EcoEarnings: A Shore Thing

jetBlue THE OCEAN FOUNDATION ATKearney

Executive Summary

Leisure travel to the Caribbean is a key pillar of JetBlue's business model, with many customers flying to the region to enjoy paradise-like beaches and pristine waters. However, the ecosystems that support and provide those crystal-clear, turquoise-tinted seas are at risk. Some have already grossly deteriorated. Large-scale environmental degradation in the Caribbean is a risk to demand for leisure air travel to the area, thus impacting JetBlue.

EcoEarnings: A Shore Thing seeks to quantify both the risk and return to JetBlue from the region's natural attractions. This study seeks to link the importance of clean, intact, and healthy beaches and shorelines to JetBlue's profitability in the Caribbean, with a focus on JetBlue and industry revenue per available seat mile (RASM).

Our study began by observing a positive correlation between ecosystem health and RASM. The goal is to calculate the impact of the underlying drivers of ecosystem health—including water quality, mangrove quality, and waste along the shorelines—on industry RASM.

We find positive correlations among water quality, mangrove health, limited waste on shorelines, and RASM, but more data is required to statistically prove and validate the model. This interim report serves as a call to gather more information about shoreline health and to rally the efforts of policy makers, the tourism industry, and tourists to protect the Caribbean's greatest natural resources—its ecosystems.

Background

It is widely written and known that airlines depend on natural resources, such as jet fuel, to operate and maintain a business. Less explored, and certainly less quantified, is how airlines rely on beautiful, natural, and well-preserved destinations to drive tourism and encourage customers to buy tickets.

The tropical Caribbean vacation experience is important for airlines and hotels, and a critical one for local economies that rely on tourism for economic development. This robust and lucrative segment of travel is generally considered "traditional" tourism with airline customers flying for relaxation, pristine blue waters, and white sandy beaches. Although this travel is not typically considered "ecotourism," the clean and paradise-like nature of the waters and beaches enjoyed by tourists are naturally preserved and protected by a healthy, functioning ecosystem, lush shore-side vegetation, and abundant marine life. However, because most customers do not specifically cite ecosystem health as a reason for purchasing plane tickets, these ecosystems are not valued in airlines' traditional demand models—although most would agree, for example, that Walt Disney World and other attractions built in Central Florida are inherent to flight demand and ticket pricing into Orlando International Airport.

The Caribbean's ecosystems are under pressure from many sources: sewage, sedimentation, pesticides, nutrient runoff from agriculture, inadequate infrastructure, and the growing impact of tourism. As these anthropogenic factors increase and natural systems degrade, the potential rises for damage to the region's quintessential wide white beaches and clear turquoise waters.

Destinations in Latin America and the Caribbean make up one-third of JetBlue's route network. As one of the largest carriers in the Caribbean, JetBlue flies approximately 1.8 million tourists a year to 23 Caribbean destinations and enjoys more than a quarter of the market share at Luis Muñoz Marín International Airport in San Juan, Puerto Rico. A large percentage of JetBlue customers are tourists seeking to enjoy the region's sun, sand, and surf. The existence of these Caribbean ecosystems and shorelines has a direct impact on demand for flights, as can their appearance and cleanliness.

Caribbean tourism is 16% of the region's GDP[1] and is the main driver of economic development. Because this tourism is primarily associated with the beach and shorelines, it has both direct and indirect impacts on coastal ecosystems. Tourist activities like boating, snorkeling, fishing, and diving exist only because of coral reefs and mangroves. The same activities can also cause physical damage to reefs and mangroves and can negatively impact water quality. Development, construction, and operation of tourism infrastructure along the coast can indirectly impact these ecosystems. Tourism brings 22 million visitors a year to the Caribbean, including from cruise ships and multiple destinations that JetBlue does not serve. Regardless of how they travel to the region, these millions of tourists create revenue, jobs, and improved GDP, but tourist consumption contributes to the more than 100 million tons of trash per year that end up unprocessed in open-air dumps or local waterways in Latin America and the Caribbean.[2]

This land-based trash quickly finds its way into the ocean via wind, rain, storm surges, and poor human stewardship. It washes up on beaches, contaminates fragile ecosystems, and is a health hazard to animals and humans alike. These impacts, coupled with the fact that 89.1% of manmade debris produced in the region finds its way to the Caribbean waters comes from shoreline and recreation activities (such as tourism),[3] make the nexus of travel, tourism, and environmental degradation in the Caribbean a particularly important area of study.

