Organisation of Eastern Caribbean States

Mapping Ocean Wealth in Dominica, Grenada, St. Kitts and Nevis, Saint Lucia, and St. Vincent and the Grenadines

Final Synthesis Report
Caribbean Regional Oceanscape Project
(CROP)

Component 2; Subcomponent 2.1

Expanding Marine Data Aggregation and Analytic Tools

RFP Reference No.: LC-OECS COMMISSION-18987-CS-QCBS
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About This Project

The Global Environment Facility (GEF), the Organisation of Eastern Caribbean States (OECS) Commission, in partnership with the World Bank, is implementing the Caribbean Regional Oceanscape Project (CROP) to improve systems and put relevant structures in place in an effort to foster a Blue Economy and to promote greater consideration of the ecosystem functions and services which the ocean provides for member states. The project timeline was October 2017 - December 2021.

Under this project, The Nature Conservancy used the Mapping Ocean Wealth approach to develop ecosystem service models and maps at the scale of the Eastern Caribbean in support of CROP. The outputs, statistics, and data referenced in this report can be found at: oceanwealth.org/project-areas/caribbean/CROP

CROP Project Overview: https:/oecs.org/en/crop
Map Viewer: maps.oceanwealth.org/oecs

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gef WORLD BANK GROUP The Nature Conservancy MAPPING OCEAN WEALTH

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Executive Summary

The small island nations within the Eastern Caribbean represent some of the most ocean-dependent economies on earth, relying heavily on coastal ecosystems for income, employment, health and well-being. Coastal ecosystems are the basis for much of the region's critical fishing and tourism sectors, while in some places they also play a critical role in defending populations from the tropical storms, which can ravage the region. Due to the significance of the ocean, the region is well-positioned to adopt a Blue Economy approach to evaluating and managing its ocean resources.

With support from the Global Environment Facility (GEF), The Organisation of Eastern Caribbean States (OECS) Commission, in partnership with the World Bank, is implementing the Caribbean Regional Oceanscape Project (CROP). The CROP is designed in alignment with the Eastern Caribbean Regional Ocean Policy (ECROP) and has an overall objective to develop and implement integrated ocean governance policies to leverage sustainable public and private investment in the waters of OECS member states and other participating Caribbean countries. The first component of the CROP project is to strengthen ocean governance through the development of National Ocean Policies (NOPs) and Coastal and Marine Spatial Plans. The second component of the CROP is to strengthen knowledge and capacity building.

Under CROP Subcomponent 2.1, the OECS engaged The Nature Conservancy (TNC) to develop ecosystem service (ES) models for five countries in the Eastern Caribbean (Dominica, Grenada, Saint Lucia, St. Kitts & Nevis, and St. Vincent & the Grenadines) using methodologies developed under TNC's Mapping Ocean Wealth (MOW) initiative, and to develop training and resources to improve data access for decision-makers. Modelling efforts focused on tourism and artisanal fishing, and included maps and models of coral reef related tourism (i.e. SCUBA and snorkeling), nature-dependent beach tourism, recreational fishing, wildlife tourism (birdwatching and whale/dolphin watching), and coral reef fisheries.

This document serves as the final synthesis report to describe project outcomes, provide recommendations for future directions, and to describe potential applications for the outcomes as well as linkages to other CROP subcomponents. This work was conducted between January 2019 and September 2021.

Highlighted high-level regional findings from the modelling efforts are as follows, though results should be interpreted to reflect a pre-Covid-19 time period:

- Across the combined CROP countries, coral reefs are generating an estimated US$118 million annually through snorkeling and diving activities. This can also be expressed in terms of visitor numbers, with 83,000 overnight visitors and 60,000 cruise visitors choosing these islands for their on-reef activities.

- Natural values of the beaches in the CROP countries are estimated to be generating some combined total of US$318 million of tourism expenditure annually with 143,000 overnight visitors and 565,000 cruise visitors who are attracted specifically to the pristine, natural aspects of the region's beaches.

- Recreational fishing is widely dispersed across each of the CROP countries, with both nearshore fishing and widespread offshore fishing in deep waters, particularly in the more southerly countries (Saint Lucia, St. Vincent & the Grenadines, Grenada). There are over 100 charter operators offering recreational sportfishing tours, and the data suggest an annual direct expenditure of over $US 6.4 million.
- Birdwatching activities are most intense in coastal areas with a likely correlation with accom-

modation density, but many observations are still recorded from offshore waters to wetlands and mountain areas. The patterns of species importance underline the particular value of these locations away from tourist accommodations, notably mountainous and forested areas.

- Whale and dolphin watching is particularly important in Dominica and Saint Lucia, with St. Vincent and the Grenadines also having a nascent whale and dolphin watching industry. In all cases, activities extend out predominantly from the western shores, from coastal areas (where dolphins are more likely to be observed) out to deeper waters favoured by whales. There are at least 30 operators offering whale/dolphin watching tours, and this activity is estimated to generate over $US 5.7 million per year in direct expenditures.

- The major drivers of fishing impact on coral reefs were distance to a fish landing site, the estimated number of small-scale fishers in a country, and the size and proximity ('gravity') of the nearest potential fish market. In general, fishing impact was high where biomass of snapper groupers was low, and vice versa.

- Fishing impact is medium to high on all coral reefs in the focal CROP countries, and the only areas of low impact in the region are relatively remote reefs away from human populations.

- Statistical models allowed for the simulation the effects of a no-take fishing closure on snappers and groupers and coral restoration on parrotfishes for every 1 ha reef area in the region. These simulations demonstrated, for example, that marine reserves have the potential to increase the biomass of snappers and groupers by up to 113%. However, reserves need to be well-enforced and established for a long time to have this effect, and such reserves are currently rare in the region. The results highlight considerable potential to increase fish stocks in the focal countries through management and conservation initiatives such as marine reserves.

All model methodologies and outputs are described in detailed technical reports, with associated maps and spatial data available for download. Other outputs from this project include:

- A four-page summary for each CROP country describing country-specific model highlights

- Two mobile-enabled web-based applications allowing users to easily access data, maps, and statistics

- Two stakeholder workshops designed to provide training, obtain model feedback, and improve data access

- A Mapping Ocean Wealth Advisory Board, which included representation from the OECSC

- Infographics and other social media assets

- Executive summaries of each model

- Technical guidance documents for each model

All project outputs, including technical reports, data summaries, country summaries, model summaries and user guides, downloadable datasets, maps, infographics, and data tools can be found at https://oceanwealth.org/project-areas/caribbean/crop/.

This project relied heavily on sustained stakeholder engagement from over 100 different contributors in the region. While travel restrictions under Covid-19 hindered certain planned in-person stakeholder engagement activities, most notably Workshop 2, TNC's Caribbean Division's experi-

ence in the region and strong existing relationships with stakeholders was a driving factor in the project's success.

The ecosystem service data generated through this, and similar projects, can strengthen existing knowledge, but can also create new understanding, filling knowledge and data gaps on human uses that had been less widely considered or mapped. Despite their many benefits, ecosystem services are just starting to be incorporated into marine spatial planning (MSP). While the work described in this project was undertaken in parallel to the drafting of Coastal and Marine Spatial Plans for the region under another component of the CROP project, and as such did not inform the development of these plans, the cyclical and adaptive nature of MSP means that this new information that has been generated can be incorporated into future marine planning cycles, or applied to other management contexts.

The onset of the global Covid-19 pandemic in early 2020 provided the most immediate and obvious challenge to the work by preventing planned in-person engagement for the remainder of the project. Another key impact of Covid-19 is on the future interpretation and applicability of the model data. The models were built to reflect values for the period immediately preceding Covid-19, typically using multi-year summaries up until this date. The pandemic has had a dramatic impact on tourism and will likely have also impacted patterns and effort in fisheries. The longer-term impacts, post-pandemic, are too early to predict.

In some locations around the world, decreases in tourism revenue during Covid-19 have driven increases in coastal fishing pressure as communities turn back to traditional fishing as a source of food and revenue (Stokes et al., 2020, Vyawahare 2020). In other cases, a drop in demand for local seafood from tourism attractions has temporarily decreased pressure (Stokes et al. 2020). At present, there is no data suggesting what the impact will be on coral reef fisheries in CROP countries; however, the pandemic presents an opportunity to evaluate future scenarios and promote active management to ensure long-term stability of these. For tourism, it seems likely that the natural values, so important in CROP countries, will prove a key driver in tourism recovery following the Covid-19 pandemic. Low density tourism in natural areas may be critical and may begin to play a more important role in generating tourism receipts than pre-pandemic. To that end, there is reason to believe that the models will still be relevant in the planning context; however additional contextualization and interpretation may be needed

Setting the Scene

The Blue Economy in the Eastern Caribbean

The small island nations within the Eastern Caribbean (EC) represent some of the most ocean-dependent economies on earth, relying heavily on coastal ecosystems for income, employment, health and well-being. Coastal ecosystems are the basis for much of the region's critical fishing and tourism sectors, while in some places they also play a critical role in defending populations from the tropical storms, which can ravage the EC region.

Due to this high dependence on the ocean, the region is well-positioned to adopt a Blue Economy approach to evaluating and managing its ocean resources. While the term "Blue Economy" has many definitions, the World's Bank definition, the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs, while preserving the health of ocean ecosystems" is one that is frequently invoked when describing the region's vision of the role of ocean resources. Many of the EC region's developing states have embraced the notion of the Caribbean Sea as shared resource and centerpiece of future growth strategies.

Regional Policy and Project Context

Recognizing the need for a more integrated and sustainable and equitable approach for managing across marine sectors, there has been increasing investment in initiatives intended to advance Blue Economy goals. Within the EC region, the Organization of Eastern Caribbean States (OECS) Commission has established an Ocean Governance and Fisheries Program with a mandate to support the articulation of clear policy frameworks for governance of the many economic activities dependent on the Caribbean Sea and to promote greater consideration of the ecosystem functions and services, which the ocean provides for member states. Further, the OECS Heads of Government endorsed the Eastern Caribbean Regional Ocean Policy (ECROP) in 2013. In 2019, the ECROP was revised to align with the UN Agenda 2030 for Sustainable Development – SDG 2030.

With support from the Global Environment Facility (GEF), The Organisation of Eastern Caribbean States (OECS) Commission, in partnership with the World Bank, is implementing the Caribbean Regional Oceanscape Project (CROP). The CROP is designed in alignment with ECROP (2013) and has an overall objective to develop and implement integrated ocean governance policies to leverage sustainable public and private investment in the waters of OECS member states and other participating Caribbean countries.

CROP Subcomponent 1 – Strengthening Ocean Governance

The first component of the CROP project is to strengthen ocean governance through the development of National Ocean Policies (NOPs) and Coastal and Marine Spatial Plans. NOPs have been developed (in Dominica, Grenada, and Saint Lucia) or enhanced (in St. Kitts and Nevis) to align with the ECROP. A gap analysis report was prepared for St. Vincent and the Grenadines to guide strengthening of their NOP. This is currently before the National Ocean Governance Committee for consideration. Saint Lucia's NOP was approved by their Cabinet of Ministers in 2020. The NOP and accompanying Strategic Action Plan (SAP) establish a framework for integrated marine planning within each country's EEZ.

Building on these frameworks, outputs under the CROP have also included the development of coastal master plans and marine spatial plans in each of the participating countries: national MSPs for each of Grenada, Saint Lucia, St. Vincent and the Grenadines, Dominica, and St. Kitts and Nevis, and one regional marine spatial planning framework. These plans offer a framework

for the adoption of multiple-use ocean planning and integrated management approaches within each country's EEZ and across transboundary marine systems. They also offer a vision and roadmap for a transition to a Blue Economy over a 15-year timeframe through sustainable development, sustainable and equitable use of coastal and ocean spaces, and protection of coastal and marine ecosystems.

Countries either will or have established National Ocean Governance Committees (NOGC), which are responsible for moving the NOPs forward and implementing the MSPs. NGOCs include representatives from public sector departments, statutory bodies and NGOs, and serve as an integrated coordinating mechanism to bring together all relevant stakeholders together and align relevant agencies on implementation. At the regional level, these country-scale committees and policies align and link to the ECROP at the regional level, with the OECS as the coordinating body among these entities.

CROP Subcomponent 2 - Strengthening Knowledge and Capacity Building

The work described in this project falls under the second component: Strengthening knowledge and capacity building. Under the CROP, the OECS Commission engaged The Nature Conservancy (TNC) to provide consultancy services during the period January 11, 2019 to October 31, 2021. Under this project, The Nature Conservancy used its Mapping Ocean Wealth approach to develop ecosystem service models at the scale of the OECS region for the five participating CROP countries (Dominica, Grenada, Saint Lucia, St. Kitts and Nevis, and St. Vincent and the Grenadines). The team refined and adapted existing coral reef tourism and fisheries models, while developing novel methodologies to characterize recreational fishing and cultural values in participating Eastern Caribbean countries. These datasets were integrated into innovative tools to help better support decision-making using these novel data products.

These data products can contribute to strengthened capacity in developing and implementing plans to improve overall access to region-specific marine spatial data coverage. Specifically, through the focus on tourism and fishery themed data, the models describe both spatially and quantitatively the social and economic benefits of marine habitats. These areas of focus were selected due to the dependence of the CROP region's economy on these sectors, which, in turn, rely on healthy ocean habitats. This type of knowledge is key to making informed decisions about ocean uses and economic development in support of the Blue Economy in the region. By focusing on tourism and fishery-themed data, the outputs of this project speak specifically to Blue Economy goals by providing spatial footprints of socioeconomic data in the region, pointing to opportunities to expand existing activities or promote sustainability of key sectors. The development of tools and training materials under this project have the objective of enabling practical use and application of ecosystem service values into planning.

Box 1 provides additional details on how the outputs of this project align with specific ECROP goals.

Mapping Ocean Wealth Approach

What is it?

The Nature Conservancy's Mapping Ocean Wealth (MOW) project has achieved world renown as the leading partnership and research enterprise seeking to enhance understanding of the benefits provided by ecosystem services in coastal and marine areas. The MOW project has included global and local studies. Its work grew out of the need to consolidate the many areas of expertise both globally and locally, around key coastal ecosystems. MOW originates from the premise that a sufficient body of available knowledge and information is available to quantify natural values or ecosystem services: the critical task is therefore to gather the skills and the informa-

Box 1. Alignment of Project Outputs with ECROP (2013) Goals

Policy 2: Maintain and improve ecosystem integrity

Goal 2.1. The overall quality of the marine environment is conserved and enhanced through protection, maintenance or restoration of natural and physical features, processes and biological diversity and the ecologically sustainable use of marine resources.

Mapping and identifying areas where coastal and marine habitats provide a specific socio-economic value is a critical underpinning to any attempts to secure their sustainable use. Such maps can be built into the forward planning needed to build blue economies and can also provide critical information for optimising programmes of conservation and restoration.

Policy 3: Promote social and economic development

Goal 3.1 – Sustainable use of marine resources, taking into account social, economic and environmental needs, is promoted and incorporated in national development policies and planning framework to ensure long term social and economic development.

Goal 3.2 - Opportunities from existing, under-utilised resources are optimized while new and emerging opportunities for marine industries and marine-related development are identified and encouraged.

The maps, statistics and data products developed from this work are highly aligned to support the develop of policies and for active planning around natural resources. They enable the direct embedding of environmental data into wider decision-making. They can also inspire visionary approaches for the development or enhancement of tourism and fisheries resources.

Policy 4: Adopt multiple-use ocean planning and integrated management

Goal 4.1 - Clear coordinated institutional mechanisms for integrated regional and national coastal and ocean management are established and implemented across relevant sectors such as fisheries, tourism, transport, energy, health and environment including, where appropriate, partnerships between government, the private sector and civil society.

Multiple-use ocean planning and integrated management require the availability of high resolution, scientifically-grounded data on a variety of human uses. In the past, data on natural resources and on human dependency on these resources has been sparse and of low accuracy. The data presented here on various aspect of nature-dependent tourism and on coastal fisheries change all that. This project provides such datasets through publicly accessible tools intended for use by a wide variety of planners. Such data are intended to inform decision-making and to enable all stakeholders to see how these values relate to the many other opportunities and demands on marine and coastal spaces.

Policy 5: Promote public awareness, participation, and accountability

Goal 5.1 - Public awareness, understanding and appreciation of the importance

of the ocean is raised while the needs and aspirations of communities are accommodated through active public participation in the development of new policies.

Goal 5.2 - All citizens have access to information concerning the marine environment, as well as the opportunity to participate in the decision-making processes. In this regard, the access to justice by citizens for redress and remedy in environmental matters is a cornerstone of enhancing accountability.

Although public understanding of the general importance of nature to lives and livelihoods is relatively high in much of the Eastern Caribbean, detailed information and hard numbers are lacking. Such numbers can be powerful and compelling. The outputs of this project are available to all citizens and can be used to promote awareness of the sustainable use of marine resources. By presenting the findings in multiple formats from simple social media outputs to online mapping tools to technical reports the project team seeks to make the findings available at multiple levels. At the same time, by working in partnership with governments, the non-governmental sector, business and civil society groups the project team hopes that the findings will be spread widely and foster a more detailed and complete understanding of natural values in tourism and fishing.

Policy 6: Support research and capacity building
Goal 6.1 - Our understanding of the marine environment, its natural processes and our cultural marine heritage is increased and our capacity for informed decision making is developed and strengthened.

The work undertaken here is unique, globally. It presents, for the first time, high resolution information about multiple facets of nature-dependent tourism, and, in addition, the first high resolution map of coastal fisheries at this scale for the Caribbean Sea. The outputs of this project demonstrate direct linkages between coastal and marine ecosystem health and social benefits, and the provision of these data increase capacity for improved decision-making in the region.

tion together and to put them to work under one simple, scientifically robust, but user-friendly framework.

To this end MOW has convened experts in coastal protection, fisheries, carbon storage and sequestration, and recreation and tourism. In multiple collaborations around the world, these experts have developed maps and models of values to people created by ecosystems such as mangroves, seagrass beds, coral reefs and more. Much of this work has been published in reports and papers, and is summarized in the Atlas of Ocean Wealth, while an associated web-site provides further information and links. Separately a mapping tool has been developed which enables users to explore the maps and utilize specific apps to generate their own maps and reports to match specific demands.

What are ecosystem services?

Ecosystem services are the benefits natural ecosystems provide to people. This broad definition covers a wide variety of benefits, from the number of fish caught on a reef, to the amount of carbon stored by a seagrass bed. In general, these services are classified into three broad groups:

- Provisioning services are those that provide tangible, harvestable goods—fish, shellfish and seaweed for food, but also mangroves timber, algae, minerals and health products.

- Regulating services are the benefits ecosystems play in regulating our environment—coastal protection, prevention of erosion, water purification and carbon storage.

- Finally, cultural services are the many non-material benefits derived from nature—recreation, beauty, as well as spiritual, intellectual and cultural benefits.

Why is it needed?

MOW aggregates existing research and data, building tools and maps to reveal patterns in the value of ocean environments (for example, cost of degradation, value of healthy coasts/marine areas, scenario visualization, etc). It also makes such information more widely available, notably to non-science audiences at the local, national, and international levels.

As OECS countries move towards more holistic marine spatial planning, spatially-explicit data on ecosystem services becomes essential. Unfortunately, the small size of these nations means that they are often poorly reported in global studies, while the costs of generating similar data at local scales can be prohibitive. The World Bank and OECS have recently drawn attention to this work and the benefits of using spatial data on ecosystem services in marine spatial planning in the report, Toward a Blue Economy: A Promise of Sustainable Growth in the Caribbean.

Even with this vision in mind, the direct connections between these ecosystems and the personal direct benefits they generate can be difficult to quantify. Without such information, there is a constant, ongoing risk that ecosystems will be mismanaged, and opportunities to enrich society through restoration or enhancement of ecosystem functions may be lost.

The work described in this report is intended to help bridge this gap by:

- Delivering novel maps and statistics of ocean assets, focusing on tourism and fisheries, with sufficient resolution and accuracy to support marine spatial planning and other ocean management activities.

- Developing and enhancing tools to enable easy access to both visualize and interrogate data and information, at the scale of the Eastern Caribbean.

- Providing training to familiarize regional partners with data and tools to ensure uptake of information by the government and other regional practitioners.

- Incorporating stakeholder input and feedback into data and tool development to ensure accuracy, relevance, and shared benefits of CROP and its associated data products to the region.

- Leaving a baseline of critical information that can be revisited, revised and enhance in the future as a means to inform future management and to track change or progress of past management efforts

The MOW ecosystem service models are unique in many respects. Each of the models of ecosystem service has been built up and tested by leading experts and institutions, ensuring that they contain the very best recent science. The same models have been used to generate high-resolution maps, many of which are now available for use in local scale applications. The MOW team is thus already well placed to apply global science to better evaluate ecosystem service in the OECS and to generate the information that can ensure wise planning to maintain or even enhance these benefits. This work will support the OECS countries – including governments, pri-

vate enterprise and civil society – in ongoing and future marine spatial planning efforts through the direct provision of spatially explicit information on their ecosystem service values, particularly relating to fisheries and nature-dependent tourism. This will include existing information, new information generated locally, and the provision of both tools and training to enable practical use and application of ecosystem services values into planning.

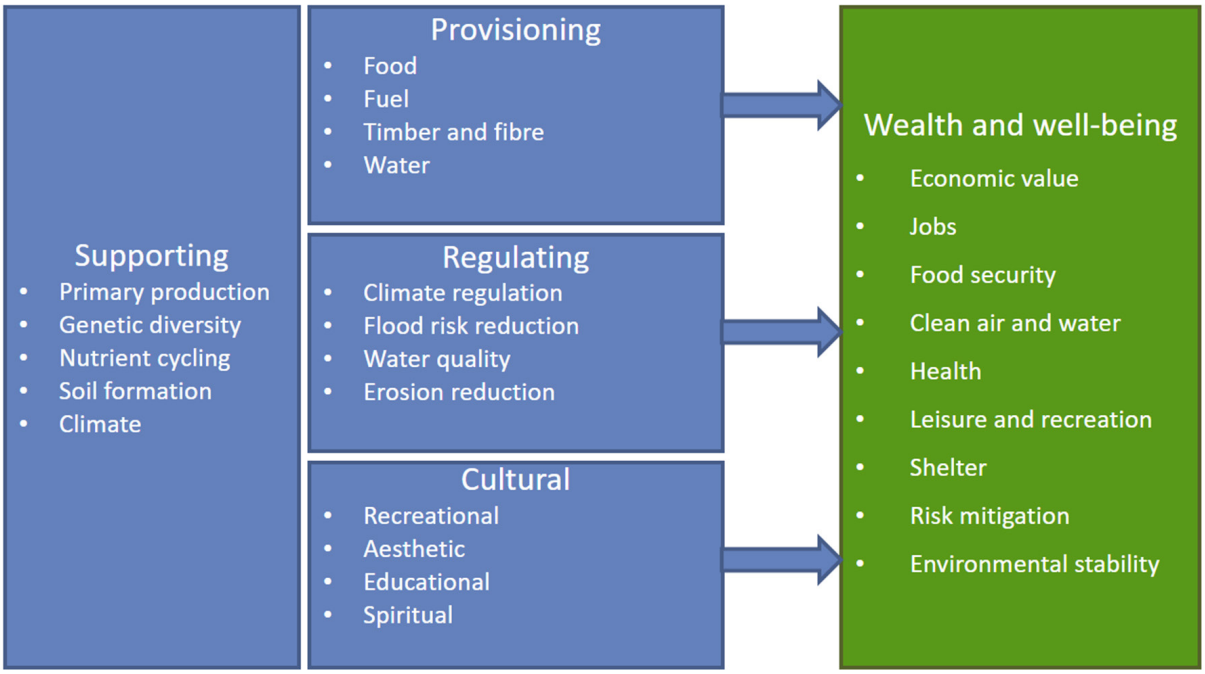


Figure 1. A conceptual framework for the linkages between ecosystems and their benefits to human wellbeing.

