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Marine Zoning in Saint Kitts and Nevis

A Path Towards Sustainable Management of Marine Resources

Report by:

Vera N. Agostini, Shawn W. Margles, Steven R. Schill, John E. Knowles, Ruth J. Blyther

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This report was made possible by the generous support of the American people through the United States Agency for International Development (USAID) under the terms of its Cooperative Agreement Number 538-A-00-09-00100-00 (Biodiversity Threat Abatement Program) implemented by prime recipient The Nature Conservancy and partners. The contents and opinions expressed herein are the responsibility of the Biodiversity Threat Abatement Program and do not necessarily reflect the views of USAID.

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Published by: The Nature Conservancy

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Cover photographs: Top photograph by Shawn W. Margles. All others by Steven R. Schill.

Suggested Citation:
Agostini, V. N., S. W. Margles, S. R. Schill, J. E. Knowles, and R. J. Blyther. 2010. *Marine Zoning in Saint Kitts and Nevis: A Path Towards Sustainable Management of Marine Resources*. The Nature Conservancy.

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Participants in one of the project's workshops.

Steven R. Schill

The skilled staff from St. Kitts and Nevis Coast Guard played a key role in seabed mapping.

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EXECUTIVE SUMMARY

Human activities are placing increased and often conflicting demands on coastal and marine waters worldwide. As a result, important coastal areas are under intense pressure, threatening the biological diversity of marine habitats and the ecosystem services they provide, such as coastal protection, food security, tourism amenities and biodiversity protection. Marine zoning, one of the possible outcomes of a marine spatial planning process, has emerged recently as an approach to address these issues. The case for marine zoning is particularly strong in the Caribbean, but there are few examples to date of comprehensive marine zoning for tropical island nations.

This project initiated a marine spatial planning process and developed a draft marine zoning design for a small island nation in the Eastern Caribbean. St. Kitts and Nevis was chosen as the project site because it met a set of selection criteria, including that its government was aware of marine zoning as a useful management approach and was interested in applying it in their country.

The goal of this project was to lay the groundwork for future implementation of marine zoning in St. Kitts and Nevis by assisting in the development of a marine zoning design and providing a set of tools that could inform this and other management efforts. The project had two primary guiding principles: (1) rely on the best available science for making decisions and (2) engage stakeholders at all possible levels. The project team used the following process:

1. **Engage Stakeholders.** The project included more than a dozen formal and numerous informal meetings with diverse stakeholders and decision makers from government, community groups, the private business sector, and fishers' associations.
2. **Establish Clear Objectives.** Through a participatory process, stakeholders and decision makers defined a vision for marine zoning in their waters. This vision was used as a basis for all project activities.
3. **Build a Multi-objective Database.** The project team devoted significant resources to gathering, evaluating and generating spatial data on ecological characteristics and human uses of the marine environment. Three main approaches were used to fill data gaps: (a) expert mapping, (b) fisher surveys, and (c) habitat surveys.
4. **Develop Decision Support Products.** To help the people of St Kitts and Nevis to make planning decisions, finalize a zoning design, and implement a marine zoning plan, the project team produced a spatial database, georeferenced portable document format (PDF) files, a web-based map viewer, maps of fisheries uses and values, seabed habitat maps, compatibility maps, and outputs of multi-objective analysis.
5. **Generate Draft Zones.** As a culmination of the aforementioned activities, the project team created a marine zoning design that was reviewed by select government agency staff and stakeholder groups.

The draft marine zoning design and all of the project activities leading up to it have built a strong foundation for marine zoning in St. Kitts and Nevis. To build on this foundation, we recommend additional steps that the government and stakeholders of St. Kitts and Nevis can take to finalize and implement a marine zoning plan. Every effort should be made to continue this process of open debate between sectors that helped identify conflicts and means of co-existence between different users of the marine environment. By adopting marine zoning, the people of St. Kitts and Nevis can take action to ensure the sustainability of their ocean resources.

ACKNOWLEDGEMENTS

This work would not have been possible without the generous support of the United States Agency for International Development (USAID) and The Nature Conservancy's Global Marine Team.

The project staff thanks the members of the project Steering Committee (Table 3), who provided vital input over the course of the project. We acknowledge the support, assistance, and guidance from the following organizations, agencies, and individuals.

In St. Kitts: Ministry of Finance and Sustainable Development – Mr. Randolph Edmead, Mr. Graeme Brown, Mr. Eduardo Mattenet, and Mrs. Hughes; Ministry of International Trade, Industry, Commerce, Agriculture, Consumer Affairs, Constituency Empowerment and Marine Resources – Hon. Timothy Harris, PhD, Mrs. Anthony, and Mrs. Shez Dore-Tyson; Department of Fisheries – Mr. Joseph Simmons, Mr. Ralph Wilkins, and Ms. Hazel Richards; Ministry of Tourism and International Transport – Hon. Richard Oliver Skerritt; Department of Maritime Affairs – Mr. McClean Hobson; St. Kitts and Nevis Coast Guard – Captain Comerie, Captain Julius, Captain Lee, Engineer Lewis, and the crew of the Ardent; St. Christopher National Trust – Director Mrs. Jacquelyn Armony, Mrs. Kate Orchard; St. Kitts Tourism Authority – Mr. Randolph Hamilton. Our coordinator in St. Kitts, Mr. Patrick Williams. Special thanks to the fishers and fisheries cooperatives of St. Kitts including Mrs. Lorna Warner, Mr. William Spencer, Mr. Todville Peets, Mr. Theophelus Taylor, Mr. Melvin Gumbs, Mr. Dave Martin, Mr. Samuel Maynard, Mr. Jack Spencer, Mr. Marcus Spencer, and the numerous other fishers that participated in the fisheries mapping and verification effort; Mr. Kenneth Samuel of Dive St. Kitts; and John Break and Emma Grigg of Ross University.

In Nevis: Ministry of Agriculture, Lands, Housing, Cooperatives and Fisheries – Honorable Minister Robelto Hector and Permanent Secretary Dr. Kelvin Daley; Department of Fisheries – Mr. Emile Pemberton, Mr. Clive Wilkinson, and Delisia Richardson; Ministry of Communications, Works, Public Utilities, Posts, Physical Planning, Natural Resources and Environment – Permanent Secretary Mr. Ernie Stapleton; Department of Physical Planning Natural Resources and Environment – Mrs. Angela Walters-Delpeche and Ms. Rene Walters; Nevis Fishermen's Marketing and Supply Cooperative Society, Ltd. – Ms. Melissa Allen; Nevis Tourism Authority – Mr. Devon Liburd; Mr. Alistair Yearwood of Oualie Beach Resort; Mr. Ellis Chadderton of Dive Nevis; Captain Arthur "Brother" Anslyn; Mr. Audra Barrett; Ms. Barbara Whitman of Under the Sea-Nevis; Ms. Janice D. Hodge of Cadenco, Inc. Special thanks to the fishermen of Nevis including Mr. Winston "Atta" Hobson, Mr. Lester "Abba" Richards, Mr. Roy "Mikey" Williams, Mr. Everett Cozier, Mr. Jason Molle, and the numerous other fishers who participated in the mapping and data verification of the fisheries; Nevis Historical and Conservation Society former Executive Director Mr. John Guilbert, Mr. Paul Diamond, and current Executive Director Mrs. Evelyn Henville.

We thank the numerous individuals who offered review of documents and provided input on data collection and analysis including Hedley Grantham of the University of Queensland; George Raber of the University of Southern Mississippi; Sam Purkis and Gwilym Rowlands of Nova Southeastern University's Oceanographic Center; and Charles Steinbeck, Sarah Kruse, Cheryl Chen, and Jon Bonkoski of Ecotrust. Finally, we thank Waterview Consulting for editing and design of this report.

Steven R. Schill

1 INTRODUCTION

1.1 Clarifying Terms: Marine Spatial Planning and Marine Zoning

A wide range of activities are placing increased and often conflicting demands on coastal and marine waters worldwide. Future outlooks show that many of these activities are likely to accelerate in the next few decades (Millennium Ecosystem Assessment 2005). As a result, important coastal areas are under intense pressure, threatening the biological diversity of a wide variety of marine habitats and the ecosystem services that they provide (e.g., coastal protection, food security, tourism amenities, biodiversity protection).

Marine spatial planning has emerged recently as an approach to help better address activities taking place in the ocean and to integrate marine management strategies (Agardy 1999, Norse 2005, Russ and Zeller 2003, Sanchirico 2004). Also referred to as coastal and marine spatial planning (CMSP), marine spatial planning (MSP) is an umbrella term referring to an extensive planning process required for equitable and just management of a marine area to accommodate multiple activities and objectives (i.e., multi-objective planning). Marine spatial planning is much like land use planning except that it looks at how to more efficiently and sustainably manage marine resources instead of land resources.

A marine zoning plan is one of the possible outcomes of the MSP process (Ehler and Douvere 2009, Agardy 2010). A draft zoning design is an essential first step to developing a zoning plan. In a zoning design, the boundaries of zones are outlined in the marine space. When the design is translated into a zoning plan, acceptable uses or levels of use are defined for those marine spaces. A marine zoning plan is then implemented through a set of regulations that specify allowable uses of the marine space in question. The suite of activities necessary to support the design and implementation of a zoning plan are described later in this report. Although marine zoning is often a central outcome of the MSP process, the two are not the same. Marine spatial planning is the framework that makes comprehensive marine zoning possible (Foley *et al.* 2010), and "zoning represents the doing to which MSP leads" (Agardy 2010). In a marine zoning plan, uses are allocated and management schemes are developed across space in an integrated fashion by including ecological, economic, and social considerations.

1.2 The Need for Marine Zoning

To date, marine protected areas and fisheries management tools have been the main approaches used to manage marine environments. The goals of these approaches are generally limited to particular species (e.g., fisheries regulations) or small areas that are considered to have particular environmental values (Agardy 2007, Agardy 2009, Agardy 2010). To accommodate multiple uses and manage cumulative effects in the marine environment, we must turn to tools that are wider in scope, such as marine zoning.

Scaling up from marine protected area (MPA) networks to marine zoning is considered by many an important milestone for achieving effective marine conservation (Agardy 2010). Marine zoning offers important benefits:

1. It will help achieve sustainable use of marine resources more effectively.
2. It is based on a recognition of the relative importance of ecological and use characteristics as well as environmental and economic vulnerabilities of marine spaces.
3. It will help address spatial and temporal mismatches between ecological and governance systems.
4. It will facilitate a shift away from the current fragmented approaches to ocean management toward more effective and integrated holistic management that addresses not only uses but also impacts on the ocean.

Marine zoning is currently being applied worldwide and efforts span a range of spatial scales from large, integrated sea-use management projects such as those in the China Sea and Australia's Great Barrier Reef to smaller-scale examples that essentially apply zoning to networks of MPAs like those in St. Lucia, Soufrière Bay in the Caribbean's Lesser Antilles, and the Bird's Head in Indonesia. Each effort is motivated by different goals and outcomes. Examples of marine zoning for small island states are unfortunately few and far between, mostly focused on MPA networks and generally poorly documented.

1.3 Selecting a Pilot Site for Marine Spatial Planning in the Caribbean

The case for marine zoning is particularly strong in the Caribbean. This area has been identified as one of the top five biodiversity hot spots in the world (Mittermeier *et al.* 2005, Shi *et al.* 2005, Myers *et al.* 2000), based primarily on the high number of globally important endemic species. A majority of residents in this densely populated region inhabit coastal zones and are heavily dependent on marine resources for their livelihoods. The economy and public health of the small island developing states (SIDS) of the Eastern Caribbean depend on marine and coastal ecosystems and the biodiversity which they support (Heileman 2005). Lamentably, the Caribbean's large endowment of biodiversity-rich marine ecosystems is being lost at an alarming rate while coastal development continues to rise (Brown *et al.* 2007). A recent analysis published in the journal *Science* noted that the Eastern Caribbean was among the five regions worldwide showing the highest cumulative human impact on marine ecosystems (Halpern *et al.* 2008).

Main threats to nearshore habitats and the biodiversity that they support include poorly planned coastal development, land-based pollution sources, over-exploitation of fisheries resources, and global climate change. As a result, important biological systems are under intense pressure, threatening the biological diversity of the region's beaches, coral reefs, wetlands, mangroves, and seagrass beds, the marine life reliant upon them, and the important ecosystem services that they provide.

This project initiated a marine spatial planning process through the development of a draft marine zoning design for a small island nation in the Eastern Caribbean.

A number of different island nations in the Eastern Caribbean were considered as potential pilot sites for this project. A suite of criteria guided the project team in the selection of a pilot site for island-wide marine zoning. St. Kitts and Nevis (SKN) was selected as the pilot site as it met all of the following criteria:

- The project team has a presence on the ground.
- An existing or potential conflict between users/uses has been clearly identified and is deemed workable.
- The local government is aware of zoning as a useful management approach and is interested in applying it in their country.
- The project team has a good history of working with the local government.
- Relevant regional inter-governmental bodies are interested in zoning at the site in question.
- Potential for stakeholder engagement (both relationships and appropriate venues) exists.
- Potential policy instruments for implementation have been identified.
- Spatial information representing multiple uses exists.
- A rapid assessment of available data has been completed.

Shawn W. Margles

- Potential in-country sources of information have been identified, and relationships exist with appropriate individuals/agencies to help with data transfer.
- Relationships currently exist with stakeholder groups able to provide expert knowledge, and promising conditions exist for establishing new relationships.

1.4 Objectives of the Project

The primary objective of this project was to lay the groundwork to support future implementation of a marine zoning plan in the Federation of St. Kitts and Nevis and to assist in the development of a marine zoning design. To accomplish our objectives, we used two primary guiding principles:

1. Rely on the best available science for making decisions.
2. Engage stakeholders at all possible levels.

We prioritized choosing tools and methods for data collection and analysis that met the highest scientific standards, while engaging stakeholders and fostering buy-in and ownership. The outcome of this project was a draft marine zoning design, which engaged over 200 people over the course of a year in various activities central to its development.

This report outlines the process we used to develop the draft marine zoning design and concludes with a discussion of next steps that will enable the design to be translated into a marine spatial plan and ultimately lead to implementation. The information from this project can be used to inform other management activities in St. Kitts and Nevis, and the process used in this project can serve as a model for marine zoning in other small island states.

Steven R. Schill

The project included a series of meetings with government staff and stakeholders.

Steven R. Schill

2 THE CONTEXT: SAINT KITTS AND NEVIS

2.1 Geography and Physical Setting

The Federation of St. Kitts and Nevis is a federal two-island nation located in the West Indies (Figure 1). At 17° 20’ N, 62° 45’ W, it lies in the Caribbean Sea approximately one-third of the way from Puerto Rico to Trinidad and Tobago. The capital city of the federated state is Basseterre on the larger island of St. Kitts. The smaller island of Nevis lies about 3 kilometers southeast of St. Kitts, across a shallow channel called The Narrows. The coastline length of both islands combined is 135 kilometers, and the two islands are approximately 261 square kilometers in total area. The Federation’s surrounding EEZ waters extend out to adjacent territorial waters (e.g., St. Eustatius and Anguilla) to cover 20,400 square kilometers with a shelf area of 845 square kilometers. The islands are volcanic in origin and have large central peaks covered in tropical rainforest. The surrounding flatter terrain is where the majority of people reside on both islands. The islands vary in elevation from a low of sea level to a high of 1,156 meters (Mount Liamuiga) on St. Kitts.

Capital	Basseterre
Official Language	English
Government	Parliamentary democracy
Independence	19 September 1983
Area	261 square kilometers (104 square miles)
Coastline Length	135 kilometers
Highest Point	1,156 meters (3,793 feet)
Population	51,300 (Density: 164 per square kilometer)
GDP (2009)	$726M (Total) $13,429 (Per capita)
Literacy Rate	98%

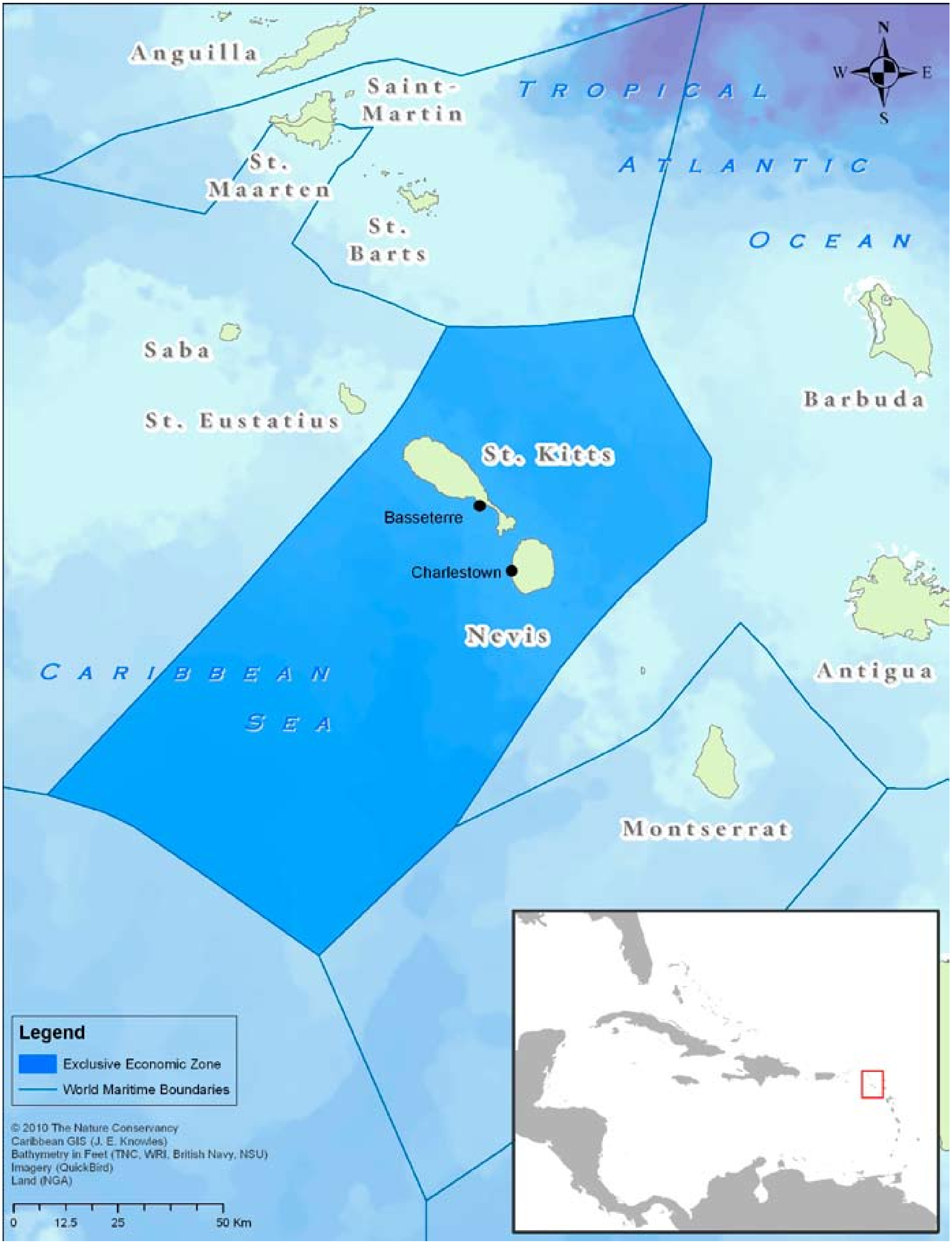


FIGURE 1. General Reference Map: The Federation of St. Kitts and Nevis is a federal two-island nation located in the eastern Caribbean. The Federation's surrounding exclusive economic zone (EEZ) waters extend out to adjacent territorial waters and cover 20,400 square kilometers in area with a shelf area of 845 square kilometers.

2.2 Marine Ecology

St. Kitts and Nevis has a relatively small ocean shelf area that surrounds both islands (Figure 2). On the western side of St. Kitts, the ocean shelf drops off steeply after reaching the depth of 30 meters. The shelf is covered primarily with bare carbonate sand, while healthy reefs and other coral structures cover a small percentage of the area (Figure 3). The small shelf area and relatively stable annual water temperature limits the marine biological diversity. Additionally, the minimal areas of upwelling restrict nutrient supply and subsequently the offshore fisheries. Coastal fisheries have declined sharply in recent years, and storms and anchoring have heavily damaged the reefs. Anecdotally, fishers have reported smaller catches of conch, lobster, and large pelagic and demersal fishes. Major threats to the marine ecology of the islands include coastal development, unsustainable fisheries practices, land-based sources of pollution, rising ocean temperatures, and the increasing intensity of hurricanes and other storm events.

Despite its small shelf area, St. Kitts and Nevis boasts a representative cross-section of Caribbean marine life, including endangered corals, marine mammals, fish species, and sea turtles. The diversity of corals ranges from species categorized as critically endangered by the International Union for Conservation of Nature (IUCN), such as staghorn (*Acropora cervicornis*) and elkhorn (*Acropora palmate*), to the more common finger coral (*Porites divaricata*). Complementing the hard coral varieties are an array of sponges and soft corals. Additionally, there are several large seagrass beds, most notably in the area between the two islands known as The Narrows. These seagrass communities are typically co-dominated by turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*) and serve as vital breeding grounds for fishes and conch, including queen conch (*Strombus gigas*), which is regulated by the Convention on International Trade in Endangered Species (CITES). Migrant mammals, including humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), common bottlenose dolphin (*Tursiops truncatus*), rough-toothed dolphin (*Steno bredanensis*), and spinner dolphin (*Stenella longirostris*) are consistently present on an annual basis. Marine fishes number approximately 460 species, including 126 species that are threatened or endangered.

TABLE 1. Total area of seabed habitat types and coverage in coastal waters (less than 30 meters deep) around St. Kitts and Nevis. See Appendix B for a key to the benthic habitat classes.

Benthic Class	Hectares
Sand	16,351
Dense seagrass	3,098
Flat gorgonian hardgrounds	2,854
Dense macroalgae on hardground	2,774
Semi-consolidated rubble	2,595
Unconsolidated sand with algae	1,929
Hardcoral framework	1,578
Acropora palmata stumps	574
Sparse seagrass	370
Rugose gorgonian slope	258
Lagoonal mud	165
Algal reef flat	61

FIGURE 2. Satellite Imagery: Landsat ETM multispectral satellite imagery of St. Kitts and Nevis that was used as base map and for general reference during the project.

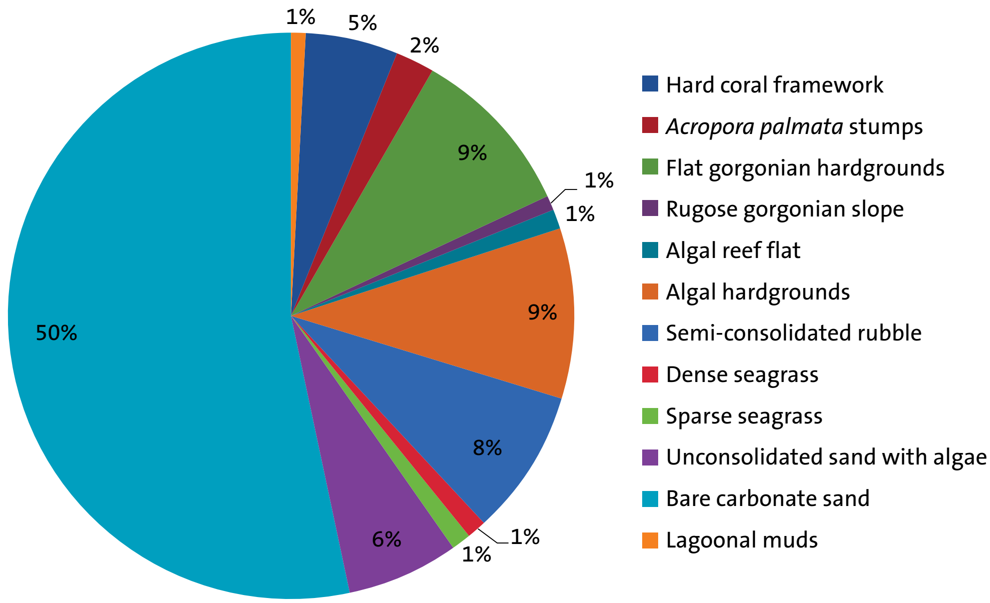


FIGURE 3. Benthic Habitat Classification: Near-shore (less than 30-meter depth) benthic habitat map of St. Kitts and Nevis showing the distribution of 12 benthic habitat classes derived from extensive underwater video sampling and multispectral image classification using high-resolution (2.5 x 2.5-meter) IKONOS and Quickbird satellite imagery.

Three species of sea turtles are known to nest on the beaches of St. Kitts and Nevis: hawksbill turtle (*Eretmochelys imbricata*), green turtle (*Chelonia mydas*), and leatherback turtle (*Dermochelys coriacea)*. The IUCN categorizes the leatherback and hawksbill turtles as critically endangered and the green turtle as endangered.

2.3 Historical Context

Carib Indians occupied St. Kitts and Nevis for hundreds of years before the British began settlement in 1623. Prior to British settlement, there was intense fighting between France and the United Kingdom for control of the islands and their resources. In 1967, the islands became an associated state of the United Kingdom with full internal autonomy. Initially, the island of Anguilla was associated with St. Kitts and Nevis. In 1971, however, Anguilla rebelled and was allowed to secede from the union in 1980. Anguilla returned to being an overseas British territory. St. Kitts and Nevis achieved independence in 1983. In 1998, a vote in Nevis on a referendum to separate from St. Kitts fell short of the required two-thirds majority. As of July 2010, the federation had an estimated population of 49,898, including approximately 12,000 people on Nevis.

2.4 Economy

Tourism and consumer product assembly are the main sources of income on both islands. In 2005, the gross domestic product from commercial fisheries was approximately $3.8 million (FAO 2006). Tourism has replaced the sugar industry, the traditional mainstay of the economy until the 1970s. Tourism has been reported to increase steadily (9.4%) between 2007-2008 (World Wildlife Fund 2009). Following the 2005 harvest, the government closed the sugar industry after decades of annual losses equivalent to 3-4% of gross domestic product (CIA 2010). To compensate for employment losses, the government has embarked on a program to diversify the agricultural sector and to stimulate other sectors of the economy, such as tourism, export-oriented manufacturing, and offshore banking. Like other tourist destinations in the Caribbean, St. Kitts and Nevis is vulnerable to damage from natural disasters and shifts in tourism demand. The current government is constrained by a high public debt burden equivalent to nearly 185% of gross domestic product at the end of 2006, largely attributable to public enterprise losses.