If airlines lose the natural surroundings that draw tourists to the region in the first place, the Caribbean will cease to be an attractive travel destination. A unique and beautiful place would be at risk as well as the economic and social benefits of tourism, which is a vital revenue stream for countries as well as for JetBlue and other travel and tourism businesses.

EcoEarnings: A Shore Thing

For these reasons, JetBlue and The Ocean Foundation announced their partnership at the Clinton Global Initiative meetings in February 2013. The intent is to determine the value of pristine and functioning natural environments and to better understand how to integrate those benefits into the financial models that service industries such as airlines use to calculate their revenue.

JetBlue and The Ocean Foundation sought to determine the economic value of clean beaches by directly tying the importance of nature to RASM, the airline industry's main economic measure. By attaching actual dollar values to unspoiled shorelines, The Ocean Foundation hopes to strengthen JetBlue's interests, along with other businesses and governments, in protecting the destinations and ecosystems upon which travel and tourism depend. In 2014, A.T. Kearney, introduced by the Clinton Global Initiative and motivated by the concept, joined the commitment to help validate the concept with detailed analytics. JetBlue named the project *EcoEarnings: A Shore Thing* after the company's belief that business could be positively tied to shorelines.

The partnership set out to connect economic profit and conservation by developing a new economic model that incorporates the value of "eco-factors." By quantifying the value of conservation in terms of a product offering (as opposed to ecosystem service value), the group hopes to spur a new line of thinking and measurement in the private-public conversation about the value of an ecosystem.

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[1] Willard Phillips, "Regional environmental policy and sustainable tourism development in the Caribbean," *Economic Commission for Latin America and the Caribbean,* October 2012, http://www.cepal.org/en/publications/regional-environmental-policy-and-sustainable-tourism-development-caribbean

[2] "Solid Waste and Marine Litter," *United Nations Environment Programme (UNEP) Caribbean Environment Programme,* accessed December 11, 2014, http://www.cep.unep.org/publications-and-resources/marine-and-coastal-issues-links/solid-waste-and-marine-litter#links

[3] United Nations Environment Programme, *Marine Litter: A Global Challenge*, by Ljubomir Jeftic, Seba Sheavly, and Ellik Adler, (Nairobi: April 2009), p 232.

Ecosystem service valuations are often too abstract, too large, and ironically even show numbers too valuable for decision makers to be able to easily attribute to their businesses. By measuring the value of conservation in RASM, the partners in this study are seeking to make the concept more relevant and translatable to business and governments, thus spurring investment into funds committed to environmental protection, planning, and infrastructure in the Caribbean. This measurement would not necessarily be a model to increase revenue or income for travel and tourism service industry companies such as JetBlue but would help determine whether JetBlue profits more from destinations that have cleaner beaches and a healthier ocean and, if so, by how much.

We first observed a negative correlation between RASM and high trash volume (see figure 1). Simply stated, RASM decreased across JetBlue destinations as trash volume increased. This finding prompted us to attempt to demonstrate causation between the industry's revenue (through JetBlue's RASM data) and intact coastal environments (healthy corals and mangroves, clean beaches, and good water quality) in order to build a compelling case for including eco-factors in industry businesses' and governments' interests. By removing the greatest barrier to corporate engagement with ecosystems—the absence of measured dollar value assigned to an ecosystem, in this case healthy shorelines—a return on investment could be assigned to conservation, and the latter could be viewed as an investment in tourism (i.e. demand) growth as opposed to philanthropy or even strategic corporate responsibility. Measuring the value of a product, service, or investment is a universal business concept that is used in all industries but is often overlooked in the connection between aviation and tourism.

This interim report provides an update on the *EcoEarnings: A Shore Thing* project. By explaining the background and current status of the project, we hope to engage a larger audience of stakeholders and take the project further than the three partners could alone.