Overview of Outputs and Key Findings

This project focused on two categories of ecosystem services: tourism and artisanal fishing. The Caribbean is more dependent on the travel and tourism sector than any other region worldwide, and the CROP countries are among the most dependent in the Caribbean, with tourism contributing to between 32% and 68% of GDP pre-pandemic (WTTC 2019). This sector is almost entirely focused on coastal areas, notably through beach-based activities, cruise tourism, and in-water activities, including sailing and diving. Coral reefs in particular encircle most islands and make a critical contribution to the region's overall ecosystem service values, especially for tourism and fishing. Many people in the region rely on coral reef fisheries for food and income, and reef fisheries also play a role in the region's cultural identity.

Models

Coral Reef Recreation and Tourism

In 2017, The Mapping Ocean Wealth team, including partners at The World Resources Institute, the Natural Capital Project, and the University of Cambridge, published an award-winning study describing worldwide patterns of coral reef tourism (Spalding et al. 2017). This work took a unique and highly innovative approach that involved aggregating multiple large datasets, which were then used in combination with expert input and published literature to build up value estimates for coral reef related visitation and expenditure.

The results from this initial work showed that coral reefs generate $36 billion dollars of tourism spending annually, and drive almost 70 million visits per year, worldwide. Closer examination revealed the particularly heavy dependence of many developing economies, including Small Island Developing States (SIDS) on coral reefs. Some of these countries have limited options for economic development; for many, tourism is a lifeline, generating livelihoods, wealth, and foreign exchange. While the resolution of the work was already sufficient to support the management of these fragile ecosystems in some larger countries, for others the need and the opportunity to revisit the approach at finer resolutions was clear.

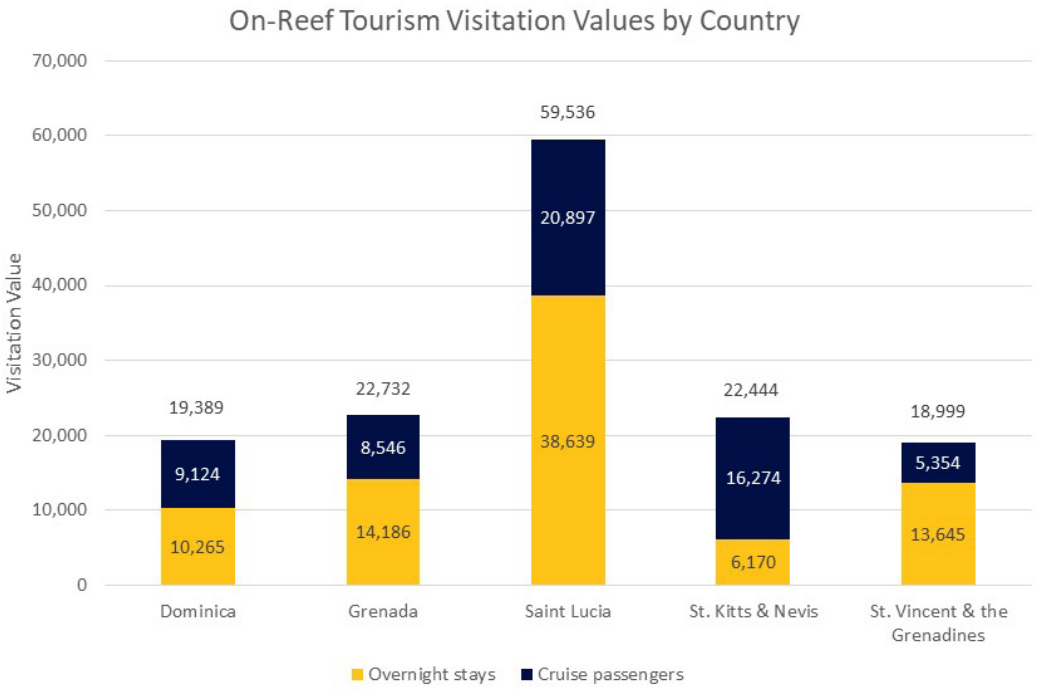

Photo credit: Mark Spalding

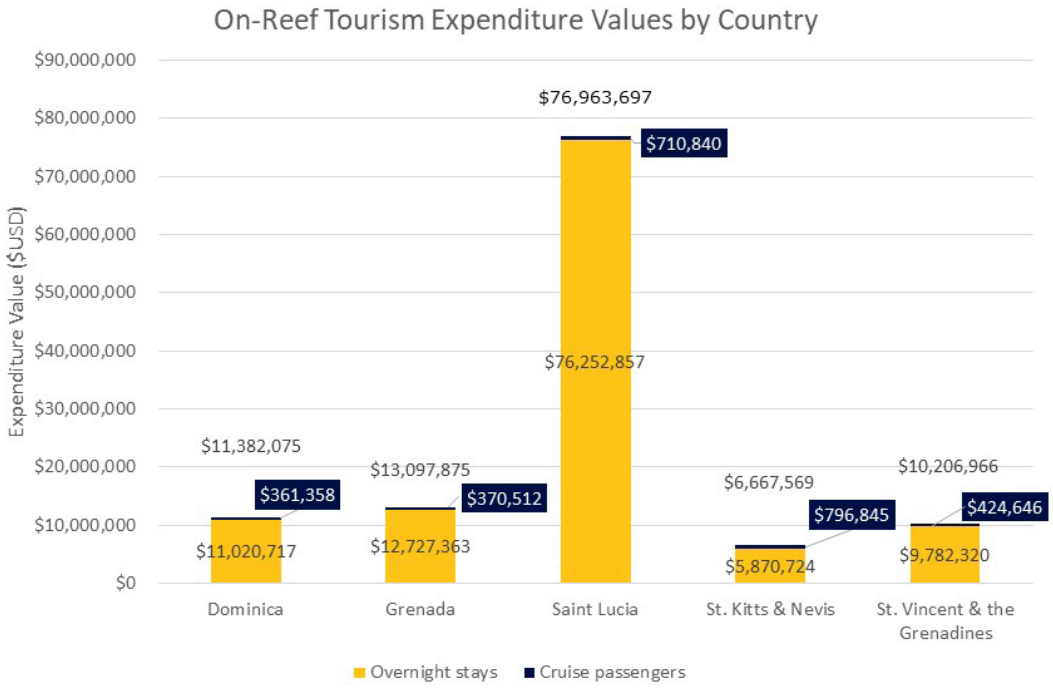
This project built on existing techniques to refine the mapping and valuation of coral reef tourism for the CROP countries, adding significant enhancements. An initial phase of the work built maps of "use intensity", showing the "weight" of diving and snorkeling activities in the region. Coral reef maps were extracted from fine-scale (2m) regional benthic habitat data developed by The Nature Conservancy in the Caribbean (Schill et al. 2021, in prep.). Global datasets on diving locations were bolstered with local sources of information on dive sites, dive shops, and hotels. Additionally, artificial intelligence and machine learning (AI/ML) methodologies were devised to identify user-uploaded photos and reviews from Flickr and TripAdvisor to further highlight patterns of reef-related tourism.

Final values of on-reef activities were determined at the national level, as a propor-

tion of overall tourism arrivals and expenditure. These numbers were informed by a number of pre-existing studies and national level datasets, which pointed towards the relative importance of on-reef activities alongside other activities in those countries.

As with the previous global study, the final values have been assigned to the particular reef locations where on-reef activities take place. Across the combined CROP countries, these reefs are generating an estimated US$118 million annually through snorkeling and diving activities. This can also be expressed in terms of visitor numbers, with 83,000 overnight visitors and 60,000 cruise visitors annually choosing these islands for their on-reef activities.





Figures 2 and 3. On-reef visitation and expenditure values, broken out by cruise arrivals and overnight arrivals.

On-reef activities are widespread, especially near diving centers such as those in southern St. Vincent, southern Grenada, the Tobago Cays, and Monkey Shoals (St. Kitts and Nevis). Most of the reefs with a modelled value are on the leeward (western) sides of the islands where calmer waters provide more favorable environmental conditions for snorkeling and diving. The highest value reefs in Dominica and Saint Lucia are generating expenditure of over one quarter of a million dollars per hectare of reef every year.

These, and similar high value reefs on all of the islands, should be of particular interest for conservation attention. Reefs are fragile ecosystems and can be quickly degraded by uncontrolled use, overfishing, or pollution. Equally, however, reefs can be supported by sound management, and interventions to improve water quality or to reduce overfishing can greatly enhance visitor experiences. The potential of reefs to generate such values can also provide a clear signal of potential value of other reefs and might be used to inform coral reef tourism investment in other areas.

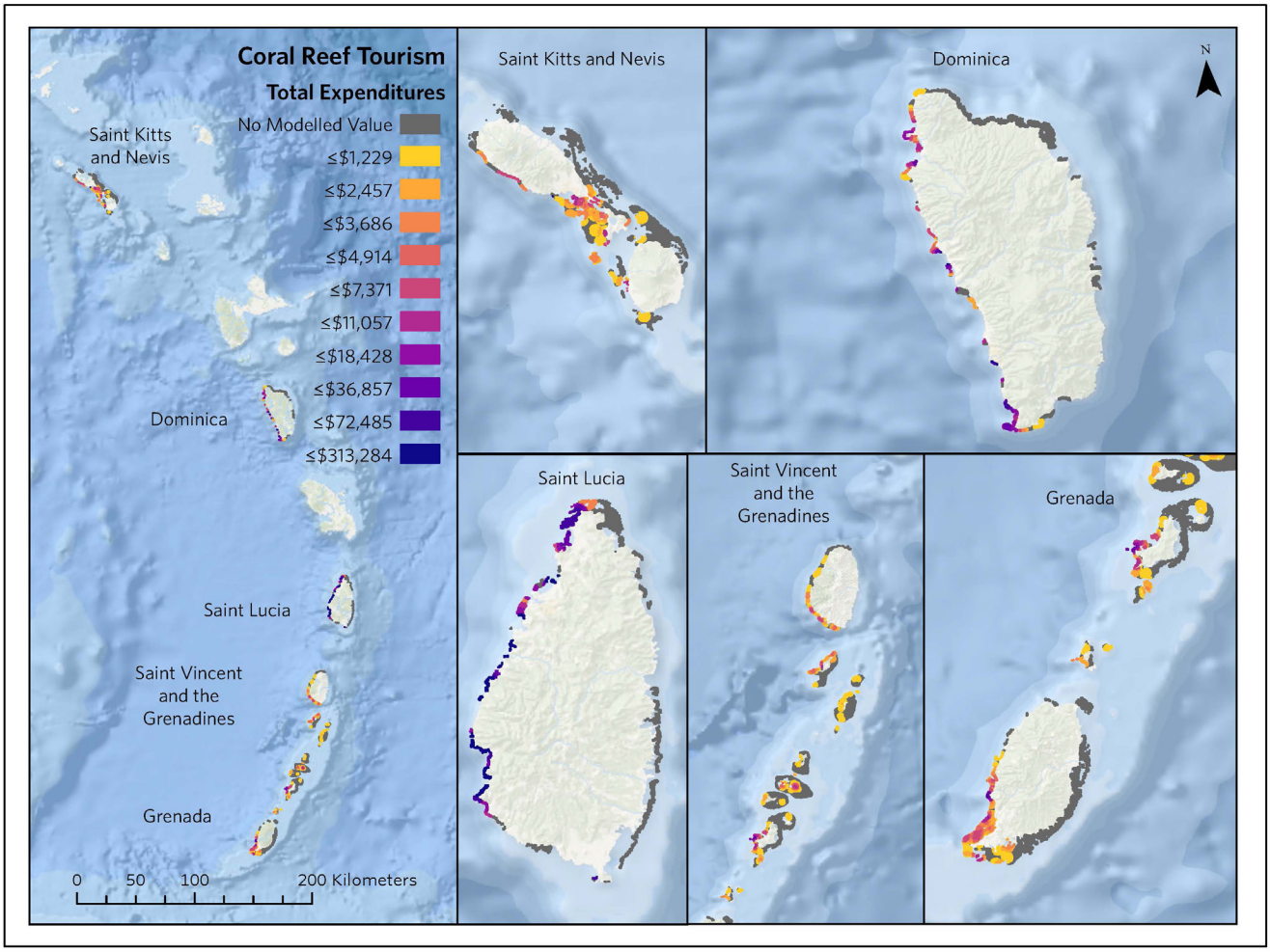


Figure 4. Regional distribution of tourism spending associated with on-reef tourism

Another element of the study was to identify and quantify other aspects of coral reef tourism, specifically the provision of fresh seafood for tourist attractions (restaurants and hotels). Initial efforts to develop image recognition algorithms for seafood were unsuccessful, in part due to a relatively small number of example photos available to train the model. However, the team succeeded in developing a text-based methodology for recognizing fresh seafood restaurant reviews from TripAdvisor and developed a map based on the results. As is typical for the region, most of these restaurants serve a mix of coral reef fish and other local pelagic species and so these maps indicate the dependence on local seafood generally rather than coral reef seafood.

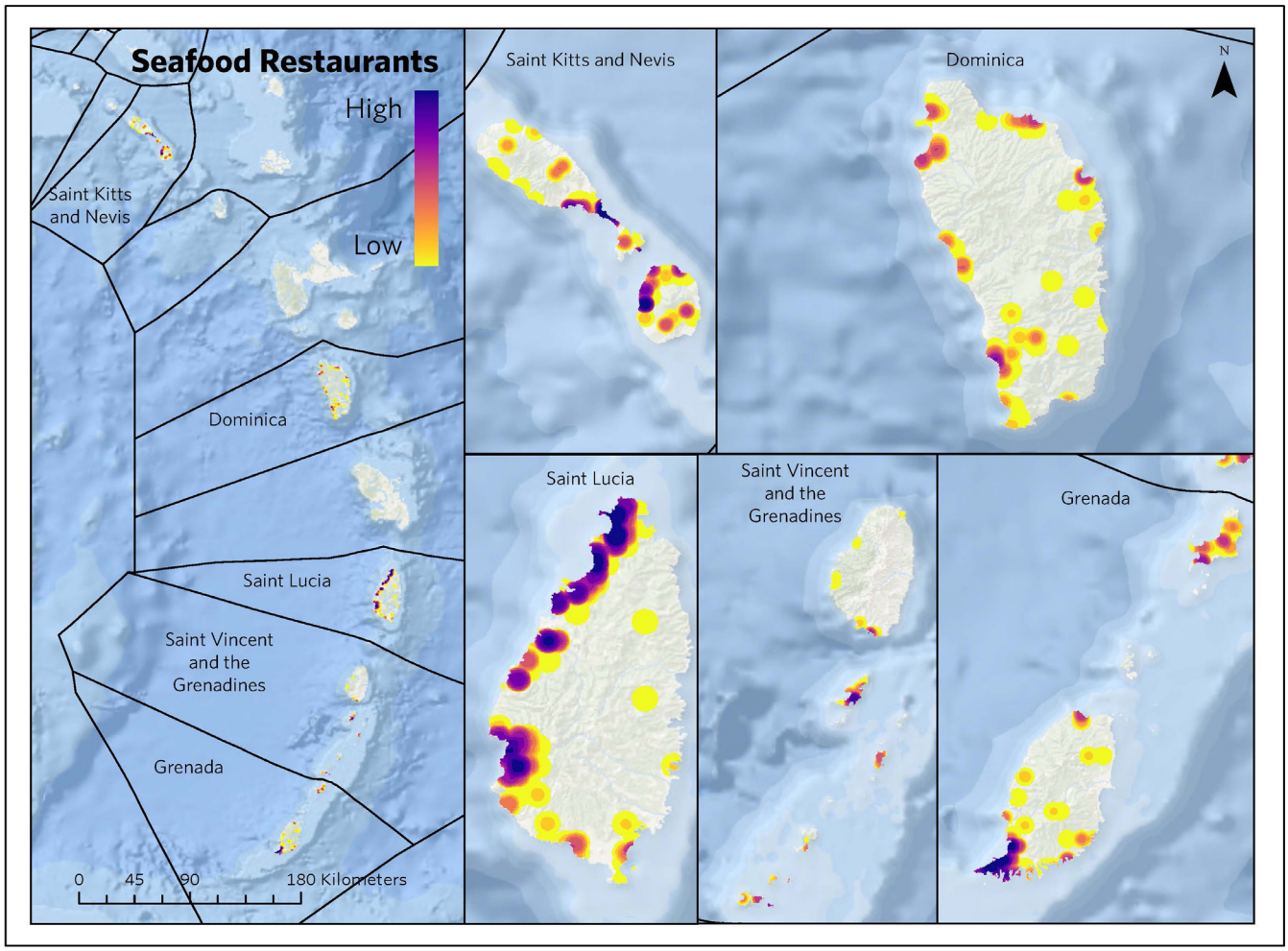


Figure 5. Intensity map of tourist attractions featuring local seafood

User-generated content from very large crowd-sourced datasets such as Flickr and TripAdvisor provide a very powerful resource for understanding relatively fine-scale patterns in tourism. Concerns have been raised about accuracy and bias, and it is clear that any public sourced datasets will contain errors. Data cleaning plays an important role prior to utilization. In reality, however, it is the very high volume of data that makes these datasets so powerful in that it allows for very high accuracy limits for data inclusion at the expense of losing some data points. Any remaining errors are still largely dwarfed by the sheer volume of data. Bias may still be an issue; however, by by drawing data from multiple sources much of this can be avoided. Additionally, the review of all input data, and of the output maps, by experts in the region provides some confidence that bias is minimized.

One particularly powerful element of the current work is the high degree of local engagement, which has enabled significant enhancement of the data coming from international sources, by proofing, corroborating, and correcting the final models and output maps. It is recognized that other platforms, notably social media platforms, would represent another rich source of data; however, such platforms do not allow large-scale data extraction due to user privacy agreements and cannot at present be used for data mining in this way.

Concerted efforts were made to collect both spatially and economically explicit information about diving from all the CROP countries, but the data availability was not always consistent across the region. For example, while some dive shops were able to provide information about numbers of divers and their expenditures at their specific location, this level of detail did not exist for enough locations to use it in the model. In the future, finer scale modeling may leverage the approach presented in this report to incorporate higher precision datasets as appropriate for improved

local estimates.

More details about this model, including the technical report, metadata summary, data download, and other resources, can be found here.

Nature Dependent Beach Tourism

In a previous study (Spalding et al. 2017), a significant indirect value of coral reefs was mapped as "reef-adjacent" benefits – in large part, this referred to the benefits that reefs provide to beaches, including the provision of clear, calm waters, white sand and beautiful views. Such values were linked back to the coral reefs themselves. With this study, it was considered important to develop a clearer description of the natural values of the beaches themselves, including coral reef associated values, but also to draw on a slightly wider range of natural factors. Nature-dependency in beaches thus describes the level of dependence that beach tourism may have on key natural values, including: white sand (coral-derived); natural vegetation adjacent to, or dominating views from the beach; and turquoise/dappled clear water.

These natural values are highly visual and a key starting point was the utilization of emerging AI/ML technologies. Algorithms were trained to identify key components of nature in user-uploaded imagery (most were kindly provided by TripAdvisor, with additional photos downloaded from the Flickr API) giving a detailed quantification of the importance of nature for beaches in different locations. Images were identified if they had beaches with at least some of these key natural components (sand, water and vegetation). Data were further enhanced with information from local sources and by engaging with stakeholders. The resulting "density" of nature-dependent imagery gave a model of nature-dependency of different beaches. These values were then linked to a high-resolution map of beaches derived from remotely sensed data.

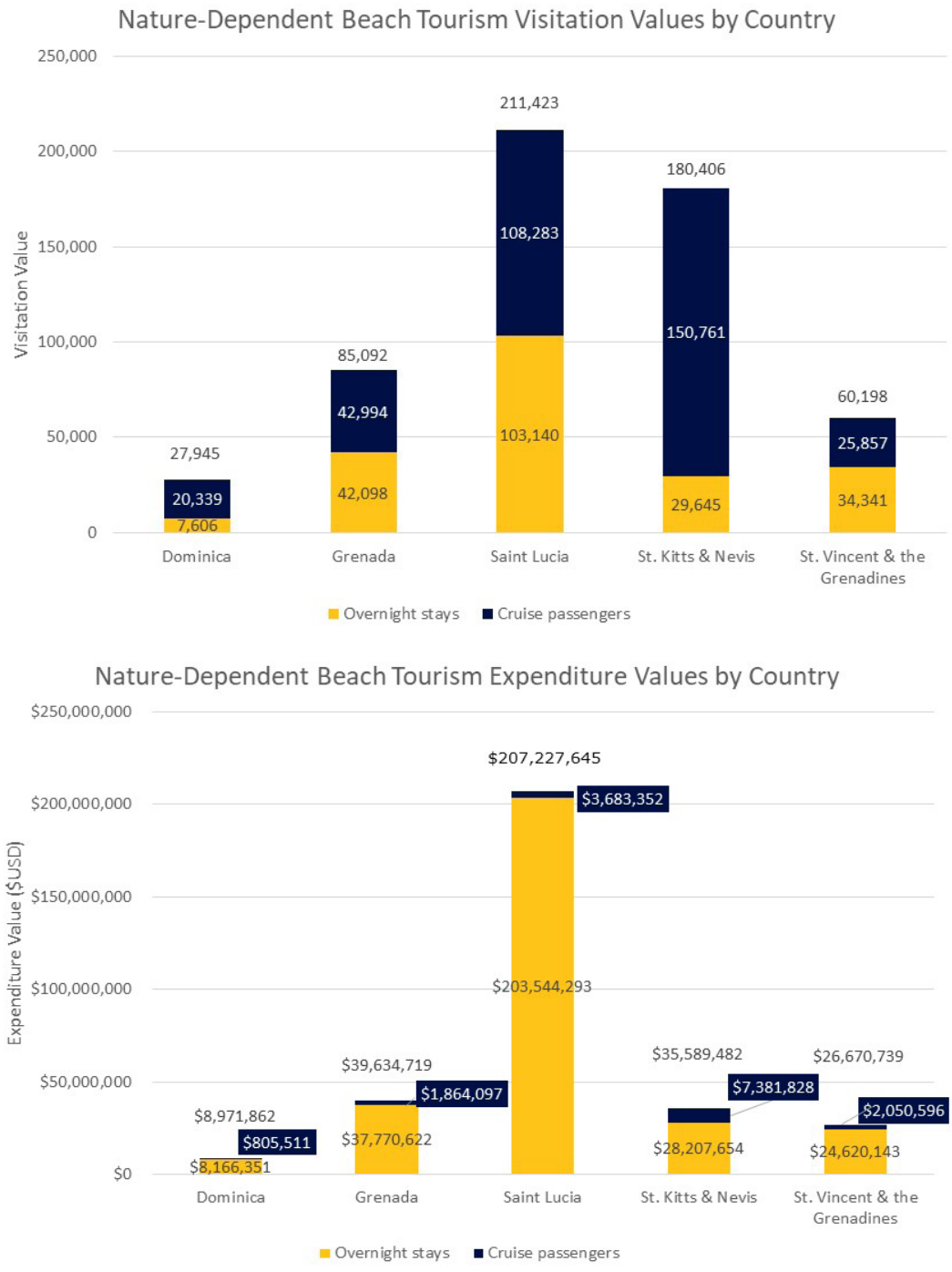
Separately, values for the importance of nature as a component of beach tourism were estimated for each country. This work drew heavily on prior research in the region (notably in collaboration with Peter Schuhmann, University of North Carolina), including exit surveys indicating likelihood of return by departing tourists following likely environmental degradation. Such numbers, modified by local factors enabled estimates of likely loss of tourism arrivals and expenditures which might be incurred by minor levels of environmental decline to beaches. These values at the national level were then spread to the beaches based on the natural value maps described above.

