Stemming Decline of the Coastal Ocean:
Rethinking Environmental Management

A Policy Brief from the United Nations University,
International Network on Water, Environment and Health

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UNITED NATIONS UNIVERSITY
UNU-INWEH

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ISBN 92-808-6008-9

This document should be cited as:

Sale, P.F., M.J. Butler IV, A.J. Hooten, J.P. Kritzer, K.C. Lindeman, Y. J. Sadovy de Mitcheson, R.S. Steneck, and H. van Lavieren, 2008. Stemming Decline of the Coastal Ocean: Rethinking Environmental Management, UNU-INWEH, Hamilton, Canada.

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Acknowledgements

Between them, the authors of this document have well over 100 years of experience working on tropical coastal ecology and management in countries around the world. Most of our experience comes from the Caribbean, South-east Asia, and Australia, but we have experience in other parts of the tropics and in temperate coastal environments. Despite this breadth of experience, we approach the problems of coastal management as marine scientists, while acknowledging that other forms of knowledge are also vital to their solution. While many of us had interacted in the past, we all came together as participants in the Coral Reef Targeted Research Project, a GEF—World Bank—University of Queensland project now in its fourth year that seeks to undertake new scientific research targeted to specific questions judged to be critically important to management of coral reef systems, and to do this in the context of capacity building to improve reef management. This is a global project with activities being undertaken in many places around the world, and UNU-INWEH is managing the component dealing with connectivity of coastal ecosystems. It was through our discussions in the course of planning and implementing this programme that we realized the many similar lessons we had been individually learning over the years, and it was logical to join in producing this document.

Preface

Coastal areas offer enormous value to society in economic, cultural and aesthetic terms. An indirect recognition of this value can be seen through a growing trend of urbanization around the coastal areas and migration from inland areas. This trend also creates fierce competition for resources, space and political importance in the coastal areas. Human intervention – particularly to meet the growing demands for infrastructure development in and around coastal zones – also creates many environmental challenges.

Key ecosystems – bays and estuaries, coral reefs and seagrasses, and mangrove and wetland ecosystems inland – have suffered dramatically in the past 50 years. While many prominent scientific contributions have pointed to the continuing degradation, improved environmental management remains elusive. Positive and successful actions taken at the community level are seldom replicated, or scaled up, and regional-scale actions also frequently fail.

Global drivers of change play a significant role in what happens in any coastal environment. Intensification of large-scale agriculture, driven by global food demands and more recently by biofuel production, contributes to over-nutrification and creation of "dead zones" off-shore. Shipping and commerce add to the influx of pollutants and exotic species. Ill-planned tourism in ecologically sensitive areas often causes irreversible damage. Over-fishing of coastal and pelagic stocks, when considered in combination with damage to the coastal nursery grounds of many fish species, is already showing far-reaching consequences for economies and ecosystems.

Global climate change and population stresses are further exacerbating our adverse impacts on coastal ecosystems. Warmer water temperatures – particularly in the tropics – are going to drive a change in the composition of and inter-relationship between species. We should be quite alarmed by predictions of total disappearance of coral reefs in some parts of the world.

How do we change human behaviour and societal attitudes to reverse these negative trends?

This document responds to that key question. The extensive work UNU has undertaken over the years, together with its partners, and particularly the work of UNU-INWEH in tropical coastal environments, can help us identify the problems that impede progress, and suggest practical answers and doable solutions that will improve management approaches and fill scientific gaps.

By creating a bridge between state-of-the-science and policy formulation, we see a ray of hope. We believe that use of scientific and traditional knowledge, together with better understanding of the economic value of healthy coastal ecosystems, can help change the political discourse that eventually determines societal pressures. Societal responsibility and responsiveness can only increase as we improve the flow of pertinent and useable scientific information.

We believe this document will be a significant contribution to the ongoing dialogue on coastal management, including recent publications by FAO on fisheries and UNEP on coastal pollution. The dialogue is enriched by ongoing scientific research by our partners – we are indeed indebted to their contributions to the thinking presented in this publication.

As the title of this book suggests, we must rethink the management approaches to stem the decline of these precious ecosystems. We have all the necessary tools and resources at our disposal today.

Dr. Zafar Adeel
Director, UNU-INWEH

30 April 2008

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1 Summary for Busy Managers

The coastal ocean environment provides enormous value in fishery and other products and in ecosystem services including coastal protection, water purification, and appropriate locations for ports, harbors, urban centers, tourist destinations, and numerous recreational pursuits. Coastal environments can also cleanse the soul, stimulate the mind, and restore the body. But 40% of all people live within 50km of a coast, and our enthusiasm for coastal living is creating ever more environmental damage.

Current management practices are ineffective and to continue them will endanger coastal economies and ecosystems that support over one half of the world's population. The trend for coastal ocean ecosystems over recent decades has been for progressive decline in the face of growing human populations, growing demand for coastal resources, and growing use of the coastal environment. Now climate change is starting to add to the pressures on the coastal environment, further stressing ecosystems there. In the following pages, we summarize the present state of management, identify the impediments limiting success, and propose steps to make the substantial improvements needed in management of the coastal ocean.

1.1. There is Ample Evidence of our Failing Management

FAO now concedes that 52% of 441 global fishery stocks are "fully exploited", 17% are "overexploited" and 7% are "depleted". Independent assessments indicate that total global fishery yield has been falling since the late 1980s, despite continued increase in fishing effort, and that we have been progressively fishing out the larger species. Many coastal fisheries are ineffectively managed yet are critically important for food supply and livelihoods in tropical coastal areas with millions of people. Fisheries globally are facing increasing pressures as human populations and wealth grow, commercial markets expand, cash economies develop, and demand for seafood increases.

By 2050, 91% of the world's coastlines will have been impacted by development. Much coastal development is poorly planned and all of it, as well as much inland development, impacts the coastal ocean. Shorelines are hardened, channels and harbors are dredged, spoil is dumped, submerged and emergent land is moved, and patterns of water flow are modified. Important ecological processes that sustain coastal ecosystems are impeded by our careless alterations of coastal habitats – fisheries decline, water quality deteriorates and so does human health and quality of life.

Some 80% of ocean pollution originates from land-based activities, and, outside Europe and North America, over 80% of sewage enters the coastal ocean untreated. Coastal pollution is of growing concern because coastal populations, their associated cities and industries are rapidly expanding. Largely as a consequence, nutrient over-enrichment of coastal waters is a growing problem. In some locations, it results in anoxic "dead zones" seasonally or permanently that have major impacts on fishery production and on quality of life for coastal communities. The largest dead zones at present are in the Gulf of Mexico (70000 km^2, seasonally) and the Baltic Sea (permanent, up to 100000 km^2).

Marine protected areas (MPAs) are becoming the principal tool used for conservation management in the coastal ocean but they are poorly used. There are about 4600 MPAs worldwide, covering 1.4% of the global coastal shelf area. The great majority are "paper parks". They are legal creations, may have management staff, usually have detailed regulations governing their use, but there is little if any enforcement of regulations. As a consequence, the deterioration of the coastal environment goes on as rapidly inside most MPA boundaries as it does outside, and the effort to establish and then to maintain protected sites is largely in vain.

Still Pictures © Reinhard Dirscherl/WaterFrame

Growing attention to, and evidence of, climate change impacts are also forcing recognition that the many different causes of environmental degradation act synergistically, and are resulting in a serious decline in the capacity of coastal ocean environments to provide the goods and services on which we depend. The decline is well-documented in a near-continuous stream of publications warning of the coming disaster. The decline is terminal, unless we introduce much more effective management immediately.

Although the situation is dire, there is reason for hope. Our understanding of the ecological functioning of the coastal ocean is quite good, and we have a basic kit of useful management tools at our disposal. Good examples of well-managed coastal environments, and sustainably harvested coastal fisheries occur around the world. The reversal of negative trends and the improvement of water quality in some areas indicate that decline of coastal ecosystems is neither inevitable nor always irreversible. Why then is the situation so poor in the great majority of locations?

In the following pages, we briefly document the current state of the coastal ocean environment, adding one more voice to the growing chorus. We then turn to a critical examination of why we are failing to manage the coastal ocean, and conclude with an outline of the steps which need to be taken to remedy the failure of management in any particular coastal region.

1.2. Reasons for our Failure

Coastal management fails in most instances for some or all of five reasons.

1. Human societies, for the most part, do not understand the immense economic, cultural, and aesthetic value that a sustainably managed coastal environment provides, or the societal cost of allowing them to degrade. Things that are not valued get neglected.

2. Environmental managers work in a constantly changing world, because our impacts on the coastal ocean grow with our coastal populations and our demands for environmental goods and services. What was sufficient last year to manage a particular type of problem will not be sufficient next year.

3. Environmental management is fragmented across and within jurisdictions, with different aspects handled by departments of environment, agriculture, health, commerce. For marine environments, the fragmentation across jurisdictions is particularly damaging because neither fish nor pollutants obey political borders and neither should management. Within jurisdictions, different departments have very different management goals; these reinforce the natural bureaucratic tendency to protect turf and maintain boundaries.

4. Environmental management has never become sufficiently scientifically based. As a consequence, it is seldom proactive, using specific management tools to reduce human impacts, and monitoring results to gauge effectiveness and adjust those actions as necessary. The lack of science has also made it difficult to implement truly integrated coastal zone management, particularly given the administrative impediments to such a holistic approach. In poorer countries this lack of scientific basis can be ascribed to the fact that management agencies lack resources of all types including scientifically trained staff. But in richer countries, the failure is also widespread, and

Large scale moderations to coastal areas can lead to beach erosion, as is the case here in Dubai, UAE. Good planning and comprehensive pre-construction environmental impact assessments that are properly implemented, can minimize these effects. Photo by: Hanneke Van Lavieren

the consequences are the same – management agencies that have lost their way and treat management as a game of enforcing regulations, more or less, with little regard to whether the regulations actually do anything useful to address the human impacts of concern

5. The management programme, whether well-designed or not, fails to become adopted by the local communities that depend upon the coastal environment for their livelihood and well-being, and it fails because of their lack of compliance. No management agency has the resources to control human environmental impacts if the people do not support the management goals.

The need for more effective coastal environmental management has been recognized by the multinational agencies, donor countries and foundations, and the large international environmental NGOs, and a very substantial effort has been mounted to assist poorer nations that are most in need of guidance and help. Unfortunately this effort has been far less effective than it might have been. The aid comes via numerous multinational, bi-national and other governmental programmes, and the activities of many economically powerful, and fiercely competitive, international NGOs. The assistance is most often in the form of poorly coordinated, competing, short-term (3-5 year) projects. Such short-term support rarely builds management activities that are then sustained by internal resources even if the recipient community has bought into the need for the new actions.

Donor agencies must share responsibility for the unspoken pretense that problems can be solved within a single 5-year project, but beyond that, there is a pressing need for phased external support that works to integrate proactive management strategies into the fabric of coastal societies. This obviously requires longer time-frames, more effective coordination, and more patience from those who fund international programmes for sustainable development. However, while becoming engaged over longer time-frames, multinational agencies must also demand real results in the form of demonstrably improved management, rather than be satisfied that nations are signatory to, and are planning to implement obligations under treaties, conventions and similar legal documents.

1.3. How to Build Improved Management of the Coastal Ocean

To be successful, efforts to improve environmental management need to be holistic in focus, scaled appropriately to the ecological processes they are designed to protect, and yet still enthusiastically adopted as their own by local coastal communities. This requires regionally scaled programmes comprised of replicated local projects, a challenging approach indeed. Only by bringing greater transparency to government decisions will we succeed, given the world-wide prevalence of economic/governmental structures and procedures that tend to discount environmental costs when evaluating the benefits of coastal development projects. Greater transparency can also become effective armor in combating effects of widespread public-sector corruption on environmental decisions. Management agencies of poorer nations, lacking financial resources or scientifically trained staff, and frequently faced with greater levels of corruption and more degraded coastal environments than wealthier nations, will not be able to make significant improvements without effective outside help.

The international community can help build greater success by 1) encouraging and publicizing up-to-date and comprehensive economic valuation of coastal environments at national, regional and local scales, 2) fostering truly integrated coastal zone management, and 3) rigorously holding national and local governments accountable for their management failures.

The steps to building better coastal environmental management begin by appreciating the need for more sustainable practices, and the urgency with which sustainability should be achieved, while being confident that we already have most of the needed tools. Improved management will require committed support for environmental protection from the local community, appropriate penalties for non-compliance, transparency to minimize corruption, and legal protection of whistle-blowers. Making such changes will be quite difficult, particularly for poorer nations that have fewer well-educated people, greater need for improved management, but greater levels of corruption in government and civil affairs.

Fish trap used to catch wild juvenile grouper (*Serranidae*) destined or mariculture grow-out to supply the live reef food-fish trade in SE Asia/ Malaysia. Photo by: Yvonne Sadovy/APEC

Within governmental agencies, major structural and procedural changes may be needed to achieve more sustainable management. These changes may include realigning departmental responsibilities to ensure more effective collaboration, developing and using economic valuation tools to inform the public of environmental values and to help resolve the conflict between short-term and long-term economic interests when making management decisions, and fostering internally a scientific culture so that management can become properly proactive.

As well as structural changes to improve the flow of information among management agencies, there is a need to improve the quality of the information that flows and of the analysis it receives. To fully achieve scientific literacy, the collaboration of the science and management communities must be strengthened, and, within the science and management communities, there must be less advocacy for, and more critical evaluation of, management tools in order to either reduce uncertainty, or help decision-makers realize the logical options in the face of high uncertainty. Capacity-building efforts must be coordinated to ensure that there are appropriate jobs for people who get training, and strengthened management agencies as a result.

New management initiatives are more readily adopted by local communities when economic and other incentives are appropriately aligned with management needs, and when the initiatives are seen to have clear and rapid, or multiple positive impacts on environmental issues. The elimination of inappropriate economic subsidies for business enterprises can often realign incentives and help lead to acceptance of environmental policies and goals. A new policy will also be more readily accepted by the community if people can be shown direct local benefits, if it has been crafted to recognize cultural and political norms and realities in the local region, and if penalties for failure to obey regulations are sufficient. A transparent and holistic approach to coastal management may also prove effective in achieving local community acceptance of truly difficult decisions, such as the need to reduce the catch of wild fish. There is no question that the great majority of coastal environments are overfished at present. Reducing that catch can only be achieved when local communities recognize the greater overall value of a sustainably managed coastal ocean, and when the plan put forward also addresses the employment and other societal needs of the population. Reducing catches requires integration across jurisdictions, and an integrated view of fisheries management. It also requires a close and effective interaction between managers and local populations. The international and scientific communities, and especially the international NGO community can play an important role in building this local community support for improved management through carefully implemented educational programmes targeted to specific community sectors and to the schools, and by identifying, and supporting local "heros" who want to advance an improved environmental agenda.

Sustainable management of fishery resources is now benefiting from a growing culture of social responsibility in the corporate sector. Further efforts to build a culture of informed consumer choice will encourage this. Such societal pressures to adopt preferred patterns of behavior can be applied to sustain other aspects of environmental management.

It is past time to implement truly integrated coastal zone management around the world, across geopolitical boundaries, among administrative structures, and among management goals. Management must be scaled appropriately to ecology, by ensuring that its spatial and temporal scales are guided by those of coastal structures and ecological processes. Boundaries of political jurisdictions, or the impact footprints of particular coastal enterprises are not appropriate borders for management actions. A seamless approach to coastal management also provides an effective way to build recognition of and support for the need to link management of coastal waters with management of activities taking place in terrestrial environments, often far inland from the coast. At the same time, this holistic management has got to be built on a foundation of strong local community support. The international community can do much to help build that local support while also helping build the improved management structures and processes that will be needed. The task ahead is challenging and substantial, but it is not impossible, and there is no good reason to avoid taking it up.

