Environmental Impact Assessment
Cruise Berthing Terminal
for Cayman Islands:
Appendix J2: PRELIMINARY ECONOMIC VALUATION OF ECOSYSTEM GOODS AND SERVICES PROVIDED BY GTH REEFS

PREPARED FOR:

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1 Introduction

Coral reefs cover less than 1% of the ocean floor yet support 25% of all marine fish and thousands of other species (Burke et al., 2011). In addition to supporting a wealth of biodiversity, coral reefs form the foundation of much of the Caribbean tourism, fishing and pharmaceutical industries (World Resource Institute, 2009). Despite their importance, more than 70% of coral reefs in the Caribbean are under immediate threat from anthropogenic stressors ranging from coastal development, dredging, runoff and raw sewage discharge to overfishing and climate change (Jackson et al., 2014). These stressors have the potential to degrade coastal environments in the immediate, and diminish the benefits from these ecosystems in the future (Waite et al., 2014).

Monetary valuation of ecosystem goods and services plays an important role in conveying the importance of the resource to the local population. It provides the economic basis for assessing damage or loss of resources and sets guidelines for financial commitments by the governments toward coral reef conservation and management (Cesar and van Beukering, 2004). In the context of coastal development projects, economic valuation provides a metric for evaluating environmental, social and economic impacts of projects, as well as a framework for evaluating costs and benefits of alternatives in a process that seeks to balance the need for development and conservation of coastal ecosystems.

1.1 Ecosystem Goods and Services

Ecosystem goods and services are defined as ecological components or functions that provide an economic benefit; they can be quantified in physical terms (e.g. kg of fish), which can be converted into economic benefits and valued in monetary terms (e.g. market value of kg of fish) (Principe et al., 2012).

It is recognized that coral reefs provide a range of goods and services that have an inherent economic value. Goods and services provided by coral reefs include renewable resources (e.g. fish, seaweed, etc.), as well as non-renewable resources (e.g. coral mining). Services provided by coral reefs include:

- Structural services such as coastal protection;
- Biotic services both within (e.g. habitat maintenance) and between ecosystems (e.g. genetic and population connectivity);
- Information services (e.g. climate records);
- Social and cultural services, such as aesthetic value, recreation and heritage (de Groot et al., 2012; Cesar and van Beukering, 2004; Costanza et al., 1997).

The sum of component goods and services provides the basis for estimating the economic value of an ecosystem. The total economic valuation (TEV) is based on the premise that the total value of any resource is comprised of different components, some of which have very obvious and marketable use values, others that are more indirect, and still others that are intangible, such as the mere existence of the resource or the heritage value to be passed onto future generations. Total economic value is a useful tool and can be calculated for a specific reef to estimate the economic benefit of the area, especially in the context of evaluating alternative uses of the resource including conservation, tourism or combined use (Principe et al., 2012).
1.2 Use and Non-use Values

Use values come from net benefits that arise from the actual use of the ecosystem, both direct and indirect. When referring to coral reefs, direct use values can come from either consumptive or extractive use including fisheries, collecting, corals, shells or reef fish, or from non-consumptive uses such as tourism/recreation (e.g. snorkelling, diving or other water sports) as well as education/research and aesthetic value (e.g. beachfront properties). In general, direct uses, both consumptive and non-consumptive, are more readily quantified and are frequently driven by market forces. Non-use values encompass existence value, which reflects the value of the ecosystem to the local population, whether the reef is used or not. Indirect use values are best characterized as ecosystem benefits associated with healthy coral reefs; for example, coastal protection, nursery areas for reef fish, and healthy habitat for a variety of reef flora and fauna are just some of the indirect use values (Cesar and van Beukering 2004; de Groot et al. 2012). Indirect uses or ecosystem services do not have a market-based valuation and, as such, it is much harder to assign a value.

The third type of value is referred to as “option or deferred use” value and it represents the option of using the resource at a later date and for which there is a willingness to spend money to ensure protection of the resource for future use (Thur, 2010). The fourth category of use values refers to pure existence and bequest values (Hicks et al., 2009); these values represent the willingness of individuals or society to pay in order to safeguard a resource for future generations (DaCosta et al., 2009). It is challenging to ascribe existence value, since this aspect of the resource does not entail values that can be based on present day consumption of the resource. Usually some form of survey technique is used to identify and quantify non-use values.

The components of ecosystem values, including direct use (consumptive and non-consumptive), indirect use, and non-use (existence and bequest) values, are all important and contribute to the total social and economic valuation of coral reefs (Figure 1.1). However, it is important to note that the TEV is anthropocentric and places values based on actual uses and people's perceptions (Koch-Weser, 1997); it does not give as much weight to valuing the inherent or intrinsic biodiversity and ecological functionality of the ecosystem (Cesar and van Beukering, 2004) and is therefore best used in conjunction with ecological assessments for any given project.

Figure 1.1 Total Economic Value (TEV) components of coral reefs as illustrated in Cesar & van Beukering, 2004
1.3 Site Description

Grand Cayman has very few well-developed, shallow water, near-shore reefs; many of these are located in George Town Harbour (GTH) and form a unique marine ecosystem on the island (Lang and Land, 1976). The unique aspect of the reef system in the harbour can be attributed to a combination of ecological and topographical factors. The high relief “spur and groove” formations converge to create a network of tunnels and grottos. These complex habitats in turn support diverse assemblages of stony and soft corals, sponges, and an equally diverse population of fish species.

The clear harbour waters allow for the proliferation of healthy coral cover (recruitment, resilience), including the spotty recovery of Acropora cervicornis and Acropora palmata (found at one site); both species are listed as Critically Endangered on the IUCN Red List, and listed in Appendix II of CITES. The reef system covering the area from Soto’s Reefs located just north of the harbour (i.e. T1-T5, T14) to Devil’s Grotto and Eden Rock south of the harbour represents a significant portion of the designated Marine Park Area (MPA) on the west side of the island. The proximity of the reef to shoreline offers protection from storm waves and may play a role in protecting/maintaining the sediment budget (i.e. volume of sand) in the harbour.

