Economic Analysis of Marine Managed Areas in the Main Hawaiian Islands

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30 April 2004

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Colophon

This study is part of a larger report with the title “Assessment of Economic Benefits and Costs of Marine Managed Areas in Hawaii" by Herman Cesar, Pieter van Beukering and Alan Friedlander. This publication is a result of research carried out by Cesar Environmental Economics Consulting (CEEC) and funded by the National Oceanic and Atmospheric Administration, Coastal Ocean Program, under awards NA 160A2412 to the University of Hawaii for the Hawaii Coral Reef Initiative Research Program. Co-funding was obtained from the Division of Aquatic Resources (DAR) and the Department of Business, Economic Development & Tourism (DBEDT). Comments from Linda Flanders were greatly appreciated.

1. Introduction

In recent years, there has been growing interest in marine parks, reserves, no-take zones and refugia as tools for conserving and managing coral reef ecosystems, both in the US and in the rest of the world. This has resulted, for instance, in the establishment of an ever-increasing number of such areas. The US Coral Reef Task Force, established by President Clinton under Executive Order 1308 is playing a very active role in this process in the US. These marine areas are sometimes referred to as Marine Protected Areas (MPAs). However, as the management objectives of these areas is often broader than protection or conservation alone, this paper will refer to these areas as Marine Managed Areas (MMAs).

MMAs provide several direct and indirect benefits to the economy of Hawaii. These include (a) enhanced attractiveness of reefs, (b) maintenance of shoreline, and (c) support for reef fisheries in adjacent areas as well as pelagic fisheries in coastal areas through improved reef health and fish biomass. In order to maximize these potential benefits, strong MMA management is required. However, this incurs operational costs and necessitates seeking increased revenues.

The main aim of this report is to estimate the economic value of MMAs in Hawaii and to evaluate the costs and benefits of different management and financing regimes of these MMAs. This study only looked only at valuation in the inhabited areas of the main Hawaiian islands, not the coral reefs in the Northwest Hawaiian Islands. These islands are too distinctly different to be included.

During a meeting with DAR, HCRI and other organizations, six sites representing typical characteristics of MPAs in the main Hawaiian Islands were selected for more in-depth analysis. As shown in Table 1, this selection includes sites with different coral reef habitats and varying degrees of economic activity and reef uses. Habitat distinctions include standard zonation patterns (reef flat, bench, slope, etc.) as well as specific features, such as surf, etc.

Table 1 Scores on various criteria for the six sites (low = 1, high = 6)

Sites	Tourism	Research	Fisheries	Real Estate	Biodiversity	Cultural
Hanauma Bay	6	6	1	2	5	2
Diamond Head	2	5	5	4	1	4
Molokini	5	2	2	1	4	1
Honolua Bay	3	4	3	3	3	3
Kahalu'u Beach	4	1	4	5	2	5
Waiopae	1	3	6	6	6	6

This report is structured as follows. First, the method is briefly explained in Section 2. Section 3 elaborates on the origin of the underlying data used in the economic analysis. Future scenarios for the six sites are explained in Section 4. Simulations and results are presented in Section 5. Finally, conclusions and recommendations are formulated in Section 6.

2. Methodology

2.1 Model

The basis of this analysis is an integrated model that dynamically links ecology and economy. Figure 1 provides an overview of the approach of the study. It shows how the mutual relationships in the model evolve. On one hand, it shows how coral reef ecosystems generate a wide range of goods and services which benefit Hawaiian society. On the other hand, the over-exploitation of these economic goods and services can lead to threats to the coral reef ecosystems and can destroy the flow of goods/services. Measuring the impact of these threats requires more technical approaches, such as dose-response functions and hydrological models. Management options lead to benefits (reduction of threat) and typically cost money. Therefore the final step in the analysis is to compare these costs and benefits. An elaborate explanation of the approach is provided in Cesar et al. (2002).

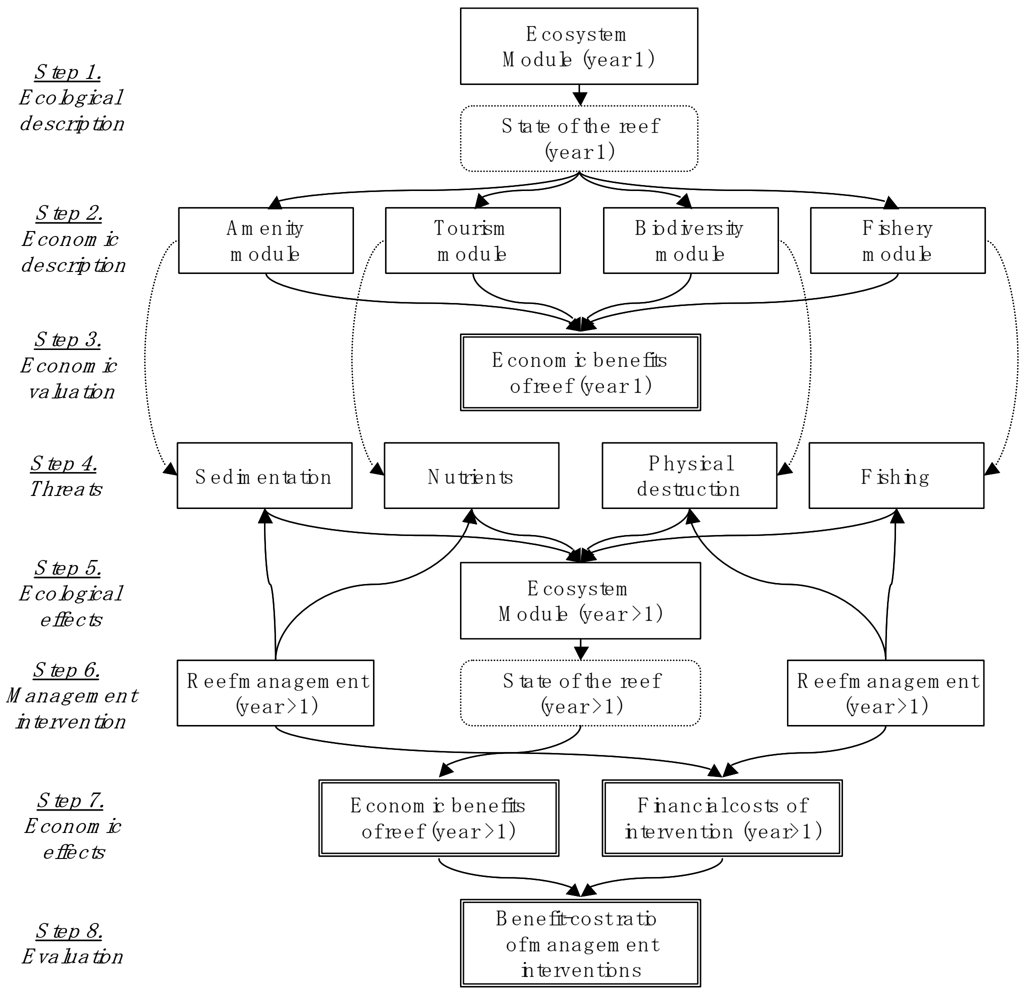

Figure 1 General framework of the dynamic simulation model

2.2 Boundaries

For a clear overview of the economic consequences of the different MMA management scenarios considered in this study, project boundaries need to be clearly defined. The main boundary definitions include time, space and benefits. (1) The *temporal* boundary of the project is set for the period 2005 to 2030. This period allows enough time for the main ecological effects to become apparent, while it is still short enough to to enable prediction about future developments. (2) The *spatial* boundaries are the boundaries of the study area and the impact area. Tourists can go diving in the study area while staying and spending most of their money outside this area. (3) Resource and budget constraints call for a selection of the most important goods and services for coral reef valuation. Additionally, the natural science basis for quantification of biotic and bio-geo-chemical services is controversial. Therefore, the following goods and services, in particular, will be quantified to obtain a 'lower boundary' estimate of the total economic value (TEV):