As in all coastal regions, marine resources provide important subsistence income for local people. This young boy, from the Hundred Islands National Park region of the Philippines, uses a good collection of local cowrie shells-which are common in the Hundred Islands-and persistence to entice tourists. Photo by: Andy Hooten, CRTR

2 Introduction

Continuing migration and growth in human populations mean that we are now predominantly urban and coastal. Just over 50% of humans reside in cities, and 40% live within 50 km of a coastline. Both trends are continuing, and average population density in coastal areas (99.6 people.km-2 in 2000) is over twice the world average. Most of the still growing cities are coastal (14 of 17 largest, and 49.7% of all cities over 500K in size), and these trends mean both that coastal environments are of growing importance for us, and that our impacts on coastal ecosystems are growing (UNEP 2006, 2007).

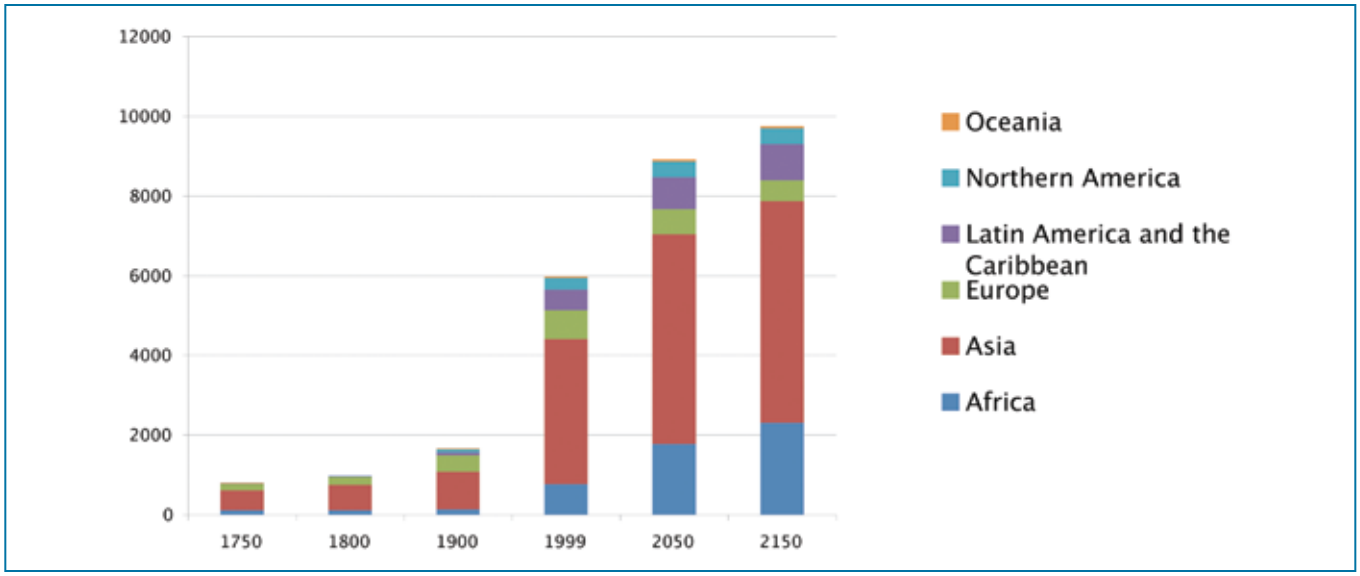
Coastal ocean ecosystems traditionally give us important fishery resources, shoreline protection, and suitable environments for tourism, aquaculture, and the ports and harbors needed for transoceanic trade. They also serve as final repository for many of our waste products.

Despite its importance, our management of the coastal ocean has not been very successful. Fishery effort has continued to increase, but yields have been declining for several years in many regions. Efforts to conserve coastal habitats, and their biodiversity, while enhancing the possibility of sustainable resource extraction, have been marginally successful at best. Integrated coastal zone management is widely advocated but minimally used, and the proportion of coastal area with effective levels of ecosystem protection is typically quite low. Impacts of pollution from upstream and terrestrial sources are known to be serious, but the effectiveness with which pollution of coastal waters is mitigated can be quite limited. Meanwhile rampant coastal development, expanded aquaculture and port and harbor activity cause unsustainable changes to coastal ecosystems and the environmental goods and services they provide.

The earth at night reveals the extent to which humans live close to the coast. Image from http://apod.nasa.gov/apod/ap001127.html

iStock Photo © James Wright

Historical and Predicted Populations per World Region (in millions).



Adeel and King (2002) reviewed the state of coastal environmental management in the Asia Pacific region and made policy recommendations. This report extends that assessment globally to provide a critical assessment of our management of coastal ocean ecosystems, its frequent failures and its rare successes, and puts forward an explicit agenda for actions to improve coastal management. The good news is that there are success stories, and we do have the management tools to make a very significant improvement globally in the sustainable management of these immensely valuable ecosystems. The bad news is that the current trend is for continued ecological deterioration at a time when rising demand makes the goods and services provided by sustainably managed coastal waters more important than ever before. Climate change is exacerbating a difficult situation, and current actions by multinational organizations, donor nations, and the international NGO community, aimed at improving sustainability of coastal waters, are unlikely to stem the downward trend. We have an important task; one that requires a rethinking of the steps that achieve successful management.

Box 1 Definitions:

'Coastal' can include all continental shelf environments, but primarily refers to those ocean locations that can be accessed from the coastline without need for ocean-going vessels. 'Coastal' also includes intertidal, marsh, estuarine and other habitats at the fringe of the sea.

'Coastal management' refers to all forms of management of human impacts on these coastal ocean environments and their flora and fauna – fisheries management, conservation management, management of water quality, and management of coastal development.

'Integrated Coastal Zone Management' (ICZM) is a holistic approach to managing all aspects of human impacts on coastal (aquatic and terrestrial) ecosystems. ICZM can help break down barriers between administrative departments or neighboring regions or countries so that management is scaled to ecological processes.

3 Coastal Management Today

3.1. The Capacity to Manage

Our impacts on the coastal ocean are diverse. Environmental management is the proactive manipulation of these human impacts so that they do not reduce the capacity of these ecosystems to continue to provide their goods and services. The need for proactive environmental management is achieved in each nation over time through a patchwork of new law and expanded action. Even so, all environmental management takes place in a changing world – one in which climate change is altering the capacity of coastal ecosystems to respond, and one where our expanding populations and growing demand for products of all types continually increase the human impacts on environment, and thus the need for ever more aggressive management action.

In an ideal world, environmental management is based on scientific understanding, managers are scientifically trained, and managers interact with scientists (either from academia or within the management department) to evaluate and improve the effectiveness of their management. Our robust understanding of the ecology of coastal systems (Sale et al. 2006) should make this approach feasible. Unfortunately, links between managers and scientists are frequently weak, and many managers lack scientific training or even the knowledge that management involves actions that need to be assessed for their effectiveness. Further, our less-than-ideal world includes impediments that must be overcome before environmental management can flourish – insufficient "ownership" by local communities, administrative structures that build barriers instead of bridges, lack of transparency, widespread corruption, and chronic overuse of coastal waters.

Fragmented responsibility in wealthier nations

Governmental structures in wealthier countries generally partition coastal management among separate departments for fisheries, water quality, conservation, and other goals, each governed by relevant law. In larger countries the partitioning is repeated within each successive tier of regional to local governments. The division among departments is rarely mirrored perfectly among these layers of government. Spatially overlapping jurisdictions, both within and among tiers of government, and less than fully effective coordination of effort, often lead to less effective management, and to a tendency to not see the coastal management forest while caring for specific fisheries or conservation trees. Fisheries management has usually evolved as management of an important industry rather than for ecosystem sustainability, and water quality is more frequently a public health than an environmental management concern. As a consequence, different sectors often have very different management goals, and gaps in coverage can exist. Under these circumstances it is remarkable that environmental management in wealthy countries is as effective as it often is, but not surprising that it could be much better.

Lack of management capacity in poorer countries

In poorer countries, environmental management suffers from the same patchwork of governmental agencies as in wealthier countries, but there are additional problems that further limit management effectiveness. Management departments rarely have adequate resources – financial, logistic, or intellectual – and many management responsibilities are simply not undertaken even though responsibility may be clearly assigned. The result is that management effectiveness is less than in wealthy countries, often by a wide margin.

This deficiency has been recognized by multinational agencies and donor countries, and efforts to aid poorer countries manage their environments more effectively are a significant component of international aid. Since 2003, about $800 million has been provided from major multilateral development institutions (i.e. Global Environment Facility, World Bank, Asian Development Bank, Interamerican Development Bank) for projects dealing with coastal and marine environments.

This level of international aid could be sufficient to make real advances if it was administered more effectively than it is. This aid comes from donor countries via a plethora of multinational,

Yvonne Sadovy

binational and other governmental programmes, and the activities of numerous economically powerful, and fiercely competitive, international NGOs. The assistance is often in the form of poorly coordinated, competing, short-term (3-5 year) projects. Such short-term support rarely builds management activities that are then sustained by internal resources even if the recipient community has bought into the need for the new actions, and donor agencies must share responsibility for the pretense that problems can be solved within a single 5-year project. There is a pressing need for phased external support that works to integrate proactive management strategies into the fabric of coastal societies. This obviously requires longer time-frames, more effective coordination, and more patience from those who fund international programmes for sustainable development.

This situation encourages some recipient countries to adopt a 'cargo cult' wait for a continuing succession of externally funded projects that may not relate directly to the perceived priority management needs within the country. This achieves some modest environmental management gains without the need to grapple with difficult decisions concerning national priorities or effective allocation of limited resources. Unfortunately, this approach also seems to satisfy some donor agencies and NGOs.

A major effort by multinational agencies is devoted to developing over-arching conventions, treaties and agreements that governments are encouraged to join, but without effectively coordinated mechanisms to build the capacity or funding needed to carry through the management responsibilities that signing has created. The result is policy overload (Caddy and Seijo 2005). A country that has signed onto a treaty does have legal obligations, but if that country does not have the capacity to fulfill those obligations, and if there is not both a will to succeed and coordinated support to enable success, those obligations will not be met.

Box 2 Effort by UNU-INWEH in Coastal Management

UNU-INWEH's coastal programme focuses on building scientific understanding to foster sound decision-making. This is directly linked to capacity development efforts to address critical gaps, achieved through diffusion of scientific research and promotion of human and institutional capacity. These initiatives are all directed to the long-term goal of Integrated Coastal Zone Management (ICZM), linked to the integrated management of adjacent inland watersheds. The current portfolio includes projects in the Caribbean, South Asia, and the Middle East. Experience gained through these and earlier projects has given us an understanding of why management is failing, and is causing us to make significant changes in the way we approach our own capacity-building projects.

UNU-INWEH Training Workshop in Akumal, Mexico, coral reef connectivity project. Photo by: UNU-INWEH

UNU-INWEH strives to promote integrated, demand-responsive capacity development, based on community ownership, multi-stakeholder participation, greater equity in North-South sharing, and reliance on South-South partnerships. By drawing on an extensive network of experts, we strengthen local know-how and institutional capacity using a multi-disciplinary, ecosystem-based approach to coastal management.

Current projects include Coral Reef Research and Capacity Building, a Mangroves Training Course, Coastal Zone Management in the Arabian Gulf, and Persistent Organic Pollutants in Coastal Ecosystems of the Caribbean.

3.2. Management of Fisheries is Failing

Fishing as a simple predator-prey interaction

Fisheries management has been a strongly science-based activity that developed in concert with major temperate commercial fisheries (Ricker, 1975). Fishery science is largely that of demography, and of 'predator-prey' interactions in which the population of interest is the single-species fishery stock, while the predator is the fishing fleet. This perspective can work for the industrial fisheries for which it was developed, but is far less suited to management of those fisheries (all artisanal and many commercial ones) that hunt multiple species using multiple types of fishing gear.

Management based on fishery science requires data on catch and effort at minimum, yet even this is often not available. In its absence, scientifically based management plans are absent, or are patched together by co-opting regulations governing catch and effort from other fisheries. Limited management may occur without fishery data, through the application of traditional knowledge, or by attending to specific unsustainable activities such as dynamite fishing, but many fisheries are simply unmanaged.

FAO now concedes that 24% of 441 global fishery stocks are either overexploited (17%) or "depleted" (7%). This is an increase from 10% in the mid-1970s. FAO considers 52% of stocks are "fully exploited", but this definition concedes that some will decline without more effective management (FAO 2004). Independent assessments of the FAO data strongly suggest that total global fishery yield has been falling since the late 1980s, despite continued increase in fishing effort (Pauly et al 1998), and that we have been progressively fishing out the larger species (Myers and Worm 2003). A pragmatic assessment is that many of FAO's "fully exploited" stocks are in fact already overfished and declining. In any event, there are numerous fisheries not monitored by FAO. Most of these (54% of 530 stocks within US waters [NMFS 2007]) are completely unassessed and effectively unmanaged, and the widespread failure to manage appropriately is of concern (Botsford et al. 1997). Many coastal fisheries, such as those associated with coral reefs, are ineffectively managed yet are critically important for food supply and livelihoods in tropical coastal areas with millions of people (Sadovy 2005). Fisheries globally are facing increasing pressures as human populations and wealth grow, commercial markets expand, cash economies develop, and demand for seafood increases.

Limitations of fisheries science

Shortcomings in management paradigms ensure even 'managed' fisheries get routinely overfished:

- Fishermen, driven by the need to feed their family or to pay off hefty loans on fishing vessels, are highly motivated, intelligent predators that continually adapt to be more effective, circumventing regulations even while obeying the letter of the law. Ineffective enforcement encourages this behavior.

- The simple 'single-species' paradigm underlying fisheries science is inadequate or impractical for multi-species fisheries. The interaction between fishing fleet and fish can change dramatically when more than one species is involved or when species interrelationships are profoundly changed. Ecosystem-based management (EBM) is increasingly acknowledged as a more realistic approach to fisheries management, but in practice it is rarely implemented.

- Fishing also has important impacts on fish populations other than the removal of individuals as a catch. Habitat modification, such as via trawling or dynamite fishing, and by-catch are perhaps the two most obvious, although the species selectivity inherent in fishing also leads to important shifts in species composition in the fished community (Frank et al. 2005).

Mining, not fishing. The Orange Roughy (*Hoplostethus atlanticus*) is a deep-water, slow-growing, late-to-reproduce fish of Australia and New Zealand. A fishery developed in the 1980s on deep, shelf-edge seamounts where the species is targeted on its spawning aggregations (Clark et al. 2000, Lack et al. 2003). Catches declined markedly within 10 years of discovery; by 2000 about 80% of known seamounts in the appropriate depth range had been fished out. The fishery is unsustainable, continuing only through the discovery and exploitation of new aggregation sites (Clark 2001). Photo by: Matt Sherlock CSIRO.

- Fishing also departs from theory when subsidies are paid, and when luxury fishery products have a value that increases with the rarity of the species. Globally, subsidies worth 25% of total fishery yields encourage fishing that would otherwise not be profitable, and fishing effort does not decline as expected when catches fall if the item being fished for is becoming ever more valuable as it becomes rarer (Box 3).

