AN ENVIRONMENTALIST'S PERSPECTIVE ON RESPONSIBLE FISHERIES: THE NEED FOR HOLISTIC APPROACHES

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EXECUTIVE SUMMARY

The new millennium marks a time when scientific opinion and environmentalist sentiment are at last converging on the perception that the world's natural marine heritage is facing grave threats. What environmentalists have come to call the "marine biodiversity crisis" is a pervasive and by now well-documented phenomenon, until recently occurring largely unnoticed beneath the deceptively unchanging blanket of the ocean's surface. The fact that this problem is essentially an invisible one makes it all the more insidious, and our terrestrial bias makes combating the problem a huge and difficult task. Human impacts on our seas take many forms and result from activities that not only affect species directly – such as overfishing, in-filling of wetlands, and coastal deforestation – but also from activities that affect oceans indirectly, as through land-based sources of pollution, freshwater diversion from estuaries, invasive species and climate change.

Due to the expanding scope of both global coastal degradation and fisheries conflicts, environmental groups have recently become more and more involved in fisheries management and conflict resolution. In tackling fisheries issues, most organizations attempt to base their projects and advocacy on the best available scientific information. These groups sometimes undertake in-house scientific research, predictive modelling, and meta-analysis. However, in most cases the NGOs are recipients of scientific information and liaise between the scientific community, decision-makers, and the public. The key scientific information underpinning campaigns and field projects addresses three facets of sustainability: (1) the levels of resource removal that can be realized without adverse impact on the ecosystem, given the particular environmental condition of the ecosystem at time of harvest; (2) the least invasive means by which that harvest can be undertaken at desired levels of harvest, such that habitat impacts and by-catch are minimized; and (3) the most appropriate stocks for large-scale harvest, namely protecting stocks that are sole representatives of genetically unique organisms and stocks whose ecological role is critically important and so not redundant.

Environmental groups, however, are as diverse in their character, approach, and constituencies as the environmental problems they address. They variously function as purveyors of information, as translators of scientific and management language to the vernacular, as honest brokers (although their own value systems cause some to question their honesty), as advocates and lobbyists for certain types of reform or regulatory measures, and as adversaries to management agencies and industry when invoking environmental litigation. In many of these roles, environmental groups have been seen as the antithesis to development, to business interests, and to the needs of many user groups. Yet today environmental groups play an increasingly

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important non-adversarial role in demonstrating how conservation and sustainable use can be accomplished, through practical, applied conservation projects that benefit users, community groups, business and national interests. If a common environmentalist response to fisheries-induced loss of marine biodiversity can be said to exist (and this is a dangerous assumption, given the diversity of groups and their approaches), it is to synthesize existing information, communicate it, and advocate change in policy and regulations where felt necessary. In addition, some groups go beyond fisheries-by-fisheries management reform to advocate: (i) shifting the burden of proof when evaluating fishing impacts on ecosystems, and (ii) establishing strictly protected marine reserves to further our understanding of and protect species, habitats and ecological processes. Such reserves are implemented in a variety of fashions: as components within larger, multiple-use protected areas that seek to accommodate a wide array of users; as single elements in scientifically-designed reserve networks; and as one tool of many used in corridor approaches, coastal management and regional planning.

From the environmentalist's or conservationist's perspective, solutions lie not in shutting down fisheries but rather in modifying the way we undertake management, and in using public awareness to help raise political will to conserve marine systems. Coupling current consumer awareness and purchasing power with strong and effective management could indeed alleviate pressure on many marine species and allow their subsequent recovery. Additionally, environmental groups will need to recognize and support real willingness among governmental agencies and decision-makers to protect areas needed for fish spawning, feeding and migration through marine reserves, and help such forward-thinking agencies to enter into enforceable international agreements to protect shared or commons resources. By highlighting such potential successes, and by working to demonstrate how success can be achieved, environmental groups can begin to shed their image of extremist adversaries, and help decision-making bodies implement effective and beneficial management regimes.

A common thread is now emerging from analysis of cases where fisheries management and marine conservation has succeeded – and we can well learn from this common thread. The central element in these initiatives is a holistic approach – one that considers renewable living resources as part of a wider, interconnected ecosystem, one that evaluates all aspects of production or development, and one that treats humans as *bone fide* elements of living systems. These integrated approaches take into account ecosystem interconnections and the true ecological costs of fisheries, the entire production chain and its environmental costs, and human interconnections, and thus the social costs (and benefits) of fisheries development. Holistic solutions are those that recognize these connections and try to minimize ecological, environmental and social costs, while maximizing the benefits (and benefit-sharing) that can accrue from engagement in well-managed marine resource use. Given the magnitude and complexity of global fisheries issues, only such holistic prescriptions will make it possible for nations to achieve responsible fisheries in the future.

INTRODUCTION

[1] Environmental groups increasingly influence the direction of resource management and habitat protection in many parts of the world, addressing marine as well as the more traditional terrestrial issues of conservation. Commonly held roles for such groups include synthesizing understanding about marine issues, highlighting findings in a way that can be communicated to the general public, and advocating for policy reform and incentives that will change human behaviour to make resource use more sustainable. In addition, and perhaps most importantly, environmental groups play a crucial role in leading by example – demonstrating how environmentally sound and socially beneficial resource use can be achieved through field projects and interventions.

[2] In general, the environmental community espouses a widely held view that management of ocean and coastal resources is poorly handled by most governments, leading time and time again to conflict. Decision-makers fumble in the dark with classically ineffective fisheries management, create marine parks and other management areas with little to no control over activities within them, and are so overwhelmed by the complexity of river basin management that they are largely unable to deal with problems of land-based sources of pollution and degradation. Effective measures to address declines in ocean health and productivity remain few and far between, and are often too little, too late. The basis of this crisis may rest in large part on our inability to communicate what is happening and why (Agardy *et al.*, 1999). This lack of effective communication about ocean issues can and should be addressed by the environmental community – both non-governmental and intergovernmental – but in this we, too, have fallen short of the mark, as much as the governments we criticize.

[3] As a result of all these factors, the world's natural marine heritage is facing grave threats in many regions. What environmentalists have now come to call the marine biodiversity crisis is thus a pervasive phenomenon, occurring largely unnoticed beneath the deceptively unchanging blanket of the ocean's surface. The fact that this problem is essentially an invisible one makes it all the more insidious, and our terrestrial bias makes combating the problem a huge and difficult task (Wilder *et al.*, 1999). The global marine environment seems to be undergoing dramatic change at hitherto unprecedented rates, revealing as folly our previously held notion of vast and limitless oceans. Human impacts on our seas take many forms and result from activities that affect species directly, such as overfishing, in-filling of wetlands, and coastal deforestation, to activities that affect oceans indirectly, as through land-based sources of pollution, freshwater diversion from estuaries, and climate change.

