Economic Valuation, Economic Instruments and Property Rights: Coral Reefs in Southeast Asia

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Paper presented at the 4th International Conference on Property Rights, Economics and the Environment (Theme 2002: Coastal Zone), Aix-en-Provence, France, June 26-29, 2002

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1. Introduction

In most tropical countries, coral reef ecosystems provide many goods and services to coastal populations. The goods and services form an important source of income to the local population (fishery, mariculture, etc.), often living at subsistence levels. Also, they are a potential tourist attraction, thereby contributing to local income generation and foreign exchange. Besides, they form a unique natural ecosystem, with important biodiversity value as well as scientific and educational value. And coral reefs form a natural protection against wave erosion.

A variety of anthropogenic practices threatens reef health and therefore jeopardizes the benefits flowing from these services and goods. These threats range from local pollution, sedimentation, destructive fishing practices and coral mining to global issues like coral bleaching. Often, these threats are the result of externalities: people causing the threat benefit from unsustainable economic activities, but the costs are borne by others depending in some way or another on coral reefs.

Economists argue that this is often due to the absence of a well-functioning market for environmental goods and services. Hodgson and Dixon (1988) describe a clear externality situation with 'no-market' where logging causes sedimentation resulting in reef degradation (tourism) and fishery losses. For the logging company, these tourism and fishery losses are not part of their profit calculation. In the absence of government policy and/or public outcry, logging would continue even if the external costs to society were much higher than the net profits of the logging industry, as was the case in the example of Hodgson and Dixon. Also, economic instruments linked to property rights can for instance solve the 'tragedy of the commons' by giving fishermen exclusive access to certain fishing grounds. Another economic instrument is the creation of markets for sustainable resource utilization. This can enhance the value captured by the local population from these goods and services and enhance the ownership felt by local communities. Economic valuation can help to shed light to the importance of the services and goods by 'getting some of the numbers on the table' and by showing the costs of inaction. This paper gives an overview to these economic instruments and valuation.

This example shows two points: (i) it highlights the fact that in the absence of markets for environmental goods and services, an optimal allocation of these goods and services can only be obtained through some form of intervention; (ii) it shows the importance of obtaining economic values for the various reef goods and services, e.g. a fishery value and a coastal protection value. These goods and services can deal with concrete marketable products, such as shell fish, for which the value can be determined based on the demand, supply, price and costs. Other services depend on the possible future uses of yet unknown biodiversity on reefs for which sometimes markets can be created. The values of all these goods and services together forms the Total Economic Value (TEV) of reefs ecosystems (e.g. Spurgeon, 1992). This TEV can be calculated for a specific area or for alternative uses (e.g. preservation area, tourism area, multiple use area, etc.). We can also use economic valuation to calculate the economic losses due to destruction of reef functions, as in blast fishing (Pet-Soede et al. 1999).

This paper deals with economic valuation, economic instruments and property rights with respect to coral reef ecosystems. First, the goods and services of coral reefs are described and basic concepts of economic valuation and markets are discussed in Section 2. The next two sections describe case studies on market creation for sustainable grouper capture and on economic valuation of a marine protected area. The case studies are:

Case 1: Market transformation live food reef fish trade Current practices in the live reef fish trade pose a critical threat to global marine biodiversity. The trade also imperils the food security and income provided by traditional reef fisheries in Southeast Asia. This case study describes today's trade and its underlying destructive and unsustainable fishing practices. The concept of a marine market transformation is introduced and applied to reef fisheries. In particular, current wild-caught supply mechanisms are described and the potential for mariculture and sustainable wild-catch as ways of introducing property rights are evaluated.

Case 2: Economic Valuation and Cost Benefit Analysis for Marine Protected Area: The Total Economic Value is given for the Portland Bight area (Jamaica) together with a Benefit Cost Analysis for establishing a Protected Area. Establishing a marine protected area (MPA) is a costly affair and a government needs to be well-informed about the pros and cons of an additional MPA (McClanahan, 1999). Evaluating the costs and benefits of establishing and running an MPA is a crucial step for an economist involved in MPAs.