- *Recreational services for residents and tourists*: MPAs provide several direct and indirect benefits to the tourism industry, including: (a) maintaining and enhancing coral cover and diversity which increases satisfaction from diving, snorkeling and glass bottom boat rides; (b) a healthy reef will protect the shoreline from erosion and maintain sand levels on beaches; (c) game fishing in deep seas may benefit from improved reef health.
- *Educational spillover effect*: If snorkelers and divers are educated concerning sustainable reef use, this "investment" will not only generate results in the reef where education is provided, but also in most other coral reefs that the tourists will visit. Sound behavior in other areas prevents reef damage at other sites, which implicitly avoids further economic damage through tourism, coastal protection, fisheries, etc. The multiplier effects of education are labeled as the 'educational spillover effect'.
- *Commercial and recreational fisheries*: Fishery production in areas adjacent to 'no-take' zones can be enhanced through the following: (a) Larval spillover: egg production is increased as the number of fish reaching maturity increases in 'no-take' zones. The larvae are dispersed by ocean currents and the MPA may then act as a source of larvae for other areas; (b) Non-larval spillover: fish stocks in 'no-take' zones will increase over time. A study in Mayotte, for instance, estimated that the mean biomass of commercial species was 202g/m^2 in the reserve compared to 79g/m^2 outside it (Letourneur, 1996 as quoted in Rodwell & Roberts, 2000). Juveniles and adult fish can both migrate to adjacent areas especially when the 'no-take' zone becomes 'overcrowded'; (c) Nursery and feeding grounds: 'No-take' zones in seagrass beds, mangrove areas and coral reefs provide nursery and feeding grounds for oceanic and reef fish from adjacent areas; (d) Species protection: 'No-take' zones can provide refuges for protection of endangered species and other fish that may be important in the complex tropical marine food-chain.

2.3 Quantification of benefits

The quantification of the benefits of the coral reefs ecosystem involves various research activities, including field (market) surveys, benefit transfers, literature reviews and expert judgement. Due to financial resource constraints, no field survey was conducted. Therefore, quantification was based on existing literature in combination with benefit transfer and a recreational survey. In processing this data, a host of valuation techniques are available to quantify the value the goods and services provided by coral reef ecosystems. Standard techniques in micro-economics and welfare economics rely on market information to estimate value. However, for most externalities inherent to environmental issues, standard techniques, such as market prices, cannot be used.

Three general categories of valuation techniques are distinguished: (i) generally applicable techniques that directly use the market to obtain information about the value of the affected goods and services or of direct expenditures; (ii) revealed preference methods that indirectly calculate external benefits using the relationships between environmental goods and expenditure on market goods; (iii) stated preference methods ask the individuals their willingness to pay (WTP) for the environmental good directly by using structured questionnaires. The WTP is defined as the maximum amount of money a person is willing to pay to obtain a good or service. Three valuation techniques were used for this study: Effect on Production (EoP); Travel Costs (TC); and the Contingent Valuation Method (CVM). For a discussion of these methods in the Hawaiian context, see Cesar et al. (2002).

2.4 Quantification of current trends and threats

Traditionally, economic valuation of renewable resources has been conducted in a static manner. In the past decade, however, the trend shifted towards dynamic systems for the economics of renewable resources. In this project, dynamics are particularly important because one of the objectives is to assess how disturbances and management interventions influence the costs and benefits of the coral reef. The impact of these disturbances may vary over time, often in a non-linear manner. Therefore, the baseline development under different management scenarios and the potential for threats to occur will be taken into account.

In order to deal with these ecological-economic complexities, a simplified dynamic simulation model will be used. The ecological-economic relations follow a pathway, linking the type of coral reef ecosystem, its uses and location with, the physical goods and services provided by the reef, and the economic value of these factors (see Figure 1). In an earlier valuation study, a general coral reef model was developed to address a large range of threats and management options. This general model will serve as the basis for the MPA specific study.

2.5 Assessment of management approaches

The main questions to be addressed in relation to MMA management include the following: (1) What is the economic value of different types of MMA management? (2) Is it worth protecting the reefs? In other words, do the benefits of MMA management exceed the costs? And (3) besides economic considerations, what are the criteria for selecting a specific type of MMA management? For example, political sensitivity of specific management strategies may lead to an alternative approach, despite its favorable economic considerations. These questions are elaborately addressed in the overall project. In this specific report, we focus on questions (1) and (2).

Great care needs to be taken in balancing the costs and benefits of an MMA, and in ensuring that there is an acceptable distribution between all groups. Provision of alternatives to losers could make the MMA attractive to all stakeholders, thereby improving the chances of success, but compensation schemes should only be introduced after careful consideration, so that communities do not become dependent on such initiatives.

3. Data

A number of different sources were used in order to obtain data for the various sites' benefits and costs, their management options. First, a survey among residents and tourists has been conduct to retrieve specific information about their perception of different types of coral habitats. A summary of the results has been presented in Van Beukering et al. (2004). Second, a literature review on fishery benefits of MPAs in Hawaii has been produced. More information on this overview study can be found in Friedlander and Cesar (2004). Third, specific information has been collected on the different MMA schemes around the world to learn more about the cost-efficiency of different regimes. This information has been reported in Cesar and Van Beukering (2004). In this section, we will provide the most fundamental data used to estimate the costs and benefits in the different case studies.

3.1 Physical data

To provide an idea of the ecological characteristics of each site Table 2 summarizes their physical parameters. Interestingly, all six sites are relatively small and none of the sites is larger than one square kilometer. Fish biomass also differs substantially with a low average of around 0.4 tons per hectare for Diamond Head and Honolua and a high 1.38 tons per hectare for Hanauma Bay. Note that Hanauma Bay is the area with the strictest enforcement, while Diamond Head and Honolua are the MMAs with lowest levels of compliance (Cesar, 2004). Coral cover also differs notably per site, with Hanauma and Honolua both at low levels below 25%, whilst reaching up to 84% in the deep areas of Molokini.

Table 2 Physical parameters of study sites

Physical Parameters	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Area estimate (m^2)	407,682	959,585	809,368	181,267	22,259*	202,350@
Reef estimate (m^2)	100,937	142,424	48,571	34,709	n.a.	n.a.
Sand estimate (m^2)	47,234	39,939	n.a.	82,448	n.a.	n.a.
Fish biomass (*t/ha*)	1.38	0.41	0.98	0.91	0.39	*0.81*
Fish species (*#*)	28	11	21	23	15	81@
Coral cover - shallow^	21.8%	n.a.	64%	15.5%	n.a.	35.0%
Coral cover - deep^	22.2%	n.a.	84%	24%	n.a.	45.0%

Source: Friedlander and Cesar, 2004; Holland and Meyer 2003; Meyer 2003.

* estimate by Ku'ule Rogers

@ estimate by Kristian Kerr (50 acres); this is an estimate of the total number of fish species; the number of fish species for the other sites represents the average number of fish species per transect.

^ definitions of 'shallow' and 'deep' vary per site, e.g. for Hanauma 3 meters and 10 meters resp.

3.2 Basic tourism and recreation estimates

Given the importance of recreational benefits in our analysis, basic visitor statistics were gathered for each of the sites. This data is summarized in Table 3. We focus on the group of so-called 'active visitors'. Hence, sun-bathers at Diamond Head who do not engage in any water activities are not incorporated in our statistics. Note that Hanauma Bay has by far the largest number of active tourists (1 million per year), followed by Kahalu'u (350 thousand per year). Lowest is Diamond Head with only 10,000 active visitors per year. The vast majority of these active visitors are snorkelers, although diving takes place in some of the MLCDs, particularly Molokini (around 86 thousand divers per year) and Hanauma (around 35 thousand per year).