2.5 Governance

The Federation of St. Kitts and Nevis is organized under the Constitution of 1983 as a parliamentary democracy. While it declared independence from the United Kingdom in 1983, it remains a Commonwealth realm with the Queen as its official Chief of State. A unicameral National Assembly with fourteen members makes federal laws and laws concerning St. Kitts. The Nevis Island Administration and Nevis Island Legislature perform executive and legislative functions on Nevis as provided for in the 1983 Constitution. The legal system in St. Kitts and Nevis is based on English common law.

Implementation of a comprehensive marine zoning framework will require due recognition and consideration of the authorities, obligations, and institutions currently in place in St. Kitts and Nevis that govern marine planning and management. The sources of these may be treaties, policies, and statutes. An analysis of current governance and political frameworks that present opportunities and challenges for implementation of marine zoning is presented in Appendix F.

2.6 Human Uses

The coastal waters around St. Kitts and Nevis are used for a wide range of activities. Tourism is presently the major economic driver, and stretches of the coast are dominated by coastal tourism development, private yachts, cruise ships, and associated water activities. Additionally, as elsewhere in the Caribbean, commercial and artisanal fisheries form a significant part of the local economy. Fisheries involve vessels of varying sizes and capacities, using a variety of gear types and fishing strategies and covering a large part of the coastal waters. Combined with the inter- and intra-island transportation needs of a small coastal state—including ferries, cruise ships, personal recreation vessels, and large industry vessels—within the limited shelf area of St. Kitts and Nevis, the result is a congested marine environment with mounting conflicts.

Shawn W. Margles

Fishing is an important part of the culture and economy of St. Kitts and Nevis.

Shawn W. Margles

Fishers provided information for mapping fishing areas around the islands.

3 GENERATING A DRAFT ZONING DESIGN

Designing and implementing a zoning plan requires a number of essential steps (Agardy 2010, Ehler and Douvere 2007, Klein *et al.* 2009, Crowder and Norse 2008, Douvere 2008), ranging from defining objectives and a strategic vision to drafting legislation and establishing a governance structure that will help support implementation. In this report, we describe the process that we used to develop frameworks to support implementation of a zoning plan for the waters of St. Kitts and Nevis, including the development of a draft zoning design. We document our efforts to address elements that are key to any marine spatial planning effort. However, this is not meant to be a comprehensive review of elements that will take a zoning plan from design to implementation. For a thorough discussion, we refer the reader to the wide range of publications that attempt to outline steps necessary to generate a zoning plan (e.g., Ehler and Douvere 2009, Beck *et al.* 2009). We also note that a policy analysis documenting important legislation and regulation elements for a zoning plan was part of this project (Appendix F).

The following activities are generally considered to be necessary for generating a marine zoning plan: (i) engage stakeholders, (ii) establish clear objectives, (iii) build a database that spatially represents marine uses (i.e., a multi-objective database), and (iv) generate tools to assist stakeholders and decision makers in considering options and tradeoffs (i.e., decision support products) (Foley *et al.* 2010, Agardy 2010). These elements provide the foundation of any marine spatial planning effort and as such they should be carefully considered. Below we describe the suite of activities conducted during this project to provide a solid foundation for a marine zoning plan for the waters of St. Kitts and Nevis.

3.1 Stakeholder Engagement

To be successful, each element of a planning process—from designing draft zones to plan development through implementation—needs national and local champions. During this project, we carried out a number of activities to engage Kittitian and Nevisian partners and to ensure that every step of the project included perspectives of local partners. Table 2 presents a list of meetings held with main objectives and key participants.

The first step in the engagement process was to identify and meet with appropriate departments and government and community leaders to determine the level of interest in a marine zoning process and their willingness to commit to help move the planning process forward. Given the governance structure in St. Kitts and Nevis, this meant engaging with government ministries on both islands and determining how this project could facilitate communications between stakeholders across the islands. Key government departments included fisheries, planning, and tourism on both St. Kitts and Nevis. On the federal level, we consulted with maritime affairs officials, and in the non-government organization (NGO) sector we engaged with representatives from the St. Kitts National Trust and the Nevis Historical and Conservation Society. Individuals from these key government agencies, local NGOs, and the private business sector served as informal and formal advisors throughout the planning process.

We organized a series of workshops to reach out to varied government and community groups to ensure that the planning effort was based on in-country needs and desires for the federal waters of St. Kitts and Nevis. All of these meetings were carefully coordinated to include appropriate stakeholders. Target audiences varied from high-level government officials to community groups, the private business sector, and fishers' associations.

A Steering Committee guided stakeholder engagement, provided direction for the project, and reviewed and approved data and analyses (Table 3). The committee comprised representatives from government agencies (fisheries, planning, tourism, and maritime affairs) on both St. Kitts and Nevis, as well as local NGOs, fishers, tourism businesses, and dive operators. Steering Committee members served as focal points for disseminating information about the marine zoning plan to their agencies, organizations, and departments. Members of the Steering Committee also played key roles in other aspects of the overall effort, such as liaising with government and reviewing policy analyses.

Key to the success of the project was the selection of an in-country project coordinator to be responsible for frequent and direct communications with high-level government officers, board members of organizations, and individuals from the community. This allowed for timely updates on project development and input from local partners along the way, as well as important in-country workshop coordination. We also held a series of informal meetings to collect existing information, identify new information needs, and build in-country support.

TABLE 2. Table of stakeholder meetings.

Major Stakeholder Meeting/Activity	Date	Main Objectives	Major Outputs	Key Participants
Expert Mapping Focus Groups	September 28-October 2, 2009	To meet with a variety of interest groups and discuss the zoning project; get feed back on the proposed approach; map key marine uses via expert knowledge	Identification of interested persons, groups, and agencies; key marine uses mapped	St. Kitts and Nevis Departments of Tourism; Hoteliers Association; St. Kitts and Nevis Departments of Physical Planning Department; St. Kitts and Nevis Fisheries Departments; Maritime Affairs; Nevis Disaster Management; Port Authority; Energy Planning; developers; environmental consultants; St. Kitts Historical Trust; Nevis Historical and Conservation Society; dive operators
Project Kick-off Meeting	October 5-6, 2009	Conduct visioning exercise to identify main goals for St. Kitts and Nevis marine areas; identify major existing barriers to achieving goals and discuss possible strategies to overcome barriers	Articulated vision for categories of marine uses (meeting) report document); table of barriers and strategies (included in meeting report document)	St. Kitts and Nevis Departments of Tourism; Hoteliers Association; St. Kitts and Nevis Departments of Physical Planning; St. Kitts and Nevis Fisheries Departments; Maritime Affairs; Nevis Disaster Management; Port Authority; Energy Planning; developers; environmental consultants; St. Kitts Historical Trust; Nevis Historical and Conservation Society; Ross University
Fisheries Survey Development	December 15-16, 2009	To develop first draft of fishers survey	First draft of fishers survey	St. Kitts Department of Fisheries; dive operators
Benthic Habitat Mapping	January 5-14, 2010	To collect sea bed habitat video from entire shelf area of St. Kitts and Nevis; to provide capacity building opportunity for in-country partners; provide educational opportunity regarding project objectives and benefits to in-country fishers	Over 400 video samples from various locations around St. Kitts and Nevis (key data input into the benthic habitat product); active participation from in-country agencies and fishers	St. Kitts and Nevis Departments of Fisheries; St. Kitts and Nevis Physical Planning Departments; St. Kitts and Nevis Coast Guard; Nevis fishers
Key Interest Group Meetings	March 23-24, 2010	To meet with key interest group leaders to update them on project progress and get feedback on key issues	Meeting minutes	St. Kitts Department of Fisheries; Nevis Department of Fisheries; St. Kitts Physical Planning Department; Nevis Physical Planning Department; St. Kitts Historical Trust; Nevis Historical and Conservation Society; dive operators
St. Kitts & Nevis Fishers Cooperative Leaders Meeting		To update Fishers Cooperative Leaders on project progress and to get feed-back on proposed fishers survey and mapping exercise approach	Meeting minutes	Leaders from St. Kitts and Nevis cooperatives; St. Kitts and Nevis Fisheries Departments
Fisheries Survey Review		To review fisheries uses and values survey and get feedback from key leaders from the commercial fishing community	Revised fisheries uses and values survey and mapping tool	St. Kitts and Nevis Fishers Cooperatives leaders; St. Kitts and Nevis Departments of Fisheries; St. Kitts and Nevis Physical Planning Departments
Fishers Survey Training	April 13-16, 2010	To train in-country data collection team and key government agency staff on data collection and survey techniques	Trained in-country data collection team; increases government capacity on survey techniques and data collection methods	St. Kitts and Nevis Fisheries Departments

(continued on next page)

TABLE 2. Table of stakeholder meetings (*continued*).

Major Stakeholder Meeting/Activity	Date	Main Objectives	Major Outputs	Key Participants
Fishers Co-operative Meetings	April 13-28, 2010	To meet with fishers at their co-operatives to provide project information, describe purpose of interviews and mapping exercise; and provide an opportunity for questions	Meeting minutes	Members of Fishers Co-operatives from St. Kitts and Nevis; St. Kitts and Nevis Fisheries Officers; Fisher Cooperative staff
Fisher Interviews		To interview St. Kitts and Nevis fishers and map fisheries uses and associated values	Draft maps of commercial fisheries and associated values	St. Kitts and Nevis fishers; St. Kitts and Nevis Fishers Cooperative leaders; in-country data collection team (composed of key fisheries officers and Fisher cooperative staff)
Compatibility Matrix Meeting		To discuss compatibility of marine activities with stakeholders.	Compatibility matrix of marine targets	St. Kitts and Nevis Departments of Tourism; St. Kitts and Nevis Departments of Physical Planning; St. Kitts and Nevis Fisheries Departments; Maritime Affairs; Port Authority; environmental consultants; St. Kitts Historical Trust; Nevis Historical and Conservation Society; dive operators
Steering Committee Meeting 1		To establish project Steering Committee and discuss major decision points	Steering Committee established; major project decision points discussed; meeting minutes with action steps	Ministry of Marine Resources; St. Kitts and Nevis Departments of Fisheries; St. Kitts and Nevis Physical Planning Departments; St. Kitts and Nevis fishers leaders; Maritime Affairs;
Steering Committee Meeting 2		To follow up on action items from first meeting, review data inputs, generate initial zoning portfolio	Draft Steering Committee zoning portfolio map; meeting minutes with action steps	Ministry of Marine Resources; St. Kitts and Nevis Departments of Fisheries; St. Kitts and Nevis Physical Planning Departments; St. Kitts and Nevis Fishers Cooperative leaders; Maritime Affairs
Fishers Data Verification		To verify maps and information with fishers	Verified maps and updated final report on fisheries uses and values component	Fishers from St. Kitts and Nevis; St. Kitts and Nevis Fisheries Departments
Steering Committee Meeting 3		To review digitized Steering Committee Portfolio map, consider feedback from fishers obtained during data verification process, update portfolio as needed, and review policy outputs	Updated Steering Committee Portfolio map; meeting minutes with action steps identified	Ministry of Marine Resources; St. Kitts and Nevis Departments of Fisheries; St. Kitts and Nevis Physical Planning Departments; St. Kitts and Nevis Fishers Cooperative leaders; Maritime Affairs;
Final Stakeholder Meeting		To review project products, hand over data and information generated and collated during project and identify next steps	Data and information turned over to in-country partners and decision makers	St. Kitts and Nevis Departments of Tourism; St. Kitts and Nevis Departments of Physical Planning; St. Kitts and Nevis Fisheries Departments; Maritime Affairs; Port Authority; environmental consultants; St. Kitts Historical Trust; Nevis Historical and Conservation Society; dive operators

TABLE 3. Steering Committee Membership.

MARINE ZONING PLAN FOR ST. KITTS AND NEVIS

MEMBERSHIP OF PROJECT STEERING COMMITTEE – ST. KITTS

Agency/Organization	Member
Department of Physical Planning and Environment	Mr. Randolph Edmead (Director)
Department of Fisheries	Mr. Ralph Wilkin
Tourism Authority	Mr. Randolph Hamilton
Department of Maritime Affairs	Mr. McClean Hobson
St. Christopher National Trust	Mrs. Jacqueline Armony
Dive boat operators	Mr. Kenneth Samuels
Fishers	Mr. Oliver Spencer

MEMBERSHIP OF PROJECT STEERING COMMITTEE – NEVIS

Agency/Organization	Member
DPPNRE	Mrs. Angela Delpeche
Department of Fisheries	Mr. Lemuel Pemberton
Tourism Authority	Mr. Devon Liburd
Dive boat operators	Mr. Ellis Chadderton
Nevis Conservation and Historical Society	Mrs. Evelyn Henville
Fishers	Mr. Winston Hobson

3.2 Establishing Clear Objectives

A marine zoning effort should be guided by clear objectives and a strategic vision (Gilliland and Laffoley 2008, Crowder and Norse 2008, Ehler and Douvere 2007). Building these elements through a participatory process creates a strong basis for successful implementation of the zoning plan. The strategic vision and objectives for the St. Kitts and Nevis marine zoning plan were defined during a workshop early in the project (Table 2). Prior informal meetings with government officials, agencies, and stakeholders (Table 2) helped identify the right mix of participants for this workshop and the best approaches to facilitate this discussion. Participants varied from high-level government officials to representatives of community groups and fishers' associations. Information collected during this meeting provided important building blocks for the overall project (see Appendix A for a detailed report on this meeting). During this workshop, the participants discussed their vision for uses of the draft zones and management of their seascape, as well as objectives for education, regulation, and enforcement. Later, this project addressed some of these elements in detail, but a comprehensive treatment for each element was outside of the project's scope.

3.3 Building a Multi-Objective Database

Effectively managing a wide variety of uses across a seascape requires access to disparate types of information. One of these types of information is spatial data that shows the distribution of marine features and where certain marine activities take place. These spatial datasets are used in a geographic information system (GIS), one of the key tools for marine spatial planning. Collating and integrating data on diverse human activities and the ecological systems that support them is not a simple feat. This process can require considerable time and resources, depending on data availability and the need to generate new data when gaps are identified. The scales of information are often very different, and integrating them to generate a balanced view of the system is complex. For this project, significant resources were devoted to gathering, evaluating and generating spatial information from a wide variety of sources. Special attention was devoted to ensuring a balanced representation across use sectors and ecological characteristics.

Spatial data provided from past mapping efforts were evaluated, and data gaps were identified. As is typical in most small island states, spatial data for the terrestrial realm in St. Kitts and Nevis was much more prevalent than data for the marine realm. Consequently, filling marine data gaps represented a major effort and contribution of this project. One clear gap was the lack of data on marine uses of the waters surrounding St. Kitts and Nevis. We used three main approaches to fill data gaps: (a) expert mapping, (b) fisher surveys, and (c) habitat surveys.

3.3.1 Expert Mapping

To ensure a wide representation of marine uses in St. Kitts and Nevis, information on the fisheries, tourism, industry, and transportation sectors was gathered during workshops and several days of meetings with representatives from each of these sectors. Data collected from these meetings were supplemented with existing and accessible data from independent research and regional datasets housed outside of the country. These efforts produced a representative and thorough collection of spatial data, which were reviewed and validated by in-country experts across all marine sectors.

To capture local knowledge, the project team spent two weeks in St. Kitts and Nevis working with groups and individuals to map consumptive and non-consumptive marine activities, as well as ecologically important areas. Team members met with over 30 individuals representing more than 15 organizations (Table 2). This data collection effort was designed to build upon the work completed under a previous Ecological Gap Assessment conducted for St. Kitts and Nevis. The project team developed a framework to track important and necessary data for a marine zoning process. Information was captured on paper maps and subsequently digitized and verified with local experts.

3.3.2 Benthic Habitat Survey

Previous data collected from benthic habitat surveys on St. Kitts and Nevis were too coarse in resolution or too limited in geographic extent to be useful for this project. Consequently, we conducted a mapping effort to produce the first high-resolution (2.5-meter) benthic habitat maps for the two islands' coastal waters (less than 30 meters deep). We collected data on 12 habitat classes using high-resolution satellite technology in combination with field measurements (Figure 4); for a detailed description of methods, see Appendix B). The clear waters of the Caribbean allow sunlight to reflect off the ocean floor at depths to 30 meters, providing a way to map underwater features and structures in areas as small as 2.5 meters. GPS-referenced underwater video clips collected in the field are used to "train" image-classification software to recognize patterns in the imagery that correspond to underwater habitat types.

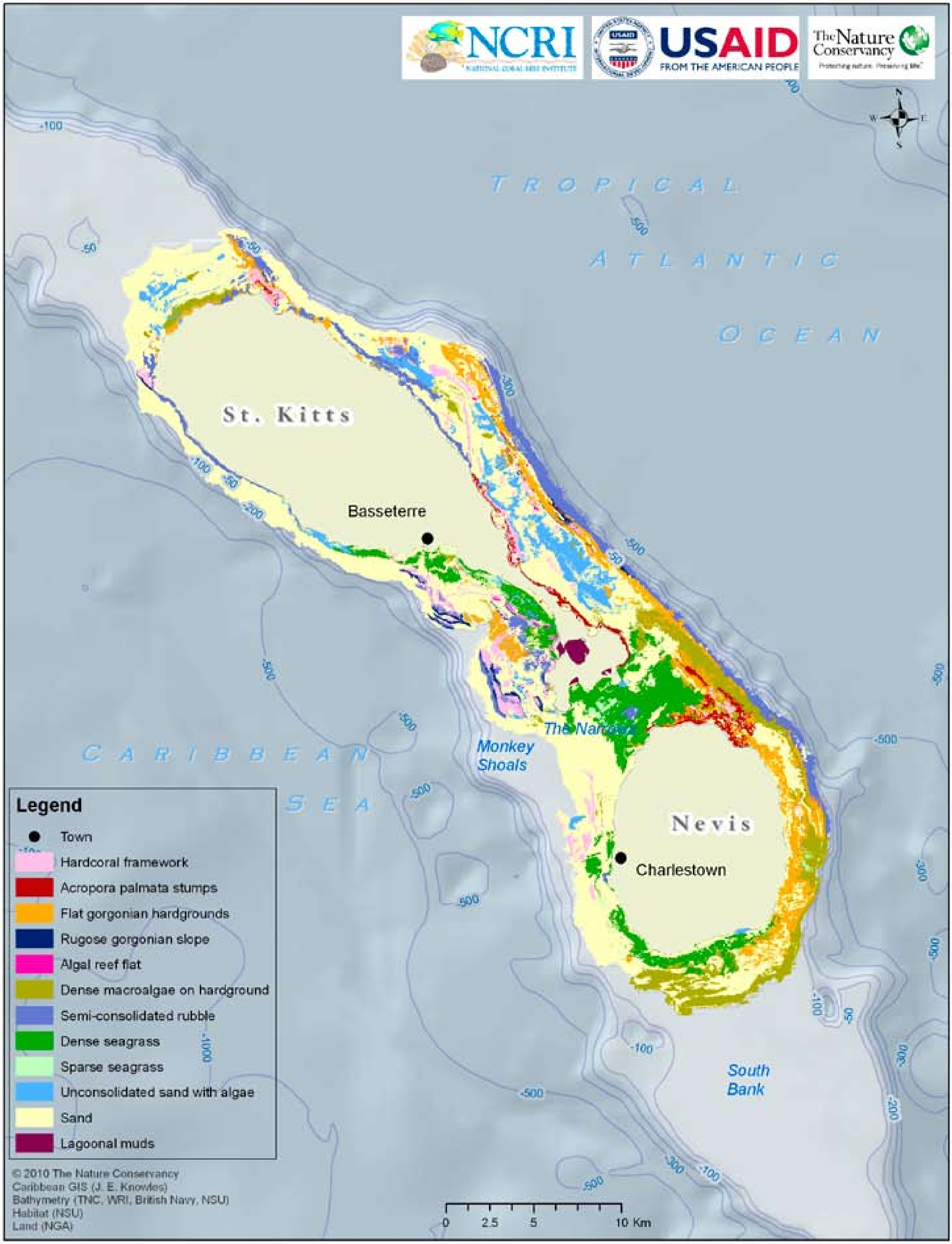


FIGURE 4. Camera Drop Sites: GPS locations of camera drop sites where underwater video was collected for each of the 12 benthic classes between Jan 6-13, 2010. The different colors represent the different dates that the videos were collected. These videos were interpreted and used to assist with the benthic habitat classification using the satellite imagery.

Steven R. Schill

Clive Wilkinson, Fisheries Assistant from the Nevis Department of Fisheries, pulling the underwater camera up after collecting a video sample for mapping of seabed habitats.

The underwater mapping effort was a collaborative effort of staff from The Nature Conservancy (TNC), Nova Southeastern University Oceanographic Center, and local government agencies. An underwater video system coupled with GPS and a depth-sounding device was used over the course of ten days aboard the St. Kitts and Nevis Coast Guard vessel *Ardent*. With this system, field crews collected more than 425 underwater video samples (Figure 5) of the narrow, 260-square-kilometer ocean shelf that surrounds St. Kitts and Nevis. For each video sample, the researchers recorded the GPS location, which enabled them later to match the underwater video samples to the same location on the satellite image. For each of the 12 benthic habitat classes seen in the video samples, scientists analyzed the corresponding patterns of light reflections seen in the satellite imagery. Because the patterns appear different for each depth and habitat class, these patterns can be used to map the entire seafloor for depths less than 30 meters. By taking this approach with advanced image-processing techniques, we produced detailed benthic habitat maps (Figure 4), showing the extent and distribution of each of the 12 habitat classes (e.g., coral reef, seagrass, sandy bottom, mud flat).

3.3.3 Fisher Survey

We conducted expert interviews with local fishers to collect data on the locations, distributions, and importance of commercial fisheries within the waters of St. Kitts and Nevis. This effort was a collaboration of staff from The Nature Conservancy, Ecotrust, and local government agencies and partners. An in-country coordinator was hired to advise on data-collection methods and to coordinate data-collection with the St. Kitts Fishery Department and the Nevis Fishery and Planning Departments. We collected data on ten fisheries: coastal demersals, coastal pelagic, deep shelf and slope, ocean pelagic, conch, lobster, shark, diamondback squid, turtle (which is caught legally during an open season), and bait. To identify the full spatial extent, relative value, and "socio-economic personality" of each fishery, we interviewed a representative sample of fishers from each fishery at the 12 major landing sites—five on St. Kitts and seven on Nevis (Figure 6). We used an interactive, customized, computerized-interview instrument, Open OceanMap, to collect geo-referenced data from fishers.

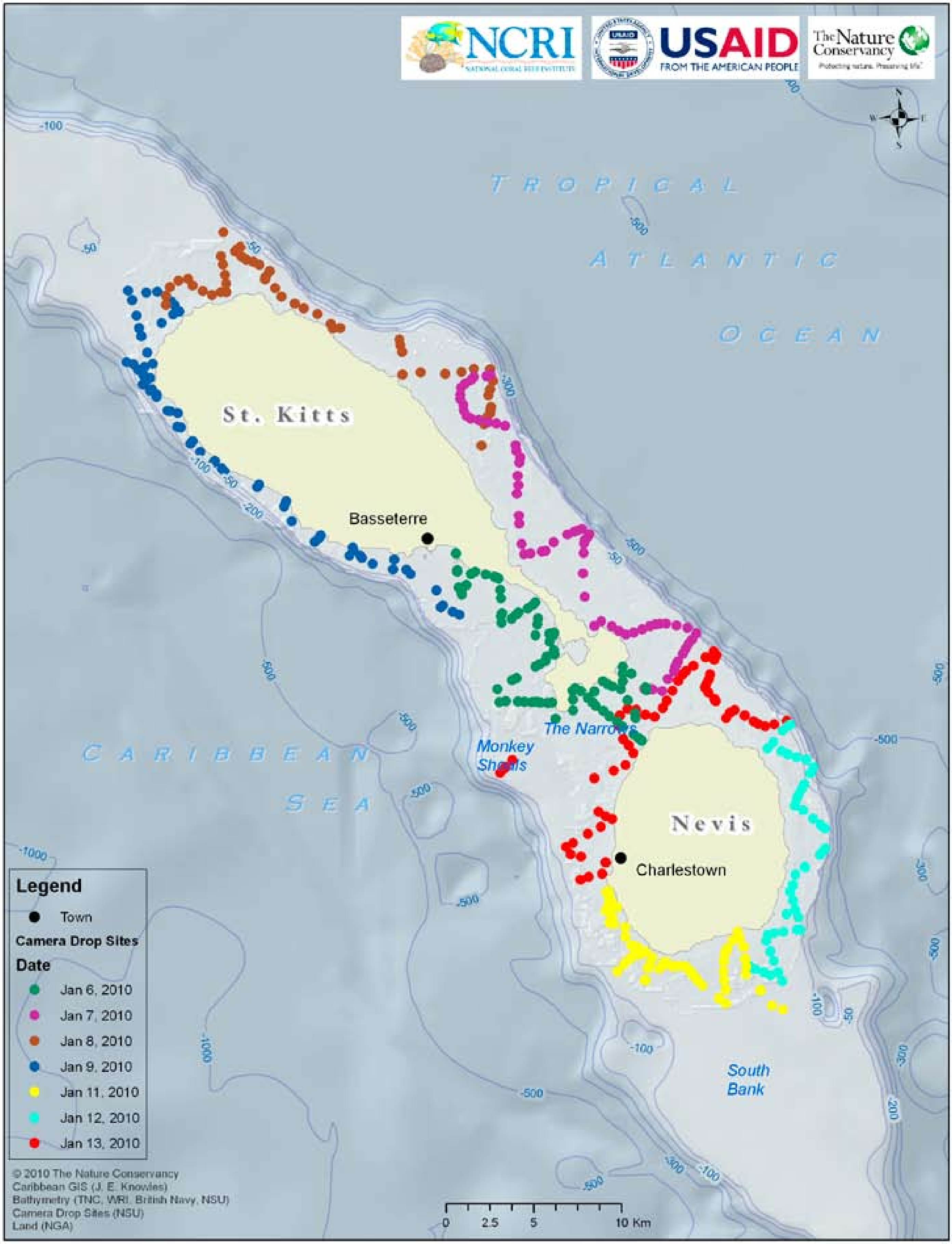


FIGURE 5. Bathymetry: Modeled bathymetry (ocean depths) of the near-shore areas (less than 30-meter depth) based on 2.5 x 2.5-meter satellite imagery. These depths were modeled using field-referenced depth sounding and correlated with multispectral imagery to provide an estimation of depth and assist with the classification of benthic habitats.