2: Goods and Services of Reefs, their Market and Economic Value[1]

Ecosystems provide a great many functions, goods and service. The terms ‘functions’, ‘goods’ and ‘services’ have, in this context, slightly different meanings, though these terms are used interchangeably by many in the environmental economics literature. Costanza et al. (1997, p.253) define functions, services and goods in the following way: “Ecosystem functions refer variously to the habitat, biological or system properties or processes of ecosystems. Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem services”. For example, a forest provides the function of retention of water, with the associated service of water supply.

For a reef ecosystem, the economic value is often defined as the total value of its instruments, that is the goods and ecological services that an ecosystem provides. We therefore need to know the major goods and services of reef ecosystems as well as their interactions with other ecosystems. Next, these goods and services need to be quantified and monetized. For goods sold in the market place, this is straightforward by looking at their market price, but for ecological services, this is not the case. Therefore, complex valuation techniques are used to arrive at an economic value of these services. Note also that for each of the goods and ecological services where no markets exist at present, markets could be established in principle, although this might be very costly and impractical.

Figure 1: Total Economic Value and Attributes of Economic Values for Coral Reefs

Total Economic Value

- Use Values
- Non- Use Value

direct use value	indirect use value	Option value	Quasi-option value	Bequest value	Existence value
Outputs / services that can be consumed directly	Functional benefits enjoyed indirectly	Future direct and indirect use	Expected new information from avoiding irreversible losses of:	Value of leaving use and non-use values to offspring	Value from knowledge of continued existence, based on e.g. moral conviction
Extractive: capture fisheries mariculture aquarium trade pharmaceutical Non-Extractive: tourism/recreation research/education aestetic	Biological support to: sea birds turtles fisheries other ecosystems Physical protection to: * other coastal ecosystems * coastline * navigation Global life-support: carbon store		* species * habitats * biodiversity	*species *habitats *‘way of life’ connected to traditional uses	* threatened reef habitats * endangered species * charismatic species * aestetic reefscapes

Source: Barton (1994).

[1] This section is an abbreviated version of Cesar (2000).

The value of all the compatible goods and services combined gives the Total Economic Value (TEV) for an ecosystem. The neo-classical foundations of economic value and its relationship with willingness to pay and consumer surplus are not discussed here (Barton, 1994 and Pendleton, 1995 for a specific discussion on the economic value of coral reefs). Each of the goods and services of coral reefs generate economic value. Fishery resources can be harvested and sold, creating value added and likewise, the coastal marine area enables sea transportation that creates profits. Similarly, preservation and eco-tourism create value. The mapping between the goods and services on the one hand and their values on the other hand is straightforward, as is shown in Figure 1.

As indicated in Figure 1, there are six categories of values: (i) direct use value; (ii) indirect use value; (iii) option value; (iv) quasi-option value; (v) bequest value and (vi) existence value. Direct use values come from both extractive uses (fisheries, pharmaceuticals, etc.) and non-extractive uses. Indirect use values are, for example, the biological support in the form of nutrients and fish habitat and coastline protection. The concept of option value can be seen as the value now of potential future direct and indirect uses of the coral reef ecosystem. An example is the potential of deriving a cure for cancer from biological substances found on reefs. Bio-prospecting is a way of deriving money from this option value. The quasi-option value is related to the option value and captures the fact that avoiding irreversible destruction of a potential future use gives value today. The bequest value is related to preserving the natural heritage for generations to come where the value today is derived from knowing that the coral reef ecosystem exists and can be used by future generations. The large donations that are given to environmental NGOs in wills is an example of the importance of the bequest concept. The existence value reflects the idea that there is a value of an ecosystem to humans irrespective of whether it is used or not.

These values all are quite abstract and theoretical. Measuring these values in monetary ways is not straightforward, and in some cases (nearly) impossible. For an overview of different techniques, see Barton (1994), Dixon et al. (1988), etc. Yet, it is important to take these values into account. As Dixon (1989) states: “Whether a coastal resource is a good or service, marketed or nonmarketed, is not important in terms of its function in the coastal ecosystem. The extent to which coastal resources represent easily marketed goods, however, heavily influences resource management decisions. Nonmarketed goods and environmental or ecosystem services are frequently overlooked or their importance played down. This is one of the factors leading to resource management conflicts and poor decisions”. Therefore, creation of non-existing markets and transformation of markets that do not function well can be a solution to environmental problems and overextraction of resources, as is shown in the first case study. The art and science of valuing environmental goods and services will be discussed in the other case study.