Table 3 Basic visitor statistics (rounded figures)

Visitor type	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Total active visitors	1,000,000	15,000	224,000	86,000	350,000	40,000
Total divers	35,000	1,500	86,000	2,000	-	-
Total snorkelers	965,000	8,500	139,000	84,000	350,000	40,000

Source: Cesar et al. 2002; Holland & Meyer 2003; and pers. comm. Alan Hong, Jan Dierking and Linda Flaunders. The Waiopae numbers are very rough estimates and include other 'active non-extractive' users.

For each of the sites, the number of visitors per country was derived from our surveys in combination with official statistics. Table 4 summarizes this information, which is important for a number of reasons. Firstly, different nationalities have different spending patterns. Also, the costs of arriving at a site depends crucially on the country and this is important for the economic valuation exercise. Finally, for the entrance fees discussed below, Hawaii residents are excluded from paying the fee in some scenarios and therefore, these numbers need to be estimated. It is interesting to observe that some sites are particularly popular among Hawaiian residents, such as Waiopae (61% Hawaiian), while others are catering mainly to outsiders, such as Molokini with 95% of visitors from out-of-state.

Table 4 Visitors by country

	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Hawaii	12%	24%	5%	7%	19%	61%
US West	43%	38%	55%	55%	45%	20%
US East	20%	20%	28%	29%	25%	11%
Japan	15%	6%	7%	2%	3%	1%
Canada	3%	4%	4%	2%	2%	4%
Europe	4%	5%	1%	2%	4%	2%
Other …	2%	2%	1%	3%	2%	1%

3.3 Economics of visitors

For the economic valuation and cost benefit analysis of the MMA sites, the recreational benefits need to be calculated. The methodology for calculating these recreational benefits is given in Cesar et al. (2002). First, actual expenditures of visitors to the MMA sites need to be determined. Table 5 gives the expenditures of visitors to Hanauma Bay as an example.

Table 5 Expenditures of visitors to Hanauma Bay

Country	International ticket costs	National travel costs	Expenditure per day (excl. snorkel)	Costs per dive experience
Residents	$0	$25	$0	$75
US West	$500	$25	$136	$75
US East	$700	$25	$167	$75
Japan	$600	$25	$227	$75
Canada	$650	$25	$143	$75
Europe	$1,200	$25	$135	$75
Other …	$1,000	$25	$175	$75

Recreation benefits can be calculated based on these expenditures, and on the welfare aspects presented in Cesar et al. (2002) and the survey results of our study (Van Beukering and Cesar, 2004). Four categories of benefits are idenitfied:

1. The welfare gain of the visitors as reflected in their expressed consumer surplus. In other words, the amount the visitors would have been willing to pay in addition to the actual payment to enjoy the reef experience at an MMA site.
2. The actual expenditure directly related to snorkeling or diving experience. This includes entry fee, hiring of mask and fins, bus fare etc. We assume that only 55% of these expenditures can be considered as value-added.
3. The expenditure indirectly related to the marine experience such as hotel costs and travel costs. DBEDT (2001) reports that marine activities such as diving and snorkeling form 18% of the total motivation of visitors to come to Hawaii. For hotel and other local expenditures, we assume that 35% can be considered as value-added for the Hawaiian economy. For travel within Hawaii, we assume a value-added figure of 15%, while for international travel, we assume a value added figure of 3%.
4. A multiplier effect on expenditures. We use a multiplier of 1.25 for the Hawaiian economy (DBEDT, 2001).

Based on these assumptions, the current annual recreational value of the coral reefs of each of the MMA sites can be estimated. These are given in Table 6.

Table 6 Total recreational benefits in 2003

Country	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Residents	2,005,747	37,465	713,147	97,068	1,084,810	124,414
US West	15,671,314	126,876	10,700,448	1,382,351	4,382,582	73,259
US East	8,072,503	77,095	5,867,203	843,854	2,750,439	45,208
Japan	5,760,900	20,666	1,335,041	45,487	322,306	4,193
Canada	1,131,627	16,159	950,770	50,137	192,848	13,539
Europe	1,398,915	15,726	154,331	55,734	319,860	6,525
Other …	1,124,610	9,923	192,266	97,482	307,918	5,291
Total	35,165,617	303,910	19,913,205	2,572,112	9,360,764	272,429

From Table 6, it is clear that the differences in recreational benefits per MMA site are enormous. At one extreme, Hanauma Bay and Molokini have annual recreational benefits of US$35 million and US$20 million respectively, while at the other, Waiopae and Diamond Head have recreational reef-related benefits of around US$300,000.

Honolua and Kahalu'u have benefits somewhere in between these extremes with US$2.6 million and US$9.4 million per year respectively.

These recreational benefits are all reef-related; composed of divers and snorkelers. The snorkelers category also includes other active non-extractive users of the sites. Table 7 summarizes the allocation of recreational benefits. Note that these percentages are somewhat different from the numbers presented in Table 3. The reason is that divers tend to spend much more than snorkelers. Hence, even in places where the number of divers is small, such as Diamond Head, their contribution to overall recreational reef-related benefits may be substantial.

Table 7 Allocation of recreational benefits between divers and snorkelers

Visitor	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Divers	9%	42%	47%	8%	0%	0%
Snorkelers	91%	58%	53%	92%	100%	100%

4. Scenarios

MMAs have higher biomass and diversity of marine life than other most accessible marine areas in Hawaii, adding to the enjoyment of many residents and tourists. Yet, the management of these MMAs could be improved upon in several ways. This study explores five different aspects of improvement in the context of each site. These aspects are:

- *Services*: this is defined as the presence or absence of basic facilities, such as restrooms, showers and waste-bins;
- *Enforcement/Compliance*: this describes how well existing regulations regarding fishing and non-extractive use are enforced, and the overall level of compliance with site regulations;
- *Education/Awareness*: this is defined as the presence/absence of basic education and awareness information, such as bill-boards about marine life and threats, leaflets, videos, as well as the presence or absence of interpretive staff or volunteers who can answer any questions about the MMA and marine life;
- *Assessment/Monitoring*: this describes the level of monitoring activities in the MMA (coral transects, use studies, etc.);
- *Infrastructure*: this refers to the presence or absence of parking facilities, small piers to enter the water safely and to reduce impacts on corals, mooring buoys, etc.

Based on observations and interviews, the current level of these management aspects are summarized in Table 8 For each of the sites, the level of each of the aspects is described as 'high', 'medium', 'low' or 'none'.

Several caveats apply: for the Honolua-Mokuleia MLCD, we focus on the items present for the recreationists, that arrive at the MMA by car or on foot. In this table, we therefore ignore the aspects present on the commercial tourist catamaran that also brings visitors to Honolua. For Molokini, infrastructure refers to the buoys situation. Finally, for Hanauma, no improvements appear possible. However, for the description here, we will use the situation before the construction of the visitor center and introduction of the obligatory marine life information video as our baseline.

Table 8 Current level of selected State or County management-related aspects of the six MMAs.

Management	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Services	High	Low	High	None	Medium	None
Enforcement	High	Medium	Medium	Low	Medium	Low
Education	High	None	Medium	None	Low	None
Monitoring	High	Medium	Medium	Medium	Low	Low
Infrastructure	High	Medium	Medium	None	Medium	None

There are many possible management alternatives for each of the sites. We consider one option per site and hence one cost-benefit analysis per site. We will also carry out a sensitivity analysis for each site, with respect to the cost of the selected management option. This gives an idea of the robustness of the cost-benefit estimate. For each site, a different hypothetical scenario is worked out, resulting in a different long-term situation regarding each of the management aspects. These improvements are summarized in Table 9.

Table 9 Future level of selected State or County management-related aspects of the six MMAs.

Management	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Services	High	Low	High	High	Medium	Low
Enforcement	High	High (different)	High	High	High	Medium
Education	High	Medium	High	Medium	Medium	Medium
Monitoring	High	Medium	Medium	Medium	Medium	Medium
Infrastructure	High	Medium	High	Medium	High	Low

For each of the sites, the management actions to progress from the current situation (Table 8) to the hypothetical future situation (Table 9) are described below Note that for Hanauma, no additions to further actions are envisaged.