Fisheries science has grown in recent years to address such issues, but it remains data-intensive. Amassing the data is beyond the capacity of all but the wealthier nations or those for which the fishing industry is particularly important. There is little reason for optimism given the wide range of other problems that impact fishery management, and the fact that data suggest that current global fishery yield is not sustainable and that we have been overfishing, globally, since the late 1980's (Pauly et al. 1998).

Employment now vs sustainable management

Fisheries management is inherently a political activity involving many factors other than fisheries science. A number of conspicuous collapses of apparently well-managed, economically important fisheries have been exacerbated by pressure to keep people employed, encourage fisheries growth by promoting and subsidizing absurd overcapacity, and protect resulting capital investment in fishing industries. In some cases, a strong belief in alternatives to effort management, such as aquaculture or restocking, or an unwillingness to accept stock predictions of fishery models, has resulted in spectacular collapses.

Fishermen returning home with their catch and scoop net fishing gear, after collecting small groupers (*Serranidae*) destined for mariculture grow-out to supply the live reef food-fish trade in SE Asia/ Java, Indonesia. Photo by: Yvonne Sadovy/APEC

The cod, *Gadus morhua,* off eastern Canada, became seriously depleted by 1993 principally because of changes to their resource base that reduced recruitment (Rothschild 2007). However, over-capitalized fleets and hefty government subsidies kept fishing profitable while stocks declined, and permitted consistent over-exploitation and mis-reporting that played a significant role (Myers et al 1997).

In China, despite clear signs of declines of the large yellow croaker, *Larimichthyes crocea*, and introduction of management measures to reduce effort, the latter were not enforced. Rather, confidence was high that alternative measures such as mariculture and restocking would solve the problem without any real attempt to reduce fishing effort (Lui and Sadovy de Mitcheson, 2008). Such collapses are more sudden and more complete than they need to be, recovery is likely to take much longer, and jobs are ultimately lost in any case.

Box 3 Non-conventional fisheries

Artisanal fisheries, curio fisheries and live restaurant fisheries violate the conventional fisheries science model. An occupation of last resort in many poorer coastal communities, either because the jobs do not exist or because the skills are not present, artisanal fishing directly feeds the family and provides a minimal income to secure other requisites. Because it takes any edible fish, by any means, lands at multiple sites and sends little of the catch to market, catch statistics are difficult to collect. And effort-management tools are not easily applied when fishermen need to place food on the family table. As a result, the sometimes sizeable artisanal catch is unregulated, and ignored when deciding catch limits for other fisheries in the region.

Certain non-conventional fisheries for luxury food, ornamental fish or shellfish, curios, or seahorses for traditional medicines, form part of multi-species artisanal fisheries and are collected opportunistically along with more common species. When luxury items become particularly valuable with increased rarity, extra effort may be exerted to catch the last remaining animals in large areas. This severely reduces such populations and can even threaten populations or species with extinction. Fisheries science has provided few solutions for these fisheries, and fisheries managers frequently treat them as outside their sphere of responsibility.

The long-term consequences of fishery collapse on employment and social well-being of coastal populations and even on food security are rarely considered, yet could have great social and economic impacts. Where coastal communities depend largely on the sea for food and income, as in many Pacific island nations, they are likely to disintegrate as members either drift to urban areas adding to poverty there, or migrate elsewhere (Sadovy 2005). Planning that will ameliorate this social upheaval is rare.

New fisheries – overfished before they are managed

Fishing is the last major global hunter-gatherer activity that humans conduct. Fishermen seek out new populations to harvest and respond to new markets, a practice that frequently masks fishing impacts on fishery stocks. Few undiscovered stocks remain, but when these are discovered through exploratory fishing in deep slope waters, or when new market opportunities arise, there tends to be a rapid onset and growth of fishing pressure, such that the new fishing stock is largely depleted before managers commence collection of basic data needed to define a management plan. What is missing is the equivalent of an 'environmental impact assessment' (EIA) to determine the capacity of a new fishery before it is fished, and the consistent application of a precautionary approach to management.

Box 4 Fisheries Management Failure in the Galápagos

Galapagos fisherman with a red spiny lobster *(Panulirus penicillatus)* carrying eggs and spermatophore. Photo by: Alex Hearn, Charles Darwin Institute

Fishermen protesting enactment of more restrictive fishing regulations while police bar the entrance to the Galapagos National Park offices. Photo by: Alex Hearn, Charles Darwin Institute

Growing demand, multiple stakeholders, management challenges, and government shortcomings contribute to the failing fisheries of the Galápagos Islands. In the early 1980s, a small (100 fishermen) loosely regulated fishery for sea cucumber, lobsters, sharks, and tuna existed within the Galápagos Marine Reserve. A boom in the valuable lobster and sea cucumber fisheries in the early 1980s prompted a migration of fishermen from coastal Ecuador. A second wave followed a collapse of the mainland sea cucumber fishery in the early 1990s, and by 2006, there were 900 fishermen in the Galápagos Islands (Shepherd et al. 2004). As a consequence, the abundance of lobsters plummeted and the sea cucumber population collapsed, prompting officials to enact a series of emergency fishery restrictions, including complete closures of the sea cucumber fishery. This has increased illegal fishing and pressure on other fishery resources. The social legacy of this weak management is an annual crisis of protests and conflicts between fishermen, resource managers and park administrators with serious threats of violence to people and property. Ironically, the fishermen themselves favored, and lobbied the government for, stricter regulations and better enforcement of existing regulations, including moratoriums on catch and on human migration into the Galápagos (Bremmer and Perez 2002). Not until August 2007 did the President of Ecuador finally approve a law restricting migration. Protests from excluded user groups continue, and whether populations of lobster, sea cucumber, shark, and other species long subjected to over-fishing will ever recover is difficult to predict.

The international live reef food-fish trade is for groupers and other reef fishes that are maintained alive until minutes before cooking. It developed explosively when high retail prices, and improvements in air-freight services, permitted fish to be transported to Asian demand centers from throughout the Indo-Pacific during the last decade (Sadovy and Vincent 2002). Suddenly, reefs that had been fished for local consumption were feeding a demand that appeared to have no limits. The sudden increase in fishing pressure taxed the capabilities of fishery managers in small island states, and the high value of the fishery made fisherman willing to violate regulations, while wholesalers acted as "roving bandits", moving from one place to the next with little concern for local resources. The result has been a dramatic decline in abundance of many reef fish species, and the insatiable demand is pushing populations of vulnerable species below sustainable levels (Johannes and Riepen 1995, Sadovy and Vincent 2002, Scales et al. 2006). Roving bandits also drive fisheries for hagfish, monkfish, spiny dogfish and sea urchin around the world (Berkes et al. 2006, Shakell and Frank 2007). Unlike local fishermen who exploit local resources that they expect to rely on in the future, the international wholesalers have no vested interest in sustaining local stocks, and are very willing to bribe government officials for access permission. The consequences of such access only become apparent to the affected communities much later.

Diversity of fish and invertebrate species on retail sale for the live reef food-fish trade/Sai Kung, eastern Hong Kong. Photo by: Yvonne Sadovy/IUCN

Many novel fisheries are arising as the demand for marine resources intensifies and diversifies. Few such are well served by conventional fisheries science, government infrastructure often cannot address issues appropriately, and most go unmonitored or undocumented (Sadovy and Vincent 2002, Vincent 2006). Other examples include fishes and invertebrates taken for the marine aquarium trade, baitfish fisheries, and juvenile fisheries of a range of species for aquaculture grow-out. Indeed, aquaculture's high and growing demand for fish feed, in the form of small fish formerly taken as by-catch is a growing concern because the demand for fish feed is actually maintaining fisheries that otherwise would no longer be viable because they are too overfished (Naylor et al. 2000).

Conclusions

Our management of most of the world's fisheries remains poor, despite the analytical and enforcement tools that have been developed and the lessons learned over the last couple of decades. Fisheries scientists have given attention to the problems inherent in multi-species fisheries, fisheries using a multiplicity of gears, and especially in artisanal, curio, and other novel fisheries in which (for various reasons) effort does not decline with growing rarity, but this attention has yet to be properly incorporated into management practices, and fishery models typically fail to reflect the real world closely (Caddy and Seijo 2005). In addition, such challenges as corruption, excessive subsidies, and lack of appropriate management infrastructure make it hard to deal with the need to reduce effort, never mind controlling suddenly exploding demand or 'roving bandits'. Efforts to inform consumers about the sustainability of particular fisheries are a welcome new tool for shifting demand towards sustainably managed operations, but they have had only modest success to date. Widespread adoption of the principles and practices laid out in FAO's Code of Conduct for Sustainable Fisheries would improve the dire state of many fisheries, but until fundamental problems in management theory and application are resolved, management is likely to continue to be, in most cases, inadequate and fisheries will continue to collapse.

3.3. Impacts of Coastal Development

The phrase "coastal development" encompasses a wide array of challenges and opportunities, and as population pressure increases, development activities result in ever more modification or elimination of coastal habitats on the land and in the sea. Administratively, coastal development is governed by many regulations at federal through local levels in some countries, while there is relatively little regulatory infrastructure guiding coastal development in others. It is predicted that 91% of coastlines will be impacted by development by 2050 (Nellemann et al. 2008).

Much coastal development is poorly planned and all of it, as well as much inland development, impacts the coastal ocean (Pilkey and Dixon, 1996). Shorelines are hardened, channels and harbors are dredged, spoil is dumped, and submerged and emergent land is moved. Patterns of water flow are modified, and pathways used by organisms in their movements from nursery to adult habitats and spawning sites may also be modified or blocked. Shallow estuarine and marine habitats used by the developing life stages of many economically important invertebrates and fishes are particularly susceptible to direct and indirect impacts from coastal development (Butler et al. 1995, Lindeman and Snyder 1999).

Dredge and fill, and coastal armoring

Dredge and fill activities are used to increase or maintain channel depth, to remove wetlands, to create spoil islands, and to create or maintain marine beaches. They move millions of cubic yards of sediments from one site to another. A well-sanitized language -- reclamation rather than construction, and removal of material from borrow pits – suggests the activity is much less disruptive than it is. Environmental impacts can occur at the mining site and downstream through turbidity, siltation and direct mechanical impacts. At the fill site, the pre-existing marine ecosystem – typically a sandy or rocky ocean floor – is substantially modified, but there are also potentially significant indirect effects on surrounding habitats, fauna and flora, because of the long-term changes in turbidity and water circulation, and the interruptions in faunal movements among habitats that can occur (Messieh et al. 1991, Bush et al. 2004, Peterson et al. 2006). Deepened channels and basins also permanently alter patterns of water flow and require the use of seawalls, dykes and associated armoring methods.

Armoring provides for "shoring up" using large jetties for maintaining channel entrances, and seawall and groin construction on erosional beaches, Offshore megaprojects to create new real estate for industrial, commercial, or high-end residential use are now occurring in some Middle Eastern and Asian countries. Dubai, with a 70 km coastline is adding over 220 km of armored seawalls around five such residential developments. (Box 5)

In many jurisdictions, approval for such construction is not needed, or is granted with only superficial impact assessment (Peterson and Bishop 2005). Approval is particularly routine in emergency scenarios after storms, when the question of whether to rebuild sustainably or to relocate is politically unpopular. Rarely if ever does approval of coastal armoring projects require that they are engineered for consensus estimates of coming sea level rise (Bush et al. 2004).

Box 5 Coastal Zone Management in the Arabian Gulf

In the Middle East, UNU-INWEH has established a partnership with Nakheel, a subsidiary of Dubai World and creator of the large off-shore residential developments Palm Jumeirah, Palm Jebel Ali, The World, Dubai Waterfront and Palm Deira now being constructed along the Dubai coast. Our primary goal is to design and implement a long-term environmental monitoring programme and sustainable management plan for the marine waters surrounding these large-scale developments. To do this requires a programme of ecological/environmental research to understand the nature of the newly developed ecosystems and how they respond to weather and other environmental variables.

UNU-INWEH is using this project as a platform for broader capacity-building in relevant aspects of coastal marine management for the UAE, the wider Gulf region, and internationally. We are offering a series of training workshops on appropriate topics, research collaborations with members of the regional academic community, and international scientific conferences as well as long-term mentoring of Nakheel and affiliated personnel. In this way we intend to share the experience gained in Dubai waters and promote best practice for environmental sustainability in the face of major off-shore construction projects. This project is just commencing its 2nd year, but it is already apparent to us that, despite the enormous differences in environment, economy, and culture, there are similar problems in effectiveness of coastal management in Dubai and in the Caribbean. Administrative structures impede cross-sectoral as well as cross-jurisdictional collaboration, and there is widespread lack of awareness of the ecological characteristics of coastal marine ecosystems and how these characteristics may drive responses of these ecosystems to the novel opportunities or impediments created by large-scale construction projects. There is also a lack of public awareness of the economic and esthetic value of a sustainably managed marine environment.

Large scale reclamation: man-made islands are being built in the shape of palm trees - Palm Jumeirah, Dubai UAE. Photo by: Peter Sale

Land use, zoning, and permitting

Coastal development is driven by business interests, often based off-site, that are behind particular development projects, and by the governments (local, regional and national) that anticipate future tax revenue and jobs. These form powerful allies in favor of coastal development even when it is environmentally and socially unsustainable. Coastal land use and zoning policies put in place tend to focus primarily on each project in isolation, rather than on effects on overall coastal landscapes. A considerable local grassroots and NGO effort exists at village councils, county commissions, and regional planning boards in both wealthier and poorer countries to limit unsustainable coastal development, but these local citizen groups tend to be much weaker than the powerful and organized industry and government interests. A widespread lack of familiarity with principles of sustainable environmental management by those charged with making development decisions combines with the weakness of the opposition to ensure that coastal development usually proceeds with limited scrutiny.

Although many jurisdictions now mandate procedures for acquiring construction permits that include Environmental Impact Assessment (EIAs), there is widespread dissatisfaction with the effectiveness of EIA procedures. Too often, the EIA process has become one in which developer, environmental consultant, and approving agency join in 'ticking off the box', rather than carefully evaluating risk of impacts of the proposed construction project. Construction often proceeds in advance of EIA approval, and in many cases mitigation measures included in EIAs are never implemented or monitored. Even in the U.S.A., with substantially more coastal management infrastructure than most other nations, EIAs and associated monitoring documents routinely suffer from major technical and interpretation problems (Wanless and Maier 2007). Many recent EIA documents and their bibliographies read as if the recent literature on coastal science and management doesn't exist (Peterson et al. 2000, Peterson and Bishop 2005).

New challenges looming

Human use of coastal and ocean waters is changing. Once the domain primarily of fishing, shipping, recreational activities and, in some areas, oil and gas extraction, the sea is increasingly becoming the site for new energy projects, and might soon see new mineral extraction and carbon capture projects emerge. Alternative energy projects such as wind, current, wave, tidal, and thermal energy conversion can help meet our increasing energy demands while curbing global climate change. They also have direct impacts on coastal ecosystems. The Kyoto Protocol has already stimulated development of coastal renewable energy projects, especially wind farms, in Europe (Zervos 2003). In the United States,

Box 6 Tourism and coastal development

While coastal tourism can provide substantial revenue and jobs for poorer countries, tourism also drives many less positive aspects of coastal development. Many regions have been developed for mass "sun and sand" tourism with little attention to long term environmental degradation (Honey, 2002). Conventional business models often neglect environmental and social best practices, and the widespread use of these is a missed opportunity for new on-site measurement and analysis of sustainability practices using business-centric methods tailored for hotel managers (Stewart, 2004). Rapidly developed coastal tourism markets, as in Hurghada, Egypt and Riviera Maya, Mexico, are examples of major infrastructural growth that is degrading the resource base used by the developers as the destination brand in the first place. Modest environmental degradation is not a business problem, because impacts on environmental goods and services are not treated as costs, and marketing adjustments are able to preserve profitability (sun, sand and fun rather than a unique environment; low-cost package deals to generate high volume). Burke and Maidens (2004) calculated the cost in lost revenue due solely to reduced visits by SCUBA divers for Caribbean reefs. Net annual revenue to Caribbean countries in 2000 due to visits by dive tourists were estimated as US$2.1 Billion, and based on expected growth, this would rise to $5.7 Billion by 2015. However, if reefs became moderately degraded (as seems likely), the estimated loss in net revenue was $100 - $300 Million per year. These calculations ignore additional losses if the degradation also began to turn other tourists away.