3. Case Study on Marine Market Transformation of Live Reef Fish Food Trade[2]

3.1. Introduction

Reef fish stocks have seen a dramatic decline over the last decades with growing fishing pressure. Their sedentary nature and the habit of some of the larger species of reef fish of congregating in spawning aggregations, make them easy to target. A relatively small but important segment of reef fisheries is the live reef fish trade (LRFT) which involves the capture of living coral reef fish from Indo-Pacific island nations such as Indonesia, the Philippines and Papua New Guinea. The trade has traditionally focused on ornamental fishes, but recently, the bulk of the trade has shifted to reef food fish principally to supply Hong Kong, Taiwan and mainland China (Johannes and Riepen, 1995). Global annual retail value of the LRFT was roughly US$1.2 billion in 1995, of which US$1.0 billion from live food fish (Barber and Pratt, 1998). This case study focuses on the live food fish segment, primarily comprising groupers (Family Serranidae, especially the genera *Epinephelus* and *Plectropomus*) and small volumes of humphead wrasse (*Cheilinus undulatus*, also referred to as Napoleon or Maori wrasse).

The substantial profits generated by the LRFT are counterbalanced by serious environmental impacts. The two most pressing problems are the use of cyanide and overfishing of target species. During the 1980s, destructive cyanide fishing techniques, which enable the capture and transport of live reef fish to distant markets, became widespread for the LRFT. The ecological and economic impacts of cyanide fishing have recently gained considerable popular as well as scientific attention (Johannes and Riepen, 1995; Erdmann and Pet-Soede, 1998; Cesar, 1996; Barber and Pratt, 1998; Mous et al, 2000). While cyanide is a very effective method to capture reef fish, its effects reach beyond targeted fish to damage corals, other reef invertebrates and non-target fish. The Indo-Pacific region contains over 90% of the world’s coral reefs and serves as the planet’s central repository for marine species. The destruction of these reefs poses a critical threat to global marine biodiversity.

Overfishing for the LRFT also imposes severe constraints on sustainability (Mous et al, 2000). As a direct result of the live reef fish trade, catches of giant grouper and humphead wrasse are increasingly rare. Spawning aggregations are increasingly targeted often removing a significant proportion of spawning fish during the course of their brief annual spawning period. Such fishing practice could compromise the reproductive potential of these species. Mariculture of grouper species may also be contributing to overfishing problems. With its heavy reliance on wild-caught breeding stocks and juveniles for grow-out and its use of so-called ‘trash’ fish (i.e., by-catch which consists of normally non-commercial species and juveniles of a range of species), the grouper mariculture industry may in fact be intensifying rather than decreasing existing pressure on wild grouper stocks (Sadovy and Pet, 1998).

The degradation of coral reefs and overfishing for the LRFT threaten the livelihood of already marginalized fishing communities. Vast areas of Indonesian reefs are being exhausted to support the LRFT and the collapse of its grouper fishery is imminent (Erdmann and Pet, 1999). A recent economic analysis estimates quantifiable losses to Indonesia from cyanide fishing to be US$280 million compared with profits from the fishery of US$234 million, a net loss of US$46 million. Sustainable live reef fisheries were estimated to have a net societal benefit of US$322 million in present value terms (Cesar et al. 1997). The discrepancy between profits and societal losses due to the LRFT, as well as the potential for better alternatives to the trade, drive the fundamental research question of this case study: in the absence of clear property rights, can the current destructive practices and unsustainable market for live reef fish in Southeast Asia be transformed into a trade that is both non-destructive and sustainable?

