exploited species. Reserves create mosaics of conditions that favour those species most affected by fishing, and so help sustain biological diversity and ecosystem functioning. Reserves are most valuable and their performance is greatest if they are fully protected from fishing, and other extractive or harmful uses. Ideally every marine protected area should have at least one zone that is afforded full protection. However, anywhere that offers protection against some harmful activities will have value in a network of reserves that includes a large element of full protection elsewhere. Furthermore, reserve networks are most effective when supplemented by other forms of management.

Reserves will be most effective when established in networks, and those networks will perform best when reserves are sufficiently close for protected populations to interact. Isolated reserves have shown many benefits, but populations within them will depend, to varying degrees, on species persisting in unprotected areas. Networks increase the likelihood that species will persist and fisheries will be sustained over the long-term. Practical experience suggests that precise reserve placement is probably not critical, especially if reserves are networked with others. However, simple rules-of-thumb can be applied in choosing places where reserves are likely to work well. Given that it will take time to build reserve networks, there will be greater fishery and conservation benefits if the first sites protected are biologically better than average. However, the best areas are often the most controversial, since they are usually heavily used by people. If your top candidate site gets mired in controversy, it could be more sensible to opt for an alternative, biologically-adequate site that can be implemented more quickly at less cost. Creation of a functioning reserve often reduces opposition and may make it easier to protect other sites nearby.

Key lessons for the creation of effective marine reserves

1. *Marine reserves should be designed to achieve specific objectives, which should evolve according to changing circumstances if*

necessary. Objectives are important. They provide critical input to the selection and design of reserves. However, it is important not to be a slave to objectives stated at the outset. Reserves produce many surprises that may call for their revision. Large fishery closures established on the George's Bank off the US east coast in 1994 were designed to help recover populations of groundfish such as cod and haddock. Few people expected the spectacular rebound of scallops within them, yet the closures clearly became important in restocking local scallop fisheries.

2. Marine reserves must be tailored to local conditions, attitudes, and needs. What works in one place may not be as successful in others. For example, community-based management has worked well at the village level in places such as the Philippines where there is a strong sense of community and use of the sea is primarily by locals. However, different forms of community involvement are needed for places with large transient populations, such as holiday resorts in the Florida Keys.

3. Stakeholders must be involved at all stages of marine reserve planning and management. Marine reserves established by government order in St. Lucia in the 1980s failed because there was inadequate community participation in the process. Only when officials went back to the drawing board in the early 1990s and initiated detailed discussions with local stakeholders, did the process get back on track. St. Lucia now has a strong coastal zone management programme based around multiple-use MPAs.

4. Marine reserves often benefit from having a legal base. Reserves that have strong community support can function without a legal basis, but they are vulnerable to loss of protection. Voluntary marine reserves have been established by local supporters around the coast of Britain out of frustration with the inadequacy of the process to establish statutory protection. However, they offer little real protection to the marine life within them.

5. All marine reserves need a management plan. Although it was first established in 1986, the Galapagos Marine Resources Reserve (as it was then known) did not have a management plan until the early 1990s. This undermined efforts to provide protection.

6. Local communities should have a role in enforcement. If local people feel they have no role in the management of reserves, they are less likely to support them. Enforcement by government alone can foster local resentment, leading to the development of an 'us versus them' mentality. Furthermore, governments can rarely afford to implement the level of patrolling necessary to secure protection.

7. Marine reserves require sufficient, well-trained personnel. The most successful MPAs are those that are watched over and cared for, whether it is by paid staff or volunteers. Sumilon Island reserve in the Philippines was enforced by a single watchman on the beach, the Hol Chan and Saba Marine Parks in the Caribbean are patrolled daily. Lack of staff to implement protection is one of the most pervasive reasons for failure of reserves. In Florida, the Experimental Oculina Research Reserve was established to protect fragile deep water corals from damage by trawling. Unfortunately, the coastguard, who were given the responsibility of enforcing protection, were fully occupied patrolling for drug runners and the reserve has done little to stem habitat destruction.

8. Marine reserves must be financially sustainable. International donor organizations are very good at injecting large amounts of money for short periods of time to get reserves up and running. They are much less good at ensuring those reserves become self-supporting, despite the fact that parks are worth little more than the paper their regulations are written on without it.

9. Marine reserves should be established within a framework of integrated coastal management. Most marine reserves stop at the high tide line, despite widespread recognition that land and sea are interlinked. The sea is downstream of all that happens on land and what happens there can impact on marine resources. On the island of Bonaire, in the Caribbean, coral reefs are being damaged by nutrients released into the sea from coastal developments. Uncontrolled nutrient pollution will undermine the best efforts of the park to protect those reefs, but the manager can do little more than lobby for better treatment of waste water.

10. Marine reserve management effectiveness should be monitored and

evaluated. Few reserves are adequately monitored yet this is the only way to establish how successful they are. Although the Virgin Islands National Park on St. John in the Caribbean was established in 1956, it wasn't until the 1990s that monitoring of fish populations began, revealing that the park had presided over their long-term depletion by fishing. If monitoring had been instituted early on, the park would have discovered the problem long before it became so severe.

11. You cannot separate the need for conservation from the issues of resource use. Throughout the world, millions of people depend on the sea for a livelihood. They will not support reserves if they feel that their livelihoods are threatened by them, even if this is a misperception. Ecological reserves in the proposed management plan for the Florida Keys National Marine Sanctuary were vehemently opposed by fishers who failed to appreciate how those reserves could contribute to sustaining their livelihoods. It is vital that such concerns are clearly addressed from the outset and resource users have a direct input to the crafting of proposals.

12. Socioeconomic considerations usually determine the success or failure of reserves. Many reserves never make it from proposal to implementation because they are opposed on the grounds that they will adversely affect some user group. For example, an ecological reserve was proposed offshore of Key Largo in the Florida Keys but was shot out of the water by wealthy local residents who were concerned that they would be unable to land fish at their local jetties. Some reserves are implemented and subsequently fail because a few user groups refuse to accept them and lobby for their removal. The most successful reserves are those where benefits of reserve creation are fed directly back into local communities and help compensate those whose livelihoods have been affected.

13. An imperfect reserve is better than no reserve. As human impacts in the sea grow, so also does the urgency of protecting them. Canadian authorities have been working for years to identify the best sites for marine protected areas, in the process developing detailed maps of marine habitats and resources. Although their aim of creating a comprehensive and representative network of MPAs is laudable, many years passed before the first reserves were established, while depletion and damage to marine resources continued apace. Less deliberation and quicker action might have offered greater benefits, even if the sites chosen were not perfect.