Mahahual, Costa Maya, Mexico. Growth of an "undiscovered" region exploded in three years (2001 – 2004) based entirely on cruise-ship tourism with low performance in most environmental and social indicators (Greenberg, 2004). Photo by: K. Lindeman

Development should ideally be managed to ensure long-term sustainability of the location's particular environmental features or attributes – the more sustainable the destination's brand, the more sustainable the profits. Instead, investors from out of country frequently "mine" the environment by rapidly locking small communities into artificial economic growth trajectories for short-term profits. Long-term environmental, social and other quality-of-life attributes for the local population are secondary to business plans focused on quick return on investment.

Many policy options exist to aid the development of policies that balance investor needs with local community needs in tourism-based coastal economies. These are underutilized in almost all countries (Honey, 2002), and more business-centric conservation outreach to tourism interests is needed. For example, many large coastal tourism destinations collect substantial bed taxes per visitor-night, but put the money into advertising or development subsidies rather than towards needs like MPA management, wastewater treatment, or public environmental outreach (Lindeman et al 2003). Shifting a small portion (5%) to these needs would be an easily affordable way to ensure the long-term viability of the environment and the tourism and other interest groups it supports. Conservation bed-taxes should become as common as protected area user fees, with benefits on much larger scales.

state-level energy portfolio standards that call for minimum supply from renewable sources, tax incentives, and consumer demand have all spurred growth of wind energy in particular (Bird et al. 2003). If the United States eventually places a limit on carbon emissions through a cap-and-trade system, there will be tremendous incentive for additional growth of renewable energy sources in the world's largest energy consumer (Criqui et al. 2000), which could spur similar development in other nations by creation of a larger global carbon market.

While many ocean energy technologies have the potential to produce energy without greenhouse gas emissions, the impacts of such technologies on coastal ecosystems will need to be effectively assessed, minimized and mitigated (Gill 2005; Pelc and Fujita 2002). Evaluation and permitting of proposals will require an improved framework that more rigorously considers marine impacts, including both local and cumulative impacts. That framework must be developed soon to be ready for the rapid changes that could occur with new incentives to develop renewable sources (Criqui et al. 2000).

In the United States, various state and federal statutes require that a range of environmental impacts be assessed when permitting an offshore energy project, including impacts on marine resources (Santoro et al. 2004). However, two concerns often seem predominant in public debate: aesthetics and bird strikes. These issues, while legitimate, must be weighed against the benefits of transitioning to renewable, clean energy sources, and core ecological and economic costs and benefits must ultimately guide our decision-making. Effects of coastal energy developments on species and habitats below water deserve to receive more attention. The nature and magnitude of impacts will differ among locations, and certainly among different types of projects. Wind turbines

Offshore windpower engines on the high seas, Sweden. Photo by: © M. Woike / Still Pictures

and wave generators are unlikely to impose direct mortality on fishes through physical damage, whereas tidal turbines are more likely to do so (Dadswell and Rulifson 1994). Wave generators will generally have a smaller footprint where each unit is anchored to the seafloor, but tidal and especially wind turbines will each physically displace a larger area of existing bottom habitat.

Often these projects are proposed for sites where the underlying substrate is primarily sand or mud, and the misconception that these are unimportant habitats must be corrected – they are often highly productive and provide support for major fisheries (Thrush et al. 2001). Even in places where the cumulative footprint of energy-generating units is a small percentage of the local area, their presence and density may disrupt the transport of sediment, and can also disrupt the physical and chemical environment in coastal waters by leaking lubricants and other chemicals, or altering electromagnetic fields that can be important for navigation of certain species (Gill 2005). Such potential impacts should help guide the assessment of impacts and strategic placement of valuable clean energy facilities.

3.4. The Pollution Problem

Humanity has been sending wastes downhill to the sea since the first cities and towns were established. This approach worked until the concentration of pollutants became too much for the natural system to deal with. Now pollution of coastal waters is of growing concern due to rapidly expanding coastal populations, their associated cities and industries. Some 80% of ocean pollution originates from land-based activities via runoff, river transport, ground water seepage, or direct dumping of solid or liquid waste. Pollutants include excess nutrients (fertilizers, sewage, other nitrogenous compounds), persistent organic pollutants (POPs) (halogenated hydrocarbons, PCBs, and dioxins), radioactive substances, heavy metals, litter, and excessive amounts of sediment with pollutants or nutrients often bound to them. Each of these pollutants, independently or in combination, can contribute to the degradation of marine ecosystems.

Outside Europe and North America, over 80% of sewage enters the coastal ocean untreated, and the situation grows worse as coastal populations grow. Largely as a consequence, nutrient over-enrichment of coastal waters is a growing problem. In some locations, it results in anoxic "dead zones" seasonally or permanently that have major impacts on fishery production. The largest dead zones at present are in the Gulf of Mexico (70000 km^2, seasonally) and the Baltic Sea (permanent, up to 100000 km^2).

Contamination by POP, heavy metals, and other chemical substances can be locally serious, particularly in Asia, although radioactive contaminants are well-controlled and oil releases have been halved since 1985. Sedimentation is a growing problem in most regions, due primarily to deforestation and coastal development, and marine litter is a growing concern (UNEP 2006). Some progress has been made, but lack of adequate sewage treatment, the formation of large coastal dead zones due to over-enrichment, the abundant stream of new chemicals entering waste water, and the products of electronic waste are emerging challenges.

Cleaning up our oceans

The diversity of point- and non-point sources, the distributive capacity of water, and the difficulty in positively identifying the specific source of an identified pollution problem make coastal pollution a complex issue to manage. It is also made more difficult because most coastal managers lack both skills and administrative or political connections to adequately trace sources of pollution, and then prosecute polluters. Regulators operating closer to sources of the pollution may not recognize that the low concentrations being released are accumulating in the biota of ecological communities miles away and causing significant problems. UNU-INWEH's newest coastal project, Persistent Organic Pollutants in Coastal Ecosystems of the

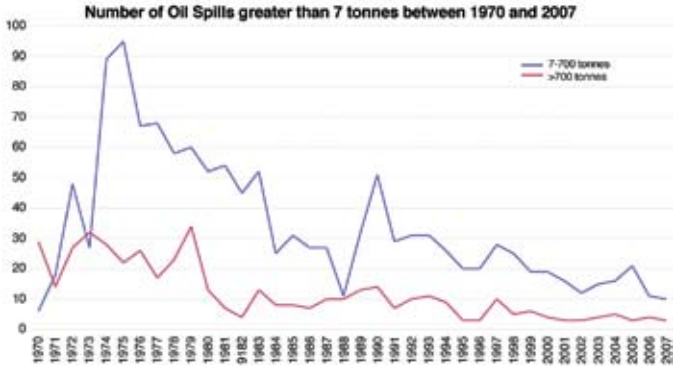
Fish kill (White Perch). Jamaica Bay, NY. Photo by: © Don Riepe / Still Pictures

Caribbean, is an attempt to build South-South partnerships within and across nations of the Caribbean in order to build the linkages between coastal managers and analytical laboratories that will be essential to begin to address the problem of coastal marine pollution by PTS of all types.

Causes of failure to manage pollution vary by region, country and situation. They include inadequate capacity to monitor and ameliorate, inefficient or ineffective bureaucracies, and lack of adequate regulatory and enforcement tools. Corruption, lack of will to enforce regulations or absorb cost of mitigation, and lack of basic understanding of impacts and risks also play important roles. We have been slow to learn, and the damage done to coastal ecosystems is largely out of view.

A clear point source of pollution: liquid waste from a phosphate factory is dumped directly into sea, Morocco. Photo by: © Biosphoto / Digoit Olivier / Still Pictures

A major problem in managing coastal pollution lies in the usual disjunct pattern of coastal management by a wide array of different agencies with different missions. Effective management of pollutants requires these agencies to work not only together, but also with agencies managing other sectors such as agriculture and industry. Such an integrated management approach, including a regional – perhaps international – focus, is needed because pollution management requires shared responsibility between neighboring coastal zone managers, water quality agencies, land use planners, decision makers and neighboring countries. The need for integration is most apparent for non-point source pollution due to agricultural run-off, groundwater discharge, and releases from moving vessels, and success with non-point source pollution has been quite limited. Some success in achieving such integration has come through international Conventions and Treaties established to foster pollution management. Examples are the reductions achieved in ocean dumping, discharges from industry, oil spills, and specific toxic pollutants. UNEP's Global Programme of Action for the Protection of the



Some good news, the number of oil spills has reduced over time

Marine Environment from Land-Based Activities (GPA) has now been adopted by 115 governments. So far, more than 60 of these countries have developed national action plans, some of which have included revisions to, or enactment of new laws in areas such as coastal policy, water policy and integrated coastal management.

Since 1959, the International Maritime Organization (IMO) has promoted the adoption of some thirty conventions and protocols dealing with maritime pollution. One such Convention (MARPOL) deals with the prevention of pollution from ships, including all forms of ship-caused marine pollution except the dumping of land-generated waste. This Convention reduced global oil pollution of the marine environment by 60 per cent from 1.4 million tonnes in 1981 to 580,000 tonnes in 1989 (Oil in the Sea III, 2003). The ship construction requirements of MARPOL have made a significant contribution to the global reduction in oil spills in recent years, with the average number of spills from tankers down to about one-third of the level seen during the 1970s.

Cost of inaction

Coastal ocean pollution brings economic and human health costs. Effects on human health are numerous. People are exposed to water-borne diseases by bathing and swimming, and to heavy metals, POP or other toxins that have bio-accumulated in the food chain by consumption of contaminated seafood. The annual global impact of human infectious diseases due to contact with polluted coastal waters is approximately 3 million `Disability-Adjusted Life Years`, with an economic loss of US$12 Billion (Shuval 2003). Non-health economic costs are also substantial. In 1998, a pollution–caused major algal bloom of *Gymnodinium mikimotoi* and *Gyrodinium sp*. killed most fish in Hong Kong harbor with an economic loss to the fishery of US $40 Million (Songhui and Hodgkiss 2004). Tourism, which drives economies of many developing countries, can also be greatly impacted by coastal pollution – littered beaches, dying reefs, smelly waters, poisoned fish and shellfish and uncontrolled discharge of waste water into the coastal waters do not make for an attractive holiday environment.

Improving pollution management also carries significant costs for facilities and trained staff in management agencies, and infrastructure for sewage treatment. It also requires improved land-use planning and zoning practices, stronger waste management regulations and penalties, improved agricultural methods, and educational awareness efforts. EPA (2008) estimated that total capital investment needed to control wastewater pollution in the U.S. over the next 20 years was $202.5 Billion, an increase of $16 Billion over the estimate provided in 2000. The increase in overall cost was due to a combination of population growth, more rigorous water quality standards, and aging infrastructure. The economic cost in countries with currently negligible control of pollution will be substantially higher, but the cost of permitting continued deterioration of coastal ecosystems will be far greater than that. For example, Chesapeake Bay was once the most valuable site for commercial fisheries (menhaden, oysters, red drum, white perch) in U.S. waters. Beginning in the 1960s, increasing nutrification, chiefly from domestic wastewater discharge and agricultural run-off, has reduced a $3 Billion per year fishing industry to $100 Million (Randall 2003).

Pro-active management versus reactive management; an example of the latter is putting up a sign on the beach warning of the dangers of swimming in water polluted by sewage, New Zealand. Photo by: © Lorraine Adams / UNEP / Still Pictures

There is a need globally for promotion of better use of market-based instruments, such as taxes, charges and tradable permits, in environmental policy. For example in much of Western Europe and parts of North America comprehensive systems for charges for air and water pollution, for resource use and for generation of waste are being implemented. These effectively move the cost of pollution mitigation back to the individuals and corporations that generate the pollution, instead of leaving them as costs borne by the community.

3.5. Marine Protected Areas

There are about 4600 MPAs worldwide, covering about 2.2 million km^2 or 0.6% of the world's ocean surface or 1.4% of the global coastal shelf area (Wood 2007). They are fast becoming the principal tool used for conservation management in the coastal ocean. These range from large, zoned, multi-use areas to the more common, smaller, usually un-zoned sites in which all or certain extractive activities are prohibited (World Bank 2006). All MPAs are locations within which certain types of human activity, and particularly fishing, are regulated more restrictively (usually banned in un-zoned MPAs) than they are outside those boundaries.

MPA networks: what are they in reality?

Terrestrial conservation increasingly uses a series of protected areas with buffer zones, linked by corridors to allow the direct dispersal of animals between the different components. In the marine environment, most MPAs have been established on an ad hoc basis with few attempts to design an interconnected system. Selecting a suite of sites based on their individual priority for biodiversity conservation, as sometimes happens, is not likely to be sufficient, because appropriate linkages among sites must be provided. These depend on specific connectivity processes that are as yet poorly understood, and further research on this topic is needed (Sale et al 2005).

There also appears to be an over-reliance by managers on the no-take protected area concept. MPAs can manage activities that occur within their borders well, but MPAs have been particularly ineffective for managing fisheries in surrounding waters, or extrinsic disturbances such as coral bleaching, pollution, or invading species (Jameson, et al.2002). Yet, much of the literature on protected areas is advocacy suggesting that a network of MPAs is practically all a nation needs to effectively manage its coastal waters. Of course, if numerous, well-managed, MPA networks existed, our coastal ocean would be in much better state than it is – mostly there are small, isolated, poorly managed MPAs. This management tool could be used much more effectively than at present, and with some additional research it should be possible to design networks of MPAs effectively (World Bank 2006)

Box 7 Connectivity and management of coral reef systems

Under the title Coral Reef Research and Capacity Building, UNU-INWEH directs the Connectivity component of the GEF-funded global project: Coral Reef Targeted Research and Capacity Building for Management (CRTR). The CRTR project, implemented by the World Bank and executed by University of Queensland and now in its 4th year, seeks to integrate advanced scientific research on questions deemed critical for improved management with capacity-building efforts in key regions of coral reef development around the world. We have focused the Connectivity component on the Mesoamerican Reef region of the western Caribbean (Mexico's Yucatan coast, Belize, Guatemala, and the Bay Islands of Honduras). The programme concerns the linkages between reef species populations due to larval and juvenile dispersal – linkages which should be fundamental to design and management of MPAs. Through demonstration research projects, capacity-building workshops, and advanced training of students we are developing tools, measuring connectivity for selected species at specific sites, and extending local knowledge of the importance of connectivity in management planning. The next phase of this project will need to focus more explicitly on building effective links between managers and the science community, and a coherent effort to advance a scientific approach to MPA design and management that is sorely lacking in much of the world.

Coral reef, Caribbean. Photo by: © Jonathan Bird / Still Pictures

Natural and social science of MPAs?