GTH reefs are highly valued as a dive "product". Due to the proximity of these reefs to the shoreline, the sites have been long-time favourite dive and snorkelling sites. Unlike other dive sites in the area (e.g. dive sites along 7 Mile Beach to the north and Armchair Reef to the south) which require boat transportation, the dive and snorkelling sites in the harbour can be accessed easily from shore, making them very popular among cruise ship and overnight tourists who wish to explore Caymanian waters. The GTH reefs offer a wall-like environment in shallow water, with tunnels and two ship wrecks (the Cali and the Balboa), and a great variety of fish.

1.4 Objective

Construction of the proposed cruise berthing facility (CBF) in George Town Harbour (GTH) will result in the destruction of corals within the project footprint. The impacted area can be characterized as a combination of uncolonized bare substrate and patch reefs giving way to a well-developed network of spur and groove reef formations. The shipwreck of the Balboa is also located within the project footprint and will be affected by the proposed dredging and subsequent construction activities.

In the context of the Environmental Impact Assessment, an estimate of economic valuation of the ecosystem under investigation provides an important variable that complements the ecological assessment of the CBF; as such, due consideration must be given to economic benefits of GTH reefs when assessing the layout options and the overall impact of the project on the environment, and on the people and businesses in the area. The objective of this report is to estimate the economic value of George Town Harbour reefs.

1.5 Approach

While undertaking a full Total Economic Valuation for Grand Cayman reefs is beyond the scope of the Environmental Impact Assessment, it is important to integrate the economic benefits of the GTH reefs into the overall impact analysis. To estimate the economic value or benefit of ecosystem goods and services, we used the cumulative estimated use value from direct, indirect and future use of resource, and non-use value derived from the existence value placed on the resource by stakeholder perception. Direct use includes consumptive use (food) and non-consumptive use...
derived from cultural services, which can be broken down into three categories: 1) tourism and recreation; 2) heritage, historical value, culture and tradition; and 3) science, knowledge and education. Indirect use includes services such as shoreline protection, regulating services and provisioning services. The scope of this estimate excludes future use. The reefs are located within a Marine Protected Area designated as a no-take zone, hence consumptive use was limited to subsistence fishing.

Given the constraints in collecting data for all ecosystem goods and services, efforts were focused on tourism, coastal protection, biodiversity, threatened species, MPA status and subsistence fisheries. The estimated economic value of George Town Harbour reefs is based on:

- Data from the socio-economic questionnaires addressing stakeholder perception of the value of GTH reefs and the importance they place on the proposed cruise ship pier construction;
- Data from questionnaires administered directly to the dive shops that depend on GTH coral reefs for their livelihoods;
- Tourist data for Grand Cayman, including cruise ship and air arrivals;
- Values derived from a literature review of relevant economic valuations for reef ecosystems to identify a range of proxy or transfer values for ecosystem goods and services that can be applied to GTH reefs.

The Cayman Islands’ Department of Environment (DoE) is currently undertaking a study with the specific goal of establishing the Total Economic Value (TEV) of the marine ecosystem services of the Cayman Islands. A component study that has already been completed – The economics of expanding the Marine Protected Areas of the Cayman Islands – The cultural and recreational value of the Marine Environment to the Cayman Islands’ residents (Schutter et al. 2014) – addresses peoples’ perceptions about the importance of protecting the marine environment through management strategies such as Marine Protected Areas and evaluates peoples’ willingness to pay for the marine environment from the perspective of cultural and recreational values. It is understood that the economic benefit values generated by this report are based primarily on transfer values and will be superseded in the future by the formal TEV of the Cayman Island’s natural resources.

For the purpose of this study, the cultural category (recreation and tourism) was based on information and data collected through stakeholder consultations conducted for the proposed George Town cruise berthing facility.

Qualitative data of the intrinsic value of GTH marine resources were derived from the perception survey. Public perception survey questionnaires were customized to each stakeholder group and administered to obtain baseline social, economic and cultural data, as well as perceptions of the natural environment. Over 423 surveys were conducted using face-to-face interviews, self-administered questionnaires and online delivery. Stakeholder groups interviewed included:

- Households (308);
- Tender boat operators (Captains and Linesmen) (12);
- George town business operators (mainly retail and services) (16);

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• Water sports operators (independent) (11);
• Transportation service providers (5);
• George town dive shops (9); and
• Chambers of Commerce (62).

Selected questions from each questionnaire provided the data required for this analysis. Questions on the perceived importance of the project, the natural and cultural resources, were administered to all stakeholders, while questions pertaining to dredging were administered primarily to business stakeholders.

Quantitative data for tourism and recreation value were obtained from questionnaires administered directly to the dive shops that directly use the GTH coral reefs for their livelihoods. The questionnaires addressed: 1) the current levels of business (dive/snorkelling excursions) from overnight tourists and from cruise ship tourists, including revenues; and 2) anticipated impacts (positive and negative), from the development of the cruise ship terminal in GTH. Tourist data were obtained from the Cayman Islands Economics and Statistics Office (ESO).

A literature review of existing economic valuation studies was also undertaken to obtain proxy values that could be used in estimating the economic value of the ecosystem goods and services provided by the GTH reefs. In the absence of survey data for provisioning, regulating and supporting ecosystem goods and services for GTH reefs, case studies were selected from published works in order to obtain proxy values for the various ecosystem components.

2 Literature Review

Ecosystem valuations for Bonaire, Montego Bay Marine Park, and a meta-analysis of 94 reef locations (de Groot et al. 2012) were selected to represent a range of values for ecosystem components of direct and indirect use values of coral reefs. For ease of comparison, the resulting ecosystem component values were standardized to per hectare values.

Bonaire was chosen on the basis that it is a small island state and, like the Cayman Islands, it is highly dependent on tourism from both air and cruise ship visitors. The island is 40km long and 11km wide, with 280km² of land area; the island population is 16,541. Bonaire is renowned for its diving and also for taking a very aggressive stand when it comes to the conservation of its reefs. The Bonaire National Marine Park was established in 1979 and covers 27km². The mission of the Bonaire National Marine Park is “to protect and manage the island’s natural, cultural, and historical resources, while allowing ecologically sustainable use for the benefit of future generations”. Based on the 1999 AGRRA survey, Bonaire has the highest coral cover (~50%) and lowest algal cover in the Caribbean. It has been estimated that Bonaire’s economy benefits from the tourism industry to the tune of US$105 million annually (van Beukering and Muresan, 2013). Based on the TEV, the economic benefit derived from a hectare of coral reef is estimated at US$40,000 per hectare year.

