Payments for Coastal Ecosystem Services: Development and Testing of Assessment Tools for Coastal Fishery and Flood Protection

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I. Rationale and Context

A. Coastal Ecosystem Services

Coastal and marine ecosystems are among the most productive, yet threatened, ecosystems in the world; included in this category are terrestrial ecosystems, areas where fresh water and salt water mix, and nearshore coastal areas and open ocean marine areas. The distinction between coastal and marine is largely a human-centric construct: coastal systems are places where people live and where a spate of human activity affects the delivery of ecosystem services derived from marine habitats; marine systems are places that humans relate to and affect mainly through fisheries extraction. Continental shelf areas or large marine ecosystems span both coastal and marine systems and provide many key ecosystem services: shelves account for at least 25% of global primary productivity, 90–95% of the world's marine fish catch, 80% of global carbonate production, 50% of global denitrification, and 90% of global sedimentary mineralization.

Dependence on coastal zones is increasing around the world, even as costs of rehabilitation and restoration of degraded coastal ecosystems is on the rise. In part, this is because population growth overall is coupled with increased degradation of terrestrial areas (fallow agricultural lands, reduced availability of fresh water, desertification, and armed conflict all contributing to decreased suitability of inland areas for human use). Resident populations of humans in coastal areas are rising, but so are immigrant and tourist populations (WRI 2001). At the same time, wealth inequities that result in part from the tourism industry decrease access to coastal regions and resources for a growing number of humans (Creel 2003). Nonetheless, local communities and industries continue to exploit coastal resources of all kinds, including fisheries resources; timber, fuelwood, and construction materials; oil, natural gas, strategic minerals, sand, and other nonliving natural resources; and genetic resources. In addition, people increasingly use ocean areas for shipping, security zones, recreation, aquaculture, and even habitation.
Coastal zones provide far-reaching and diverse job opportunities, and income generation and human well-being are currently higher on the coasts than inland.

Coastal ecosystems are among the most productive in the world today, rivaling even tropical rainforests in terms of their overall productivity of raw materials and goods used by humans (Primavera 1991; Spurgeon 1992; Barbier 1993). As the following examples show, many coastal regions are valued through market activities that directly support humans—such as fishing, hunting, fuelwood and woodchip extraction, harvesting ornamental materials, and the extraction of medical resources.

Coastal systems generate a variety of seafood products such as fish, mussels, crustaceans, sea cucumbers, and seaweeds (Moberg and Folke 1999; Ronnback 1999). Many commercially important marine species, like salmon, shad, grouper, snapper, bluefish, striped bass, and invertebrates (such as shrimp, lobster, crabs, oysters, clams, mussels), use coastal nursery habitats. Capture fisheries in coastal waters alone account for $34 billion in yields annually. Given this level of economic productivity, it is perhaps not surprising that overfishing and intensive aquaculture have caused serious ecological and social problems in coastal regions throughout the world (Primavera 1991; Primavera 1997; Jackson et al. 2001).

Valuation studies of food directly or indirectly supplied by coastal systems have predominantly focused on the economic value of fishery products (Batie and Wilson 1978; Lynne, et al. 1981; Farber and Costanza 1987; Buerger and Kahn 1989; Rivas and Cendrero 1991; Bennett and Reynolds 1993; Ruitenbeek 1994; Kaoru et al. 1995; Deb 1998; Gilbert and Janssen 1998;

Ronnback 1999; Barbier 2000; Sathirathai and Barbier 2001). Most often, the market price of seafood products is used as a proxy when calculating the value of ecosystem goods provided by coastal systems. For example, the annual market value of seafood supported by mangroves has been calculated to range from $750 to $16,750 (in 1999 dollars) per hectare (Ronnback 1999). High-value species are also harvested from coral reefs to meet live fish demand in restaurants, mainly in Asia.

Coastal areas also provide the foundation for the mariculture (marine aquaculture) industry, which uses coastal space or relies on wild stock to produce valuable fisheries products, from tiger prawns to bluefin tuna. Human reliance on farmed fish and shellfish is significant and growing. Global annual per capita consumption of seafood averages 16 kilograms, and one third of that supply currently comes from aquaculture (Lubchenco 2004). Globally, aquaculture is the fastest-growing food-producing sector, with production rates doubling in weight and value from 1989 to 1998 (Goldburg et al. 2001). Much of that growth has occurred in the shrimp and salmon farming industries.

Besides food and raw materials, at least three other types of marketable goods are provided by coastal systems: genetic, medical, and ornamental resources. For example, coral reefs have been shown to be an exceptional reservoir of natural bioactive products, many of which exhibit structural features not found in terrestrial natural products (Carte 1996). The pharmaceutical industry has discovered several potentially useful substances among the seaweeds, sponges, mollusks, corals, sea cucumbers, and sea anemones of reefs (Carte 1996; Moberg and Folke 1999). Furthermore, many coastal products are collected not only as food but also to sell as jewelry and souvenirs. Mother-of-pearl shells, giant clams, and red coral are collected and distributed as part of a worldwide curio trade (Craik et al. 1990). The marine aquarium market is now a multimillion-dollar industry trading in live reef-dwelling fishes that are collected and shipped live from coral reef communities (Moberg and Folke 1999).

In addition to marketable goods and products, landscape features and ecological processes within the coastal zone also provide critical natural services that contribute to human well-being and have significant economic value (Farber and Costanza 1987). As the data just cited suggest, much of what people value in the coastal zone—natural amenities (open spaces, attractive views), good beaches for recreation, high levels of water quality, protection from storm surges, and waste assimilation/nutrient cycling—is provided by key habitats within coastal systems. In Thailand, the conversion of mangroves to shrimp aquaculture ponds reduced the total economic value of the intact mangroves by 70% in less than a decade (Balmford et al. 2002).

