This study was funded by NOAA’s Coral Reef Conservation Program (CRCP). The CRCP supports effective management and sound science to preserve, sustain and restore valuable coral reef ecosystems for future generations.

**The Challenge:** The coral reefs of the United States Virgin Islands (USVI) provide a wide range of ecosystem services of economic, cultural and ecological value including recreational uses, subsistence fisheries, beach sand production, coastal protection and tourism revenue. Given the importance of these coral reefs to the USVI, and in light of increasing natural and anthropogenic threats, there is a need for sound scientific and user information to guide decision making regarding the protection and management of coral reefs.

**The Approach:** The objective of this study is to provide a logical and scientific measure of how important coral reefs are to the USVI in monetary terms, and to provide a defined reference point that can be used as a tool to help guide future development/conservation plans. Information on the Total Economic Value (TEV) of coral reefs will be used to build a strategy to advocate for the conservation of USVI coral reefs; to establish guidelines for damage compensation, develop appropriate regulations and their implementation; set fees for permit applications; and evaluate the potential for user fees.

**Results & Recommendations:** The value of the USVI’s coral reefs amounts to US$202 million annually. These values vary significantly between ecosystem services: recreation ($48 million), amenity value ($35 million), coastal protection ($6 million), tourism ($96 million), and support to fisheries ($3 million). The local community is a prime beneficiary of the value of healthy coral reefs. Through stronger engagement of the local public in marine management, decision makers can build more support for conservation-oriented measures while at the same time enhancing community awareness of the importance of coral reefs to USVI quality of life.
Introduction
Coral reefs are important to the USVI for both the ecological and socio-economic benefits they provide. Reefs provide food, tourism dollars, jobs, support social and cultural practices and recreational opportunities, shoreline protection and more. USVI reefs and the communities that rely upon them, like those worldwide, are increasingly threatened by both global stressors such as climate change and local ones such as unsustainable coastal development. As a result, there is a need for a better understanding of the science, condition and use of USVI coral reefs to guide decision making regarding management and conservation of this valuable ecosystem. The main objective of this study was to determine the Total Economic Value (TEV) of various ecosystem services derived from USVI coral reefs. The economic valuation of these ecosystem services generated an estimate of their importance, and provides a defined reference point that can be used as a tool to guide future alternative development and conservation scenarios.

The USVI and its’ coral reefs
The territory of the US Virgin Islands consists of three main islands: St Thomas, St John and St. Croix. The total population is around 112,000. USVI coral reefs are found around the main islands as well as several smaller islands and cays. USVI coral reef ecosystems are quite extensive both in shallow and deeper waters measuring 344 km² (to 18m depth) and 2,126 km² (to 183m depth), respectively.

Coral reef ecosystems in the USVI are affected by many anthropogenic and natural stressors:
- Increasing runoff and sedimentation from land clearing and grading;
- Poor water quality (pollution);
- Overuse and mis-use;
- Limited local management capacity;
- Diseases;
- Episodic bleaching; and
- Coral bleaching and/or thermal stress.

These threats highlight the need for targeted, environmentally-sensitive development planning and the need for better regulation to begin to control/mitigate local threats.
The approach

The coral reefs of the USVI provide a wide range of ecosystem services to Territorial residents, the nation and the region including recreational opportunities, fisheries, tourism revenue, coastal protection and property values, cultural and social values (e.g. one generation within a family teaching the next to fish, not only how to use the gear in the right way in the right conditions but reading the ecosystem and then the protocol of sharing the catch and preparing food) and education and research opportunities (see conceptual framework applied in this study).

A host of valuation techniques is available to quantify these types of direct and indirect ecosystem services. In this study, several of these techniques were used. One of the most informative valuation techniques used was face-to-face interviews with the main stakeholders, residents and visitors, benefiting from USVI coral reefs. In total, 780 USVI households, 450 visitors to the USVI, 15 reef-related tourist operators on St Thomas, St Croix and St John, and a large number of fishermen were interviewed. Moreover, a database containing 6,000 house sales was assembled and analyzed. Due to this high level of primary data collection, this study is rich in providing new insights into how local coral reef ecosystems support the USVI economy.
Ecosystem Services

People benefit from coral reef resources in many ways, and collectively, these benefits are known as ecosystem services. Well-known and clearly visible services provided by coral reefs include fisheries and tourism. Not as apparent but still important services from reefs are coastal protection and positive influences on property values. This study estimated the economic value of six of the most important services provided by coral reefs in the USVI. Highlights of the findings are described here.