In modifying the approach for valuing reef-adjacent tourism by modelling and evaluating the nature-dependent beach element separately, the results are more helpful for the public, industry and governments to consider and manage natural resources for the benefits of both the industry and nature. In doing this the focus has shifted away from a strictly reef-centric approach to one where natural values are more broadly derived from an array of coast-


Photo credit: Marjo Aho

al and nearshore ecosystems, that are themselves tightly interconnected. The map of natural beach values (expressed as both visitation and expenditure) draws on a range of natural factors including the beach itself alongside adjacent waters, reefs and also the naturalness of adjacent land areas. Any management of these values would require consideration of these adjacent ecosystems on land and in the water.

Natural values of the beaches in the CROP countries are estimated to be generating some US$318 million of tourism expenditure annually with 143,000 overnight visitors and 565,000 cruise visitors who are attracted specifically to the pristine, natural aspects of the region's beaches.



Figures 6 and 7. Nature-dependent beach visitation and expenditure values, broken out by cruise arrivals and overnight arrivals.

The very high natural values of beaches overall is not surprising. There are many beaches where natural values are considered to be critical to the overall beach value, generating many millions of dollars of expenditure annually – these include beaches such as South Peninsula Beach in St. Kitts, Grand Anse in Grenada and several beaches in Saint Lucia such as the very small beaches La Toc, Anse Chastenet and Jalousie. As with coral reefs, the highest values of all occur where the beach itself is small but attracts high use, and beaches on the leeward sides of the islands tend to attract the most tourism activities, likely due to calmer, warmer waters.

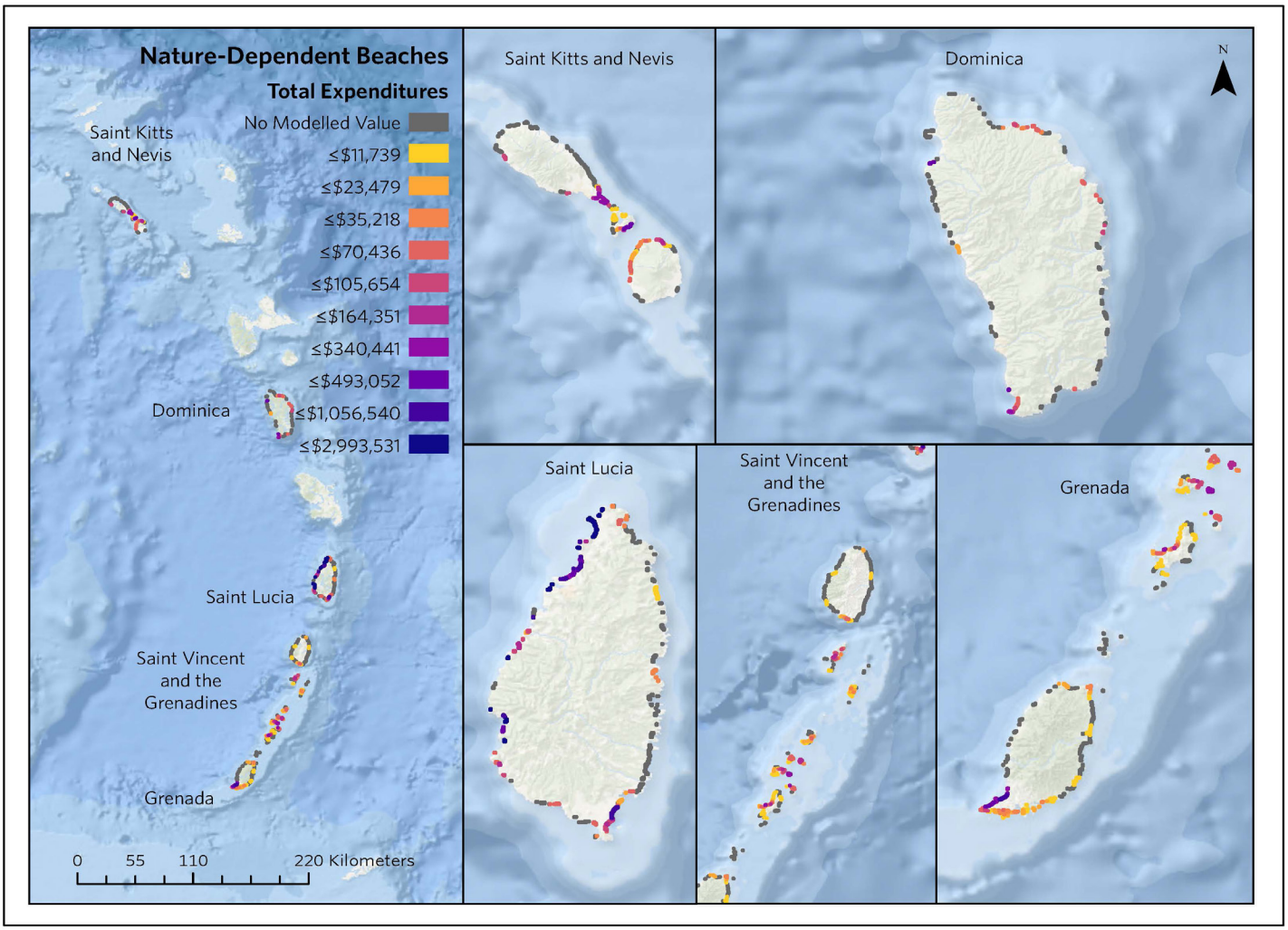


Figure 8. Regional distribution of tourism spending associated with nature-dependent beaches

As with the coral reef recreation and tourism model, the utilization of crowd-sourced data presents a risk of error, which the project team attempted to mitigate through data cleaning, verification with local data, and stakeholder validation. The fact that the definition of a "nature-dependent beach" is somewhat subjective, and the approach of using machine-derived algorithms to identify such nature-dependency prevents the development of a more objective definition. Many beaches that met the criteria of "nature-dependent" for the purposes of AI/ML protocols were also near developed and tourism-heavy areas that to some, might suggest the opposite of a nature-oriented experience. That said, the approach does allow for the recognition of natural values on any beach - the relative importance of nature is defined by the proportion of images uploaded by public users which emphasize that value. Small highly natural beaches may have a far higher proportion of nature-dependent images, however the total images will be low. This is exactly what is needed if overall natural value is to be effectively accounted.

One key assumption in this work is that the loss of natural values would imply a direct and immediate change in tourism arrivals and expenditure. This assumption was informed by research

and exit surveys, which indicate losses that would be incurred from the current "type" of visitors to these countries. In reality, there are many different modalities to tourism across the Caribbean, with some areas appearing to thrive on mass tourism with relatively low natural values. Whether such tourism models could be transferred to the CROP countries is debatable, but what is clear from this work is that the current model of tourism in the CROP countries is indeed highly nature-dependent. These maps are modelling the natural values perceived by the current visitors to these islands. Environmental degradation, it follows, would generate the risk of losing the current "type" of visitor and the benefits they provide to the local economy.

The role of nature and natural ecosystems in supporting coastal sports and activities is of course well understood. Diving and snorkeling are already addressed in the on-reef mapping work, but under the current work, the project team decided to assess the feasibility of quantifying a variety of other sports, including open water swimming, kayaking, stand-up paddleboards, small boat sailing, and kite surfing.

Early exploratory work with image analysis showed that there were simply insufficient data to train AI/ML approaches for most of these, however there was considerable success with the identification of kayaking/canoeing and stand-up paddleboarding. As with the work on beaches, the approach represents a departure from earlier efforts, which focus entirely on reef dependence. These sports may benefit from the proximity of reefs, generating calm and sheltered waters, however they are also popular in natural inlets, mangroves, and seagrass beds and so they are not necessarily reef adjacent or reef dependent, but rather nature-dependent. While healthy natural ecosystems are not a pre-requisite for these activities, it is clear that most users enjoy them because of a proximity to nature.

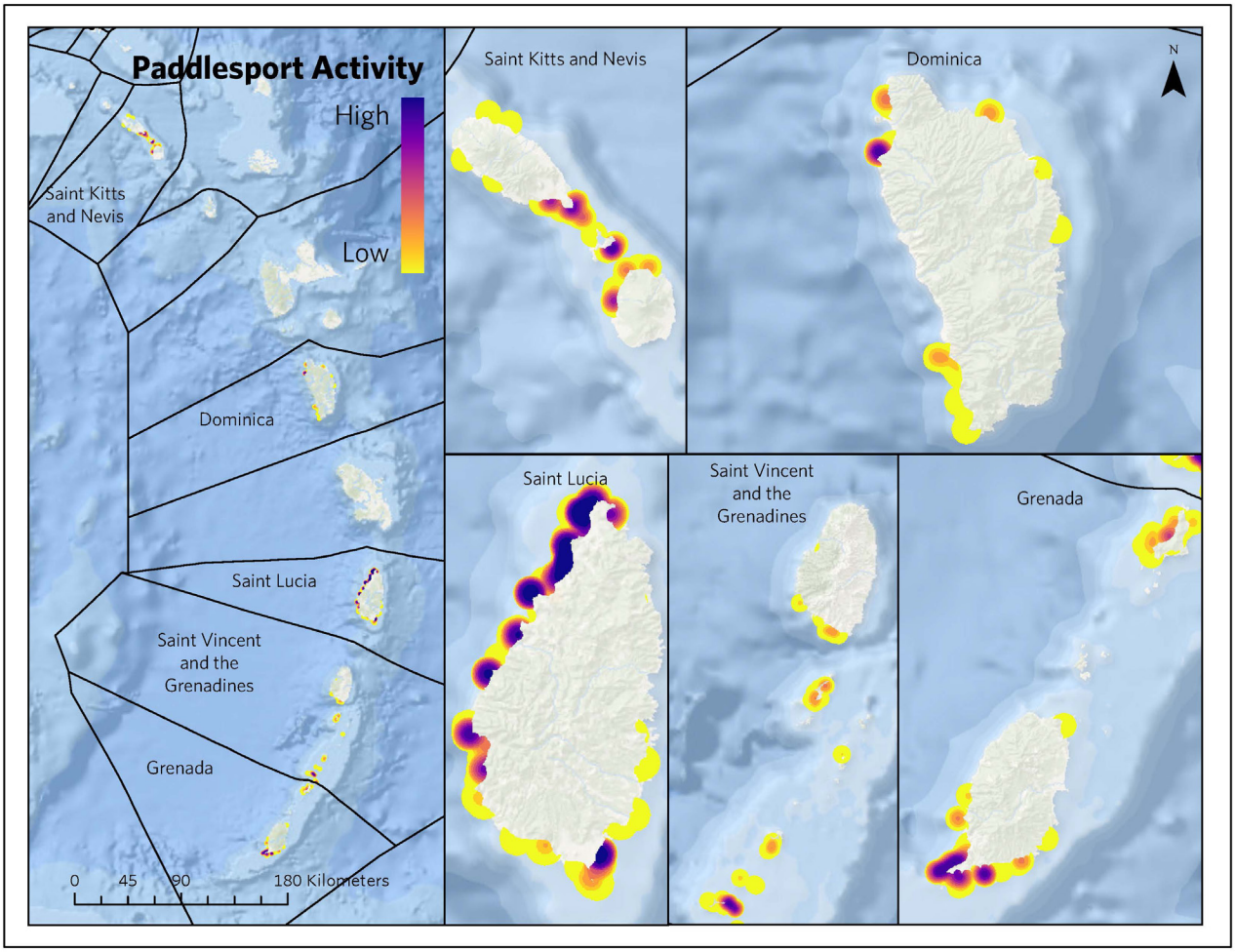


Figure 9. Regional map of intensity of paddlesport activities

More details about this model, including the technical report, metadata summary, data download, and other resources, can be found here.

Recreational Fishing

Recreational fishing is a popular activity for tourists visiting coastal destinations. Generally, recreational fishing is defined as fishing activity where the sale or consumption of the catch itself is not a primary objective. Globally, recreational fisheries are of considerable value. Over ten years ago they were estimated to generate an estimated US$39.7 billion in expenditures annually, supporting at least 954,000 jobs (Cisneros-Montemayor & Sumaila 2010).


Photo Credit: Antonio Scant/UnSplash

Most recreational fishing in the region takes place from private or chartered vessels, rather than from on-shore locations, and is frequently termed deep sea, sport, or game fishing. These vessels typically take tourists to deeper offshore waters where target species are pelagic fish, such as dolphinfish, wahoo, king mackerel, serra Spanish mackerel, yellowfin tuna, sailfish, blue marlin, white marlin and blackfin tuna, with other species, such as a barracuda, caught incidentally (Mohammed 2012). Many sportfishing charter operators diversify their services, offering other vessel-based activities such as diving in addition to fishing charters. Fishing tournaments also play a role in the sector. The Spice Isle Billfish Tournament, operated by the Grenada Yacht Club, is the largest billfish tournament in the southern Caribbean, and in 2012, generated EC$ 2,330,031 in economic activity (Charles & Associates 2012). Saint Lucia also hosts a yearly tournament out of Rodney Bay, and historically the Nevis Sportfishing Tournament has taken place at Oualie Beach (Mohammed 2012); however, it does not appear to have taken place in recent years. Overall, the sector has benefited local economies, and has also contributed to conservation scientific efforts; however, more information is needed to ensure that the sector can continue to operate sustainably (Mohammed 2012).

While there have been several studies documenting the region's socioeconomic trends associated with this sector (e.g., Mohammed 2012, Scott 1994, Gentner & Obregon 2018), map-based data depicting the spatial footprint of this activity are particularly lacking. A purpose of the MOW project was to address the spatial data gap. The model primarily focused on charter vessels catering to tourists, rather than activities by individual fishers, including locally-based recreational fishers, although there is likely considerable spatial overlap of fishing grounds between the two. The resulting map also accounts for fishing activity taking place during major fishing tournaments.

The map was created using a combination of image analysis applied to crowd-sourced data from Flickr and TripAdvisor, complemented by participatory mapping, and survey data from charter vessel operators, locations of fishing aggregation devices (FAD), as well as other stakeholder-provided information and guidance. By applying a series of geospatial processing techniques, informed by stakeholder input, the team has developed a map of recreational fishing intensity for CROP countries, as well as several complementary summary statistics intended to further emphasize the importance of this sector to the region's economy.

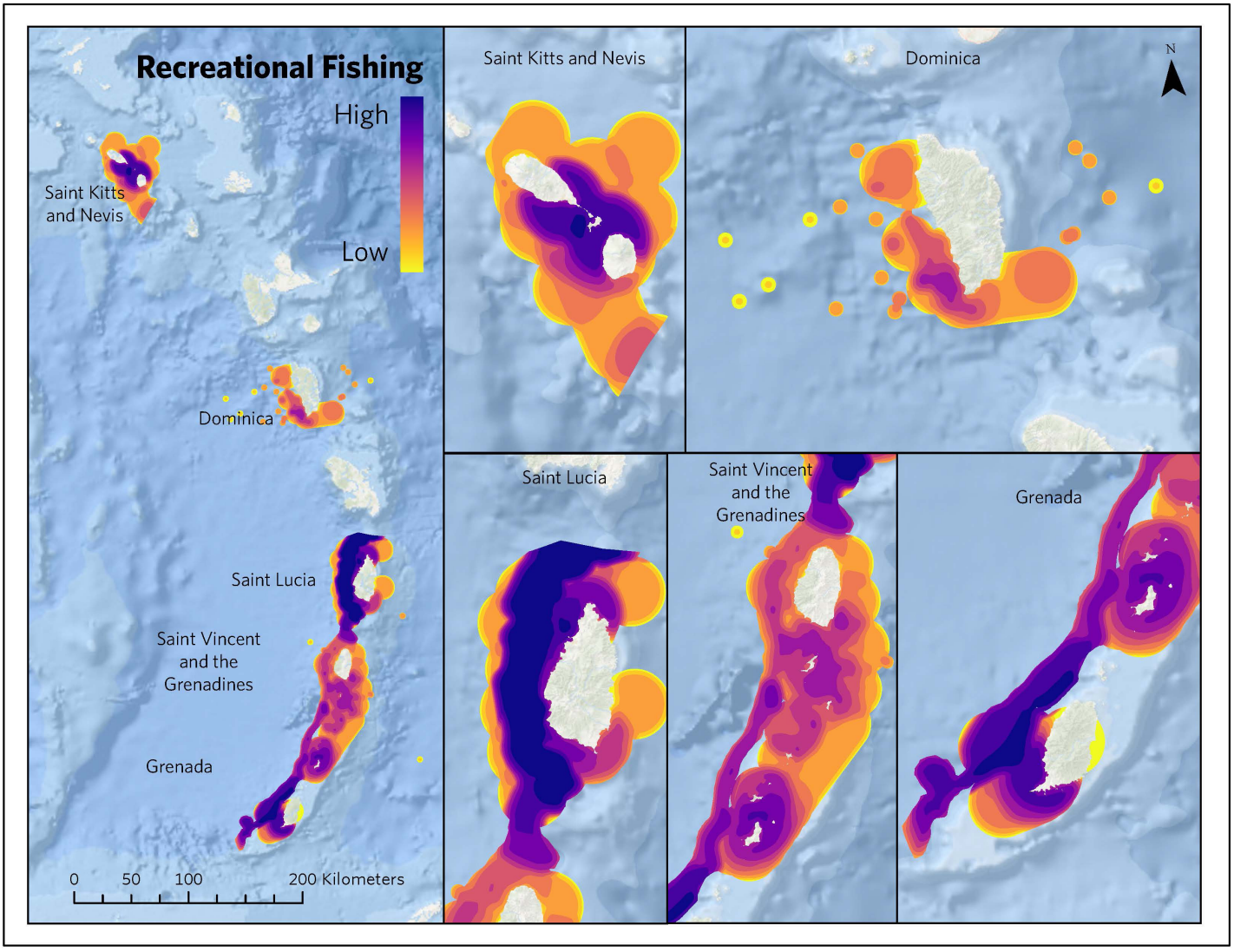


Figure 10. Regional map of modelled recreational fishing intensity

The maps show how widely dispersed recreational fishing is across each of the CROP countries, with both nearshore fishing and widespread offshore fishing in deep waters, particularly in the more southerly countries, where a steep undersea drop-off provides an ideal location for fishing. The more exposed windward shores are the only areas where fishing is often absent.

While the financial assessment is drawn from a relatively small sample size, the results indicate a direct expenditure of over $US 6.8 million per year. On a per country basis, the estimated expenditures can be found in Figure 11.

The maps received positive feedback from a stakeholder survey, supporting the approach of using multiple data sources to triangulate towards an overall map of recreational fishing. Future iterations of this model would be strengthened by an effort to incorporate more data from private fishing vessels, including those operating within the countries, but also those coming from further afield: as an example, the tournament-associated fishery in Grenada is heavily dominated by private vessels and the intensity of fishing from these may not be captured here.

The financial assessment is drawn from a relatively small sample size and could be improved with a more in-depth survey of the sector including, as mentioned, an effort to include private vessels. The results indicate a direct expenditure of over US$6.8 million per year, but these represent only the payments to the operators themselves: the total associated expenditures (trans-

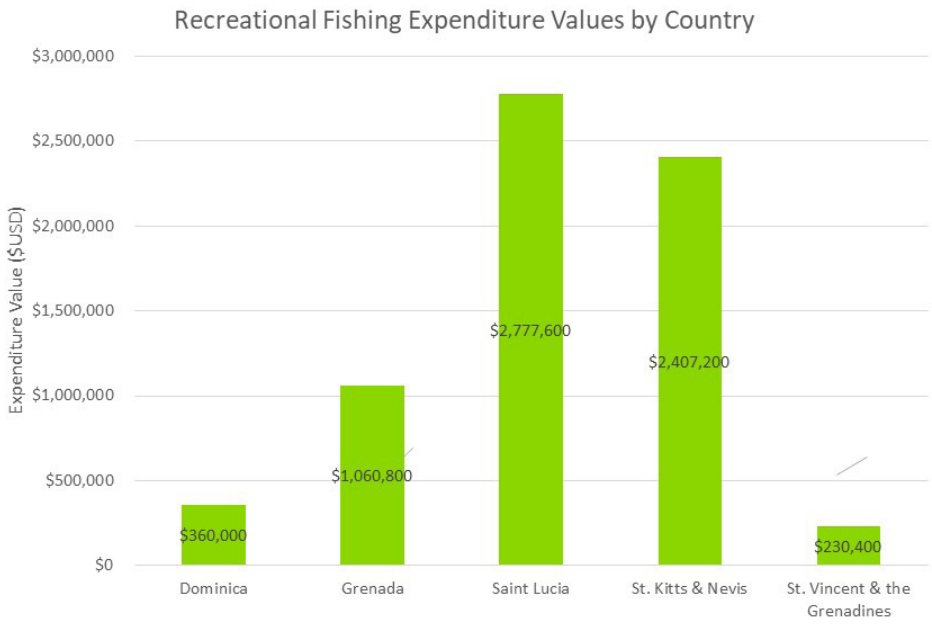


Figure 11. Recreational fishing expenditure values by country

port, hotels, restaurants) will likely be some multiple of this, with some tourists even selecting destinations based on fishing opportunities. Earlier reviews of exit polls and motivation surveys regularly show fishing to be an activity highlighted as a key or prime motivator for between one and six percent of tourist arrivals in the Caribbean and it might be reasonable to conjecture that such visitors might move elsewhere if the quality of fishing was diminished.

Further thought could usefully be given to how to strengthen recreational fisheries as a sector in the region. This is a very high-value activity, and most participants, particularly the more regular fishers are generating high expenditure overall on their visits (Gentner and Obregon, 2018). For example, in the Bahamas, when accounting for expenditures such as restaurants, transportation, and lodging, it is estimated that sportfishing tourists spend $USD 527 million annually. There is good evidence that fishers are willing to pay well and a system of licensing may support the growth of this sector, while other management efforts, such as catch and release or other catch restrictions, combined with appropriate management of commercial fisheries might be considered to enhance recreational fisheries if this was considered a key sector for development.

Given the diffuse nature of this activity, and its lack of a direct link to any physical habitat it was decided that it would not be helpful to try to spread economic value to the fishing areas. Future maps might, however, attempt to show these values at the points of departure/landing.

More details about this model, including the technical report, metadata summary, data download, and other resources, can be found here.

Wildlife Tourism (Other Cultural Values/Nature-Dependent Tourism)

Wildlife tourism ("viewing and experiencing animals in their natural habitat") is estimated to contribute $120 billion and 21.8 million jobs annually to the global economy (WTTC, 2019). The value of wildlife tourism represents an opportunity to secure, diversify and enhance local economies, whilst simultaneously protecting wildlife and preserving key habitats. The Eastern Caribbean's interesting and diverse avifauna provides a unique selling point for certain visitors choosing between various destinations, and the region has a significant opportunity to tap into the growing interest in birdwatching, especially from US-based tourists. The opportunity to see whales and dolphins in the wild is also an important attraction for many of the CROP countries, especially Dominica, where sperm whales inhabit the country's deep offshore canyons. Despite

this, like many aspects of nature-dependent tourism, map-based data depicting the distribution of these activities across the region have never been generated.

Under this output, the spatial gap associated with these activities was addressed using crowd-sourced data, namely from eBird (www.ebird.org), iNaturalist, TripAdvisor, and Flickr, complemented by participatory mapping and survey data from charter vessel operators, as well as other stakeholder information and guidance. The results are maps of birdwatching and whale and dolphin watching intensity for CROP countries, as well as several complementary summary statistics intended to further emphasize the importance of these sectors to the region's economy. Although the importance of sea turtle watching was raised by some stakeholders, in-water observations were already covered, more broadly, in the on-reef mapping, while information on turtle-nesting observations were inconsistent. Concerns were also raised about the sustainability of some nesting-observation opportunities. Instead of a map a short qualitative overview of turtle watching is provided in the technical report associated with this output.