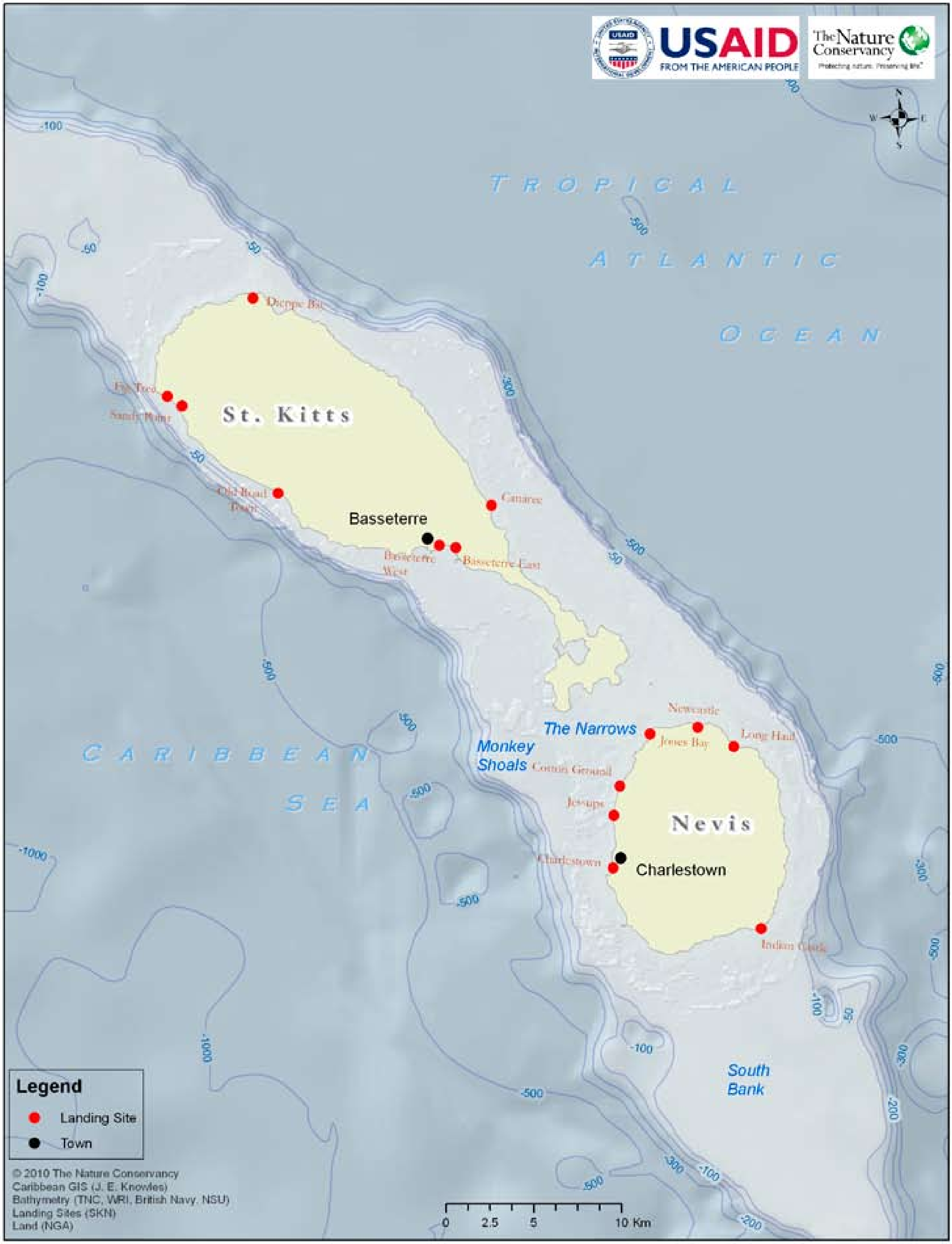


FIGURE 6. Landing Sites: Location of fish landing sites in St. Kitts and Nevis.

Open OceanMap is a computer application that uses a place-based designed survey as a basis to collect information on fishing. Participants are guided through a discussion about the fisheries in which they participate and are asked to indicate the locations, extents, and relative values of fishing areas. Interviewers use either a software tool (Open OceanMap) or a paper copy of the survey to map and record the values indicated by the interviewee. The in-country coordinator and a team of data-collection assistants were trained in the use of the computer application, interview methods, and data entry. They visited each major landing site between April and June 2010, interviewing a total of 114 fishers (51 on St. Kitts and 63 on Nevis). We aggregated information at the landing-site, island, and federation levels, and we produced maps to illustrate the extent and relative importance of each fishery. For a sample map, see Figure 7. Fishers reviewed and verified the maps in August 2010. We compiled data in a GIS and subsequently integrated the data into the project's centralized spatial database. In the analysis, we used data aggregated to the federation level. See Appendix D for a detailed description of the approach and methods used to collect, compile, and analyze commercial fisheries data in St. Kitts and Nevis.[1]

3.4 Providing Decision Support Products

One of the most important aspects of a successful marine spatial planning process is having access to and integrating complex information that will facilitate zoning decisions. A major aim of this project was to integrate complex information representing a variety of sectors and to generate a suite of products that will help the people of St Kitts and Nevis to make decisions, finalize a zoning design, and implement a marine zoning plan.[2]

Interactive decision support systems (DSS) are the future of marine spatial planning. They provide transparency and engage a diverse array of people in the planning process. Interactive DSS can capture, share, and compare many people's ideas about planning options, help people understand the real-world implications of different management regimes and environmental conditions, and reveal tradeoffs among possible management scenarios (Beck *et al.* 2009).

The marine zoning component of the USAID project leaves the country with a strong foundation for a variety of marine planning and management efforts, which even in isolation support the objectives of integrated multiple-use marine spatial planning and management. Each of the discrete products has a diversity of uses beyond marine zoning and can be utilized for efforts *inter alia* fisheries management planning and co-management arrangements, coastal zone management, climate change adaptation, protected areas planning and management, socio-economic analysis, maritime affairs, hazard mapping, and environmental protection. The major DSS products from this project were:

1. Spatial information products (i.e., spatial database, georeferenced portable document format [PDF] files, and web-based map viewer)
2. Maps of fisheries uses and values
3. Benthic habitat maps

[1] Note that data storage and reporting on fishing methods and spatially explicit information is conducted in a manner that maintains the confidentiality of sensitive information, with only the non-confidential portion of the information collected being made available to the public.

[2] This component of the integrated USAID project focuses on designing spatial decision support tools to facilitate zoning. Other components of the overall USAID project address policy and legislation, which are integral parts of implementation. The policy analysis is presented in Appendix F.

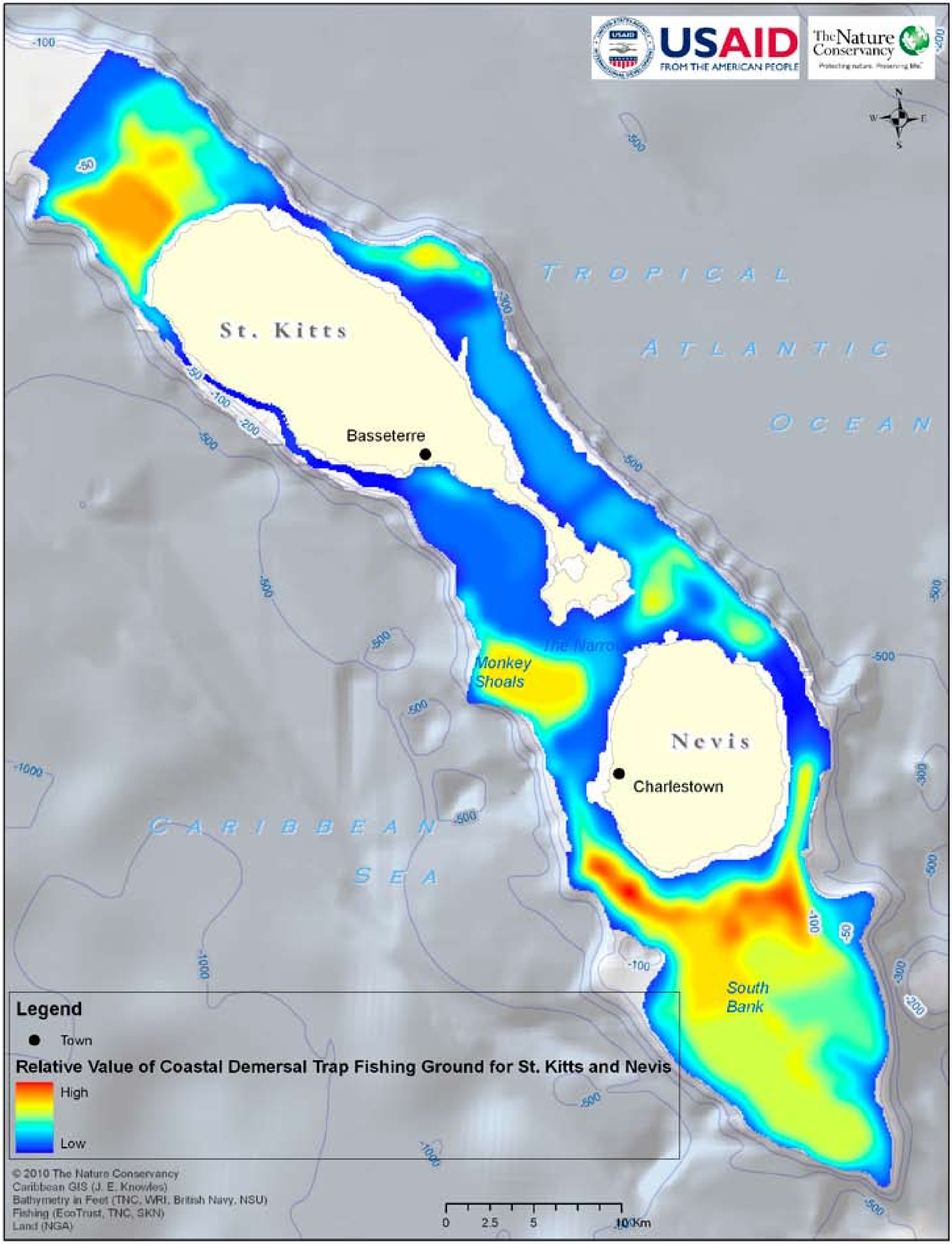


FIGURE 7. Sample fisheries uses and values map.

4. Compatibility maps
5. Outputs of multi-objective analysis

3.4.1 Spatial Information Products

An interactive database allows users and decisions makers to view and overlay different layers of information. This is invaluable in a decision-making process when a variety of scenarios and tradeoffs must be considered and there are a wide range of interests involved. Information must be stored in a manner that it is easily accessible, understood, and used. Given the wide range of technical knowledge that a diverse set of stakeholders and decisions makers is likely to have, it is important that decision support products accommodate a range of technical skills and understanding. To support the effective use of data, this project used three main modes for delivering spatial data: (a) a spatial database, (b) georeferenced portable document format (pdf) files, and (c) a web-based map viewer.

3.4.1.a Spatial Database

The spatial information collected during this project was organized and managed in an Environmental Systems Research Institute (ESRI) geodatabase format. A geodatabase is frequently used to store several layers of spatial data ("geo" means spatial and "database" refers to a data repository). The geodatabase allows for centralized data storage for easy access and management, and a range of sophisticated spatial analysis. A drawback to the geodatabase is that it requires a high-level commercial software license to fully manipulate and properly manage the data. For that reason, all spatial information was also stored and made available in ESRI's more universal shapefile format. The geodatabase and each shapefile include metadata about how and when the data were created and/or collected.

The project geodatabase comprises several base layers, imagery, and all other spatial information used in the project, including information on benthic habitats, fisheries[3], and spatial analysis results. The geodatabase and shapefiles will be housed and maintained by the GIS officers in each of the planning departments of St. Kitts and Nevis. The complete geodatabase will also be incorporated and maintained by The Nature Conservancy's Caribbean Program as part of the Caribbean Decision Support System (CDSS), a suite of data and tools designed to encourage sustainable living and biodiversity protection in the Caribbean (Huggins *et al.* 2007).

3.4.1.b Georeferenced Portable Document Format (PDF) Product

Complementing the data are corresponding map documents and georeferenced portable document format (geoPDF) files that provide a pre-defined symbology and overlay for easy access and viewing of GIS data. These documents can be viewed and utilized easily with free Adobe Reader software (http://get.adobe.com/reader) and the free TerraGo Toolbar (http://www.terragotech.com/products/terrago-toolbar).

The advantage of the geoPDF format is that the files are highly portable and do not require access to advanced technology or software. The TerraGo Toolbar allows users to embed

[3] Due to the confidential nature of some of the information collected from fishers, only a portion of this information is publicly provided and distributed. The data and information housed at the planning departments will include only aggregated information, which protects the sources and complies with the verbal agreement that was arranged with fishers during the interview process.

georeferenced comments[4] in the document. This facilitates the collection and collation of feedback from less technically savvy partners and provides a streamlined process for editing spatial data files. Several geoPDF files have been generated and will be provided to the fisheries and planning departments of St. Kitts and Nevis, and to the St. Kitts National Trust and the Nevis Historical and Conservation Society. Additional copies of these files are available and can be obtained by contacting the aforementioned agencies and organizations, or by contacting The Nature Conservancy via John Knowles (jknowles@tnc.org).

3.4.1.c Web-Based Map Viewer

For people who do not have access to GIS software, desire interactivity, and might not be able to use the georeferenced PDFs outlined above, we created an Internet-based map viewer at http://maps.tnc.org/SKN/index.html. It enables people with Internet access to view, display, query, and print maps of several important data layers including benthic habitats, zoning scenarios, and examples of the maps of fisheries values. The benefit of this product is that it requires no special software, only a standard Web browser, allowing a wide audience to review and provide feedback during a marine planning process.

3.4.2 Fisheries Uses and Values Map

Mapping of fisheries uses and values (summarized in Section 3.3.3 and described in detail in Appendix D) was a key activity in developing the draft zoning design. This mapping effort had three main outcomes. First, the approach and tools that we deployed were critical for engaging fishers, a significant and often under-represented stakeholder group in the planning process. Second, the results of this work supplied essential information pertaining to the extent and value—from the perspective of fishers—of the St. Kitts and Nevis fishing grounds. Third, the island- and federation-level maps and the summary of socio-economic information can be used in fisheries management and site-specific management, in addition to marine spatial planning.

Shawn W. Margles

Charles Steinback of Ecotrust verifies maps of fishing areas with local fishers.

[4] The TerraGo toolbar allows people to view a pdf that is georeferenced. This means that the TerraGo-generated document that they view can be imported into an ArcGIS platform and will be automatically spatially registered. The advantage of this type of document is that, for example, a partner can view a draft zone with Adobe Reader and embed comments in the document. These comments are automatically registered to the same spatial location as the base document. This means that with a TerraGo-enabled ArcGIS license, a user can import comments that are already spatially rectified. This facilitates the process for receiving feedback on proposed zones or when verifying spatial data.

Our survey approach created an opportunity for us to discuss the overall project with fishers and for them to communicate their preferences for marine management. After an extensive process to verify the preliminary draft maps with fishers, we printed final maps and provided them to cooperative leaders on each island, giving fishers direct access to the maps representing information that they had shared. These maps not only serve as a reminder to fishers about the zoning project, but they also help fishers visualize where their most valuable areas are. This understanding may enable them to better advocate for and protect their interests. This aspect became particularly useful when discussing with fishers what areas they would favor to protect as fishing areas and what areas they felt were acceptable to be managed for other objectives such as conservation or tourism. Fishers were able to see clearly on a map where their most important fishing areas were and then consider how the marine areas could be managed jointly to accommodate other objectives. This often led to an agreement that some areas could be better managed for conservation, tourism, or transportation, as long as their most valuable grounds were managed for sustainable fishing objectives.

3.4.3 Benthic Habitat Maps

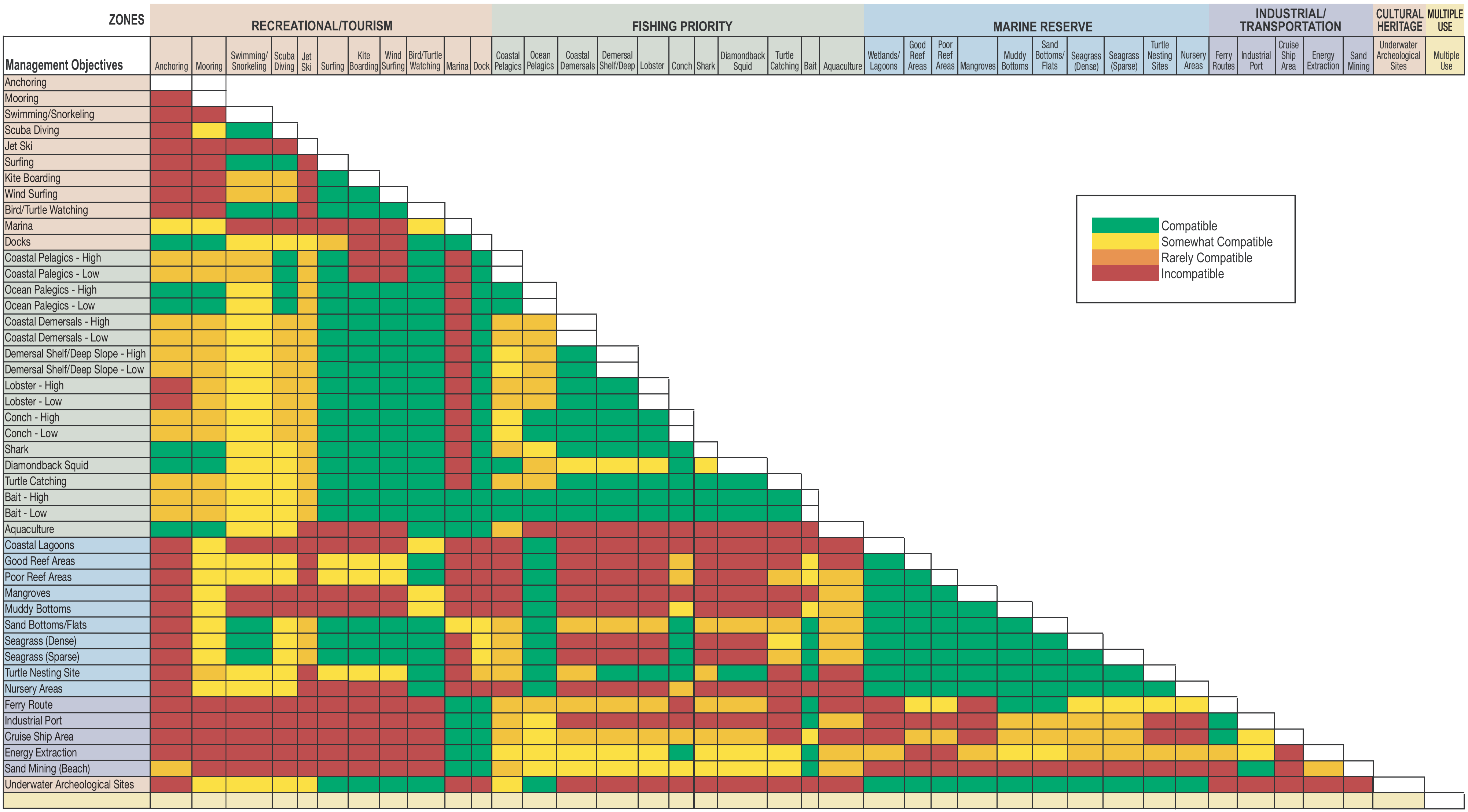
Based on the surveys of benthic habitats, we produced detailed marine habitat maps for coastal waters (less than 30 meters in depth) of St. Kitts and Nevis. These maps display the extent and distribution of 12 distinct benthic habitat classes. These data were used in multiple-objective analysis, and the resulting maps have versatility to be used for planning purposes by a variety of agencies and organizations. For example, these maps can be used to help identify areas potentially suitable for anchoring, environmental restoration or conservation, research, exploration, tourism (i.e., dive sites), and possibly coastal development.[5] These maps have been provided in electronic format to the departments of planning and fisheries on each island as well as the St. Kitts National Trust and the Nevis Historical and Conservation Society. The associated GIS shapefiles can be obtained from either planning department or directly from the Caribbean Program of The Nature Conservancy. For more details on the benthic habitat survey, please see Appendix B.

3.4.4 Compatibility Maps

Identifying where to allow or prohibit activities within a seascape can be challenging. Understanding how these activities interact is vital to determining uses that are compatible and those that are not, and how this plays out in space. To achieve this understanding in the context of St. Kitts and Nevis, we engaged stakeholders in an organized discussion (see the second workshop in Table 2) to document how compatible different marine uses were with one another. Discussion facilitators asked participants to focus on activities that were prioritized to be incorporated in the draft zoning design. The discussion resulted in a detailed matrix quantifying the compatibility of various marine activities into compatibility scores (see Table 4). We produced a suite of compatibility maps by correlating the compatibility scores with spatial information associated with each activity (see Appendix E). These maps became an integral part of the multi-objective analysis described below and will be invaluable for understanding the interactions between activities across the seascape. This understanding will play a key role when considering how to accommodate new locations for marine activities. For example, if a hotel wanted to create a new area for windsurfing, the department responsible for permitting this activity could reference the compatibility map for windsurfing and determine initially if this activity is compatible with existing activities in the proposed area. These maps have the

[5] It is important to note that these maps are part of a suite of decision support products. This summary is not intended to suggest that the benthic habitat maps alone would be sufficient to identify without question an appropriate location for any of the examples provided.

TABLE 4. Marine zoning compatibility.



potential to minimize conflict and greatly improve efficiency. As a result, they may result in cost savings when people seek to locate new activities within the seascape.

The compatibility maps are available through the planning departments on each island or can be obtained directly from the Caribbean Program of The Nature Conservancy.

3.4.5 Outputs of Multi-objective Analysis

To consider tradeoffs and make decisions, it is useful for alternative scenarios to be viewed spatially. So that a variety of actions across the seascape could be viewed spatially in an integrated fashion, we applied a new version of the popular conservation planning tool Marxan (Ball *et al.* 2009) called Marxan with Zones, released in 2009 (Watts *et al.* 2010, Watts *et al.* 2009). Given the complexity of integrating information on uses across space that characterize a wide spectrum of sectors, software tools such as Marxan with Zones can help facilitate this much needed integration.

Marxan with Zones is freely available decision support software that incorporates pre-determined "zones" to allocate resources and optimize the needs of multiple sectors across a particular space (Watts *et al.* 2009). Considering varying zones moves away from looking at space as either appropriate for one activity or not (e.g., an area for fishing or not for fishing, an area for conservation or not for conservation) and facilitates the consideration of all activities equally as part of the planning process. Unlike traditional zoning methods, Marxan with Zones employs a quantitative approach to finding the most optimal areas based on zoning needs. It is a tool able to take a very complicated problem and optimally assign areas in a study region to a particular zone in order to meet a number of ecological, social, and economic objectives, while minimizing conflict and producing the most efficient solution.[6] Outputs from this analysis can be represented spatially and enable users to consider different scenarios and potential tradeoffs.

To support the zoning decision-making process in St. Kitts and Nevis, we generated a series of scenario-analysis maps using Marxan with Zones (Appendix E). We provided these maps to the project's Steering Committee with a careful explanation of the map information, enabling the committee to delineate draft zones for consideration by a broader body of stakeholders. A full and detailed description of how the analysis using Marxan with Zones was set up and how the resulting outputs were interpreted and presented is provided in Appendix E.

3.5 Generating Draft Zones

In previous marine spatial planning efforts, we have found that the lines delineating marine zones must be considered carefully and typically are most effective when generated by those who will be involved in the management and enforcement of a plan. A top-down approach is seldom effective in these situations (Agardy 2010, Gilliland and Laffoley 2008). Instead, it is more effective to make scientifically sound information that has been collected in a participatory fashion available to managers and stakeholders, so that they are able to make informed decisions. In this project, we initiated this process during formal and informal meetings.

At a Steering Committee meeting (Table 2), we presented information collected during the course of the project and the suite of multi-objective analysis outputs. This step was a culmination of the aforementioned activities, which serve as the basis for generating a marine

[6] In this analysis, cost was calculated for each planning unit based on the compatibility of activities contained within the specified area. See Appendix E.

zoning design (i.e., stakeholder engagement, establishing clear objectives, building a multi-objective database and decision support products). Figure 8 shows the final draft marine zoning design based on that review.

The meeting began to lay out a clear process toward a zoning configuration that was feasible for all sectors, minimizing conflict and achieving goals in an optimal way. In addition, we talked with fishers about the draft zoning design produced by the Steering Committee. Overall, fishers recognized the mounting conflicts and in principle supported implementation of some closures, particularly on a seasonal basis. Additional meetings with the Steering Committee and stakeholder groups occurred as this document was going to print and are not reported here. Recommendations generated from these meeting are incorporated in the draft zoning design (Figure 8) and in the Discussion section of this document.

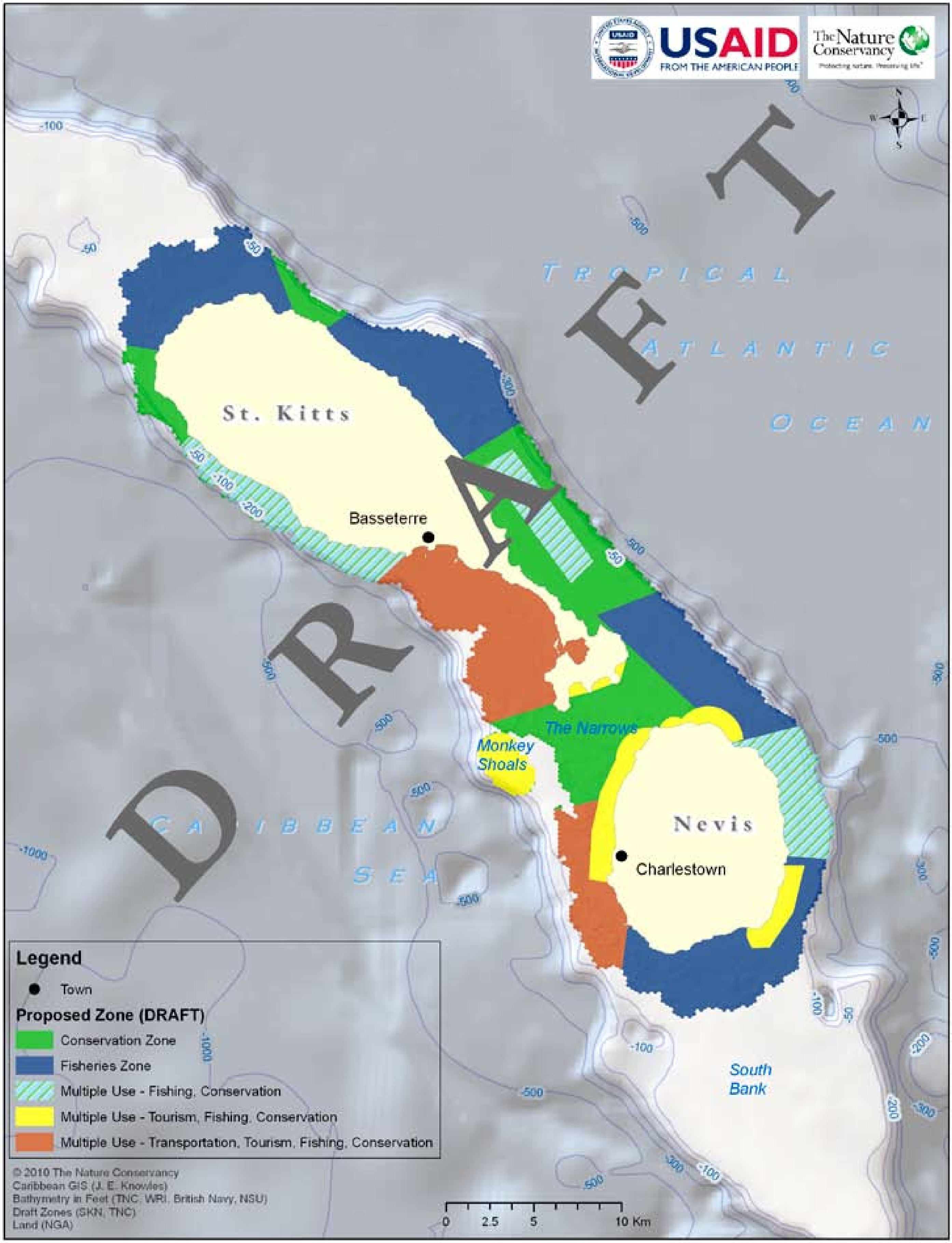


FIGURE 8. Final draft marine zoning design based on steering committee review.