Local recreation and cultural values

The results of this study show that local residents are strongly connected to the reef and therefore have a high willingness to contribute to its conservation. Locals have the following primary bonds with the marine environment of the USVI:

- Swimming is one of the most popular recreational activities: 77% of the respondents state that they occasionally go swimming in the sea;
- Of all respondents interviewed in the survey, 34% snorkel and 10% scuba dive;
- Roughly 20% of the households are involved in recreational fishing.

The survey also addressed the main concerns people have about the marine environment. Personal health concerns ranked high, with residents especially worried about poor water quality and clarity. Therefore, residents saw proper sewage treatment as a form of coral reef preservation and as a high priority (Figure 1).

The main aim of the household survey was to determine the Willingness to Pay (WTP) of residents for coral reef conservation. Factors influencing the WTP include the level of income and education, environmental awareness, and whether or not a respondent is involved in beach and coral reef-related recreation. Overall, the data show that local residents are willing to contribute between $10 to 20 million per year for improved coral reef management in the USVI.

Tourism value

The USVI is advertised as America’s Caribbean Paradise. A stay on the islands is considered by many as nothing short of true bliss. Each year around 2.4 million visitors come to the USVI, a prime reason being the beautiful beaches and coral reefs. Considering that the tourism sector accounts for 80% of the USVI’s GDP, it is easy to understand that ensuring proper management of coral reefs is not only vital from an environmental perspective but also from an (socio) economic point of view.

The study showed that cruise ship tourists generate $35 million annually as a result of reef-related activities while stay-over (airline visitors) generate $68 million as a result of reef-related activities each year, bringing the annual total value of coral reef resources to tourists to $103 million. The study also found that without a healthy marine environment many visitors would be hesitant to return to the USVI for future holidays. Half of the tourists indicated they would not return to the USVI if the marine environment degrades further. Loss of these visitors and the associated revenue due to mis-management of coral reef ecosystems would lead to substantial economic losses for those both directly and indirectly involved in the USVI tourist industry and the Territory as a whole.
Fisheries
Healthy USVI coral reef ecosystems support local fisheries by providing nursery, forage and residential habitat for these fish. Losses in quality habitat negatively affect fish numbers. Reef fish have been and still are an important part of the weekly diet in the USVI. The survey revealed that 75% of the households in the USVI consume locally-caught fish at least once a week. The number of households in the survey that are involved in recreational fishing is approximately 20%. Recreational fishing is not only economically important, but also culturally important: sharing fish with family and friends and enjoying the ocean are crucial elements of USVI culture. Commercial fishermen add value of around $1.4 million to the local economy by catching and selling reef fish. Recreational fishermen contribute another $1.9 million each year. The total value of USVI coral reef-related fisheries is $3.3 million per year.

Coastal protection value
Coral reefs help to protect land and buildings in the USVI from storm and flood damage. They do this by absorbing the energy from waves. Houses and hotels built near the coastline and beaches would also be much more at risk from storms. Reefs also supply the fine, white sand on USVI beaches; without the reefs there wouldn’t be as much sand on the beaches. The annual coastal protection value of USVI coral reefs is estimated at $8 million.

Putting value to use
The economic value of ecosystem services can be used by decision makers in various ways. By calculating the Total Economic Value (TEV) we get a better sense of how healthy reef ecosystems support the overall economy. Also, economic values are useful inputs in standard cost benefit analyses. By looking at the spatial distribution of the TEV, we can better understand which reef areas support different reef-related services and
contribute value to the USVI economy in different ways. In a similar way, the value map can be used to inform damage assessment protocols which help managers and decision-makers determine penalties for coral reef damages. Some examples are illustrated in the following.