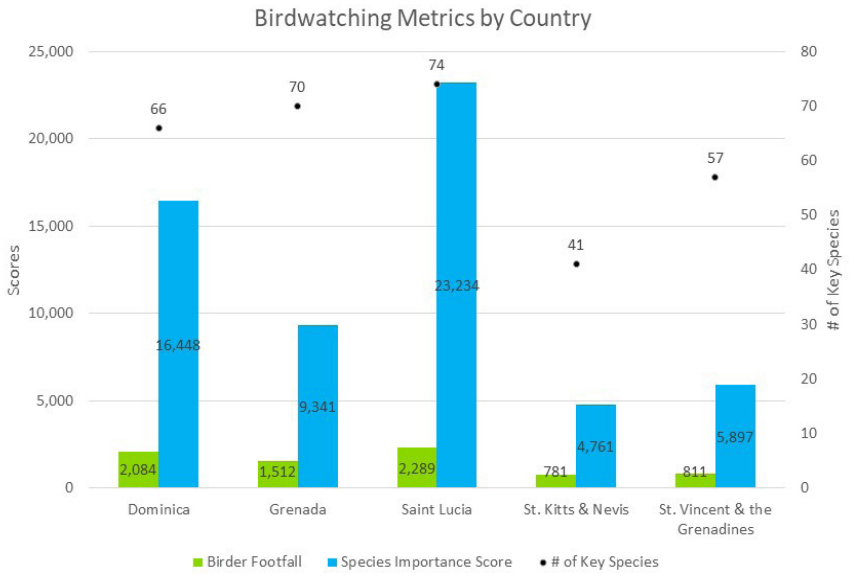

Photo Credit: Charles J. Sharp

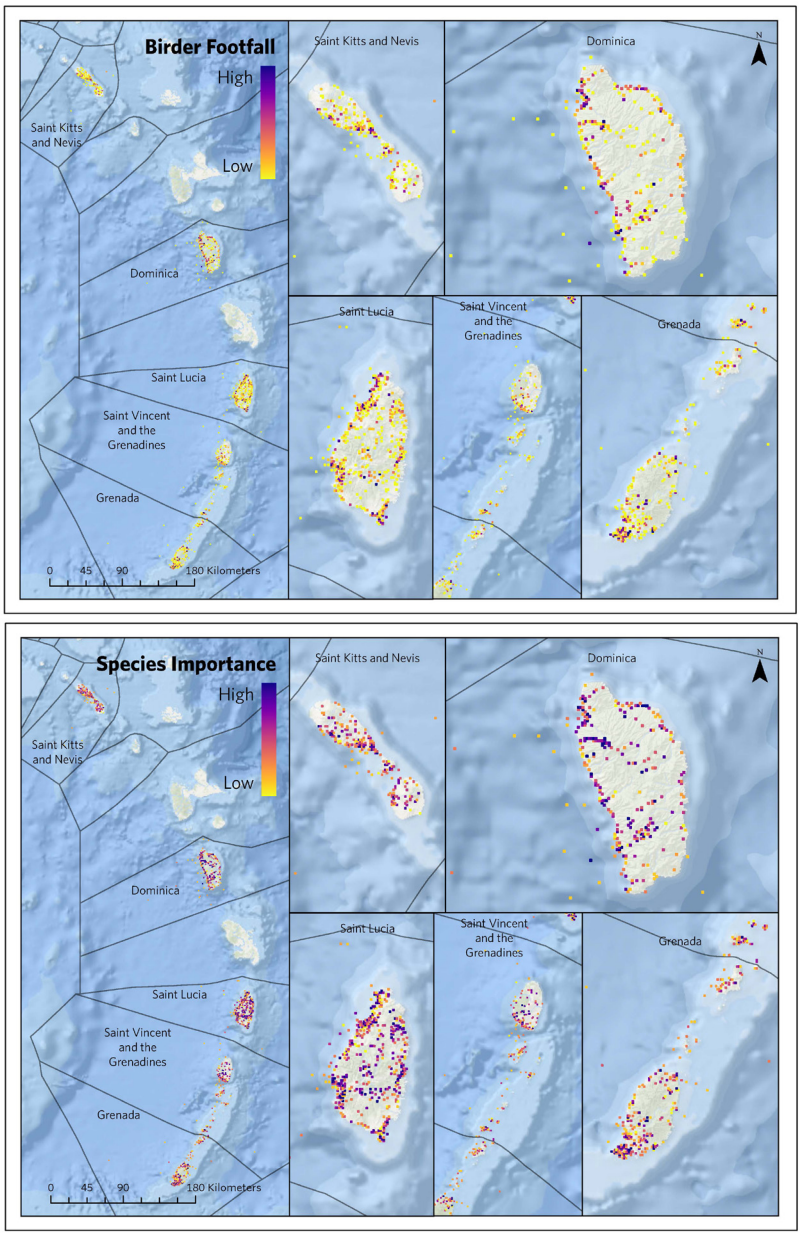
The key single data source for modelling the intensity of birdwatching and understanding key species was eBird (Levatich & Padilla 2019). This is a citizen science data repository for birdwatchers managed by Cornell Lab of Ornithology, with more than 100 million bird sightings contributed annually by "eBirders" around the world (https://ebird.org/). eBird observation points were accessed through the Global Biodiversity Information Facility (GBIF) online data portal (GBIF 2019). Further understanding of the importance of different species, including aspects of rarity, endemism, and interest was developed using data from BirdsCaribbean and the IUCN Red List.

Using these data, three separate metrics were developed:
1. Birder footfall captures simple birdwatching effort, based on eBird observation data. To avoid double counting, only one record per observer per day was allowed in any single location. These values can be summarized and mapped by grid cells, protected areas, or country boundaries, or other mapping units.
2. Key species are intended to characterize birds that would be of particular interest to birdwatchers, and are defined as birds that are rare, endemic, endangered, or otherwise charismatic (as identified by stakeholders).
3. Species Importance is a sum of each of the four key species metric applied to each species. When this score is multiplied by the number of observations of each species per person per day, and these totals are summed, these values can be summarized and mapped by grid cells, protected areas, country boundaries, or other mapping units to provide a species importance score. Summaries of these metrics by country can be found in Figure 12.

The maps of birdwatching activity show a predominance of activities in coastal areas, with a likely correlation with accommodation density, but these maps still show observations recorded from offshore waters to wetlands and mountain areas. The patterns of species importance underline the particular value of these locations away from the tourist accommodation, notably mountainous and forest areas. Many of these important species depend heavily on the existence of a relatively large and intact ecosystem and for this reason, both the mapping tool and the associated technical report also show the protected areas and Important Bird Areas.

In reviewing the maps related to birdwatching, several considerations are encouraged. Firstly of course is the importance of birdwatching across multiple locations, including many that are beyond the regular path of many tourists. Such areas should be safeguarded, and could potentially promoted through the expansion of visitor facilities, trails and protected areas. As mentioned the highly focused nature of observation points may be misleading and in many cases the protection





Figures 12, 13, 14. Birdwatching metrics by country; Regional map of birder footfall and species importance scores

and encouragement of this industry will also require continued or improved efforts to protect the entire functioning natural habitats in adjacent areas required by birdlife.

The promotion of whale and dolphin watching as a tourism activity in the Eastern Caribbean began to take hold in the late 1980s, with Dominica leading the way (Hoyt 1999). The sperm whales in Dominica provide a clear draw for visitors to the island; other CROP countries, particularly Saint Lucia, have followed suit, offering visitors the opportunity to see whales and dolphins in their offshore natural habitats. In Grenada, St. Kitts & Nevis, and St. Vincent & the Grenadines, also benefit from a cruise season that coincides with humpback migration season, though smaller whales and dolphins, especially spinner and bottlenose dolphins can be seen year-round. Indeed, the industry in these countries has historically been sensitive to fluctuations in cruise tourism, both benefiting from growth, and declining during years of decreased tourism (e.g., hurricane damage in St. Vincent & the Grenadines in 2008) (O'Connor 2009).

Globally, whale and dolphin watching was estimated to be attracting 13 million people annually as far back as 2008, generating over $2.1 billion in tourism revenues and supporting 13,000 jobs (O'Connor et al. 2009). For the CROP countries,

total expenditures (indirect and indirect) for this activity were estimated at over $6 million in 2008. A more recent study estimated a yearly revenue of $3 million for Dominica alone (Gerst et al. 2020).

The opportunity to see birds and marine mammals offers a specific attraction for many tourists visiting the region and generates highly memorable experiences for many more. Despite this, like many aspects of nature-dependent tourism, map-based data depicting the distribution of these activities across the region have never been generated. Addressing this gap was a major objective of this output.

Although the original intention had been to use of user-generated content for this work, the key sources for such work had only limited data points. AI based image recognition was effective in locating images of marine mammals from Flickr, however this approach only returned 62 images. These data were complemented using a combination of image and text analysis applied to TripAdvisor data, to understand the intensity of the activity from ports and other land-based charter departure locations. The values were spread seaward using participato-


Photo Credit: Romain Barats/TNC Photo Contest

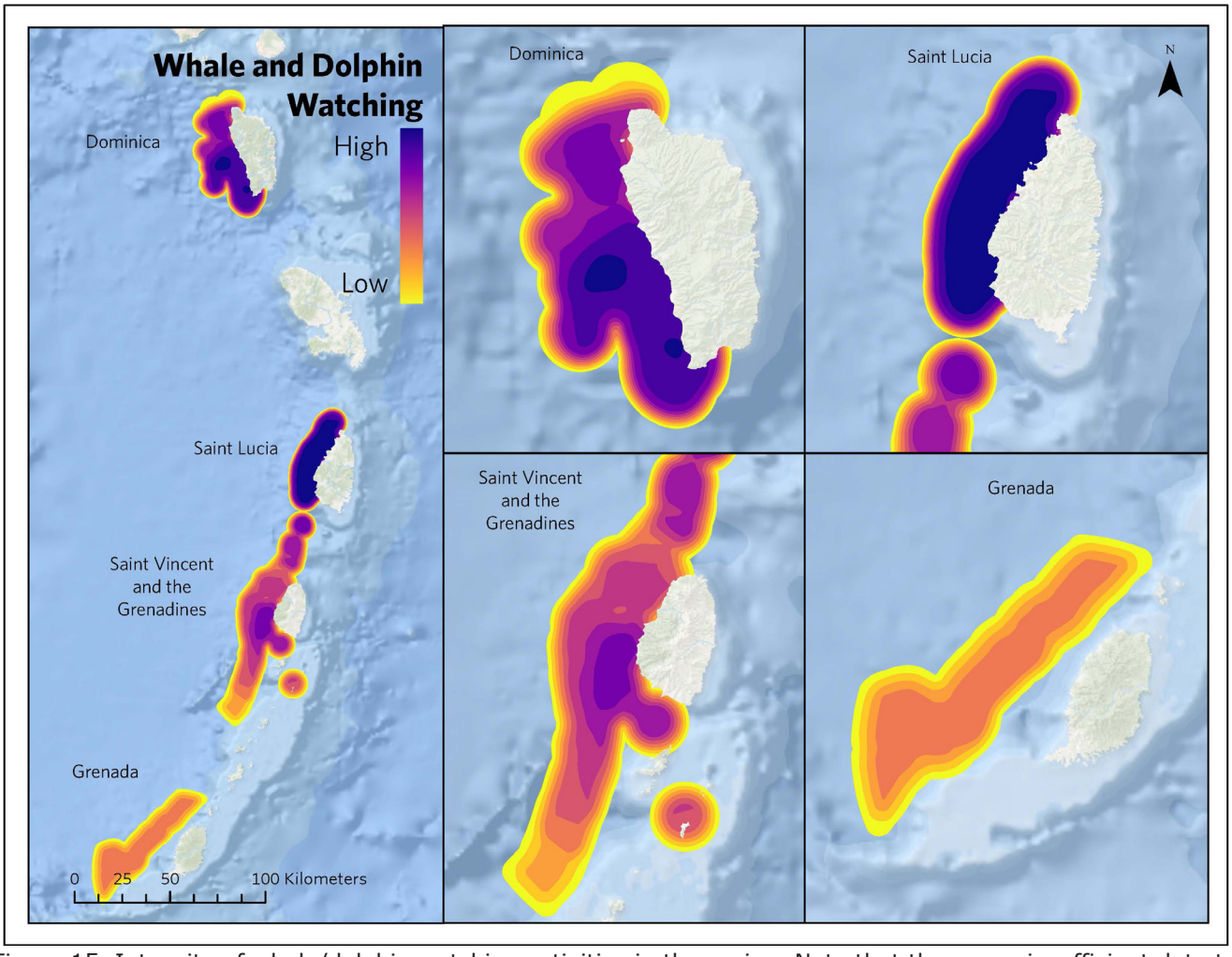


Figure 15. Intensity of whale/dolphin watching activities in the region. Note that there was insufficient data to model this activity for St. Kitts and Nevis.

ry mapping and survey data from charter vessel operators, as well as other stakeholder-provided information and guidance.

Both the maps and the expenditure estimates highlight the particular importance of whale and dolphin watching activities in Dominica and Saint Lucia, with St. Vincent and the Grenadines also having a nascent whale and dolphin watching industry. In all cases, activities extend out predominantly from the western shores, from coastal areas (where dolphins are more likely to be observed) out to deeper waters favoured by whales.

While the financial assessment is drawn from a relatively small sample size and were not inclusive of Grenada or St. Kitts & Nevis due to insufficient data, the results indicate a direct expenditure of over $US 5.7 million per year. Figure 16 shows the estimated expenditure values by country.

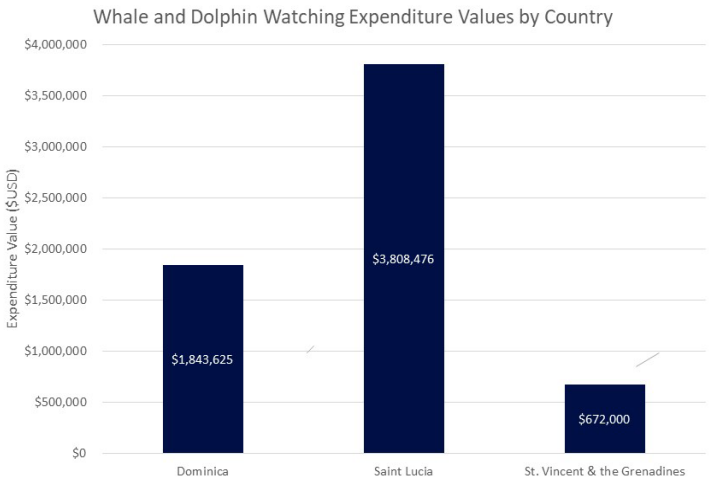


Figure 16. Estimated tourism expenditures on whale and dolphin watching by country

It is important to note that these economic values represent direct expenditure only. They do not capture ancillary expenditure, or the role that such experiences may have had in destination choice, return likelihood or indeed word-of-mouth encouragement of other visitors. Thus, the expenditure figure for Dominica represents 1.8% of all tourism expenditure, but if the ancillary expenditure could be factored in, it may be double that. Although numbers are highest for Saint Lucia, it should be noted that, as a proportion of visitors and expenditure, it is likely that this industry represents a far more critical element of tourism expenditure in Dominica which has fewer visitors and lower expenditure overall.

In this work the potential impacts of whale and dolphin watching in the CROP countries were not explored (New et al. 2015). Nor are the potential opportunities to expand these industries considered. However, this works shows all too clearly that this is an important component of tourism, with a large spatial footprint. It will be important for governments and tour operators to consider this industry and to manage it for sustainability.

More details about this model, including the technical report, metadata summary, data download, and other resources, can be found here.

Coral Reef Fisheries

Coral reefs within the CROP area provide vital nutrition to local communities and income to fishers, but are threatened by a range of stressors that have impacted the health of reefs and the fish assemblages they support. Under this project, a team at Florida International University mapped fish and fishing throughout the region. The aims of this project were to model and map fishing impact, model and map current reef-fish biomass, and assess the potential benefit of conservation and management measures on reef fisheries.

Using data obtained from a range of organizations and researchers, the project had access to 202 fish surveys from coral reef and pavement (non-accreting hardbottom) habitats across both the focal countries and other nearby islands, which were analyzed to increase the available dataset. The approach could be applied to other habitats (e.g., seagrass) if sufficient data become

available.

Fishing impact

The fish survey dataset was haphazardly split into two groups, and fish data from the first group (109 sites) were used to statistically model fishing impact (a unitless metric varying from 0 to 1 representing the cumulative effect of fishing on fish assemblages while controlling for biophysical gradients, such that 0 means the assemblage in the region closest to its natural state). At each survey site, the mean length of parrotfishes (>10 cm), which are known to be susceptible to fishing (i.e. mean length decreases with increasing fishing pressure), were used as a proxy of fishing impact. The mean length data were modelled in relation to 25 potential predictor variables, such as the distance to nearby fish landing sites and sea surface temperature. These analyses demonstrated that both human-related and biophysical gradients, particularly wave exposure, are important factors affecting mean parrotfish length.

The human influence on fish populations, assumed to be through fishing, was best correlated with the distance to a fish landing site (greater distance was associated with higher mean parrotfish length), the estimated number of small-scale fishers in a country (more fishers was associated with lower mean parrotfish length), and the gravity of the nearest potential fish market (very low market gravity was associated with higher mean parrotfish length). Using only the three fishing-related variables (i.e. considering biophysical influences as homogeneous across the region to isolate the anthropogenic impact), the model was used to extrapolate relative fishing impact on reef fish assemblages to all reef sites across the project region and generate a continuous map at a 1 ha resolution. The results show medium to high fishing impacts in the CROP countries relative to more remote areas in the Eastern Caribbean. These maps do not apply to pelagic or invertebrate (e.g. lobster and conch) fisheries.

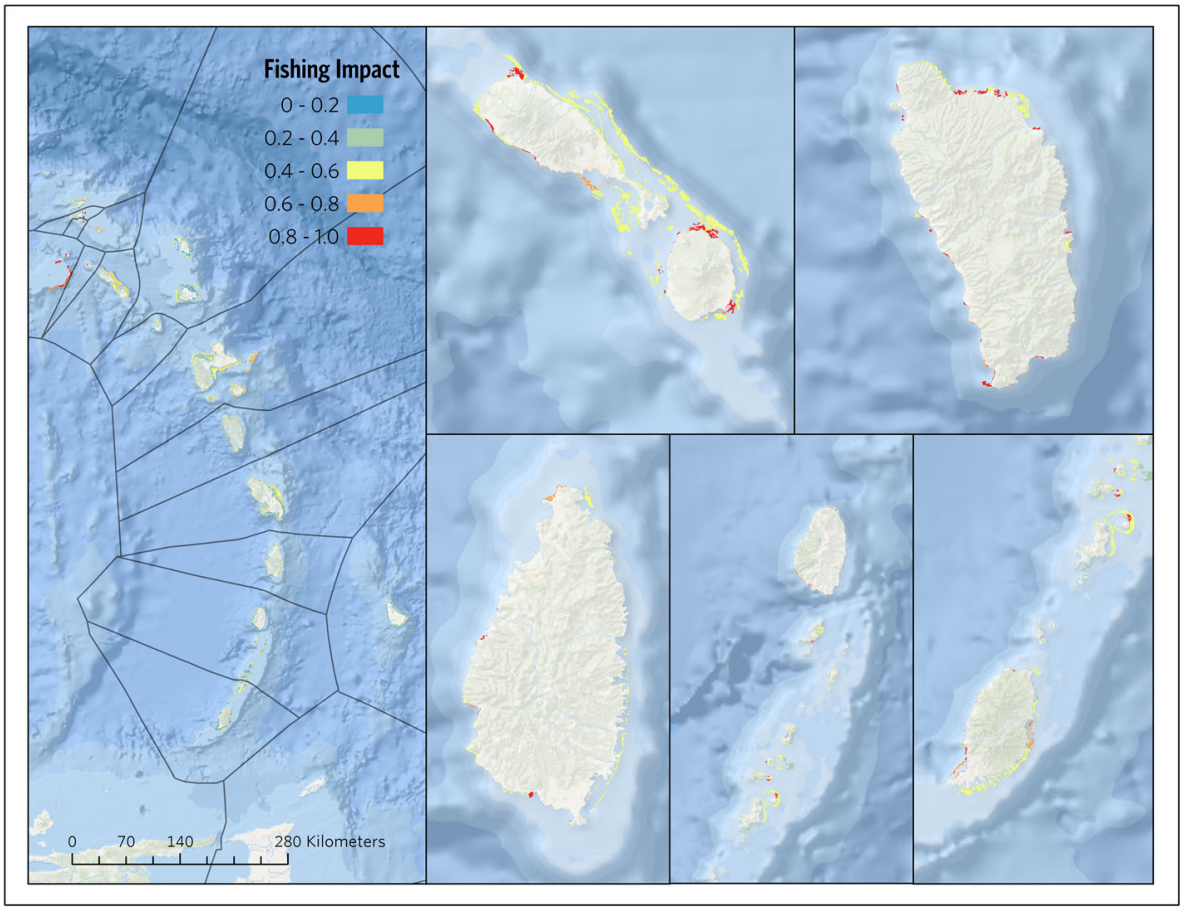


Figure 17. Estimated fishing impact for the Eastern Caribbean region and for individual CROP countries

Current biomass

Estimates of fishing impact were then used as a key data layer, along with 19 environmental variables, to model the current biomass of all surveyed reef-fish species, snapper and grouper species, and parrotfishes using the remaining 93 sites (second group) where survey fish biomass data were available. These three models included relationships with biophysical variables that were consistent with the ecology of these species. For example, fish biomass generally increased with increasing depth, decreased with increasing sea-surface temperatures, and parrotfish biomass was positively correlated with the availability of seagrass and mangrove nursery habitats. Fishing impact was a significant variable in the model of snapper and grouper biomass, reflecting that these species are particularly targeted by fishers. However, the relationship was weaker than expected, and was not present in the models of total biomass or parrotfish biomass, perhaps reflecting data limitations, the relatively homogenous fishing pressure across the entire area, or the complexities of modeling fishing across the region where gear types and target species are known to vary in space and time. Marine reserves have repeatedly been demonstrated to increase local fish biomass, but were not important in the models. This absence is likely due to other large biophysical gradients and because reserves only cover a small area of reefs in the region and hence few data points fell within reserves. However, reserves remain a key tool for managing fishes in the region. Although the models could potentially be improved with further data, they explain a large amount of variability in the dataset and were used to extrapolate estimates of current biomass across the project area to generate previously unavailable maps.