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4 DISCUSSION

4.1 Putting Saint Kitts and Nevis on the Zoning Map Worldwide

The vulnerability of marine areas and the ecosystem services they provide is becoming more and more apparent. Human dependence and impacts on marine resources are on the rise. Ocean zoning is often invoked as a tool that will help slow the degradation and overexploitation of marine resources (Agardy 2010, Ehler and Douvere 2007, Klein *et al.* 2009, Crowder and Norse 2008, Douvere 2008).

In St. Kitts and Nevis, the need to address a number of management objectives under a common framework is apparent, and the marine zoning process initiated with this project holds great promise to fill this need. Zoning can serve as an integrative process in which "planners must recognize connections, including connections between different elements in an ecosystem, between land and sea, between humans and nature, and between uses of ocean resources or ocean space and the ability of ecosystems to deliver important goods and services" (Agardy 2010). It can also provide "the space for an open debate between different marine sectors, active in a certain area, in order to identify conflicts and means of co-existence between sectors—an objective deemed crucial for ocean management" (Barale *et al.* 2009). This project facilitated this integration and open debate between sectors and has laid the groundwork for increased dialogue.

Before this project, decision makers and stakeholders in St. Kitts and Nevis generally did not have an integrated view of marine systems, and little capacity existed for marine spatial planning. The decision support tools developed during this project enable stakeholders and decision makers to take an integrated view of the ocean. Ultimately, these tools could help the people of St. Kitts and Nevis to take a holistic approach to marine management and to make decisions resulting in sustainable use of their ocean waters.

4.2 Moving From Design to Implementation

The decision of exactly where and how marine uses should be allocated in space (a zoning plan) ultimately lies with the people of St. Kitts and Nevis through their government and management agencies. The decision support products developed in this project should be viewed as building blocks that collectively provide a foundation for a final zoning plan. No single tool provides the "golden key" to sustainable marine resource management. The suite of products discussed above can be used to support an in-depth public process started during this project, that analyzes both the spatial and temporal patterns of human activities in marine areas in order to achieve balanced requirements for ecological, economic, and social objectives. Inevitably, there will be multiple, cumulative, and conflicting uses of the sea. As a result of this project, each sector group – tourism, fisheries, conservation, industry, transportation – can develop a greater understanding about the need for solutions to be negotiated and a compromise agreed upon for the benefit of everyone. The decision support products developed during this project have already begun to facilitate such discussions.

The challenge for St. Kitts and Nevis will be to keep the process moving forward and arrive to a fully integrated marine zoning plan to support sustainable use of the ocean. Many other zoning efforts have ended at the planning stage without reaching the implementation phase (Agardy 2010). Activities conducted during this project can be leveraged to prevent a similar outcome in St. Kitts and Nevis. In the short term, we recommend that the people of St. Kitts and Nevis consider taking the following steps to keep the zoning process moving forward:

- Finalize the zoning design and describe specific uses allowed in each zone
- Officially adopt the marine zoning design
- Continue public and government engagement
- Continue to develop the governance framework (for important guidance on this see Appendix F) including working with Ministries to reaffirm high-level government mandate
- Complete the drafting of new legislation to support marine zoning (for important guidance see Appendix F)
- Integrate the outputs of this project into other sectors of government, especially coastal zone management, fisheries management, and protected areas planning

The role of the Steering Committee established during this project is vital. All activities outlined above should be coordinated by this committee. Its membership should be re-evaluated to ensure that private sector representatives are included.

A number of other longer-term activities to support implementation of the marine zoning plan will need to be considered (e.g., design a monitoring plan to help evaluate zoning plan efficacy, develop a budget for management operations). A full discussion of these is outside the scope of this document; for these we refer the reader to the wide range of publications that synthesize and document other zoning efforts worldwide (e.g., Day *et al.* 2007, Day 2008, Douvere 2008, Douvere *et al.* 2007, Gilliland *et al.* 2008).

4.3 Incorporating Expert Knowledge and Supporting a Participatory Process

Building a spatial database that represents uses and characteristics of an ocean space requires integrating a wide variety of information and is essential in a marine zoning process. For most small island tropical nations where financial resources are limited, such spatial data is typically inaccurate, out of date, or not available. This project deployed approaches that leverage local knowledge concerning marine space and the uses it supports, as well as tools that allow for a rapid assessment of ecosystem components. It demonstrates the types of approaches and tools that can be deployed to facilitate the collection of expert information. While detailed field surveys will be necessary to measure the status of ecosystem health for the waters of St. Kitts and Nevis, rapid assessment tools such as those used in this project (i.e., mapping of habitats and fishing values) allowed for a baseline description of where important habitats and uses occur.

For an ocean zoning plan to be achievable—that is, supported by user groups and feasible in the local context—the design process should be as participatory as possible. This project required a major commitment to engaging local communities and government agencies in the marine zoning process. To ensure participation, the project conducted activities ranging from stakeholder workshops to field data collection. These steps helped to engage key stakeholders and to forge important partnerships. The resulting in-country partner relationships were a key asset and greatly benefited the draft zoning design. Information flowed in both directions, both to and from the in-country project partners and the project team, an essential ingredient of any marine zoning process (Agardy 2010). With the decision support tools and draft zoning design now available, the process of engaging the public and developing a national appreciation for the ecosystem services provided by the ocean is more feasible. Support for the zoning plan from the general public will be key to its eventual success. The foundation developed during this project to facilitate community input and access to information (e.g., the establishment of a Steering Committee, printed maps, and interactive database housed in-country with multiple agencies and NGOs) can continue to be leveraged by the citizen of St. Kitts and Nevis and serve as a model for other places engaging in marine zoning efforts.

4.4 Challenges and Lessons Learned

One purpose for conducting this project was to uncover challenges that may be encountered during a marine zoning process and to develop solutions and recommendations that could be applied not only in St. Kitts and Nevis but in other places. This section describes challenges and lessons that this project identified for marine zoning.

4.4.1 Establishing In-country Partnerships

We invested a great deal of time and resources in forging relationships with government Ministries, their respective agencies, and stakeholders of St. Kitts and Nevis. These relationships were instrumental for many activities from project management to collection of data during field surveys. However, cultivating stakeholder involvement in every step of the process often diverted effort from other priorities such as scientific analysis. Initially, building and maintaining these important relationships was especially difficult because none of the core team members lived in St. Kitts and Nevis. This issue was resolved by adding an in-country project coordinator to the core team. Having a local counterpart with good government contacts was essential to the effort. Similar projects should carefully allocate sufficient resources to build relationships, effectively engage stakeholders, and provide outreach to the general public. Finding a balance between ensuring a participatory process and maintaining leadership to reach the project's goals is tricky and should be considered carefully in these types of efforts. In addition, the government agencies for fisheries, planning, and other relevant areas of responsibility in St. Kitts and Nevis are stretched thin due to low number of staff and lack of funding available for staff positions. A serious need exists for additional government staff with expertise in marine resource management.

4.4.2 Conducting Stakeholder Workshops

We dedicated significant time and effort to planning and conducting three stakeholder workshops where essential elements of a zoning plan were defined. We took great care to deploy effective approaches to facilitate discussion, to engage stakeholders, to record their opinions and needs, and to incorporate the information into the decision support products. Bringing together such diverse interests and facilitating discussion among stakeholders was not a simple task. Future efforts should consider investing additional resources in planning and deploying appropriate facilitation tools. Furthermore, while our mapping and data-verification efforts were instrumental in building relationships with the fishers of St. Kitts and Nevis, we need to ensure more participation of fishers at stakeholder meetings. This will likely require providing options for meeting venues and for schedules that will accommodate everyone's livelihoods.

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Participants in the project kickoff meeting work on the St. Kitts-Nevis Vision Map.

4.4.3 Representing Habitats and Uses at the Edges

As mentioned earlier, the need to develop a zoning plan that would extend to the limit of the EEZ was identified by all parties early in the process. However, our ability to collect spatial data for habitats extending beyond the 30-meter depth contour line was limited given the scope of resources for this project. Future efforts should carefully consider this element and invest in approaches and tools aimed at describing deeper habitats and offshore waters. In addition, the inshore boundary for our study area was defined as the farthest extent of seawater influence. While we did include information on sand mining and some other land activities that affect coastal waters, important influences such as watershed inputs and coastal development were not included. While we decided early on that these land-based influences were beyond the scope of this project, they need to be addressed at some point to improve the effectiveness of any eventual zoning plan. Approaches to human impacts and activities on coastal lands, short of including them in a full land-sea zoning plan, should be developed. Opportunities to leverage the current maritime boundaries project and a latent coastal zone management program should be considered.

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Coastal development is an important influence on the marine ecosystem. It was outside the scope of this project but should be considered as part of the marine zoning process.

4.4.4 Representing the Future Vision

An ocean zoning process is about creating a desired future, not just documenting present conditions (Agardy 2010). Although we dedicated considerable effort to helping citizens of St. Kitts and Nevis to define a shared vision (see first workshop in Appendix A), we struggled with spatially representing that shared vision and explicitly incorporating the vision into quantitative and analytical tools. While the decision support products developed here are successful at representing current conditions, they are not effective at depicting projected uses of the ocean into the future. At present, there seems to be a disconnect in most zoning efforts between the desire to represent human uses and impacts into the future (including climate change impacts) and the ability to map projected distributions of system characteristics (both ecological as well as human uses) into the future. There is a need to develop practical examples of approaches that link current state and future vision for marine space. While ocean zoning represents a promising framework to do so, the lack of existing data and tools makes it difficult to address this need.

4.4.5 Integrating Ecological and Socioeconomic Data

Ecological and socioeconomic information need to be integrated to effectively represent the variety of uses occurring in the ocean and the habitats supporting them. Prioritizing the collection of a wide variety of information across this spectrum and integrating this information can be challenging. Making balanced decisions on investments of data resources, acknowledging the mismatch in scale between types of data, and making transparent choices to overcome this challenge is essential. This project filled important data gaps, prioritizing both ecological and socioeconomic information and conducting rapid assessment surveys to build the information base for zoning. The following strategic investments would strengthen this integration for future marine planning efforts in St. Kitts and Nevis:

1. Develop cost-effective methods and tools to map marine habitats beyond the 30-meter depth contour and on offshore banks.
2. Develop approaches for integrating data from a multitude of spatial scales.
3. Invest resources in describing the current state of ecosystem health, understanding the socioeconomic fabric of the islands, and monitoring ecosystem changes.

4.4.6 Using Systematic Conservation Planning Tools

The systematic conservation-planning tool applied in this project (Marxan with Zones) helped organize a wide range of information and assign actions to specific locations across the seascape. Like any modeling tool, Marxan with Zones presents a set of challenges and opportunities. There is a danger of such tools becoming a "black box" with choices and assumptions unclear to stakeholders, setting up a negative chain reaction against other decision support products. In order for these tools to be useful, it is important that they are applied in the most transparent manner, with stakeholder involvement in the definitions of key assumptions and parameters. The participatory process that took place during this project facilitated stakeholder input at a number of key analysis junctures, producing zoning scenarios that reflected community input. Facilitating that input proved to be challenging, as a transparent synthesis of underlying assumptions and necessary inputs is not simple to convey. A careful balance between leadership and stakeholder participation needs to be struck for this process to be productive. Future efforts should continue to strive to communicate the importance of balancing the two and to facilitate stakeholder discussions that support this approach.

The Marxan with Zones software represents a new generation of systematic planning tools in which multiple needs and desires of people are considered in one framework. While Marxan with Zones is an evolution of the widely used Marxan software and may seem similar in look and feel, the two have important differences in information requirements. In addition to ecological data, Marxan with Zones requires a considerable amount of data on ecosystem services and people's desires regarding ocean uses. This difference needs to be considered carefully when evaluating data needs and the required resources for data collection and analysis. Model outputs are only as good as the data used to build them.

While the need to integrate ecological and socioeconomic information into conservation planning efforts is increasingly apparent, there are still few examples of projects that have done so with Marxan-based modeling for marine systems (Klein *et al.* 2009, Watts *et al.* 2009). We should continue to prioritize activities that identify, distill, and communicate lessons learned from these projects and that strengthen this type of integration. These efforts should include development and application of field survey tools such as the ones we deployed here, as well as spatial modeling approaches to supplement and integrate current datasets.

At the end of the day, it is important to remember that the outputs of these types of tools provide decision support and should not be considered the decision makers alone. For example, the model results that we provided in Marxan with Zones scenarios can reveal areas that are important for habitats and human activities based on specified goals across multiple sectors. They can also be used to identify important sites for management action, which can be especially useful for governments working with limited resources.

4.4.7 Matching the Scale of the Problem and the Solutions

There is a fundamental dilemma in ocean management: the scale at which we can readily practice effective management and the scales at which marine ecosystems operate are very different (Agardy 2010). This is a very common problem in small island developing states. Successfully achieving sustainable ocean use will require recognition of this problem, mobilization of resources to develop solutions, and leadership in driving change. The citizens of St. Kitts and Nevis are faced with this dilemma as a number of operational management scales exist, including a very island-specific approach to planning and management and two separate governance structures. This project has laid the foundation for a potential federation-wide approach to zoning the waters surrounding St. Kitts and Nevis. We strongly recommend taking a federation-wide approach, as this will be the only effective path to sustainable use of ocean resources. While we anticipate that there may be significant challenges during implementation, we do believe that the marine ecosystem of Saint Kitts and Nevis should be considered and managed as one space.

4.5 Looking to the Future

Thinking strategically and planning for sustainable use is imperative in today's overexploited marine systems. In St. Kitts and Nevis, the need to address multiple management objectives under a common framework is apparent, and the marine zoning process initiated with this project holds great promise to fill this need. This project helped to identify connections between humans and nature, and between uses of the ocean and the ability of ecosystems to deliver important goods and services. To fully understand these important connections, information such as use and characteristics of offshore habitats and current health of the marine ecosystem (e.g., coral reefs and fish populations) should be added to the information base developed in this project (see Section 4.4.5). Predictions of future conditions in the marine ecosystem of Saint Kitts and Nevis and the implications for resource management within the context of climate change should also be prioritized.

Efforts should also be focused on leveraging activities conducted during this project and the integrated platform that now exists, such as the spatial database. A strong coordinated public outreach program should be set in place and build on the range of stakeholder engagement activities conducted during this project. The role of the Steering Committee will be central to achieving these actions and should be carefully evaluated and refined.

All resource management takes continued effort and inputs. Marine zoning is still in its early stages in St. Kitts and Nevis, as it is throughout the world. Currently, the capacity of the country's marine management agencies is limited and needs to be addressed; co-management arrangements are one possible mechanism to help supplement this capacity. Ultimately, additional funding will need to be secured in order to move this process forward. Moving the marine zoning design generated for St. Kitts and Nevis to a fully implemented marine zoning plan will take a concerted effort on the part of government, user groups, NGOs, and the international community. Unfortunately, many zoning efforts stop at the planning stage and never move to the implementation phase (Agardy 2010). It is our hope that this will not be the case here. As a result of this project, the people of St. Kitts and Nevis have laid a solid foundation for sustainable marine resource management that can incorporate multiple uses and user groups. Every effort should be made to continue to support the process provided through this project for open debate among sectors that helped to identify conflicts and means of co-existence between sectors.

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APPENDIX A

Summary Results of the St. Kitts Nevis National Marine Zoning Workshop: October 5th & 6th, 2009

Summary Results of the St Kitts-Nevis National Marine Zoning Workshop: October 5th & 6th, 2009

Visioning a National Marine Zoning Plan to balance multiple uses for a sustainable future

Report prepared by
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Acknowledgments

*This report was made possible by the generous support of the American people through the United States Agency for International Development (USAID) under the terms of its Cooperative Agreement Number 538-A-00-09-00100-00 (*BIODIVERSITY THREAT ABATEMENT *Program implemented by prime recipient The Nature Conservancy and its partners. The Nature Conservancy would like to thank the staff of the Ministry of Physical Planning and Environment, St. Kitts, the Ministry of Communications, Works, Public Utilities, Posts, Physical Planning, Natural Resources and Environment, Nevis, the Ministry of Maritime Affairs, and the Ministries of Fisheries of St Kitts and Nevis . The contents and opinions expressed herein are the responsibility of the* BIODIVERSITY THREAT ABATEMENT *PROGRAM and do not necessarily reflect the views of USAID.*

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Executive Summary

Both extractive (e.g. fishing) and non-extractive (e.g. tourism) activities are placing increased and often conflicting demands on the marine waters of St. Kitts and Nevis. Future outlooks show that many of these activities and uses are likely to accelerate in the next few decades. The increasing demand on marine resources along with increasing threats, including climate change, necessitates effective management if these uses are to remain viable in the future. The Federation of St Kitts-Nevis has been chosen as the pilot site for the development of a multiple use marine zoning plan that will address these challenges and create a sustainable foundation for managing multiple marine uses. The outcomes of this project will serve as a model for the Caribbean and small island nations.

On October 5 & 6, 2009 The Nature Conservancy (The Conservancy) along with partner agencies held a "kick-off" stakeholder forum for this pilot project, funded by USAID. The forum brought together representatives of non-government organizations (NGOs), government agencies, and user groups and guided them through a process of mapping a future vision for the federal waters. The results of the forum are summarized in this report.

Approximately 115 ideas for the future management of the marine environment were generated. The ideas generally fell into four major components:

- **Policy & Regulations**
- **Enforcement**
- **Education**
- **Uses**

Six overall *Use* themes emerged and 20 goals pertaining to these *Uses* were identified, with an umbrella theme of Policy, regulation, and enforcement. The identified use themes were:

- **Recreation**
- **Tourism**
- **Fishing**
- **Development & Planning**
- **Conservation, and**
- **Transportation**

These uses will form the basis for the comprehensive National Multiuse Marine Zoning Plan. For these *Uses* the participants identified goals and potential strategies to achieve goals and overcome barriers. The goals identified can be found in Part 3 of this report.

The Kick-Off workshop provided a basis for moving forward with the Biodiversity Threat Abatement Program and identified a number of important next steps including:

- The need for the formation of a steering committee to guide the development of the multiple use zoning plan;
- A government briefing on the program and multiple use zoning for endorsement by Cabinet;
- Gaps in data and resulting necessary data collection efforts (e.g. spatial distribution of fisheries and federation wide benthic habitat maps);
- Outreach and education for communities on multiple use marine zoning;
- Integration of the project with other efforts including Protected Area Systems Planning and Coastal Zone Management; and
- The need for in-country coordination of the program

The Conservancy will utilize the information provided by the participants in development of a multiple use marine zoning plan for St Kitts-Nevis.

Part 1
Background

Why Marine Planning & Zoning?
Marine planning is a place-based holistic management strategy that aims to facilitate sustainable development and use for all activities occurring in a defined marine and coastal area. Both extractive and non-extractive activities are placing increased and often conflicting demands on the Eastern Caribbean's coastal and marine waters. Future outlooks show that many of these activities and uses are likely to accelerate in the next few decades. As a result, important coastal areas are under intense pressure, threatening the biological diversity of the region's beaches, coral reefs, wetlands, mangroves and seagrass beds and the environmental services they provide (e.g. coastal protection, food security, tourism amenities, biodiversity protection, climate change adaptation).

Marine zoning has recently emerged as one of the tools that will help us better address multiple activities taking place in the ocean (e.g. tourism, ports, fisheries, and biodiversity). The outcome of a marine planning process is a comprehensive marine zoning plan that allocates use across space in an integrated fashion by including ecological, economic, and social considerations. Marine zoning is currently being applied worldwide and efforts span a range of spatial scales from large, integrated sea-use management projects (ex. China Sea, Australia's Great Barrier Reef) to smaller-scale examples that essentially apply zoning to networks of marine-protected areas (ex. Soufriere Marine Management Area, St. Lucia, Wakatobi Archipelago in Indonesia). Examples of marine zoning for small island states are unfortunately few and far between and generally have been poorly documented. The marine planning and zoning pilot project for St. Kitts & Nevis could provide a model for the Caribbean and around the world.

St Kitts-Nevis was chosen as the site of this pilot project because of expressed priorities within the country along with the federation's commitment to the Convention on Biological Diversity and other international treaties to which it is signatory. This project supports the St. Kitts-Nevis National Biodiversity Strategic Action Plan and integrates with the Protected Areas Systems Planning process currently underway.

Part 2
Details on the Biodiversity Threat Abatement Program

In April 2009, USAID entered into a cooperative agreement with The Nature Conservancy (The Conservancy) to fund a program titled Biodiversity Threat Abatement in the Eastern Caribbean. A significant part of this project is to develop a general framework and tools that will facilitate the implementation of multiple use marine zoning in the federal waters of St. Kitts-Nevis. The project also includes a component for policy, legal and regulations, and one for marine biodiversity education and outreach that will support the zoning effort. The project is being conducted in partnership with the government agencies of St. Kitts-Nevis including: Physical Planning and Environment, Fisheries and Marine Resources, Tourism, Maritime Affairs, and Finance.

The project duration is from April 15, 2009 to September 30, 2010 and includes funding for data collection, stakeholder outreach, data analysis, capacity building, and imagery and GIS data as needed. In order to reduce the impact on already over-committed staff resources the project has contracted an in-country project coordinator. There are additional funds for the policy and education components.

This project will provide St. Kitts-Nevis with a solid basis for marine zoning and planning including detailed marine biodiversity data, maps, and surveys as well as data on other marine uses (e.g. fisheries, tourism); it will also provide significant capacity building for key in country staff. Specific activities will include:

- **Evaluate enabling conditions for island wide marine zoning and assess data availability**
- **Develop data sets and incorporate into proposed draft zoning plan**
- **Build a decision support framework for the implementation of an island wide marine zoning plan**

Part 3
Summary of the Two-day Project Kick-Off Workshop

Day One: Creating a Vision

In order to achieve multiple use objectives for the federation's waters, representatives from St Kitts and Nevis created a vision that was shared by a variety of constituency groups and stakeholders. The process of creating a vision for multiple uses of the federation's waters under the USAID funded project began on October 5 & 6, 2009 with a "kick-off" stakeholder forum. The agenda for this meeting can be found in Appendix A. A complete participant list can be found in Appendix B. This forum brought together representatives of non-government organizations (NGOs), government agencies, and user groups and guided them through a process of mapping a future for the federal waters. The keystone activity of this forum was the creation of a vision map, which addressed the question, "What do you love about your ocean? What are the changes you would like? What changes do you not want? And how do you picture the uses of the ocean in the future"? Participants generated a wealth of ideas, and a vision for the future of the federation's waters emerged.

This visioning process will serve as the foundation for the USAID funded Marine Zoning Project, and this forum was just the beginning of the work necessary to translate the overall ideas and goals of the federal vision into a specific draft zoning plan. A complete list of vision statements (ideas) can be found in Appendix C. Based on priorities set by the participants, a few of the major (highest priority) ideas from the Vision include:

- Marine protected areas
- Anchoring and mooring areas for commercial and recreational usage
- Marine areas set aside to replenish fish stocks
- Public facilities on beaches
- Green practices used by hotels and restaurants adopted
- Education for tourists on "proper behavior" underwater
- Better enforced regulations
- Protection of marine mammals
- Setbacks from sandy beaches
- Vibrant sports fishing industry
- Turtles for tourism not food
- Fish traps with biodegradable doors
- Alternative livelihoods to fishing available
- Mangroves protected and restored
- Better motor vehicle connectivity between St Kitts and Nevis
- Designated swimming areas

Approximately 115 ideas were generated. The ideas generally fell into four major components:

- **Policy & Regulations**
- **Enforcement**
- **Education**
- **Uses**

These four major components play a vital role in achieving a comprehensive and effective multiple use marine zoning plan.

After the completion of day one activities The Conservancy's staff analyzed the participants' vision statements and identified approximately 56 ideas relating primarily to the component of marine uses (Appendix C). These 56 ideas were further consolidated. Seven overall marine and coastal use themes emerged and 20 goals pertaining to *Uses* were identified. The identified use themes were:

- **Recreation**
- **Tourism**
- **Fishing**
- **Development & Planning**
- **Conservation**
- **Transportation**

In addition, a cross-cutting theme of Policy, regulations, and enforcement was identified.

Some vision statements could be addressed by several of the themes. These cases are indicated in the table in Appendix C. Further cross over between vision statements and multiple themes are likely possible.

Day Two: Multiple Marine Uses for St Kitts-Nevis and Barriers to Achieving Marine and Coastal Use Goals with Strategies to Overcome Barriers

The second day of the two day workshop focused on identifying existing barriers that were in the way of achieving each of the Use goals. To begin the day participants were given a presentation on the Use goals that had emerged from the synthesis of vision statements, which had been prepared the night before by Conservancy staff. Workshop participants then split into groups that aligned with each of the 6 themes (listed above) to first verify the goals and then identify existing barriers to achieving the articulated goals. The Recreation and Tourism themes were combined to form a single group because of the close alignment of goals (see Part 5) and overlap in participant interests. TNC staff facilitated each group in making any necessary adjustments to the articulated goals and in developing strategies and approaches most likely able to address the identified barriers. The final recommendations can be found in Appendix D.