An MPA usually restricts fishing. This has important implications for the fishing community, and there is likely to be little compliance with MPA regulations if the local community is not properly engaged (Agardy 2005, World Bank 2006). How individual fish move about, relative to the locations of MPAs, determines the extent to which fishing pressure is reduced. Thus MPAs should be situated in places where the fishes are otherwise most vulnerable to being caught, and they should be of sufficient size to enclose individuals during vulnerable times. Despite this logical and direct link, MPAs are routinely established without reference to this need, and no science exists documenting the relationship between, for example, MPA size or shape, and effectiveness for particular species (Sale et al. 2005).

The *30% rule* advocates placing 30% of all coastal waters in no-take MPAs, and was recently used effectively in rezoning the Great Barrier Reef Marine Park to increase the area of no-take zones. This rule is a rule of thumb developed during deliberations of an expert panel charged to recommend on fishery management for the Florida Keys (Plan Development Team 1990). It derives from a logical, but totally untested, argument that protecting this fraction of habitat will protect this same fraction of a fish population, and that protecting 30% of the population provides escapement for 30% of eggs released. This extent of escapement is held by some to ensure a sustainable catch. The 30% rule is an example of 'collective subjectivity', an accepted approach when adequate empirical data are lacking. The problem is not the existence of the 30% rule, but the widespread complacency that, with this rule available, there is no need for research on the important topic of how much ocean area should be placed in no-take MPAs.

Every MPA deprives the local community of an area in which to fish, while providing a conservation benefit for organisms residing within it. Yet numerous MPAs have been sold to stakeholders as tools to improve fisheries in surrounding waters. There is evidence of modest spillover or out-migration of adults from no-take reserves, but the larger expected downstream "recruitment effect" of reserves has yet to be documented (Sale et al 2005). This should give managers cause to rethink how they promote this management tool to the stakeholders who must live with it. Only in places where the effect on the livelihood of local populations can be shown to be positive, by improving fishing elsewhere or by replacing fishing with more profitable employment, is stakeholder support for MPAs likely (Agardy 2005).

Properly protected areas are rare

MPAs are widely advocated and widely declared. But nearly all of them are paper parks (Mora et al 2006). They are legal, may have management staff, usually have detailed regulations governing their use, but there is little if any enforcement of regulations.

The paper park syndrome exists for several reasons. Many coastal states have quite limited budgets, and adequately resourcing an environmental management department to administer MPAs simply does not happen. Some governments

calculate that putting a law on the books creating a protected area is sufficient to satisfy international scrutiny, comply with international treaty obligations, and keep donor organizations willing to continue investments. Donor agencies, including UN and other multinational agencies, and the international environmental NGO community are perhaps too willing to tick off the box on legal creation of an MPA as a sign of progress, without monitoring to ensure the MPA actually becomes protected. Indeed, the financial donors of NGOs are usually more enthusiastic about the creation of new MPAs than about management of existing ones. The time, effort and money invested in the creation of MPAs that do not become properly managed has been a significant drag on the effort to improve coastal management – a drag that the system can ill afford.

Swimming narrow belt transects to cencus reef fish and estimate abundance and diversity. Photo by: Cynthia Shaw

3.6. Species Introductions

The planned introduction of exotic usually terrestrial species used to be a common practice, to make colonized lands seem more like 'home', to bring new agricultural species to a region, or to attempt to control previously introduced noxious species. In the marine environment most planned introductions have been of open aquaculture species, such as certain oysters or other fishery products, however, snappers of the *genus Lutjanus* were successfully introduced into Hawaiian coral reefs from the Marquesas Islands during the early 1950s, filling a perceived gap in the fish community structure on those reefs. Unlike most introduced species, *Lutjanus kasmira* became established, and have not had any particular effects-either positive or negative-on the ecology of Hawaiian reefs (Friedlander et al. 2002).

Today, anthropogenically facilitated, yet unintended, invasions have become far more prevalent, and much more important, and their rate has been accelerating with increased trans-oceanic shipping. While tools such as ballast water regulations can help stem the flow, management of introductions largely exists in a reactionary/response mode world-wide. Most nations are well aware of the issue and some have programmes in place to respond to new invasive species. The economic implications are obvious when invasives out-compete natives for space and disrupt ecological and economic balances within a given region.

Many foreign aquatic species arrive in ports and harbors via ballast water or biofouling. Management of these threats is both more proactive and better integrated internationally, thanks to programmes such as the GEF/UNDP/IMO Global Ballast Water Management Programme (globallast.imo.org). GloBallast is assisting countries to reduce the transfer of harmful aquatic organisms and pathogens in ships' ballast water, implement the IMO ballast water Guidelines and support the new IMO ballast water Convention.

Other invasives migrate through new canals and seaways or arrive with marine debris. The discard of unwanted aquarium species, the accidental or intentional release of live seafood, and the escape of pen-reared aquaculture species are additional pathways. Invaders are seldom detected before they have already become well established and efforts to eliminate them have a high rate of failure. The invasions of both Asian carp in Columbia-Missouri rivers of the USA, and zebra mussels in the Great Lakes region are clear examples of species with negative consequences (Chick and Pegg 2001, Karatayev et al. 2007).

Atlantic salmon (*Salmo salar*) are now sea-ranched in large cages in all oceans, and inevitably there are escapes. Their invader risk lies in the possibility that such escapees will survive to out-compete native salmonid species, or to interbreed, introducing genes deleterious for survival in the natural environment. The green alga, *Caulerpa taxifolia*, has become a major pest species in the Mediterranean extending over 6000 hectares of shoreline. This was a well documented escapee from the aquarium industry first seen in 1984 at Monaco, and has proved well-adapted to the environments of the Mediterranean shoreline, as well as to other countries, such as Australia (Meusnier et al. 2001). The same genetic strain has

The Pacific Lionfish or firefish (*Pterois miles*) has successfully invaded several western Atlantic sites. Photo by: © H. Goethel / Still Pictures

more recently been found in Carlsbad and Huntington Harbor, California (Jousson et al. 2000) and concern is expressed for its likely impacts on biodiversity there. Another undoubted aquarium escapee is the Pacific Lionfish (*Pterois miles*), which is now well established in Florida, North and South Carolina, and on Bahamian reefs, having first been sighted in Biscayne Bay in 1992 (Meister et al. 2005).

While managers are generally aware of their impacts, and some programmes exist to control them, the rate of spread of invasive species due to economic globalization exceeds the pace at which management can effectively respond. This issue will only increase in severity.

3.7. Synergies Among Problems

Various management problems may interact with each other, sometimes in non-intuitive, and frequently in synergistic ways. Overfishing, whether through poaching or through inadequate fisheries management, has direct effects on fishery stocks, but it can also have effects on benthic communities through modification of grazing regimes, and through the damage caused by some types of fishing gear, such as trawls. Aquaculture affects fishing practices through its demand for forage fish, but also contributes to pollution of coastal basins and the risk of escapees. Pollution by nitrates and phosphates will stimulate plant growth, with complex and highly damaging effects on aquatic systems, including harmful algal blooms, creation of dead zones, and (in extreme cases) system-wide eutrophication. Pollution by more exotic chemicals may have very different effects on different organisms in the downstream waters, and modify community composition as a consequence. A coastal development may cut a critical pathway between nursery and adult habitats of a critical fishery species. The severe die-offs of American Lobster in Long Island Sound in 1999, and of Atlantic cod in eastern Canadian waters in 1989-92 were both due to the synergistic effects of multiple factors including over-fishing and climate changes (Myers et al 1997, Balcom and Howell 2006).

To deal effectively with this synergy requires a more holistic approach to management, but this is impeded when management is not integrated across government departments. In such circumstances, causes of perceived problems may not be recognized, and what appear to be straightforward solutions to those problems may be ineffective. In particular, because there may be several management problems present at once, a one-at-a-time approach to solving them seldom yields the dramatic results that may be needed to encourage buy-in by stakeholders and continued effort by managers.

Sea cages of a Norske Salmon farm on the west coast of Scotland; escapees from these cages can compete and/or interbreed with native salmon species. Photo by: © Adrian Arbib / Still Pictures

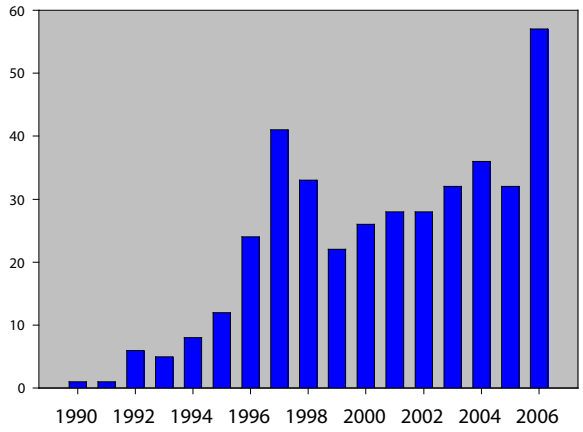
4 Critical Improvements Needed

Three critical needs can be identified, without which, improvement in the management of coastal environments is very unlikely. The first is to improve the integration of management, both geographically, and across administrative departments and management targets. The second is to build better understanding of the true value of the goods and services provided by sustainably managed coastal environments, and to promulgate knowledge of this value so that communities recognize what is at stake when their coastal ecosystems become degraded. The third is to tackle the many reasons for failure of management effort that are encompassed by the phrase 'lack of political will'. Here we examine each of these, and propose steps that will lead to improvement.

4.1. Integrated Management

The emergence of holistic management

The provocative notion that management should focus on whole ecosystems rather than species or specific locales has become a common theme in the marine literature. "Integrated coastal zone management" (ICZM) recognizes the strong connections between adjacent marine, freshwater, and terrestrial habitats, and the benefit of undertaking environmental management in a unified way over regional scales, while "ecosystem based management" (EBM) emphasizes a shift from single- to multi-species management by restoring and maintaining whole ecosystems.



Graph showing the explosion of published scientific papers concerning ICZM or EBM in the marine realm. Based on a December 2007 review of all papers with ICZM or EBM appearing in the abstract using the Cambridge Scientific Aquatic Sciences and Fisheries Abstract Indexing service.

Bridging artificial boundaries

The primary challenge in ICZM is to bridge administrative boundaries separating departments with different environmental responsibilities, and political boundaries among states or nations. These bridges permit a management plan that is effectively seamless. This is not easily done and despite many years of academic discussion, clear examples of truly integrated CZM are rare.

Where there is sufficient political will, the bridging of political boundaries is usually done by the development of mirroring legislation on the two sides of the border so that separate political entities retain sovereignty while management proceeds as if the border was not there. It seems more difficult to bridge administrative barriers, because fisheries managers, conservation managers, and others do not speak the same scientific language, nor share the same specific goals. The benefits of cooperative management may not be immediately obvious, and will likely run counter to natural bureaucratic tendencies to protect turf and to grow.

Nowhere are all components of coastal ocean management handled as an integrated whole. Most frequently, the management of water quality and environmental pollution is separated from that of fisheries or environmental conservation, and management of coastal construction is usually handled on a case-by-case basis as part of the development approvals process. Significant trans-boundary enforcement problems also exist, affecting trade and management in neighboring jurisdictions.

© Biosphoto / Gunther Michel / Still Pictures

With countries routinely claiming jurisdiction out to 200 nm, and their coastal states claiming responsibility out to 3 or 12 nm, most coastlines present a patchwork of administrative units separated by both intra- and international boundaries, and the overall effectiveness of an integrated management programme must depend on the capacity of the least effective of these units. In many poorer countries, management within MPAs has been delegated to, or assumed by, various NGOs, each with their own agendas and regulations adding further complexity.

The Atlantic States Marine Fisheries Commission (ASMFC) is an example of a relatively effective trans-boundary management device. The ASMFC was formed to help coordinate fishery management practices among the multiple jurisdictions that exist along the east coast of the United States. The ASMFC strives to balance the political realities regarding political boundaries with the ecological reality that many of the fishery stocks along that coastline are indeed shared. The ASMFC preserves states' rights while emphasizing an integrated coast-wide fisheries management, but its success has not been total. It has helped to standardize fishery regulations and establish fishery quotas, but it has been less successful at integrating habitat management along the coast due to within-state, multi-agency jurisdictional issues.

The challenges of ICZM and EBM implementation

Despite being broadly endorsed by scientists and managers, introduction of ICZM does not yet have a clear way forward. Regardless, ecosystem-based plans of action are being implemented worldwide and though often idiosyncratic in their detail, some general insights have emerged. Implementation of EBM in the Northwest Hawaiian Islands, for example, required the creation of collaboration tools, such as interagency working groups and cooperative multi-disciplinary review of coastal zoning and permitting applications (Fielding and Chow 2006). Likewise, the framework for Australia's national ocean policy is founded largely on EBM and although not yet fully implemented, new initiatives, institutions, and governance processes have greatly improved coordination among disparate jurisdictional sectors (Vince 2006).

Another challenge in implementing ICZM is the need to plan globally while acting locally, because broad-scale management plans imposed from above rarely obtain local buy-in. The importance of explicitly including non-traditional stakeholders, especially artisanal fishermen who often bring to the table a cultural predisposition for holistic management approaches, has been a common lesson when developing EBM plans in locales as diverse as Hawaii (Fielding and Chow 2006), Madagascar (Rakotosan and Tanner 2006), South Africa (Branch and Clark 2006), and the United Kingdom (Shipman and Stojanovic 2007). If stakeholders do not see tangible benefits from a particular resource management scheme, their compliance with management regulations will be compromised (World Bank 1999, 2006, Geogehan et al. 2001, Christie et al. 2005).

Recent advances in modeling techniques capable of simultaneously seeking multiple objectives (such as ecosystem conservation, risk management, and conflict minimization) are easing the introduction of ICZM (Carr and Crist 2007). Models developed for specific regions such as south Florida (Butler 2003, Butler et al. 2005), the Black Sea, and the coast of Denmark (Rasch et al. 2005) explicitly incorporate an integrated coastal zone approach in considering the effects of coastal land and freshwater management on coastal water

Sun and sand tourism are primary components of market-based coastal economic valuation in many countries: beach tourism in Calella, Spain.Photo by: © Biosphoto / Borrell Bartomeu / Still Pictures

quality and ecological communities. Further advances are likely, however other technical impediments remain. One vexing issue is the establishment of valid and universally accepted ecosystem reference points to assess the effectiveness of ICZM (Babcock and Pikitch 2004). Candidate reference points range from measures of the abundance of single species or guilds (Hooker and Gerber 2004) to comprehensive environmental impact assessments that capture most measurable change in the ecosystem (Scandol et al. 2005). However, recent Australian studies suggest that indicators at the level of the ecological community are the most reliable, and that it is necessary to use a variety of indicators simultaneously to detect the full range of impacts (Fulton et al. 2005).

Our ability to quantitatively assess multiple ecosystem stressors and deliver scientifically defensible strategies to avert environmental degradation is still in its infancy, and a precautionary management approach is the safest strategy in lieu of more explicit information for managing environmental risks. Boesch (2006) suggests that emerging concepts of ecosystem resilience provide promising theoretical underpinnings and that EBM could be advanced by:

1) more scientific activity on ecosystem restoration techniques,
2) more attention to predicting restoration outcomes that consider possible state changes and ecosystem resilience,
3) more effective scientific reporting to characterize and effectively communicate uncertainty, and
4) better integration of modeling, observations, and empirical research to facilitate adaptive management.