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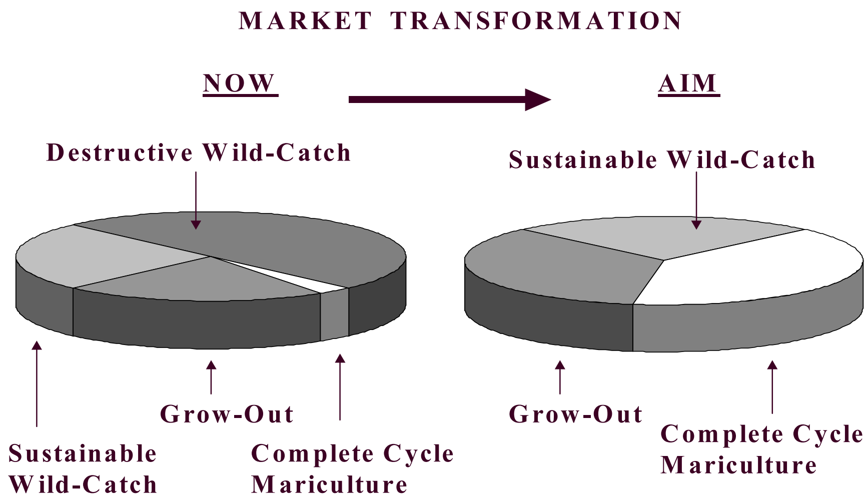
[2] This section is an abbreviated version of Cesar et al. (2000).

3.2 Marine Market Transformation

The LRFT is not sustainable in its current form, due to the use of cyanide, the catch of overexploited species, the targeting of spawning aggregation and the capture of juveniles from the wild. Yet, the harvesting of groupers as a renewable natural resource provides a food source to consumers, a livelihood for many fishers, and foreign exchange for developing countries. Therefore, if harvesting is done in a non-destructive and sustainable way, this trade could be a selective (i.e., reducing bycatch by selecting for groupers) and value-added fishery that needs not be discouraged.

The challenge is how to move from today's non-sustainable and habitat-destructive situation to a future trade that is both sustainable and non-destructive (Figure 2). This shift is problematic because: (i) the LRFT is very lucrative for some stakeholders; and (ii) traditional enforcement of customs and fisheries regulation is weak. To enable a shift toward sustainability requires that policy makers and NGOs 'go with' rather than 'go against' the market. This key concept underlies the Marine Market Transformation (MMT). In the grouper fishery case, given the existing demand for live reef fish, the MMT would 'unleash the market' by stimulating a sustainable substitute for cyanide-caught groupers and thereby undermine current destructive practices. Three potential ways of supplying groupers sustainably are: (i) sustainable wild-catch of marketable size fish; (ii) complete cycle mariculture; i.e. situation where juveniles originate from fish culture and (iii) grow-out based on sustainable wild-catch of fingerlings.

Figure 2. Current situation and future goal for the LRFT through a marine market transformation.



The concept of the MMT for groupers is similar to the idea behind two recent initiatives, the Marine Stewardship Council (MSC) and the Forest Stewardship Council (FSC). Their aim is to improve fishing and forestry practices respectively through eco-labelling (Holthus, 1999). The MSC-logo and the FSC-label show that these fish and wood products come from well managed sources. Each of these initiatives encourages the responsible use of renewable resources by offering a sustainable alternative to consumers. Whether the substitutes proposed are enough to supply the demand for live reef fish remains uncertain. However, failing concrete action, the alternative is the collapse of the LRFT in due course, with its correlative negative impact both on the regional economy and on biodiversity. The main ways of supplying groupers sustainably are:

Wild-Caught Supply for the LRFT: Due to the cyanide issue, a non-destructive alternative to cyanide - hook-and-line grouper fishery - has become increasingly popular in countries such as the Philippines and the Maldives. Fish are caught using a variety of baits, which differ for individual grouper species, and are kept alive using needle decompression, which releases built-up pressure in a fish's air bladder to prevent death at the surface (Barber and Pratt, 1998). But even with hook-and-line, the environmental sustainability of the LRFT may still be threatened in the long-term, as groupers are vulnerable to overfishing due to their long life, large size at sexual maturity and predictable reproductive behaviour (Mous et al., 2000). However, even with proper regulations and enforcement, the wild-catch of groupers is likely to be insufficient to supply future demand for the LRFT. Therefore, alternatives to wild-catch have to be developed.