Located on the north coast of Jamaica, the Montego Bay Marine Park encompasses the bay’s shoreline. Beginning in the 1970s, activists in the Montego Bay area worked towards

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3 http://www.bmp.org/
institutionalizing conservation measures for the Montego Bay coastline (World Resource Institute 2011). The area was declared Jamaica’s first marine park in 1992 under the Natural Resources Conservation Authority (NRCA) Act of Jamaica. The Montego Bay Marine Park covers an area of 15.3km². The mission of the park is focused on the preservation and restoration of marine ecosystems; the flora and fauna are monitored, as are the physical parameters including water quality and beach erosion. The economic valuation of the Montego Bay Marine Park has been extensively documented and is relevant to GTH reefs, which are also located within the bounds of a marine park.

In a study based on the analysis of more than 80 coral reef valuation studies, monetary value was attributed to “ecosystem services” provided by biomes like coral reefs, including food, pollution treatment, and climate regulation (The Economics of Ecosystems and Biodiversity, TEEB, 2009). “Undertaken to help societies make better-informed choices, the economic research shows a single hectare of coral reef, for example, provides annual services to humans valued at US$130,000 on average, rising to as much as $1.2 million.” The study provides insights into the worth of ecosystems in economic terms. The monetary value of goods and services provided by a hectare of coral reef is broken down as follows:

- Cultural services (e.g. recreation / tourism): average US$88,700 (up to US$1.1 million);
- Food, raw materials, ornamental resources: average US$1,100 (up to US$6,000);
- Climate regulation, moderation of extreme events, waste treatment / water purification, biological control: average US$26,000 (up to US$35,000);
- Maintenance of genetic diversity: average US$13,500 (up to US$57,000).

In a similar study, the estimated valuations put forth by de Groot et al. (2012) are based on a meta-analysis of 94 data sources specific to coral reefs “that enabled selection, or calculation of estimates presented on a per hectare per year basis and for which the biome, and ecosystem services were explicitly specified”.

Table 2-1 summarises the ecosystem values for Bonaire, Montego Bay Marine Park and the study by de Groot.

<table>
<thead>
<tr>
<th>Ecosystem Goods and Services</th>
<th>Bonaire ($/ha/yr)</th>
<th>Montego Bay ($/ha/yr)</th>
<th>De Groot et al. (2012) ($/ha/yr)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cultural Services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tourism and recreation</td>
<td>$14,615</td>
<td>$210,000</td>
<td>$108,837 *</td>
</tr>
<tr>
<td>History, culture, traditions, art</td>
<td>$808</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science, research, knowledge, education</td>
<td>$423</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-use (stakeholder perception)</td>
<td>$23,077</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4 https://diversitasconference.wordpress.com/
3 Cultural Services Provided by GTH reefs

3.1 Stakeholder Perception of the Importance of the new Cruise Berthing Facility

The following sections summarise the results of a survey administered to various stakeholder groups as a part of the socio-economic and cultural impact assessment of the proposed cruise terminal at George Town Harbour. These results are derived from questions common to multiple stakeholder surveys and focus on perceived importance and impacts of the proposed project. Questions pertaining to dredging were administered to business stakeholders and are also summarized.

Awareness of the project was very high among all stakeholder groups (over 90%) with the media being the main source of information. All stakeholder groups with the exception of GTH Dive Shops provided views on the importance of the project to the Cayman Islands. Overall, a higher percentage of all stakeholder groups think the project is important/very important to the Cayman Islands, compared to the percentage that thought the project was not important (Figure 3.1). The general view is that the proposed project will benefit business, stimulate the tourism industry and the economy at large. Given that the island economy depends heavily on tourism, “any efforts to enhance the tourism industry would be welcomed”.
Figure 3.1  Views on the importance of the proposed project to the Cayman Islands

3.2  Importance and Use of Natural Resources Among Households

Community members reported using marine/coastal (coral reefs and fishing grounds) and terrestrial (beaches) natural resources in their communities. Approximately 98% stated that marine/coastal resources are important/very important. Similarly, 94% stated that terrestrial resources are important/very important (Table 3-1). Almost 70% of respondents reported using these resources (}
Natural resources are used for domestic, commercial and recreational purposes. Recreational use was the most common use among respondents accounting for 52% of total respondents (Table 3-3). Only one percent of households surveyed use resources for commercial purposes. Recreational uses of marine/coastal resources are mainly swimming, diving, sailing and water sports. Terrestrial resources such as the geologic outcrop at Hell are attractions for site seeing.

Table 3-1 Importance of natural resources (Households)

<table>
<thead>
<tr>
<th>Importance of Natural Resources</th>
<th>Important/Very Important</th>
<th>Not Important</th>
<th>Don't Know/ No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
<td>Frequency</td>
</tr>
<tr>
<td>Marine/Coastal</td>
<td>302</td>
<td>98</td>
<td>1</td>
</tr>
<tr>
<td>Terrestrial</td>
<td>288</td>
<td>94</td>
<td>11</td>
</tr>
</tbody>
</table>
### Table 3-2 Use of natural resources (Households)

<table>
<thead>
<tr>
<th>Use of Natural Resources</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>88</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>No Response</td>
<td>7</td>
<td>2</td>
<td>31</td>
</tr>
<tr>
<td>Yes</td>
<td>213</td>
<td>69</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>308</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3-3 Purpose for Use of Natural Resources (Households)

<table>
<thead>
<tr>
<th>Purpose for Use of Natural Resources</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>4</td>
<td>1.3</td>
</tr>
<tr>
<td>Domestic</td>
<td>78</td>
<td>25</td>
</tr>
<tr>
<td>Recreational</td>
<td>161</td>
<td>52</td>
</tr>
</tbody>
</table>

### 3.3 Degree of Public Support of Dredging Required for the Pier Construction

The proposed project layout will require dredging to be carried out in order to accommodate the Oasis class cruise ships. Dredging will destroy an estimated six hectares of coral reef and will expose an additional seven hectares in the immediate vicinity to excessive sedimentation and turbidity resulting from the dredging operation, the dewatering of the dredge material, and construction activities.