After completing the small group exercise, worksheets were posted in the main workshop hall. Each working group selected a spokesperson to present the barriers they had identified and their strategies to overcome them. Participants were then given time to view the worksheets and indicate their preferred strategies and identify the barriers they felt were most significant. The results of voting are indicated in Appendix D.

Part 4
Four Components of a Successful Marine Spatial Zoning Plan

The four major components identified at the Project Kick-off Meeting will all play a vital role in achieving a comprehensive and effective multiple use marine zoning plan for St. Kitts-Nevis. All of these components must work in concert to achieve the overarching goals of a marine zoning plan. These four components were discussed at the October 2009 Kick-off meeting. Goals, objectives, and long terms strategies for each major component should be further developed in order to support a zoning plan. This project will address these issues for the development of a multiple use marine zoning plan and set the foundation for regulation and education. At the kick-off meeting goals and long terms strategies were identified for the themes in the *Use* component and will be summarized in the next section.

Policy & Regulations – Harmonized policies and regulations are a vital component needed to support a marine zoning plan. Policies and legislation must be comparable to recognize and address key management issues. Establishment of long-term funding mechanisms to support managed areas and enforcement of regulations are also essential. Policies must be established to meet the overarching objectives inherent to a multiple use zoning plan. Supporting regulations must exist to enact those policies. At the kick-off workshop participants indicated that St. Kitts-Nevis already has a number of appropriate regulations in place that would support a multiple use zoning plan. The greatest challenges expressed largely involved ineffective enforcement.

Enforcement – Enforcement of supporting regulations is essential to the success of a marine zoning plan. Without effective mechanisms in place for enforcement a zoning plan will in essence remain a paper plan. Enforcement responsibilities must be clearly defined and delegated to appropriate agencies. These agencies must also be given an appropriate level of support and resources to achieve enforcement.

Education – Public misperception of marine spatial zoning can be a major obstacle for a successful zoning plan. Stakeholders may skeptically view rules and regulations that limit historical uses of marine resources. Not only must stakeholders understand the intent of a zoning plan but government officials and policy makers must understand the economic benefit of a comprehensive multiple use marine zoning approach to managing marine resources. Broad education is therefore needed both within the community and within the government at a local and national level.

Uses - A marine zoning plan seeks to incorporate multiple uses in a spatial layout in order to achieve multiple objectives. Both extractive and non-extractive activities are placing increased and often conflicting demands on coastal and marine waters. Recognizing what uses are currently taking place and what uses may occur in the future can help users identify and anticipate conflicts so that they may be mitigated or avoided. The October Kick-off meeting identified six major areas of uses. Participants articulated specific goals for each of these sectors along with potential barriers and long term solutions.

Part 5
Summary of St. Kitts-Nevis Marine Use Goals

Six main marine uses were identified at the Project Kick-off Meeting in October 2009. They were recreation, tourism, fishing, development and planning, conservation, and transportation. These uses will form the basis for the comprehensive National Marine Zoning Plan. At the Kick-off meeting information regarding the goals and potential strategies to overcome barriers and achieve goals was collected. Below the goals for each category of uses has been summarized. Specific information on strategies to overcome barriers to goals with priority voting is located in Appendix D. Additional information pertaining to the spatial distribution and compatibility between uses must be collected and integrated into a final layout for review by stakeholders.

Recreation – Having ample opportunities for local recreation is culturally important. It allows residents to stay connected to long standing traditions as well as provides opportunities to build social capital and maintain community health and wellbeing. St Kitts and Nevis have many locations and activities that are long standing and significant to the way of life in these communities. Areas supporting these activities must be maintained and respected in a National Marine Zoning Plan.

Goals

- Recreational fishing opportunities (near-shore and game) with large and variable fish species
- Ample facilities for recreational boating (beach and pier access, moorings)
- Clean water, healthy reefs, and clean beaches for swimming, snorkeling, sailing, diving, etc.

Tourism – Tourism is a vital part of the St Kitts-Nevis economy. Visitors come to the islands to take pleasure in the pristine beaches and surrounding waters and to enjoy an authentic Caribbean experience. Maintaining and improving the tourists' experience is important to present and future economies. A National Marine Zoning Plan must incorporate present tourism sectors and anticipate future ones in order to support an evolving and adaptable tourism industry.

Goals

- Appropriate/Adequate areas for swimming and other tourist activities (such as snorkeling, diving, wind surfing, jet skis, other water sport e.g. sailing)
- Key sites managed for marine tourism (turtle watching, top dive sites)
- Areas designated for future tourism infrastructure (hotels, golf, access roads)/areas where development is not allowed

Fishing – Commercial and artisanal fishing is extremely important in St. Kitts-Nevis. Fishing activities supports families, restaurants, local and export markets, and even tourism. In order for Kititian and Nevitian fisheries to thrive, abundant species of ample size must be available. However, today species are dwindling and smaller and smaller catch size is all that is available. A balance between restocking and adequate opportunities to fish must be reached in order to achieve sustainable fisheries within federation waters.

Goals

- Unrestricted access to landing and mooring facilities for fishers
- Zoning to include closed areas, open access and other areas where selected gear or access restrictions apply
- Enhanced productivity and ongoing replenishment of target species

Development & Planning – Development is essential for a sustainable St. Kitts-Nevis economy. Although it is important to identify critical areas of cultural and environmental importance that should remain free of activities, development opportunities must be made available in order to adapt to future population and market needs. Areas best suited to development must be identified so that activities do not unnecessarily harm important resources that support other uses. Additionally, development best practices should be devised and/or employed in order to minimize impacts of development.

Goals

- Sufficient space for energy generation and transmission for local consumption and export
- Coastal engineering (including "hard" solutions - sea walls, beach replenishment; and "soft" solutions - mangrove restoration) to be well regulated
- Zoning to include sustainable development and no development

Conservation – Conservation is an important tool to insure that future generation in St. Kitts-Nevis can enjoy the same, or better, quality of life as those today do. Conservation supports and improves healthy fisheries, maintenance of sustainable levels of biodiversity, improved tourist experiences, and ample recreational opportunities. Unfettered uses without integrated conservation may threaten stable and long term usage of marine resources.

Goals

- Protection of key submerged marine resources (critical habitats, species, nursery, feeding, and reproduction areas)
- Culturally important marine areas protected
- Protect terrestrial resources critical for marine health (including watershed protection, 120ft setbacks on beaches)
- Restored critical habitat (mangrove, nursery areas)
- Protect key coastal resources (beaches, mangroves, salt ponds)

Transportation – Marine transportation is an important part of daily life in St. Kitts-Nevis. Marine transportation is necessary to connect the islands within the federation and to connect the federation to other countries. Identifying appropriate routes for marine transportation is important for safety and to ensure adequate traffic can be accommodated. Establishing transportation corridors can minimize accidents and improve the efficiency of inter and intra island transport.

Goals

- Distinct identification and demarcation of ferry and shipping lanes
- Marina development plan - locations where marinas may be developed in future (to include commercial/recreational/tourist)
- Distinct identification and demarcation of ferry and shipping lanes

Part 6
Conclusions and Recommendations

The Biodiversity Threat Abetment Program seeks to assist the government of St Kitts-Nevis to develop a National Multiple Use Marine Zoning Plan. The October 5th & 6th Kick-off Meeting Workshop was only the beginning of the work needed in order to realize this plan. The Kick-Off workshop provided a basis for moving forward with the Biodiversity Threat Abatement Program and identified a number of important next steps including:

- The need for the formation of a steering committee to guide the development of the multiple use zoning plan;
- A government briefing on the program and multiple use zoning for endorsement by Cabinet;
- Gaps in data and resulting necessary data collection efforts (e.g. spatial distribution of fisheries and federation wide benthic habitat maps);
- Outreach and education for communities on multiple use marine zoning;
- Integration of the project with other efforts including Protected Area Systems Planning and Coastal Zone Management; and
- The need for in-country coordination of the program

Overarching and reemerging themes consistently arose over the course of the two day workshop. Among the most mentioned topics was the need for education and outreach on the importance and timeliness of such an effort. Also, education on how a zoning approach to multiple marine uses could help alleviate current and future conflicts and improve situations so that goals could be more readily achieved. It was expressed that both communities and government officials must be educated on these issues. Concerns were raised about the ability of regulating agencies to enforce new rules and regulation with limited resources. The importance of enforcement and the provision of adequate resources to managing authorities was made clear.

Over the next several months The Nature Conservancy will work with in-country partners to help fill the data gaps and facilitate a planning process for a National Multiple Use Zoning Plan for St Kitts-Nevis.

Appendix A: Agenda Kick-off Workshop

National Marine Zoning Workshop
Visioning a National Marine Zoning Plan to balance multiple uses for a sustainable future
Monday 5th to Tuesday 6th October, 2009
Ocean Terrace Inn
<u>AGENDA</u>

Day 1
Meeting Objectives:
1) Introduce marine zoning
2) Present need for marine zoning in St. Kitts & Nevis
3) Describe marine zoning in the context of the Caribbean & the world
4) Introduce the USAID funded marine zoning project
5) Envision St. Kitts & Nevis marine resource use 20-50 years from now

9:00 AM Welcome & Agenda Review	Mr. Randolph Edmead, Director of Physical Planning and Environment, St. Kitts & Ms. Ruth Blyther, The Nature Conservancy
Introductions	All
Past experiences with zoning; Federation objectives; Existing and potential use conflicts	Mr. Joe Simmonds, Dir. of Fisheries, St Kitts Mr. Lemuel Pemberton, Dir. of Fisheries, Nevis Mr. McClean Hobson, Dir. of Maritime Affairs
10:30-10:45 AM Break	
Introduction to Marine Zoning	Dr. Vera Agostini, The Nature Conservancy
The Caribbean Picture	USAID
St Kitts & Nevis Marine Zoning Project	Ms. Ruth Blyther, The Nature Conservancy
12:30 PM Lunch	
Visioning: 20 years from now…how do you envision your marine & coastal areas?	Group Activity Facilitated by Ms. Shawn Margles, The Nature Conservancy
2:45-3:00 PM Break	
Prioritizing marine components	Group Activity Facilitated by TNC
4:00 PM Close	

Day 2
Meeting Objectives:
1) Reach consensus on marine zoning plan goals & objectives
2) Define barriers to achieving those goals & objectives
3) Identify potential solutions to identified barriers

9:00 AM Agenda review		
Re-cap of day 1		The Nature Conservancy
Discussion/Verification of marine area goals		Group Activity Facilitated by The Nature Conservancy
10:30 – 10:45 AM	Break	
Activity: "Barriers, Strategies" What are the major barriers to marine area goals? What are potential strategies to address the barriers to the goals?		Group Activity Facilitated by The Nature Conservancy
12:30 PM	Lunch	
Report outs from each group on "Barriers, Strategies"		Group Activity Facilitated by The Nature Conservancy
Prioritization of biggest challenges to zones		Group Activity Facilitated by The Nature Conservancy
Group discussion		Facilitated by The Nature Conservancy
2:45-3:00 PM	Break	
Next steps		Eastern Caribbean Director, Mr. James Goggin, United States Agency for International Development (USAID) & Ms. Ruth Blyther, The Nature Conservancy
4:00 PM Close		Permanent Secretary Mr. Ernie Stapleton, Ministry of Communications, Works, Public Utilities, Posts, Physical Planning, Natural Resources and Environment

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Appendix B: Kick-off Workshop Attendees

Participants		
First Name	**Last Name**	**Organization**
Sylvester	Belle	Physical Planning
Lester	Blackett	Nevis Disaster Management
John	Brake	Ross Vet School
Kelvin	Daly	Nevis Fisheries
Paul	Diamond	Nevis Historical & Conservation Society
Karen	Douglas	Sustainable Dev. St. Kitts
Titlon	Douglas	Physical Planning
Jay	Farier	St Kitts Physical Planning
Mackee	France	Four Seasons
John	Guilbert	Nevis Historical & Conservation Society
John	Hanley	Tourism - Nevis
Ellis	Hazel	Christophe Harbour
McClean	Hobson	Maritime Affairs
Winston	Hobson	Fishermen Co-op Nevis
Janice	Hodge	CADENCO Inc
Cynthia	Hughes	Nevis Historical & Conservation Society
Rawlinson	Isaac	West Indies Power
Devon	Liburd	Tourism - Nevis
Everette	Mason	NASPA
Eduardo	Mattenet	St Kitts Physical Planning
Kerry	McDonald	West Indies Power
Kate	Orchard	St Kitts National Trust
Maria	Pena	Barbados. UWI
Kenneth	Samuels	Dive St Kitts
Joe	Simmond	St Kitts Fisheries
Rene	Walters	Nevis Physical Planning
Barbara	Whitman	Under the Sea
Patrick	Williams	Independent
Nigel	Williams	Coast Guard
Alastair	Yearwood	Oualie Hotel
Observers		
Michael	Taylor	USAID - Barbados
James	Goggin	USAID - Barbados
Facilitators		
Vera	Agostini	TNC Global Marine
Ruth	Blyther	TNC - Caribbean
John	Knowles	TNC - Caribbean
Shawn	Margles	TNC - Caribbean
Steve	Schill	TNC - Caribbean
Mark	Spalding	TNC Global Marine

Appendix C: Visioning Exercise Photos and Results

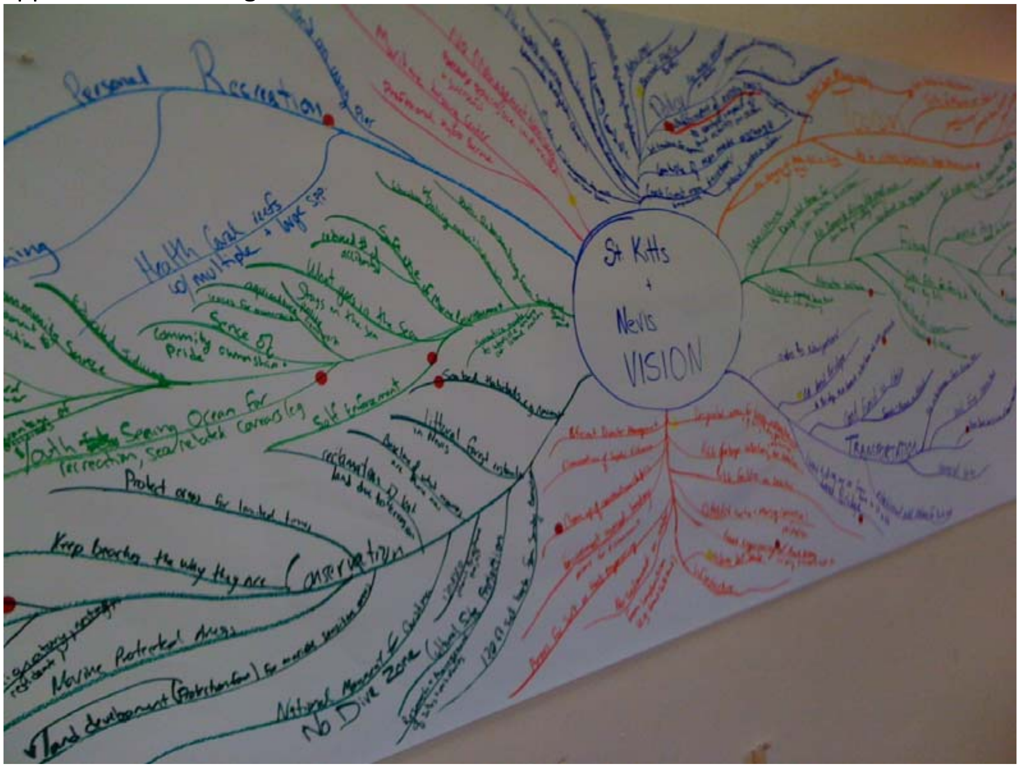


Figure 1 Photo of St. Kitts-Nevis Vision Map (photo credit: S. Margles)

Figure 2 Prioritization of Vision Map Components (photo credit: S. Schill)

Major Area	Major Component(s)	Vision Statement/Idea	Prioritization
Recreation	Uses/ Policy & Regulations	Public access to all beaches by boat	2 high priority/8 low priority
Recreation	Uses	Recreation fishing	No votes
Recreation	Uses/ Policy & Regulations	Tie up to any pier	14 low priority
Recreation	Uses	Zoning for swimming	3 high priority
Recreation	Uses/Policy & Regulations	Control on disposal of fish waste	1 high priority
Recreation	Uses	Nevis to win a gold medal in sailing!	1 high priority
Recreation	Uses	Launching slips/ramps for small boats	No votes
Recreation	Uses	Establish mooring and anchorage areas for commercial and recreation	See Tourism
Tourism	Uses	Develop and support sports recreational fishing	3 high priority
Tourism	Policy & Regulations/ Education	Green practises from hotels and restaurants	8 high priority
Tourism	Uses/ Education	Turtles for tourism not food / moratorium on all harvesting	3 high priority
Tourism	Education	Classes for tourist divers and snorkelers. Responsible dive operators.	4 high priority/1 low priority

Tourism	Policy & Regulation	Community based tourism	1 high priority
Tourism	Uses	Pump out stations for yachts	1 high priority
Tourism	Uses	Zoning for future hotel planning	1 high priority
Tourism	Uses/ Education	Responsible cruise industry (including waste disposal, no ballast dumping)	1 high priority
Tourism	Uses	Zoning for swimming (see also Recreation)	1 high priority
Tourism	Policy & Regulations	Invasive species	See Conservation
Fishing	Uses	Commercial fishing	1 high priority/1 low priority
Fishing	Education	Education of fishers	3 high priority
Fishing	Policy & regulation	Provision of alternative livelihood to get fishers out	4 high priority
Fishing	Uses	Diversify fishing (e.g. to pelagic)	1 high priority
Fishing	Education	Good relations between fishers and coastguard	1 high priority
Fishing	Uses	Aquaculture	2 high priority
Fishing	Uses/ Policy & Regulations	Mariculture leases with associated policy framework	See Policy/Regulation/Enforcement

Fishing	Uses/ Education	Reduction of bycatch	3 high priority
Fishing	Uses/ Policy & Regulations	Restrictions on certain fishing methods – small mesh seines (when pulled on shore), gill-netting (high-bycatch – turtle, shark, sting-ray), dynamite, poison	3 high priority
Fishing	Uses/ Policy & Regulations	Allow traditional methods, but continue monitoring (e.g. mesh size)	1 low priority
Fishing	Policy & Regulations	Want a shark fishery	5 low priority
Fishing	Uses/ Policy & Regulations/ Enforcement	Spear fishing controls – outright ban, licensing, no scuba, spatial restrictions, ban for tourists	2 high priority/1 low priority
Fishing	Policy & Regulations	Fish-traps with biodegradable panels	4 high priority
Fishing	Enforcement	Enforcement of existing regulations including stiffer penalties	2 high priority
Fishing	Uses/ Policy & Regulations	Set aside areas to replenish fish stocks	8 high priority
Fishing	Education/ Policy & Regulations	Ciguatera awareness, control and response planning	No votes
Fishing	Uses	Multiple water-front locations to provide access to fishers	2 high priority
Fishing	Uses/ Policy & Regulations	No pots in shipping lanes	No votes

Development/ planning	Uses	Reclamation of land lost by erosion sea wall and back filling	1 high priority/7 low priority
Development/ planning	Uses	Minimise sediment release and employ sediment trapping during development (e.g. around Great Salt Pond)	2 high priority
Development/ planning	Uses	Elimination of septic effluent	1 high priority
Development/ planning	Uses	Elimination of sand-mining and regulation of rock quarries. Shut down all quarries that fail to clean up	2 high priority
Development/ planning	Enforcement/ Policy& Regulation	Removal of construction waste from beaches	3 high priority
Development/ planning	Uses	Designated areas for energy development	3 low priority
Development/ planning	Uses	Zones for permitted hard engineering vs soft engineering	1 high priority
Development/ planning	Uses	Armouring – very strict monitoring/planning/engineering / not to block public access	1 high priority
Development/ planning	Uses	Government to acquire property on all beaches with provision of facilities (parking, conveniences…). Trash collection from beaches.	5 high priority
Conservation	Uses	Protection of marine habitats e.g. Narrows	1 high priority
Conservation	Uses/ Policy & Regulations	Marine protected areas	8 high priority

Conservation	Uses	Keep beaches the way they are	No votes
Conservation	Uses/ Policy & Regulations	Protect areas for a limited time	3 low priority
Conservation	Uses	Christina (wreck) national park. Christina no-dive zone	2 high priority/2 low priority
Conservation	Uses/ Policy & Regulations	No building within 120ft of beaches coast (aesthetics, tourist, hazard reduction)	3 high priority/3 low priority
Conservation	Uses	Littoral forest restoration W coast Nevis	2 high priority
Conservation	Uses/Policy & Regulations/ Enforcement	Banishment of all vehicles from beaches (either regulation or enforcement)	1 high priority/1 low priority
Conservation	Uses	Allow seagrass to remain on beaches (don't over-rake) – habitat, food-chain, sand-binding.	3 low priority
Conservation	Policy & regulations	Ban on plastic bottles	4 low priority
Conservation	Uses	Research, management and preservation of culturally important sites and artefacts.	2 high priority
Conservation	Uses	Built nursery facilities for stock enhancement	2 low priority
Conservation	Uses	Habitat protection or restoration to act as nursery areas	1 high priority

Conservation	Uses	Protection of seagrass beds in Narrows, Grass Bay, Ballast Bay (restore), Major's Bay	1 high priority
Conservation	Uses	Certain critical land areas set aside in perpetuity because their important role in the watershed	1 high priority
Conservation	Uses	Reclamation of land lost by erosion sea wall and back filling	See Development/ planning
Conservation	Uses	Map, identify and protect all wrecks	2 high priority
Conservation	Uses	Protect / restore do not ignore mangroves	3 high priority
Conservation	Policy & Regulations	Baseline information on marine habitats	1 high priority
Conservation	Education/ Policy & Regulations	Invasive species	No votes
Conservation	Uses	Birds – sea, coastal, ponds, migratory species – better protection	1 high priority
Conservation	Uses	International recognition – Ramsar, UNESCO Biosphere Reserve	1 high priority
Conservation	Policy & Regulations	Marine mammals – no harvest	4 high priority/1 low priority
Transportation	Uses	Commercial routes mapped out (shipping lanes)	1 high priority
Transportation	Uses	Zones for ferry routes	2 high priority

Transportation	Policy & Regulations	Coastguard on Nevis	9 high priority
Transportation	Policy & Regulations	Search and Rescue in Nevis	2 high priority
Transportation	Uses	Land bridge between the islands	4 high priority/5 low priority
Transportation	Uses	No bridge between the islands	2 high priority/10 low priority
Transportation	Uses	No solid structure (causeway) between the islands	3 high priority/4 low priority
Transportation	Uses	Establish mooring and anchorage areas for commercial and recreation	4 high priority
Transportation	Uses	Aids to navigation throughout water (e.g. light on Cowes, Booby Island)	3 high priority
Transportation	Uses	Dumping of ballast banned in regional waters – enforcement	See Tourism
Transportation	Uses	No pots in shipping lanes	No votes
Transportation	Uses	Commercial marina	1 high priority/1 low priority
Transportation	Policy & Regulation	Green certification of building new boats and of existing boats	1 high priority

Policy/ regulation/ enforcement	Enforcement	Enforcement of existing regulations o land-based activities that impinge on marine environment o discharge into ocean o safety regulations	8 high priority
Policy/ regulation/ enforcement	Policy & Regulations	Judicial system in place and educated to support enforcement	No votes
Policy/ regulation/ enforcement	Education	Youth seeing the ocean as a source of recreation, and employment/careers	1 high priority
Policy/ regulation/ enforcement	Education	Sensitised politicians and rule of law	1 high priority
Policy/ regulation/ enforcement	Policy & Regulations/ Uses	Development of emergency and disaster plans	2 high priority
Policy/ regulation/ enforcement	Enforcement	Coastguard more active and more powerful more boats, more manpower	2 high priority
Policy/ regulation/ enforcement	Policy & Regulations	Establishment of maritime training centre	2 high priority

Policy/ regulation/ enforcement	Policy & Regulations	Setting down of hydrographic service (keep updated and improve charts)	4 high priority/1 low priority
Policy/ regulation/ enforcement	Education	Sensitised people to holistic nature of island nations	No votes
Policy/ regulation/ enforcement	Education	Education – what goes in the sea stays in the sea	No votes
Policy/ regulation/ enforcement	Policy & Regulations	Policy framework for mariculture/aquaculture (leases)	1 low priority
Policy/ regulation/ enforcement	Education	Citizens have a sense of ownership and value	1 high priority
Policy/ regulation/ enforcement	Policy & Regulations/ Education	Community service component to education	No votes
Policy/ regulation/ enforcement	Education	Society becomes so environmentally aware that behaviour becomes less damaging	1 high priority
Policy/ regulation/ enforcement	Policy & Regulations/ Education	Successful fisheries exchange programme	1 high priority

Policy/ regulation/ enforcement	Policy & Regulations/ Enforcement	Control of manmade discharge	1 high priority
Policy/ regulation/ enforcement	Enforcement/ Education	Self-enforcement	2 high priority
Policy/ regulation/ enforcement	Enforcement/ Education	Safe use of environment (reduced number of accidents)	No votes
Policy/ regulation/ enforcement	Policy & Regulations	New regulations	2 high priority
Policy/ regulation/ enforcement	Policy & Regulations	Strategies must tie into political systems and timescales	No votes
Policy/ regulation/ enforcement	Policy & Regulations	Set timeline for approval and completion of zoning plan	No votes
Policy/ regulation/ enforcement	Policy & Regulations	Climate change modelling particularly for SLR	No votes
Policy/ regulation/ enforcement	Policy & Regulations/ Education	Better use of science to inform decisions	1 high priority

Policy/ regulation/ enforcement	Policy & Regulations/ Education	Better use of sociology and behavioural expertise to modify human behaviour	No votes
Policy/ regulation/ enforcement	Policy & Regulations	Ongoing scientific monitoring	2 high priority
Policy/ regulation/ enforcement	Policy & Regulations	Adaptive management	No votes

Additional Overarching Ideas

- No restriction at all of marine uses following successful recovery – 2 low priority
- Marine environment that provides for all –no votes
- Good fish available to feed families and pay bills –no votes (overarching Fishing idea)
- Healthy reefs, corals and large fish. 3 high priority (overarching Conservation & Recreation/Tourism idea)

Appendix D: Goals, Barriers, & Strategies for Success (with priority voting)