Full Cycle Mariculture for the LRFT Reef fish mariculture in Asia is still in its nascency, with the only major commercial activity in Taiwan with about 600 grow-out and hatchery farms producing 5,000 to 7,000 tons of marketable-sized groupers annually. Three species -- *Epinephelus coioides, E. tauvina* and *E. malabaricus* -- comprise about 90% of the total. Rearing of high-valued grouper species such as giant grouper in significant numbers is still problematic. Challenges in general include: (i) adult wild groupers are taken directly for brood stock (mature spawners); (ii) wild juveniles (fry and fingerlings) are caught for grow-out, even for full cycle mariculture because of seasonal periods of limited supply; (iii) non-target wild species are used as fish feed or wasted as bycatch - for each tonne of grouper, 8 tonnes of trash fish are needed; and (iv) high mortality is observed during transition to the sedentary life-stage, as well as difficulties with starter feeders and cannibalism. See Cesar and Hempel (2000) for a recent description of grouper aquaculture in Asia.

Grow-Out Based on Sustainable Catch of Wild Fingerlings: The sustainability of wild capture of seed and juveniles for mariculture is still debated among scientists. The key issue centers on whether the capture of seed and juveniles for grow-out contributes to total mortality in wild grouper populations, or if it represents harvesting of young fish that would otherwise die of natural mortality. Natural fish mortality rates decrease with time from egg production to settlement and post-settlement. Highest natural mortality rates occur early on (stage 1) prior to settlement or within a few weeks or months thereafter and then drop rapidly within a few weeks to months afterwards (Sadovy and Pet, 1998). Survivorship rapidly increases as individuals become established in nursery or adult habitats (stage 2) and quickly attain adult natural mortality levels (see also the discussion below).

Sustainable management of the live reef fish trade requires active participation on the part of both importing and exporting economies. However, action to date has been one-sided, with demand countries shifting responsibility for environmental damage to supply nations. With coordinated efforts on the part of both importing and exporting economies, particularly APEC members Hong Kong and China, I believe the live reef fish trade can move from a legacy in the late 20th century of ecological destruction and irresponsible economics and practices to a future that is cyanide-free and sustainable into the 21st century.

4. Case Study 2: Economic Analysis of Portland Bight Protected Area - Jamaica[3]

4.1 Introduction

In an effort to preserve its ecological heritage, the Jamaican government has announced a plan to set aside fourteen protected areas (including National Parks and Marine Parks) as well as 100 smaller areas in need of special protection. In 1990, the Blue and John Crow Mountains National Park came into being, and in the following year, the Montego Bay Marine Park, was created. In addition, in 1997, the Jamaican government created the Negril Environmental Protection Area which includes the Negril Marine Park and its watersheds. Most recently, on Earth Day 1999, the Jamaican government declared its largest conservation area, the Portland Bight Protected Area (PBPA) along Jamaica's southern coast just west of Kingston (Jamaica's capital). Its marine region runs due south into the Caribbean Sea and then east-west along the 200 m depth contour. The area has a number of valuable ecological resources, including coral reefs, sensitive wetland systems, unique dry limestone forests, and a number of endangered, rare or protected species.

Given the scarce financial resources of the Government of Jamaica and the international donor community, it is crucially important to show the economic benefits in relation to the costs of managing the area. Cost benefit analysis (CBA) is a valuation technique that can help in this process. The key challenge is that many of the benefits of managing the park are not directly measurable in money terms, and various environmental valuation methods need to be used to monetize these benefits. Once the major costs and benefits are quantified, a more informed political decision by Government and international donors is possible. Therefore, the aim of this study is to quantify the costs and benefits associated with the Portland Bight Protected Area to help the Government of Jamaica and the international donor community in making informed decisions about supporting the management plan.

4.2 The Study Area – Geography and Ecology

The PBPA covers 519.8 km^2 of land (which includes 82.0 km^2 of wetlands and 210.3 km^2 of forests), and a marine area of 1356.4 km^2. The land area of the PBPA is 4.7% of Jamaica's total land mass, an area larger than the entire island of Barbados. Coral cays and reefs occur sporadically through the marine area of Portland Bight, notably at the edge of the island shelf, and associated with the several coral cays and islands. Mangrove wetlands predominate along much of the coastline, particularly on the western coast of the Hellshire Hills and along West Harbour on the northern coast of Portland Ridge. There are occasional mangrove-lined sandy beaches, often at the base of limestone cliffs or rocky shores. The inland geography of the region includes a diversity of features, notably the limestone surface which predominates on the Hellshire Hills, Portland Ridge, Braziletto Mountains and the Goat Islands. This soft and porous limestone geography is characterised by deep gorges and steep ridges, and gives the land surface a pitted appearance with sinkholes resulting from networks of underground caves.