4.1 Hanauma Bay

Hanauma Bay is an enclosed embayment formed through the partial collapse of two volcanic craters and subsequent erosional processes. In the late 1980s, Hanauma Bay was almost being ‘visited to death’ with 13,000 visitors a day at peak times. These crowds stirred up sediment, disturbed and trampled the coral and algae, dropped trash, fed the fish and left a slick of suntan lotion on the Bay's surface. To decrease these impacts, the number of visitors was reduced by limiting the entry of cars to the parking lot. Also, a Hanauma Bay Educational Program (HBEP) was set up to improve the marine awareness of visitors. A $3 admission fee was charged to non-Hawaii residents over the age of 13, as well as a $1 parking charge per car. These fees, together with shop concessions, give Hanauma Bay a solid financial base. In August 2002, a new visitor education center opened with an obligatory video to be watched by all visitors to the Bay. Cesar et al. (2002) investigated the question of whether this visitors center was a worthwhile investment. The current study repeats this question with some new additional numbers. One of the changes is that the entrance fee to the Bay has been increased to $5.

In this paper, the management option for Hanauma assumes the pre-2002 situation without the visitors center. The 'management improvement' is then the construction of a visitors center. Visitors of Hanauma Bay pay their entry fee, stroll through the education stands, and sit through a compulsory short film which explains about coral reefs in Hawaii and how the visitors should behave to protect marine life. It is anticipated that physical damage and fish feeding will be considerably less in this scenario with additional education spillover effects on other snorkeling/dive sites in Hawaii.

The investment costs of the new center are $13.5 million and operating expenses of the center are estimated at around $2 million annually. These costs can be entirely defined as education/awareness costs.

4.2 Waikiki Diamond Head

Waikiki MLCD and Waikiki-Diamond Head Shoreline Fisheries Management Area (FMA) are located on the south shore of Oahu and comprise about 76 acres. The MLCD includes the waters offshore of Kapiolani Beach Park. The Waikiki-Diamond Head Shoreline FMA extends from the sea? wall of the Waikiki War Memorial Natatorium to the Diamond Head Lighthouse. The FMA has a rotating closed area, which is open to fishing throughout even years, and closed throughout odd years. In the open years, all fishing is allowed except gillnets and night spearfishing.

Currently, very few visitors to the MLCD and the FMA are attracted by the snorkeling, although there are some interesting snorkel sites along the reef edge. The FMA is not very successful: the build-up of fish in the closed year is fished within weeks of opening the fishing season (Meyer, 2003). Therefore, the management option selected in Waikiki-Diamond Head is to split the FMA in half: one half is always open and the other is always closed. This is a step in the direction of increasing the MLCD as suggested by Meyer (2003) in his dissertation on fish and fisheries at Waikiki Diamond Head.

The following improvements are envisaged in the 'with management' scenario:

- The FMA is split into a no-take zone and a take zone;
- A floating platform is fixed in the water close to the reef edge to facilitate snorkeling;
- Education and awareness for visitors is increased through additional billboards, free leaflets and volunteers.
- Enforcement is enhanced in collaboration with local residents, DOCARE and the Municipal Police, for which additional money is made available.

The advantage of the permanent closure is that fish can build up in the closed area. This would enhance the snorkeling experience and therefore, an awareness program could be set up. The infrastructure expenditures would further add to the enjoyment of the snorkeling experience. Also, the fish build-up would lead to fishery spillovers. The cost of this package of measures is assumed to be US$105,000 in terms of initial investment costs in year one, and annual operation and maintenance costs of US$58,000. Specification of these costs is given below in Table 10.

4.3 Molokini Shoal

The Molokini Shoal MLCD is the southern rim of an extinct volcanic crater, off the coast of Maui. The actual crater is a Bird Sanctuary and landing on the island is prohibited. Snorkeling and diving is only possible from boats. There are currently slightly over 40 licensed boats that offer dive and snorkel trips to Molokini, bringing more than 220,000 active recreationists to Molokini every year.

The services discussed above (restrooms, etc.) are present on these boats. Compliance with the fishing and other regulations is fairly good, although there are reports of poaching during the evening and night. Marine life education/awareness takes place on the boats by various means, including dive briefings. The level of education and the amount of knowledge transferred depends on the crewmembers of these boats. The only infrastructure present is mooring buoys.

The following improvements are envisaged in the 'with management' scenario:

- Measures to decrease poaching in the evenings and at night are improved through more regular patrols and full time evening/night surveillance from the Maui coast;
- Education and awareness on the boats is increased through training and certification of education program by DAR as a condition of commercial use permit of the tourist operators and by making information materials freely available;
- Buoys are well maintained and replaced if needed.

These measures lead to higher biomass and diversity of marine life and less damage to the reefs. This in turn increases the satisfaction of divers and snorkelers. It also increases fish yields in adjacent areas through larval and adult spillover. Finally, there is an educational spillover, as discussed above.

The costs for this package of measures is difficult to estimate as it is not entirely clear how much additional manpower is needed to increase enforcement. We assume here that the suggested improvements can be realized with an initial investment of US$150,000 in year one (US$25,000 for education and US$125,000 for enforcement) and recurrent costs of US$90,000 in subsequent years (US$20,000 for education and US$70,000 for enforcement).

4.4 Honolua Mokuleʻia Bay

The Honolua Mokuleʻia Bay MLCD consists of two semi-enclosed bays bordered by north and south basalt cliffs. The north reef is generally sheltered, except from north Pacific swells in winter. This area has high human use: water recreation, boat traffic, tourism. The primary threats include poaching, fish feeding, anchoring, trampling and sedimentation. Visitation is high with around 86,000 active visitors per year. Access to the MLCD is possible by land and by sea. Sea access is organized by a commercial operator offering a sailing trip with a catamaran, the Trilogy, including a snorkel/dive trip in Honolua Bay. Most people, however, access the Bay by land. Cars can be parked next to the road from which is it only a short walk to the Bay.

The Trilogy has restrooms and other facilities, and snorkelers and divers are briefed on the boat about marine life. As yet, there is no mooring buoy to anchor the boat to. For people accessing from shore, there are no restroom and shower facilities. There are billboards with information about the MLCD, but generally the information about marine life is minimal. There is no infrastructure to facilitate access into the water, nor are there good parking facilities on land. As the MLCD is a CRAMP site, there is considerable monitoring. During the day, the sheer number of visitors leads to a reasonable level of compliance of no-fishing regulations. However, there are reports of spear fishing and other activities during the evening and night.

The following improvements are envisaged in the 'with management' scenario:

- Measures to decrease poaching in the evenings and at night are improved through a 24-hour guard presence;
- Education and awareness for visitors accessing from land is enhanced through additional billboards. At weekends, volunteers are also present to explain about marine life;
- Buoys are introduced for the commercial tourism boats;
- Basic restroom and shower facilities are built and a short pier is constructed to facilitate access to the water;

These measures result in higher quality reefs, more marine life, and better amenities for visitors, all of which lead to increased snorkeler and diver satisfaction. In addition, increased fish yields are expected in adjacent areas. The measures also enhance marine life in the adjacent marine area. Finally, there is an educational spillover due to the fact that recreationists will use the awareness raised during the Honolua visit to be more careful during future snorkeling and/or dive trips in the State.

The costs of a 24-hour guard presence are considerable. The costs are estimated at $12 per hour, plus 15% benefits/medical insurance, etc. Including uniform, raincoat and laundry allowance, we estimate the 24-hour guard presence at around US$125,000 per year. The guard also needs a small shed and a restroom, and equipment (binoculars, night vision goggles, cameras, walky-talkies, boat) requiring an estimated US$25,000 in investment. Basic shower and restroom facilities for the visitors are estimated to cost US$25,000 in investment costs and US$5,000 per year for maintenance and cleaning. The volunteer program including free leaflets is assumed to cost US$5,000 per year. Development of the awareness program is estimated at US$15,000. A 100-car parking lot is envisaged to decrease the dangerous situation where people park alongside the road at a cost of US$50,000 to construct and US$5,000 to maintain. This gives total additional investment in the first year of US$115,000 and recurrent costs of US$15,000 plus enforcement at US$125,000 per year.