The results of the questionnaires administered to business stakeholders indicate that dredging and environmental damage and destruction due to dredging were identified as negative impacts across all stakeholder groups. On average, 48% of business stakeholders do not support dredging activities that would allow the construction of the berthing facility while 42% are in support of dredging (Figure 3.2). In the group formed by GTH dive shops, tender boat operators and Chamber of Commerce membership participants, opponents to the dredging outnumbered supporters. The group formed by independent water sports operators, tour bus operators and downtown business (mainly retail, food services) opposes dredging. Some of those in support indicated that they support dredging only if absolutely necessary.
3.4 Public Perception of the Importance of Cultural Heritage Assets

The many shipwrecks around the islands contribute to the cultural heritage and, as such, carry economic value to stakeholders. There are two shipwrecks in GTH, both of which will be impacted directly and indirectly by the proposed project. In addition to their cultural significance, these shipwrecks have also become a part of the reef ecosystem and provide habitat for marine life. Stakeholders’ views on the importance and significance of these shipwrecks are therefore indicative of their intrinsic value.

Three stakeholder groups provided views on the importance and significance of any damage or loss of shipwrecks to the Cayman Islands. Eighty-five percent (85%) of households stated that shipwrecks are important/very important to the Cayman Islands and that any loss or damage to these shipwrecks would be a significant/very significant loss (Figure 3.3). On the other hand, only 53% of the downtown George Town businesses and 56% of the independent water sports operators view the wrecks as important/very important. A larger percentage of these groups, however, think that any damage or loss of shipwrecks would be significant/very significant to the Cayman Islands.

Further, the Balboa and the Cali shipwrecks, as well as the GTH reefs, were identified by GTH dive shops that participated in the survey as being “among the best dive sites” in the islands. The main reasons offered for this designation included easy access, close proximity to shore and to businesses, and abundant marine life (fish and coral). Other reasons included the shallow depth, calm waters, “staff and customer favourite”, and the “unique and adventurous” swim-through at Devil’s Grotto. Also mentioned was the suitability of the site for divers of various skill levels. The use of shipwrecks as dive sites is another indicator of their value and, in fact, makes them contributors to the cultural and tourism value presented in this report.
3.5 Tourism and Recreation

According to the Cayman Islands Economics and Statistics Office Public Tourism Arrivals Report for 2013, a total of 1,375,872 tourists arrived by cruise ships and another 345,385 by air. An estimated 5.6% of visitors arriving by air reported “diving” as the main purpose of their visit. This figure was used to estimate the number of tourists arriving by cruise ship that would dive during their stay in Grand Cayman, which for 2013 was estimated at 77,049. Although 5.6% of all tourists reported diving, there was no indication where they were diving. There are approximately 80 popular dive sites listed in promotional material6 for divers; seven of these sites are located in George Town Harbour, including Eden Rock, Devil’s Grotto, the Balboa, and Cheese Burger Reef, just to name a few. It was assumed that of the 5.6% of tourists arriving by air who would be diving, at least 47% (9,091 or 2.6% overnight tourists) would take the opportunity to dive at GTH sites. This assumption is deemed conservative (personal communication) but was chosen to represent the lower range of values for overnight tourists partaking in water activities in GTH. The cost of water activities is the median value of the range of prices for various water sport activities advertised in GTH (range US$50-150 per activity). Based on 2013 data, the ESO estimated that overnight tourists spend an average of US$246 per person per night with average length of stay being five nights; the average group size was two persons. The average daily expenditure for cruise visitors was estimated at US$86 per person.

Table 3-4 and Table 3-5 show the estimated cultural values based on ESO statistics and the GTH dive shop surveys, respectively. Based on the ESO data, the value for water activities in GTH was estimated at US$20M. The value for diving, snorkeling and other water activities based on surveys conducted at GTH dive shops in 2014 was estimated at US$19 million.

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6 http://www.caymanactivityguide.com/DiveSites.htm
Table 3-4  Estimated tourism (Cultural) value based on ESO Tourism Statistics

<table>
<thead>
<tr>
<th></th>
<th>Total # of arrivals (2013)</th>
<th>% # tourists diving</th>
<th>% # air tourist diving in GTH</th>
<th>Direct Spend Value diving, snorkelling, boat, sub tours (US$)</th>
<th>Indirect spend value Cruise (US$)</th>
<th>Other spend Air (US$)</th>
<th>Total for GTH (US$)</th>
<th>Tourism Valuation/ha (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rates</td>
<td>1,375,872</td>
<td>5.6%</td>
<td>47%</td>
<td>$9,631,104</td>
<td>$6,626,200</td>
<td>$16,257,304</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cruise</td>
<td>345,385</td>
<td>77,049</td>
<td>9,091</td>
<td>$1,136,317</td>
<td></td>
<td>$2,236,271</td>
<td>$3,372,588</td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>38,700</td>
<td>47</td>
<td></td>
<td>$3,008,000</td>
<td></td>
<td>$9,513,234</td>
<td>$12,521,234</td>
<td></td>
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<tr>
<td>Total (US$)</td>
<td>1,721,257</td>
<td>96,390</td>
<td></td>
<td>$10,767,421</td>
<td>$6,626,200</td>
<td>$19,629,891</td>
<td>$669,515</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-5  Actual Tourism (Cultural) values based on surveys of GTH dive shops

<table>
<thead>
<tr>
<th></th>
<th>Total # of tourists reported by GTH dive shops</th>
<th>% tourists per group</th>
<th>Direct Spend Value diving, snorkelling, boat, sub tours (US$)</th>
<th>Indirect spend value Cruise (US$)</th>
<th>Other spend Air (US$)</th>
<th>Total for GTH (US$)</th>
<th>Tourism Valuation/ha (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>38,700</td>
<td>47</td>
<td>$3,008,000</td>
<td></td>
<td>$86</td>
<td>$9,513,234</td>
<td>$12,521,234</td>
</tr>
<tr>
<td>Cruise</td>
<td>39,523</td>
<td>48</td>
<td>$3,072,000</td>
<td>$3,386,331</td>
<td>$6,458,331</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>4,117</td>
<td>5</td>
<td>$320,000</td>
<td></td>
<td>$320,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total US$</td>
<td>82,340</td>
<td>100</td>
<td>$6,400,000</td>
<td>$3,386,331</td>
<td>$9,513,234</td>
<td>$19,299,565</td>
<td>$551,416.13</td>
</tr>
</tbody>
</table>

Notes:
- Average direct use cost: Average US$120; Median US$95
- Indirect spend value (cruise): US$86
- Indirect spend value (air): US$246
3.6 Non-use Value

Non-use values are those benefits that arise without any physical use. There are three types of non-use values: option value, existence value and bequest value. Option value includes the opportunity to preserve a resource for future use instead of using it at the present time. For example, coral reefs may have yet-to-be-discovered important pharmaceutical compounds and ecological functions. Existence value is derived from the knowledge that a particular natural resource or endangered animal is preserved. For example, protection of coral species that have been identified as threatened or endangered may have a perceived value in the present and a tangible value in the future. Bequest value is derived from the desire to pass on a value to future generations.