Open space, proximity to clean water, and scenic vistas are often cited as a primary attractor of residents who own property and live within the coastal fringe (Beach 2002). Hedonic pricing techniques have been used to show that the price of coastal housing units varies with respect to characteristics such as ambient environmental quality (proximity to shoreline, for example, or water quality) (Johnston et al. 2001). For example, Leggett and Bockstael (2000) use hedonic techniques to show that water quality has a significant effect on property values along the Chesapeake Bay in the United States. They use a measure of water quality—fecal coliform bacteria counts—that has serious human health implications and for which detailed, spatially explicit information from monitoring is available. The data used in this analysis consist of sales of waterfront property on the western shore of the Chesapeake Bay between 1993 and 1997 (Leggett and Bockstael 2000). The authors consider the effect of a hypothetical localized improvement in observed fecal coliform counts on a set of 41 properties. The projected increase in property values due to the hypothetical reduction in coliform bacteria totaled approximately $230,000. Extending the analysis to calculate an upper limit benefit for 494 properties, it is estimated that the benefits of improving water quality at all sites would be around $12.145 million (Leggett and Bockstael 2000).

Stretches of beach, rocky cliffs, estuarine and coastal marine waterways, and coral reefs provide numerous recreational and scenic opportunities. Boating, fishing, swimming, walking, beachcombing, scuba diving, and sunbathing are among the leisure activities that people enjoy worldwide and thus represent significant economic value (King 1995; Kawabe and Oka 1996; Ofiara and Brown 1999; Morgan and Owens 2001). Both travel cost and contingent valuation methods are commonly used to estimate this value. (See Chapter 2 for more on these valuation techniques.) For example, the Chesapeake Bay estuary has also been the focus of considerable research on nonmarket recreational values associated with coastal systems. When attempting to estimate the monetary worth of water quality improvements in Chesapeake Bay, Bockstael et al. (1989) focused on recreational benefits because it was assumed that most of the increase in well-being associated with such improvements would accrue to recreational users. The authors estimated the average increases in economic value for beach use, boating, swimming, and fishing with a 20% reduction in total nitrogen and phosphorus being introduced into the estuary. Using a combination of the two valuation methods, the annual aggregate willingness to pay for a moderate improvement in the Chesapeake Bay's water quality was estimated to be in the range of $10–100 million (in 1984 dollars) (Bockstael et al. 1989).

These coastal values also underlie much of the world's coastal and marine tourism. The link between tourist visits and the revenues from and condition of the coastal system has not been analyzed at the global level, but local case studies point to a strong correlation between value and condition. In the United States alone, reef ecosystems with their nursery habitats support millions of jobs and billions of dollars in tourism each year. For example, reef-based tourism generated over $1.2 billion in the Florida Keys alone, while in Hawaii, reefs generate some $360 million per year, with annual gross revenues generated from just one half-square-mile coral reef reserve exceeding $8.6 million (Birkeland 2004).

As these reefs decline in biodiversity and ecosystem health, these nature-based tourism industries stand at risk (Cesar et al., 2003). In Jamaica and Barbados, for instance, destruction of coral reefs resulted in dramatic declines in visitation; loss of revenue streams subsequently led to social unrest and even further tourism declines (MA Sub Global Assessment on Caribbean Sea). Similarly, "willingness to pay" studies in the Indian Ocean suggest that the health of coral reefs is an important factor for tourists: they were willing to pay, on average, $59–98 extra per holiday to experience high-quality reefs (Linden et al. 2002). And in Florida, reef degradation is rapidly changing the structure of the tourism market, from high-value, low-volume tourism toward larger numbers of budget travelers (Agardy 2004).

Recreational fishing is also a major industry in many parts of the world, and it primarily targets marine or anadromous fishes in coastal ecosystems. Coral reef–based recreational fisheries generate over $100 million annually (Cesar et al. 2003). The coastal zone also supplies nonmarket values associated with both recreational and commercial fisheries by providing some of the most productive habitat refugia in the world (Gosselink et al. 1974; Turner et al. 1996). Eelgrass, salt marsh, and intertidal mud flats all provide a variety of services associated with their nursery functions (Gosselink et al. 1974; Turner et al. 1996).

As already noted, improvements in the condition of these habitats may ultimately lead to measurable increases in the production of market goods such as fish, birds, and wood products. In other cases, however, ecological productivity itself can represent a unique class of values not captured by traditional market-based valuation methods. Instead, these values represent an increase in the production of higher trophic levels brought about by the increased availability of habitat, though analysis must be careful not to risk double counting some aspects of value or measuring the same benefits in different ways.

The seas and coasts are also of great spiritual importance to many people around the world, and such values are difficult to quantify. While the depth and breadth of these values are as diverse as the cultures that are found worldwide, there is the common theme of a cultural or spiritual connection. For example, the Baju peoples of Indonesia and the aboriginal people of the Torres Strait in Australia have a culture intimately connected to oceans, while many of the native peoples of North America have similar strong ties to coastal systems. Even systems on which we place low economic value today may be of importance and value tomorrow because they support species that may turn out to have pharmaceutical value or because they support species or habitat types that may become rare and endangered in the future. This gives them high option value associated with an individual's willingness to pay to safeguard the option to use a natural resource in the future, when such use is not currently planned. Non-use values are representative of the value that humans bestow upon an environmental resource, despite the fact they may never use or even see it.

In summary, ecosystem services are critical to the functioning of coastal systems and also contribute significantly to human well-being, representing a significant portion of the total economic value of the coastal environment. The best available market and nonmarket data suggest that substantial positive economic values can be attached to many of the marketed and nonmarketed services provided by coastal systems.