Portland Bight is Jamaica's largest embayment, hosting a diversity of wildlife within complex ecosystems. Shoreward benthic regions of the Bight are dominated by mudflats, sheltering organisms that provide an important food source for fish species in neighbouring cays and reefs. Moving seaward from the mudflats is a transitional area of sea-grass in mixed mud, sand and sediment, beyond which is found a thick sea-grass habitat. This ecosystem functions as habitat for a number of marine organisms, including shellfish, finfish, turtles, sea birds and the endangered West Indian Manatee (Trichecus manatus). Beyond the sea-grass beds are coral reefs containing 60 species of reef-building coral as well as a large variety of fish and crustaceans (Hughes, 1994 and references given there). Among the varieties of hard coral found in the Bight, the most common include the Boulder Star Coral (Montastrea annularis) and the Massive Starlet Coral (Siderastrea siderea).

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3 This section is based on Cesar et al. (2000).

The coastal areas of the Portland Bight are characterised by the largest remaining mangrove system in Jamaica, comprising 48 km2 of almost unbroken red mangrove (Rhizophora mangle) mixed with buttonwood (Conocarpus erectus), white (Laguncularia racemosa) and black (Avicennia germinans) mangrove trees. The endangered American Crocodile, Crocodilus acutus lives in the mangrove streams. In addition to mangrove systems, the coastal areas of the Bight include ecologically valuable salt marshes and salt flats, which are habitats and nursery areas for fish and waterfowl including migratory ducks. The PBPA contains four prominent examples of tropical dry limestone forest, comprising a unique evergreen forest as well as cactus scrubs. The Hellshire Hills is the largest remaining pristine dry limestone forest in Central America and the Caribbean. It has approximately 60 km2 of virtually undisturbed forest, and is uninhabited by humans due to its nearly impenetrable, rough limestone terrain.

To preserve these, a management plan for the Portland Bight Protected Area was prepared by the CCAM and published in May 1999. Regarding its finances, operational expenses of the PBPA will be financed from government subvention, the collection of user fees, the income from a trust fund and with profits from tourism activities and merchandising. Grant funds will play a large part in making the necessary capital expenditures. The recurrent costs of the PBPA Management Plan are estimated at US$ 1.496 million per year while the capital investments are estimated at US$ 2.422 million. Using a 5 year write-off period, the combined recurrent and capital costs of managing the PBPA are roughly US$ 19.2 million over 25 years in net present value terms (10% discount rate). This information will be used for the cost-benefits analysis.

4.3 Resources, Services and Functions

The various ecosystems in the PBPA support a host of different resources, services and functions (RSFs). Some of the most important ones are described here in three categories: (1) RSFs with direct use-values, such as wood and fish; (2) indirect use-values, such as tourism and coastal protection; and (3) non-use-values, such as the biodiversity function.

Direct Uses: The Fishery consists of pelagic and demersal fish that feed along the coral reefs and the rest of the island shelf of Portland Bight. The fishing grounds of South Jamaica cover an area of 258,590 ha. Lobster, shrimp and conch stocks, although severely depleted, are an economically valuable resource. Forestry products from the limestone woods of the PBPA feed local demand for timber products such as fuelwood and charcoal in surrounding urban areas such as Kingston and Portmore. Mangrove wood is also valued as a source of poles for fences, stakes, scaffolds, and yamsticks, and is used in housing construction. Besides, the mangroves and dry limestone forests provide a host of non-timber products, such as honey, orchids and medicinal plants.

Indirect Uses: The tourism and recreation sector is a fundamental component of the Jamaican economy, bringing in 1.8 million visitors and receipts over US$1.3 billion in 1997. Tourism along Jamaica's south coast is far underdeveloped compared to the north coast but efforts are currently underway to change this. The Portland Bight region, like the rest of Jamaica, appeals to tourists interested in relaxation, touring, swimming/sunbathing, and enjoying natural surroundings. The area has been identified for its potential to develop a tourist sector that also helps to maintain the region's ecological integrity. Other indirect uses include the navigation function. Two major ports located within the Bight are major alumina storage and shipping complexes also used for the export of goods brought in by rail and the import of oil, grain, and other bulk cargo. As well, the area bustles with fishing boats and pleasure craft. Furthermore, the wetlands allow for natural waste treatment, sediment retention and coastal protection. The latter is important to prevent coastal erosion. The mangrove and limestone forests fix carbon dioxide, a process referred to as carbon sequestration. This is increasingly being recognised as an important ecosystem service for mangroves to offset CO2 emissions and thereby to slow down the Greenhouse Effect.