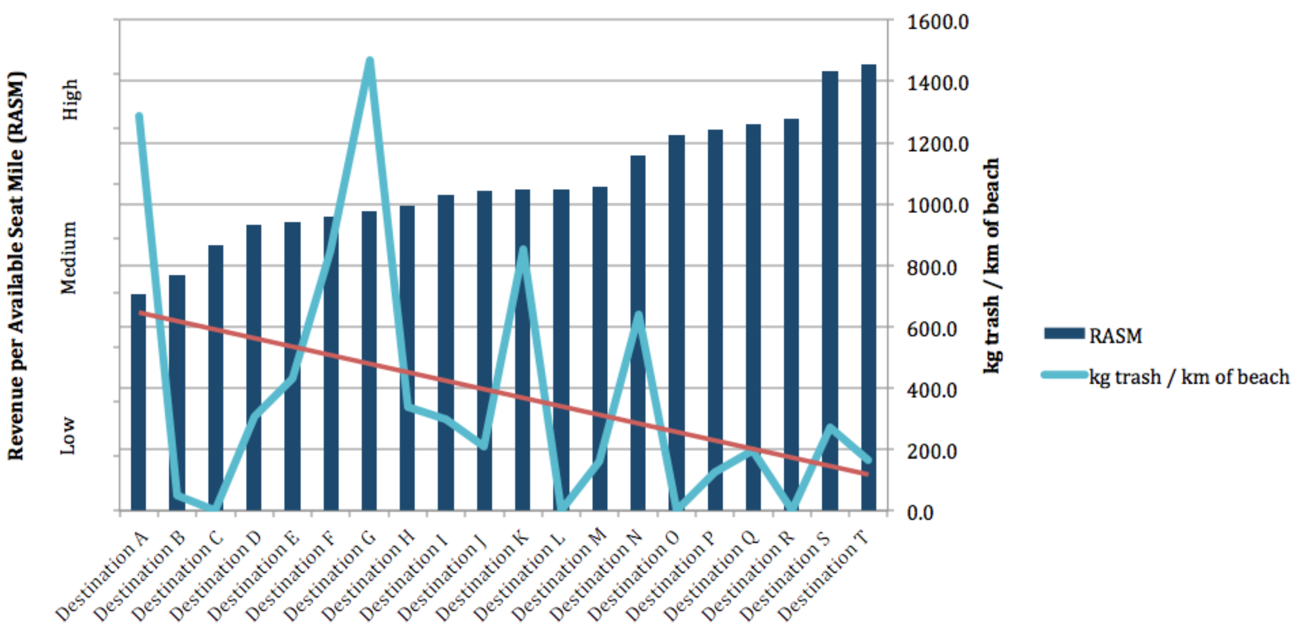

Figure 1. A sample of the correlations we tested. This correlation shows 2012 trash and RASM levels for JetBlue flights to the Caribbean. Each RASM bar represents a specific beach destination in the Caribbean. Marine debris is measured in kilograms per kilometer of beach. (Note: International Coastal Cleanup trash data was not available for Ponce, Puerto Rico; Bermuda; Aruba; and Turks and Caicos.) Specific destinations and RASM numbers were omitted to protect proprietary information.

Project Hypothesis

JetBlue and The Ocean Foundation's theory was that there is a direct causal relationship between low RASM and polluted beaches and water and, conversely, high RASM and cleaner, more desirable beaches. By analyzing the data, we believed we could make the case that JetBlue can command a higher RASM to destinations with clean beaches supported by healthy ecosystems. Higher revenue and demand can increase the profits of companies related to the Caribbean tourism industry, which thereby increases tax revenue to the governments of these islands and shore-side locations. This income stream from taxes is crucial, as small islands often depend on tourism as the main economic driver, not just in the form of jobs but also from tax revenue. Our hope is that this work would promote the understanding that without financial investments in the preservation and conservation of the natural resources upon which tourism depends, degradation will increase, tourism will decline, and tax revenues will diminish.