[4] Environmental groups are as diverse in their character, approach and constituencies as the environmental problems they address. They variously function as purveyors of information, as translators of scientific and management language to the vernacular, as honest brokers (although their own value systems cause some to question their honesty), as advocates and lobbyists for certain types of reform or regulatory measures, and as adversaries to management agencies and industry through the use of environmental litigation. In many of these roles, environmental groups are seen as the antithesis to development, to business interests, and to the needs of many user groups. However, environmental groups play an increasingly important non-adversarial role in demonstrating how conservation and sustainable use can be accomplished, through on-the-ground conservation projects that benefit users, community groups, business and national interests.

[5] Due to the ballooning scope of global fisheries problems and conflicts, environmental groups are becoming more and more involved in fisheries management and conflict resolution. In tackling fisheries issues, most organizations attempt to base their projects and advocacy on the best available scientific information. These groups sometimes undertake in-house scientific research, predictive modelling, and meta-analysis. However, in most cases, the NGOs are

recipients of scientific information and act as a liaison between the scientific community, decision-makers and the public. Key scientific information that forms the underpinnings of campaigns and field projects addresses three facets of sustainability: (1) the levels of resource removal that can be realized without adverse impact on the ecosystem given the particular environmental condition of the ecosystem at time of harvest, (2) the least invasive means by which that harvest can be undertaken at desired levels of harvest, such that habitat impacts and by-catch are minimized, and (3) the most appropriate stocks for large-scale harvest – those being stocks that are not the sole representatives of a deme or particular genetic structure and those for which the ecological role of the species is either not critically important or redundant (Agardy, 2000b).

[6] If a common environmentalist response to fisheries-induced loss of marine biodiversity can be said to exist (and this is a dangerous assumption, given the diversity of groups and their approaches), it is to synthesize existing information, communicate it, and advocate for change in policy and regulations. In addition, some groups go beyond fisheries-by-fisheries management reform to advocate: (1) shifting the burden of proof when evaluating fishing impacts on ecosystems, and (2) establishing strictly protected marine reserves to further our understanding and to protect species, habitats and ecological processes. Shifting the burden of proof has received recent attention in the fisheries management community (Dayton, 1998), but there remain misconceptions (Agardy, 2000b). Much of the conservation community advocates shifting this burden of proof in evaluating the prospective impacts of new fisheries, expanded fisheries, or new technologies, and for regulators to permit such fisheries development only when proof of no likely impact exists.

[7] From the environmentalist's or conservationist's perspective, solutions lie not in shutting down fisheries but rather in modifying the way we undertake management, and in using public awareness to help raise political will to conserve marine systems. Coupling current consumer awareness and purchasing power with strong and effective management could indeed alleviate pressure on many marine species and allow their subsequent recovery. This is further addressed below. Additionally, environmental groups will need to recognize where there exists real willingness among governmental agencies and decision-makers to protect areas needed for fish spawning, feeding and migration through marine reserves, as well as entering into enforceable international agreements to protect shared or commons resources. By highlighting such potential successes, environmental groups can begin to shed their image of extremist adversaries, and help decision-making bodies implement effective and beneficial management regimes. Already a common thread is emerging from analysis of cases where fisheries management and marine conservation has succeeded. The central element in these initiatives seems to be a holistic approach – one that considers renewable living resources as part of a wider, interconnected ecosystem, one that evaluates all aspects of production or development, and one that treats humans as *bone fide* elements of living systems. The following sections will discuss these aspects of interconnectedness, and conclude with holistic prescriptions to achieve responsible fisheries in the future.

ECOSYSTEM INTERCONNECTIONS AND ECOLOGICAL COSTS OF FISHERIES

[8] There are ample data to suggest fisheries exploitation affects not only target stocks but also communities of organisms, ecological processes, and even entire ecosystems (Jennings and Kaiser, 1998; NRC, 2000; Sumaila *et al.*, 2000). Marine ecosystems and the substantial biodiversity they support continue to be threatened by human activity the world over (NRC, 1995). As downstream recipients of degrading impacts caused by poor land use practices and simultaneously under increasing pressure to supply natural resources and space to accommodate human needs, the world's coastal zones and shallow seas are affected both directly and indirectly. Multiple and cumulative threats have already caused the loss of both species and genetically

unique stocks of organisms and have undermined the functioning of many marine systems (Dayton *et al.*, 2000).

[9] The drive to exploit living marine resources stems from an increasing reliance on fisheries-derived protein to feed burgeoning human populations, livestock and cultivated aquatic organisms (NRC, 1995). This growing demand is exacerbated by poor agricultural practices that reduce the potential of terrestrial sources to meet these protein needs. Overexploitation stems not merely from need but from the tragedy of the global commons – that is, the inability of governments to adequately regulate use of common property resources (Hardin, 1966), or to recognize valid and sustainable methods of communal management (Bavinck, 2001; McCay and Jentoft, 1996). Commercial fishing operations, whether large-scale industrial fisheries or small-scale operations (Jamieson, 1993; Holt, 1998), commonly overexploit stocks, in some cases collectively causing trophic mining (Pauly *et al.*, 1998). Though the list of marine endangered and threatened species pales in comparison to that of terrestrial and freshwater systems, marine biodiversity is being lost at an alarming rate as genetically unique populations of marine organisms are extirpated (Dayton *et al.*, 1995; Tegner *et al.*, 1996; Vermeij, 1993). Even for cosmopolitan species, this reduction in genetic diversity is damaging (Jennings and Kaiser, 1998).

[10] So-called serial mismanagement of fisheries extends beyond overexploitation effects to include exploitation methods that compromise marine biodiversity. Fishing methods commonly used to catch highly valued species selectively affect many other species – not only fish, but also sea turtles, sea birds, porpoises and unutilized finfish (Dayton *et al.*, 1995). These incidentally-caught and wasted species, some of which are already endangered, may constitute a higher percentage of catch than the target species, and in some cases, nearly 30 times more by weight (Alverson *et al.*, 1994). Surface longlining contributes to the mortality of thousands of seabirds annually, while mid-water longline has been implicated in the dramatic population decline of the leatherback turtle, and shrimp trawling has dramatically reduced populations of other sea turtle species (NRC, 1995). Habitat alteration, as exemplified by bottom trawling, which rakes the benthos, kills epibenthic plants and animals and interrupts key ecological processes, is also problematic (Auster, 1998; Engel and Kuitek, 1998; Watling and Norse, 1998).

[11] To understand the extent of the marine biodiversity crisis and the role of fisheries in it, a greater understanding of how selective removal of target species affects ecosystem health and productivity must be attained. By concentrating harvest on top predators (e.g. mako shark, billfish, bluefin tuna), our fishing practices dramatically affect biological communities by causing cascading effects down food webs that decrease diversity or productivity (Steele, 1998). Removal of such apex predators need not be at industrial scales to result in these effects, since many of these species are naturally rare or patchily distributed. At the same time, decreases in the abundance of valuable apex predators and other species high in the food chain have caused fishers to target less valuable resources at lower trophic levels (Pauly *et al.*, 1998). Because of their lower inherent value, such fishing is undertaken with increased intensity, such that entire trophic levels can be affected in a phenomenon known as trophic mining. Decline in abundance of primary consumers removes important forage species for organisms higher in the food web, again with cascading effects (Dayton *et al.*, 1995; Jennings and Kaiser, 1998). Such altered ecosystems may have impaired function and be unable to replenish lost resources.