Non-uses: Some ecosystem functions are remote and are not accounted for as either direct or indirect use. The many unique ecosystems contained within the PBPA make an important contribution to the biological diversity of the island, and provide habitat or nesting areas for endangered species, several of which are endemic to Jamaica. Note that this non-use function is related to use-functions. Tourists come to enjoy the biodiversity and culture, but the idea of "non-use value" is the intrinsic existence of these functions independent of human use.

4.4 Economic Valuation

The numerous resources, services and functions (RSFs) of the three categories of ecosystems (marine; wetland; terrestrial) have been discussed above. Each of these RSFs has an economic value. Following the environmental economics literature (Dixon & Sherman, 1990), we distinguish: (a) extractive direct use values; (b) non-extractive direct use values; (c) indirect use values; (d) non-use values. The main problem with the valuation of these RSFs is that measuring these values in monetary ways is, at the very least, quite time consuming and in some cases (nearly) impossible. The RSFs valued are:

Fisheries: The total yield of the Portland Bight fishery was 1088,4 t in 1997. This corresponds to 0.8 mt km-2 yr-1. Haughton (1988) suggested that the maximum sustainable yield (MSY) for the south Jamaican fishery is 2.2 t km-2 (Cesar et al., 2000). Given the relatively low capital intensity, this is close to the maximum economic yield (MEY). The discrepancy between actual yields and the MEY shows the enormous level of overfishing. Given the open access nature of Jamaican coastal fisheries, it is assumed that current yields equal the open access equilibrium (OAE), where all economic rents are squeezed out of the market. Reasonable profit margins for south-shelf fishermen are known of 50% (pot fishers) and 54% (net fishers). With growing piracy, fishpot stealing and overfishing, we assume that profits have declined to zero over the last decade. Cesar et al. (2000) estimate that MSY profits are US$5,000 km-2 yr-1 or US$ 6,780,000 for the PBPA at an average fish price of US$2.8 kg-1. In the OAE, the value would be zero.

Forestry: In the mangrove and limestone forests, tree cutting is undertaken for construction material, fuelwood and charcoal production. Though some level of mangrove thinning is sustainable if regulated properly, wood extraction in the dry limestone forests is nearly by definition unsustainable due to the absence of top-soil. In the Hellshire hills, some 60 people are involved in charcoal production, creating a total value per year of US$100,000. Harvesting of non-timber produce takes place at such a small scale the value of these non-timber resources currently is put to zero here.

Tourism and Recreation: Currently, the number of tourists visiting the PBPA is very small, except at Hellshire Bay, a popular beach day-trip destination for local Kingston residents. Nine local game clubs are active in the area, specifically for recreational bird hunting and reef fishing and there are 20-50 international bird tourists visiting the area annually. Future eco-tourism development possibilities in the PBPA are suggested. The extent to which tourism develops further depends on expansion of facilities, marketing, as well as on reduction of possible violence and tourism harassment. Two scenarios are identified here, one where these constraints are not adequately dealt with and one where gradual and sustainable expansion of eco-tourism is realised over time. In the latter scenario, the value of tourism and recreation is taken to be US$75 ha-1 yr-1 based on benefit transfers (Costanza et al. 1997) or US$ 4,700,000 for the whole PBPA (assuming that 1/3 of the area is of interest to tourists). In the former scenario, we assume tentatively that tourism profits are 1/10th of this amount (US$470,000), the same as in the future 'without PBPA' case. We further assume that currently, the value added from tourism is zero.

Carbon Fixation: Growing forests can sequester carbon, thereby reducing the net emissions of CO2 into the atmosphere and slowing down the enhanced greenhouse effect. The net growth of the dry limestone forests is very limited and the carbon fixation value is assumed to be zero. Mangroves have a much larger potential for carbon sequestration. Sathirathai (1998) estimates a value of US$8200 km-2 yr-1 based on US$5.67 per ton of carbon and a primary productivity for mangroves in Thailand's Kanjanadit district of 15.1 tonC ha-2 yr-1. Using this value as a benefit transfer, the 55 km-2 of mangroves in Portland Bight has an annual value of US$45 million. Over the last decades, mangroves have been cut in an unsustainable manner which has led to some coastal erosion. It is assumed that the net area of mangroves remains stable in the PBPA while it will decline with 1% per year in the absence of management.