B. Coastal Ecosystem Services by Habitat Type

The coastal and marine areas of the world are not homogenous, and different habitat types produce different ecosystem services (or provide different relative magnitudes of services). Of all coastal subtypes, estuaries and marshes support the widest range of services and may be the most important areas for ecosystems services. One of the most important processes is the mixing of nutrients from upstream as well as from tidal sources, making estuaries one of the most fertile coastal environments (Simenstad et al. 2000). There are many more estuarine-dependent species than estuarine-resident species, and estuaries provide a range of habitats to sustain diverse flora and fauna (Dayton 2003). Estuaries are particularly important as nursery areas for fisheries and other species, and form one of the strongest linkages between coastal, marine, and freshwater systems and the ecosystem services they provide (Beck et al. 2001). Mangroves grow under a wide amplitude of salinities, from almost fresh water to 2.5 times seawater strength; they may be classified into three major zones (Ewel et al. 1998) based on dominant physical processes and geomorphological characters: tide-dominated fringing mangroves, river-dominated riverine mangroves, and interior basin mangroves. The importance and quality of the various goods and services provided by mangroves varies among these zones (Ewel et al. 1998). Fringe forests provide protection from typhoons, flooding, and soil erosion; organic matter export; animal habitat; and a nursery function. Riverine mangroves also provide protection from flooding and erosion, as well as sediment trapping, a nursery function, animal habitat, and the harvest of plant products (due to highest productivity). Basin forests provide a nutrient sink, improve water quality, and allow the harvest of plant products (due to accessibility).

Mangrove forests thus provide many ecosystem services, playing a key role in stabilizing land in the face of changing sea level by trapping sediments, cycling nutrients, processing pollutants, supporting nursery habitats for marine organisms, and providing fuelwood, timber, fisheries resources. They also buffer land from storms and provide safe havens for humans in the 118 coastal countries in which they occur (Spalding et al. 1997). Mangroves have a great capacity to absorb and adsorb heavy metals and other toxic substances in effluents (Lacerda and Abrao 1984). They can also exhibit high species diversity. Those in Southeast Asia, South Asia, and Africa are particularly species-rich, and those in association with coral reefs provide food and temporary living space to a large number of reef species. In some places mangroves provide not only nursery areas for reef organisms but also a necessary nursery ground linking sea grass beds with associated coral reefs (Mumby et al. 2004). Removal of mangrove can thus interrupt these linkages and cause biodiversity loss and lower productivity in reef and sea grass biomes.

Mangroves are highly valued by coastal communities, which use them for shelter, securing food and fuelwood, and even as sites for agricultural production, especially rice production. Due to their function as nurseries for many species, fisheries in waters adjacent to mangroves tend to have high yields; annual net values of $600 per hectare per year for this fishery benefit have been suggested. In addition, an annual net benefit of $15 per hectare was calculated for medicinal plants coming from mangrove forests, and up to $61 per hectare for medicinal values (Bann 1997). Similarly large economic benefits are calculated for shoreline stabilization and erosion control functions of mangroves (Ruitenbeek 1995).

Along with mangroves, sea grass is thought to be a particularly important in providing nursery areas in the tropics, where it provides crucial habitat for coral reef fishes and invertebrates (Gray et al. 1996; Heck et al. 1997). Sea grass is highly productive and an important source of food for many species of coastal and marine organisms in both tropical and temperate regions (Gray et al. 1996). It also plays a notable role in trapping sediments and stabilizing shorelines. Sea grass continues to play an important ecological role even once the blades of grass are cut and carried by the water column. Drift beds, composed of mats of sea grass floating at or near the surface, provide important food and shelter for young fishes (Kulczycki et al. 1981), and the deposit of sea grass castings and macroalgae remnants on beaches is thought to be a key pathway for nutrient provisioning to many coastal invertebrates, shorebirds, and other organisms.

Rocky intertidal, nearshore mudflats, deltas, beaches, and dunes also provide ecosystem services such as food, shoreline stabilization, maintenance of biodiversity (especially for migratory birds), and recreation. The rocky intertidal habitats of temperate areas are highly productive and, in some cases, an important source of food for humans (Murray et al. 1999b). Offshore, kelp forests also provide services: they support fisheries of a variety of invertebrate and finfish, and the kelp itself is harvested for food and additives.

Intertidal mudflats and other soft-bottom coastal habitats play pivotal roles in ocean ecology, even though research and public interest have not historically focused on these habitats. Soft-bottom coastal habitats are highly productive and can be extraordinarily diverse (Levin et al. 2001), with a species diversity that may rival that of tropical forests (Gray 1997). Mudflats are critical habitat for migrating shorebirds and many marine organisms, including commercially important species like the horseshoe crab (*Limulus polyphemus)* and a variety of clam species. Beaches and sandy shores also provide ecological services and are being altered worldwide and although dune systems are not as productive exporters of nutrients as many other coastal systems, they act as sediment reserves, stabilize coastlines, provide areas for recreation, and provide breeding and feeding sites for seabirds and other coastal species.

Coral reefs exhibit high species diversity and endemism and are valued for their provisioning, regulating, and cultural services (McKinney 1998). Reefs provide many of the services that other coastal ecosystems do, as well as additional services: they are a major source of fisheries products for coastal residents, tourists, and export markets; they support high diversity that in turn supports a thriving and valuable dive tourism industry; they contribute to the formation of beaches; they buffer land from waves and storms and prevent beach erosion; they provide pharmaceutical compounds and opportunities for bioprospecting; they provide curios and ornamentals for the aquarium trade; and they provide coastal communities with materials for construction and other uses.

A summary of the services provided by these coastal subtypes is provided in Table 1.

Table 1. Summary of Ecosystem Services and their Relative Magnitude by Subtype

Services\Systems	Estuary	Mangrove	Lagoon	Intertidal	Kelp	Rock reef	Seagrass	Coral reef
Food	●	●	•	●	•	●	•	●
Fibre, timber, fuel	●	⬤	●					
Medicines, other	•	•	•		●			•
Biodiversity	●	●	●	⬤	●	⬤	●	⬤
Biological regulation	●	⬤	●	•		•		●
Freshwater Retention	•		•					
Biochemical	•	•			•			•
Nutrient cycling	●	●	●	•	•	•		●
Hydrological	•		•					
Atmospheric & climate regulation	●	●	●	•		•	•	●
Human disease control	●	●	●	●		•	•	•
Waste processing	⬤	⬤	●			•	●	•
Flood/storm protection	●	●	•	•	•	●	●	⬤
Erosion Control	●	⬤	•				•	•
Cultural & amenity	⬤	•	●	⬤	•	●	●	⬤
Recreational	⬤	•	•	⬤	•			⬤
Aesthetics	⬤	•	⬤	⬤				⬤

Coastal ecosystems thus provide a wide range of services to human beings (Wilson et al. 2004). These include regulation and supporting services such as shoreline stabilization, nutrient regulation, carbon sequestration, detoxification of polluted waters, and waste disposal; provisioning services such as supply of food, fuelwood, energy resources, and natural products; and amenity services such as tourism and recreation. These services are of high value not only to local communities living in a coastal zone (especially in developing countries), but also to national economies and global trade (Peterson and Lubchenco 1997).