4.2. Assigning Value to Coastal Environments

Coastal management will more rapidly realize its potential if the full value of sustainably managed coastal ecosystems can be computed, advertised, and employed in decision-making. We must explicitly recognize the full array of values, and encourage agencies, industry, and local communities to employ these valuations in order to build impetus for coastal protection.

Few people are aware of the full value of coastal ecosystems which extends far beyond the market value of their harvested resources (NRC 2005). Coastal ecosystem goods and services play a critical role in the economic, social and environmental health of all citizens on all coasts. Four categories of ecosystem services: regulating, supporting, provisioning, and cultural, were identified by the Millenium Ecosystem Assessment (2005), based on Costanza et al. (1997) who identified at least 17 ecosystem services and associated functions ranging from climate regulation to soil formation to recreation. All of these categories and their services add to the value of coastal areas, but many are not directly amenable to traditional market-value based valuation tools. Research progresses on the valuation of coastal ecosystems and the impact of perverse subsidies (Wilson and Liu 2007, Bagstad et al. 2007), but ecosystem value does not yet play the role it should in management decisions.

Catch and release fishing has developed into a significant local economic driver and alternative to mass sun and sand tourism in some countries. Photo by: K. Snyder..

Market and non-market values

Measures of economic health continue to favor simpler, short-term growth metrics such as GDP, rather than complex, but more thorough valuations that include non-market services. Yet with the application of new tools for valuing non-market services and traditional market methods for harvested goods, it should be possible to more logically influence decision-points in environmental management (Costanza 1999, Burke and Maidens 2004).

Coastal fisheries and "sun and sand" tourism are primary components of market-based coastal economic valuation in many countries. For fisheries, valuation is commonly based on market value alone, and the non-market fishery value of habitat and water quality is usually ignored. Commercial catch and effort statistics are usually available at a national level as annual data on FAO websites, but catch data from less developed countries can be limited or unreliable. The value of artisanal fisheries is quite difficult to estimate despite these being the main driver for many local economies, while recreational (or "sport") fisheries in some wealthier countries can have very high market valuations (e.g., US$ 6 billion per annum in Florida), while their advocates gain concomitant power in terms of political positioning. Recreational fishing in many poorer nations exists as a small, niche industry practiced almost entirely by tourists, and is sometimes best valued as a component of tourism.

For tourism, while valuations are also largely market-based, it is recognized that environmental sustainability has importance because of links to market value. If standards of environmental quality are allowed to slip at a destination, values generally also fall. This can narrow market focus, and critical decisions are

Box 8 Mangroves and tsunamis

Sometimes data do not support common assumptions concerning value of ecosystem services. The value of coastal vegetation, particularly mangroves, in providing storm protection is a recognized ecosystem service. Following the devastating tsunami that followed the Sumatra-Andaman earthquake of December 2004, and created enormous property damage and loss of life from the Indonesian archipelago to East Africa, a number of claims were made that communities on shores with well-established mangrove forests fared better than others. More detailed research has called this general conclusion into question. It now appears that mangrove forests do offer significant protection from most storm-caused wave action but this protection decreases monotonically with increases in storm intensity (Kerr and Baird 2007). Despite this, many NGOs and multinational agencies have used tsunami protection as a 'new' way to justify new projects to establish or improve mangrove forests along tropical coastlines.

Of course, mangroves provide many other important ecosystem services to coastlines that possess them, including provision of essential fish habitat (EFH), filtration of pollutants and sediments from upland sources, and erosional protection, so there remains ample reason to manage them more effectively than is currently the case in most parts of the world. Modest investments in early warning systems, and encouragement to build settlements on higher ground, might be more beneficial for tsunami protection.

Mangrove forest. Photo by: iStock Photo © Alberto Pomares

likely to be forced by unsustainable efforts to preserve revenue or to pay off infrastructure loans, rather than by efforts to secure long term environmental sustainability. The valuation of environment for tourism is often further complicated by government subsidies that distort true values and foster further development even when it is environmentally unsustainable. Many examples exist of tenuous expenditures and subsidies leading to environmentally damaging river and beach management (e.g., NWF and TCS, 2004; Bagstad et al., 2007).

Business and government agencies often remain reluctant to abandon current paradigms based on markets and quarterly/annual production. One problem is that strong measurements of non-market services are often difficult to obtain, because of the complex nature of the measuring tools typically used (e.g., hedonic pricing, replacement cost, contingent valuation methods). Continued efforts to make ecosystem service valuation accessible to business people and politicians are necessary.

Towards full economic valuation

The concept of total economic value (TEV) is a framework for identifying and categorizing ecosystem benefits (Barbier 2005). It computes total net benefits by summing all net benefits from use and non-use values (NRC 2005). Diverse methods move beyond market prices to assess public preferences or estimate values indirectly through purchase of related goods and services.

Non-monetary valuation techniques, measuring items such as quality of life, deserve more development (Costanza et al. 2007). Ecosystem services can carry significant social and cultural value, adding complexity to attempts to compute TEV. Certain coastal fisheries have cultural values that are greater than their economic value (Johannes 1981, Pauly 1995), and such cultural values can manifest in market settings (e.g., the continued illegal taking of sea turtle eggs because of tenacious social beliefs in their power as aphrodisiacs among some cultures). Knowledge of these cultural values can explain fishery performance, and can provide effective incentives that manage effort. There are also the remediation costs following inappropriate action, such as the cost to make an environment safe for human health following pollution – these can be extremely large. There is clearly room for further research on ecosystem valuation, but that is no good reason to defer efforts to incorporate TEV estimates, where possible, when prioritizing management actions.

At present, Australia's Great Barrier Reef (GBR) is valued primarily for its tourist revenue and fisheries yield. The tourism revenue alone is now estimated at US $6.22 Billion per year (2005-6, AU$6.877 Billion; Fenton et al. 2007). In the 1970's, tourism was smaller in scale, but many overseas visitors still chose to visit the GBR and this importance was not fully recognized. In the mid-1970s, a perceived threat of oil exploration on the GBR stimulated heightened public awareness of the "iconic" or heritage value of the GBR. This heightened awareness ultimately led to passage of legislation permanently banning the extraction of oil or gas from the GBR, and for legislative and other actions that created the GBR Marine Park and, ultimately, the World Heritage Site designation. Australians now assign a (non-monetary) value to the GBR far beyond the very substantial economic value it provides. Such iconic value is assigned to other places of spectacular beauty, or particular environmental significance – examples include the Galápagos Islands, Ecuador, Dorset and East Devon Coast, UK, Tubbataha Marine Park, Philippines, and Sian Ka'an Biosphere Reserve, México – and multi-

national instruments such as World Heritage or Biosphere Reserve status foster such attitudes. These can provide a valued driver for sustainable management.

The rapidity of the turn-around in national attitudes on the value of the GBR holds out hope for the likelihood of future revisions of attitudes in other places. Of course, bringing about such changes requires concerted effort in each community simply to counter the opposition from interests that benefit when coastal areas supporting healthy ecosystems are undervalued. Using the market value of tourism and other coastal industries in addition to fisheries yield, and combining these with non-market values for ecosystem services, cultural and ethical values, we can build the understanding necessary to establish the TEV of coastal environments – and the ultimate costs of non-management. Perhaps these tasks should be seen as one of the greatest priorities for the international NGO and economics communities at the present time.

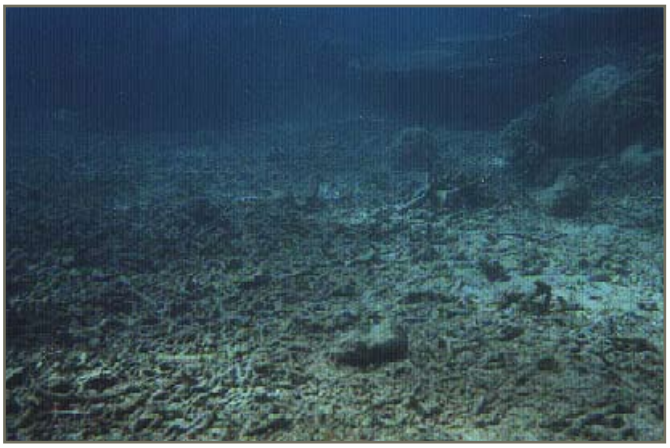
4.3. Political Will

The throw away excuse

Critics often attribute the failure of coastal management to a "lack of political will", and cite this as a major reason that solutions to environmental problems have made little progress in the marine realm. For example, "paper parks" are referred to as proof that governments give lip service to sustainable management, yet lack the 'will' to follow through with monitoring, outreach or enforcement.

The term "lack of political will" oversimplifies complex challenges to implementing sustainable management. Political will is not solely about "politics" although politics is one part. Good governance, once policies have been set, can definitely lead to good environmental stewardship. However, governing policies have to be implemented by an appropriate administrative structure, and must be grounded in the realities of coastal living – they must be adopted by the local community, build from an understanding of the environmental and social drivers that affect their ecosystem, and must manage their human impacts upon it. This grounding is not necessarily reached through political compromise among alternatives. Nor is it necessarily achieved when results must be measured on short, election-cycle timelines typical of political life. And when management confronts trans-boundary issues, as it often does in the marine environment, the process of developing agreed management plans is complicated by the differing political schedules and priorities of the partner states or nations. None of these issues is as simple as the will of politicians to act.

Governments have frequently decided to promote economic growth or other priorities ahead of environmental quality,



The destructive effects of dynamite fishing (or blast fishing); although outlawed, the practice remains widespread in some regions. Photo by: Hanneke Van Lavieren

failing to realize that one can have both. In many such cases they have acted with inadequate information concerning the long term economic benefits of proactive environmental policy, but such decisions remain reasoned decisions on priorities (even if incorrect), not cases of a lack of will to make decisions. In many poorer countries, governments do not have sufficient resources or capacity available to address the full range of issues before them, or may have the financial and human resources, but cannot sustain the commitments needed to manage marine resources across extended fiscal or electoral cycles. Individual members of their populations are faced day to day with problems that demand all of their resources in order to continue to feed and shelter themselves and their families. Environmental protection is a lesser priority for both people and government when issues of basic need and survival persist, even though economic degradation is often correlated with environmental mismanagement (Diamond 2005).

Successful coastal resource management usually enjoys strong support from the local community, and the value of working locally to build effective management is widely recognized. Local decisions are the closest to, and most effective for, management of the resource base, can have the greatest impact on resource use, and can most readily adapt to changing situations. Local communities are also more likely to benefit from support networks that help regulate behavior and actions through the twin forces of social influence and moral obligation (Kuperan and Sutinen 1998). On the other hand, local government is also the most accessible, can be most readily influenced by special interests, and usually imposes the mildest penalties for infractions against regulations and ordinances. Locally developed management can be successful, but it can also be weak and ineffective, depending largely on the overall effectiveness of relationships between government and governed. And it can result in poor integration across jurisdictions.

Multinational or regional projects more readily conform to holistic, ecosystem-wide management paradigms, but it is much more difficult to develop strong buy-in and compliance from local communities and they frequently fail. A regional initiative can serve a crucial coordinating role by providing important communication and education throughout a region, and it can foster competitive spirit and peer-based expectations for meeting mutually agreed-upon targets. It also offers economies of scale where human and financial resources are limited. However, a regional project can fail because a single partner lacks capacity, fails to contribute, or lags behind with previously agreed-upon responsibilities. When this happens, for whatever reason, that partner brings failure to an otherwise well-conceived regional initiative. Past projects to improve environmental management within the Latin America and Caribbean regions have involved as many as nine partners across seven different countries with more than 100 collaborating organizations. This more often than not translates into excessively high transaction costs, less of the investment or activities having measurable ground-level effects, an inability to effectively measure success because of the level of complexity involved, and, most importantly, poor or absent buy-in from local stakeholders.

Public awareness and education programmes are essential in building support within communities for major changes in management, and management can fail because of inadequate attention to this need (Alder 1996). In reaching common understanding, stakeholders have to rely upon documentation in the form of agreed upon principles, priorities and management plans, and an appropriate scientific input can aid in this process. There is a need to guard against the tendency for the development, public consultations, and political adoption of management plans to become an end unto itself (Pandolfi et al. 2005). Nevertheless, whether at regional, national or local governance levels, public consultations must take place to validate management plans and build community support for their goals, priorities, and regulations. Systematic support of such consultations can build a network of leaders within regions with the potential to make significant improvements in marine resource management.

Improving capacity: mangrove biodiversity training in India. Photo by: K. Kathiresan, Annamalai University

Building political will

While it is easy to identify the components of weak political will, the steps that are needed to improve this situation are less easy to define. It will not happen without outside encouragement, and we identify important roles for the international community (multinational agencies, and international NGOs) and for the science community. Success is more likely if efforts are applied locally and sustained long enough to be effective, but there is also an urgent need to commence this process around the world.

Actions by the international community

Elements within the international community should undertake to work with local partners to increase transparency in all governmental processes that lead to management decisions for the coastal environment. By doing so, they will be able to illuminate the components that contribute to weak or failed management policy and practice. In this way it becomes possible for the public to demand changed rules and better application of those rules in order to achieve effective management.

Greater transparency will reveal financial and human resource failures in management agencies, poor administrative structures and procedures, lack of accountability for failure, and evidence of corruption in government and the community that distorts management action. Local political action may then be enabled to bring about reform. Goals should include:

- **Improve financing and reduce damaging subsidies** – Effective management requires adequate financing, but many poorer countries lack resources to adequately support activities across all sectors. It is therefore important that taxes or fees generated by users of the marine environment (fisheries and tourism, chiefly) are retained locally, or transparently distributed to ensure adequate support for local environmental management. This builds stakeholder support and rewards management success. Subsidies such as tax concessions to developers, grants that encourage overcapitalization of commercial fishing fleets, and pork-barrel funding of coastal infrastructure projects drain current and future treasuries while degrading the environment. A well-informed public is able to pressure government to avoid granting subsidies, while also ensuring fees earned from healthy environments support environmental management. As well as encouraging financial transparency by governments

and management agencies, the international community should demand maximum effectiveness in the use of any funding provided from external sources.

- **Improve capacity-building and training** - The highly variable nature of employment in governmental management agencies of poorer nations can limit effectiveness and the morale of qualified staff, yet effective environmental management requires scientific and other skills. The international community has recognized the need for building human capacity in management agencies, but while it has done a good job of providing educational opportunities, it has paid less attention to ensuring employment is available following training.

- **Reduce corruption and bureaucratic inefficiencies**- Byzantine administrative structures can result in power struggles, unnecessary paperwork, and other inefficiencies that disrupt, bias, or delay granting of permits and enforcement of regulations. Stakeholder compliance is reduced when management appears to be ineffective or unresponsive (Kuperan and Sutinen 1998). Corruption throughout government and communities is a very widespread problem that is more serious in poorer nations (Transparency International, 2007). Corruption has a long-standing history within environmental management through its effects on the police, political parties, legal/judicial system, and registry and permit services. The result is biased management action, and concomitant failure of stakeholder support. Environmental audits and similar devices which highlight failures due to inefficiencies or corruption can build public will for improvement.

Local and international NGOs, and the multinational organizations should also put renewed effort into culturally and educationally appropriate public outreach to ensure that coastal populations have the knowledge to understand the value of sustainably managed coastal ecosystems, and make their political decisions accordingly. In undertaking this educational effort they should consider the following tools and approaches:

- **Assemble and use adequate socio-economic valuations** - The value that healthy ecosystems provide in coastal protection, economic production, and quality of life remains crucial to national economies, but must be effectively measured if it is to be considered by decision makers, many of whom are not familiar with the notion of valuing ecosystem services. Without effective indicators, monitoring and evaluation, policymakers will either undervalue the goods and services provided by coastal ecosystems or will fail to incorporate such considerations into policies.