Recreation				
Goals	**Barriers**	**Votes**	**Strategies**	**Votes**
Recreational fishing opportunities (near-shore and game) with large and variable fish species	Overfishing		No fishing zone for stock replenishment, mangroves planting/restoration	
	Inappropriate fishing activities (gill net, gear)		Enforcement of appropriate regulation and appropriate regulation and appropriate placement of fishing activities	
	Damage to coral reef, sea grass (human activities - yachting)		Anchorage sites, moorings in place	
	No limit/regulation in fish size		Regulation for fish size	
	Natural disaster damaging habitat		Resiliency	
Ample facilities for recreational boating (beach and pier access, moorings)	Perception of public service that piers are evil (smuggling is why perception persists)	High priority = 1 vote Low priority = 1 vote	Education of department about piers, changing public sector attitude about pier	High priority = 2 votes
	Natural disasters	High priority = 2 votes	Effective disaster plan & construction	High priority = 2 votes

	Haul-out facilities	Low priority = 2 votes	Engineering design and location for longevity	
Clean water, healthy reefs, and clean beaches for swimming, snorkeling, sailing, and diving	Runoff from golf course, ag. Land, over grazing	High priority = 2 votes Low priority = 1 vote	Mitigation practices for construction and BMP --> and changing chemicals in golf course	
	Litter and dumping in water and on beach (perception of the sea taking waste away)	High priority = 4 votes	Trash collection and bin placement education	High priority = 2 votes
	Eutrophicatioin (N, P) from hotel/big development/domestic waste	High priority = 1 vote	Regulations for large sized development sites have aerobic sewage plant	
	Not enough info/data on water quality	High priority = 2 votes	Water testing & adequate baseline established	High priority = 2 votes
	Inappropriate disposal of dead fish	High priority = 1 vote	Designate disposal techniques & areas	
	Fueling boats (drum, siphon)	High priority = 1 vote Low priority = 1 vote	Designated proper fueling areas and techniques	High priority = 3 votes
	Incompatible adjacent land use			

Appendix D: Goals, Barriers, & Strategies for Success (with priority voting)

Tourism				
Goals	**Barriers**	**Votes**	**Strategies**	**Votes**
Appropriate/Adequate areas for swimming + other tourist activities (snorkeling, diving, wind surfing, other water sport e.g. sailing)	Push back from operators if zones are isolated		Appropriate clustering of zones	High priority = 1 vote
	Additional costs to launch at isolated + distance zones			
	Noise pollutions	High priority = 4 votes		
	Inadequate enforcement and capacity		Having trained personnel and adequate equipment	High priority = 4 votes Low priority = 1 vote
	Designated areas for activities that lack the necessary conditions		Zoning matches the activity	
	Negative impacting adjacent activities - pollution (solid, silt)	Low priority = 1 vote		
	Untrained operator	High priority = 1 vote Low priority = 4 vote	Boat safety course and/or license	High priority = 3 votes
	Land-based operations that restrict water activities (airport and fly zone)			
Key sites managed for marine tourism (turtles, top dive sites)	Traditional uses (fishing)	High priority = 2 votes	Education, social studies, & incorporate traditional use as much as possible into zoning plan	High priority = 2 votes
	Conflict of interests			
	Ignorance			
	Emotional attachment (Cristina site)	Low priority = 1 vote		

	Further distance between key sites and associated costs (fishers, water taxi, dive operators)			
	Runoff, blocked currents, light pollution, abandoned fishing gear	High priority = 2 votes	Clean habitat	
	Economic feasibility		Fees	High priority = 2 votes
	Destruction of turtle nests (dogs, mongroose, human consumption)	High priority = 3 votes	Patrol by turtle program, enforcement of law, eyes on the beach	High priority = 1 vote
Areas designated for future tourism infrastructure (hotels, golf, access roads)/areas where development is not allowed	Limited land space and limited suitability for development	High priority = 2 votes Low priority = 4 votes	Selected zoning to capture prioritization of development placement & type	High priority = 3 votes Low priority =1 vote
	Attitudes of people for where not to develop		Education on development and conservation	High priority = 1 vote
	Short-term political goals	High priority = 3 votes	Clear legislation	High priority = 1 vote
			Broad education	
			Strong pressure group	
	Zoning effort of land values	Low priority = 2 votes	Other mechanisms to make land viable economically (easement, ecotourism)	
	Pressure of waterfront by various groups (fishers, tourist, water sports)	High priority = 1 vote Low priority = 1 vote		

Fishing				
Goals	**Barriers**	**Votes**	**Strategies**	**Votes**
Unrestricted access to landing and mooring facilities for fishers	Rapidly increasing coastal development	High priority = 3 votes	Regulate coastal development	High priority = 3 votes
	Inadequate # of landing facilities	High priority = 3 votes	Provide more landing facilities, government purchase	High priority = 3 votes
	Lack of sheltered areas	High priority = 2 votes	Construction of marinas for fishing vessels	High priority = 1 vote Low priority = 1 Vote
	Potential conflict between tourism and fishing RE use of/constraint of marinas	High priority = 3 votes	Marinas should include areas for fishers and tourism	
Zoning to include closed areas, open access and other areas where selected gear or access restrictions apply	Lack of enforcement of current regulations	High priority = 8 votes	Self enforcement by fishers, establish and fund marine police	High priority = 6 votes
	Lack of political will to enforce the law		Targeted education of the political directorate, est. non political bodies to regulate fishing	High priority = 4 votes
	Lack of fisher involvement/engagement at all levels	High priority = 9 votes	Engage fishers early in process. Fisher exchange program	High priority = 6 votes
	Conflicting interests between dive operators and fishermen	High priority = 1 vote Low priority = 1 Vote	Establish specific	
	Boats interfering with fishing operations	High priority = 2 votes	Areas for dive operations and boat traffic	High priority = 3 votes

	Unwillingness of fishers to accept gear restrictions and closed areas	High priority = 6 votes	Establish incentives program. Outreach to fishers and consumers. Alternatives livelihoods.	High priority = 5 votes
Enhanced productivity and ongoing replenishment of target species	Use of inappropriate gear	High priority = 4 votes	Education/outreach for fishers, provide fishers with alt. gear/ incentives; diversify target species/markets	High priority = 4 votes
	Sedimentation/pollution from land based activities	High priority = 4 votes	Regulate/enforce land based activities	High priority = 4 votes
	Lack of stock assessment/research	High priority = 4 votes	Fund Stock assessment research	High priority = 16 votes

Development & Planning				
Goals	**Barriers**	**Votes**	**Strategies**	**Votes**
Sufficient space for energy generation and transmission for local consumption and export	Location of cable for the transmission from Nevis to SK, need to avoid sensitive habitats	High priority = 2 votes	EIA	High priority = 2 votes
	Where do you bring cable on the land --> private lands		Proper studies	
	Unknown where or what kind of energy would be developed	High priority = 1 vote Low priority = 1 Vote		
	For geothermal - Location of fault lines --> Earthquake concerns. -->		Proper silting and studies	
Coastal engineering (including "hard" solutions - sea walls, beach replenishment; and "soft" solutions - mangrove restoration) to be well regulated	Size of islands --> not much room for soft project	High priority = 1 vote Low priority = 1 Vote	Adopt Nevis - Marine building code + coastal development plan	
	Expertise is not available			
	$ - it is expensive			
	Climate change --> sea level rise	High priority = 1 vote	Funding from international conventions	High priority = 3 votes
	Disasters - Hurricanes storm surge --> swells -->	High priority = 2 votes	Good info - mapping - do not allow development in the high risk areas	
	People are just doing work to protect property --> w/no control		Gov't needs to acquire properties that are in direct threat - relocation from high threat areas	High priority = 1 vote

	Need coherent and clear info on where hazards are: some info but need in a coherent plan for coastal development		Need to have a coastal hazards study + have coastal/national disaster mitigation project - 2001 DINE. Fill gaps from this project - need better contour maps + lidar coverage --> then can do proper models	
	EIA + Natural hazard impact assessments CDB website	High priority = 2 votes	Training via CDB -->	High priority = 1 vote
Zoning to include sustainable development and no development	Climate change - sea level rise		Proper modeling + information - look at long term plan for redevelopment involvement at international climate change talks	High priority = 2 votes
	Natural land form - no natural embayment		Require mitigations --> in impact assessment -- EIAs required - Need strengthen law + training for rewards	High priority = 5 votes
	Coastline alteration will be needed	High priority = 1 vote		
	Conflicting use/livelihoods	High priority = 1 vote	Training for government staff - capacity building	High priority = 4 votes
			Marine zoning - or spatial planning	

			External influence on parent company to mitigate - and prevent impacts --> work with developers	
	Private SK lands no fully under government code --> S.E. Peninsula	High priority = 2 votes	Expand code - to include private lands	
	Political will --> short-term vs. long-term, no continuity - 5-year horizon		Plans with specific timelines --> + adaptive --> revise each 5 years	
			SK + National landuse plan -	
	$ drive development -- jobs are priority		Job creation - in natural resource management, restoration	
	Integration with land based activity not easy --> CZM needs to be done at same time	High priority = 1 vote	Adopt/approve the Nevis land use plan/ coastal plan + marine building code use draft to inform marine zoning process. Adopt protected area plan	High priority = 1 vote
	Lack of data /information --> or not well consolidated or analyzed	High priority = 1 vote		
	Cost implications of marine zoning plan/implementation	High priority = 1 vote		
	Location of critical/sensitive habitats	High priority = 1 vote		

	Lack of awareness (development plans) - about resource --> values - political/people - all		Education for public - Develop political education	High priority = 4 votes
			Target each sector of population Holistic -	

Appendix D: Goals, Barriers, & Strategies for Success (with priority voting)

Conservation				
Goals	**Barriers**	**Votes**	**Strategies**	**Votes**
Protection of key submerged marine resources (critical habitats, species, nursery, feeding, reproduction areas)	Lack of enforcements of existing law	High priority = 4 votes	Better enforcement	High priority = 3 votes
	Lack of legal framework (NCEPA)		Integrated planning	High priority = 6 votes
	Lack of co-ordination between agencies	High priority = 4 votes Low priority = 1 vote	Integrated planning	High priority = 6 votes
	Poor maps of natural resources	Low priority = 1 vote	Better Natural Res. Inventory	
			Remote Sensing	High priority = 1 vote Low priority = 1 Vote
			Field Survey/in water/fisheries stats/local knowledge	
	Distrust by fishers	Low priority = 1 vote	Education/dissemination	High priority = 3 votes
			Government intervention/involve	
			Learn from other fishers in other countries	
			Demonstration sites	
			Self enforcement	
	Lack of full engagement of stakeholders			
	Funding			
Culturally important marine areas protected	Lack of knowledge	High priority = 4 votes	Better map + inventory	High priority = 1 vote
	Fishers want to use	Low priority = 1 vote	Compromise	Low priority = 1 vote
Protect terrestrial resources critical for marine health (including	Traditional uses on upland/steep slopes (charcoal, illegal clearance) over-grazing	High priority = 4 votes	Alternative uses/livelihoods	
			Enforcement	High priority = 1 vote

watershed protection, 120ft setbacks on beaches)			New regulation	
	Insufficient or non-functional sewage treatment	High priority = 1 vote Low priority = 2 votes	Infrastructure planning	
	Competing demand for coastal (1km from shore) lands	High priority = 2 votes	Planning + zoning	High priority = 2 votes
Restored critical habitat (mangrove, nursery areas)	Seagrass - competing uses		Compromise	High priority = 1 vote Low priority = 2 votes
	Mangrove	High priority = 6 votes Low priority = 2 votes	Maximum/use/loss threshold	
			Mitigation + offset	
Protect key coastal resources (beaches, mangroves, salt ponds)	Non-adherence to existing policy/regulation (Ministerial over-ride)	High priority = 3 votes	Increase transparency	High priority = 1 vote
	Piecemeal approach to planning + EIA - lack of holistic vision (St. Kitts)	High priority = 2 votes Low priority = 1 vote	Policy change, close loop-holes	High priority = 3 votes Low priority = 1 vote
			Tie-in environmental standards to international funding	
	Existing penalties insufficient	High priority = 7 votes Low priority = 1 vote		
	Pushback from big developers		Compromise	
			Maximum loss threshold	
			Mitigation + offset	
	Local resistance (jobs, $$$)		Education	
			Community leaders (long-term vision, full natural resource accounting)	High priority = 1 vote

Transportation				
Goals	**Barriers**	**Votes**	**Strategies**	**Votes**
Distinct identification and demarcation of ferry and shipping lanes	Funding		Effective marketing	High priority = 3 votes
			Lobbying	
			User fee/tax	
	Education/planning	High priority = 2 votes	Outreach/ awareness	
			Workshop	Low priority = 1 vote
	Conflict with fishermen	High priority = 1 vote	Workshops to map areas	
	Identification of appropriate areas		Mapping of sandy bottom/demarcation on charts	High priority = 1 vote
	Enforcement		Funding for ranger patrol - collect user fees	High priority = 1 vote
Marina development plan - locations where marinas may be developed in future (to include commercial/recreational/tourist)	Funding	High priority = 3 votes	Effective marketing	
			Lobbying	
			Slip fees	
	Environmental concerns	High priority = 1 vote Low priority = 1 vote	Identify (through EIAs) optimal areas with minimum impact	High priority = 3 votes
			Enforcement	High priority = 3 votes
	Limited land space	High priority = 2 votes Low priority = 1 vote	Reclamation/creation	Low priority = 1 vote
			Good use/Efficient use of current land	
	Governmental/politics	High priority = 1 vote Low priority = 1 vote	Effective lobbying	
			Citizen involvement community	High priority = 1 vote

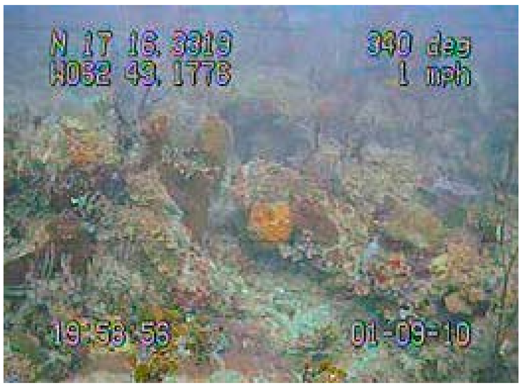
			Education	
Distinct identification and demarcation of ferry and shipping lanes	Education		Outreach, communication program, town hall/workshop	High priority = 4 votes
	Consultation	High priority = 2 votes	Meetings with ferry operators and passenger/stake holders	High priority = 4 votes Low priority = 1 vote
	Conflict with fishermen	High priority = 2 votes	Effective communication - meetings with fishermen (final demarcation in charts)	High priority = 4 votes

APPENDIX B

Key to the Benthic Habitats of St. Kitts and Nevis

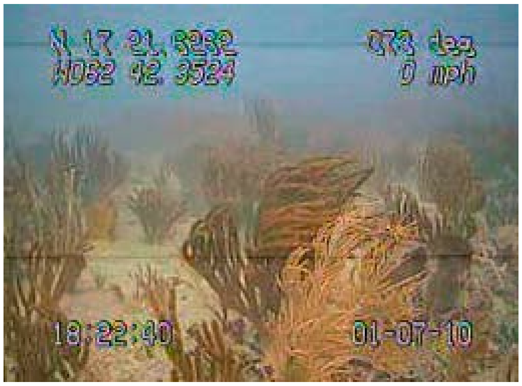
Key to the Benthic Habitats of St Kitts & Nevis

1. **Hard coral framework** – Moderately rugose frameworks with sparse coral cover (typically <10 %). Colonies are predominantly small (sub-meter) in size. The coral community is composed primarily of *Siderastrea*, *Montastrea*, *Diploria*, and *Colpophylia* spp.. Crustose coralline algae and fleshy algae (*Sargassum*, *Dictyota*) along with gorgonians dominate the remainder of substrate. This hardcoral framework tends to form a semi-continuous barrier, broken by narrow sediment filled channels.

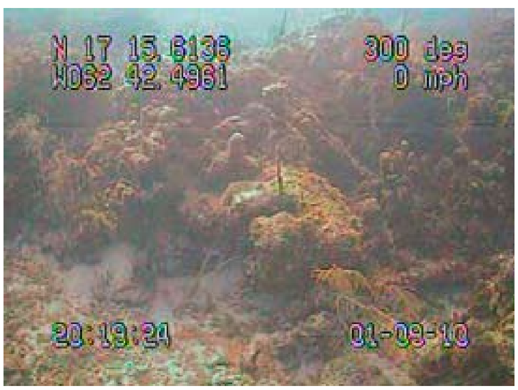


2. ***Acropora palmata* stumps** – Dense thickets of largely dead *Acropora palmata* interspersed with the occasional living colony of another hard coral species; predominantly either *Montastrea*, or *Siderastrea*. In deeper areas (< 5 m water depth) these stumps remain in an upright growth position and provide high habitat complexity. Shoreward, these corals are often displaced and mingle with rubble substrate. Narrow sand channels (1-2 m across bifurcate patches of this habitat).

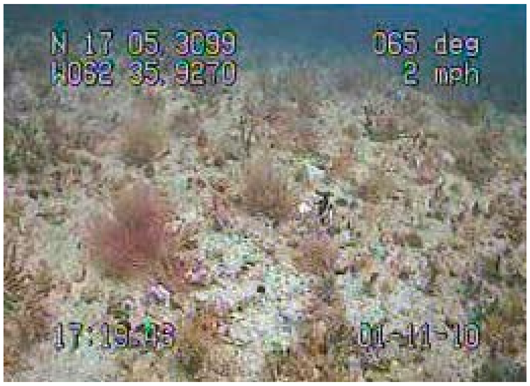
3. **Flat gorgonian hardgrounds** – Hardgrounds with a thin layer of fine sediment exhibiting a dense gorgonian cover with sparse macro-algae (typically *Halimedia*, *Udotea* etc).

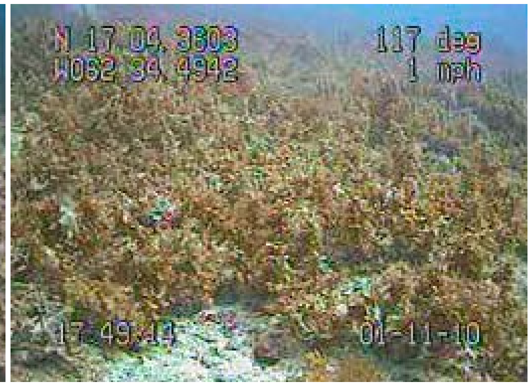


4. **Rugose gorgonian slope** - Dense gorgonian cover and sparse macro-algae (typically *Halimedia*, *Udotea* etc) found on the edge of carbonate frameworks. Patches of this habitat are often found spanning several meters in water depth.

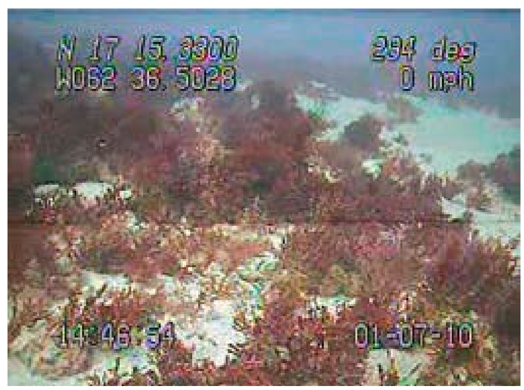


5. **Algal reef flat** - Consolidated hardgrounds with fine turf macro-algae and low lying fleshy macro-algae. This habitat is typically found in shallow environments (1-4 m water depth) atop carbonate frameworks.



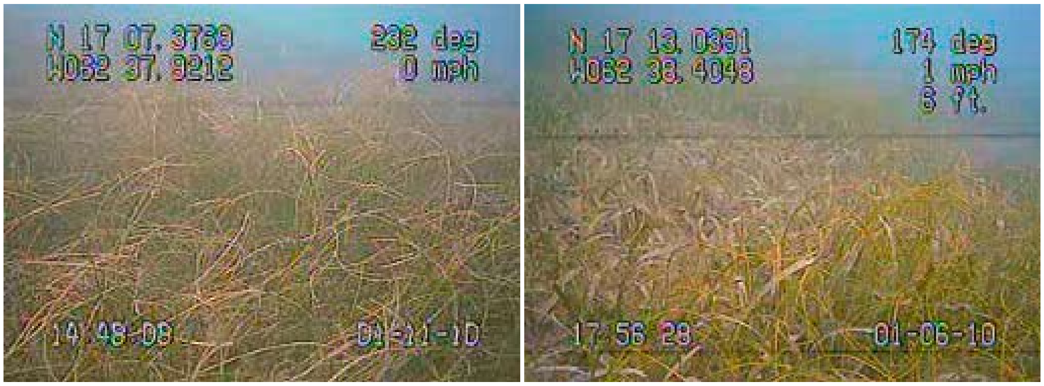


6. **Algal hardgrounds** – A dense macro-algae biota found atop low relief patches of hardground interspersed with mobile sediment. This habitat is either *Sargassum* sp. dominated, typically in the lee of carbonate frameworks and sediment channels, or *Halimeda* dominated on more exposed slopes south of the island of Nevis.

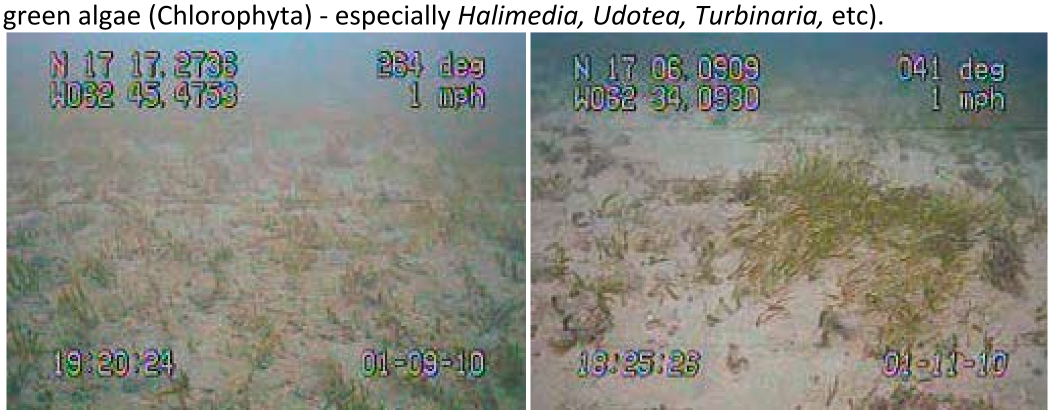


7. **Semi-consolidated rubble** – Skeletal rubble originating from reef structures and bonded by coralline algae to form a semi-consolidated framework with patchy macro algae. This habitat may also be found surrounding, or atop, carbonate frameworks.

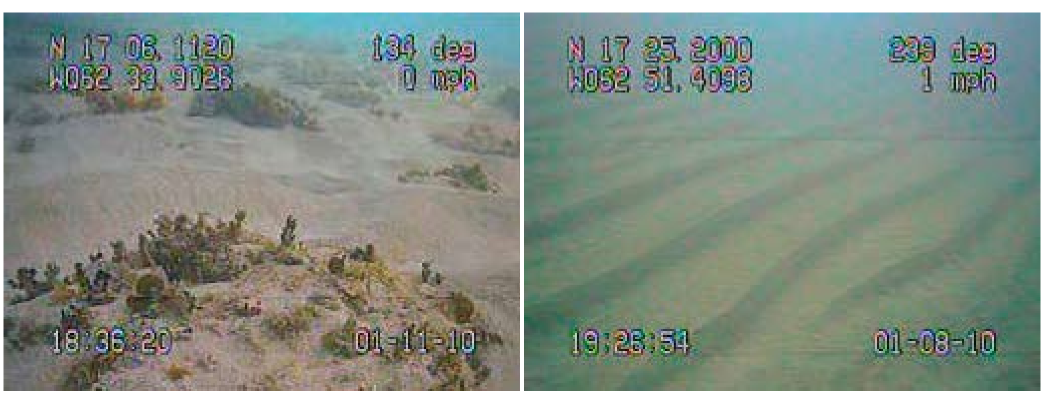
8. **Dense seagrass** – Sand sheets with a dense seagrass community (> 50% cover) dominated by *Thallassia tesdudium*, and secondarily *Syringodium filiforme.* Associated with the grass are green algae (Chlorophyta) - especially *Halimedia, Udotea, Turbinaria,* etc).



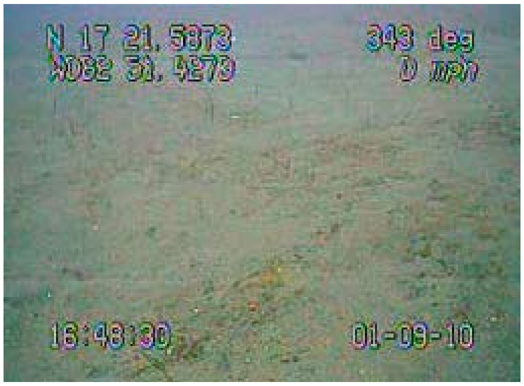
9. **Sparse seagrass** – Sand sheets with a sparse seagrass community (< 50% cover), dominated by *Thallassia tesdudium*, and secondarily *Syringodium filiforme.* Associated with the grass are green algae (Chlorophyta) - especially *Halimedia, Udotea, Turbinaria,* etc).



10. **Unconsolidated sand with algae** – Coarse, often rippled, sand sheets found in areas with higher energy flow along with small patches of *Halimedia* algae.



11. **Bare carbonate sand** – Expansive sand sheets encompass much of the benthic habitat. These are found across the whole of the mapped area, particularly to the leeward side of the barrier reef system, east of the islands, and extending at least to 30 m on the west coast.



12. **Lagoonal muds** – Enclosed muddy embayment. The salt water content of these areas varies with tidal fluctuations, with water typically percolating through the surrounding land matrix.

APPENDIX C

St. Kitts and Nevis Habitat Metadata Compilation

ST. KITTS & NEVIS METADATA COMPILATION

Name of Layer: SKN_Ac_palmata_stumps.shp, *Acropora palmata* stumps

Abstract:

Acropora palmata stumps represent one of twelve shallow water benthic habitats mapped around St. Kitts and Nevis. *Acropora palmata* stumps are defined as dense thickets of largely dead *Acropora palmata* colonies interspersed with the occasional living colony of another hard coral species; predominantly either *Montastrea*, or *Siderastrea*. In deeper areas (< 5 m water depth) these stumps remain in an upright growth position and provide high habitat complexity. Shoreward, these corals are often displaced and mingle with rubble substrate. Narrow sand channels (1-2 m across) bifurcate patches of this habitat.