In addition to the production of marketable goods, coastal systems provide services such as nutrient recycling and aesthetic benefits to humans. Coastal services, like those of other ecosystems, are therefore generally divided into two categories: the provision of direct market goods or services such as commercial fisheries and tourism and the provision of nonmarket goods or services, which include things like biodiversity, support for terrestrial and estuarine ecosystems, habitat for plant and animal life, and the satisfaction people derive from simply knowing that a beach or coral reef exists (Wilson et al. 2004). While estimating exchange-based values of marketed services in this case is relatively straightforward, as observable trades exist from which to measure value (Freeman 1993), estimating the economic value of coastal services not traded in the marketplace is more difficult (Freeman 1993; Bingham et al. 1995). However, such analysis often reveals social costs or benefits associated with coastal ecosystem services that otherwise would remain hidden or unappreciated.

A survey of how coastal ecosystems are protected shows that innovative financing mechanisms that tap into the private sector are virtually non-existent. With a few exceptions, the protection of these services has generally fallen to the public sector. Government agencies regulate coastal land use, freshwater and wetlands use, maritime activities, resource extraction, and the protection of threatened species and critical habitat. Yet the funds available to manage the coastal zone, both terrestrial and marine, are generally inadequate. And there are inequities in the way coastal areas are managed, such that taxpayers shoulder the costs of protection, while many industries receive an almost free ride in taking advantage of the benefits coastal ecosystems provide.

There is now good baseline information on the various sorts of services that coastal ecosystems provide, though awareness about anything but the most obvious services is still generally lacking in the public and among decision makers. And although studies like the Millennium Assessment highlight coastal ecosystems and their utility, the true market and non-market values of coastal ecosystem services is not fully known. Nonetheless, certain industries depend heavily on the provision of certain coastal and marine services, and these sectors can and should be tapped to provide private sector support for ecosystem protection. These sectors are described below.

II. Beneficiaries and Potential Buyers of Coastal Ecosystem Protection

Coastal services are indispensable to a great many people, and provide significant sources of revenues to individuals, industries, and nations. In order to understand the potential for markets in safeguarding such coastal ecosystem services, it is first necessary to understand who the potential buyers or investors in coastal protection might be. Major classes of investor are described below.

A. Wild Fish Consumers, Processors and Fishers

Coastal ecosystems provide food for a large proportion of the human population; in some countries, marine resources account for the great bulk of protein intake. Fisheries can be categorized as commercial, artisanal, or subsistence, depending on whether and how the products are marketed. One can also view marine fisheries as being either high volume, low value fisheries such as those that supply subsistence, are marketed cheaply, or provide the basis for animal and aquaculture feed; or low volume, high value fisheries that are essentially luxury commodities.

The costs of managing fisheries, maintaining stocks, and protecting key habitat for fishery species are currently borne by governments, either as state or national initiatives or through multilateral regional bodies. However, fisheries in general are poorly managed, and the large majority of intensively fished commercial fisheries are declining. There is ample room for the fishing industry (including retail sectors) to contribute more fully to better management, including protection of marine nurseries sometimes far removed from fishing grounds.

The marine aquarium fish trade is another example of an industry supported in large part by ecosystem services in coastal / marine habitats. The trade is a significant and growing market, supplying fish to dealers and consumers (including public aquaria) throughout the developed and developing world. While many of the species in the aquarium trade can be farmed, there are many high-value species that cannot yet be bred in captivity. The capture of reef fish for the aquarium trade is concentrated primarily in the Asia/Pacific region, and although management of these fisheries is improving, many of the practices used in wild-caught collecting are destructive (e.g. cynanide and blast fishing). In addition to fish for aquaria, corals, sponges, and encrusting organisms are collected for decorating tanks. There are few instances of the marine aquarium trade supporting the protection or management of habitats from which it derives its products.

B. Aquaculture Industry

The aquaculture industry has a paradoxical relationship with coastal ecosystems: while on the one hand, coastal systems provide both seed stock and environmental conditions needed for rearing fish, shrimp, lobster, and mollusks, coastal ecosystems also provide the space needed to create fish ponds, farms, and other aquaculture developments. Conversion of habitat for aquaculture drives much of the loss of habitat and services in the world, especially in coastal South America and Southeast Asia. Although in Latin America, habitat conversion is undertaken primarily by large international corporations, in Thailand and Viet Nam there is a more balanced mixture of small- and large-scale farms. Production is geared completely toward export markets. The growth in this industry has little or nothing to do with population growth or local demands for sources of food. In Ecuador more than 50,000 hectares of mangrove forest has been cleared to make shrimp ponds since 1969, representing a 27% decline in mangrove cover. During the same period, shrimp ponds have gone from zero to over 175,000 hectares. While there has been some recent reforestation in Ecuador (representing approximately 1% increase in a four-year period), this may be more to do with increasing market competition with Southeast Asian producers. In Thailand, both primary conversion of mangroves and wetlands and secondary conversion of rice, rubber, and other agricultural crops to shrimp farms has occurred. Ten years of observations of shrimp farm production in Thailand (Lebel et al. 2002) suggests that once shrimp farms are established, the resulting sedimentation, salinization, and changed tidal influences may seriously impede natural or planned regeneration of coastal forests or tidal basin species and may alter animal communities in waterways and wetlands. An analysis of shrimp farm production also demonstrates the multitude of linkages via the vital flow of water between human-based, land-based, coast-based, and marine-based systems.