Data and Analysis

RASM and Industry Research

Airlines use RASM to measure their own unit revenue performance and to compare with other airlines. RASM is calculated by dividing operating revenue by available seat miles (ASM) and is often expressed in cents per ASM. Stage-length adjusted RASM standardizes RASM by assuming a fixed stage length. Because stage length is an input into the ASM formula, the RASM of markets with different stage lengths are not directly comparable without this adjustment. On a stage-length adjusted basis, higher RASM represents relative unit revenue strength.

RASM data is considered to be highly proprietary and competitive information. JetBlue's willingness to share its RASM information with a limited number of parties for the sake of analysis signifies the company's commitment to this project. JetBlue made all relevant data available to the project, with a focus on our Caribbean routes. Every leg of a route originating and ending in the Caribbean was available for the analysis. Publicly available industry RASM information for the same routes was also used.

Ecological and Ecosystem Research

A wealth of data exists about the health of Caribbean ecosystems. Much of it could be used to bolster the connection between corporate revenue and the region's natural beauty. Through collaborative discussions with all stakeholders, The Ocean Foundation focused on four main eco-factors at each of the 29 destinations chosen by JetBlue: beach cleanliness, coral reef health, mangrove health, and aggregate water quality (chemicals, pathogens, and eutrophication). These eco-factors represent important aspects of both coastal health and beach desirability, and the decision to use them was meant to represent a list of categories commonly used when assessing coastal waters.

Original eco-factor data was collected from a variety of sources, including Ocean Conservancy's International Coastal Cleanup data, World Resources Institute's Reefs at Risk program, as well as other United Nations Environment Programme (UNEP) and Caribbean sources. Most of the data came from the Ocean Health Index (OHI),[4] a collaborative effort made possible through contributions from more than 65 scientists and ocean experts and partnerships between organizations including the National Center for Ecological Analysis and Synthesis, Sea Around Us, Conservation International, National Geographic, and the New England Aquarium. OHI, one of the most comprehensive global accumulations of ocean data, provides an annual assessment of ocean health using information from more than 100 scientific databases. This dataset was used primarily for its wide scope in location, the comprehensiveness in the type of data reported, and the comparability of data as all raw data was converted into an index score. All factors, with the exception of beach cleanliness, had both status (a

[4] Halpern, Benjamin S., et al. "An Index to Assess the Health and Benefits of the Global Ocean." *Nature* 488.7413 (2012): 615-20.

current snapshot) and trend (the predicted future direction) data used in the analysis (see Figure 5 in Appendix).

Beach cleanliness was measured in the volume of trash collected per kilometer of public beach cleaned. Marine debris numbers were gathered from Ocean Conservancy's 2011 International Coastal Cleanup data. Even though this data represents trash collected on one day, it is a good snapshot of what is happening at that destination.

Statistical and Economic Analysis
In 2014, A.T. Kearney, a global management and consulting firm, joined the commitment, adding a new perspective and approach to validating the concept with detailed analytics. The tripartite commitment was now complete: industry perspectives and proprietary data (JetBlue), ocean conservation guidance and research (The Ocean Foundation), and framing and validating the concept with robust analytics from a management consulting firm (A.T. Kearney).

To begin, A.T. Kearney was asked to test the hypothesis and determine the value of a pristine marine ecosystem to JetBlue's business in the Caribbean. The objective was to identify and confirm key variables that drive and predict the value of ocean conservation on JetBlue's business in the region.

A.T. Kearney started by looking beyond the original analysis, which found a negative correlation between beach trash levels and RASM. The purpose was to have a more holistic examination of the factors that can affect RASM beyond eco-factors. To do this, the analysis was expanded to include three categories that effect Caribbean tourism:

(a) Eco-factors (as explained above)
- coral reef health
- mangrove health
- beach trash
- water quality (chemicals, pathogens, eutrophication)

(b) Local supporting factors that could impact tourists' decisions to visit the Caribbean
- number of beaches
- number of attractions
- crime rate
- currency strength against the U.S. dollar
- degree of industrialization
- GDP contribution from tourism

(c) Limiting factors that impact the number of tourists that a destination can support
- number of available hotel rooms
- availability of ports
- airport capacity

The intent of expanding the subset of variables to test for relationship against RASM was to ensure that the study did not draw any false conclusions by looking myopically at eco-factors alone.