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose:

Acropora palmata stumps are mapped in accordance to their location surrounding St. Kitts and Nevis. This layer accurately represents the size, location and distribution of this habitat off the coast of St. Kitts and Nevis.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

Dr Sam Purkis, National Coral Reef Institute, Oceanographic Center, Nova Southeastern University, purkis@nova.edu, (954) 262-3647

TNC

Restrictions:

Use of this data for whatever purpose is restricted without expressed written consent of:

Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Dense_Macroalgae.shp, Algal Hardgrounds

Abstract:

Algal hardgrounds represent one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. A dense macro-algae biota found atop low relief patches of hardground interspersed with mobile sediment. This habitat is either *Sargassum* sp. dominated, typically in the lee of carbonate frameworks and sediment channels, or *Halimeda* dominated on more exposed slopes south of the island of Nevis.

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose:

Algal Hardgrounds are mapped in accordance to their location surrounding St. Kitts and Nevis. The purpose of this layer is to accurately represent the size, location and distribution of these very dense macro-algae patches atop sparse rubble and sand.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

Dr Sam Purkis, National Coral Reef Institute, Oceanographic Center, Nova Southeastern University, purkis@nova.edu, (954) 262-3647

TNC

Restrictions:

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Dense_Seagrass.shp, Dense Seagrass

Abstract:

Dense Seagrass represents one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. Sand sheets with a dense seagrass community (> 50% cover) dominated by *Thallassia tesdudium*, and secondarily *Syringodium filiforme.* Associated with the grass are green algae (Chlorophyta) - especially *Halimedia, Udotea, Turbinaria,* etc).

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification res ulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose:

Dense seagrass are mapped in accordance to their location surrounding St. Kitts and Nevis. This layer is to accurately represent the size, location and distribution which extend substantially in the channel between St. Kitts and Nevis.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

Dr Sam Purkis, National Coral Reef Institute, Oceanographic Center, Nova Southeastern University, purkis@nova.edu, (954) 262-3647

TNC

Restrictions:

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Gorgonian_Hardgrounds.shp, Flat Gorgonian Hardgrounds

Abstract:

Gorgonian Hardgrounds represent one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. The Gorgonian Hardground class is comprised as a thin layer of fine sediment exhibiting a dense gorgonian cover with sparse macro-algae (typically *Halimedia*, *Udotea* etc).

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose:

Gorgonian Hardgrounds are mapped in accordance to their location surrounding St. Kitts and Nevis. This layer accurately represents the size, location and distribution of Gorgonian hardgrounds.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

Dr Sam Purkis, National Coral Reef Institute, Oceanographic Center, Nova Southeastern University, purkis@nova.edu, (954) 262-3647

TNC

Restrictions:

Use of this data for whatever purpose is restricted without expressed written consent of:

Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Hard_Coral, Hard coral framework

Abstract:

Hard coral framework represents one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. Moderately rugose frameworks with sparse coral cover (typically <10 %). Colonies are predominantly small (sub-meter) in size. The coral community is composed primarily of *Siderastrea*, *Montastrea*, *Diploria*, and *Colpophylia* spp.. Crustose coralline algae and fleshy algae (*Sargassum*, *Dictyota*) along with gorgonians dominate the remainder of substrate. This hard coral framework tends to form a semi-continuous barrier, broken by narrow sediment filled channels. Live stony corals are present at relatively low densities and can be found typically in spur and groove morphology.

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose:

Hard coral framework is mapped in accordance to their location surrounding St. Kitts and Nevis. This layer accurately represents the size, location and distribution of hard coral.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Lagoonal_Muds.shp. , Lagoonal muds

Abstract:

Lagoonal muds represent one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. This classification can best be described as an enclosed muddy embayment. The salt water content of these areas varies with tidal fluctuations, with water typically percolating through the surrounding land matrix.

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose:

Lagoonal muds are mapped in accordance to their location surrounding St. Kitts. Lagoonal muds were absent circumventing the Island of Nevis; therefore this layer pertains mainly to the island of St. Kitts.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Reef_Flat.shp, Algal reef flat

Abstract:

Algal reef flat represents one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. Consolidated hardgrounds with fine turf macro-algae and low lying fleshy macro-algae. This habitat is typically found in shallow environments (1-4 m water depth) atop carbonate frameworks.

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose:

Algal reef flats were mainly found atop carbonate frameworks and were mapped according to the size and distribution as is relates to the location of the flat.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Rubble.shp, Semi-Consolidated Rubble

Abstract:

Semi-consolidated rubble represents one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. This habitat can be described as skeletal rubble originating from reef structures and bonded by coralline algae to form a semi-consolidated framework with patchy macro algae. This habitat may also be found surrounding, or atop, carbonate frameworks.

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose: Rubble is mapped in accordance to the location surrounding St. Kitts and Nevis. The purpose of this layer is to accurately represent the size, location and distribution of rubble.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Rugose_Slope.shp, Rugose gorgonian slope

Abstract:

Rugose gorgonian slope represents one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. Dense gorgonian cover and sparse macro-algae (typically *Halimedia*, *Udotea* etc) found on the edge of carbonate frameworks. Patches of this habitat are often found spanning several meters in water depth.

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose: Rugose slope is mapped in accordance to the location surrounding St. Kitts and Nevis. This layer accurately represents the size, location and distribution of the Rugose gorgonian slope.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S. J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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Name of Layer: SKN_Sand.shp, Bare carbonate sand

Abstract:

Bare carbonate sand represent one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. Expansive sand sheets encompass much of the benthic habitat. These are found across the whole of the mapped area, particularly to the leeward side of the barrier reef system, east of the islands, and extending at least to 30 m on the west coast.

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose: Sand is mapped in accordance to the location surrounding St. Kitts and Nevis. This layer accurately represents the size, location and distribution of sand sheets.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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TNC

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Sparse_Seagrass, Sparse seagrass

Abstract:

Sparse seagrass represent one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. This habitat class comprises of expansive sand sheets with a sparse seagrass community (< 50% cover), dominated by *Thallassia tesdudium*, and secondarily *Syringodium filiforme.* Associated with the grass are green algae (Chlorophyta) - especially *Halimedia, Udotea, Turbinaria,* etc).

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose: Sparse seagrass is mapped in accordance to the location surrounding St. Kitts and Nevis. This layer accurately represents the size, location and distribution of sand sheets.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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Dr Sam Purkis, National Coral Reef Institute

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Name of Layer: SKN_UnconsolidatedSediment.shp, Unconsolidated sand with algae

Abstract:

Unconsolidated sand represents one of the twelve habitat classes that comprise the shallow water benthic habitats surrounding St. Kitts and Nevis. Coarse, often rippled, sand sheets found in areas with higher energy flow along with small patches of *Halimedia* algae is observed when classifying unconsolidated sand patches.

This habitat layer is derived from IKONOS and QuickBird multispectral satellite data. This sensor measures the quantity and quality of light reflecting off the seafloor. Images were corrected for the absorption and scattering of photons through the atmosphere using Modtran radiative transfer code modeled based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. (2004), which is based on the relative brightness in the near-infrared region of the spectrum. Spectral probability classifiers and edge-detection techniques were hybridized to create the most accurate map possible. Edge detection was used to efficiently identify boundaries between bright and dark habitats on the seafloor. Spectral classification draws on the fact that different substrates vary in the portion of light that they absorb/reflect at different electromagnetic wavelengths. Ground truth video data was used to collect from-image reflectance statistics. A maximum-likelihood algorithm was then used to calculate the probability that a given pixel belonged to a specific class, with pixels assigned to the class with the highest probability. This algorithm was not applied to areas of land, deepwater or cloud-contaminated pixels. In the case of cloud contaminated pixels, ground truth data and image interpretation were used to interpolate the classification across such gaps. Miss-classification resulting from local aberrations in the remote-sensed image, such as might occur from wave induced surface glint, was guarded against. A median filter was used to remove 'salt and pepper' noise or speckle which is indicative of miss-classification, by replacing isolated pixels with those common in the local neighborhood. In the final step of habitat classification, products were subjected to visual quality control. This ensures that habitats described follow identifiable boundaries in the imagery. Further details on the general approach used can be found in Purkis (2005).

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Purkis, S., 2005. A "reef-up" approach to classifying coral habitats from IKONOS imagery. IEEE Transactions on Geoscience and Remote Sensing **43**:1375-1390.

Purpose: Unconsolidated sand is mapped in accordance to the location surrounding St. Kitts and Nevis. This layer accurately represents the size, location and distribution of sand sheets.

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Date of Completion:

April 29, 2010

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

Dr Sam Purkis, National Coral Reef Institute, Oceanographic Center, Nova Southeastern University, purkis@nova.edu, (954) 262-3647

TNC

Restrictions:

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Bathy.tif, Bathymetry

Abstract:

An optical model was applied to IKONOS multispectral satellite imagery to describe the water depth gradient surrounding St. Kitts and Nevis from the sea surface to a depth of ~30 m. Satellite images were corrected for the absorption and scattering of photons through the atmosphere using a Modtran radiative transfer algorithm based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. 2004, which is based on the relative brightness in the near-infrared region of the spectrum. Light is attenuated differently as it passes through the water column. The water depth derivation algorithm (Stumpf et. al 2003) is based on the ratio of reflectance in the blue and green image bands. Pixel values are extracted from the image corresponding to georeferenced water depth measurements (collected Jan. 2010 using georeferenced single-beam sonar). Depth is derived on a scene by scene basis with individual products joined into a single mosaic for the two islands. Below 30 meters optical derivation cannot be achieved as signal return to the satellite sensor from the seabed is too low. Vertical accuracy is typically in the range of ±0.5-2 m to a depth of 15 m, below which vertical accuracy is typically within ±3 m. As such, this data is not considered suitable for navigation. This particular layer does not mask out cloud. Depth values derived for cloud influenced areas are therefore likely spurious due to the high albedo of cloud.

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Stumpf, R., Holderied, K., Sinclair M., 2003. Determination of water depth with high-resolution satellite imagery over variable bottom types. Limnology and Oceanography **48**:547–556.

Purpose:

This Digital Elevation Model (DEM) layer provides an estimate of water depth to a depth of 30 meters for the shallow shelf of St. Kitts and Nevis. DEMs provide a scene wide overview of the variation of depth that can be expected. They are useful for such tasks as: viewing the 3D structure of the seascape, planning ongoing environmental survey, oor as an input for more involved geological, ecological, and hydrological analyses.

Date of Completion:

May 7, 2010

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Source Citation:

Data are produced by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project using satellite an in-situ soundings.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009. Bathymetric soundings (NCRI/TNC, Jan 2010).

Images Used:

00300000 00800000 01000000 01600000 01700000 02300000 01800000 0240000 02000000

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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TNC

Restrictions:

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer: SKN_Bathy_CloudMasked.tif, Bathy_CloudMasked

Abstract:

An optical model was applied to IKONOS multispectral satellite imagery to describe the water depth gradient surrounding St. Kitts and Nevis from the sea surface to a depth of ~30 m. Satellite images were corrected for the absorption and scattering of photons through the atmosphere using a Modtran radiative transfer algorithm based on a tropical maritime atmosphere. Image scenes compromised by sea-surface-glint were corrected using the algorithm of Hedley et al. 2004, which is based on the relative brightness in the near-infrared region of the spectrum. Light is attenuated differently as it passes through the water column. The water depth derivation algorithm (Stumpf et. al 2003) is based on the ratio of reflectance in the blue and green image bands. Pixel values are extracted from the image corresponding to georeferenced water depth measurements (collected Jan. 2010 using georeferenced single-beam sonar). Depth is derived on a scene by scene basis with individual products joined into a single mosaic for the two islands. Below 30 meters optical derivation cannot be achieved as signal return to the satellite sensor from the seabed is too low. Vertical accuracy is typically in the range of ±0.5-2 m to a depth of 15 m, below which vertical accuracy is typically within ±3 m. As such, this data is not considered suitable for navigation. Depth values derived from cloud influenced areas are likely spurious due to the high albedo of cloud and are therefore masked out in this particular layer.

Hedley J. D, Harbourne A. R., Mumby P. J., 2005. Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing **26**: 2107-2112.

Stumpf, R., Holderied, K., Sinclair M., 2003. Determination of water depth with high-resolution satellite imagery over variable bottom types. Limnology and Oceanography **48**:547–556.

Purpose:

This Digital Elevation Model (DEM) layer provides an estimate of water depth to a depth of 30 meters for the shallow shelf of St. Kitts and Nevis. DEMs provide a scene wide overview of the variation of depth that can be expected. They are useful for such tasks as: viewing the 3D structure of the seascape, planning ongoing environmental survey, or as an input for more involved geological, ecological, and hydrological analyses.

Date of Completion:

May 7, 2010

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Source Citation:

Data are produced by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project using satellite an in-situ soundings.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009. Bathymetric soundings (NCRI/TNC, Jan 2010).

Images Used:

00300000 00800000 01000000 01600000 01700000 02300000 01800000 0240000 02000000

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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TNC

Restrictions:

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Dr Sam Purkis, National Coral Reef Institute

TNC

Name of Layer:

Monkey_ Shoals.shp, Monkey shoals

Abstract:

Monkey Shoals consists of an area of reef located off the southwest coast of St. Kitts. Groundtruth was collected and surveyed for this area, though satellite imagery was not available. This layer demarcates the broad geographical location of the Monkey Shoals reef.

Purpose:

The creation of the layer Monkey Shoals is to map its broad geographical location in relation to St. Kitts and Nevis. Only an approximation of the size and location is represented, and no indication of benthic cover is provided.

Date of Completion:

April 29, 2010

Original Projection:

Universal Transverse Mercator (UTM) Zone 20 North, World Geodetic System (WGS) 1984

Source Citation:

Data are produced using satellite an in-situ field data by the National Coral Reef Institute (NCRI) on behalf of The Nature Conservancy, a USAID sponsored project for the Federation of St. Kitts and Nevis.

IKONOS multispectral satellite image data (GeoEye Ltd., http://www.geoeye.com) 2000-2009

QuickBird multispectral satellite image data (Digital Globe, http://www.digitalglobe.com) 2009.

Georeferenced video archive (NCRI/TNC, Jan 2010)

Compiled By:

Alexandra Dempsey, Gwilym Rowlands, and Sam Purkis

Reference Format:

Data should be referenced as

Rowlands, G. P., Dempsey, A., Purkis., S.J., 2010. Shallow-water benthic and bathymetric mapping: The federation of St. Kitts and Nevis. NCRI technical report.

Contact Layer:

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Dr Sam Purkis, National Coral Reef Institute

TNC

APPENDIX D

St. Kitts and Nevis Fisheries Uses and Values Project

St. Kitts and Nevis
Fisheries Uses and Values Project

Report to The Nature Conservancy

In partial fulfillment of Contract No. FY10-C-AID-ECaribe-Ecotrust,
The Nature Conservancy
Southeastern Caribbean Program and Global Marine Team

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28 October 2010

*This report was made possible by the generous support of the American people through the United States Agency for International Development (USAID) under the terms of its Cooperative Agreement Number 538-A-00-09-00100-00 (*BIODIVERSITY THREAT ABATEMENT *Program) implemented by prime recipient The Nature Conservancy and partners. The contents and opinions expressed herein are the responsibility of the* BIODIVERSITY THREAT ABATEMENT *PROGRAM and do not necessarily reflect the views of USAID.*

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1 Introduction

Ecotrust was retained by The Nature Conservancy (TNC) in February of 2010 to collect, compile, and analyze commercial fishery data in support of a larger TNC effort, funded by USAID, focused on a case study national marine zoning plan for St. Kitts and Nevis. During the spring and early summer of 2010, our research team developed and deployed an interactive, custom computer interview instrument, Open OceanMap, to collect geo-referenced information from local fishers about the extent and relative importance of St. Kitts and Nevis commercial fisheries. We compiled these data in a geographic information system (GIS) that we delivered to TNC for integration into a central geodatabase. This report, which details the approach and methods we used to collect, compile, and analyze commercial fisheries data in St. Kitts and Nevis, and the geodatabase containing the fishing grounds datasets completes our deliverables to TNC under the terms of the contract.

Conducting research in coastal communities is as challenging as it is rewarding. We have learned a tremendous amount from the commercial fishers who participated in this study as well as the countless other community members, TNC staff, and observers of this project.

We are deeply thankful to the 51 St. Kitts and 65 Nevis fishers who participated in this project—making time in their busy schedules, overcoming sometimes considerable reservations, and sharing their knowledge and experience with us. We thank our project coordinator, who was contracted by TNC, Janice Hodge, and her field staff. We also acknowledge the support, assistance, staff, and time provided by the Department of Planning and the Department of Fisheries on both St. Kitts and Nevis.

Private information of survey participants was carefully protected throughout this process. The information contained in this report is only that which respects confidentiality, as was verbally agreed upon between participants and staff conducting interviews. To protect individual information, all information contained herein and presented in mapped products has been aggregated to a level that does not allow association to any personal information.

We believe that this project has made a significant contribution to the marine knowledge base on St. Kitts and Nevis—not only by informing marine zoning efforts, but also by enhancing the public's and decision-makers' understanding of the importance of the coastal ocean to individual fishers and to coastal communities. Furthermore, we believe this project, and the lessons learned therein, can be leveraged to catalyze and inform other similar projects.

For questions or comments, please contact Charles Steinback, Ecotrust, 721 NW 9th Avenue, Suite 200, Portland, OR 97209; charles@ecotrust.org or 503.467.0777.

2 Background

In order to meet current and future demands on the marine environment, The Nature Conservancy (TNC) is supporting a national marine zoning plan for The Federation of St. Kitts and Nevis. The goal of the marine zoning plan is to minimize conflict between user groups and optimally accommodate existing/future human uses while maintaining healthy marine habitats and ecosystems. To support the plan, TNC is conducting a comprehensive assessment of human uses and the distribution of marine habitats within the country's territorial seas, also known as its exclusive economic zone (EEZ).

In order to do this, TNC has identified major data gaps such as habitat distribution, recreational/tourism use areas, and commercial fishery areas. Through the collection of these spatial data and additional coordination across the various user groups, it may be determined which human uses are compatible and should be allowed in particular marine zones.

In St. Kitts and Nevis, as elsewhere in the Caribbean, commercial fisheries support local communities and economies. Fisheries involve vessels of varying sizes and capacities, using a variety of gear types and fishing strategies, and covering a large part of the coastal ocean. In general, this spatial component of fishing activities is relatively poorly understood. While a variety of data are collected by national agencies to monitor and enforce fishery regulations, the thematic, temporal, and spatial resolution of these data vary considerably. To inform a marine zoning plan, accurate spatial information about coastal fisheries is central to inform intelligent policy decisions.

To fill these gaps in data, Ecotrust, was contracted by TNC to collect new information on the spatial extent of commercial fishing activities in St. Kitts and Nevis and the fishers who are actively engaged in these fisheries. In the absence of comprehensive observer coverage, vessel monitoring systems or spatially explicit landing receipts, by far the best source of information about the fishing grounds is the fleet itself. By engaging local stakeholders in the planning process and asking them about the value they place on specific areas of the ocean, these data can support spatial planning that protects the marine environment while minimizing impacts on fishing communities.

In this project, we built upon existing approaches to collect fisher's expert knowledge about their fishing grounds. The goal was to develop maps of the fishing grounds in St. Kitts and Nevis and to characterize the relative importance of various fisheries. The following sections contain detailed descriptions of 1) the methods; 2) summary statistics; and 3) data and map output used to address the spatial information gaps in commercial fisheries of St. Kitts and Nevis.

3 Methods

In this project, we built on methods developed in previous projects on the West Coast of the United States (Scholz et al. 2004; 2005; 2006a; 2008). More specifically, we used a computer interface to administer a survey, collect information from fishers, and analyze the responses in a geographic information system (GIS). A key innovation in this project was working with TNC staff, in-country agency officials, and local fishers to define the country's fisheries in terms of how they are managed and harvested. To that end, we differentiated fisheries in terms of practices and/or species (group)-gear configurations and used port groups to classify participants and design a representative sample.

While the use of GIS technology and analysis in marine and fishery management has expanded steadily over the past decade (Meaden 1996; Kruse et al. 2001; Breman 2002; Valavanis 2002; Fisher and Rahel 2004), its use for socioeconomic research is still somewhat limited. Many of the applications reviewed in the recent literature focus on urban populations or natural resource use in developing countries (Gimblett 2002; Goodchild and Janelle 2004; Anselin et al. 2004). Nevertheless, a growing body of literature has examined GIS-enabled approaches to community-based MPA design (Aswani and Lauer 2006; Hall and Close 2006; St. Martin et al. 2007; Ban et al. 2009).

Some of the most pertinent applications of GIS technology to socioeconomic questions in fisheries concern the spatial extent of fishing effort and intensity (Caddy and Carocci 1999; Green and King 2003) and use participatory methods similar to the ones employed here (Wedell et al. 2005; St. Martin 2004; 2005; 2006). We built on these approaches and adapted them for the St. Kitts and Nevis context, following best practices for the use of participatory GIS in natural resource management (Quan et al. 2001), as described in the remainder of this section.

3.1 Project Planning Methods

In December 2009, Ecotrust staff conducted a project planning meeting with TNC staff and St. Kitts and Nevis agency staff in Miami. The goals of this planning effort were two-fold: 1) to understand the larger project context; and 2) to develop a draft survey. These goals, as well as specific tasks completed and/or information gathered to meet these goals are described in more detail here.

3.1.1 Understand the larger project context

This project is one component of a larger four component TNC project focused on marine zoning, policy, livelihoods, and education/outreach (Project description for Associate Cooperative Agreement No. 538-A-00-09-00100-00). The marine zoning effort is only happening on St. Kitts and Nevis and is focused on multiple ocean uses, which will be analyzed and assessed using Marxan w/Zones. Uses being considered include: commercial fishing, recreation, tourism, development and planning, conservation and transportation.

In addition to providing valuable information for the marine zoning effort, TNC had three organizational goals for this project:

- To not only produce one-time project outputs, but to also create a comprehensive, standardized spatially-explicit format that can be updated in the future.
- To build in-house capacity for replicating this work elsewhere by training TNC staff in the project methods and implementation.
- To build in-country capacity.

3.1.2 Develop draft survey

Another goal of the project planning meeting was to develop a draft survey. Ecotrust, TNC, and in-country agency staff first reviewed and discussed information relevant to adapting the current Open OceanMap survey design for application to St. Kitts and Nevis. Topics discussed included a) a review of St. Kitts and Nevis fisheries, fisheries management, and existing fisheries data, which informed both survey and sample design; b) a review of existing Open OceanMap survey questions; c) preferred Open OceanMap design—desktop or internet based; and d) appropriate scales for data attribution (e.g., to individual shapes, to all shapes, to all fisheries, to an individual).

Using this base information, meeting participants next discussed how this information could be tailored to meet the project needs and objectives. More specifically, the following topics were discussed:

- Robustness of existing fishery data.
- Web based or desktop version of Open OceanMap.
- Port and fishery stratification.
- Potential weighting schemes and questions necessary to create various weightings.

- Base information for Open OceanMap maps—nautical charts, key references, etc.
- Additional quantitative or qualitative questions.
- Confidentiality.
- Outreach and educational materials.

Ecotrust subsequently presented TNC and in-country partners with a draft survey for review. Subsequent revisions and adjustment were made based on feedback received.

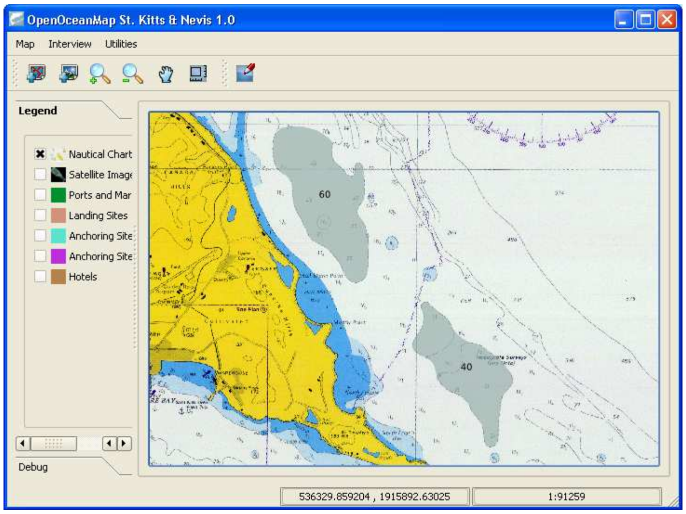
3.2 Survey Methods

Ecotrust worked with TNC and in-country staff to gather existing fisheries data and develop a preliminary survey design. TNC, in-country, and Ecotrust staff then conducted a series of in-country outreach meetings with members of the St. Kitts and Nevis fishing communities to provide a project overview, answer questions, raise general awareness, and solicit potential interview participants. Ecotrust also utilized existing data from the St. Kitts and Nevis Fisheries Departments to form an initial sample design, which was developed based on the number of full-time captain/owners found in each landing site.

Ecotrust also developed materials to train and build the capacity of TNC and in-country staff to conduct the fieldwork. These materials, already submitted to TNC, included:

- Survey Manual – this manual included a copy of the survey, detailed step-by-step information on survey and sample design, how to conduct an interview and use the Open Ocean Map tool, how to organize and track files, and examples of survey documentation.
- Fisher and Vessel Database – a database on all St. Kitts and Nevis Fisheries Department data and list of targeted fishers in each landing site.
- Data Collection Sheet – survey and spatial fishing data collection sheet.
- Data Collection Tracking Sheet – used by the in-country project coordinator to keep track of files and interviews.
- Open Ocean Map tool – survey tool to capture spatial fishing areas and additional non-spatial survey data.

Figure 1. Screenshot of Open Ocean Map Tool



During the initial outreach meetings, it was determined that the Fisheries Department data contained a number of data artifacts that made it difficult to use for sample design, so we solicited information (i.e., names and contact information) for active fisher captains within each port. Active fisher co-ops on St. Kitts were key sources of this information. On Nevis, a Department of Fisheries staff member was able to provide an updated list of active commercial fishery captains for the entire island. Using this information, a list of active full-time captain/owners for each island was created along with the goal to interview 100% of the captains from landing sites with 10 or fewer fishers and 75% for those with more than 10 fishers. Data collection then proceeded in two waves, first concentrating on St. Kitts fishers (with in-country, Ecotrust, and TNC staff) and then Nevis fishers (with in-country and TNC staff). The project's original intent was to train in-country staff to conduct all interviews with commercial fishers; however, for a two week period, an Ecotrust staff member was retained to assist in-country staff members in conducting interviews and provide technical support. In addition, additional fieldwork was conducted by TNC staff.