Interestingly, the aquaculture industry currently shoulders few if any of the costs associated with protection of coastal lands and services. In fact, researchers and conservationists have noted an environmentally-damaging phenomenon in large scale shrimp aquaculture, where shrimp ponds created from mangrove forest conversion are used for only a few years then abandoned as fallow. As a result, coastal communities who once used the mangrove area to obtain food or for shelter find themselves stripped of key ecosystem services, without having derived benefits from the aquaculture development that caused the degradation. While the aquaculture industry is showing increased awareness towards these environmental and social issues, neither a voluntary code of conduct nor industry standards of operation have been instituted.

C. Pharmaceutical Industry

Marine ecosystems are thought to harbor great potential in the search for pharmaceutical compounds, especially cancer-curing drugs. This is particularly true of coral reefs, which have already yielded pharmaceutical compounds of great value from sponge, cone snail, and other marine species. Although new synthetic technologies compete with natural products to meet the supply, demand for biochemicals and new pharmaceuticals is growing. For many other natural products (cosmetics, personal care, bioremediation, biomonitoring, ecological restoration), use of non-food marine resources is growing. Bioprospecting for medicinal compounds usually occurs in remote and undegraded reef and seagrass habitats, which are becoming increasingly rare as the overuse and destruction of these ecosystems continues.

D. Shipping and Transportation Industry

That the shipping industry utilizes the marine environment is obvious; the extent to which natural processes help maintain safe harbors and shipping routes is less so. However, in tropical and subtropical areas, mangroves provide safe haven for boats, and even large harbors that have been developed to keep their mangrove fringes are often better protected than harbors where all natural habitat has been converted. Similarly, seagrass meadows and marshlands stabilize soils and prevent large scale disruptions to shipping and navigation caused by siltation and sand transport. While it makes sense for the shipping industry to partially subsidize the protection of these regulating services, there are no known examples of the shipping industry’s contribution to protection of coastal wetlands, seagrasses, or the like.

E. Coastal Residents, Developers, Infrastructure Managers and Insurers

Humans have recognized the value of coastal ecosystems for millennia, and even today’s pattern of population reflects the extent to which people have and continue to take advantage of ecosystem services coasts provide. Coastal populations are not spread evenly throughout the coastal zone: the majority of the people live close to the sea, with more than half within 25 kilometers. Coastal population densities are nearly three times that of inland areas: in 2000, population density in coastal areas was 99.6 people per square kilometer, while in inland areas density was 37.9 people per square kilometer (Kay and Alder in press). At the turn of the millennium, half of the world’s major cities (those with more than 500,000 people) were found within 50 kilometers of a coast. Growth in these cities since 1960 was significantly higher than in inland cities of the same size (Kjerfve et al. 2002).

Not only are population pressures high relative to those in many other ecosystems worldwide, but the bulk of those pressures stress many of the most ecologically important and valuable ecosystems within coastal zones. Some 71% of the world's coastal people live within 50 kilometers of an estuary, 31% live within 50 kilometers of a coral reef system, 45% live within 50 kilometers of mangrove wetlands, and 49% live within 50 kilometers of sea grass ecosystems. This is not accidental, of course—these habitats and the ecosystem services they provide present many of the "pull" factors that resulted in initial settlement along a coast as well as subsequent migration to it. Historically, settlements first inhabited the sheltered areas near estuarine bays (many with associated mangrove and sea grass) and reef-protected coasts and only later expanded to other coastal areas (MA, 2005).

Coastal communities derive great benefits from intact coastal ecosystems and the provisioning and regulating services they provide. Wetlands such as mangroves and coastal marshes maintain hydrological balances, contribute to freshwater recharge of aquifers, prevent erosion, regulate flooding, and buffer land from storms. Rock and coral reef habitats also buffer land from storms. As the December 2004 tsunami event in southeast and south Asia proved, those coastal areas and islands which had intact mangrove, seagrass, and reef habitats suffered relatively less loss of life and property than those areas with major coastal habitat loss.

Both coastal infrastructure managers, including private sector owners and government agencies such as local municipalities, state agencies, etc., have enormous financial interests in coastal protection. Insurance agencies have similar vested interests.

F. Tourism/Recreation Operators, Consumers and Beneficiaries in Local Economies

The tourism and recreation industries rely heavily on the ecosystems services in coastal areas, including biodiversity, pollution control, hydrological regulation, erosion control and storm protection, in addition to providing areas for recreation, culturally important areas, and areas of high spiritual value.

Global tourism has been deemed the world's most profitable industry, and coastal tourism is one of its fastest-growing sectors. Much of this tourism centers on aesthetically pleasing landscapes and seascapes, intact healthy coastal ecosystems with good air and water quality, opportunities to see diverse wildlife, and so on. For instance, much of the economic values of coral reefs—with net benefits estimated at nearly $30 billion each year—is generated from nature-based and dive tourism (Cesar et al. 2003). The demand for biologically rich sites to visit increases the value of intrinsically linked habitats such as mangroves and sea grass beds. Temperate bays and estuaries can similarly generate tourism revenues of similar orders of magnitude.

Within the tourism industry, the dive tourism sector is the most obvious to benefit from protected coastal ecosystems – especially high biodiversity areas such as coral reefs. However, even the more casual observers of the underwater world, such as snorkelers, will gravitate to places where biodiversity and water quality are high. In addition, intact coastal habitats such as back reef areas and seagrass beds supply the necessary habitat for calcareous algae that produce the superfine, white sand beaches so highly valued by the beach tourism sector. And although sand can be shipped in and beaches renourished, as these beach-forming habitats are lost, environmental quality is usually much reduced (and costs can be excessive).

II. Baselines and Barriers

A. Baselines

There are no developed markets for PES in the coastal zone, and what innovative financing mechanisms do exist are "market-like", as below. The vast majority of social and economic values associated with coastal systems remain *unaccounted* for in capital market transactions.