4 Provisioning Services

Coral reef associated fisheries encompass both direct (e.g. provisioning through subsistence, artisanal, recreational and commercial fisheries, extraction of raw materials) and indirect values (e.g. habitat provisioning) (van Beukering et al. 2010). Historically, finfish fishery in Cayman Islands has been primarily subsistence, small-scale artisanal and recreational. Today, the Cayman Islands are economically well off, with an economy dominated by tourism and offshore banking, and reportedly among the highest standards of living in the Caribbean. As such, the average citizen is not dependent on locally sourced fish (Harper et al. 2009).

In 1986, several marine conservation laws were enacted in response to unprecedented coastal development that threatened mangrove areas and channels (DaCosta et al. 2009). Mangroves and coastal ecosystems, including seabeeds and coral reefs, are essential to local marine fish populations (Harper et al. 2009). Marine Protected Areas (MPAs) were created with areas that were designated as marine parks, environmental areas and replenishment zones. Restricted fishing for Nassau grouper at known or potential spawning aggregation sites was also instated. Along with grouper, lobster (Panulirus argus), conch (Strombus gigas), whelk (Cittarium pica) and several other species are also protected (Cayman Islands Department of Environment, http://www.doe.ky).

GTH is part of a Marine Park Area that was created in 1986. Despite it being a multi-use area (e.g. port facility, mooring area, water-sport recreational area, marine park, etc.) the reefs in George Town Harbour show remarkable resilience. A benefit of GTH reefs being located within the confines of the marine park is that the de facto fisheries restrictions in the harbour have kept the fish abundance and diversity relatively high. A study assessing the effectiveness of the Grand Cayman MPA system examined the “Reserve” and “Spillover” effects to areas outside the MPA (McCoy et al. 2009). The results of their study showed higher fish biomass within MPAs confirming the value of the resource management strategy and, secondly, the study confirmed the exportation of individuals from protected to surrounding areas. Given that there is not a fishery per se in GTH, the protected status may in fact be contributing to fish populations on reef areas outside of GTH.

The value of the ecosystem services provided by GTH reefs is the role they play in providing habitat and spatial heterogeneity that is essential for fish and other reef fauna. Rugosity is frequently used as an indicator of habitat complexity and appears to be strongly correlated with fish species richness (Alvarez-Filip et al. 2009). The reef structures in the harbour serve to connect the reefs on 7 Mile beach to the reefs south of the harbour. Seascape connectivity provides a patchwork of habitat types that are critical foraging areas, nurseries and refuge for fish and invertebrates alike (Mcfield and Kramer 2007).
Although there is no fishing permitted in GTH, there is still subsistence fishing from shore and beyond the 80ft contour. No official fish landings data were available specifically for the GTH fishery. Typically catches of small-scale fisheries are not recorded or are under-reported by local fisheries agencies, which appears also to be the case for the Cayman Islands (Harper et al. 2009). According to TEV studies conducted in Bonaire (TEEB_NL 2012) and for the Montego Bay Marine Park, provisioning services have been estimated at US$846 and US$867 per hectare per year, respectively (Table 4-1). In both cases the value reflects the management strategy of limited fishing and resource extraction. Using the above values as transfer values, the value for provisioning services in GTH alone is estimated at US$29,610/year.

<table>
<thead>
<tr>
<th>Provisioning services</th>
<th>US$/ha/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonaire</td>
<td>$846</td>
</tr>
<tr>
<td>Montego Bay Marine Park</td>
<td>$867</td>
</tr>
<tr>
<td>de Groot et al (2012)</td>
<td>$57,742</td>
</tr>
</tbody>
</table>

5 Indirect Use Value: Regulating Services

5.1 Shoreline Protection

Shoreline protection ecosystem services provided by coral reefs can be quantified in terms of wave energy attenuation attributable to the presence of the reef or, as the case may be, the increase in wave energy attributable to a diminishment of the reef’s size (Principe et al. 2012). Economic benefits from shoreline protection are represented by the value of the property, lives, and well-being preserved by the attenuation of the wave energy, or the value lost due to the increase in wave energy.

Shoreline protection ecosystem service can be quantified in a number of ways. Reef attributes including reef height, rugosity, width, slope and distance from shore are used in mechanistic models to simulate and predict wave heights and wave energies in the presence (or diminished presence) of coral formations. Field studies have measured as much as a 68-95% reduction in wave energy as waves travel over the reef flat (Principe et al. 2012).

Along with the physical attributes of reef formations, reef health is another important factor in wave attenuation. Degraded reefs tend to lose their rugosity, resulting in reduced friction across a reef flat; a 50% reduction in reef friction due to reef degradation (i.e. reduced reef height and rugosity) can double the wave energy reaching the coastline (Principe et al. 2012). Sections of degraded reef may afford less protection to coastal areas, including coastal ecosystems, than high relief reefs with a high abundance of large stony coral (Mumby et al. 2008). Similarly, reef continuity is an important indicator of shoreline protection (World Resource Institute 2009). Fragmented reefs may channel high energy waves toward the coastline thereby increasing the risk of wave inundation on the shore (Fernando and McCulley 2005). It is important to note that degraded or fragmented reefs can reduce the value of shoreline protection by as much as 80-90% (Burke and Maidens 2004).