[12] The conservation community is also concerned that in determining what constitutes sustainable levels, methods and targets of fisheries exploitation, we consider changing environmental conditions and contexts. For instance, resource removal that may have minimal impacts on ecosystem function and overall biodiversity in a relatively pristine ecosystem could potentially have devastating effects in ecosystems already stressed by pollution, eutrophication, and alterations to primary or ecologically-linked habitats (Zaitsev and Mamaev, 1997). When these ecological impacts caused by fisheries operations are coupled to general environmental degradation, such as the eutrophication of coastal waters, toxic pollution or global climate change, the capacity of marine systems to support sustainable fisheries is reduced (Costanza *et al.*, 1993).

Even more importantly, when essential habitat is lost, as in the conservation of wetlands or nursery areas for coastal development, the critical threshold levels inevitably move down (Dayton *et al.*, 2000). The paradox is that marine ecosystems are increasingly less able to support demand, even as demand continues to increase. For this reason, a reasonably holistic approach to understanding the resource in its ecological context will require understanding changes in dynamics and thresholds as environmental conditions change. Marine protected areas can play a vital role in increasing this understanding in that they can provide control sites for experimental manipulation of key parameters. Nonetheless, we must acknowledge that the work of evaluation into what constitutes sustainability is work that by its very nature can never be finished.

[13] Environmental groups have for some years been demanding better information on the true, ecosystem-wide impacts of fisheries activity, particularly in cases where new fisheries are being launched, where major gear modifications are taking place, or where major expansion of fishing effort is occurring. Most groups also advocate greater use of marine protected areas and fisheries reserves as a tool to strengthen management and to provide control sites to further scientific understanding and promote adaptive management. Finally, environmental groups have played a key role in developing case studies where government bodies work in concert with user groups and communities to demonstrate how co-management can be achieved. In pushing for these approaches to marine conservation, environmentalists underscore the need for a holistic perspective on conservation problems, and a holistic approach to their solution.

PRODUCTION INTERCONNECTIONS AND ENVIRONMENTAL COSTS OF FISHERIES

[14] One of the great failings of both resource managers and environmentalists addressing fisheries issues has been to focus on only a single aspect of marine fisheries production, namely resource removal. However, fisheries affect the environment – both terrestrial and marine – at many points along the production chain. Resource removal can have dire consequences for marine ecosystems when harvest levels exceed maximum sustainable yields, when certain trophic levels are heavily targeted, and when the method of capture damages habitat or causes excessive by-catch, and these effects are increasingly well documented. But fish product processing can also have severe environmental effects, occurring worldwide, from tuna processing plants in Pacific atolls to improperly regulated fish meal plants in the high temperate latitudes. As but one example, unregulated effluent discharge of fish waste into Madang Lagoon on the north coast of Papua New Guinea has dramatically affected a region of exceptionally high biodiversity, and threatens to affect the health of local communities as well. Recent lawsuits against processors suggest the environmental community is waking up to this problem, but it has certainly not yet resonated with the public or with decision-makers.

[15] Packaging of fisheries products also can incur environmental costs, especially when packaging plants occur in countries with minimum industry oversight and pollution regulations. These production impacts on the environment are substantial, and hold equally for aquaculture products and for wild-caught fisheries products. Similarly, fisheries products travel the world in greater frequency than even international conservationists – and the pollution and energy costs of this aspect of international fisheries trade must be part of the equation. A holistic view of fisheries management should thus extend not only to ecosystem impacts caused by the fishing itself, but beyond to impacts along the entire production chain.

[16] The environmental community is by no means united on this issue. Many groups have championed the efforts of the Marine Stewardship Council (MSC) and other certification programmes, which work to harness consumer interest in environmental issues to provide incentives for fisheries to practice their trade in a more sustainable manner. Green-labelled or ecolabelled products are those that can be independently certified as sustainably harvested. Note that the number of fisheries that can achieve even this simplistic level of certification are few and

far between; at the time writing, only five commercial fisheries had received MSC certification. But an even greater problem may be that certification ignores the rest of the production chain – and in so doing may totally mislead consumers into thinking the products they are purchasing have exacted no environmental costs whatsoever. The can of skipjack tuna that comes from a fishery in which by-catch is minimized, dolphin encirclement is banned, and habitat impacts are non-existent, may have nonetheless contributed to massive environmental degradation and loss of biodiversity due to processing operations far from the harvest site.

[17] Assuring the sustainability of fisheries operations requires more than merely effective control of resource extraction. Even if management measures for marine fisheries were perfect, these fisheries would not replenish themselves without additional conservation measures that protect key habitats. Many of these key habitats are coastal, and are degraded both directly and indirectly by human activity. Such impacts do not affect solely coastal species, since even many pelagic species have life stages at least partially spent in nearshore areas. While anadramous and catadramous species clearly require intact coastal and even freshwater habitats, other species, including sharks, many pelagic and neritic fishfish, and many commercially important kinds of shellfish spend early life history stages in estuaries and other nearshore areas. Even for species that remain pelagic throughout their life, food sources often originate in estuaries or other coastal areas. Paradoxically, in some parts of the world, fisheries-related industries are destroying the critical habitats upon which the target species (and other equally important, though not as economically valuable, species depend). This is the case with aquaculture (often touted as the best way to relieve pressure on wild stocks, a claim rarely substantiated (Golding and Triplett, 1997), and fish processing and packaging industries.

[18] What can be done about this aspect of interconnectedness? First, understanding that these connections occur is key to a holistic and effective approach. Instead of asking the question, "How can fisheries management for target species be improved?" it makes sense to ask, "What is needed to maintain these fisheries over time?" Admittedly, this question is difficult enough to answer in the narrow realm of setting limits to exploitation. The question becomes even more complex – though no less important – when one attempts to apply it to the fisheries industry along its entire production chain. Second, raising awareness about these connections, and highlighting the importance of critical areas that sustain fisheries, must be a challenge to which environmentalists rise with enthusiasm. Groups that advocate certification and green-labelling will have to address the broader complexities and realities of measuring fisheries sustainability. Finally, environmental groups can catalyse the protection of critical habitats through regulatory reform and marine protected area designations, in order to complement conventional fisheries management measures and move us towards effective conservation.