The study collected detailed data on each variable in these three categories. The study ensured that the data collected for each variable was consistent in definition and methodology and available for all Caribbean destinations in the study, which was important to ensure quality and consistency of input for the analysis.

For example, a comparison of tourism's contribution to GDP[4] shows that St. Maarten generates the greatest share of GDP from tourism of any country in the Caribbean (see figure 2).

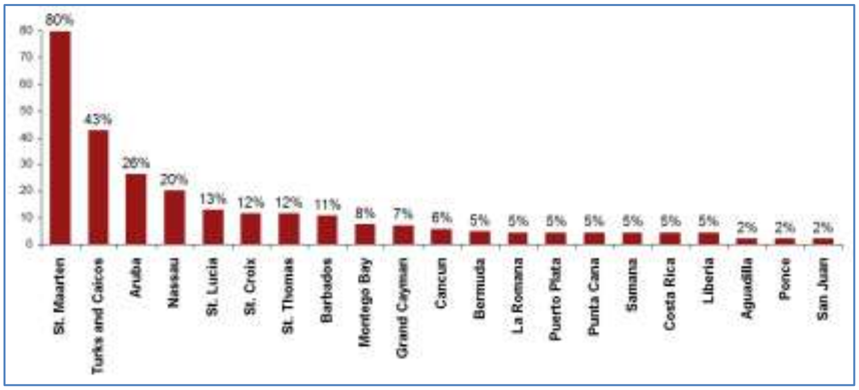

Figure 2. Baseline Data: GDP Contribution from Tourism By Country (%)

Similarly, a baseline analysis of limiting factors such as the number of hotel rooms in the region shows there is a wide range in the variables that could have a direct impact on the number of tourists a destination can support from a supply perspective (see figure 3).

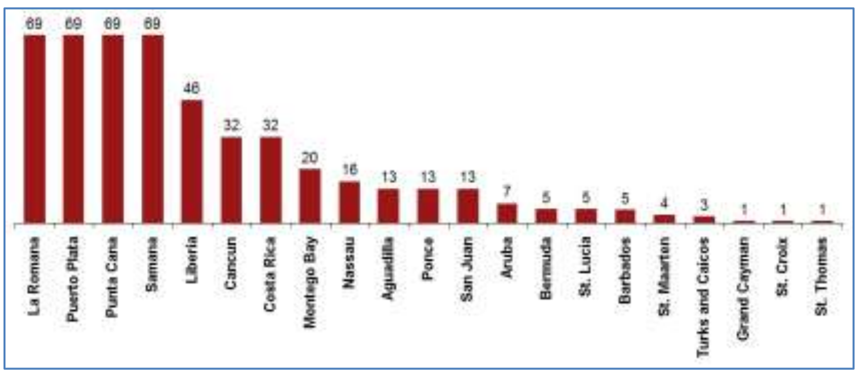

Figure 3. Baseline Data: Number of Available Hotel Rooms by Destination Location (10^3 number of hotel rooms)

The second step of the analysis was to test the relationship of each variable across the three categories of factors against RASM. To do this, A.T. Kearney was asked to conduct a bivariate analysis to establish the relationship between the variables and economic value as represented by JetBlue’s stage-adjusted RASM.

When conducting a bivariate analysis to compare each eco-factor to stage-adjusted RASM—with 1.0 meaning a perfect causal relationship between that factor and RASM—A.T. Kearney confirmed a correlation between these eco-factors and RASM, although not causation. Mangrove health had the highest correlation with RASM of 0.3. Beach trash was second at 0.21, and water quality was third at 0.17. Among the factors affecting water quality, chemicals status was the most important factor (see figure 4).

	Aggregate Water Quality	Trash On Beach	Mangrove Health	Coral Reef Health	Stage Adjusted RASM
Stage Adjusted RASM	+	+	+	+	1.0
Coral Reef Health	+	+	-	1.0	
Mangrove Health	-	+	1.0		
Trash on Beach	-	1.0			
Aggregate Water Quality	1.0				

Figure 4: Bivariate Analysis Results for Eco-Factors against Stage-Adjusted RASM

Based on the bivariate analysis, the study then focused on these three eco-factors for further analysis in developing the economic model for RASM incorporating eco-factors.