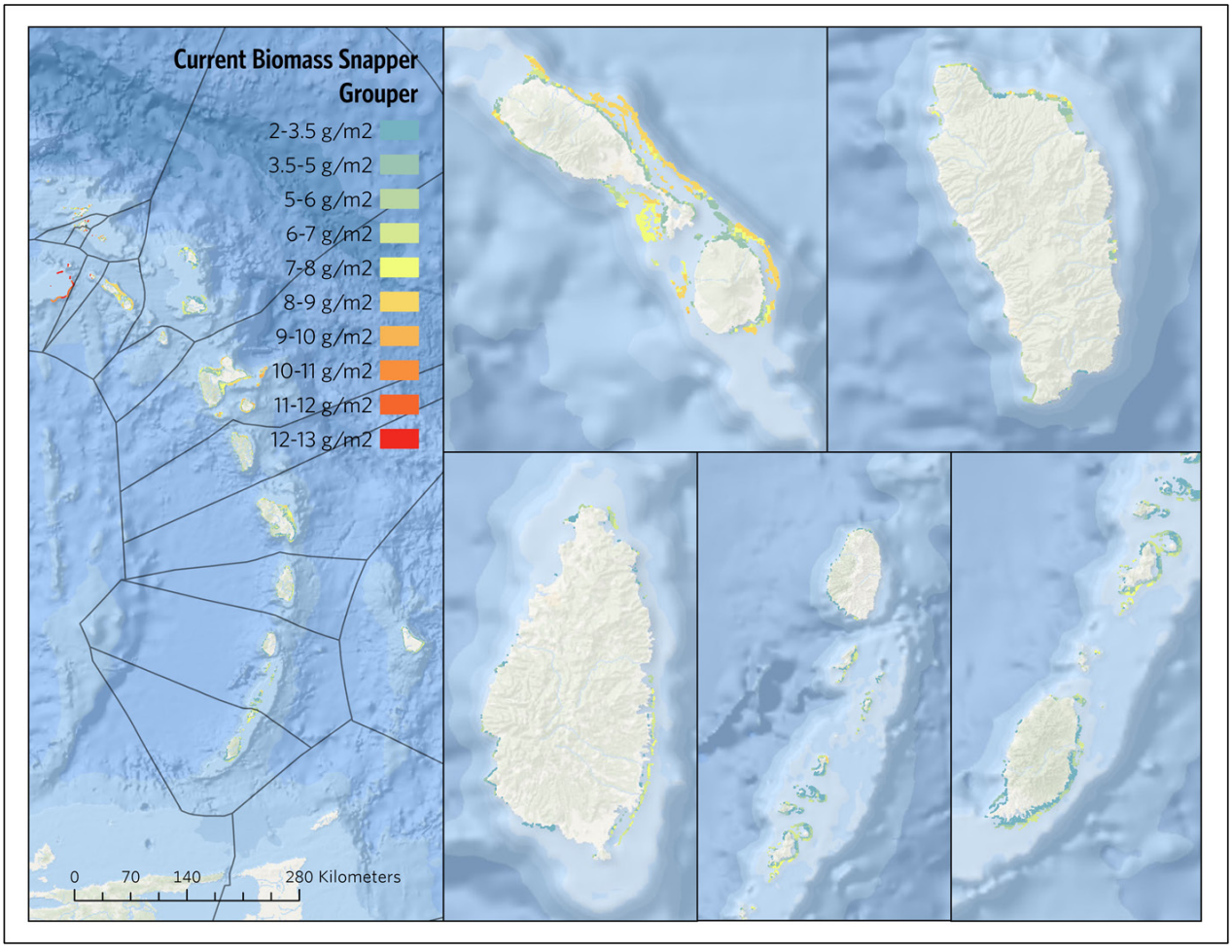


Figure 18. Estimated current biomass for snapper grouper species for the Eastern Caribbean region and for individual CROP countries

Scenario building

Finally, the model of current biomass was adjusted to represent two potential management scenarios: the cessation of fishing on snapper and grouper species and the effect of coral restoration on parrotfish biomass. The first scenario involved reducing fishing impact to 0 to simulate a reserve (i.e. to estimate the biomass possible on a reef given zero fishing impacts with the current biophysical conditions). To simulate coral restoration, coral cover was increased by 25%. These scenarios allowed the production of maps estimating patterns of potential biomass if these management measures were implemented. These simulations demonstrated, for example, that marine reserves have the potential to increase the biomass of snappers and groupers by up to 113%. However, reserves need to be well-enforced and established for a long time to have this effect, and such reserves are currently rare in the region. The number of years estimated for snapper and grouper populations to recover under a simulated no-fishing scenario was also mapped, providing data-based estimates that can be used to inform expectations of population recovery for proposed reserves.

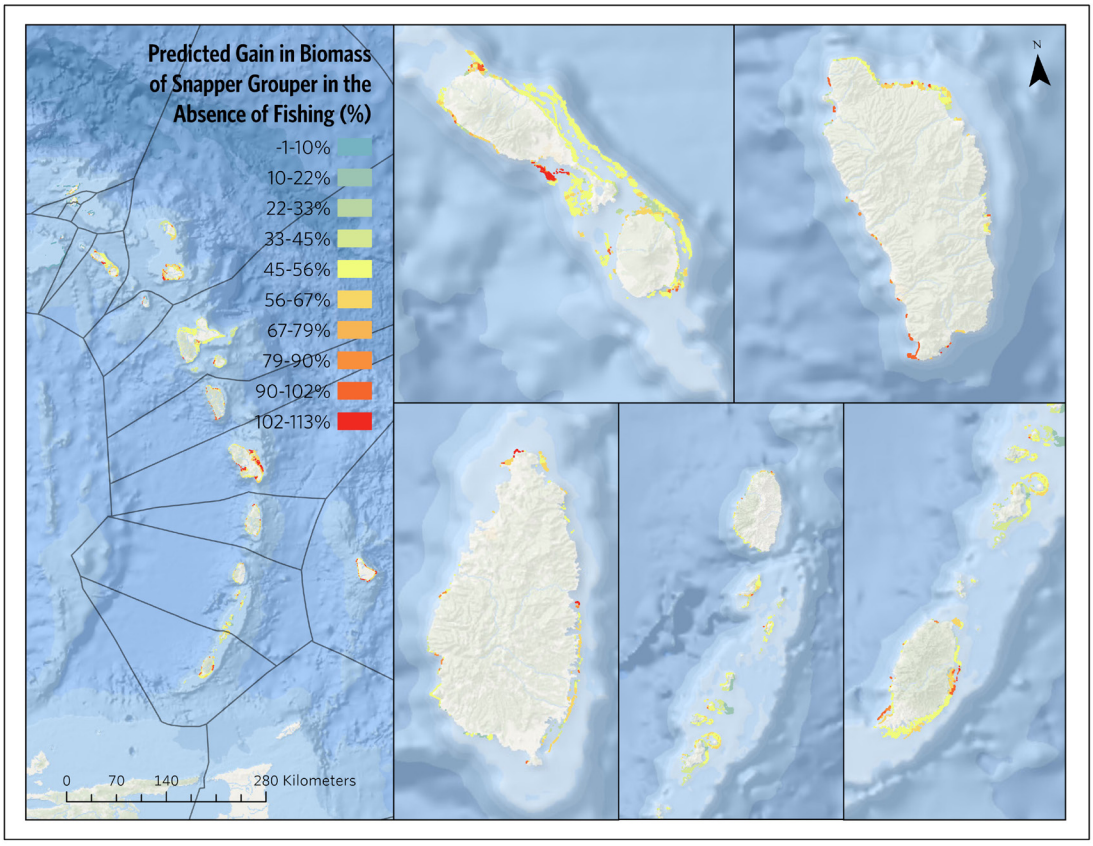
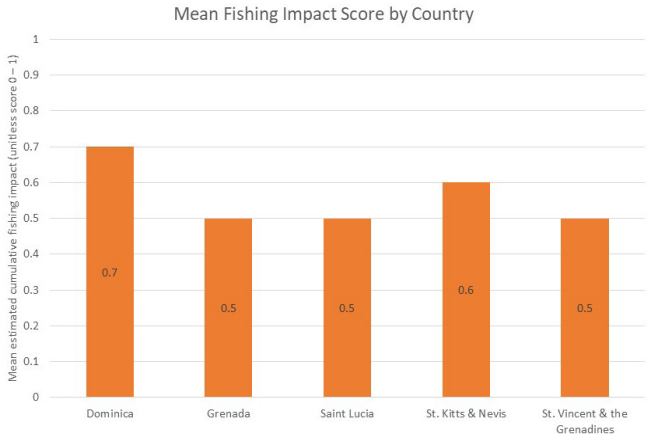
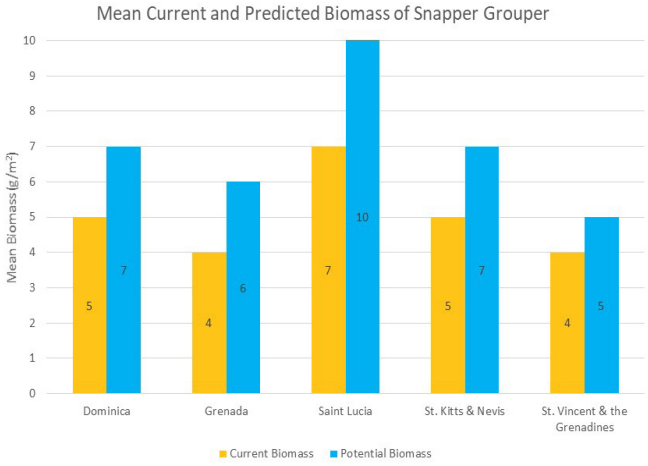


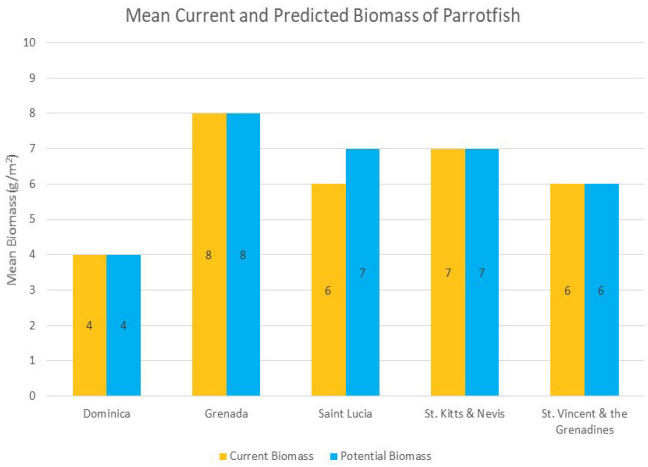
Figure 19. Estimated percent gain in snapper grouper in the absence of fishing for the Eastern Caribbean region and for individual CROP countries

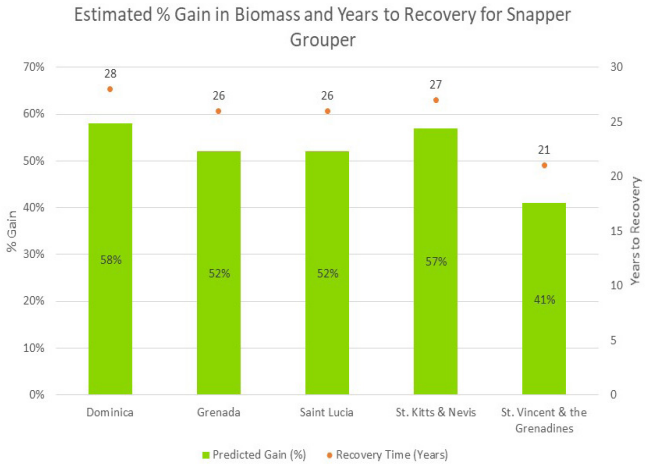
The maps generated by this project represent the first spatially explicit, continuous maps of fishing impact and current and potential biomass for the CROP area. While the maps could certainly be improved with further survey work (data in the region are relatively sparse), current iterations can be provided to management agencies to support reef and fishery-related decisions. For example, decision-makers might use these maps of fishing impact and estimates of current and potential biomass to highlight reefs where there is a high potential for fishery benefits with spatial protection or other initiatives that strengthen management. Potential protected areas could be designated on reefs with low levels of fishing impact (relatively unfished reefs that could be protected from increases in anthropogenic impact) or on more heavily fished reefs with a large potential for fish biomass increases if fishing was limited. Furthermore, the models can be used by planners to examine a wide range of management scenarios for their effects on fish biomass.

Figures 20 - 23 provide statistics by country for fishing impact, current biomass, and future sce-









Figures 20 - 23 (Clockwise from top left). Mean fishing impact score by country (unitless score 0 - 1); Mean current and predicted biomass of snapper grouper by country under a no-fishing scenario; Estimated percent gain in biomass and years to recovery by country for snapper grouper in a no-fishing scenario. Mean current and predicted biomass of parrotfish by country in a coral restoration scenario.

narios. More details about this model, including the technical report, metadata summary, data download, and other resources, can be found here.

Country Summaries

As a deliverable under this project, the team produced for each of the countries a four-page summary of project results. Each summary identifies specific locations that are high value, highly used, or otherwise notable for each of the models. The summaries also provide maps and tabulated statistics. These summaries are intended to provide high-level highlights that can be used by each country to quickly access key results and outcomes of the project specific to their geography. Country summaries can be found here.

Web-based Tools

Under this project, the team led the development of two web-based applications designed to provide easy access to data, maps, and statistics derived from this project. These tools are mobile-enabled and build upon existing tools.

Mapping Ocean Wealth

Launched in 2015, the Mapping Ocean Wealth Data Explorer (maps.oceanwealth.org) contains a robust data-viewing framework with interactive web applications designed to visualize ecosystem services associated with marine and coastal habitats. The tool contains social and economic data alongside ecological features allowing policy analysts, decision makers, conservation practitioners, scientists, business managers, coastal planners, and investors to connect these values with specific places. Most of the models featured on the site are global in scale.

Under CROP, the project team developed a dedicated, mobile-enabled extension of this tool (maps.oceanwealth.org/oecs) specifically to support implementation of Blue Economy objectives by promoting greater consideration of the ecosystem and functions which the ocean provides

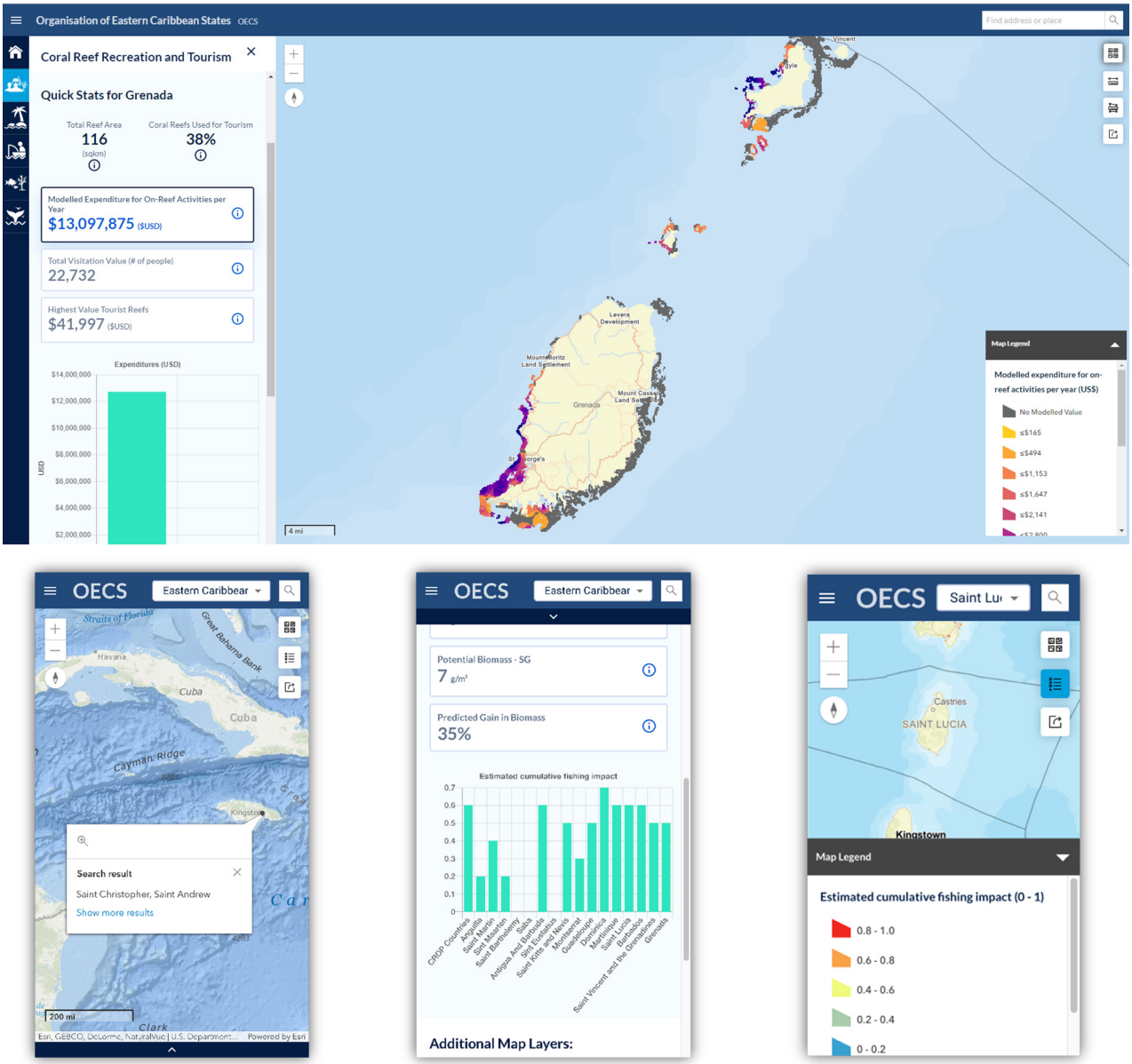


Figure 24. Screenshot of the MOW/CROP tool on a desktop (top panel), and on a mobile phone (bottom 3 panels)

Spatial Agent

The Spatial Agent tool was developed the World Bank with the objective of improving data transparency and promoting open data platforms. The original Spatial Agent application provided an interactive mobile platform from which users could explore over 300 web-based spatio-temporal maps from a wide range of institutions broadly focused on development. While Spatial Agent was originally deployed as a downloadable mobile app, it is currently being adapted into a more flexible web-based platform that is also mobile-responsive.

Under this project, the team worked with the web developers at the World Bank responsible for developing the original tool to devise a Spatial Agent tool specifically focused on the Eastern Caribbean (spatialagent.org/Caribbean). Here, the ecosystem service maps developed under this project can be viewed alongside over 100 global and regionally-specific datasets related to coastal and marine sustainability and the Blue Economy. For example, coral reef tourism data could also be viewed against the backdrop of climate-related data such as sea level rise and coral bleaching, to emphasize the potential impacts of climate change on coastal tourism. The app also integrates new, innovative features from ArcGIS online such as a proximity tool, which allows users to select for ecosystem service values within user-defined distances of specific locations. The tool also incorporates a slider bar allowing users to compare current and future scenarios for coral reef fisheries (Figure 25). Like the MOW tool, this app is mobile-enabled and will automatically adjust the layout of the screen based on the dimensions of the screen.

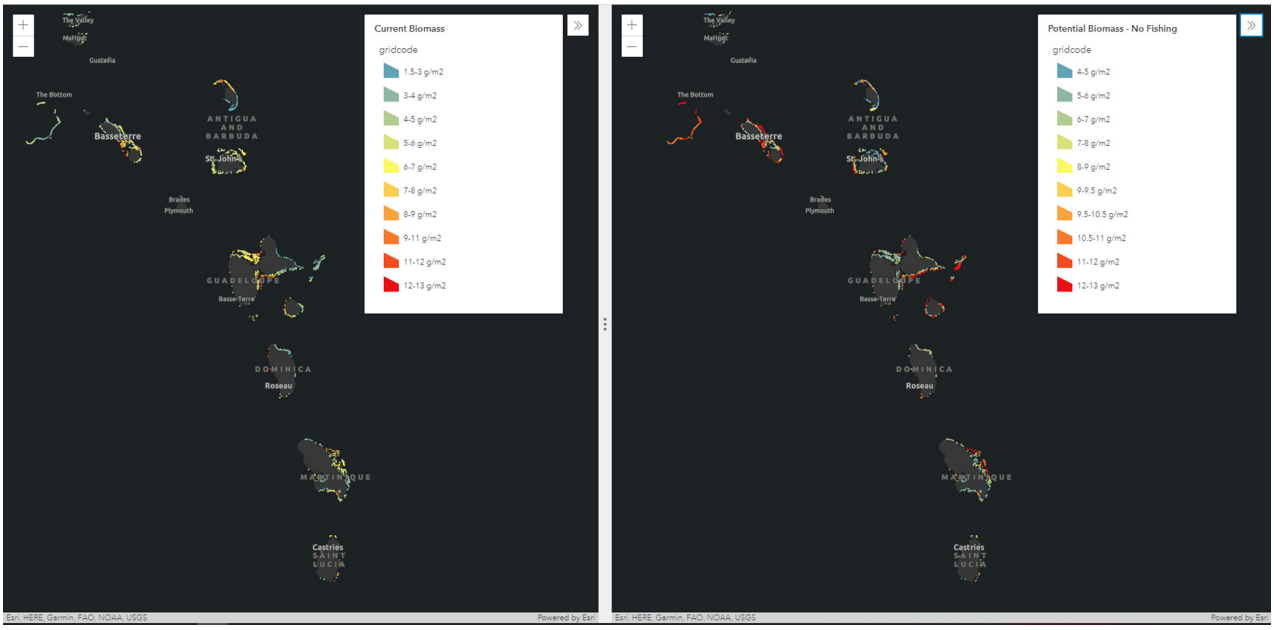


Figure 25. Slide bar to compare current and future scenarios for coral reef fisheries in the Caribbean Spatial Agent app.

Trainings and Workshops

Under this project, the team held two workshops designed to provide training and improve access to data for decision-makers. Workshop 1 (May 20 – 22, 2019) was held towards the beginning of the project while Workshop 2 (June 8, 2021) was held towards the completion of the project.

Workshop 1

Workshop 1 was held at the Bay Gardens Hotel in Rodney Bay, St. Lucia, from May 20 – 22, 2019. The three-day workshop was designed to build participants understanding of coastal and

marine ecosystem services and how to integrate ecosystem services into policy, coastal master planning, and MSP. Outcomes of the workshop included:

·Improved participant understanding of CROP and the role of the Mapping Ocean Wealth Project within CROP

·Improved participant understanding of ES, ES assessments, and the benefits of including ES in policy and planning

·Improved participant understanding of existing MOW tools and ES assessments

·Improved TNC understanding of regional data sources, existing assessments, and regional priorities, especially the importance of wildlife viewing and boating as key nature-dependent tourism activities

·Identification of key expert advisors in the region to provide feedback on project deliverables

The first two days of the workshop introduced participants to the concept of ecosystem services, ecosystem service applications in policy and planning, existing ecosystem models, and planned ecosystem service model outputs as they related to CROP. Participants were trained on how to use the Mapping Ocean Wealth Data Explorer, and facilitated discussion focused on engagement and collaboration in expanding the MOW platform to include data and models produced using fine scale, locally-relevant data to address regional planning priorities.

Attendees of Workshop 1, held in Rodney Bay, Saint Lucia, in May 2019. Photo credit: Cherie Wagner/ TNC

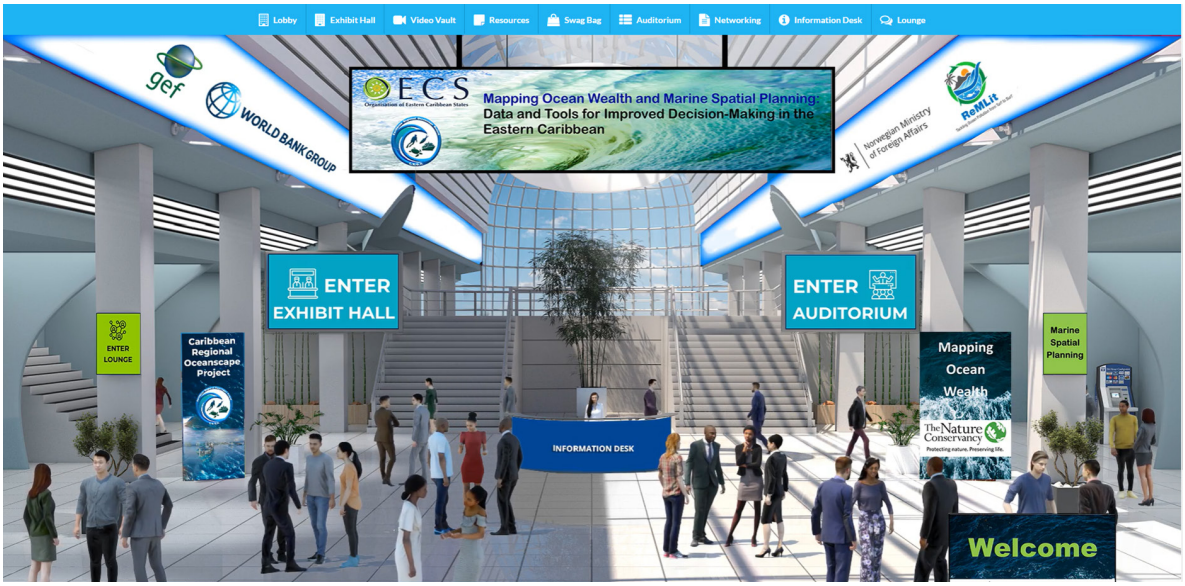
The third day of the workshop specifically focused on carbon sequestration. Although the MOW/CROP project did not include scope for new models on carbon sequestration, it is a key ecosystem service that will likely need to be considered under the MSP and coastal master planning process under CROP, and existing data on carbon sequestration may be presented as reference information alongside novel ecosystem service data products produced by the MOW team.