Evaluation of coastal protection ecosystem services offered by the reefs in GTH was carried out using models showing wave heights and wave energies under various scenarios. Figure 5.1 shows the
computed wave heights in front of the shoreline with (existing scenario) and without the reef present, over a period of one year (2011 to 2012). The reefs reduce wave heights in storm events by 30-50% and wave energy by 10-25%. According to the wave simulation model, GTH reefs play a significant role in wave attenuation in the harbour and, as such, their destruction may have implications for the properties along the shoreline, in particular the existing Watler Pier, as well as nearby shops and restaurants which are already subject to wave inundation during storm events. While the proposed land reclamation area may offer limited shelter and reduce wave action along the adjacent shorelines, there may still be localized increases associated with the extension of the north and south vertical walls further seaward, (refer to SWI nearshore wave model comparisons in Chapter 10 and Appendix D.1).
Coastal protection can also be valued using the “avoided damages” method, which estimates the likely economic losses (in property value) to a coastal area from a given storm event, both with and without the reefs. This difference represents the “avoided damages” which can be attributed to the presence of reefs. Alternatively, the value of coastal protection can be based on an estimated cost to replace the loss of a reef with artificial reef structures or the cost of beach and shoreline restoration needed as a consequence of lost coral reefs (Principe et al. 2012). For the purpose of this report, replacement value for coastal protection was also used to estimate the value of coastal protection services (cost of artificial reef structures, wave dissipating blocks, tetrapods as coastal breakwaters, etc.). It is estimated that implementing shoreline protection works over 1,000-1,300 ft (300-400m) of shoreline that would be affected by the destruction of coral reef due to dredging and the subsequent reduction in natural protection would cost approximately US$2.5M.

Although shoreline protection can be a significant contributor to the total economic value of coral reefs, it is largely undervalued by decision-makers, except during times of crisis (Principe et al. 2012). A robust estimate of the economic value of coral reefs must integrate biological, physical and socioeconomic factors that influence the need for and the provision of coastal protection (World Resource Institute 2009).

The following factors must be considered when estimating the potential economic damages resulting from the loss of reefs (Principe et al. 2012):

- Whether the coast is vulnerable to erosion or storm damage, as is the case for low-lying coastal areas;
- Whether the coast is vulnerable due to lack of coastal stability (including coastal geology, geomorphology, elevation and vegetation) and the potential for storm surges (including offshore wave energy and the frequency of severe storm events (e.g. Nor’Westers);
- The protective capability of the reef, which is determined by distance of reefs from shore, reef continuity, reef health and reef type;
- The amount and value of coastal development.

The value of coastal protection afforded by GTH reefs in the proposed CBF project footprint was first based on “replacement value” of corals reefs, which was estimated at US$2.5M or ~$89,693/ha/year; however, this is likely an underestimation as it is based solely on the distance of the coast that would be affected and not the area of the reef lost, and it does not take into account other factors contributing to regulating services. The estimated valuation put forth by de Groot et al. (2012) is based on a meta-analysis of 94 data sources specific to coral reefs “that enabled selection, or calculation of estimates presented on a per hectare per year basis and for which the biome, ecosystem services and location were explicitly specified”. According to their study, the monetary valuation for regulating services provided by coral reefs was estimated at US$171,478/ha/year, including coastal protection, disturbance, climate regulation, and waste assimilation. For the purpose of this report, the two estimates will serve as a possible range of valuation estimates for regulating ecosystem services provided by the GTH reefs (}
Table 5-1).
Table 5-1  Valuation of regulating ecosystem services based on meta-analysis of 94 data sources and on estimated cost of implementing coastal protection works

<table>
<thead>
<tr>
<th>Regulating Services</th>
<th>(de Groot et al 2012) $171,478/ha/yr</th>
<th>Replacement Value (SW) US$2.5M/yr $71,429/ha/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal protection/erosion prevention</td>
<td>$153,214</td>
<td>$71,429</td>
</tr>
<tr>
<td>Disturbance</td>
<td>$16,991</td>
<td>$16,991</td>
</tr>
<tr>
<td>Climate regulation</td>
<td>$1,188</td>
<td>$1,188</td>
</tr>
<tr>
<td>Waste treatment</td>
<td>$85</td>
<td>$85</td>
</tr>
<tr>
<td>Total</td>
<td>$171,478</td>
<td>$89,693</td>
</tr>
</tbody>
</table>

5.2  Habitat or Supporting Services

At the root of habitat and supporting services is ecological integrity, which is defined as “the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region” (Angermeier and Karr 1994). The Millennium Ecosystem Assessment (MEA 2005) describes supporting services as “those that are necessary for the production of all other ecosystem services”; in the case of coral reefs, this would include photosynthesis, primary production, and nutrient cycling, among others. These biotic or fundamental services represent ecosystem functions that underpin ecosystem resilience, which is essential to the persistence of the ecosystem and the associated goods and services (Principe et al. 2012). Primary production, nutrient cycling, species/ ecosystem protection can be valued along with the Marine Park Status. Ecology survey data for GTH have been used to characterize the ecosystem in terms of coral cover, fish abundance, biodiversity, endangered species etc. According to the study by de Groot et al. (2012) valuation of habitat or supporting services is estimated at US$16,210/ha/year, which amounts to an estimated US$567,350/year for GTH reef (Table 6-1).

5.3  Climate Regulation and Carbon Sequestration

Indirect use values provide a wide range of important benefits that are less tangible as they are not directly consumed. The value of some services like carbon sequestration may just now be gaining recognition as an important ecosystem service. Given their ambiguous status, these ecosystem services are much harder to value based on conventional valuation methods, thus leading to undervaluation of their importance in decision making. Coral reefs are net sinks for carbon, primarily as CaCO₃ accretion (Kinsey and Hopley 1991). For climate mitigation, which is provided locally through carbon sequestration, the benefits are mainly global and therefore, difficult to value at a local scale. Monetary value of climate regulation and carbon sequestration has been estimated at US$1,188/ha/year (de Groot et al. 2012) and is included along with other regulating services.

6  Estimated Economic Value or Benefit of George Town Reefs

According to Koch-Weser (1997), the challenge with valuing coral reefs relates to identifying the various components of value, and what monetary prices to assign to them. Since resource valuations are based on locals’ perception and expression of value, the resulting valuations tend to be very site-specific. Consequently, caution has to be exercised when using the ‘benefit transfer’ approach, whereby values established in studies are applied to other areas.
In this study, data derived from ESO Tourist Statistics and questionnaires conducted during the course of the Socio-Economic Impact Assessment were used to estimate a range of values of cultural services provided by GTH reefs. Proxy or “transfer values” from published valuation studies were used to estimate provisioning, regulating and supporting services (de Groot et al. 2012). The range of estimated values for ecosystem goods and services provided by GTH coral reefs are summarized in Table 6-1. These values bring to the forefront the need to include the economic benefits of ecosystem goods and services in cost/ benefit analysis of development projects, especially when projects threaten sensitive ecosystems.