The next step was to conduct factor analysis to reduce statistically relevant variables and validate against the economic model. To do this, JetBlue, The Ocean Foundation, and A.T. Kearney looked at two elements: any outliers related to RASM data and the statistical robustness of the eco-factor data.

On the first point, A.T. Kearney identified select markets that experienced significant upward and downward shifts in both JetBlue and industrywide RASM in recent years because of structural changes in market dynamics (for example, a significant increase in the number of carriers or flights) and excluded them from the analysis.

Secondly, we attempted to develop a more robust database of the eco-factor data. However, we were limited by the lack of consistent and comparable historical data. Although the OHI played a key role in enabling consistent comparable information for this study, the index has only recently been developed, and historical information is not available. As such, the study was somewhat limited to the quality and availability of eco-factor information as provided by OHI.

Results

Before discussing results, it is important to emphasize that all parties acknowledged that this project was taking a risk. The point of this analysis was to assign a hard dollar value to what were previously merely assumptions and to base subsequent reactions and conclusions on the facts of the analysis, not on our expectations.

At this point, the eco-factor data is not consistent enough to prove a statistically significant relationship between RASM and eco-factors. However, the correlation of the two is evident. Our calculation found that RASM is equal to 1.65 + 1* mangrove health + 9.55 * trash on beach + 8.9 * chemicals status. In this equation, RASM is the dependent variable that is influenced by the independent variables (in this case, mangrove health, beach trash, and chemicals status). The regression coefficients related to each independent variable denote the magnitude of impact or the relationship between that independent variable and RASM, the dependent variable. Of the three eco-factors examined in the model, beach trash has the highest regression coefficient and most direct impact on RASM. In a way, this is good news because of the three eco-factors, beach trash is the most immediately addressable. On the other hand, restoring mangrove health requires much more coordinated effort among the relevant stakeholders, with results that could be years away.

The R2 value of any multiple regression is an indicator of how much the Y variable (in this case, stage-adjusted RASM) is accounted for by the multiple regression model. In the multiple regression of the eco-factors against RASM, the R2 value was 0.17. This value is not a very strong indication of predictability correlation. To have a more robust regression, more statistically robust historical eco-factor data is required to test the correlation against RASM.

From the beginning, we were prepared for the fact that our hypothesis could either be supported or not. If our hypothesis was supported, we hoped a financial calculation would determine the real dollar value to the revenue stream from clean beaches. As may be expected with a project that charts relatively new territories, we ended up in a decidedly gray area somewhere between supported and not supported. There was a clear correlation between environmental health and RASM but insufficient data to do an adequate regression analysis. Therefore, we cannot reach any definitive causation and conclusions.

Conclusions and Next Steps

Had our hypothesis been supported, the results would be used to validate a common industry assumption—that sand, sun, and sea sell—by quantifying the value of shoreline conservation in terms of RASM and moving the conservation conversation from jargon to dollar signs. This study would then serve to motivate stakeholders to invest in conservation as part of a business strategy. As explained in this interim report, there is an evident correlation between eco-factors, industry factors, and RASM. However, using the data available to the group, the causal link among these factors was not strong enough to justify specific action.

So where can these findings take us?
A major challenge for ocean conservation is the lack of consistent and comparable data to measure and monitor progress. While an abundance of environmental data exists, definitions are too inconsistent and information is often not robust enough to develop business cases and action plans with the environment as a basis.

Gathering consistent and comparable data will be no small feat. Environmental non-government organizations (NGOs) and research entities need to join forces and agree on a standard for measuring and monitoring ocean health. In parallel, governments and industries need to play an active role in funding these measures to ensure that we can continue to value and model the economic impact of conservation.

Next steps include increasing the consistency and robustness of the data. It would be beneficial to contribute to our model by gathering hotel data such as total capacity, occupancy over time, and hotel expenditures on beach cleanups relative to revenue. Collecting a time series of historical eco-factor data would strengthen the analysis.