1. Ecotourism Payments for Fisheries Protection

A preliminary survey of the literature demonstrates the novelty of private sector investment in the protection of coastal ecosystems and their services. The idea is not necessarily new, but the idea has not been widely put into practice. In fact, in the late 1990s, the World Bank started the Marine Market Transformation Initiative with the purpose of identifying projects that could serve as models for broader private sector investment in coastal conservation. However, there were only a handful of projects that could qualify as true payments for ecosystems services, and the initiative eventually faltered and then disintegrated.

Well known examples of direct private sector investment are limited to tourism operations in which hotel owners have established marine protected areas or underwrite beach patrols to see that regulations are indeed upheld. Habitat protection is the most obvious investment that tourism operators can make to conserve ecosystem services (most typically, biodiversity). Perhaps the best known example of this is the oft-cited Chumbe Island Coral Park in Tanzania. Chumbe Island is situated 8 miles southwest of Zanzibar Town and covers an area of approximately 20 ha. It is an uninhabited island dominated by coral rag forest and bordered, on its western shore, by a fringing coral reef of exceptional biodiversity and beauty. Based on the initiative of Chumbe Island Coral Park Ltd, a private company created for the management of Chumbe, the island was gazetted in 1994 as a protected area by the Government of Zanzibar.

According to the resort owners, the objectives of the Chumbe Island Coral Park (CHICOP) project are non-commercial, while operations follow commercial principles. The overall aim of CHICOP is to create a model of sustainable conservation area management where ecotourism supports conservation and education. Profits from the tourism operations are re-invested in conservation area management and free island excursions for local schoolchildren. The resort owners claim there are clear long-term benefits when the private sector establishes and manages small marine parks, as seen in resource protection, environmental awareness and economics. Over-fished and depleted reefs adjacent to and upstream of the marine park are being restocked, and local people and tourists are educated about related issues. Private management is considerably less costly and more efficient than government-controlled management bodies set up by over-funded donor projects. The Chumbe project receives no donor or other support and depends entirely on income from ecotourism. This now fully covers the running costs, but would not suffice for capital repayment and profits under strictly commercial terms. As long as the country remains peaceful, the operator expects that tourism will continue to fund the project (http://www.csiwisepractices.org/?read=185).

About two thirds of the investment costs of approximately 1 million US$ were financed privately by the project initiator (a conservationist and former manager of donor-funded aid projects). More than 30 volunteers from several countries provided, and continue to provide, crucial professional support. However, this initiative is not without controversy, and many local people, donors, scientists and conservationists have found fault either with the concept of privately held marine parks or with the execution of this particular project. There is also the question of the extent to which this small protected area, flanked by open and largely unregulated use, is actually acting to conserve the biodiversity of the area (as opposed to just drawing in the fish and thus enhancing the visitor experience by "borrowing" biodiversity from elsewhere).

2. Developer-Financed Conservation or Restoration/Rehabilitation

The most common examples of innovative financing for coastal conservation come from developer-financed conservation or restoration/rehabilitation projects, such as those undertaken as part of no net loss of wetlands programs in the US, Australia, and the UK. These efforts occur under legal requirements that coastal developers do not unduly destroy wetlands – developers are thus required either to protect some portion of natural wetland or reconstruct (or artificially construct) new wetlands equivalent to the ones that are lost to habitat conversion. There is much debate, however, about the ecological contribution (esp. equivalency of services) provided by wetlands built under these programs. In any case, the services being protected include hydrological balance (flood protection), biodiversity, provision of nutrients, and nursery habitat for fisheries, *inter alia*.

3. Public /private partnerships for coastal protection

There are myriad examples of public private partnerships in conservation, though most would not fall under the rubric of PES-like arrangements. However, examples of public-private partnerships such as a municipal government teaming with the local Chamber of Commerce, have institutional arrangements that could easily be built upon for true PES initiatives. Another example is Australia's Hilltops2Oceans project, which aims to engage local communities and their governments in watershed-wide management that is synergistic with integrated coastal management being undertaken at the state and national level (Bruce, 2004). Again, a spate of services is the target of conservation, including but not limited to, biodiversity, flood protection, pollution control, freshwater and food, nursery habitats, etc.

Environmental NGOs commonly execute the kinds of surveillance, ecological monitoring, and use surveys that would normally be under the purview of government or other management agencies. In the Florida Keys, for instance, The Nature Conservancy has a long tradition of patrolling Florida Bay and the reef tract with volunteers, who notify authorities of regulation infractions, and who do simple ecological and resource use monitoring. In another example, an independent NGO undertakes patrols in Port Honduras' marine reserves. In some cases the NGOs are subsidized by government funds, but in most cases, private monies are funneled through the NGO to allow fiscal co-management with underfunded government agencies otherwise unable to execute their environmental mandates.

4) Recreation, fishing and hunting fees

Much resource management and ecological research or monitoring has its roots in the private sector, even when government agencies carry out the work. Examples of private financing of public sector resource management include the generation of conservation funds through licensing fees for fishing and hunting, which either support state management agencies or are pooled in national programs (in the U.S., Dingell-Johnson funds for aquatic research, for example). Supporting species and biodiversity are the services that these programs aim to protect.

5) Private payments for coastal monitoring

Another example of indirect payment for coastal and marine ecosystem protection is the growing movement of communities hiring watchdogs to monitor compliance with existing pollution and/or fishing regulations, and to publicly blow the whistle when infractions occur. A good example of this approach is the pooling of community funds in Long Island and coastal Connecticut (USA) to underwrite the salary and expenses of a Soundkeeper. Similar examples exist in Narragansett Bay, and along the Hudson River (in fact, the Hudson Riverkeeper is probably the best known model for this sort of approach).

B. Barriers

The barriers to expanding and institutionalizing private sector payments for ecosystem services are manifold. Some of the major barriers are discussed below.

1) **Problems of aggregation.** One fundamental barrier is that coastal management and conservation professionals are not naturally aggregated, lacking global or even regional associations. A key goal of this project will thus be to network these professionals, both in a general sense through outreach and in a more localized sense by seeking their participation in demonstration projects.