HUMAN INTERCONNECTIONS AND SOCIAL COSTS OF FISHERIES

[19] Environmentalists have often been labelled "nature-centric" – a disparaging term used to contrast the value systems of those who would put biodiversity conservation above considerations of human need. While it is true that many environmental groups see their niche in extremist positions that provide counterbalance to the wise-use movement and other equally extreme anti-environmental philosophies, most groups practice a human-centric conservation that recognizes human needs, especially those of marginalized coastal communities and traditional fishers. These groups work to understand the social costs of massive economic development, the tension between artisanal and commercial fisheries, and the social impacts of large-scale fisheries and aquaculture operations that act to dis-empower local peoples and steer profits away to large multinational corporations (Kurien, 1978; Kurien and Achari, 1994). In fact, when developing small-scale models of integrated coastal management, environmental groups only seem to succeed when these more local concerns have been adequately appraised and addressed.

[20] When humans are not considered *bona fide* elements of ecosystems, and human needs are ignored in either the rush to develop or the defensive move to protect the environment, social conflicts worsen. The resulting social effects include social disruption (Acheson, 1987; Berkes, 1987); migration and resulting interference with traditional sustainable patterns of resource use in areas of in-migration; environmental refugee movements that put pressures on scarce resources or vulnerable ecosystems; undermined national security; and resource use conflicts that sometimes escalate into resource wars (McGoodwin, 1990; Poggie and Polnac, 1988).

[21] Again, we must recognize these interconnections before we can help turn unsustainable fisheries into responsible ones. In places where artisanal and commercial fisheries clash with intensity, such as much of coastal West Africa, documenting and empirically assessing the problem is crucial to being able to deal with it. Further, resource management authorities must look to ensure equitable sharing of benefits whenever possible (De Fontaubert *et al.*, 1996), and explore ways to address more local needs in addition to national economic interests. Co-management has much potential in this regard, and may prove to be the way forward in many settings (Stroud, 1994; Tamanaha, 1993). Co-management that recognizes the legitimacy of traditional management regimes, such as those demonstrated by marine tenure or community-imposed limited access (Ruddle, 1988; Ruddle and Johannes, 1985; Ruddle *et al.*, 1992), have especially good chances of succeeding (Dyer and McGoodwin, 1994). However, this does not automatically invoke a push for pluralistic approaches to marine resource use and management, as described by Hooker (1975) and others, since pluralism can lead to chaos and erode responsibility to institute effective management. Successful models of fisheries management that have addressed social issues well seem to be those that clearly define roles and responsibilities of local communities and government authorities, and recognize the benefits of participatory planning and management (Pinkerton, 1987; Jentoft and McCay, 1995).

HOLISTIC SOLUTIONS THAT RECOGNIZE INTERCONNECTIONS

[22] Nothing described in these pages is new, nor are holistic approaches that move us away from previously faulty sectoral management an invention of enlightened environmentalists. However, few scientists or managers seem willing to talk about these complexities – leaving a vacuum that the environmentalist community can and should work to fill. The complicated nature of marine conservation has heretofore shrouded our collective understanding of issues and made it impossible for us to consistently apply or even advocate effective solutions. We seem, if nothing else, paralysed by the complicated position that humans occupy in the natural world, and keep falling back on simplistic approaches that fail us time and again.

[23] Given the current situation, the roles that environmentalists can play in brokering information and communicating it in ways that the public can grasp are increasingly critical. In adopting a holistic approach to describing human impacts on marine environments, we need to be objective, and scientifically rigorous, but we also must present the big picture (Caddy, 1993). Recognizing linkages is a prerequisite, and hard as it may be, we need to weed through all human impacts that affect marine systems and fisheries potential simultaneously. It will be critically important not only to recognize and prioritize threats to ecosystem health and function, but also to identify the underlying drivers behind these threatening human activities (Table 1). Perhaps the biggest challenge here will be to describe these complicated situations in ways that will be fathomable, yet at the same time will not act to frighten people away by the enormity of it all.

[24] The other role of environmental groups in catalysing more responsible fisheries and overall coastal and marine management is in field projects and interventions that demonstrate how these principles can effectively be applied. Marine protected areas are key here, because they are most often the venues for such demonstration projects. In addition, marine reserves and other protected areas are crucial in serving as benchmarks and baselines in furthering our understanding of how ecosystems function, and how humans affect such functioning.

Table 1. Types of threat to marine ecosystems, drivers, and possible policy responses.

Type of threat	Driver	Policy responses
	Habitat Loss or Conversion	
Coastal development (ports, urbanization, tourism-related development, industrial sites)	Population growth, poor siting due to undervaluing and lack of knowledge, poorly developed industrial policy, tourism demand, environmental refugees, and internal migration	Requirement for environmental impact assessment (EIA), technology transfer and training in planning, tourism policies, identification of ecologically critical areas, Marine Protected Areas (MPAs)
Destructive fisheries (dynamite, cyanide, other poison-fishing, bottom trawling)	Shift to market economies, demand for aquaria fish and live food fish, increasing competition in light of diminishing resources	MPAs, training for alternative methods, green-labelling and certification policies, cost-benefit analyses and awareness raising
Coastal deforestation (especially mangrove deforestation)	Lack of alternative materials, increased competition, poor national policies	Access to and training in use of alternative materials, cost-benefit analyses and awareness raising
Mining (coral, sand, minerals, maintenance dredging)	Lack of alternative materials, global commons perceptions	Cost-benefit analyses, technology transfer for employing alternatives
Civil engineering works	Transport and energy demands, poor public policy, lack of knowledge about impacts and their costs	Mainstreaming marine conservation into national policy, cost-benefit analyses, awareness raising
Environmental change brought about by war and conflict	Increased competition for scarce resources, political instability, inequality in wealth distribution	Social policy reform, policies to deal with immigrants, limited access (in special cases), mainstreaming marine conservation into foreign policy
Aquaculture-related habitat conversion	International demand for luxury items and regional for food, demand for fish food, decline in wild stocks and decreased access to fisheries (or inability to compete)	International security of trade and its impacts, international agreements, training in environmentally-sensitive aquaculture, certification
	Habitat Degradation	
Eutrophication from land-based sources (LBS) (agricultural waste, sewage, fertilizers)	Urbanization, lack of sewage treatment or use of combined storm and sewer systems (CSS), unregulated agricultural development, loss of wetlands and other natural controls	Regional agreements involving both sources and sinks, common policies and actions on waste treatment, adequate financing for waste treatment and run-off mitigation (river basin and watershed management), artificial wetlands construction and stricter protection of existing wetlands
Pollution:toxics and pathogens from LBS	Lack of awareness, increasing pesticide and fertilizer use (especially as soil quality diminishes), unregulated industry	International standards and compliance on toxics, awareness raising
Pollution: dumping and dredge spoils	Lack of alternative disposal methods, increased enforcement and stiffer penalties for land disposal, belief in unlimited assimilative capacities, waste as a commodity	Technology transfer and training in appropriate methods for dumping, enforcement of treaties (LDC and MARPOL), financing and construction of waste accepting stations in ports of call
Pollution: shipping-related	Substandard shipping regulations, no investment in safety, policies promoting flags of convenience, increases in ship-based trade	International regulations on ship hulls and safety measures, establishment of Sensitive Sea Areas (SSAs)
Salinization of estuaries due to decreased freshwater inflow	Demand for electricity and water, territorial disputes	Cost-benefit analyses, technology transfer for water re-use
Alien species invasions	Lack of regulations on ballast discharge, increased aquaculture-related escapes, lack of international agreements on deliberate introductions	Ballast water discharge regulations, active controls against spreading of invading species
Global warming and sea-level rise	Controls on emissions lacking, poorly planned development (vulnerable development), stressed ecosystems less able to cope	Adherence to emission standards, sea level-rise defences

Table 1 (cont.) Types of threat to marine ecosystems, drivers, and possible policy responses.