The OHI is a useful instrument and provided advantages for the first round of analysis because of its consistency and broad geographic range of data. However, its limited scope (only one year of data) and its presentation of the data as only an index limits its overall usefulness. The OHI was expensive to create and will be costly to maintain, and in the current climate, we are unsure whether it will be sustained. For example, one major funder who gave $5 million for the first year will not be renewing support for subsequent years. Thus, we plan to find other sources of raw data that will allow us to compile historical data and rely on the future provision of comparable data.

From Theory to Action

Although not definitive, our results have given root to our original theory. Our analysis has taken us as far as we can with our limited eco-factor and economic data, and our immediate next steps are to repackage and clarify our approach and analyses. Potential for this project remains, but as mentioned, more specific raw data is needed.

Eventually, The Ocean Foundation plans to use the analysis to justify a pilot project in which a host of environmental commitments could be implemented at a chosen destination in the Caribbean. The data would help explain how increased environmental management of specific environmental categories is integral to the tourism business model to produce revenue and thus a return on community and government investment in protecting natural resources.

The airline industry is only one industry that relies on the existence of beautiful places, and it is certainly not the only one that has yet to make incorporating ecosystem services into its core business a standard practice. Going forward, businesses, governments, and NGOs must work together both to quantify the value of environmental protection of the Caribbean's beaches and to take steps to make sure this beautiful and prosperous scenery is preserved. We hope to test and expand this concept and enable it to become a new standard in how companies translate ecosystem value into the language of business. A number of other tourism businesses and conservation organizations are also looking at sustainability issues, and together we plan to take an open-platform approach to this endeavor.

The commercial aviation industry was born by combining science and a passionate belief that the dream of flight was achievable. The industry was built on cutting-edge technology and the latest understanding of wind patterns and natural forces and was fueled by a universal desire to travel to new places, revel in beauty, and expand trade. The concepts embodied in *EcoEarnings* can become mainstream thinking because they share many of the same qualities that created aviation. A belief is just that until it is numerically proven, at which point it can become a new industry.

Sparks, Chad. *St. Thomas Beach*. N.d N.p.

Appendix

The methodology of marine debris data from the OHI is described in the index's supplementary information:

> "The Status of trash pollution was estimated using globally available coastal beach cleanup data from the Ocean Conservancy, which records the weight of trash per year that were collected. We normalized this data per length of coastline to create a tons/km of trash metric.
>
> The Status of this goal (x_{CW}) is then calculated as the geometric mean of the four components, such that:
>
> $$x_{CW} = \sqrt[4]{a * u * l * d}\,, \qquad \text{(Eq. S38)}$$
>
> where *a* = the number of people without access to sanitation (i.e. coastal population density times % without access to enhanced sanitation) rescaled to the global maximum, *u* = 1 – (nutrient input), *l* = 1 – (chemical input), and *d* = 1 – (marine debris input)…
>
> Trends in trash were estimated using trends in coastal population density for the 50 miles closest to shore, based on the significant (albeit weak) relationship between the amount of trash found along beaches and coastal population (log-log correlation; R^2=0.13, p<0.001; n=99). We acknowledge that this approach to calculating the trend does not account for marine debris derived from ships and other ocean-based sources."

The methodology of coral reef health data was described in the OHI's supplementary information:

> "Coral reef extent data are derived from the 500m resolution dataset developed for Reefs at Risk Revisited, and we calculate extent area using a resampled version of our EEZ regions to match their 500m resolution. For coral reefs, we use condition data from percent live coral cover from 12,634 surveys from 1975-2006. When multiple data points are available for the same site and year, we average these data, and also average the site data to calculate a per-country per-year average. However, data were missing for several countries and some countries did not have data for the reference or current year time periods or had only 1-2 surveys. Because coral cover can be highly temporally and spatially dynamic, having only a few surveys that may have been motivated by different reasons (i.e. documenting a pristine or an impacted habitat) can bias results. To calculate C_k we used fitted values from a linear trend of all data per country, which was more robust to data poor situations and allowed us to take advantage of period of intense sampling that did not always include both current and reference years. Then, we create a fitted linear model of all these data points in 1975-2010, provided that 2 or more points are in 1980-1995 and 2 or more points are in 2000- 2010. We defined the 'current' condition (health) as the mean of the predicted values for 2008-2010, and the reference condition as the mean of the predicted values for 1985-1987. Where country data were not available, we used an average from adjacent EEZs weighted by habitat area, or a geo-regional average weighted by habitat area, based on countries within the same ocean basin."