2) **Limited recognition of the services and their value**. Coastal and marine ecosystems present a complex web of goods and services, perhaps more so than any other major ecosystem type. Clearly individuals and communities value the coast, as burgeoning population growth and resource use in coastal areas attest. But there is not a clear understanding of the extent to which intact ecosystem services, particularly when taken individually, support human well-being and economies. Too often we realize the value of services in the wake of calamities, once the ecosystems providing them have been degraded or destroyed. This project will help raise awareness of the value of these services, and the wisdom of investing in their protection.

3) **Inadequate mechanisms to prevent free-riding**. The "tragedy of the commons" problem in marine environments is not an insignificant one. The common pool resource nature of fish and other resources, and the open access to ocean space, fuels conceptions about unalienable rights and privileges that are difficult to overcome (Agardy, 1997). Many sectors of many societies feel they have a right to use, and even damage, coastal and marine ecosystems, because those ecosystems "belong to them". In such a sociological climate, cheating the system of regulation is often not frowned upon. In addition, coastal and particularly offshore areas are difficult to monitor. Surveillance under the water or far out to sea is prohibitively costly, and modern technology has only presented a few viable tools to address these problems. This project has great promise in overcoming the problem of free-riding by keeping the scope of the initiative small enough that the services, and their use and protection, will be carefully monitored. And once beneficiaries realize their investment in ecosystem services pays off, opportunities for self-regulation and self-policing will undoubtedly arise.

4**) Lack of institutional support and insurance for collecting payments for protection of ecosystem services from the private sector**. No marketplace yet exists for PES trades. Yet more surprising is that although innovative financing mechanisms have captured the attention of institutions worldwide, there have been no concerted efforts to build such a marketplace. It seems that research and conservation institutions remain in an exploration phase. This project will help break the stasis that exists and catalyze actual movement towards the development of a fullblown coastal PES market. This market will be both robust and low risk, with insurance mechanisms to protect investments built in.

5) **Information barriers.** Information about ecosystem service markets is scarce and the capacity to assess and develop markets is limited. Progress is hampered by lack of understanding and political support form key stakeholders. Few national, state, or local government entities have access to the information needed to shape policy on market design. Most market expertise is available only from the private sector, generally companies and consultants who are motivated by the opportunity to promote deals. The Katoomba group has identified a lack of transparent information as the greatest obstacle for the development of these markets. To realize the potentials of ecosystem service markets for biodiversity conservation we will need to fill these knowledge gaps. If there is not appropriate action to address this at both national and international levels, many market opportunities will simply fail to materialize, especially in poorer countries and for poorer forest producers. This project will identify information barriers and put a framework in place to surmount them.

6) **Conservative institutions.** Another barrier that needs mentioning is the conservatism of management agencies with jurisdiction over coastal and marine areas and resources. In general, such agencies have been slow to embrace innovative new ideas and unconventional co-management opportunities. The U.S., Europe, and Australia have long been considered pioneers in coastal management, yet the typical approach is very much command /control, with few incentives for users to practice good stewardship. A promising exception, however, has been the emergence of efforts to practice ocean zoning. The concept of ocean zoning is rising in popularity in this country and abroad, as managers struggle to slow or halt coastal degradation and over-exploitation of marine resources. It is widely recognized that ocean zoning has great potential, but much like the concept of “ecosystem-based management”, ocean zoning may be like the joke that everyone laughs at but no one really gets. Although the ocean zoning concept itself is not difficult to understand, and the need for new tools is ever clearer, zoning is currently much more theoretical than practical, as there have been few efforts to design and implement zoning plans. This project will look for opportunities to move market-based conservation in synergy with ocean and coastal zoning and other non-traditional management of marine areas and species.

7) **Limited spatial allocations of coastal resources and space.** Zoning can facilitate the establishment of PES markets by creating the foundation for clearly defined “use” areas. But whereas zoning on land is an established practice that has occurred in various forms for centuries, ocean zoning is a relative new phenomenon. The large scale experiments in ocean zoning that are occurring outside MPAs include the national efforts of New Zealand to develop its Ocean Policy and some nascent initiatives elsewhere in the world. In Belgium, efforts have been underway to define the relative biological values of all parts of the Belgium EEZ (see Derous et al., 2005). In Canada, the government is toying with the idea of ocean zoning as it implements its policies and programs under the Oceans Act. And closer to home, the state of Massachusetts has committed itself to developing a zoning plan for state waters. The latter is a response to two developments that were viewed as possible threats to Massachusetts’ coastal waters: 1) the siting of an LNG terminal outside Boston, and 2) the proposal to develop an offshore wind farm in Nantucket Sound. These prospective ocean zoning initiatives have implications for coastal PES projects for a number of reasons. First, ocean zoning is a potentially powerful tool to improve management of coastal areas and more fully safeguard ecosystem services. Secondly, PES markets could provide a direct link to zoning plans by providing information that might well be used to develop “trade zones” in more broadly zoned areas. Finally, making zoning operational will further coalesce a wide variety of institutions and actors that need to come together in order to make coastal ecosystem services market fully viable.

III. Project Strategy

Vision and objectives

Recognition of the value of ecosystem services is growing. New sources of potential market demand are emerging for ecosystem services. Markets are expanding rapidly and there is growing awareness of market potential among business, investment and conservation communities. At the same time, there is a tremendous variety of market structures and business models. Schemes differ according to the number and type of participants involved, the payment mechanisms that are employed, the degree of competition and their level of maturity.

There is an opportunity today to achieve large-scale institutionalization of ecosystem markets that will shift economic incentives in favor of conservation while benefiting livelihoods, and to overcome identified obstacles limiting market development. This will require:

- Making available timely and accurate market information;
- Identifying and connecting key market actors;
- Establishing policy frameworks and institutional arrangements for new types of markets;
- Developing innovative business models for buyers and sellers of conservation services; and
- Building leadership and institutional capacity to design and implements PES

This project will provide essential background information for developing and evaluating new payment for service systems for coastal environments. Once completed, the baseline information provided through this project can be matched with public and private interests to more effectively facilitate the development of global ecosystem markets and payment schemes which are financially viable and effective in promoting conservation in the coastal zone. There are two sectors that appear most ripe for development of markets for coastal PES.