4.5 Kahalu’u

Kahalu'u Beach Park (Hawaii): This Park is home to the largest sand beach between Kailua and Keauhou on the Kona coast of the big island. Kahalu'u Beach Park and is one of the most popular swimming and best snorkeling sites in the Kona district, with 350,000 visitors per year (Rogers, ??). Note that Kahalu'u is not an MLCD and therefore, the standard DAR fishing regulations apply. However, any fishing connected to the aquarium trade is prohibited as it lies within the Kailua-Keauhou Fish Replenishment Area (FRA).

Currently, Kahalu'u has restrooms, showers, billboards with some information, and a volunteer program. Regular fishing is allowed within the Beach Park and compliance is reasonable. Some monitoring is taking place, but this could be improved. Other than the car park, there is no infrastructure that assists public access to the water.

The following improvements are envisaged in the 'with management' scenario:

- The Beach Park is designated a 'no fishing area' and this is enforced through a system of evening/night guard surveillance. During the day, the sheer presence of visitors is assumed to prevent fishing activities once this is prohibited.
- Visitor education and awareness is enhanced through a set of new billboards, as well as more volunteers;
- Meters are introduced for the parking lot and this money is earmarked for management activities at Kahalu'u;
- Consistent monitoring is envisaged, partly with the aid of volunteers.

This set of measures will increase reef quality, resulting in higher satisfaction of the visiting snorkelers and additional fishing yields in adjacent areas. Finally, the additional awareness activities are assumed to have 'educational spillovers'.

The estimated costs of these management improvements are as follows. We assume here that the suggested improvements can be realized at US$100,000 in year one and recurrent costs of US$75,000 per year in subsequent years. The distribution of costs is given below in Table 10.

4.6 Waiopae

The Waiopae MLCD was established less than a year ago in an tidal pool environment. People can drive to within a few yards of the nearest pools and, except for during major storms, it is possible to swim in the tide pools under most weather conditions. The MLCD area has a total coral cover of approximately 47% in selected monitored sites. There are only about 40,000 recreational visitors to Waiopae per year.

Currently, there are no restrooms, showers or other facilities. There is some monitoring by DAR in collaboration with the University of Hawaii in Hilo as well as by a local non-profit organization. Compliance with the regulations which prohibit all fishing is low, partly because the MLCD is very new and people are not yet fully aware of 'what is allowed where'. There is no infrastructure to facilitate access. In fact, most people enter the MLCD by threspassing people's private property instead of using the one pedestrian access corridor. The State's education outreach program is limited to signs along the boundaries that summarize the rules and show the boundary. In addition, a community "reef watch" program hands out DAR and NOAA educational brochures and state fishing regulations and informs peole about the MLCD, as well as monitors patterns of human use.

The following improvements are envisaged in the 'with management' scenario:

- Measures to decrease poaching in the evenings and at night are improved through a reef watch program;
- Education and awareness for visitors is stepped up by additional billboards and through state collaboration with the community reef watch program;

- Basic individual septic-type restroom and shower facilities are built (the State would need to purchase a lot to make this possible) and a short pier is constructed to facilitate access to the water;
- Underwater monitoring is increased, partly with the aid of the local reef wathc project.
- The current parking lot is improved and parking meters are installed (as all roads and parking lot are on private land, this would require approval of the private community association).
- Litter control - both daily litter pick-up and trash hauling as well as periodic beach clean-ups of marine debris (the community has been paying around $1500 per year plus volunteer time in the past for this service).

These improvements lead to higher fish biomass and better quality corals, and improved services and infrastructure. This leads to more visitor satisfaction and to higher fishing yields in adjacent areas. Also, the volunteer-based awareness-raising program will generate an off-site educational effect. In the specific context of Waiopae, where residential houses and vacation homes are situated directly adjacent to the MLCD, the introduction of these investment measures may alter the housing prices. However, it is not clear in which direction and with how much, so it is assumed here that the prices remain constant.

The costs for these measures are difficult to estimate. We assume that the suggested improvements can be realized with an initial investment of US$80,000 in year one (enforcement US$20,000; education US$10,000; services US$25,000 and infrastructure for parking lot US$25,000) and annual recurrent costs of US$35,000 in subsequent years (enforcement US$10,000; monitoring US$5,000; education US$5,000; services US$5,000 and infrastructure US$10,000). This estimate is lower than the proposed budget for the second year of the local reef watch project, to be done in collaboration with DAR and UH in Hilo (proposed budget: $56,000), which includes collaborative monitoring and litter control and public education outreach by reef watch during days on weekends and holidays only. Also, the purchase of the lot for the restroom facilities is not included.

5. Results

This chapter provides an overview of the simulations of the ecological-economic model, which is presented in Chapter 2. The physical and socio-economic data described in Chapter 3 provides the inputs for the model. Variations over time are caused by the assumptions formulated in the scenarios in Chapter 4, and endogenous interactions between the ecological and economic modules of the model. Throughout the analysis, we assume a time period of 25 years, starting in 2005 and running till 2030. Costs and benefits are discounted at a discount rate of 3 percent. This is in line with the common assumption in environmental economics applied to biodiversity related goods and services. This Chapter subsequently describes the costs, the benefits, and the cost benefit analysis in which the issue of sustainable financing is addressed.

5.1 Costs

Based on the discussion and data presented for each of the sites in Section 4, the summary of annual additional costs for the 'with management' scenario is given in Table 10. This combines the investment costs and recurrent costs associated with expenditures in services, education/awareness, monitoring/assessment, enforcement/ compliance and other costs such as infrastructure.

*Table 10 Summary of annual costs over time and aggregated/discounted costs **

	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Fixed enforcement	-	40,000	125,000	25,000	35,000	20,000
Fixed monitoring	-	10,000	-	-	20,000	-
Fixed education	13,500,000	20,000	25,000	15,000	30,000	10,000
Fixed service	-	30,000	-	25,000	25,000	25,000
Other	-	5,000	-	50,000	50,000	25,000
Total fixed	13,500,000	105,000	150,000	115,000	160,000	80,000
Variable enforcement	-	30,000	70,000	125,000	15,000	10,000
Variable monitoring	-	7,500	-	-	10,000	5,000
Variable education	500,000	10,000	20,000	5,000	10,000	5,000
Variable service	-	10,000	-	5,000	5,000	5,000
Other variable	-	500	-	5,000	10,000	10,000
Total variable	500,000	58,000	90,000	140,000	50,000	350,000
NPV overall	22,317,187	1,127,963	1,807,183	2,617,841	950,657	654,460

* discount rate 3%, period 25 years. Fixed costs are initial investments and variable costs are on-going annual costs.