Type of threat	Driver	Policy responses
	Overexploitation	
Directed (low value, high volume) exceeding sustainable levels	Demand for subsistence and market (food and medicinal), industrialization of fisheries, improved fish-finding technology, poor regional agreements, breakdown of traditional regulation systems, lack of enforcement, subsidies.	International agreements (global codes of conduct, regional management) and enforcement, consumer awareness, quotas, limited access
Directed take for luxury markets (high value, low volume) exceeding sustainable levels	Demand for specialty foods and medicines, aquarium fish, and curios, lack of awareness or concern about impacts, technological advances, commodification	International pressure on key demand hot spots, trade embargoes, quotas, limited access, MPAs
Incidental take or by-catch	Subsidies, by-catch has no cost	Regulations on gear, MPAs for critically important habitats, seasonal closures
Directed take at commercial scales decreasing availability of resources for subsistence and artisanal use	Unempowered local peoples, breakdown of traditional structures	MPAs, campaign to highlight the problem, artisanal fishing cooperatives

MARINE PROTECTED AREAS AS A SUPPLEMENT TO CONVENTIONAL MANAGEMENT

[25] Marine protected areas (MPAs) are increasingly being selected from the portfolio of options available to marine resource managers, largely because conventional measures to manage fisheries and conserve marine ecosystems have repeatedly failed (Agardy, 1994). This failure has started to enter the realm of public consciousness as signs that mismanagement affect consumers as well as fishermen have become apparent. Limiting fisheries management to controls on quantity of effort or catch ignores the potentially significant impact that fisheries activities have on ecosystems and their function. The use of spatial and temporal regulations, as made possible by area closures, ensures that the benefits of management are extended beyond just the target stock to wider segments of ecosystems themselves (Davis, 1989). Thus fully protected closed areas, when used in conjunction with other forms of regulation, can move fisheries management away from largely ineffective species-by-species fisheries management to more ecosystem-based conservation (Jamieson and Lessard, 2001).

[26] Marine protected areas are fundamentally different from terrestrial protected areas, though whether these differences are in kind or degree is debatable. An important factor underlying these differences is the nebulous nature of boundaries in the fluid environment of the sea (Steele, 1998), making it difficult to attach boundary conditions to marine ecological processes and threats to those processes. While this is also true for inland freshwater systems, these ecosystems commonly have discernable outer bounds and distinct thermoclines that delimit biotic communities. To a far greater extent than on land, it is impossible to ‘fence in’ living marine resources or the critical ecological processes that support them, just as it is impossible to ‘fence out’ the degradation of ocean environments caused by land-based sources of pollution, changes in hydrology, or ecological disruptions occurring in areas adjacent or linked to a protected area. Long distance dispersal and the vastness of linkages between critical habitats in a coastal and marine ecosystems requires comprehensive management of all its parts (Caddy and Sharp, 1986; Costanza *et al.*, 1993; Mooney, 1998).

[27] The open nature of coastal and ocean areas exists as a spectrum ranging from relatively fixed and “land-like” systems to highly dynamic and complex systems. Coral reef ecosystems, for instance, harbour organisms that are largely confined in their movements to the specific habitats of reef, surrounding soft or hard benthos, and coastal wetlands (Hatcher *et al.*, 1989; Roberts, 1995a). The structural framework for reef systems is fixed in place and can be mapped, much as a tropical forest provides a relatively fixed framework for the interactions of the forest community. The functional links between the water column in reef areas and the benthos are strong so one can

treat the marine organisms together with reef structures themselves (Bohnsack, 1998). In contrast, temperate open ocean systems such as estuarine-gulf-banks complexes are highly dynamic and in no way "fixed." Here living marine resources move in space and time according to physically-dominated, largely non-deterministic patterns (de Groot, 1992). The ecology of the water column is not strongly linked to that of the benthos, and physical reference points for the system cannot easily be mapped. However, even highly dynamic open ocean systems can benefit from MPAs, as long as the dynamics are considered in planning design (Hyrenbach *et al.*, in press). Thus a wide array of system types presents a challenge to conservationists and resource managers, requiring that protected area measures be appropriate to the system in question (Agardy, 1997).

[28] Since identification of critical areas, public education and enforcement are more easily achieved in coral reef and other relatively "fixed" ecosystems, MPA work has proliferated in these systems (Agardy, 1995; Ginkel, 1998; Jennings and Polunin, 1996; Quinn *et al.*, 1993). That is not to say, however, that closed areas in temperate and boreal systems are unfeasible, nor should it suggest that potential benefits of such protected areas are fewer in non-tropical systems (Auster and Malatesta, 1995). It merely suggests that random application of terrestrial models to marine environment may not result in a viable means of protecting resources and the underlying ecology that gives rise to them. New paradigms are needed, and the newest MPAs reflect both acknowledgment of fundamental differences between marine and terrestrial systems, and existence of new information and planning technologies that can optimize MPA design.

[29] Clear evidence exists that MPAs can be designed to help make fisheries and coastal management more effective (Guenette and Pitcher, 1999). In the last five years, new, rigorous, and defensible evidence has emerged to show that MPAs do indeed improve fish yields while conserving biological diversity more generally (Jennings and Kaiser, 1998; Jennings and Polunin, 1996). These benefits have included increased fish stock size inside the reserve, as well as spillover effects in which fish populations have also increased outside the reserve in the Caribbean (Rakitin and Kramer, 1996; Reynard, 1994; Roberts, 1995b; Roberts and Polunin, 1991), Philippines (Russ and Alcala, 1996, 1997), and in numerous other areas (Ballantine, 1991; Bohnsack, 1996a, 1996b; Castilla and Duran, 1985; Dugan and Davis, 1993; McClanahan and Kaunda-Arara, 1996; McClanahan and Shafir, 1990; McCormick and Choat, 1987). The ideal situation seems to be the establishment of closed areas within the context of a larger multiple-use protected area such as a coastal biosphere reserve, marine sanctuary, or other large-scale MPA.