This workshop was co-hosted by the Caribbean Public Health Agency (CARPHA) based on the many synergies between the MOW/CROP project and the Integrating Water, Land and Ecosystems Management in Caribbean Small Island Developing States (IWEco) project. In addition to the geographical overlap between the two projects (specifically for the islands of Grenada, St. Kitts & Nevis, Saint Lucia, and St. Vincent & the Grenadines), components of the IWEco project include objectives related to maintenance and management of ecosystem services, as well as enhancing knowledge exchange, best practices, replication, and stakeholder involvement for these activities. TNC and CARPHA determined that the majority of the content and objectives of the workshop would be relevant and applicable even to those IWEco representatives from countries not engaged in CROP (Antigua & Barbuda, Barbados, Cuba, Dominican Republic, and Trinidad & Tobago).

Thirty-five natural resource professionals representing ten countries and thirty agencies attended the workshop. TNC's invitees represented expertise in fisheries, sustainable development/environment, maritime administration/physical planning, and data/technical planning. CARPHA's invitees had similar expertise, and in some cases, overlapped with the invitees identified by TNC. In addition, CARPHA's invitees included managers of terrestrial ecosystems with interest in carbon storage and sequestration. (See the Stakeholder Engagement section below for metrics on workshop attendees).

Workshop 2

Workshop 2 was originally intended to be a multi-day in-person workshop held in the region; however, travel restrictions due to Covid-19 led to the decision to hold the workshop using the OECS Virtual Convention Center. This online platform, hosted by vFairs emulates a conference experience while allowing participants to remain remote. Several benefits to this approach included the ability to make the event public, allowing for greater participation and to add options for virtual exhibition booths, chat rooms for networking opportunities, and breakout sessions to target specific participant interests.



Screenshot of OECS Virtual Convention Center

With the OECSC, TNC planned and coordinated sessions for this virtual conference, held on World Oceans Day (June 8th, 2021), to present the results of the project and to provide an overview of relevant decision-support tools in the region. The MOW sessions were followed by a session on lessons learned from marine spatial planning (MSP) efforts taking place in other small island developing states (SIDS).

Outcomes of the workshop included:

·Increased understanding of ecosystem service models, including methodology, scope, and potential applications, especially MSP

·Increased understanding of available decision-support tools relevant to work taking place in the region

·Increased understanding of how to access key data and statistics using the Mapping Ocean Wealth web tool

The introductory remarks placed the CROP in the larger context of the challenges and opportunities associated with the Blue Economy in the Eastern Caribbean also served as an opportunity to launch two new initiatives: the Journalist Challenge and the Tag an Artists Challenge being done under a Norwegian funded OECS project, Building Resilience in the Eastern Caribbean through a reduction of Marine Litter (ReMLiT).

Following the opening session, Dr. Mark Spalding delivered the plenary talk, which introduced the Mapping Ocean Wealth project. The purpose of this talk was to familiarize participants with the Mapping Ocean Wealth project, including its global approach, as well as the data and products developed for the CROP countries. After an introduction to the concept of ecosystem services, Dr. Spalding provided a high-level overview of the outcomes from the project, focusing on the innovative approaches and key findings. Dr. Spalding also examples of how the data and other outputs from the project could be used to address planning questions.

The next session was a panel discussion on platforms and tools that can be applied to coastal and ocean planning and management decision-making in the region. Each presenter had 10 minutes to cover the following topics:

- Mapping Ocean Wealth and the OECS (Kate Longley-Wood)
- Ecosystem-Based Management Framework with a focus on MSP (Martha Prada)
- Ocean Watch (Lauretta Burke)
- TNC Caribbean Marine Maps (Valerie McNulty)

Meeting Recording (Passcode: %Jc&R9.z)

During the next session, participants had the option of choosing between the following breakout sessions:

1.Recreation and Tourism: In this session, Dr. Mark Spalding presented an in-depth methodological overview of the nature-dependent tourism models created under the CROP. These models include on-reef recreation and tourism (e.g., diving and snorkeling), nature-dependent beach tourism, recreational fishing, whale/dolphin watching and birdwatching. Meeting Recording (Passcode: !28tG*xT)

2.Coral Reef Fisheries: In this session, Drs. Alastair Harborne and Rachel Zuercher presented an in-depth methodological overview of the coral reef fisheries enhancement model.

Sub-components of this model included fishing impact, current biomass, and projected gains in standing stock under management scenarios. Meeting Recording (Passcode: Lu=74h.J)

3.Mapping Ocean Wealth Tool Training - In this session, Kate Longley-Wood provided an in-depth tutorial of the features and datasets available in the Mapping Ocean Wealth data explorer tool developed for the CROP. Interactive questions were posed so that participants could test their knowledge of the tool as it was being presented. Meeting Recording (Passcode: +M93JK^Q)

After the breakout sessions, there was a break, allowing participants time to eat lunch, view the exhibition booths, or network in the chatrooms. Following the break, participants reconvened for the afternoon session which focused on sharing experiences and lessons learned from MSP efforts in SIDS. Presentations ranged from projects that are currently in their beginning phases to those approaching implementation. Presenters discussed the following geographies for 30 minutes each, inclusive of time for questions/discussion:

- Barbados (Dr. Leo Brewster)
- Trinidad and Tobago (Ms. Sarah Mahadeo)
- Seychelles (Dr. Joanna Smith)
- OECS (CROP) (Ms. Susanna de Beauville-Scott)

Meeting Recording (Passcode: $+nVGG9H)

71 participants, including marine and coastal planners and data managers, academics, representatives from various sectors including fisheries, environment, blue economy, green economy, as well as tourism stakeholders in the OECS, logged on to the workshop throughout the day. (See the Stakeholder Engagement section below for metrics on workshop attendees).

MOW Advisory Board

The Mapping Ocean Wealth Advisory Board provides general guidance and input on existing and future MOW initiatives, as well as other projects and collaborations where ecosystem services are being quantified and where MOW datasets could be used or leveraged. Advisory Board meetings are coordinated by Kate Longley-Wood (TNC) and chaired by Dr. Mark Spalding (TNC). The Advisory Board is composed of the following members:

Dr. Rob Brumbaugh (Caribbean Division Director, TNC)
Ms. Lauretta Burke (Senior Associate, World Resources Institute)
Dr. Will McClintock (Senior Fellow at the National Center for Ecological Analysis and Synthesis, UC Santa Barbara; Director, SeaSketch)
Dr. Linwood Pendleton (Executive Director, Ocean Knowledge Action Network)
Mr. David Robin (Director, Ocean Governance and Fisheries, OECS)
Ms. Susanna de Beauville Scott (CROP Project Manager, OECS)
Ms. Rochelle Turner (World Travel & Tourism Council (WTTC))*
Dr. Philine zu Ermgassen (Postdoctoral researcher, University of Edinburgh)

*Ms. Turner joined the first Advisory Board call but has since left her position at WTTC.

Under the objective of MOW governance expansion, the project team was tasked with expanding the MOW Advisory Board to include representation from the OECSC with at least one MOW Advisory Board meeting held in the OECS region. While a physical face-to-face meeting was not possible during the life of the CROP due to travel restrictions and other impacts of the global Covid-19 pandemic, the OECSC has been included on the Board, and at least one member of the OECSC has attended each meeting.

Since the project's inception, the Board has convened four times and covered the following topics:

November 7, 2019

• Mapping Ocean Wealth Phase I recap and overview of anticipated Phase II activities (including CROP)
• Overview of synergies among team members' work and potential future applications

May 21, 2020

• Overview of TNC's Blue Bonds project
• Discussion around the impacts of Covid-19 on tourism and fisheries in the region and how that applies to ecosystem services being modelled under CROP

November 11, 2020

• Demonstrations and discussions around family of Global "Watch" platforms (Global Mangrove Watch, Global Resource Watch, Global Oceans Watch)

June 24, 2021

•Discussion around increasing the uptake and use of MOW/CROP models for planning or other applications in the region

Other communication and reporting outputs

Covid-19 related restrictions on travel led the team to re-allocate the project's travel budget to develop additional communications and reporting tools to promote understanding and uptake of the models and data within the EC region. These additional communications products included:

Infographics & Social Badges

Using existing MOW infographics as templates, the project team adapted these specifically for the CROP countries integrating project specific statistics and findings by both model and country. These visually-appealing designs can be downloaded from the MOW website and used in presentations, printed as promotional materials, or shared on social media and other websites (Figure 26)

Executive Summaries

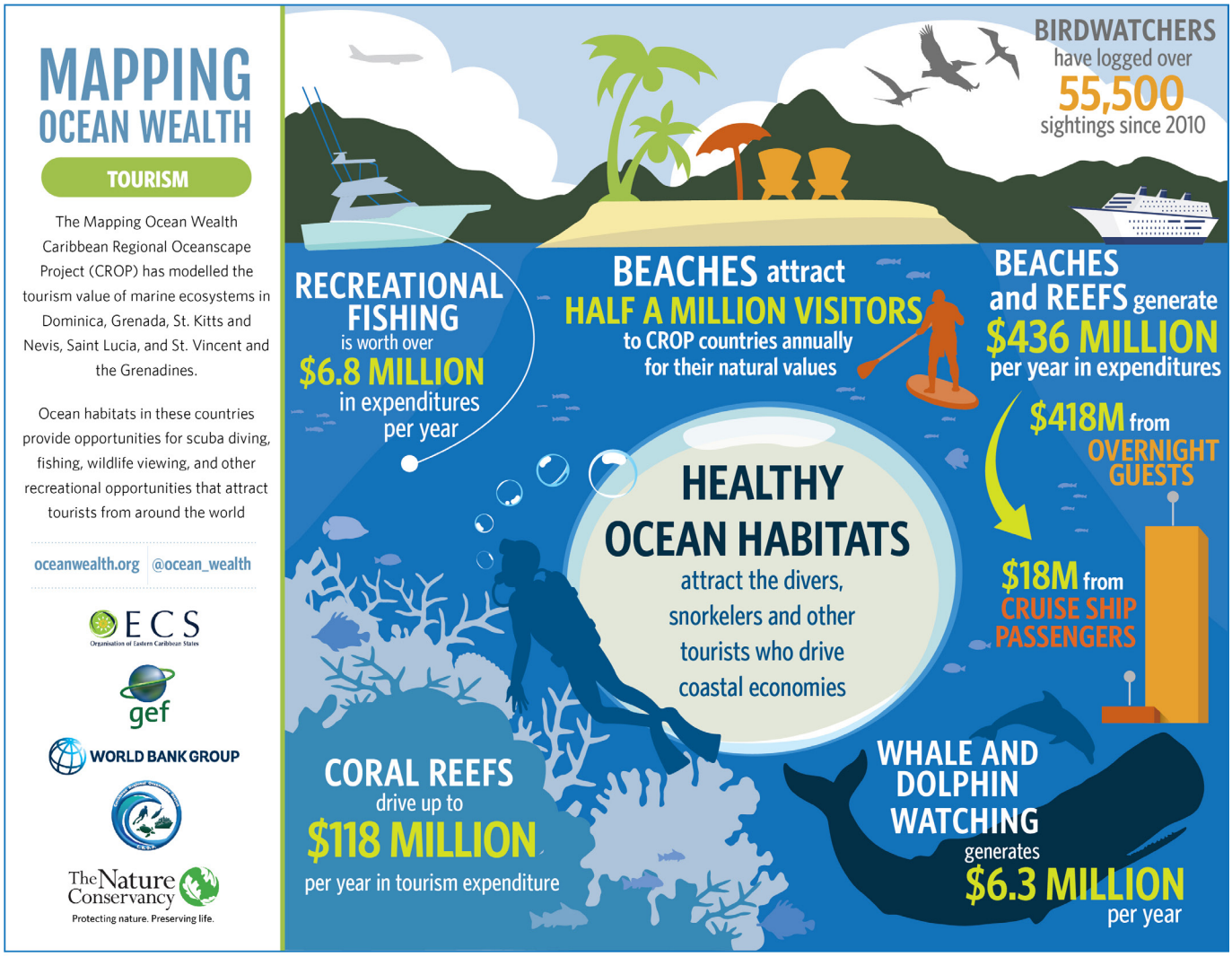
For each model, the team developed a visually-driven, high-level overview of model outcomes and applications. These are intended for non-technical audiences and are intended to convey the significance and main findings of each model.

Technical Guidance Documents

For each model, the team developed a guidance document for individuals who are interested in downloading, analyzing, and applying the data for projects within CROP countries. While the primary audience for these documents are technical planners engaged in marine spatial planning in the CROP countries, these documents describe a wide range of possible applications across multiple sectors along with practical advice on the methodology, interpretation, and caveats surrounding each dataset. This document is intended to complement the longer and more detailed

technical reports developed for each model.

The Executive Summaries and Technical Guidance documents will be available digitally on the project website (https://oceanwealth.org/project-areas/caribbean/crop/) under the applicable model heading once they are completed in October 2021. Printed copies of these documents will be mailed to the OECS office in Castries, Saint Lucia and to the Ocean Governance Focal Points in each CROP country who can distribute them to interested stakeholders.



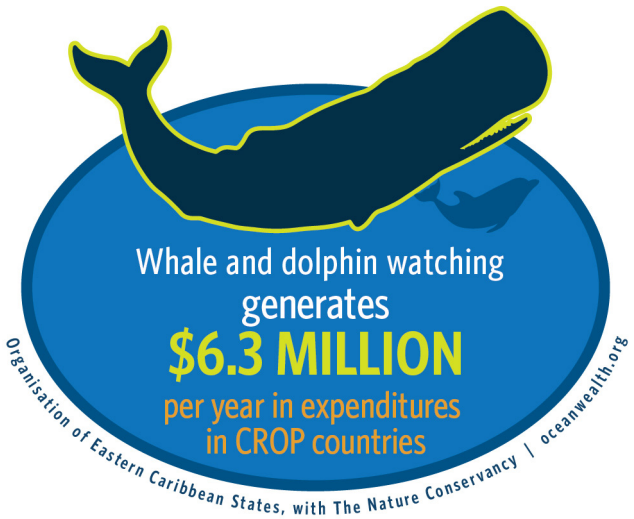


Figure 26. Examples of infographics and social badges developed for this project

Stakeholder Engagement

From the planning and inception of this project, stakeholder engagement has been considered critical for the success of this work to ensure uptake and buy-in of these data products in the region. The team had originally planned to conduct stakeholder engagement activities through a combination of in-person and virtual meetings. A summary of the stakeholder engagement activities conducted in the region, organized by year, can be found below, followed by an analysis of the overall success and quality of stakeholder engagement over the course of the project.

2019

Stakeholder engagement activities in 2019 took place primarily at the MOW/CROP Workshop 1, detailed in a previous section of this report. Stakeholders participating in this workshop are characterized in Table 1. The stakeholder engagement components of the workshop included gathering feedback on proposed modeling methodology, obtaining information on key regional datasets that could be used as model inputs, reaching consensus on additional nature-dependent activities to be modelled and mapped under the "Other Cultural Values/Other Nature-Dependent Tourism" model heading, and identifying additional stakeholders who can review interim model products and tools.

It should be noted that the stakeholders in Workshop 1 were heavily skewed towards public sector employees. While this was the intended audience for Workshop 1, there was an identified need following this workshop to bring a wider array of stakeholders into the model review process. It was difficult to obtain participation from Dominica, and only one person from this country was present at the workshop while there were at least three persons from each of the other CROP countries.

Table 1.Number of participants at Workshop 1 by sectoral and demographic categories

May 2019 MOW/CROP Workshop 1	Community	Academia	Private Sector	Public Sector	NGO	Indigenous People	Male	Female
Dominica (1)	0	0	0	1	0	0	1	0
Grenada (4)	0	1	0	3	0	0	4	0
Saint Lucia (17)	0	0	0	12	5	0	7	10
St. Kitts & Nevis (3)	0	0	0	3	0	0	1	2
St. Vincent & the Grenadines (4)	0	0	0	4	0	0	2	2

2020

February 2020 Recreational Fishing/Whale and Dolphin Watching Charter Operator Survey and Participatory Mapping Exercise

As described under the model descriptions for Recreational Fishing and Wildlife Viewing (Other Cultural Values), in February 2020, the project team conducted a survey and a participatory mapping exercise with charter operators (recreational fishing and/or whale and dolphin watching) from each of the five CROP countries. Two of the participants from Dominica identified as members of the indigenous community in Dominica, the Kalinago. Participants were mostly male. In Table 2, participants are characterized as representing the private sector; however, it could also be argued that these are stakeholders from the local communities.

Table 2. Number of participatory mapping exercise participants by sectoral and demographic categories

February 2020 Charter Operator Survey and Mapping	Community	Academia	Private Sector	Public Sector	NGO	Indigenous People	Male	Female
Dominica (6)	0	0	6	0	0	2	6	0
Grenada (5)	0	0	5	0	0	0	5	0
Saint Lucia (6)	0	0	6	0	0	0	3	3
St. Kitts & Nevis (6)	0	0	6	0	0	0	6	0
St. Vincent & the Grenadines (8)	0	0	8	0	0	0	6	2

May 2020 Stakeholder Webinars and Feedback Sessions

In May 2020, the project team hosted five one-hour stakeholder webinars and feedback sessions (one per country) to obtain feedback on draft models for the Coral Reef Recreation and Tourism model (encompassing On-Reef Tourism, Nature-Dependent Beaches, Paddle Sports and Seafood) and the Recreational Fishing model. The project team provided an overview of model methodologies and draft maps and asked for feedback on the general accuracy of the model and any additional modifications that were needed.

Stakeholder feedback during these sessions was generally positive. For on-reef tourism, there was some concern that not all dive shops in Dominica were represented, however, the Consultant verified the locations following the workshop. There was also some skepticism around the concept and meaning of nature-dependent beaches, and the Consultant has explained the definition and methodology in greater detail in the technical report and will be prepared to respond to similar questions in future communications products. Most participants preferred to see paddle sports characterized separately from the nature-dependent beach layer. Participants were near unanimous in their opinion that cruise ship tourism should be considered separately from overnight stays, and as a result of this feedback, the Consultant conducted a separate analysis for both types of tourism activities. For recreational fishing, feedback was generally positive, but many stakeholders suggested incorporating FAD data where available. Participants also suggested the inclusion of information on fishing tournaments in the region which led to a conversation with a tournament organizer on how best to spatially characterize this activity. Data on fishing tournaments and FADs were included in a subsequent version of the model.

Participants were invited based on their knowledge of marine and coastal tourism in each country, with an emphasis on diving/snorkeling, and fishing. Participants were primarily from the public sector, with some representation from academia and the private sector community organizations related to diving and fishing (Table 3).

November 2020 Stakeholder Webinar and Feedback Session

In November 2020 the project team hosted a stakeholder webinar and feedback session to obtain feedback on draft Coral Reef Fisheries model products, Wildlife Tourism methodologies and draft intensity maps, and to provide an opportunity for any final feedback into the Coral Reef Recreation and Tourism and/or Recreational Fishing models. It was decided to hold this workshop in a different format compared to the May 2020 sessions to provide more time for discussion and feedback and held break-out sessions by country after providing an overview of the products.

For the Coral Reef Fisheries model, discussions largely centered around the question of fishing impact, which does not always reflect current levels of fish stocks and enforcement if historical pressure has been high. In St. Kitts & Nevis in particular, the Consultant was encouraged to verify data in several areas. For Wildlife Tourism, much of the discussion centered around the question of how certain key habitat data can be used to characterize tourism, if it all. For example, in Saint Lucia there is very little tourism around sea turtles but there is some interest in developing that type of tourism, so turtle nesting site data may be helpful. Conversely, there is understandable concern that a map, which shows the locations of nesting sites, even in a generalized way, may promote tourism in areas where it shouldn't take place. Participants suggested a number of different sources of information on this topic, including Ocean Spirits, Widecast, and EPIC.

Participants were invited based on their knowledge of tourism and fishing activities in the region. All countries were represented except for Dominica (Table 4).

Table 3. Number of May 2020 stakeholder webinar participants by sectoral and demographic categories

May 2020 Stakeholder Webinars	Community	Academia	Private Sector	Public Sector	NGO	Indigenous People	Male	Female
Dominica (5)	0	0	2	3	0	0	2	3
Grenada (8)	0	3	0	5	0	0	5	3
Saint Lucia (9)	6	0	0	3	0	0	6	3
St. Kitts & Nevis (5)	1	0	0	4	0	0	3	2
St. Vincent & the Grenadines (7)	0	0	2	5	0	0	4	3

Table 4. Number of November 2020 stakeholder webinar participants by sectoral and demographic categories

November 2020 Stakeholder Webinar	Community	Academia	Private Sector	Public Sector	NGO	Indigenous People	Male	Female
Dominica (0)	0	0	0	0	0	0	0	0
Grenada (6)	1	0	2	2	1	0	5	1
Saint Lucia (6)	0	0	0	5	1	0	3	3
St. Kitts & Nevis (6)	1	0	1	4	0	0	3	3
St. Vincent & the Grenadines (4)	0	0	0	2	0	0	1	1

2021

May 2021 Communications Focus Group

In May 2021, the Consultant hosted a virtual focus group to gather feedback on final reporting and communications products being planned under the project. As described in earlier sections, the project team re-allocated budget from previously planned travel to develop additional communication products. This focus group was intended to gather feedback on the format and content of these bonus products, and also to gather feedback on the nature of the country summaries that were under development as a project deliverable. Stakeholders confirmed that the

country summaries would be impactful for policy makers, especially if they highlighted a medium-to-high level of detail and also provided some point of comparison among CROP countries. They also supported the development of infographics as a quick snapshot of the data that could be used by a wide range of stakeholders.

In this session, the team presented options for additional written summaries or videos. Participants favored the development of Technical Guidance Documents over Executive Summaries; however discussions following this workshop led to the team's conclusion that both products would be useful and would address the needs of different audiences. In general, there was low enthusiasm for videos as their utility as a promotional product tends to have a short shelf-life. All countries were represented except for St. Kitts & Nevis (Table 5).

Table 5. Number of May 2021 communication focus group participants by sectoral and demographic categories

May 2021 Focus Group	Community	Academia	Private Sector	Public Sector	NGO	Indigenous People	Male	Female
Dominica (4)	0	0	0	4	0	0	1	3
Grenada (3)	0	0	0	3	0	0	2	1
Saint Lucia (3)	0	0	0	3	0	0	2	1
St. Kitts & Nevis (0)	0	0	0	0	0	0	0	0
St. Vincent & the Grenadines (3)	0	0	0	3	0	0	2	1

Workshop 2

As described in previous sections, Workshop 2, originally planned as an in-person delivery of model results and training opportunity, was held online due to Covid-19 travel restrictions. Held on June 8, 2021 to coincide with World Oceans Day, the workshop was attended by marine and coastal planners and data managers, academics, representatives from various sectors including fisheries, environment, blue economy, green economy, as well as tourism stakeholders in the OECS. Global and regional partners collaborating with the OECS on various Blue Economy initiatives also attended. A total of 71 participants (not including presenters/facilitators) logged on throughout the day. This represented a participation rate of 40% when compared to the number of individuals registered. Participants represented a total of 26 countries and 48 organizations. Out of these participants, 28 represented CROP countries. The distribution is strongly skewed towards Saint Lucia; however, many of the participants were from the OECS, a co-host of the event, whose staff is located in Saint Lucia (Table 6).