**Total Economic Value (TEV)**

By summing up the above-mentioned values, the TEV of coral reefs in the USVI is estimated conservatively at more than $200 million annually. To get an idea of the importance of coral reefs for the USVI, it is useful to compare the TEV of coral reefs to the GDP. The GDP of the USVI was around $1.6 billion in 2010 which means that revenue derived either directly or indirectly from coral reef ecosystem services comprise 13% of the USVI economy. Compared to other studies, this is shows that the USVI economy has a relatively high dependence on the marine environment.

**Value mapping**

Not all of the USVI’s coral reefs are worth the same amount of money. With a limited amount of money to spend on protection, the USVI needs to know the variation in economic importance of the reefs. One way to assess this variation for various ecosystem services is to use a computer mapping tool called Geographic Information Systems (GIS). These GIS maps show us the location of high and low productive reefs. An example of a coral reef value map for St. Thomas is shown below. If you look at this value map you will see the most valuable reefs are the pink ones. These are mostly small reefs located within 200 meters of the most popular diving and snorkeling spots or reefs that have an important coral reef protection or real estate value. These reefs are worth nearly $1.9 million per hectare.

**Damage assessment**

The study also investigated how the generated economic values can be used to estimate the damage from specific threats to the coral reefs of the USVI. Possible applications involve estimating the damage of ship groundings or oil spills, which are generally sudden events mostly affecting relatively small areas. Other threats that cause damage on a broader scale include terrestrial sedimentation and run-off. By combining the value maps with maps that specify the locations of affected and damaged coral reefs by sedimentation, the researchers were able to estimate the total damage of sedimentation in the USVI through coral reef impairment. This damage amounted to $28 million annually. This damage includes losses in terms of reduced coastal protection of coral reefs, declines in fish productivity in reef areas, and a decline in attractiveness for divers and snorkelers of coral reefs. Similar estimates were made by the involved researcher for anchoring damage. This novel damage assessment method can also be applied to characterize the loss of value from other threats.
Recommenations

USVI territorial coral reef health is declining due to ineffective natural resource management, inadequate land use planning, exploitation of resources, and natural events. This decline is exacerbated by a lack of data and institutional capacity to address the anthropogenic stressors that adversely affect the coral reef ecosystems. This study can help to address these limitations by informing the development of policies for more sustainable management of coral reefs in the USVI.

Engage local residents in management

The most important beneficiary of the coral reefs is the local community. Through recreational and cultural activities as well as through the hidden amenity value of a healthy marine environment, people in the USVI are connected to their marine environment in various ways and therefore value and benefit from the health of this ecosystem greatly. At present, this local connectivity with the marine environment is insufficiently recognised by decision makers who mainly focus their interventions on the tourist industry and the fishery sector. Through stronger engagement of the public in marine management, decision makers may find more support for conservation-oriented measures while at the same time enhancing the awareness of local communities.

Role of Tourism

The tourism sector plays a dual role in the coral reef economy of the USVI. On the one hand, tourism is an important beneficiary of coral reefs in the USVI. Without healthy reefs, the tourist industry and thus the island economy of the USVI would be harmed substantially. On the other hand, the tourism sector can also drive significant threats to the USVI coral reefs through development pressure and overuse. Therefore, it is in the interest of the tourist industry itself to be proactive and support measures that will further reduce the impact of tourists on the marine environment: the goose laying the golden eggs. The USVI Government has important decisions to make whether to expand tourism even further thereby jeopardising the ecology and the economy alike, or pursuing sustainable tourism and establishing policies that can provide sustainable funding for coral reef ecosystem management programs to ensure their long-term viability to support tourism. The USVI government could also play an important role in facilitating regional collaboration on policies, such as cruise ship head taxes) that uniformly address the tourism sector in the Caribbean.

Sustainable financing

A key question in establishing effective management of coral reefs is how to “capture” the estimated benefits in order to finance the cost of management. Numerous countries and parks around the world have implemented sustainable financing projects and programs which provides the empirical basis for recommendations on financing coral reef ecosystem areas. This study provides a clear perspective of who is benefiting most from healthy coral reefs in the USVI. Combined with the insights generated through the household and tourist surveys in the USVI, the study can provide the basis for concrete action such as the revision of CZM permitting fees and penalties, as well as the modification of a tourism head tax.

Further Information

The full research report can downloaded at www.ivm.vu.nl. For further information about the study, contact Pieter van Beukering at IVM (pieter.van.beukering@vu.nl).