[30] Area closures that are designated specifically to protect "seed banks" or sources of recruits are becoming more common (Roberts, 1995a; Russ and Alcala, 1996). The link between certain coastal areas and maintenance of marine fisheries resources has been clearly established (Lozano-Alvarez *et al.*, 1993; Odum, 1984). Although recruitment dynamics are often complex and seemingly unpredictable (Fogarty *et al.*, 1991; Holt, 1990), dispersal pathways for recruits can be readily identified in some ecosystems (e.g. Gaines and Bertness, 1992). The important biological processes that support fisheries productivity include spawning, migratory pathways, feeding, settlement, and concentrated feeding (de Groot, 1992). Such ecologically critical processes in nearshore ecosystems are often concentrated in areas that can be easily identified by physical parameters such as reef formations, extensive shallow water areas, certain types of coastal wetlands, continental shelf breaks and frontal systems.

[31] An additional role for MPAs is to serve as control sites for scientific research and experimentation, especially to foment true adaptive management in which the controls on use serve as experiments to test management effectiveness. Without control areas and rigorous hypothesis testing, management cannot be adaptive in the true sense of the term. Unfortunately, many managers and the public at large tend to think that any management that is revised over time or is flexible is adaptive management. Without the science behind it, such flexibility is in essence only bet-hedging.

[32] Although the usefulness of closed areas and harvest refugia is being increasingly documented as resource managers turn to this management option, there are undeniable constraints to the broad applicability of this measure (Russ and Alcala, 1998; Allison *et al.*, 1998). Limited scientific knowledge on population replacement rates, dynamics, recruitment patterns, and impacts of fishing pressure on ecosystem function have all been used as excuses hindering establishment of no-take reserves. The stochastic nature of many marine systems also undermines the usefulness of this approach, particularly if closed areas are treated as static and immutable entities instead of flexible management measures. There may be social constraints also limiting the applicability of closed areas. The fishing industry is notoriously hard to regulate, precluding the acceptance of any new, potentially effective management tool. Closures having a scientific basis can be viewed by the fishing community as exclusionary practices that are somehow rooted in social discrimination. This predisposes user groups to reject the idea of area closures even before they have the chance to discover exactly why and how these would be beneficial to them.

[33] Despite these constraints, closed area designations can be an effective tool to complement other fisheries regulation if they are carefully planned and grounded in good scientific understanding of ecosystem dynamics. The prospect of increased management and enforcement that the implementation of closed areas entails will not be readily embraced by most fishing communities, but only until the effectiveness of such areas in maintaining and even increasing catch is demonstrated. Managers using this technique will have to be responsive to changes in scientific information, in the status of the resources, and in management needs in order to make MPAs optimally effective. This will require adopting management techniques that require refinement based on periodic reassessment of zone boundaries, regulations, and overall extent of the protected area.

[34] MPA design and implementation has clearly entered a new phase of sophistication as more rigorous approaches to protected area planning have emerged, and as experiential learning over several decades has increased. Certain scientifically-rigorous criteria now guide the selection of MPA sites as well as the subsequent size, shape and management regime of individual protected areas. These criteria (Table 2) relate directly to the specific objectives that the protected area or protected area system are established to achieve. Such objectives include *inter alia* habitat protection for overall biodiversity conservation, fisheries management and stock enhancement, nature-based tourism development, protection of traditional use and tenure, and scientific research. MPAs can be classified according to these objectives with objective-specific subsets of criteria for selection and design. Specific examples are given for each subset, spanning the spectrum from small-scale, community-based marine protected areas, to large-scale protected areas and networks of protected areas administered by centralized government authorities. Finally, we must recognize that though serious advances have been made in MPA planning, the "science" of MPA site selection and design is still something of an art, and neither hard and fast rules for optimizing design nor a model MPA can be said to exist.

Table 2. Relationship between marine protected area (MPA) objectives, size, and design complexity

SPECIFIC MPA OBEJCTIVE	RELATIVE SIZE	COMPLEXITY
Protecting an Endangered Species	Small to Medium	Simple
Protecting a Migratory Species	Large (or Network)	Simple to Complex
Protecting Habitat from Single Threat	Medium	Simple
Protecting Habitat from Multiple Threats	Medium to Large	Complex
Preventing Overfishing	Small	Simple
Enhancing Stocks	Small to Medium	Simple
Protecting an Area of Historic or Cultural Interest	Small	Simple
Providing a Coastal Zone Management (CZM) Model or Empowering Local People	Small to Medium	Simple to Complex
Promoting Marine Ecotourism	Small	Simple
Providing Site(s) for Scientific Research	Small	Simple
Conserving Biodiversity	Large (or Network)	Simple to Complex

Multiple-use zoning in large-scale protected areas

[35] MPAs are site-based conservation initiatives that run the gamut from small-scale, strictly protected fisheries reserves (no-take areas), to larger-scale marine parks and sanctuaries. Although usually thought of as purely in-water designations, MPAs can also have terrestrial and aquatic components. Larger-scale protected areas, especially those encompassing land and estuarine areas, generally use zoning to allow different levels and kinds of use in different areas. Such designations are known as multiple-use MPAs.

[36] When a functional approach is adopted, in other words, where the object of conservation is not a single stock of resources or a single species but the reef ecosystem and its processes, MPAs will have to be large and encompass many types of linked habitats (Agardy, 1994), or will have to be designed as part of a linked or integrated network. The large-scale, multiple-use protected area can demonstrate the practical application of ecosystem-based management (Costanza *et al.*, 1993; Hatcher *et al.*, 1989). The underlying ecology and movement of species defines the outer boundaries for the area of protection, or management unit (Dayton *et al.*, 2000). In recognizing these linkages, MPA planners can work towards conserving ecosystem integrity, not just individual resources or ecosystem structure.

[37] Virtually all multiple-use MPAs that serve to maintain ecosystem integrity (as opposed to merely providing sites in which the segregation of uses can be accomplished in the effort to resolve user conflicts) rely on no-take or strictly protected core areas (Allison *et al.*, 1998; Roberts, 1995a). These critical areas usually protect ecological functions like breeding, dispersal and growth in populations of organisms that are crucial – by virtue of their economic value, ecological value or role as indicators (Guenette and Pitcher, 1999). This ecological information, however, is but a part of the sorts of information required for developing multiple-use areas. Equally important is socio-economic information on uses of the area, both current and prospective.

[38] Multiple-use MPAs that are of appropriate ecosystem scales, that contain management units grounded in ecology, and that allow multiple uses by establishing zoning to protect areas deemed most critical, most sensitive or most amenable to monitoring and evaluation, are a crucial tool for conservation. In many cases, such protected areas provide managers opportunities to test various management regimes and practice adaptive management (Agardy, 1997). In what may be more appealing to decision-makers and government bodies, these MPAs can also serve as small-scale demonstration models for what can and should be done to integrate terrestrial, aquatic and marine management most optimally.