- **Commit early to fostering effective compliance and enforcement** - Proactive and sustained outreach to all sectors of the local community is essential to build compliance for most regulatory actions. This requires hands-on interactions with the affected users (Kuperan and Sutinen 1998). Education initiatives need to target resource users and managers, policy makers, the judiciary, religious leaders, and the public, and can come in a diversity of forms including programmes through the schools. A better understanding of marine environmental issues helps build the constituency and support for change.

- **Recognize immigration effects and provide incentives for responsible action** - Mass population movements are increasing and result in influxes of individuals with little environmental awareness of their new communities. Weak immigration policies or outreach initiatives can allow migrants to engage in practices which impact coastal environments without personal understanding or commitments to basic principles of sustainability. This contributes to a desensitizing of local stewardship of the coastal environment.

- **Support Individual Champions** -- The power of dedicated individuals in shifting public opinion and shaping public policy cannot be overstated. Without charismatic and committed individuals leading by example, the best strategic planning, and execution of management plans fail. Leaders, whether local or national, need consistent support, not just from governments, but from local communities.

Actions by the science community

Environmental management needs to become more strongly scientifically based to become more effective, but a firmer scientific base can also help to build political will. We recommend that environmental scientists contribute their expertise, in collaboration with NGOs and others, to effect important changes in public perception, and in management agency processes that will help build political will. Needed changes in public perception include:

- **Learn from local knowledge** – Scientists who begin by seeking out and learning from local stakeholders about the particulars of their lives, the local environment, and its natural history achieve two things: They often learn useful things that are new to science, and they gain the trust and confidence of the local people through their evident display of mutual respect.

- **Enhance fundamental scientific literacy** - In order for science to be most useful to society, a broader social goal must be to drastically improve scientific literacy among

the public at large. An educated public should understand basic principles, and should be aware of, yet not intimidated by, complexity and uncertainty. Importantly, the citizenry should understand that scientists are always seeking new or better answers, and that complexity and uncertainty are not justification for inaction. An educated public should be outraged when science is misrepresented, marginalized or ignored outright in policy formation.

- **Understand and increase the role of science in public policy** - Government leaders and citizenry must appreciate the value of science in crafting public policy, in order to advocate effectively for its place in policy debates. Strictly speaking, science tells us what was, is, or will be under alternative courses of action, but it should not determine values or set social or economic goals. The risk of science being compromised by subjectivity of a scientist is real, but can be controlled by requiring that he/she clearly specifies whether speaking as a technical expert, or expressing personal views.

Working closely with governments and management agencies, the science community should work for changes including:

- **Improve statutory and administrative frameworks** - A concrete step needed to improve interactions between science and policy is to establish law that provides a clear place for science in the policy development process, and legally-binding responsibilities for decision-makers to consider and respond to scientific findings. For example, one significant improvement in the Magnuson-Stevens Fisheries Conservation Act re-authorized by the U.S. Congress in 2007 is a requirement for regional fishery management councils to adhere to catch limits determined by their science and statistical committees (SSCs). Previously, there was no formal accountability, and roles of SSCs varied greatly across the country. This change strengthened the role of science in this case, and is an approach that should be replicated more widely.

- **Shift the burden of proof** – Communities and governments need to reverse the burden of proof when making decisions concerning the environment. At present, to deny a potentially destructive activity requires demonstration that impacts will occur. In the absence of information on the extent of an impact, the default position is that the action can take place. This is a dangerous approach in an ecological world characterized by complexity and uncertainty and has failed before. A precautionary approach to management would only allow actions or approve regulations for which it can be shown that no severe ecological impacts will occur (Dayton 1998). This is a less risky criterion that would better safeguard coastal ecosystems. Coincidentally, it also shifts power in decision-making away from special interests towards the wider community.

- **Expect change and manage adaptively** - A vital component of managing impacts on ecological systems is the ability to incorporate new information and quickly modify management actions accordingly. This process of adaptive management requires effective mechanisms for collecting data on the system being managed, evaluating states and trends, and interpreting the results with reference to desired management outcomes. This interpretation then guides modifications of management regulations. Adaptive management is an essentially scientific approach, and is most effectively implemented in situations where the management agency supports a scientific branch charged with data collection and evaluation rather than with regulation and enforcement. In poorer nations, it may be possible to achieve the goal of adaptive management by relying on academic or other scientists outside the regulatory agency, at least in the short term.

- **Use independent experts to review decisions** – Management agencies benefit when the science driving their policies is subject to independent and external review. Environmental impact assessments (EIAs) in particular need this level of scrutiny because the work is often done by a commercial contractor hired by a developer to meet legal guidelines. Vested interests of both parties can result in an assessment that addresses key environmental issues minimally. Review of EIAs by regulatory agencies themselves can suffer if political factors are pushing the outcome in a given direction, and mandatory independent and external review by appropriately qualified scientists can improve the process.

Local fishermen in typical canoe, Watamu Kenya. Photo by: Hanneke Van Lavieren.

5 Towards a Better Future

Current management practices are ineffective and to continue them will endanger coastal economies and ecosystems that support over one half of the world's population. The trend for coastal ecosystems over recent decades has been for progressive decline in the face of growing human populations, growing demand for coastal resources, and growing use of the coastal environment. Now climate change is starting to add to the pressures on the coastal environment further stressing ecosystems there. To continue management as it is currently practiced is a guarantee of disaster in the medium term if not sooner.

It is clear that we have the capacity to significantly improve our management of coastal systems by applying more effectively the knowledge we already have about them, and the management tools in our possession. A firm embrace of ICZM, improved estimates of environmental TEV, taking steps to strengthen political will, and added support for and enhancement of local "ownership" would lead to a very substantial improvement in our management of coastal ecosystems. The impediments to doing this are structural, financial, sociological and philosophical, and should not be minimized; but there are also some reasons for optimism (Box 9). In this section, we set out twenty-five steps that need to be taken in order to substantially improve our management of the coastal ocean.

5.1. The First Steps: Revise Expectations, Use Existing Tools, and Build Awareness

- **We first must appreciate the need for more sustainable practices, and the urgency with which sustainability should be achieved, while being confident that we already have most of the needed tools.** Existing multinational treaties, national and local laws, rules and regulations provide useful ways of reducing fishing pressure and habitat destruction, maintaining water quality, and permitting appropriate forms of coastal development. They need to be used, and the will to use them has to be developed.

- **Good management is proactive, and takes explicit, scientifically-based actions to solve specific problems or to prevent them arising in the first place. With climate change progressing rapidly, managers live on** a shifting playing field, and those who anticipate effects of climate change and put management actions in place to mitigate these effects will be seen as heroes. The need to think proactively has never been more important.

- **Improved management will require committed support for environmental protection from the local community, appropriate penalties for non-compliance, transparency to minimize corruption, and legal protection of whistle-blowers.** Local populations, particularly those direct users of coastal resources, must have a significant stake in the management of local coastal regions, and become part of a process to build public scrutiny of management actions. To take these first steps requires genuine, preferably local, leadership, and education in the schools and in the community. This education effort might well be taken up as a priority core activity by the NGO community.

- **These first steps will be quite difficult. Poorer nations that have fewer well-educated people also frequently need stronger environmental management, but are also likely to suffer the highest levels of corruption in government and civil affairs** (data in UNDP's Human Development Index, Transparency International's Corruption Perception Index, and the World Economic Forum's Environmental Sustainability Index). Effecting change will take a major commitment for progress to be made.

Still Pictures © Reinhard Dirscherl/WaterFrame

Box 9 Reasons for optimism

There are a number of instances of well-managed coastal environments, and sustainably harvested coastal fisheries around the world. The reversal of negative trends and the improvement of water quality in some areas indicate that decline of coastal ecosystems is neither inevitable nor always irreversible.

Examples of sustainably managed coastal fisheries include the Alaska halibut fishery, the Gulf of Carpentaria shrimp and Western Rock Lobster fisheries in Australia, American lobster in the north-east USA, and the Striped Bass fishery of the Atlantic coast of the USA. In each of these there are explicit catch controls, diligent enforcement of regulations, and high compliance by the fishery.

The Great Barrier Reef Marine Park (GBRMP), a zoned, multi-use marine management area, is a preeminent example of effective conservation management. While its success has been helped by the strong public support and the relatively light use at the time of establishment (late 1970s), the continued effectiveness of management owes much to the effective coordination of Federal and State regulations and policies, to the requirement in the Great Barrier Reef Marine Park Authority Act to publicly review zoning plans and regulations regularly, and to the consistent effort to base management policies and actions on the best science available. The recently acknowledged need to improve management of water quality which is threatened by economically important upland agricultural activities will be an important test of the administrative and regulatory processes. The Florida Keys National Marine Sanctuary (FKNMS, established 1990), together with its suite of smaller, pre-existing state and federal protected areas, is a second good example of a large multi-use area that is being managed well. The FKNMS is substantially younger than the GBRMP, and was established under more difficult circumstances because of the much more intensive use of the region and a local 'culture' that held that residents of the Keys were free to do what they wanted, where they wanted in Florida Keys waters. Those citizen concerns led to creation of considerably fewer and smaller fully-protected zones than originally recommended – just 5% of the area is no-take, compared to 30% within the GBRMP.

Smaller-scale examples of effective conservation management exist in the suite of MPAs established in the southern Philippines, notably the small Apo Island reserve protected since 1982 (Russ et al. 2004). These reserves are modestly enhancing the immediately surrounding fisheries resources while protecting ecosystem services, and are strongly dependent on local community "ownership" for their success. A somewhat similar, locally-based management of coastal fisheries characterizes much of the Chilean coastline, and is being effective in sustaining stocks and protecting other ecosystem services (World Bank 2006, Gelcich et al. 2008). In both cases local "ownership" appears to be critical in determining success, although government management performance also plays a role.

- **Within governmental agencies the major structural and procedural changes to achieve more sustainable management include a) realigning of responsibilities of administrative departments to ensure more effective collaboration, b) developing and using economic valuation tools accessible to managers and politicians, c) resolving the conflict between short-term and long-term economic interests when making management decisions, and d) building a scientific culture within management agencies so that management can become properly proactive.** These changes need to be introduced at all levels of government, and encouraged by multinational agencies as a way to ensure appropriate decisions at all scales of management including across national borders.

Box 10 Effective investment, triage, and the problem of paper parks

The international community should deliberately focus its capacity-building efforts in those nations where the socio-political climate is more supportive of coastal management, while serving notice on other nations that further support will not be provided until there is evidence of a greater will to manage sustainably. This strategy may not be popular with many in the conservation community, but we are far past the time when faith in the essential goodness of governments should drive efforts to build more effective management. For example, considerable funding, effort, and public education have now been invested in the establishment of Marine Protected Areas around the world, but the great majority of these MPAs are "paper parks" with no effort to manage human impacts, and are thus of trivial conservation value. Too many governments have proved unable or unwilling to effectively manage them, and efforts to publicize and redress this problem have been unsuccessful. A systematic review and audit should be initiated to identify and place peer pressure on governments to improve designated areas, or seek help to improve their effectiveness. This approach will lead to archipelagos of functional MPAs scattered across a large "white space" comprised of countries with ineffective coastal management. The MPAs that lie scattered within each archipelago by definition exist within regions more attendant to conservation, and are also likely to benefit from a suite of other environmental management measures (e.g., fishery and water quality regulations) that confer additional protection from environmental insults. Such an approach has the potential to create clear evidence of the benefits of effective conservation management of coastal waters, and applies resources where they can do most good. To be effective, it should be implemented with adequate forewarning, and with sympathy and support for communities that lack capacity because of poverty. Judgments against continued support for particular countries or regions must be potentially reversible, and communities should be advised of steps that must be taken to become eligible for renewed external support.

- **The need for realignment of management responsibilities will vary greatly among countries, and change will be resisted by entrenched bureaucracies.** The NGO community can help realign management responsibilities by fostering transparency in decision-making, engaging the local community, incorporating elements of local culture and tradition, guiding customization of the management approach to conform to local norms, and particularly by supporting and grooming local political leaders who are sensitive to environmental values. More effective management performance will result.

- **It is time for multinational agencies to demand results in the form of demonstrably improved management, rather than be satisfied that nations are signatory to, and are planning to implement obligations under treaties, conventions and similar legal documents.** The use of results-based management (RBM) in project management is a tiny step by the multinationals in this direction. Financial support provided to achieve improved environmental management, should be linked explicitly to the creation of administrative structures that demonstrably work to achieve needed environmental results. We also do not need more treaties; we need to fulfill existing treaty obligations.

- **The value assigned by a community to its environmental goods and services often includes ethical considerations. It is appropriate that this is so, and fostering ethical attitudes to environmental questions should be one appropriate goal for environmental education.** Ethical arguments that favor the benefits to the entire coastal population over benefits to the few; or favoring long-term benefits over short-term ones achieved by "mining" fishery or other resources can do much to guide effective management and strengthen compliance in the absence of explicit economic valuations.

- **The development and use of accessible economic valuation tools is likely to enhance appreciation for the value of the coastal environment, its resources and its services.** Cultural, ethical and economic (monetary) values assigned to coastal environments are all legitimate, but when a community agrees on economic value, the capacity is enhanced to make difficult management decisions that preserve that value. Appropriate valuation of environment may also help resolve the conflict between short-term economic incentives (usually for the few), and longer-term economic incentives for the community.

- **As well as structural changes to improve the flow of information among management agencies, there is a need to improve the quality of the information that flows and of the analysis it receives.** Management depends on application of good science using reliable data. There is a need for strengthened scientific literacy in most management agencies, particularly in poorer countries, and some of this need can be provided in the short term by the international academic and NGO communities. In the long term, however, management agencies need a core of capable, scientifically trained personnel.

- **To fully achieve scientific literacy, the collaboration of the science and management communities must be strengthened, and, within the science and management communities, there must be less advocacy for, and more critical evaluation of, management tools in order to either reduce uncertainty, or help decision-makers realize the logical options in the face of high uncertainty (Pielke 2007).** More effective integration of science and management begins with recognition that both scientists and managers have skills to contribute, and something to learn from each other. Objective evaluation of the effectiveness of tools is needed to improve those tools, or combine them in innovative ways to solve management problems. Application of tools, and monitoring of results should be central to management, but there is currently far too much manager effort wasted in monitoring to collect data that are never used because the data are insufficiently precise, the sampling design is woefully inadequate, and/or the managers collecting the data do not know why they are collecting them. The NGO and multinational communities have played a role in encouraging "mindless monitoring" and should take some responsibility for redressing this sorry situation.

- **Capacity-building efforts must be coordinated to ensure that there are appropriate jobs for people who get training, and strengthened management agencies as a result.** The efforts of training organizations are wasted if graduates find themselves over-trained for any positions available back home, and more work is needed to better link trainees with jobs.

5.2. Improving Compliance with Management Actions

- **New management initiatives are more readily adopted by communities when economic and other incentives are appropriately aligned with management needs, and when the initiatives are seen to have clear and rapid, or multiple positive impacts on environmental issues.** People resist change, but economic and other incentives can be aligned with management needs in a number of ways that will encourage acceptance of and commitment to changed management regulations or policies.