Coastal Protection: Mangroves and other wetlands, as well as coral reefs contribute to coastal protection, as such ecosystems are able to dissipate wave energy. Mangrove destruction has damaged the coastal road going into Portland Ridge in recent years. For the Portland Bight, Cesar et al. (2000) estimate that the total coastal protection value is around US$3.55 million in net present value terms or nearly US$400,000 per year (with 10% discount rate). Destruction of coastal ecosystems lowers the value of the coastal protection. It is assumed following Pet-Soede et al. (1999) that 1% loss in coastal ecosystems leads to 1% loss in the coastal protection function, and this in turn to a loss in 1% of the value of the coastline. With a 1% mangrove decline in the absence of park management and stabilisation with park management, the benefits of the PBPA in terms of coastal protection are US$40,000 per year.

Biodiversity: To estimate biodiversity in a developing country, Ruitenbeek (1992) suggests to take the value of foreign support likely to be available to protect the biodiverse resource through NGOs, the Global Environment Facility (GEF) as well as through other means. A recent study for Indonesia showed that two marine parks were able to capitalise on their global value of biological diversity, by obtaining an average of US$10,000 per km2 (Cesar et al, 2000). In the PBPA, the area of most interest to biodiversity are the Hellshire Hills (90 km2), the Portland Ridge (50 km2), the wetlands (82 km2) and the rest of the strip along the coast (around 80 km2 as well). Therefore, an area of roughly 200 km2 could be eligible for global grant funding of around US$10,000 per year, giving cash revenue of US$2,000,000 per year. This grant money would not be available in the absence of park management.

Total Benefits of PBPA: The values of the ecosystems services can be combined to calculate the total benefits of the PBPA. To do so, the difference in value between a 'with PBPA' scenario and a 'without PBPA' scenario needs to be calculated. However, as discussed, the aggregation of economic values would still need to take the compatibility of the different functions for a specific use into account (Spurgeon, 1992; Barton, 1994). Of all the services discussed above, the only one not compatible with sustainable use of the other ecosystem services is charcoal production. Therefore, in the 'with PBPA' scenario, charcoal production will stop. For the sake of argument, it is assumed that the changes will be complete in one generation (25 years), so that fisheries will be back at its maximum sustainable yield in 2025. Likewise, tourism and recreation will be at their full eco-tourism potential in 2025. Table 1 pulls all the values of the ecosystem together. The total (incremental) benefits of the PBPA are estimated at US$52.6 million in present value terms (at a 10% discount rate) for the optimistic tourism scenario and US$40.8 million in the pessimistic tourism case.

Table 1: Values for ecosystem services in the Portland Bight (in thousand US$)

	'Without PBPA'		'With PBPA'		Accumulated Difference 2000-2025 (in NPV)
Year	2000	2025	2000	2025	
fisheries	0	0	0	6,780	18,928
forestry	100	100	0	0	-916
tourism (high)	0	470	0	4,700	11,809
tourism (low)	0	470	0	470	0
carbon fixation*	0	0	450	450	4,122
coastal protection*	0	0	40	40	366
biodiversity	0	0	2,000	2,000	18,322

total (high tourism)	100	570	2,490	13,970	52,632
total (low tourism)	100	570	2,490	9,740	40,823

*These are calculated in net terms. This means that the 'with' scenario gives the net gains relative to the 'without' scenario.

Comparison Costs and Benefits: To see whether the costs of the PBPA Management are justified on economic grounds, the benefits from park management need to be compared with the management costs. It was estimated that, in net present value terms, the (incremental) costs of PBPA management are US$ 19,2 million over a 25 year time period, while the incremental benefits are US$52.6 million in present value terms for the optimistic tourism scenario and US$40.8 million in the pessimistic tourism case. This shows that the suggested Park expenditures are well justified, with benefits somewhere between two to three times the costs of managing the park.

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