While the conference succeeded in disseminating important data from the Mapping Ocean Wealth project and exploring the implications of the high value of tourism and fisheries to livelihoods in the region, lack of participation in the session on the Mapping Ocean Wealth online tool meant that the team was not able to gather feedback on the tool as originally anticipated for this workshop.

Stakeholder engagement analysis

While travel restrictions under Covid-19 prevented travel during the second half of this project, Workshop 1, held in the region in 2019, laid the groundwork for successful stakeholder engagement that persisted through the project. The primary contributing factor to successful stakeholder engagement was TNC's experience working in the region through its Caribbean Division.

Table 6. Number of Workshop 2 participants from CROP countries by sectoral and demographic categories

World Oceans Day Workshop (June 2021)	Community	Academia	Private Sector	Public Sector	NGO	Indigenous People	Male	Female
Dominica (2)	1	0	0	1	0	0	0	2
Grenada (3)	1	0	0	2	0	0	1	2
Saint Lucia (16)	1	1	3	11	0	0	4	12
St. Kitts & Nevis (1)	0	1	0	0	0	0	0	1
St. Vincent & the Grenadines (6)	0	0	1	5	0	0	2	4

Throughout the project, the TNC team based within the Eastern Caribbean identified and connected the wider team with individuals who could provide feedback on specific topics. Without the TNC Caribbean Division's existing strong relationships with stakeholders in the region, it is unlikely that the project would have had the benefit of broad stakeholder input for the duration of the project.

Based on feedback received during Workshop 1, a wide variety of data providers that were needed for model inputs were identified. While not strictly considered a stakeholder engagement activity under this project, it should be noted that in-country data collectors were hired in the second half of 2019 to make direct inquires and in-person visits to agencies, NGOs, and academic institutions who were thought to have data that could be used as model inputs. The project team believes that this had the effect of raising the profile of this project to data-providing stakeholders and enhancing the opportunities for buy-in as stakeholders could be assured that locally-relevant data were being used to inform the models.

The project team had planned to conduct in-person review of model drafts during 2020, and while this wasn't possible due to Covid-19, the team was able to collect helpful feedback during virtual work sessions in May and November of 2020. A benefit of this approach is that stakeholders who may not have been able to travel to a meeting were able to join, which provided the team with additional input that it may not have received otherwise; however, a drawback of this approach was that participants may be less willing to participate in lengthy online meetings compared to in-person workshops. This meant that the time to present on and receive input from participants was truncated in a way it may not have been if the team had been able to conduct in-person review. Similarly, additional in-person engagement would have provided an opportunity to address the somewhat disparate nature of participation among the five CROP countries, especially Dominica.

Similarly, Workshop 2 had pros and cons with respect to the virtual nature of the event. In the context of a global pandemic, the virtual conference center platform provided an innovative and cost-effective way to emulate a conference-like environment, providing an opportunity to garner participation from all over the globe and provide opportunities for interaction between participants and presenters.

Despite the success of this event, the nature of the virtual platform made it more difficult to engage and interact with participants compared to an in-person workshop. Multi-day virtual workshops are typically not well-received, and so the original agenda for the workshop had to be shortened. Building relationships with stakeholders can often be strengthened though more casual conversations and questions that can come up during a multi-day workshop. Had the workshop been held in-person, it would have been held in another country besides Saint Lucia,

where Workshop 1 was held. Similar to the in-person travel planned for 2020, this would have most likely balanced out the over-representation of Saint Lucia stakeholders noted in Workshop 1. Table 7 tabulates all stakeholder participants from CROP countries over the life of the project.

In the absence of an opportunity to conduct any additional travel to the region beyond February 2020 during this project, it may be useful to provide additional training and engagement on the use and applications of the data and tools to encourage uptake. More details are provided in subsequent sections of this report. In addition to the technical report and country summaries that are core deliverables of the project, the project team will be developing additional guidance documents and summary materials to assist with uptake of the data and models. These are described in more detail in the project outputs section.

Table 7. Number of stakeholders from CROP countries for all engagement activities throughout the project by sectoral and demographic categories

All Engagement Activities	Community	Academia	Private Sector	Public Sector	NGO	Indigenous People	Male	Female
Dominica (13)	0	0	8	5	0	3	9	4
Grenada (20)	1	3	7	8	1	0	15	5
Saint Lucia (41)	5	0	7	27	2	0	20	21
St. Kitts & Nevis (19)	2	0	7	10	0	0	15	4
St. Vincent & the Grenadines (18)	0	0	10	8	0	0	12	6

Applications

Strengthening the Blue Economy

The roadmap towards a Blue Economy necessitates knowledge of values and preferences surrounding the use of marine resources. Ecosystem service modelling and mapping captures and quantifies these values, makes them spatially explicit, and enables their direct utilization alongside maps and statistics from other social and cultural activities and values. Sustainable development, a key concept of the Blue Economy requires consideration of the linkages between livelihoods, socio-cultural benefits, and healthy ecosystems. Ecosystem service data are a key tool in illuminating these linkages such that they can promote a Blue Economy. Consideration of ecosystem services also helps to build the financial justification for a Blue Economy by highlighting current benefits of coastal and marine habitat conservation that may be overlooked when only considering industry or government revenues or the costs of management actions (Börger et al. 2014).

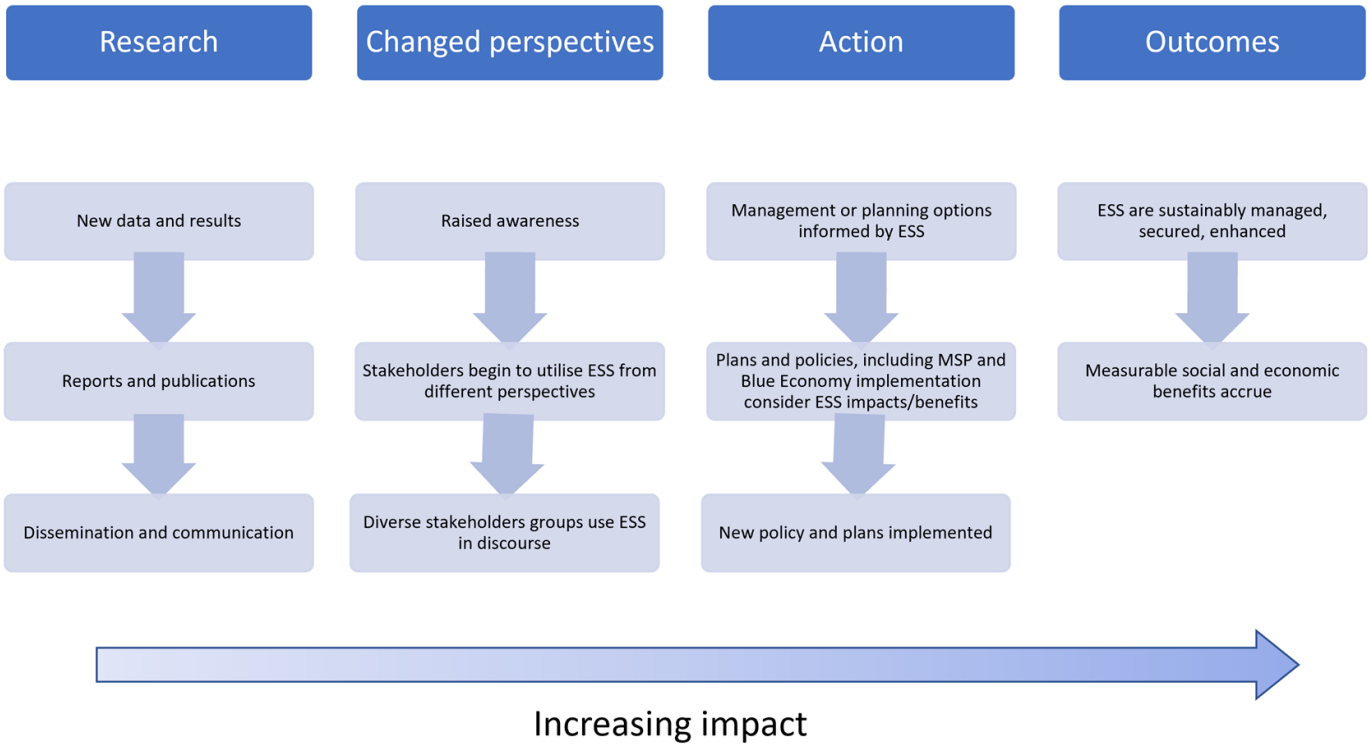
Overview of potential uses of ES data in MSP and other conservation applications

Ecosystem services underpin much of the social and economic structure of society, and any planning in any sector, from government, industry or civil society needs to account for them. Not only do they provide direct benefits to many, but their dimunition or loss can have considerable direct, downstream or even intergenerational impacts. It is particularly incumbent on those responsible for multi-sectoral planning and management to consider costs, benefits and ramifications of any and all activities that may influence ecosystem service delivery.

This places the need for high quality ecosystem service data at the core of any successful marine spatial planning process of marine spatial planning (MSP). The ecosystem service data generated through this, and similar projects, can strengthen existing knowledge, but can also create new understanding, filling knowledge and data gaps on human uses that had been less widely considered or mapped (e.g., by mapping the spatial footprint of whale/dolphin watching and chartered recreational sportfishing). By mapping values onto the ecosystems themselves they also help to generate a far better understanding of the variance of value within an ecosystem depending on multiple other factors.

Figure 27 gives an indication of how ecosystem service value can begin to shape and support benefits to people, in a sequential process. The MOW work has already included the first two pillars with research being undertaken and disseminated and, through outreach and engagement beginning to influence perspectives. Greater impact will be observed as the information from this project begins to be built into practical action, ultimately leading to outcomes that benefit people. Such benefits have been modelled, for example, in Belize where the inclusion of ecosystem service values into planning scenarios led to better outcomes for both coastal conservation and stakeholder livelihoods. This is largely accomplished by clarifying the trade-offs among various management scenarios in a way that maximizes benefits across multiple sectors (Arkema et al. 2015).

The use of ecosystem services in a management context can also enhance stakeholder engagement outcomes. The metrics associated with ecosystem service data (e.g. tourism arrivals and expenditure, fish catch) are often easier to understand than traditional scientific metrics. This can have the effect of broadening stakeholder support, especially as stakeholders can more readily understand the impacts of ecosystems on their own livelihoods. Evaluating ecosystem services can also help identify stakeholders that may not have otherwise been included in an MSP process, and can help to identify commonalities and shared objectives amongst otherwise



Ruckelshaus et al, 2015

Figure 27. Figure describing the pathways through which ecosystem services can impact thinking, action on, and benefits from on conservation and management. Figure adapted from Ruckelhaus et al. 2015.

diverse stakeholder groups (e.g., Arkema et al 2015, Granek et al. 2010, Guerry et al. 2012). Friedrich (2020) found that under the right conditions, engaging stakeholders in ecosystem service assessments not only increases the quality of the resulting data, but can improve stakeholder collaboration and support of the MSP process overall.

In addition to MSP, ecosystem services have other practical applications, as summarized in Table 8 (Adapted from Waite 2015).

Despite the many benefits, ecosystem services are just starting to be incorporated into marine spatial planning. Ruckelhouse et al (2015) documented 22 locations around the world where ecosystem service data was being integrated into decision-making; however, the majority of these locations were terrestrial. By including ecosystem service data as a key element of its planning tools, the Eastern Caribbean is already ahead of the curve in incorporating ecosystem services into future planning.

Utilising ecosystem services data in the Eastern Caribbean

Nature dependency – the importance of ecosystem services

Natural resources provide a critical bedrock to the social and economic security and prosperity of the Eastern Caribbean, a key component of employment, food security, foreign exchange earnings and indeed the health and well-being of the population.

Threats to natural resources thus present risks to society. By contrast, wise management and the enhancement or restoration of natural resources can represent an opportunity for social or

economic enhancement.

The data and maps presented through this work represent a critical information source to enable informed natural resources management decisions. Clearly in any setting, natural resources form part of a complex dynamic system – activities in one sector or location have consequences and influences. The decision to dredge a channel or to build a marina may have impacts on scuba diving opportunities or fishing. Equally, the decision not to build may have opportunity costs of lost potential income and employment.

By having detailed spatial models of the use of natural resources, and, in some cases, direct economic values associated with these, there is the potential to build, plan and optimize benefits from natural resources to ensure secure and sustainable futures.

Table 8. Summary of existing applications of ecosystem services on coastal and ocean management, adapted from Waite (2015)

Application	Example	Source
Coastal protection/sustainable use policies	St. Maarten: Valuation study leads to establishment of Man of War Shoal Marine Park	Bervoets (2010)
Increasing awareness	Belize: Understanding of value of coral reefs and mangroves leads to action on multiple fronts (e.g., new fisheries regulations, fines for reef damages, campaign against offshore drilling)	Cooper et al. (2009)
Establishing levels of damage compensation	Florida Keys: Valuation results used to establish schedule of fines for damage to live coral; fees used for restoration	Leeworthy (1991)
Determining fees for use	Bonaire: Valuation studies justified adoption and increase of user fees in Bonaire Marine Park	Dixon et al. (1993); Uyarra et al. (2010), Thur (2010)
Payments for ecosystem services (PES)	Honduras: Valuation led to PES mechanism in which tourism sector pays national park to maintain coastal water quality	PNUMA (2013)
Assessing trade-offs	Belize: Comparison of coastal zoning scenarios being considered under national Integrated Coastal Zone Management Plan	Clarke et al. (2013)

Bringing ecosystem services into marine spatial planning

A core commitment of the CROP countries in developing a sustainable Blue Economy is the development of coastal and marine spatial plans (CMSP).

Marine Spatial Planning takes countries beyond traditional single sector planning (for example fisheries, tourism, shipping, renewable energy, conservation) and seeks to integrate and optimise the use of ocean space for all users, building synergies and attempting to minimize conflicts. Central to this process is ensuring that planning is open, transparent and equitable, engaging all potential stakeholders at all stages (Figure 28). Building in the best available information, map-based where possible, is critical to support balanced and informed discussion and decision-making, and as a means to plan future activities in marine and coastal waters.

Under the CROP, a series of draft Coastal Master Plans and Marine Spatial Plans have been submitted to the national governments by a group of CROP Consultants, and it is hoped that they

will be accepted and implemented in the near future (see Box 2).

The ecosystem service modelling work was undertaken in parallel with the development of the coastal and marine spatial plans, meaning that the ecosystem service model results were not available during their planning process. Nevertheless TNC's work, for the first time, furnishes stakeholders with detailed data and maps for two of the most important social and economic sectors in these countries – tourism and coastal fishing.

Such data can now be incorporated into the MSP process and this should be a priority as part of the finalization of these, or indeed any future, plans.

At the simplest level these models and maps enable the discernment of critical areas of current use of natural resources and form a core background for stakeholder discussion and debate (Step 5 in Figure 28). The same information can also be used in the projection of future use options, including the potential costs and benefits of different uses and activities in coastal and marine waters (Step 6, Figure 28).

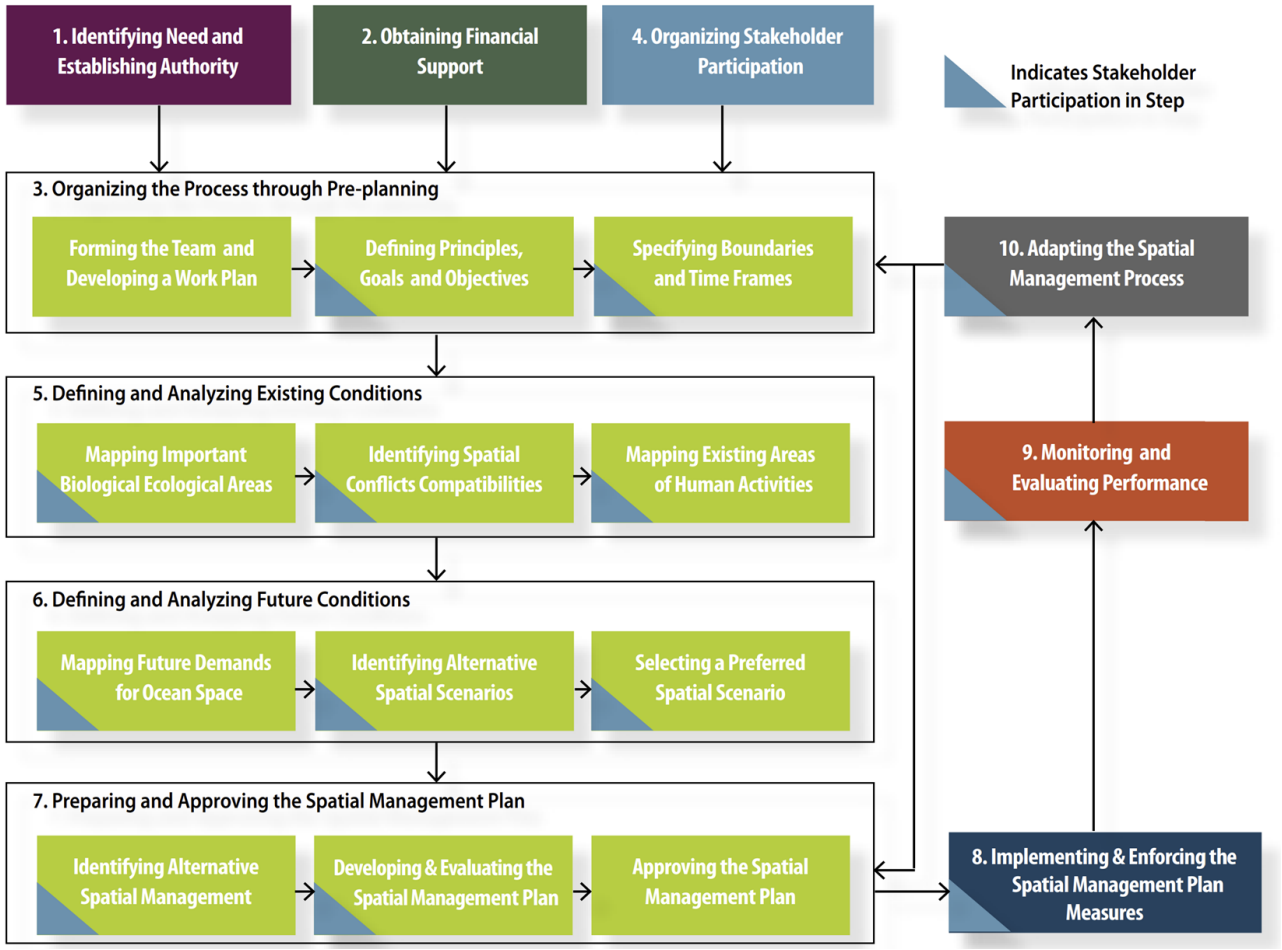


Figure 28. The step-by-step approach to MSP recommended by UNESCO (Ehler and Douvere 2009)

Another key feature of MSP is that planning needs to be cyclical and ongoing, rather than a static, one-off, process. This means that information can be continually added or updated to future planning cycles, along with knowledge or new opportunities or risks.

Box 2. Coastal and Marine Spatial Plans Created Under CROP

The marine spatial plans completed by Dillon Consulting under the CROP project provide possible frameworks under which the data from the MOW project could be analyzed as part of future planning cycles or management actions.

The MSPs contain risk hot spot maps (Figure 2a) that highlight areas where human activities have high interactions with ecosystems. Unsurprisingly, many these hot spots overlap with high ecosystem service values from the MOW analysis. Further analyses of these interactions using ecosystem service data could better illuminate risks to ecosystem service values in the face of ecosystem degradation, and illuminate opportunities for mitigating these risks.

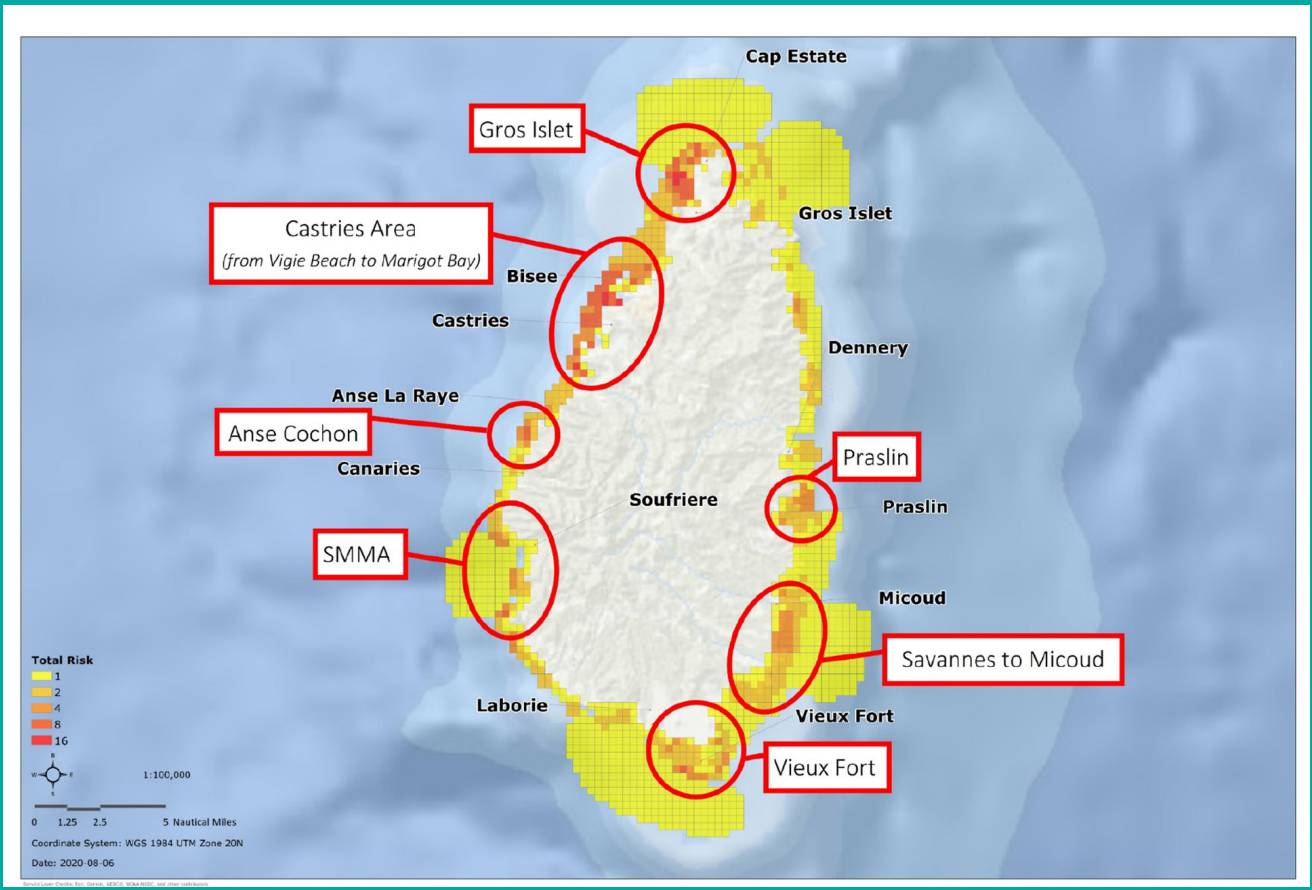


Figure 2a. Example risk hot spot map from draft Saint Lucia MSP

The MSPs also contain suggested zoning scenarios for nearshore coastal areas, intended to develop a more comprehensive approach for marine management (Figure 2b). Data from this projects could be used to refine zones during future planning cycles. There may also be value in calculating ecosystem service values within these proposed zones to further highlight the need for zoning scenarios that protect and potentially enhance existing ecosystem services within these zones.