For cultural services, which encompass tourism and recreation (for locals), the estimated economic value (annual) was estimated to be between US$19M/year and US$20M/year. For provisioning services, the annual per hectare economic valuation was based on transfer values from Bonaire (US$846/ha/year). The resulting estimate for provisioning services in GTH is estimated conservatively at US$29,610/ha/year, an amount that reflects the fact that only subsistence fishing is permitted in GTH waters. The valuation of regulating services, including coastal protection and climate regulation, was based on a yearly per hectare value of US$171,478 (de Groot et al. 2012), which at $17/m², is conservative when compared to the $1,100/m² of damaged reef estimated when the Carnival Magic dropped anchor on a healthy reef in Grand Cayman.7 Two methods were used to obtain a range of values for GTH regulating services for GTH. Using the transfer value from de Groot et al. (2012) the value of regulating services for GTH is estimated at US$6M/year compared to US$3.1M/year based on “replacement value”.

The habitat or supporting services are estimated at US$16,210/ha/year (de Groot et al. 2012) or US$567,350/ha/year for GTH reefs. The sum of ecosystem goods and services per hectare per year for GTH range between US$658,165 based on data from surveys of GTH shops to US$749,388, which is based on tourist data (ESO Tourism Statistics) and transfer values from various sources; the estimated annual economic benefit derived from GTH reefs ranges from US$23M-US$26M.

## Table 6-1  Total Estimated Economic Value of Ecosystem Goods & Services of Marine Resources in GTH

<table>
<thead>
<tr>
<th>Ecosystem Goods and Services</th>
<th>Cultural Services based on ESO Tourism Statistics (other Services as per de Groot et al, 2012) (US$/yr) (GTH reef area 35 ha)</th>
<th>Cultural Services based on Survey of GTH Dive Shops (other services as per de Groot et al, 2012) (US$/yr) (GTH reef area 35 ha)</th>
<th>Cultural Services based on survey of GTH Dive Shops, Regulating services based on SWI Estimate (other Services as per de Groot et al, 2012) (US$/yr) (GTH reef area 35 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural Services</td>
<td>$19,629,891</td>
<td>$19,299,565</td>
<td>$19,299,565</td>
</tr>
<tr>
<td>Provisioning Services</td>
<td>$29,610&lt;sup&gt;1&lt;/sup&gt;</td>
<td>$29,610&lt;sup&gt;1&lt;/sup&gt;</td>
<td>$29,610&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Regulating Services</td>
<td>$6,001,730&lt;sup&gt;2&lt;/sup&gt;</td>
<td>$6,001,730&lt;sup&gt;2&lt;/sup&gt;</td>
<td>$3,139,240&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Supporting Services</td>
<td>$567,350&lt;sup&gt;3&lt;/sup&gt;</td>
<td>$567,350&lt;sup&gt;3&lt;/sup&gt;</td>
<td>$567,350&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Total estimated economic value per year for GTH (35 hectares)</strong></td>
<td><strong>$26,228,581</strong></td>
<td><strong>$25,898,255</strong></td>
<td><strong>$23,035,765</strong></td>
</tr>
<tr>
<td><strong>Estimated economic value per year/hectare</strong></td>
<td><strong>$749,388</strong></td>
<td><strong>$739,950</strong></td>
<td><strong>$658,165</strong></td>
</tr>
</tbody>
</table>

Notes:

1) Provisioning services in estimated and actual values based on Bonaire valuation (MPA) US$846/ha/year
2) Regulating services in estimated and actual values based on deGroot et al 2012 (Table 2-1)
3) Supporting services in estimated and actual values based on deGroot et al 2012 (Table 2-1)
4) Regulating Services in actual values base on SW estimate for shoreline protection (}
5) Table 5-1).
7 Estimated Economic Losses

Several cruise berthing facility (CBF) design options were evaluated. The final option was selected on the basis of “avoiding construction in deep waters, while at the same time maintaining a good alignment to the prevailing wind and wave conditions” (CIG TOR 2013, p.2). Environmental damage, specifically destruction of the coral reef is inevitable under all CBF design options, however, the option selection process took into consideration minimizing direct impact (destruction of the reef) while ensuring that operational requirements, from the cruise lines’ perspective, were met.

Based on a comparative assessment of numerous project layout options, Options A, B and C were selected as the final three (refer to Figure 7.1). Option A was developed to maximize functional performance and minimize capital costs, but has significant environmental impacts. The overall project footprint for Option A is approximately 15.3 ha, of which 7.3 ha is comprised of “coral reef habitat”, including intermittent areas of “coral substrate” (spurs, patch reefs and individual coral heads) as well as hard pan and sand bottom areas located amongst/between the coral reef features (these areas are part of the functional ecosystem within the project footprint). Based on an assessment of the results of dredge plume model simulations (refer to Appendix D.2), it is estimated that an additional 6-8 ha of coral reef habitat within a 200 m buffer zone around the project footprint would be negatively affected (degraded) due to elevated turbidity and sedimentation levels during the construction of the project (in particular, during the dredging and land reclamation works, and also during the operation phase due to sediment re-suspension caused by cruise ship traffic (in particular, the use of props and thrusters during berthing and de-berthing manoeuvres). Based on the valuation of GTH reefs presented earlier, the economic loss due to the destruction and degradation of reefs under Option A is estimated to in the order of US$9-11.5M/year (refer to Table 7.1).

Option B was developed to minimize dredging and the associated environmental impacts, and has a dredge footprint of approximately 1.5 ha. In addition to the dredge footprint, it is estimated that reefs within 100 m of the project footprint (an additional 2 ha) would be adversely affected (degraded) due to sediment re-suspension associated with cruise ship traffic. The economic loss for Option B is estimated to the order of US$2.5M/year (refer to Table 7.1). Based on feedback from the cruise lines, the functional performance for Option B was less favourable.

Option C was developed to provide a “middle ground” with respect to functional performance and environmental impacts. The total project footprint for Option C is approximately 13 ha, including 6 ha of coral reef habitat that will be destroyed by dredging (red areas in Figure 7.1). It is estimated that an additional 6-8 ha of coral reef habitat located within approximately 200 m of the project footprint, including portions of Soto’s Reef, Eden Rock and possibly Devil’s Grotto (orange areas in Figure 7.1), will be subjected to extended periods of lethal/sub-lethal sedimentation and turbidity (shading) during the dredging and land reclamation works, and to sediment re-suspension during the operational phase; as such, these areas are designated as high-impact zones where coral mortality is likely. The economic loss due to the destruction and degradation of reefs under Option C is estimated to in the order of US$8-10.5M/year (refer to Table 7.1).