Fisheries Protection. One is fisheries, including coastal aquaculture or mariculture, in which farmed organisms rely on wetlands, estuaries, or mangrove forests for either sources of seed stock or feed. A prime example is shrimp or prawn aquaculture, described in the preceding sections, but the marine aquarium fish trade and related farming of aquarium fish also deserves investigation. Both these aquaculture industries are highly profitable, and both have come under increasing public scrutiny for engaging in practices that harm the environment and reduce the provision of ecosystem services. Many of our NGO partners, including most notably WWF, have been working with the industry to develop and implement best practice guidelines.

Another industry which has not to date been engaged in coastal management but has enormous potential to do so is the recreational fishing industry. Recreational fishers have been strong advocates for protection of nursery areas that support the resources upon which their industry depends. A PES Market would allow this lucrative industry to invest in ecosystem services protection to better ensure its future viability.

Flood Protection. The second sector that is a prime candidate for PES markets is the coastal development industry, which derives enormous benefits from the flood protection services that mangroves, marshes, coral reefs, and other naturally buffering habitats provide. The recent catastrophic losses generated in the wake of the tsunami and the spate of hurricanes in the southern United States demonstrate the immense value of protecting these systems so they can protect us. There is much good data emerging from post-tsunami and post-Katrina investigations which will allow better quantification of the value of these flood protection services – data that will be extremely useful for developing a market in coastal PES. Many of our partners are involved in this post-catastrophe assessment, and will be engaged with us in developing the markets.

Objectives and outcome

The main outcome of this component of the project is the development of assessment tools for coastal fishery and flood protection PES at the landscape scale. This scoping project will provide essential information for developing and evaluating new payment for service systems for coastal environments worldwide. The following outputs will be generated:

Output 1: Analytical framework and tools to evaluate and design PES for coastal fishery and flood protection

The project will be greatly facilitated by the development of an analytical framework and typology of coastal ecosystem goods and services for the assessment of global sites, which will be completed early in the project's timeline. The assessment will also complete a literature review and conduct meta-analysis of available economic studies for coastal ecosystem goods and services. An in-depth investigation into existing market solutions for coastal ecosystem service conservation (direct conservation purchases etc.), will also be performed during the assessment phase.

A significantly more challenging step in the development of robust markets for coastal PES will be the development of analytical tools for planning coastal payments for ecological services, including identifying market criteria (business models) needed for the implementation of payment for coastal services; developing a master matrix of services, values, actors, and regions; and constructing a decision model for matching coastal systems with institutional actors for market solution, and strategies to address identified barriers.

The project team will develop integrated analytical tools that can be used by decision makers to match diverse coastal systems and their associated ecosystem services with the public and private stakeholders that form the institutional basis upon which ecosystem service markets and payment schemes will be developed. These tools will include ways to quickly assess services and the condition of ecosystems that provide them locally, matrices to identify the actors in any prospective PES scheme, analytical means to determine relative values of services for the purpose of pricing those services, ways to assess the efficacy of management and determine where gaps exist or in which ways management needs to be strengthened, and GIS-based tools to highlight the spatial configuration of resources, uses, and management (including zoning).

An international Advisory Committee will be formed to assist in the conceptual and practical development of the framework, tools and oversee the project. This committee will consist of representatives of the major academic fields and user interests whose participation underlies all effective coastal conservation: a) ecologists and environmental assessment specialists (e.g. the Millennium Ecosystem Assessment contributing researchers), b) economists, demographers, and sociologists (including MEA researchers but also including professionals from organizations such as the Society for Applied Anthropology, the International Institute for Applied Systems Analysis, etc.), c) resource managers and coastal planners, including practitioners from the World

Ocean Observatory (W2O) , d) conservationists from NGOs and the World Conservation Union (IUCN), and e) business leaders, consultants, and investment professionals, as appropriate.

Output 2: Application of framework and tools to evaluate the feasibility and design for two costal PES projects

The practicality and economic vitality of coastal markets needs to be demonstrated through operational projects. The success of payments for coastal ecosystem services will be highly dependent on the extent to which we can engage the public, specialists, decision-makers, and the private sector. Thus the outreach and education that will flow from these projects will be key in leveraging broader support for coastal PES markets. In this phase of the project, we move from robust theoretical analysis and planning to real life application. Careful analysis of actors, services and their value, and institutional capacity will allow for identification of two coastal pilot sites in selected regions of Tropical America and eastern/southern Africa. The project will work with the appropriate legal, conservation, academic, business, and government institutions to launch PES markets in two coastal areas deemed most suitable for demonstrating the potential power of innovative PES methods for improving coastal management efficacy.

Output 3: Resource materials on coastal PES compiled and disseminated through the Ecosystem Marketplace

This project intends to raise awareness through the print media, and will consolidate and engage relevant specialists through the formation of coastal PES working groups and listserves. Forest Trends has launched The *Ecosystem Marketplace*^SM (EM), an information platform for a broad audience of market participants, regulators, policy makers, NGO's, community groups and low-income producers. The *Ecosystem Marketplace*^SM will be adapted for the ground-breaking new projects involving payments for coastal ecosystem services, and will readily link internet visitors to other relevant coastal management sites.

IV. Conservation Impact

A successful project to launch robust market and payments schemes for coastal ecosystem services will not only provide a new tool to coastal managers, it will also steer broader coastal conservation towards greater efficacy. Specifically, the project will leverage attention to promising areas needing fiscal and technical support, and will help strengthen GEF International Waters and coastal Biodiversity projects that are currently underway or planned for the future. Thus this GEF project has the potential to act as a model for future projects (GEF or non-GEF), and will mobilize governmental and non-governmental institutions to more seriously take on the challenges that coastal conservation present.

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