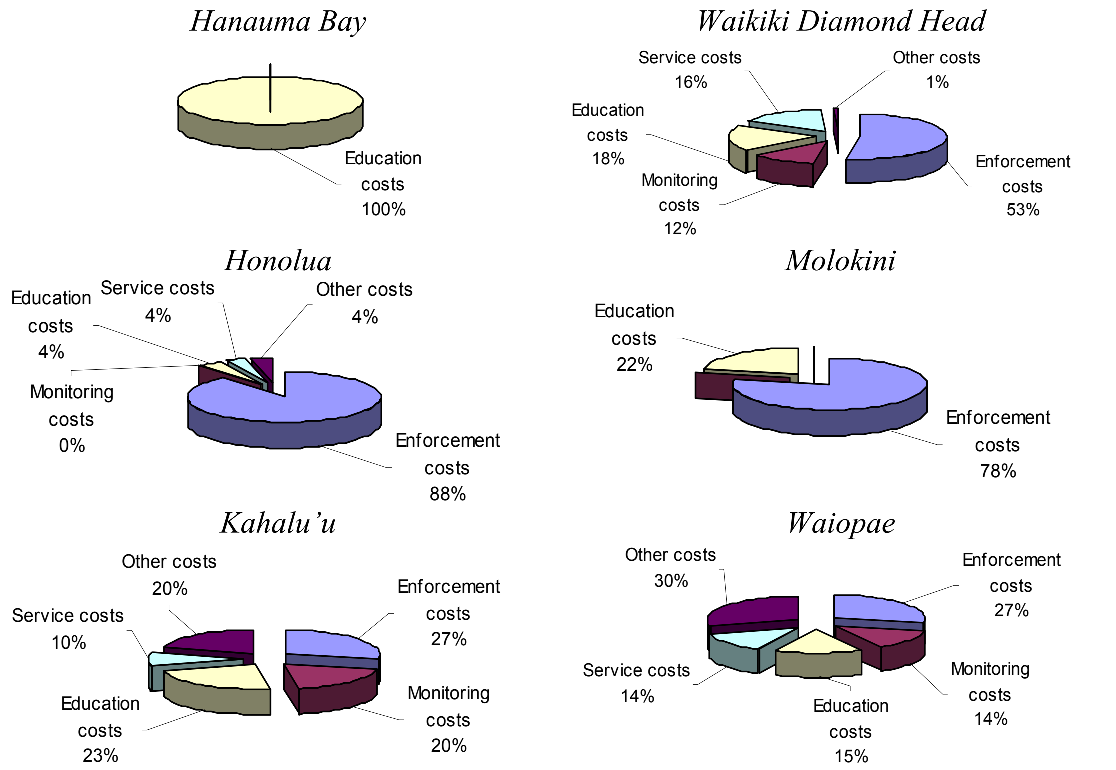

Figure 2 Allocation of the Net Present Costs (discount rate 3%, 25 years)

Table 10 shows how the level of investments differs substantially between the sites. Being a hotspot for marine-related tourism, Hanauma strategically invests a significant amount in visitor education. The construction of the visitor center is far bigger than what could ever be achieved in an economically sound manner at any of the other sites. Moreover, it can be seriously questioned whether a second center of such magnitude in Hawaii would make sense, given the fact that most people visit Hanauma anyway.

Figure 2 gives the composition of management costs for each of the six MMA sites. Interestingly, Hanauma Bay only has education/awareness costs, while costs in Honolua are primarily for enforcement. For the other sites, the various management components are more equally distributed over enforcement, monitoring, education, service and infrastructure costs.

5.2 Benefits

Recreational value

Recreational value is by far the most important value of MMAs in Hawaii. The Hawaiian economy's high dependency on tourism is also reflected in the high recreational values in the overall value of MMAs. Still, as shown in Table 11, the variation between the recreational value per site is significant. Hanauma Bay and Molokini are the most valuable MMA sites from the perspective of recreation. Despite the fact that Waikiki Daimond Head is located in one of the most expensive areas of Hawaii, this site provides the least recreational benefits. This will continue if it is not supplemented with additional MMA management. However, the last row in Table 11 shows that Diamond Head holds the mostpotential for improvements in recreational value through the provision of educational facilities and better compliance. The same can be concluded for Waiopae. In essence, these sites are heavily “under”-managed.

Table 11 Average annual recreational benefits

Scenario	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
With	41,552,902	1,273,569	21,620,178	4,538,942	10,903,723	1,850,348
Without	36,572,241	316,067	19,293,321	2,674,997	8,518,295	755,535
Difference	4,980,661	957,502	2,326,857	1,863,945	2,385,428	1,094,813
Improvement	14%	303%	12%	70%	28%	145%

Fishery value

Surprisingly, the fishery value for MMAs may well be the hardest reef-associated value to quantify. This is because these values are not based on direct catch in the area but, instead, on enhanced catches in areas outside the MMAs based on: (i) juvenile and adult spill-over effects to adjacent areas and (ii) enhanced reproductive output (sometimes referred to as larval spillover) in all areas outside the MMAs. See Friedlander & Cesar (2004) for a summary of the literature on fisheries benefits of MMAs.

For Hawaii, research is presently underway (West Hawai‘i Aquarium Project) to evaluate the effectiveness of reserves from an ornamental fisheries point of view and to better understand the ecological dynamics of the nearshore reef environment. Preliminary analysis indicates that three years after closure of the Fish Replenishment

Areas (FRAs), there have been significant increases in the overall abundance of fishes targeted by collectors. Two species, the yellow tang and Potter's angelfish (Centropyge potteri), showed significant (74-80%) increases in FRAs relative to previously protected reference areas. Furthermore, no aquarium fishes declined in abundance in open areas as might be expected if the intensity of harvesting increased outside of the FRAs. In fact, two species displayed significant increases in abundance in the open areas. Thus early results of this study demonstrate that MMAs can be a highly effective strategy for managing these resources.

This study only covers ornamental fisheries. Therefore, we have used to other studies to estimate the spillover effects in Hawaii. These are both well-known quantitative papers from the fisheries literature. Roberts et al. (2001) describe fisheries surrounding the Soufrière Marine Management Area (SMMA) in St. Lucia (Eastern Caribbean). Establishing the SMMA meant that around 35% of the previous fishing area was closed to fishing. After 5 years of protection in the SMMA, catches in adjacent areas increased by 46% (large traps) and 90% (small traps) per trip with stable levels of effort. A study by Alcala and Russ (1990) documented evidence from a village in the Philippines (Sumilon) where catches were nearly twice as high on 75% of the reef as compared to the entire reef after 25% of the area had been set aside as a fully protected reserve.

As a result of the SMMA closing off one-third of the area[1], there was an increased fish catch of roughly 67%, while the no-take reserve in Sumilon (a quarter of the area) led to an increase of around 100%. This means that for St. Lucia a closure of one hectare of SMMA leads to an additional two hectare-equivalent of pre-closure catch. For Sumilon, a closure of one hectare around Sumilon leads to an additional four hectare-equivalent of pre-closure catch. Taking the average of the two sites, and assuming that these numbers can be used for the Hawaiian situation, we assume that closure of one hectare to all fishing can lead to an additional 3 hectare-equivalent of pre-closure catch.

However, this is taken as the maximum spill-over, given the small size of the MMAs in Hawaii (small as percentage of total area). It is important to note that the MLCDs described here were never initially intended to act as fish replenishment areas for adjacent fisheries and that these fisheries benefits should be seen as a positive indirect consequence of their creation of the MMAs. With the small size of MMAs in Hawaii, the actual spill-over effect may be much smaller. Therefore, we assume that the closure of hone hectare of coastal water leads to an addition of pre-closure catch of between 0 and 3 hecatre-equivalent with a point-estimate of 1.5 hectare-equivalent.

Yields per hectare per year of nearshore fisheries in Hawaii are difficult to determine. Here we assume conservatively that such yields are 1 mT per km^2 per year. With the assumptions above, this means that the closure of Hanauma (0.408 km^2 in size), increases adjacent fisheries with up to 3 times 0.4 times 1 mT, which equals around 1.2 mT of reef-associated fish. At a price of US$ 5 per kilo, this gives up to around US$ 6,000 per year in additional catch value. This value can be transformed in economic benefit by assuming a value added percentage of 60% for nearshore fisheries (Kona data) and a economic multiplier effect of 40% for fisheries (Cesar et al. 2002), giving

[1] Assuming that large and small trap fishing were equally important and that the remaining 30% of the fisheries showed the same average growth rate in catch after establishing the SMMA.

Hanauma a total annual reef-associated fishery benefit of around US$ 0 - 5,140 with a point estimate of US$ 2,570.