- **A new policy will also be more readily accepted by the community if people can be shown direct benefits, if it has been crafted to recognize cultural and political norms and realities in the local region, and if penalties for failure to obey regulations are sufficient.** (Since local communities differ, management practices may well use community-based strategies in some locales and top-down management strategies in others to achieve the same objective, yet be effective in both.)

Community based management: using local community leaders to educate and involve communities. Luzon, Philippines. Photo by: Hanneke Van Lavieren

- **The elimination of inappropriate economic subsidies for business enterprises realigns incentives and helps lead to acceptance of environmental policies and goals.** Such subsidies commonly promote overdevelopment of shorelines or over-capitalization of fishing fleets, and conflict directly with environmental management goals.

Box 11 Catch shares to align fishery incentives with management goals

Even fisheries that limit entry and impose an overall harvest quota can suffer from the destructive "race for fish" in which each participant has a vested interest in catching as much of the quota as quickly as possible before others do so and the season closes. This race often leads to harvest quotas being exceeded, as well as fishing behavior that harms habitat, generates excessive by-catch, and endangers vessels and crew.

Limited access privilege programmes (LAPPs), also called dedicated access privilege programmes (DAPPs) or simply "catch shares", first place a limit on entry to the fishery and specify the total catch, but then allocate a portion of that overall quota to each participant. This removes the incentive to catch as many fish as quickly as possible and allows greater flexibility in deciding when, where and how to fish in response to fluctuations in supply, demand and price, weather conditions, or ecological factors such as high levels of bycatch or undersized fish in a given area. Benefits include fewer cases of total catch quotas being exceeded, less by-catch, improved safety, and greater mean income within the fishery (Environmental Defense 2007).

- **In many nations, pervasive though usually small-scale corruption within the political and administrative units can make it quite difficult to take what should be logical steps to improve management.** To align incentives and achieve compliance requires an administrative structure that is well tuned to local community attitudes and beliefs, focuses clearly on management goals, has the political power and commitment to achieve the legislative steps needed, and the capacity on the ground to educate and to police. Again, transparency and a vigilant public can help.

- **Sustainable management of fishery resources is now benefiting from a growing culture for social responsibility in the corporate sector, and further efforts to build a culture of informed consumer choice will encourage this.** Socially responsible members of the fishing industry are now able to gain accreditation of their products by the Marine Stewardship Council, an international trade body whose seal guides consumers who wish to make environmentally responsible choices, as well as through FAO's Code of Conduct for Sustainable Fisheries which provides guidelines for good fishing practices. Also CITES (Convention on International Trade in Endangered Species of Flora and Fauna) listing is now being used as a new tool to control exploitation of threatened species.

- **The facts of climate change are not yet fully known, but the case is now sufficiently clear that climate change is a significant challenge for environmental management, particularly in the coastal ocean.** A manager who does not take climate considerations into account in planning management strategy is being irresponsible. With every successive report from the Intergovernmental Panel on Climate Change (IPCC 2007), the specifics of coming changes are more precisely defined. There is no doubt that climate is changing very rapidly, and that greenhouse gases are largely responsible. It is also clear that ecological and political inertias will combine to ensure that substantial climate change will happen over the next 50 years, even if the world acts promptly and aggressively to reduce emissions. Many of these guaranteed changes (warming, increased storm intensity, increased ocean acidification, rising sea level) directly affect the coastal ocean, and coastal ecosystems are going to be modified substantially (Hoegh-Guldberg et al. 2007). Coastal nations must ensure that adapting to almost certain biophysical and economic ramifications of climate change becomes a priority topic for coastal environmental management.

Small outrigger artisanal fishing boats moored off a village in the central Philippines. Photo by: Yvonne Sadovy/SCRFA

- **The pace of construction of offshore wind farms, tidal energy collectors, and similar infrastructure, is expected to grow as part of the effort to reduce greenhouse gas emissions. Managers with responsibility for coastal waters must be effective in balancing the need for such infrastructure with the deleterious effects such infrastructure may have on the coastal environment.** Leadership is needed to ensure that vigorous defense of attitudes such as "me first" and "not in my backyard" do not become preeminent in the approvals process for such critically important energy developments, while still ensuring that construction and operation of these plants are done with minimal impact on coastal ecosystems.

5.3. Achieving Holistic Management for the Coastal Ocean

- **It is past time to implement truly integrated coastal zone management around the world, across geopolitical boundaries, among administrative structures, and among management goals. Management must be scaled appropriately to ecology, by ensuring that its spatial and temporal scales are guided by those of coastal structures and ecological processes.** Boundaries of political jurisdictions, or the impact footprints of particular coastal enterprises such as a fishing fleet based at a particular port, a local suite of aquaculture enterprises, or a particular tourism development are not appropriate borders for management actions. With a holistic perspective it will be readily apparent that most administrative departments have responsibilities which either cross important ecological borders, or are too restricted to encompass the entities that should be the focus of management, or both. Clear recognition of this fact by managers and governments will sharpen the need for effective collaboration across administrative boundaries, while harmonizing the management goals of agencies with cognate responsibilities.

- **A seamless approach to coastal management also provides an effective way to build recognition of and support for the need to link management of coastal waters with management of activities taking place in terrestrial environments, often far inland from the coast.** If pollution of coastal waters is identified as undesirable and needing to be stopped, it follows that any activities that lead to that pollution have to be modified, even if they take place well removed from the jurisdiction of coastal managers. Ultimately, all actors, even those well inland from the coast must accept responsibility for their effluents however far downstream they end up, and regardless of whether the passage downstream is via a river or through groundwater. We suggest that using ICZM to integrate the various forms of management within the coastal environment can become a first step in linking environmental management more broadly. The following specific policies are among those that can be pressed into making management more seamless.

- **In our view, pollutants will usually impact coastal ecosystem function at concentrations below those that pose risks to human health. Water quality management must be integral to coastal ecosystem management because the management of water quality impacts many coastal activities.** Costs of this management must be borne by all parties that contribute to the pollution. Tourism, for example, often has deleterious impacts on coastal ecosystems as well as economic benefits for coastal communities, and it is important to manage for economic benefits in ways that do not compromise sustainability of ecosystems on which the industry relies. Inland agriculture, coastal aquaculture and international shipping may have economically and ecologically substantial negative impacts in the coastal environment, and management to minimize these impacts is required. Indeed the issue of aquaculture demands much more objective attention by managers to its risks and benefits than it currently receives – it is not a panacea for declining wild fish stocks.

- **Transparency, a vigilant public, and a management milieu centered on preserving the goods and services provided by coastal ecosystems also may prove effective in removing the rampant conflicts of interest that underlie permitting of coastal development projects.** These conflicts – between short-term profits for a few and long-term benefits for the many – currently impede the introduction of more environmentally sustainable methods of development, and they have proved resistant to attempts to eliminate them. By transparently tying the value of ecosystem goods and services and therefore the need to maintain sustainable coastal ecosystems to decisions on coastal development, a strong impetus is built for improving the approvals process for coastal construction.

- **Fishery management should also include protection of nursery habitats and of spawning stocks, especially the larger, older individuals that in most species contribute most to reproductive success.** Both goals can easily garner public support. Protecting the babies, and protecting the mothers just makes sense to people. Nursery habitats, for many coastal fishery species, lie inshore in the shallower waters – precisely where impacts of coastal development projects are most strong, and the places most subject to pollution from coastal and upland activities. For some species, the protection of spawning populations means protection of their special spawning sites, also furthering the link between fishery management and environmental conservation, and strengthening both. There may be merit in enhancing the importance of essential fish habitat (EFH) because it is already the basis for legislation in some jurisdictions, and it provides a strong impetus towards better integration of fisheries and ecosystem management. Protection of EFH requires management of habitat and of water quality, and thus integrates the major forms of coastal management.

- **Finally, the global catch of wild fish has to be reduced, but reducing the global catch requires local action on specific fisheries. Such local actions tend to be resisted by governments that value employment and income as well as by the fishing community.** Reducing catches requires a better integration across jurisdictions, and fosters an integrated view of fisheries management. It also requires a close and effective interaction between managers and local populations. The introduction of new regulations will be more effective if it is seen as a necessary step towards local sustainability, and if an educational campaign accompanies it. The educational campaign must target politicians, the general public, and the fishing community. An educational programme centered on a holistic, ecosystem approach, and based on the concept that the ocean is not limitless can be particularly helpful in making the case for lowering catch to achieve sustainability.

Sunrise over the Gulf of Maine seen from atop Cadillac Mountain, Acadia National Park, U.S.A. Photo by: Jake Kritzer

None of this is going to be easy, but if the multinational agencies, and international NGOs work collaboratively with local leaders to build local "ownership" of coastal management, there is a way forward. If the international science community helps improve the effectiveness of our management tools, it may be possible to improve management even in the face of growing demand for coastal environmental goods and services. By insisting on a holistic, ecosystem approach to all aspects of management in the coastal environment, and by taking the steps we suggest to improve the capacity of management agencies to do their job, many of the issues that currently prove difficult for managers can be more readily decided on, and more readily accepted by an informed and engaged public. And by fully engaging the public, at manageable community-based levels, there is hope.

Healthy coastal environments should be the right of these and all children--not the burden of damaged and depauperate ones. The fast rates of change and impacts along our coasts are occurring in our lifetimes. We have the ability--and opportunity--to leave a positive legacy for our children and theirs if we rethink coastal ocean management now and act accordingly. Photo by: Andy Hooten, CRTR.

Table 1. Roles of Different Community Groups in Improving Coastal Ocean Management

Roles	Toward Stronger Coastal & Marine Management
International Community	• Improve financing and call attention to use of subsidies • Improve capacity and training • Expose corruption and bureaucratic inefficiencies • Demand results through outcomes in the form of demonstrably improved management.
Non-Governmental Organizations	• Assemble and use adequate socio-economic valuations • Commit early to fostering effective compliance and enforcement • Expose corruption and bureaucratic inefficiencies • Recognize immigration effects and provide incentives for responsible action • Support Individual Champions. • Educate coastal communities to the value of their coastal environment • Build long-term commitment aimed at transferring to local management and control of projects • Improve consultative process within countries (rather than top down) for fishery matters
Government	• Improve statutory and administrative frameworks • Shift the burden of proof • Elimination of Subsidies • Reduce or eliminate corruption • Resolve the conflict between short-term and long-term economic interests when making management decisions
Management Agency	• Expect change and manage adaptively • Use independent experts to review decisions • Develop and use economic valuation tools accessible to managers and politicians • Build a scientific culture within management agencies so that management can be proactive.
Science Community	• Learn from local knowledge • Enhance fundamental scientific literacy • Understand and increase the role of science in public policy.

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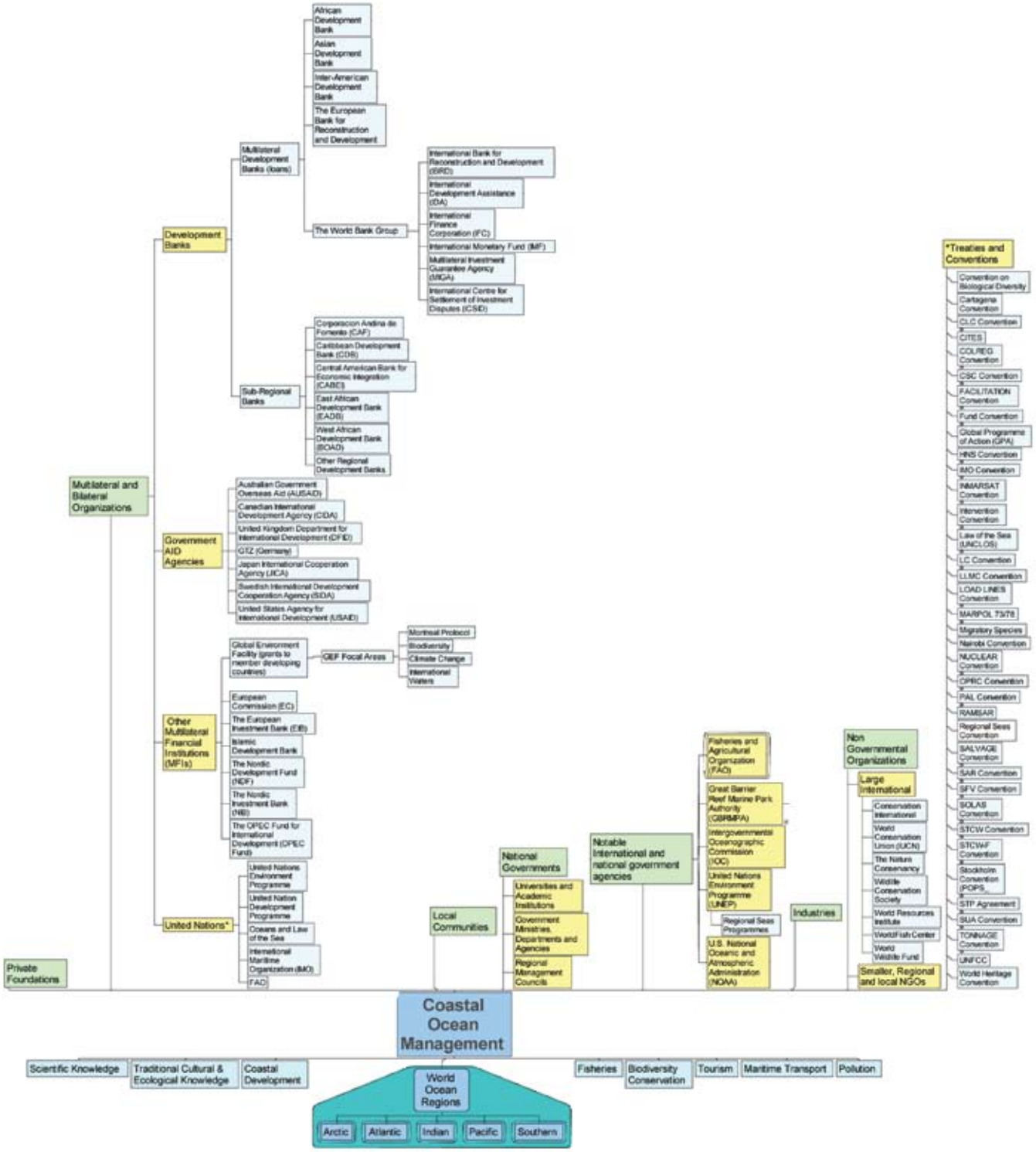
Annex 2 - Coastal & Marine Management Actors



Ecologists often refer to the complexities of coastal and ocean ecosystems and the multiple forces that influence them. The human organizational dimensions of coastal ocean management are increasingly complex as well--and that complexity is perhaps under-appreciated. This schematic attempts to depict--at a very general level--the various themes, regions, actors, organizations and instruments involved in coastal ocean management. At the bottom are those issues discussed in this document that are relevant to all of the World's ocean regions, and that require rethinking in the ways we advocate. The upper part of the schematic shows those organizations and actors who play important roles in the governance, management, funding, support, and conservation of ocean and coastal resources. It is likely not comprehensive, but worthy of further exploration and development. Specific details of all actors (especially local ones), programs, projects and specific activities are too numerous and diverse to show here.

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ISBN 92-808-6008-9

Three critical needs can be identified, without which, improvement in the management of coastal environments is very unlikely. The first is to improve the integration of management, both geographically, and across administrative departments and management targets. The second is to build better understanding of the true value of the goods and services provided by sustainably managed coastal environments, and to promulgate knowledge of this value so that communities recognize what is at stake when their coastal ecosystems become degraded. The third is to tackle the many reasons for failure of management effort that are encompassed by the phrase 'lack of political will'.

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