[39] While it is true that no model MPA can fit all circumstances of environment, society and economics, the process by which these multiple-use protected areas are designed and implemented can be thought of as a generic one. Whatever the specific objectives of a protected area, ecological information must be harnessed to determine, with as much certainty as possible, where the ecologically most critical areas are that need the strictest possible protection (Agardy, 2000a). Utilizing zoning to protect these key areas is analogous to how we employ medicine to keep us healthy: we target the vital organs first and foremost, and do everything we can to maintain them in their life-support roles. So it is with estuaries, seagrass beds, mangrove forests, sea mounts, migration pathways and other key elements of coral reef systems. However, because our understanding of marine ecology is still weak (Hillborn and Walters, 1992), we must out of necessity turn to unconventional sources of information. As planners and manager are becoming more comfortable using traditional knowledge to supplement what we understand from scientific study, this is leading to a more precautionary approach to marine conservation (Johannes, 1998). Thus large-scale multiple-use protected areas target ecological processes and conserve linkages, demonstrating how a functional approach is both possible and effective.

Marine reserve networks

[40] Even large-scale multiple-use MPAs cannot protect what is ecologically most critical on a regional scale. However, networks of marine reserves can be used to accomplish this. Such networks present little opportunity cost resulting from restrictions of use in any one local area, since these restrictions are equitably spread out over a much wider geographical area. In addition, the benefits accruing from use of strategic and well-designed networks of reserves can be enormous – and are also spread across wide areas. For this reason, networks of reserves are now being viewed as an exciting new tool to conserve whole ecosystems or even ocean regions.

[41] Fundamental principles of ecology and biological oceanography underlie the way networks are designed and constructed. The open nature of marine ecosystems and the large-scale patterns of dispersal that characterize many species mean that terrestrial models of protected area planning become largely irrelevant when applied to ocean systems. Larval dispersal and subsequent recruitment is not only geographically widespread in many marine ecosystems, it is also a highly variable process in which non-linear dynamics and stochasticity plays a large role (Fogarty *et al.*, 1991; Gaines and Bertness, 1992; Holt, 1990). Despite this natural variability, biologists have been able to study many systems to determine sources and sinks for larval recruits, in order to arrive at maps that show the most critical habitats to protect in order to conserve dispersal patterns and recruitment (Hyrenbach *et al.*, in press; Murray *et al.*, 1999), although not all critical areas determined in this way are necessarily key habitats continually – some areas that are fundamental to constructing networks to preserve ecological integrity may be only seasonally important, such as sites for spawning aggregations of fishes (Johannes, 1998).

[42] New studies have shown that even very small marine reserves can have significant positive impact on marine biodiversity and productivity (Ratikin and Kramer, 1996; Russ and Alcala, 1996, 1997, 1998). Small MPAs that are linked in a systematic network that protects a large proportion of critical habitats or particularly important sources of recruits in a region provide even more benefits. Source sink modelling has been employed to determine the relative value of various sites within a single marine protected area such as the Great Barrier Reef Marine Park (James *et al.*, 1995) and the Florida Keys National Marine Sanctuary (Bohnsack, 1996a). Such studies of connectivity are also important in the development of networks of reserves, as proposed by Roberts (1998) for the northwest Caribbean.

[43] Such systems of protected areas aiming to conserve overall ecosystem function will have to focus not only on intact, and biologically valuable areas, but also on the most highly threatened areas or degraded areas needing restoration. This approach requires evaluating threats to ecosystems and the degree to which areas are degraded, in order to establish a system of MPAs allowing restoration of sites (and replenishment of resources) as quickly as possible. Though few systematic attempts to identify coastal and marine areas in need of restoration exist, the ongoing restoration programme for South Florida (including the Everglades area, Florida Bay and the Florida Keys) is a good example of an analytical approach to establishing a network of protected areas for restoration purposes (Murray *et al.*, 1999). In some MPA examples, the restoration effort targets a single species or stock, as in the restoration of a historically overexploited fishery. Such protected areas are known as no-take zones, and they often become a starting point for subsequent more comprehensive and effective protected area management.

[44] The innovative new networks, however, attempt to amalgamate these strategies by identifying the ecologically most important and most threatened areas, together with those most likely to contribute to ecosystem functioning once restored. When threats to biodiversity are direct, such as destructive fisheries or habitat conversion, then it is easy to see how a protected area will have the potential to abate the threat (Dugan and Davis, 1993; Roberts and Polunin, 1991). However, MPAs can also help address indirect threats, such as land-based sources of pollution. The protected area becomes a tool for addressing indirect threats either when the scope of a single protected area or network of protected areas is expanded to encompass the area where

such threats originate, or when the perceived value of the area ultimately affected by the threat is increased. In other words, MPA designations can help focus attention on areas being degraded from afar, and help generate the political will to address the source of the problem.

[45] In order to protect the most ecologically critical components of a large marine ecosystem or a coastal region, we must harness information to identify the key elements. For reserve networks that aim to maintain productive fisheries, the network of reserves may target key spawning areas, larval retention areas, nursery grounds, feeding areas and migration pathways (Bohnsack, 1996b; 1998)). For networks that aim to maintain the health of key habitats within a region, the picture will be a bit more complex, requiring us to incorporate terrestrial reserves and river basin and watershed areas into the network. We must also look at what is threatening these critical areas, and tailor our network to stave off these threats. If the major threat is from overexploitation of fisheries, then strict controls must be placed in some areas to create no-take marine reserves (Bohnsack, 1998; Roberts, 1995a). If pollution is undermining the health of the system, then pollution input areas where pollution is controlled should become part of the reserve network.

[46] There is a general sense that these marine reserve networks can only utilize MPAs that are small and simply managed as no-take areas (Roberts, 2000). However, there is no reason why multiple-use MPAs cannot be used in networks (Agardy, 1995). Virtually all the world's coasts and nearshore areas are characterized by conflict within and amongst user groups or jurisdictional agencies, or at a minimum a serious lack of communication between these factions (de Fontaubert *et al.*, 1996). For instance, shipping and mineral extraction are uses that often conflict with recreational use of coral reef areas. Fishing, both commercial and subsistence, conflicts with skin and scuba diving and nature-based tourism. Different fisheries, at both commercial and artisanal scales, often conflict. In such cases of conflict, zoning can be used to accommodate a wide variety of user groups in relative harmony, and can be a tool for dispute resolution where conflicting uses clash.

[47] Networks must act to secure the rich and valuable coastal ecosystems of entire regions by focusing marine conservation action at the most ecologically critical places. This will entail providing involved parties with the means to put a systematically linked network of terrestrial and MPAS into place, either through establishment of new areas or strengthening existing ones. It will also require that all prospective development impacts in a region are understood and evaluated systemically, and that integrated management of terrestrial, aquatic and marine systems is accomplished. The keys to these essential features are in turn harnessing science, raising awareness, building stakeholder constituencies and involvement, finding alternatives to harmful development practices, developing integrated coastal and tourism planning policies, and providing the means for long lasting MPAs.

Corridor approaches

[48] Can even a well planned and extensive system of MPAs, linked in functional networks, really act to conserve large ocean regions? The answer is yes, but only if the effort does not stop with the establishment of individual protected areas within the network. Truly effective conservation requires a holistic approach – one that deals with the entire suite of impacts affecting marine and coastal systems. This means protecting the context in which sit the islands of protection created by MPAs.