The methodology of mangrove health data was described in the OHI's supplementary information:

> "Data on the extent of mangrove forests came from a global, raster-based, 30m resolution dataset. Most of the Landsat images used in this analysis were from 2000. We calculated mangrove area per oceanic region using our 1km resolution raster model, using the entire EEZ extent …. To calculate condition of the habitat we use FAO data and extract area data for 1980, 1990, 2000, and 2005 on a per country basis, using 2005 as the current condition, and 1980 as the reference condition. For Trend in mangrove habitat we use the rate of change in area over years 1980-2005. In each of the goals, we use the reference condition data from 1980 as the basis for the habitat weights."

Water quality data was measured as an aggregate of chemical, pathogen, and eutrophication (nutrients) data. In all three cases, the status of these components was the inverse of their intensity; meaning high values represented a bad status.

Chemical data, as described by the OHI, was measured as follows:

> "Because of limited data availability for chemical pollution, we measured the chemicals component as the average of land-based organic pollution, land-based inorganic pollution, and ocean-based pollution from commercial shipping and ports. We did not have global data for oil spills and so could not include oil pollution, but in future assessments where such data exist, it would be included in chemical pollution as well."

Pathogens that are human-derived primarily originate from sewage discharge or direct human defecation. The trend of pathogen pollution was directly calculated from data on access to enhanced sanitation and coastal population density, but the OHI used a proxy measure for the status of pathogen pollution:

> "Since we did not have access to a global database of *in situ* measurements of pathogen levels, we used a proxy measure for the Status of pathogen pollution, namely the number of people in coastal areas without access to improved sanitation facilities. The underlying assumption is that locations with a low number of people with access to improved facilities will likely have higher levels of coastal water contamination from human pathogens."

A proxy for eutrophication (nutrients) was also used by the OHI, and was defined as the modeled input of land-based nitrogen input from Halpern et al. The use of proxy data here also presented some limitations, as the OHI described in the index's supplementary information:

> "The modeled proxy approach does not allow the distinction between toxic and non-toxic bloom events that can arise from excess nutrient input (often both referred to in the literature as harmful algal blooms, or HABs) or at what nutrient concentration an ecosystem is pushed into a HAB condition (i.e., the threshold value)."

Data Layer	**Brief Description**	**Start Year**	**End Year**	**Native Resolution**	**Reference**
Coral reefs	Global coral habitat extent and change in condition	1980, 2002	2006, 2009	0.5 km; 1 km; Sites (points)	Burke et al. 2011, Bruno and Selig 2007, Schutte et al. 2010, Halpern et al.

					2008
Mangroves	Global mangrove habitat extent, from remote sensing and assessments	1980, 2000	2000, 2005	1 arcsec; National	Giri et al. 2011, FAO 2007
Nutrient pollution	Modeled N input from fertilizer use	1993	2002	1 km	Halpern et al. 2008, FAO 2004
Chemical pollution: land-based inorganic	Modeled pollution from urban runoff from impervious surfaces	2000	2000	1 km	Halpern et al. 2008, USGS 2000
Chemical pollution: land-based organic	Modeled pollution from pesticides	1992	2001	1 km	Halpern et al. 2008, FAO 2004
Chemical pollution: ocean-based	Modeled pollution from shipping and ports	2002	2005	1 km	Halpern et al. 2008
Pathogen pollution	Coastal population density times % population without access to improved sanitation facilities	1995, 2005	2005, 2008	5 km; National	CIESIN 2005, WHO/UNICEF Joint Monitoring Programme 2008
Trash pollution	Trash collected on beaches (lbs./mi) for 111 countries	2011	2011	National	Ocean Conservancy 2011

Figure 5. Methodological details of each eco-factor from the Ocean Health Index