Table 12 Fisheries benefits from MMA closure (range and point estimate in US$)

	Hanauma	Diamond Head	Molokini	Honolua	Kahaluu	Waiopae
Area (in hectares)	40.8	13.5 (MLCD)	80.9	18.1	2.2	20.2
Fisheries benefits (range)	0 - 5,140	0 - 1,700	0 - 10,200	0 - 2,280	0 - 280	0 - 2,540
Fisheries benefits (point)	2570	850	5100	1140	140	1.270

Source: Area estimates are from Table 2. Fisheries benefits are derived by authors based on calculations above.

All MMA sites discussed, except Kahalu'u Beach Park and part of the Waikiki Diamond Head marine area, are MLCDs in which fishing is prohibited. Therefore, the fishery value comes from the spillover effect to adjacent areas where fishing is allowed. For Kahalu'u, the actual amount of fishing occurring in the Beach Park is very limited because of the presence of large amounts of recreational users (350,000 per year). The Waikiki Diamond Head Shoreline FMA is the only site in this study in which a reasonable amount of legal fishing (in the 'even' years) takes place. This is described in the base-case for Waikiki Diamond Head. In the management alternative, we investigate the consequence of a full closure of half of the FMA and no closure of the other half.

These fisheries benefits are the long-term fisheries benefits after a number of years of full well-enforced closure, such as is currently the case for Hanauma Bay. In the short run, the fisheries benefits from Molokini may be smaller than for Hanauma. Note that for Diamond Head, only the actual MLCD was used for the calculation of fisheries benefits.

Educational spillover value

One of the side benefits of educating divers and snorkelers is the education spillover effect. This education spillover effect refers to the fact that snorkelers and divers who visit a site where they are properly instructed and educated go snorkeling at an average of 2 or 3 other locations in Hawaii. It si assumed that these snorkelers and divers will then behave better in those other reef areas. Education therefore not only benefits the site providing the educational services, but also prevents physical damage to other reefs. Education can therefore be considered a long-lasting investment in environmental awareness and tourist behavior.

In calculating the educational spillover effect, a distinction is made between residents and visitors. As far as visitors are concerned, active visitors snorkel an average of 3.8 times during their stay in Hawaii, of which 1 snorkel trip will be in Hanauma Bay. The education spillover effect for active visitors is therefore assumed to materialize in approximately 2 snorkeling trips outside the site at which the receive education. As shown in Table 13, the level of educational spillover differs between the sites. Visitors to Hanauma are better educated, due to the rich facilities available at the Bay, and go on to visit other sites because Hanauma is usually positioned early in their vacation. The potential of educational spillover in Waiopae is therefore much less because this is a location that will not be followed by many other visits, nor are the facilities as effective as is the case in Hanauma Bay. In accounting for the educational spillover effect we adopt the calculations reported in Van Beukering and Cesar (2004) on threats to the reefs, using a figure for damage rate of 2 cm^2 per trip. In accounting for the spillover effect for residents, it should be realized that the active residents, i.e. those who indicated that they snorkel an average of 10 times per year, will continue doing so in the future. In other words, the accumulative effect of their education is much larger than for the visitors.

Table 13 Net Present Value of the educational spillover value of education (in US$)

	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Education spillover	22,317,187	227,665	1,967,808	1,698,895	2,636,461	126,201
Share in total NPV	3.0%	1.1%	0.5%	2.2%	1.4%	0.4%

* discount are of 3%, period of 25 years.

Overall benefits

By aggregating the above-mentioned values, the net benefits for the scenarios "with" and "without" additional management are determined. Figure 3 shows composition of the net-benefits for the different sites for the various types of values.

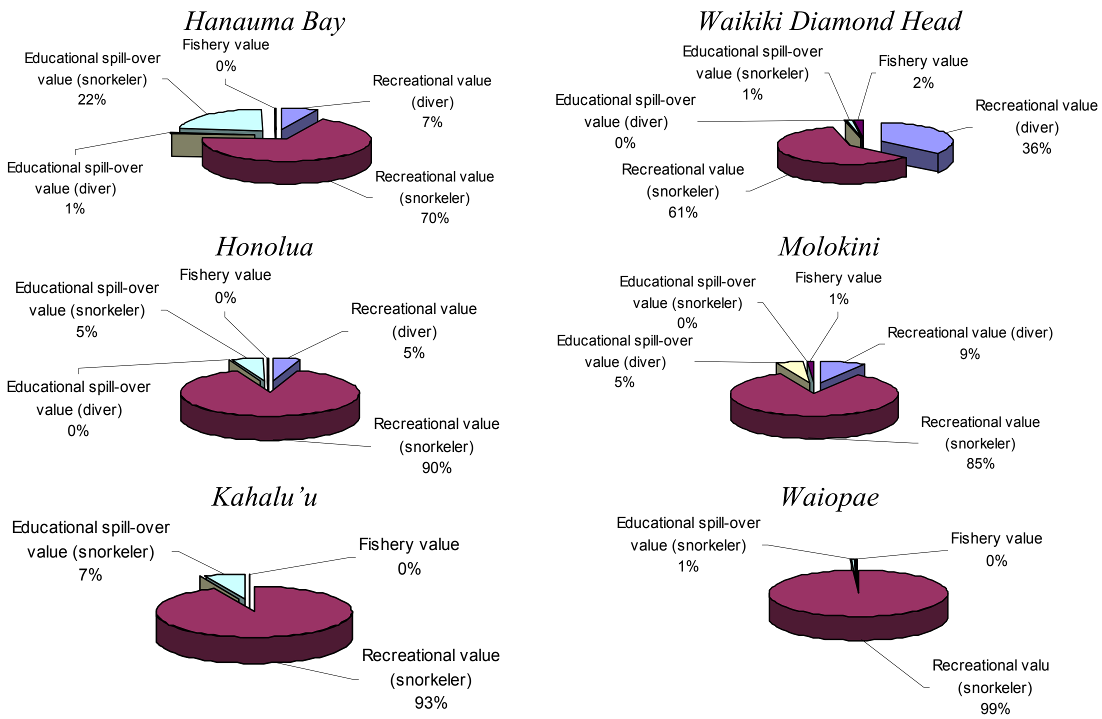

Figure 3 Allocation of the Net Present Value (discount rate 3%, 25 years)

Although the composition of the net-benefits differs for each MMA, the recreational benefits of snorkelers prevail for each case study. Snorkelers are always in large numbers and have willingness-to-pay levels that are comparable with other users. Snorkelers are also found to be very sensitive to environmental improvements of the marine ecosystems. The better the quality of the reef, the larger their consumer surplus, and therefore their contribution to overall economic welfare levels resulting from the additional management measures. Typically, in neither of the MMAs does the additional management contribute significantly to the fishery sector. The additional fishery values vary between 0 to 2 percent of the total increase in economic value.

Figure 4 shows the "with" and "without" extra management scenarios for the six MMAs. Least variation is observed in the "without" scenario. Only in the case of Molokini and Kahalu'u will the absence of additional management lead to a decline in overall benefits. This is mainly due to the fact that fewer visitors are tempted to visit these sites, while those that do, are more frequently disappointed by the deteriorating quality of the reefs. This leads to a lower consumer surplus and willingness to contribute to conservation efforts. The other sites are assumed to maintain the present level of visitors and benefits.

Figure 4 Net-benefits over time (period 2005 till 2030)

As shown in Figure 4, the "with" additional management scenarios show much more variation. The highest growth in overall benefits is achieved in Waiopae and Diamond Head. Although these sites are not the most economically valuable MMAs, they do hold the largest potential for improvements because their current level of management is limited. Sites such as Hanauma and Molokini have much less potential to develop further. Management improvements have already been achieved in the past, resulting in limiting significant growth of economic gains. Therefore, the benefits curves of Hanauma and Molokini gradually stabilize over time.