[49] The corridor concept is the most sophisticated, comprehensive and integrative of all the three MPA approaches described in this review. "Corridor," however, may be a misleading term since the application in the marine realm is not strictly analogous to terrestrial corridor concepts. On land, corridors for conservation are created by identifying crucial areas for conservation, undertaking a gap analysis to highlight areas that fall outside of protection, and implementing new protection regimes to physically link up existing protected areas and allow transmigration and genetic exchange. At sea, corridors describe a new way to package integrated coastal planning

with a strong MPA component, and it is the direction in which all coastal planners should move in years to come.

[50] In creating marine corridors, planners seek to conserve the most critically important terrestrial, aquatic and marine habitats, which together function to maintain ecosystem integrity and productivity. To do this, the best available scientific and traditional knowledge information is harnessed to identify the ecologically most critical areas (terrestrial, aquatic and marine) of a particular coastal region. The latter type of information, i.e. traditional knowledge or user-based knowledge, is crucial in most parts of the world, since scientifically-derived ecological information is in short supply (Johannes, 1998). Once these most vital areas are identified, the corridor approach applies gap analysis to highlight conservation needs. Here the process is very much like that for constructing a strategic network of reserves, although the geographic scope of the enterprise is usually larger since terrestrial portions of the region are fully included.

[51] The corridor approach attains new heights of sophistication since it is built on establishment of reserve networks, but goes well beyond such networks. While land use planning and protected areas, both terrestrial and marine, are essential elements of a corridor approach, the method provides a way to protect the context in which these "islands of protection" are found. The corridor approach can highlight areas where additional MPAs needs to be established, or where existing MPAs needs to be strengthened or expanded. The collective protected areas constitute the sum total of vital organs. These critical habitats can then be linked by a "virtual corridor," i.e. targeted policy reform that ensures that the connectivity is preserved and that these most vital parts are not degraded by direct and indirect impacts of human activity.

[52] The ecological linkages that connect life in the water with life on land necessitate that we do a better job of integrating management of watersheds, coastal lands and the oceans. Corridor approaches provide a framework to allow us to achieve that integration, in a strategic and efficient way. This tool allows place-based management to be implemented with the big-picture view in mind, bringing management interventions up to the scale of regional conservation. The natural extension of a holistic approach is to fully embody regional, ecosystem-based management (Gislason *et al.*, 2000). In practice, such broad-based management is perhaps best exemplified in the Antarctic regional management framework of CCAMLR (the Convention for the Conservation of Antarctic Marine Living Resources) (Constable *et al.*, 2000), which serves as a model for international cooperation around a conservation agenda.

[53] As regional approaches begin to be replicated in other large marine ecosystems and semi-enclosed seas, the environmental community will probably be called upon to watch for and facilitate the connections between site-level conservation and broader, multilateral policies and agreements. We must start to recognize these interconnections, too – between feet-on-the-ground interventions that effectively conserve biodiversity and at the same time confer benefits to stakeholders on the small scale, and head-in-the cloud negotiations that represent the national interests of governments and the global interests of the international community on the very largest scale. When, and only when, local-level and regional- and global-level interests can be made to work in parallel or in harmony with one another will true marine conservation be achieved.

CONCLUSIONS

[54] Environmental groups play an ever-important role in public understanding of fisheries issues, in communicating technical information in lay terms, and in advocating for reform through a wide array of measures. In addition, these groups increasingly highlight and demonstrate ways forward, by assessing where and how fisheries management has worked to conserve both stocks and ecosystems, and where benefits are equitably shared while costs are minimized. As groups take on more and more of the latter function, their roles have shifted from adversaries to welcome partners catalysing change. However, environmental auditing of fisheries, and indeed all marine

development, will only increase in the future, and unless fisheries reform is truly achieved, the fishing industry and government decision-makers can continue to expect pressure from these increasingly powerful non-governmental bodies.

[55] A review of some key environmental groups working in the fisheries field shows just how varied approaches to the fisheries problem can be. Many environmental groups lobby and advocate for policy reform and for formation of international instruments and agreements (such as FAO's noteworthy Code of Conduct for fisheries – a non-binding agreement that describes holistically-oriented principles for fisheries management). Some of these groups continue to play adversarial roles in their dealings with the fisheries industry, entering into environmental litigation when management bodies cannot be convinced to reform or are found to be ineffective in upholding regulations. Examples of these activities include efforts by the Natural Resources Defense Council, Environmental Defense, Greenpeace, the Ocean Conservancy (formerly the Center for Marine Conservation, based in Washington, DC), and the newly emergent Oceana (also based in Washington, DC).

[56] In contrast, the Worldwide Fund for Nature (World Wildlife Fund in the USA) has concentrated its recent efforts on trying to harness consumer awareness and purchasing power through the establishment of the Marine Stewardship Council. This independent body certifies capture fisheries that have been deemed "sustainable" by a set of scientifically developed guidelines. In a slightly different vein, the Nature Conservancy (TNC) has taken on a particularly troubling set of fisheries: those that support the live fish trade centred in Southeast Asia. TNC has underwritten scientific study of the trade and its impacts, and has elevated the issue in the minds of the public in both western and eastern countries. In trying to stop the destructive use of cyanide in the trade, TNC partners work closely with other environmental NGOs – most notably the International Marine Life Alliance (IMA) and its broad network of partners operating in the countries where it undertakes training of fishers in less destructive techniques. Alternative methods also figure prominently in the work of Conservation International in its Gulf of California Program, where environmentalists have worked with the shrimp industry to install by-catch reduction devices and where it has initiated grass-roots level projects in sustainable mariculture. Finally, the World Resources Institute and the International Union for the Conservation of Nature (now the World Conservation Union) both engage in systematic, global-scale analyses to track trends in fisheries exploitation and prescribe remedies for overcoming environmental destruction and social inequity.

[57] Common to nearly all these groups (most of which are based in the USA – not because all the activity is occurring there by any means, but rather because of the author's geographic bias) is the recent drive to lead by example. Many groups engage in assembling the scientific information on ecosystems and their use in order to help craft solutions to destructive or overexploitative fisheries, usually involving MPAs. Some of these MPAs are small scale and highly focused, such as the community-based marine reserves established in the Philippines and Indonesia. Others are very much larger scale, involving either zoned multiple-use MPAs that can accommodate a wide range of uses, or MPA networks. In perhaps the most useful demonstration of all, non-governmental environmental organizations are now working closely with governments within large regions to help foster corridor approaches that conserve ecosystems and promote sustainable uses of coastal and open oceans across wide geographies, using the collaborative and cooperative approaches that such regional conservation requires. This scaling up of effort, working with user groups instead of against them, seems the only logical way forward if we are to achieve truly responsible and beneficial fisheries in the future.

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