The estimated economic losses associated with impacts on marine ecosystem goods and services derived from GTH are summarized in Table 7.1 for the three options. Option C is the final EIA concept, with estimated economic losses in the order of US$8-10.5M/year. These estimated losses are based on current spend rates, and are related to direct and indirect impacts on marine ecosystem goods and services within GTH caused by the project, in particular due to the loss of coral reefs and associated business for local watersports operators, plus indirect impacts to employees’ incomes and purchasing power.
It is noted that the estimated economic losses presented herein are based on a preliminary marine resource valuation derived from current spend rates, and are subject to some uncertainty. Further analyses are required to adjust the estimated losses to reflect the Gross Value Added (GVA) to the overall economy of the Cayman Islands, and also to account for the anticipated diversion/displacement of businesses from within GTH to other locations and/or activities/attractions in George Town and around Grand Cayman Island. It is recommended that the OBC be updated to reflect these and other socio-economic impacts identified in the EIA.
Figure 7.1 Alternative project layouts were analysed to estimate the area of coral reef habitat within the project footprints. Schematic for Option C represents the coral reef habitat area that will be subject to direct impacts (red) due to construction and indirect impacts (orange) due to elevated turbidity and sedimentation levels during both the construction and operation phases.
Table 7-1  Estimated economic losses due destruction and degradation of reefs in GTH for Options A, B and C.

<table>
<thead>
<tr>
<th>Estimated Economic Loss of Goods and Services of GTH Reefs Under Various Project Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESTIMATED REEF VALUE (US$/ha/yr)</td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td>OPTION A</td>
</tr>
<tr>
<td>Dredged Area</td>
</tr>
<tr>
<td>Reef Area Destroyed (reef areas within project footprint)</td>
</tr>
<tr>
<td>Reef Impact Zone (adjacent reef areas indirectly affected by project construction and operations)</td>
</tr>
<tr>
<td>TOTAL ESTIMATED LOSS</td>
</tr>
<tr>
<td>OPTION B</td>
</tr>
<tr>
<td>Dredged Area</td>
</tr>
<tr>
<td>Reef Area Destroyed (reef areas within project footprint)</td>
</tr>
<tr>
<td>Reef Impact Zone (adjacent reef areas indirectly affected by project construction and operations)</td>
</tr>
<tr>
<td>TOTAL ESTIMATED LOSS</td>
</tr>
<tr>
<td>OPTION C - FINAL EIA CONCEPT</td>
</tr>
<tr>
<td>Dredged Area</td>
</tr>
<tr>
<td>Reef Area Destroyed (reef areas within project footprint)</td>
</tr>
<tr>
<td>Reef Impact Zone (adjacent reef areas indirectly affected by project construction and operations)</td>
</tr>
<tr>
<td>TOTAL ESTIMATED LOSS</td>
</tr>
</tbody>
</table>
8 Conclusion

In December 2013, the Legislative Assembly of the Cayman Islands passed the National Conservation Law which seeks to “protect and conserve endangered, threatened and endemic plants and their habitats as well as the variety of wildlife in the Cayman Islands” (The National Conservation Law, 2013, p.1). The construction of the berthing facility will destroy a segment of an established Marine Protected Area (MPA) at a time when the CI government is looking to expand the MPAs to cover 40-50% of the coastal shelf of Cayman (National Biodiversity Action Plan, DaCosta et al. 2009).

Balancing the need for economic growth and the need for conservation is a very challenging proposition. It is not surprising that when it comes to economic growth, environmental conservation is more often than not relegated to a lesser role in the decision making process. In addition to economic considerations, the intangible value that a society attaches to its ecosystems and their associated services determines how these resources are managed.

Until recently, the perceived value of ecosystem conservation has been largely intangible due to the complexity and multi-faceted nature of these systems. Unbound coastal development has resulted in considerable and often cascading monetary losses. These events have brought to the economic and political forefront the direct and indirect economic impacts of degraded ecosystems, and the need to develop methods to measure and mitigate these impacts.

While the Ecology Report (Task J1) assesses the environmental impacts associated with the proposed development of the cruise berthing facility, economic factors described above also play an important role in making the case for improved management and conservation of coral reefs. Economic analysis of ecosystem goods and services brings another variable into the cost-benefit analysis when evaluating the impacts of significant infrastructure projects such as the Cruise Berthing Facility.

The construction of the proposed cruise berthing facility will result in ecological losses, including loss of habitat and habitat complexity, loss of ecological functionality and connectivity, and the inevitable loss of biodiversity in the area. The associated loss of ecosystem goods and services in GTH represents an economic loss as well, with this loss estimated to be in the order of US$8-10.5M per year. The estimated economic losses are based on the preliminary marine resource valuation derived from current spend rates. Further analyses are required to adjust the estimated losses to reflect the Gross Value Added (GVA) to the overall economy of the Cayman Islands, and also to account for the anticipated diversion/displacement of businesses from within GTH to other locations and/or activities/attractions in George Town and around Grand Cayman Island. It is recommended that the OBC be updated to reflect the long-term economic impact of the loss of ecosystem goods and services resulting from the destruction and degradation of the GTH reefs and other socio-economic impacts identified in the EIA.

Mitigation measures such as coral relocation are an expensive undertaking with uncertain results. While coral relocation programs can be successful under right circumstances, it does not compensate in full for the loss resulting from dredging and should not be looked upon as an all-encompassing environmental restitution for replacing an established and complex habitat. In the case of coral reefs, habitat protection and conservation are valued above compensation. Once destroyed, coral restoration cannot replace the ecosystem functionality or the associated goods and services provided by these ecosystems. Similarly, mitigating the losses associated with the cultural services (tourism and culture) will come at a cost to the local population. For example, the relocation
plan for the Balboa will be judged not only on the cost and the execution, but also on the success of preserving the structure of the wreck along with the corals and other marine fauna that have colonized the wreck surfaces over the years.
9 References


van Beukering P Van, Muresan L (2013) IVM Institute for Environmental Studies The total economic value of nature on Bonaire.