Finally, the coastal master plans have identified for each country priority projects that would maximize Blue Economy goals. Many of these projects focus on sustainable tourism and artisanal fisheries, and for some projects, decisions around the specific locations for project implementation are still underway. Spatial ecosystem service data from this proj-

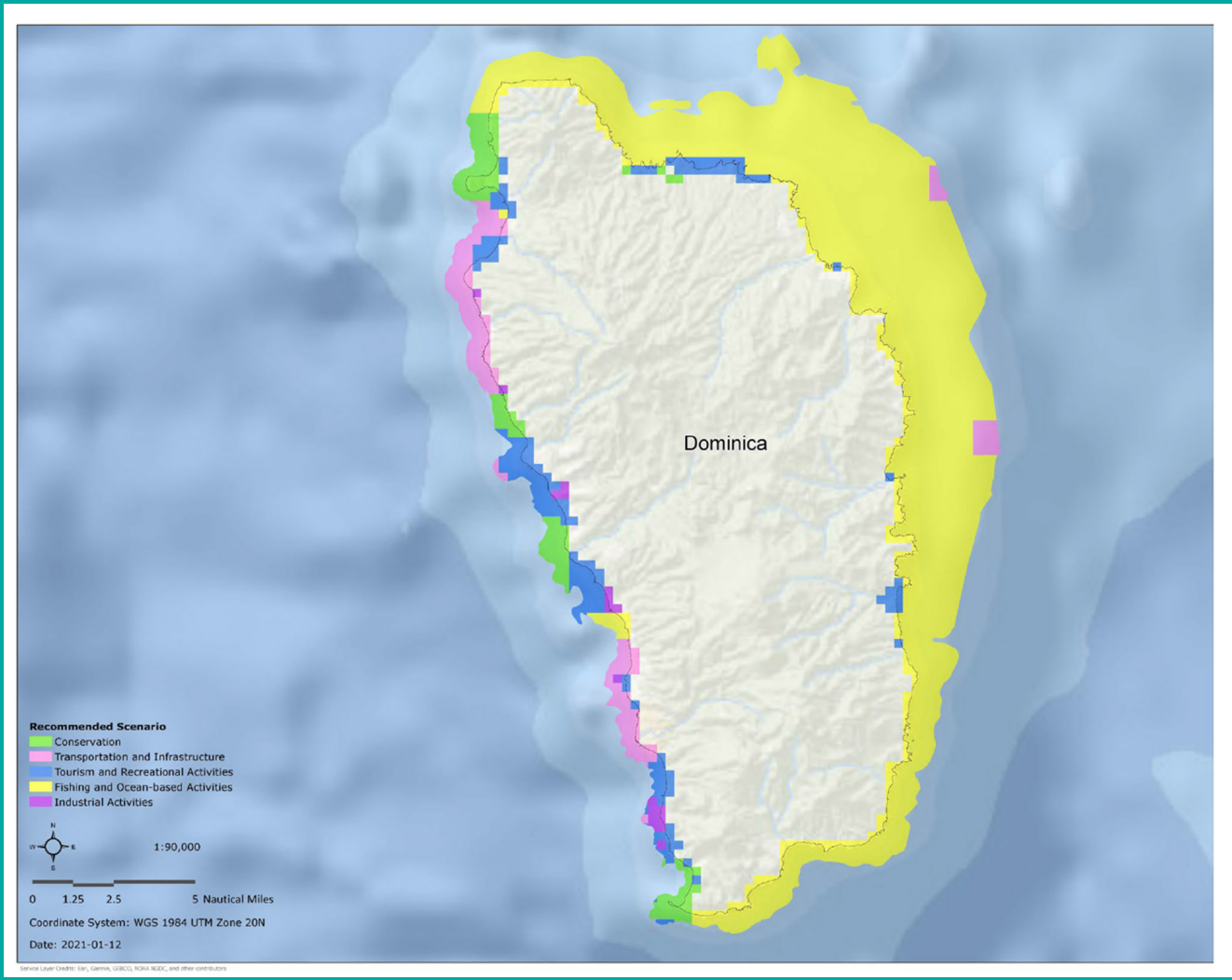


Figure 2b. Recommended zoning scenario from Dominica's draft MSP

ect could inform decisions around locations where these projects would have the greatest impact. For example, in Grenada, one priority project is a Sustainable Tourism program, which will explore the development of sustainable policies for tourism operations, fostering further connections between the local population and the tourism industry. The plan suggests that this project could be implemented in multiple locations across Grenada. The data on reef-based tourism could help identify locations where tourism pressure is high and where interventions may be needed to prevent future damages to reefs. Alternately, data may be used to identify locations that may benefit from promotion of reef-related tourism, with an eye towards proactively planning for ways to do so in a way that limits future impact.

Zoning and marine protected areas

Among the practical outcomes, which arise during theimplementation of MSP is the establishment of marine and coastal zoning. Zoning provides a practical spatial framework for human uses and activities, and enables planners to build a fair distribution of access and use, optimising benefits to all stakeholders.

Within, or parallel to, zoning is the identification of protected areas in which conservation of

biodiversity and ecosystem services is a key priority. Protected areas systems typically offer differing levels of protection, from marine reserves or no-take areas where no extractive or damaging activity is permitted (e.g. no fishing, dredging or anchoring), to other areas where human impacts are restricted, but some types of fishing or other uses may still be permitted. There are growing international calls for conservation targets to reach at least 30% of marine space by 2030 (30 x 30, see for example https://www.iucn.org/resources/issues-briefs/post-2020-global-biodiversity-framework), of which a significant proportion (typically more than 10%) should be no-take marine reserves.

The placement of protected areas within marine zoning plans is obviously part of the planning process and a detailed understanding of patterns of both biodiversity and of the ecosystem services is critical. Such data can highlight areas in greatest need ofprotection or indeed areas that will provide the greatest returns in terms of benefits to both people and nature. The same maps and data can enable the direct calculation of potential benefits for different zoning and protection scenarios, and to track progress as systems are unfolded.

Supporting new policy commitments

Government policies are always adaptive and dynamic: informed by public opinion, international events, economic change and many other factors. By making available a clear and mapped vision of some of the key elements of two of the major industries in the CROP countries we provide a tool for governments to inform policy development and decisions. Indeed, our data and maps may highlight the need to change or advance new policy as a means to secure ecosystem benefits, or to enhance such benefits.

International commitments

Many national policies are also shaped by regional and international agreements and commitments, and it is likely that other such commitments will develop in the future. One key element here is the development of area-based targets for conservation, notably the growing international support for expanding protected areas to cover 30% of marine and terrestrial space by 2030, which received overwhelming support at the IUCN World Conservation Congress in September 2021 (https://www.iucncongress2020.org/motion/101) and may be adopted by the UN Convention on Biological Diversity in early 2022 (https://www.cbd.int/article/draft-1-global-biodiversity-framework). With a focus on both biodiversity and on protecting ecosystem services, the maps and models of ecosystem services developed here should be a critical resource in developing frameworks for protection that deliver maximum benefits, equitably across the CROP countries.

Future planning

All of the maps and models developed under this work represent recent (to 2019) patterns of value. The impact of Covid-19 has been enormous – the contribution of GDP to the economy has fallen by 65-72%, with job losses of 28-34% within the sector from 2019 to 2020 (WTTC 2020).

Post-Covid, or in a Covid-adapted world, it seems like that demands for tourism may change, driven by the industry, or by the consumers (Spalding et al. 2020). It is possible that such change may be further influenced by other environmental concerns or regulations, regarding both biodiversity conservation and climate change. There is thus a growing interest in building a recovery which will cater to these concerns, and a recognition that by doing so, recovery itself may be enhanced (OECD 2021; Moses 2020). Central to such recovery may be recognizing that tourist numbers may remain low for some time, and that those who come may seek to avoid crowds and want to spend longer in the open air. All of these point to an enhanced interest in nature-based or nature-dependent elements of tourism. Our maps can play a central role in un-

derstanding the importance of nature, spatially, and should help in the drafting of recovery plans which utilize these values, without undermining them.

The maps give a real picture of recent value. Such values are informative and can, for example, be extrapolated and utilized in a predictive manner for planning purposes. Post-pandemic patterns of value will most likely tend towards those currently mapped as the infrastructure and knowledge of such places remains, however there may be shifts. There may, for example, be a move away from tourist centers perceived as crowded, towards lower density or more isolated settings; or there may be a slower recovery, or even a net decline, in cruise tourism. Even with such changes, it may be possible to use sub-components of the model to maintain a broad picture of values, or to consider scenarios, asking "what if?" questions, as a means to guide investment or planning.

Such approaches are effectively using recent or current values to predict potential values. This is explicit in the coral reef fisheries models where it is possible to see the impacts of fisheries closures or of coral reef restoration on reef fish. With the tourism values it may be less obvious, but planners can observe values and extrapolate potential to potential change. "What if" cruise tourism were to be excluded, for example; or hotels away from population centres were to become heavily preferred. Likewise, the maps give potential values that might guide, for example, the opening up of new visitor centres for birdwatching, or the encouragement of new diving operations in a region.

It is important to realize that underpinning the maps and the statistics are models and data (see the technical reports). These not only enable users to understand in more detail what may be driving patterns, but they also give the potential to re-run the maps to develop updates through time. Indeed, such updating may be a critical part of the ongoing marine spatial planning cycle.

Finally, it should be pointed out that this work is unique, and that few, if any, other countries have advanced such detailed information on ecosystem services. Sharing this work more widely will draw attention to the many facets of nature dependency that are more widespread than the countries considered here. It might be hoped that similar data could be generated for other countries as a critical input to the Blue Economy transition that is gaining traction more widely. Further work might also include expansion of the range of ecosystem services explored, for example to cover carbon storage and sequestration in mangroves and seagrass ecosystems; the role that coral reefs and mangroves play in erosion and storm protection; and patterns in offshore fisheries values.

Supporting key stakeholders

The data and maps are not solely designed for planners or government agencies, but are available to all. We envisage that many different civil, industrial or public groups may wish to utilise this information. For example:

- The diving industry may find it can use both maps and the very large values associated with their industry to support arguments for greater protection for key diving areas.

- The hotel industry may find the values of beaches, or indeed birdwatching, in their vicinity compelling, driving them to consider using these to enhance sales or to inform decisions for future development.

- Fishers may wish to protect key fishing grounds from plans for shipping lane dredging, or indeed to call for better management of more degraded areas.

- Civil society groups and NGOs may utilise information about birdwatching, whale-watching or

on-reef activities to build their case for new protected areas.

- The tourism industry may consider this information in its Covid-19 recovery efforts. There is considerable discussion amongst the sector to "build back green" Dominica, for example, is seeking to become the world's first climate-resilient nation", and in doing so, seeks to support environmentally-responsible growth of the tourism sector. Data from this project could be used to identify high-value, nature-dependent locations as a focus for these efforts.

While these and other interests and demands would likely feature strongly in any consultations and engagement associated with MSP, they can also inform independent efforts and campaigns.

As an example of future planning, the CMSP project led by Dillon Consulting led to additional analysis including risk assessment and scenario development (see Box 2); such analyses could be enhanced with incorporation of new data from our work.

Guidance for use

Users wishing to use the data generated from this project should consult the ample documentation, including technical reports, metadata, and user guides provided on the project website. Understanding the data-inputs and methodologies will clarify scope and limitations for these datasets. For example, the coral reef base-maps have a high degree of accuracy. These were gridded to a 100m grid (one hectare cells). By contrast, the input data for locating on-reef activity is of variable, and often poorly defined, accuracy. To avoid risks of geographic errors generating false accuracy, in general, we recommend that the maps be used at an assumed resolution of no less than 1:10,000 and in generating statistics we advise not attempting to summarise information for any areas smaller than 2x2 km.

All of the data used and presented represent activities up to 2019. The influence of Covid-19 on tourism has been enormous and we cannot assume that eventual recovery will include a return to the pre-pandemic patterns. At the same time, the models and maps should be of considerable use in planning new efforts to build back better post-Covid (see above). As described earlier, many of the tourism statistics have been averaged over a 5-year period (up to and including 2019). Such an approach helps to remove annual fluctuations, however it may also mask trends or step changes that may arise (for example the building of a new cruise port or a rapid and large-scale expansion of overnight infrastructure). We recommend that users who are aware of such influences bear these in mind when examining our maps and make allowances for such change.

These are modelled data products based on a series of assumptions, including the motivations and activity patterns of tourists. Model assumptions have been vetted by experts, stakeholders, and data where possible. Some of the models are also heavily based on crowd-sourced data points, which may be subject to bias. As such, interpretation of statistics, especially for very small areas, should be treated with caution. Estimates will be more robust when based on larger areas. Pixels with no measured values for any service could represent gaps in our knowledge: as not all values will be captured in the modelling approach used. Furthermore, we have not measured all ecosystem services, so a lack of value in our models should never be considered to indicate a zero value – almost every ecosystem, everywhere, will play multiple roles, from the conservation of biodiversity to the protection of coastlines, to the many cultural and existence values that remain very hard to quantify, but which play an important role in individual and societal well-being.

Recommendations for future trainings and capacity building

The Covid-19 pandemic led to considerably reduced opportunities to inform and train people in

the CROP countries about our data and the tools at their disposal to explore and analyse these. There would be considerable value in offering additional training both in the principles and approaches of ecosystem services mapping and more practical utilisation of the tools to enable people to draw maps and to generate and analyse data.

More in-depth training could also be helpful to expert practitioners and Geographical Information Systems (GIS) specialists or others working in data processing or science roles who may wish to utilise raw data or indeed the input layers. Such persons may, in turn, be able to take on the task of updating or refining maps going forwards.

In person workshops can be the most effective way of transmitting and sharing skills. There would also be considerable value in "training trainers" to develop in-region capacity to pass on further training across the region or with individuals or key sectors.

Challenges, Lessons Learned, and Recommendations for Future Work

Challenges and Lessons Learned

Covid-19

The onset of the global Covid-19 pandemic in early 2020 provided the most immediate and obvious challenge to the work, by preventing planned in-person engagement for the remainder of the project, as detailed in previous sections. Another key impact of Covid-19 is on the future interpretation and applicability of the model data. The models were built to reflect values for the period immediately preceding Covid-19, typically using multi-year summaries up until this date (see technical reports for further details). The pandemic has had a dramatic impact on tourism, and will likely have also impacted patterns and effort in fisheries. The longer-term impacts, post-pandemic, are too early to predict.

It is likely that national dependence on reef fisheries may have increased, raising the urgency for active management to ensure long-term stability of these. For tourism, it seems likely that the natural values, so important in CROP countries, will prove a key driver in tourism recovery. Low density tourism in natural areas may be critical and may begin to play a more important role in generating tourism receipts than pre-pandemic. To that end, the models are still relevant in the planning context; however additional contextualization and interpretation may be needed.

The Technical Guidance Documents that are being produced as supplementary outputs of this project are intended not only to address the gap in engagement and training brought on by the pandemic, but also to help future users of the data with data analysis and interpretation.

Data Gaps

As described in earlier sections, spatial data on human use of natural resources are often sparse, and, in the Eastern Caribbean. This work has dramatically advanced understanding of the sectors evaluated during this project. Where possible, locally-derived data was used alongside the data from visitors obtained from major data platforms like TripAdvisor and eBird. Such local data filled important gaps in some of these other datasets (for example the global dive-sites databases were far from complete). In other cases, however, there is no local equivalent (for example to weigh the natural value of beaches). The role of in-person participatory mapping exercises for determining key elements of recreational fishing and whale/dolphin watching were critical to address data gaps.

Despite this progress, gaps remain. It was not possible for us to distinguish other nature dependent activities such as open-water swimming and small boat sailing. The strong desire of various participants to map nature-dependent "sunset cruises" proved a considerable challenge and was not considered sufficiently reliable to share. There are also, inevitably, constraints on scale and accuracy (see limitations, above). These of course vary between models, but in most cases, caution needs to be applied in reading off very fine detail. For some services, it was also not possible to move beyond relative values and instead "use intensity" is recorded. While monetary values are not always the most useful (values can be expressed in terms of jobs, votes, participants, and many others), the availability of hard numbers can be critical in comparing values between uses and activities.

The coral reef fisheries models were especially impacted by the lack of consistent fish survey data across the study area. While the models still capture the main drivers of fish and fishing, users of this dataset should note the relatively wide confidence intervals for each model-derived

relationship. Another challenge was characterizing habitats and habitat attributes for the models. Additionally, some of the fish survey sites did not have accurate coordinates, which limited the ability to match them to habitat types on the underlying maps. While it is well established that reef complexity is important for predicting fish biomass, this metric was poorly quantified for many survey sites in this region. Consequently, it is unlikely that all the variation that is occurring across habitat types (e.g. between spur and groove reef and low-relief back reef areas) has been captured. Thus, while the products shown in this report were not previously available and result from many scientists and groups sharing their data, it would be prudent to use these maps in combination with other information (e.g. fishery-dependent surveys or community-generated maps) where possible.

Coordination with CMSP

As noted in previous sections, ecosystem service data is typically the most useful as data input into a CMSP process in the phase of analyzing baseline conditions and integration into scenario planning. The timeline of this project meant that activities under the MOW project were not complete until well after the data collection and planning phases of the CMSP development were underway. However, as described, the outputs provided by this project add substantial value to coastal and marine planning and management in the region moving forward under future planning iterations, and have potential applications above and beyond the marine spatial planning process.

Recommendations for future work

There are a number of ecosystem services relevant to the region, which were outside the scope of this project, but which should be considered as opportunities for future work. They are briefly described below:

Blue Carbon

There was considerable interest in blue carbon (i.e. the carbon stored and sequestered by coastal ecosystems) at Workshop 1, and ongoing improvements to mangrove and seagrass habitat data can facilitate more accurate assessments of blue carbon in the region. These estimates can not only help to prioritize conservation and management actions, but can also be used in developing or enhancing policy goals. The Mapping Ocean Wealth tool contains estimates of mangrove blue carbon on a country basis; however these estimates could be enhanced with more regionally-specific habitat data as well as field-based estimates of carbon storage.

Coastal Protection

The region's vulnerability to damage from hurricanes and other extreme weather events is only too well known and a strong case could be made for an analysis of coastal protection values from coastal habitats. Global analyses of coastal protection values (i.e. number of people and value of property protected) have been developed, however these are of very low resolution and are of no value for fine-scale planning at the scale of small island Caribbean states. Nonetheless, the knowledge behind the processes of coastal protection values of bother mangroves and coral reefs is such that future work could make these investigations and could highlight areas where coastal habitats should be prioritized for conservation. They may also highlight opportunities for restoration in areas where coastlines are vulnerable.

Commercial and Offshore Fishing

While this study highlighted the linkages between coral reefs and small-scale and artisanal fishing, it did not address fishing for invertebrates (lobster, conch, sea urchins) or fishing in offshore

waters, both from larger commercial operators, but also small-scale fishers. Future work could seek to understand the value and distribution of these fisheries, and further could investigate the enhancement value that coastal ecosystems may be providing to these fisheries.

Other Tourism Services

As described in a previous section, Workshop 1 participants identified a broad range of nature-dependent tourism activities that they were interested in seeing analyzed as an ecosystem service dataset. Options included mangrove tours, hiking, seafood-dependent tourism (e.g., gastro-tours), boating/yachting, conservation, research and educational tourism, therapeutic tourism around natural features (e.g., mineral baths), events and festivals. Sunset sails and catamaran tours came up as a major sector of interest, and while it was not possible to accurately characterize these activities under the scope of this project, it may be possible in the future to collect sufficient data to develop a spatial representation and associated value of these activities.

Other Cultural Services

This work had a strong focus on tourism, which, in large part, is international. The enjoyment of natural resources also plays a strong role in the national culture of these islands, including the physical, mental, and spiritual benefits of recreational activities. Some of the latter are notoriously hard to quantify and therefore are often missing from ecosystem service assessments; however, they arguably are the most important as they are those that are top of mind when people think of their own connection to nature. Future planning efforts would benefit from mapping cultural ecosystem services, especially those that contribute to a unique sense of place for the Eastern Caribbean.

Combined Data Products

While the outputs of the models cover a wide subject area, and also vary in terms of values and resolution, there would be value in considering how these and potentially other services interact. Such interactions can be positive, negative or neutral, but the concept of "bundling" ecosystem services helps to give a more comprehensive assessment of total values for places or ecosystems. It might also help to identify hot spots for particular aspects (e.g. tourism hot spots) as a means to focus attention or prioritise investment.

Likewise there is considerable value in placing ecosystem service values alongside other values. This of course forms a core part of Marine Spatial Planning, however the combination of datasets in an interactive setting may also be something that merits attention in the development of future mapping and planning tools.

Enhancement of Existing Models

Some of the models have resulted in basic expenditure estimates for various tourism activities; however, more in-depth economic analysis such as value chains, and downstream impacts of these services such as job creation would be a potential next step in enhancing these datasets. In other cases where it was not possible to estimate expenditures, collecting the necessary data to do so would be helpful in enhancing the models.

Expansion to Other Geographies

With the exception of the coral reef fisheries model, which relied on habitat connectivity considerations across the Eastern Caribbean, the models under this project were developed for only the five CROP countries. Expanding these analyses to the scale of the Eastern Caribbean or even the entire Caribbean region would provide valuable insights on patterns of nature-dependent

tourism and conservation opportunities and regional-scale dependencies on marine habitats to support these activities.

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Appendix A - Monitoring and Evaluation Framework

Task	Indicator	Status
1. Planning and Management	1.1 Timely delivery of Work Plan and Inception Report to Client	Complete
	1.2. Meetings between Client and Consultant are held quarterly or on an as-needed basis	Complete
	1.3. Key experts meet at least once/month	Complete
	1.4. MOW Advisory Board meets twice yearly	Complete
	1.5 MOW Advisory Board meets in person	Not possible due to Covid-19
	1.6. Timely delivery of yearly project reports	Complete Year 1 & 2 reports delivered to Client by December 15th, 2019 and 2020.
2. Training and Workshops	2.1. Trainings and workshops are held in a timely manner	Complete; Workshop 1 held in May 2019; Workshop 2 held virtually on June 8, 2021
	2.2. Workshop participants are target users of data and information	Yes, see Workshop 1 Report and Workshop 2 Report
	2.3. Workshop participants are geographically representative of participating OECS countries	All CROP countries represented in Workshop 1 & 2, though participation in workshops from Dominica was lower compared to other CROP countries
3. Tool development	3.1. OECS reporting tool is developed in a timely manner and made available users on the web	Complete
	3.2. OECS reporting tool is tested by stakeholders for usability	Complete
	3.3. Marine Spatial Agent app is developed in a timely manner and made available on mobile platforms	Complete
	3.4. Marine Spatial Agent app is tested by stakeholders for usability	Application would benefit from additional testing post-CROP
4 - 7. Ecosystem Services Models (Coral reef recreation and tourism, coral reef fisheries, recreational fishing, and other cultural values)	4-7.1. Model is developed in a timely manner and results are incorporated into OECS MOW reporting tool and Marine Spatial Agent app	Complete
	4-7.2. Model is informed by stakeholder feedback	Complete; see stakeholder engagement section of this report and model technical reports for details
	4-7.3. Geographical representation of data used to build model	Complete; see detailed maps in model technical reports
8. Synthesis and Reporting	8.1. Country-based summary reports (one per participating OECS country) integrated into MOW online tool	Complete
	8.2 Final completion report is delivered in a timely manner	Complete with the delivery of this report
	8.3. Project results are disseminated through appropriate communication channels (e.g., websites, blogs, publications)	Complete, with some additional communications products to be finalized after the submission of this report. See: https://oceanwealth.org/project-areas/caribbean/crop/