Table 14 below shows the gross benefits accumulated over time (net present value) at a discount rate of 3 percent. Hanauma Bay is by far the most economically valuable site from a marine-environmental perspective. The economic importance of the marine environment of Waikiki Diamond Head is minimal compared to Hanauma Bay. Second in value is Molokini. Kahalu'u is the third most valuable site in Hawaii. Clearly, the number of visitors strongly determines the overall value of the MMA. Note that this latter value differs from the one reported in Cesar and Van Beukering (2004), mainly due to a lower time horizon here (25 years instead of 50 years).

*Table 14 Economic value in Net Present Value terms (million US$) with and without additional MMA management**

	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
With management	732	21	383	78	193	30
Without management	648	6	345	47	154	13
Difference (net benefit)	84	15	38	30	39	17

* discount rate of 3%, period of 25 years.

5.3 Cost benefit analysis

There are different ways of looking at the economic feasibility and desirability of investments in conservation of marine ecosystems. On the one hand, one can look at the *financial feasibility* of the measure. This approach raises the question of whether the investments and operational costs can ever be recovered in financial terms. If the system is self-funding, vulnerability for political variations is much less. This "narrow" approach will be discussed in the second part of this section. First, we will consider the *economic feasibility* of the proposed measures.

Economic feasibility

Table 15 summarizes the net costs and net benefits of the measures proposed for the six MMAs. From a societal perspective, the measures are desirable from a societal point of view if the ratio between the net benefits and the net costs exceeds factor 1. As can be seen in the last row of Table 15, all the proposed investments are economically feasible. The net benefits widely exceed the net-costs to society. MMAs on the main island (i.e. Kahaluu and Waiopae) offer particularly significant potential to generate net-benefits over costs. Higher discount rates, however, may reduce the attractiveness of the proposed measures.

*Table 15 Net benefits, net costs, and the benefit cost ratio (million US$)**

	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Net benefits	84	15	38	30	39	17
Net costs	22	1.1	1.8	2.6	0.9	0.7
Benefit cost ratio	3.8	13.5	21.2	11.6	41.5	26.1

* discount rate of 3%, period of 25 years.

Sustainable financing

In the previous section, it was shown that from an economic welfare point of view, the MMA management options were favorable. Yet, there are often political forces preventing these options from being implemented. The main challenge for MMAs is therefore how to finance these management options even if the investments are justified from an economic perspective. We have looked here at one specific tool, the introduction of an entrance fee. Cesar and Van Beukering (2004) give an overview from around the world of entrance fees and other types of user fees as well as other revenue generating means for sustainably financing marine parks.

User fees can be defined as any charge for non-consumptive use of an MMA (usually 'per person' or 'per vehicle'). They include entrance fees, diver fees and yacht mooring fees among others (see Lindberg and Hallpenny, 2001 for an overview). Some user fees are very high, such as the $100 charge for entrance to the Galápagos Natonal Park in Ecuador. Lindberg (2001) states five objectives for user fees: (i) cost recovery; (ii) generation of "profit,"; (iii) generation of local business opportunities; (iv) provision of maximum opportunities for learning and appreciation of the natural resource; and (v) visitor management to reduce congestion and/or ecological damage.

The National Park Service in the US has expanded its fee collection under the authority of the Recreational Fee Demonstration Project. Yet, there is no entrance fee at some of the most well-known National (Marine) Parks in the US, such as the Channel Islands National (Marine) Park in California and the Dry Tortugas National Park in Florida. A disadvantage of user fees discussed in the US National Parks context, is that low-income people may be excluded from resource-based tourism (More and Stevens, 2000). However, in the Hawaiian setting where only minimal charges will be discussed, this is likely to be a minor issue, especially in fee schemes that exclude Hawaiian residents.

One of the main impediments to implementation of user fees in a marine setting is fee collection. Depending on the ease of access, a user fee system can be regulated through a booth at the point of entry (Hanauma Bay) as is the case for most terrestrial parks. Alternatively, it can be managed through the dive industry, where operators are responsible for fee collection (Ras Mohamed in Egypt, Bonaire, Palau and others). At Hol Chan (Belize), there is one main dive/snorkel location and rangers collect fees there, while in Kenya, rangers of the Kenya Wildlife Service collect the fee by boat at the snorkel and dive sites in the MMAs.

In the context of the six Hawaiian study sites, we have looked at several types of user fees to finance the management options discussed in the previous section. To evaluate these user fees, the financial cost benefit ratio is calculated. This ratio differs from the economic cost benefit ratio discussed above. A financial cost benefit ratio of a user fee for an MMA compares the costs of the management option for a site with the collected fee (i.e. the financial benefit) for that site. The financial cost benefit ratio is the quotient (or ratio) of these collected fees over time and the management costs. We have looked at three different user fees. One is the fee corresponding to the expressed average willingness-to-pay determined by survey at each site. The other two user fees are flat fees of $1 and $2. For Hanauma and Molokini, we have looked at fees for non-Hawaiian residents only, while for the other sites, we have looked at across-the-board fees. Besides these entrance fees, we have also looked at parking fees, which are levied on both residents and 'others' (non-discriminatory). The financial benefit-cost ratios for the three types of user fees, and the economic benefit-cost ratio from the previous section, are summarized in Table 16. This table also gives the so-called 'break-even user fee'. This is the fee at which the management costs can be exactly paid for by the fee (no profit and no loss). Note that for Hanauma, we have only looked at the costs and benefits of the education center and the user fee to finance that. This is separate from the US$5 for recreationists from outside Hawaii which is currently charged to cover other costs.

*Table 16 Economic indicators**

Management	Hanauma	Diamond Head	Molokini	Honolua	Kahalu'u	Waiopae
Financial BC ratio ($1)	0.8	-	2.1	0.8	6.1	2.0
Financial BC ratio ($2)	1.5	-	4.1	1.6	12.1	4.0
Financial BC ratio (WTP)	2.8	-	8.8	2.4	17.6	5.8
Economic BC ratio	3.8	12.5	20.2	10.6	40.5	25.1
Break-even user fee	1.5	-	0.51	1.24	0.17	0.50

* Discount rate 3%, period over 25 years.

As discussed, it may be easier in some sites to collect the user fees at some sites than at others. However, given the low break-even user fees, a collection system could be envisaged where fees are levied in MMAs where this is easy to administer, and where the percentage of people that would refuse to pay is very small. The revenues from this fee system could be used not only for that particular MMA site, but also to subsidize management of MMAs where fee collection is cumbersome or impossible to implement. This could be an interesting first step towards integrated ecological and economic management of clusters of MMAs.

6. Conclusions and recommendations

This paper has given an economic valuation of six selected MMAs in Hawaii, as well as the cost benefit analysis of management options for these MMAs. The economic value (without additional management), as an asset value in net present value terms, ranges from US$6 million for Diamond Head to US$ 650million for Hanauma. As regards the cost-benefit analysis of management options, we found that in no case did the cost exceed the benefits. The economic benefit cost ratio was actually quite high, for instance 10.6 for Hanolua. That means that, assuming people pay their stated willingness-to-pay value on entry to the MMA, over time, the benefits outweigh the costs by a factor 40.

To evaluate a system of user fees, financial benefit cost ratios were also calculated. In all cases is US$2 dollar fee is enough to finance all additional management costs. For Molokini and Waiopae, a fee of only two quarters (or 50 cents???) suffices to pay for additional management costs.

Based on this analysis, the following recommendations can be drawn:

- Management of MMAs makes both ecological and economic sense;
- Low enforcement efforts decrease the benefits from MMAs substantially. In fact, in the absence of effective enforcement, MMAs have no economic benefits, and the ecological advantages are much lower.
- The very high benefit-cost ratios of proper MMA management suggest that Hawaii should put more financial resources aside for MMA management. If there is not enough political will or priority to do so, a system of user fees should be considered.
- A small user fee would be sufficient to finance the additional costs of proper MMA management.
- Fees can be collected at those sites where implementation of this fee system is most straightforward. Part of the revenues of this system could be used to subsidize the management of remote MMAs with few tourists, or in areas where the fee system would be cumbersome or impossible to implement.

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