Interview efforts in St. Kitts typically focused on one landing site per day. Key informants such as fisheries officers or port managers would communicate to field staff an appropriate time to arrive at the landing site, which typically coincided with the time fishers would return from a day of fishing. Working from a list of captains in each landing site, port managers or field staff members would then identify these fishers as they brought their catch in. Once identified, field staff members would approach the fisher to explain the purpose of the mapping project and solicit an interview. In the process of soliciting and interview, confidentiality was discussed and project staff explained how personal information would be protected. If the fisher consented to the interview, basic demographic and socioeconomic questions were asked and then fishing areas for each of his fisheries were mapped. Approximately 43% of interviews (22 fishers) on St. Kitts were conducted using the mapping tool on laptop computers; however, due to varying levels of field staff proficiency in computer use, and/or lack of power or of the right voltage to operate laptops, data were also collected via hard copy surveys in which fishers pointed to areas on nautical charts and notes were taken describing the boundaries and depths of these areas. Approximately, 57% of interviews (29 fishers) took this form and these data were later digitized by Ecotrust staff using the mapping tool.

In Nevis, field staff members used several strategies to seek out fishers to interview. First, field staff were split into several groups, each of whom were charged with seeking out fishers operating from a particular landing site. These landing sites were usually in close proximity to where field staff members live, making it easier to find each fisher. Typically, field staff members would either call or speak with fishers to pre-arrange interview times and travel to their house to conduct an interview. Confidentiality was discussed at the beginning of each interview and it was explained that final mapped products would only depict aggregated information from 3 or more fishers. On Nevis, approximately 80% of interviews (52 fishers) were conducting using the mapping tool directly and 20% of interviews (13 fishers) were conducted using paper surveys.

3.2.1 Study region

The Federation of Saint Kitts (St. Kitts) and Nevis, is a federal two-island nation located in the Leeward Islands of the West Indies. The capital city of the federated state is Basseterre on the larger island of St. Kitts. The smaller island of Nevis lies about two miles (3km) southeast of St. Kitts, across a shallow channel called "the Narrows". The coastline length of both islands combined is 135km and both islands are approximately 360 km^2 in area. The Federation's surrounding EEZ waters extend out to adjacent territorial waters (e.g., St. Eustatius and Anguilla) to cover 20,400 km^2 in area with a shelf area of 845 km^2. The islands are volcanic in origin, with large central peaks covered in tropical rainforest, and surrounding flatter terrains in which the majority of the population on both island reside. As of 2005, approximately 48,000 people live in the Federation with approximately 10,000 people living in Nevis. At that time, the main source of income on both islands was from tourism, sugar processing (which has since closed), and consumer product assembly. In 2005, according to the United Nations Fisheries and Aquaculture Organization (FAO), commercial fisheries gross domestic product was approximately to be worth $3.8 million (FAO 2006).

Based on initial information from the in-country fisheries agencies, thirteen landing sites on St. Kitts and Nevis were selected as focus sites:

- St. Kitts: Basseterre East, Basseterre West, Old Road, Sandy Point, Conaree, and Dieppe Bay.
- Nevis: Charlestown, Jessups, Cotton Ground, Jones Bay, Newcastle, Long Haul, and Indian Castle.

It was later found that Basseterre East and Basseterre West were not substantially different enough so as to merit separation. Basseterre East and West are of relatively close proximity- approximately a quarter-mile down the main road from each other. Furthermore, as interviews commenced within both ports, it was determined that several fishers use both landing sites and that there were no differences in spatial fishing patterns or fisheries when launching from Basseterre East or West. The primary determinant of if a fisher docked in Basseterre East or West was if they were going to sell their catch at the local market in Basseterre West or sell their catch to the Basseterre East fisheries complex. For these reasons, these two ports were combined, resulting in 12 focus landing sites between the two islands.

3.2.2 Fishery names

Based on initial findings, there were ten fishery groups of interest on St. Kitts and Nevis. The groups are listed in Table 1 with the associated target species.

Table 1. Fishery grouping and associated local names species

Fishery Group Name	Associated Target Species	
Coastal pelagics	Gars Ballyhoo	Jacks Small tuna
Ocean pelagics	Billfishes Dolphinfish	Tuna Mackerel
Coastal demersals	Surgeon/Doctorfish Triggerfish Grunts Hinds Squirrelfish	Snappers Goatfish Parrotfish Groupers
Demersal shelf/deep slope	Snappers	Groupers
Lobster	Caribbean spiny lobster	
Conch	Queen conch	
Shark	Various species	
Diamondback squid	Diamondback squid	
Turtle	Leatherback Hawksbill	Green Loggerhead
Bait	Ballyhoo	Anchovy/Sardine

Fishery group names are consistent with the St. Kitts and Nevis Fisheries Management Plan (2007); however, some of the fishery and gear type combinations may have a common or local name. Table 2 lists possible local names for the fisheries associated with a particular fishery group/gear type combination. Knowing and employing these local names may be useful when referencing specific fisheries.

Table 2. Local names for formal fishery group and gear type combinations

Formal Fishery Group Name	Gear Type	Local Name
Coastal pelagics	Beach seine	Coastal pelagics or net fishery
Coastal pelagics	Troll/handline	Tuna and bonito
Ocean pelagics	Troll/handline	Large offshore pelagics
Coastal demersals	Trap	Reef fish or nearshore trap/pot fishery
Coastal demersals	Handline/rod and reel	Reef fish or nearshore handline/banking
Coastal demersals	Spear gun	Reef fish or nearshore spear
Coastal demersals	Gillnet	Reef fish or nearshore gillnet
Demersal shelf/deep slope	Trap	Snappers and groupers or deep slope trap/pot
Demersal shelf/deep slope	Handline/rod and reel	Snappers and groupers or deep slope handline
Lobster	Dive (free, SCUBA) and trap	Lobster
Conch	Dive (free and SCUBA)	Conch
Shark	Hook and line and gillnet	Shark
Diamondback squid	Light stick/hook and line	Squid
Turtle	Turtle net	Turtle
Bait	Net or castnet	Bait fish

3.3 Data Analysis Methods

Data were entered into an open source geographic information system (GIS) using a custom-built interface known as Open OceanMap, which was modified for the St. Kitts and Nevis study region. The interface allowed field staff to enter fishing grounds identified by respondents directly into a spatial database, and standardize this information across a number of respondents or fisheries. Furthermore, Open OceanMap was programmed to allow field staff to draw shapes of the fishers' grounds in their natural sizes (polygons) rather than confining responses to a grid. Although data can be summarized to a variety of grids for the subsequent analysis, the raw data were entered in natural shapes and at the spatial scale that made sense to respondents.

All interviews followed a shared protocol:

1. Maximum extent: Using electronic and paper nautical charts of the area, fishers were asked to identify, by fishery, the maximum extent north, south, east, and west they would forage or target a species.
2. Scaling: They were then asked to identify, within this maximum forage area, areas of critical economic importance over their cumulative fishing experience, and to rank these using a weighted percentage—an imaginary "100 dollars" that they distributed over the fishing grounds.
3. Landing site association: All areas each fisher identified were then attributed to his specified home landing site.

The first step established the maximum extent of the fleet in each fishery. This differed for all fisheries, some of which range far along the Leeward Islands, while others were confined to inshore waters. In the subsequent analysis this allowed us to distinguish between fisheries that take place wholly or partially in the territorial seas of St. Kitts and Nevis. While an initial concern was the limited extent of the base maps provided, additional information on depth collected by field staff allowed us to adequately capture areas beyond the boundaries of the base map. Coastal pelagics – troll/handline, demersals shelf/deep slope – handline/pole line, and ocean pelagics – troll/handline were the only fisheries that occasionally extended beyond the extent of the base maps.

The second step serves to scale respondents' reporting of the relative importance of the fishing grounds to a common scale. This is important for making inter and intra fishery comparisons. We chose 100 dollars as an intuitive common sum scale for scoring the relative importance of subareas identified within the larger fishing grounds. It also provides us with a convenient accounting unit for aggregating the stated importance per unit area in the intermediary steps of the various analyses performed.

The landing site association is relevant for linking the fishing grounds to landing sites, since not all landings are necessarily made in ports adjacent to the grounds.

The analysis of the fishing ground information follows a series of discrete steps:

3.3.1 Determining the fishing grounds

Through interviews following the above protocol, fishers are asked to identify their fishing grounds for a specific fishery. In order to determine the fishing grounds G for any given fishery, the fishing grounds identified by the fisher (i.e. the area of all the shapes, j) is summarized. Each fisher f interviewed, identifies his/her fishing grounds G_f, per fishery as one or more shapes $G_f = \sum j$, where j = 1,...,...n. The number of shapes differs for each respondent and by fishery. If there is only one shape, then $G_f = j$.

Each shape j in fisher's f's fishing grounds is then converted to a grid with a 100m-cell size. For example, in the Lobster fishery, each shape identified by a fisher now equals some multiple of 100m cells, so the total number of cells in one shape, C_j = n, where n = 1,...,C. The lobster fishing grounds for each fisher G_f, is now represented by the total number of cells for all of his\her shapes:

$$G_f = \sum_{j=1}^{J} C_j$$

But, in order to normalize each shape by the total area, the entire lobster fishing grounds $G_{lobster}$, need to be determined. This will be used in a later step that effectively weights the response according to the relative size of the respondent's fishing footprint to the composite fishing grounds. The composite fishing grounds $G_{lobster}$, is based on all the shapes provided by all fishers, and it is necessary to account for the possible overlap of shapes identified by multiple fishers. This is done by expressing whether a cell exists for j in any given location (cell) through the following equation:

$$G = \sum b_{(x,y)},$$
$$b = 1 \vee 0$$

Where b = result of the Boolean expression:
does j exist for any f for location x, y. 1 = true, 0 = false.

If we were to just sum the number of cells of every j, identified by every f, the resulting sum would not be for a unique x, y location and count multiple occurrences in the same location. In other words, the fishing grounds of any one fisher G_f, are smaller or equal to the total grounds for that fishery.

3.3.2 Determining the relative economic importance (REI)

Each respondent allocates a budget, Ω, of 100 "dollars," representing his or her total effort for that fishery, by allocating some portion of dollars, P, to each shape, j, on their fishing grounds, G_f , such that $\sum P_j = 100$. Each shape j is now associated with a distinct number of cells, C_j, and a weight, P_j.

$$\sum_{j=1}^{J} P_j = 100$$

The value of each cell in the shape is then the number of dollars allocated to the shape divided by the number of cells in the shape. So as not to overstate the relative importance of cells associated with shapes identified by fishers who reported smaller fishing grounds (thus concentrating value in a sub-section of the composite grounds, *G),* we multiply the value of each cell (P_j / C_j), by the number of cells for that fisher's grounds, G_f, divided by the total number of cells in the composite fishing grounds for the entire shape (G_f / G). This weights the response according to the relative size of the respondent's fishing footprint, C_j, to the composite fishing grounds, *G,* or normalizes by the total area.

Each cell for every given shape is now represented by the relative economic importance value normalized by the total area, or *V*.

$V_j = (P_j / C_j) * (G_f / G)$

Where:

P = the stated economic importance value
C = the number of cells
j = the shape
G = the total number of cells in the entire fishery
G_f = the total number of cells in the fishing grounds of one fisher

Consider this example:

For this example there are only two respondents. Collectively they have drawn five shapes: respondent *A* has identified three shapes and respondent *B* has identified two shapes. They have each allocated their budget of dollars accordingly.

Respondent A identifies three shapes, which cover 50, 100, and 10 cells, respectively. She then weighs them 20, 75, and 5 dollars each, for a total budget of 100 dollars.

Shape j	**No. of cells** C_j	**No. of dollars** P_j	**Value per cell** (P_j / C_j)
A_1	50	20	20/50 = 0.4
A_2	100	75	75/100 = 0.75
A_3	10	5	5/10 = 0.5
A's total grounds G_A	160 cells	100 dollars	

Respondent *B* identifies two shapes, which cover 20, and 100, respectively. He then weighs them 80 and 20 dollars each, for a total dollars budget of 100.

Shape j	No. of cells C_j	No. of dollars P_j	Value per cell (P_j / C_j)
B_1	20	80	80/20 = 4
B_2	100	20	20/100 = 0.2
B's total grounds G_B	120 cells	100 dollars	

All of respondent B's first shape ($j_{B,1}$), overlaps with a portion of respondent A's second shape ($j_{A,2}$). The total number of cells in the composite fishing grounds, G, thus equals 260. In order to account for the relative size of each respondent's fishing footprint, $C_{(j)}$, to the composite fishing grounds, G, the value per cell (P_j / C_j) is multiplied by the number of cells for that shape, divided by the total number of cells in the composite fishing grounds (C_j / G).

Respondent A

Shape j	Value per cell (P_j / C_j)	Relative Economic Importance Value $V_j = (P_j / C_j) * (G_A / G)$
A_1	20/50 = 0.4	0.4 * 0.6 = 0.24
A_2	75/100 = 0.75	0.75 * 0.6 = 0.45
A_3	5/10 = 0.5	0.5 * 0.6 = 0.3

Respondent B

Shape j	Value per cell (P_j / C_j)	Relative Economic Importance Value $V_j = (P_j / C_j) * (G_B / G)$
B_1	80/20 = 4	4 * 0.46 = 1.84
B_2	20/100 = 0.2	0.2 * 0.46 = 0.092

For each cell shared between the two shapes, the relative stated economic importance value of the cell is the sum of the values assigned by each fisher whose shapes (i.e. fishing grounds) overlap in that cell.

$$O_{x,y} = \sum_{f=1}^{F} V_{f(x,y)}$$

Where O = the sum of all Vs for a given location (x,y cell).

So for the 20 cells in respondent B's shape (B_1), with a REI value of 1.84, which overlap with 20 of the 100 cells in respondent A's shape (A_2), with a REI value of 0.45, the aggregate value equals 2.29.

The aggregate value, O, is the share of the total fishing effort budget, $B = f * 100$, where $f = 2$ for this example, that is apportioned to $O_{x,y}$. In the case of our example, 2.29 dollars out of a total of 200 would get assigned to each of the 20 cells where there is overlap. The remaining area that comprises the rest of the fishing grounds is assigned the REI values that are calculated for each cell for each shape, $O_{x,y} = V_{x,y}$

The result of this analysis is a weighted surface of the extent and stated importance of the fishing grounds for each fishery.

3.3.3 Quality assurance and quality control

Quality assurance and quality control (QA/QC) involved a four-step process:

1. Editing of shapes by Ecotrust staff based on notes from interviews and/or when required to standardize the data (e.g., clipping a shape to the shoreline).
2. Providing the project coordinator with maps and a verification checklist.
3. Reviewing the maps with in-country staff who conducted the interviews on both St. Kitts and Nevis. Those staff provided a list of comments and points of clarification for the island-wide and federation level maps.
4. Meeting with fishing communities (individuals and groups) in late August/early September on each island to:
    a. Clarify the comments and points, which were compiled by in-country and Ecotrust staff.
    b. Review and discuss how the maps were created, how individual information was combined to create the aggregate maps per port and combined to create island and federation maps.
    c. Review maps for accuracy and presentation—Local fishers were presented with maps representing fishing grounds their island. During semi-structured meetings with one or multiple fishers (approximately 45 in total) at the landing sites of Basseterre (East), Old Road, Sandy Point, Dieppe Bay, Charlestown, Jessups, Jones Bay, Newcastle, Long Haul, and Indian Castle, we solicited general feedback on the accuracy of the extent of the fishing grounds and the associated values within the extent. Additionally, the specific comments and points of clarification regarding certain datasets developed through the internal review by field staff were discussed with the fishers for confirmation.
    d. Review and discuss how this information will be used to inform the zoning analysis conducted by TNC and its potential use for other types of planning or management, including gathering ideas from the fishers regarding their thoughts on how this information could best be used.

Internally, we employed several QA/QC protocols that were designed to catch inconsistencies and other problems with individual data. For example, for non-spatial data we ran a check to make sure each fishery captured for an individual had the appropriate corresponding information such as the percentage of the fisher's income from a particular fishery. For spatial data, we checked that depth demarcations were consistent with the limits of a particular fishery (e.g., conch – free dive occurs no greater than X meters) and that mapped data were consistent with shapefile notes.

After the initial review meetings held in Charlestown, it became apparent that most of the fishers' responses on extent and accuracy of value were best reflected in the island-wide maps (versus landing site maps). Review meetings in other ports confirmed this. Additionally, to ensure that the fishing grounds (extent and value) were reflected in the island- and country- wide maps that were used in the zoning analysis, we attempted to capture and confirm responses across landing sites for each island that could be used to identify gaps (either areas that were missing from the maps or areas that were incorrect in terms of the extent and/or value associated with a given area). That said, based on the comments gathered during the in-country review process, we made changes only to the island- and country-wide maps. For details on how and what modifications were made based on the comments received, see Appendix A.

4 Results and Deliverables

Primary project results and deliverables can be broadly categorized as summary statistics and map products (geodatabases), which are both discussed in further detail below.

4.1 Summary Statistics

We report here summary statistics highlighting survey findings. Statistics are reported both by island (St. Kitts and Nevis) and for the entire country. We report on the following:

- Summary of number of fishers interviewed by landing site.
- Survey representation by landing site grouping.
- Survey results by fishery and gear type.
- Summary statistics of fish price and catch sales.
- Fisheries income dependency by landing site.
- Summary responses from qualitative questions.

As mentioned previously, over seven weeks during the spring and summer of 2010, Ecotrust personnel, TNC personnel, and in-country field staff interviewed 51 fishers on St. Kitts and 65 fishers on Nevis (116 total). The following fisheries received the highest number of responses across both islands: coastal demersals – trap (59) and demersals shelf/deep slope – pole/handline (54) (see Table 3). In total, the 51 fishers on St. Kitts and the 65 fishers on Nevis provided 151 and 139 individual fishing ground files, respectively. It should be noted that these numbers and those in Table 4 are not mutually exclusive, in that a fisher often participates in more than one fishery.

Table 3. Summary of reported fisheries

	St. Kitts	Nevis	Federation
Bait – net/cast net	8	2	10
Coastal demersals – gillnet	—	2	2
Coastal demersals – pole/handline	6	3	9
Coastal demersals – spear gun	9	1	10
Coastal demersals – trap	22	37	59
Coastal pelagics – beach seine	4	2	6
Coastal pelagics – troll/handline	2	2	4
Conch - dive (free)	1	5	6
Conch - dive (SCUBA)	7	3	10
Demersal shelf/d. slope – pole/handline	33	21	54
Demersal shelf/d. slope – trap	6	11	17
Diamondback squid - light stick	—	1	1
Lobster - dive (free)	1	4	5
Lobster - dive (SCUBA)	7	3	10
Lobster - trap	21	17	38
Ocean pelagics - troll/handline	20	21	41
Shark - gillnets	—	1	1
Shark - hook & line	3	—	3
Turtle - turtle net	1	3	4
Grand Total	**151**	**139**	**290**

Basic summary statistics are reported by fishery in Table 4. It is interesting to note that participants in the turtle fishery, on average, are substantially older than participants in other fisheries. The five participants in the lobster—dive (free) fishery had the highest average household income from fishing (88%).

Table 4. Summary statistics by fishery

	Average						
Fishery	**Number sampled**	**Age**	**Years experience in fishery**	**Household income from fishing**	**Household size**	**Income from specific fishery**	**Number of crew**
Bait – net/cast net	10	50	26	78%	4	0%	2
Coastal demersals – gillnet	2	51	16	30%	6	33%	2
Coastal demersals – pole/handline	9	56	28	81%	3	36%	1
Coastal demersals – spear gun	10	40	17	74%	5	29%	3
Coastal demersals – trap	59	53	27	70%	5	56%	1
Coastal pelagics – beach seine	6	57	16	81%	4	56%	3
Coastal pelagics – troll/handline	4	56	30	70%	2	11%	2
Conch – dive (free)	6	48	25	78%	5	33%	1
Conch – dive (SCUBA)	10	41	20	76%	5	69%	2
Demersal shelf/deep slope – pole/handline	54	48	22	71%	4	36%	2
Demersal shelf/deep slope – trap	17	51	26	69%	2	35%	2
Diamondback squid – light stick/hook and line	1	48	10	80%	1	5%	1
Lobster – dive (free)	5	46	22	88%	3	25%	2
Lobster – dive (SCUBA)	10	42	21	74%	5	22%	2
Lobster – trap	38	50	25	80%	4	28%	2
Ocean pelagics - troll/handline	41	44	20	66%	4	51%	2
Shark – gillnet	1	–	35	20%	1	21%	1
Shark – hook and line	3	48	17	80%	2	4%	3
Turtle – turtle net	4	68	38	68%	2	20%	2

Table 5 reports basic port level summary information. All respondents were male. The average respondent (at the Federation level) was 50 years old, have 24 years of commercial fishing experience, and participates in three fisheries. On average, fishing accounts for approximately 68% of his household income. It is interesting to note that, on average, there is greater dependency on commercial fishing from St. Kitts respondents (79% of household income) than Nevis respondents (60% of household income).

Table 5. Summary statistics by port

		Number responding	Average: Age	Years experience	% household income	Household size	Number of fisheries	% co-op members
St. Kitts	Basseterre	15	49	22	92%	3	2	29%
	Conaree	2	41	14	70%	6	5	0%
	Dieppe Bay	16	44	21	68%	5	3	86%
	Old Road Town	9	55	26	91%	4	3	88%
	Sandy Point	9	50	24	69%	3	3	0%
Nevis	Charlestown	16	54	28	46%	8	2	93%
	Cotton Ground	2	60	19	68%	2	2	50%
	Indian Castle	11	54	28	46%	2	2	63%
	Jessups	5	54	23	90%	4	3	80%
	Jones Bay	10	52	24	63%	3	2	38%
	Long Haul	5	46	25	78%	3	2	80%
	Newcastle	16	50	22	62%	4	2	79%
St. Kitts - TOTAL		51	49	23	79%	4	3	62%
Nevis - TOTAL		65	52	25	60%	4	2	73%
Federation - TOTAL		116	50	24	68%	4	3	69%

Individuals participating in the conch, lobster, and snapper fisheries were asked to estimate the average price (in EC dollars) per pound typically received for these species (see Table 6). It is interesting to note that while prices for conch and snapper are comparable across the two islands, the average price of lobster varies substantially.

Table 6. Average price per pound received ($EC)

	Fishery: Conch	Lobster	Snapper
St. Kitts	$8.00	$17.93	$12.21
Nevis	$8.00	$14.63	$11.84
Federation	$8.00	$16.00	$11.98

Given that the survey targeted captains, participants were asked to provide information about how their crew is typically compensated (see Table 7). Receiving either a share of the revenue or a share of the catch were the most popular methods of compensation on both islands, although it is interesting to note that sharing of revenue was more common on Nevis (55%) and share of catch was more common on St. Kitts (55%). Only two respondents, both on St. Kitts, reported paying salary as compensation.

Table 7. Summary of crew compensation

	Payment Method	Number of respondents	Percentage of respondents
St. Kitts	Salary	2	4%
	Share of the Revenue	17	33%
	Share of the Catch	28	55%
	TOTAL	51	—
Nevis	Salary	0	0%
	Share of the Revenue	36	55%
	Share of the Catch	27	42%
	TOTAL	65	—
Federation	Salary	2	2%
	Share of the Revenue	53	46%
	Share of the Catch	55	47%
	TOTAL	116	—

Note: Some respondents did not specify how crew was paid— the total number of responses does not equal the total number of respondents
Note: Some respondents cited different payment methods for different fisheries

Table 8 reports on the average percentage share of profit (in the form of revenue or catch) allocated between crew members and captains. During the interview process, several survey respondents indicated that the dominant social norm is to share all profits equally amongst the crew and captain. Table 8 corroborates this information as, of the 78 respondents to this question, 72% of them indicated they share profits equally.

Table 8. Average crew and captain shares

	Average			Equal shares	
	Number of crew	Crew share (% after expenses)	Captain share (% after expenses)	Summary of respondents	Percentage of respondents
St. Kitts	2	60%	40%	38	84%
Nevis	1	49%	52%	40	62%
Federation	2	53%	48%	78	72%

Table 9 presents a summary of typical species-specific distribution channels. As expected, the conch fishery is the primary export fishery, with over half of the conch harvested by respondents being sold to exporters. Popular sales to hotels and restaurants include ocean pelagics and lobster on both islands.

Table 9. Distribution of catch

		Personal use	Private customers	Hotels/ restaurants	Basseterre fisheries complex	Nevis fisheries complex	Exporter	Other
Ocean Pelagics	St. Kitts	4%	47%	48%	1%	1%	0%	0%
	Nevis	4%	19%	63%	0%	11%	4%	0%
	Federation	4%	30%	57%	0%	7%	2%	0%
Coastal Pelagics	St. Kitts	7%	50%	23%	8%	0%	12%	0%
	Nevis	4%	71%	0%	0%	0%	25%	0%
	Federation	6%	57%	16%	5%	0%	16%	0%
Demersal Fisheries	St. Kitts	2%	49%	26%	21%	0%	0%	2%
	Nevis	10%	72%	11%	0%	7%	0%	0%
	Federation	7%	64%	16%	8%	5%	0%	1%
Conch	St. Kitts	0%	25%	8%	1%	0%	66%	0%
	Nevis	2%	37%	19%	0%	0%	41%	0%
	Federation	1%	32%	15%	0%	0%	51%	0%
Lobster	St. Kitts	2%	36%	51%	10%	0%	0%	0%
	Nevis	5%	30%	56%	0%	0%	10%	0%
	Federation	3%	33%	54%	4%	0%	6%	0%
Shark	St. Kitts	1%	50%	49%	0%	0%	0%	0%
	Nevis	0%	100%	0%	0%	0%	0%	0%
	Federation	1%	67%	33%	0%	0%	0%	0%
Squid	St. Kitts	–	–	–	–	–	–	–
	Nevis	0%	0%	100%	0%	0%	0%	0%
	Federation	0%	0%	100%	0%	0%	0%	0%
Turtle	St. Kitts	–	–	–	–	–	–	–
	Nevis	10%	90%	0%	0%	0%	0%	0%
	Federation	10%	90%	0%	0%	0%	0%	0%

In addition to asking individuals what percentage of their total household income comes from commercial fishing, we also asked them to estimate what percentage of their commercial fishing income comes for specific fisheries. Table 10 shows the average percentage income from each fishery for those individuals participating in that specific fishery. For example, for the 62 respondents who participate in the coastal demersals–trap fishery, on average, this fishery represents 56% of their commercial fishing income. Generally, greatest income dependency on both islands is associated with the conch–dive (SCUBA) fishery.

Table 10. Summary of fishery dependency[1]

Fishery	Federation		St. Kitts		Nevis	
	Number of respondents	Average % income from fishery	Number of respondents	Average % income from fishery	Number of respondents	Average % income from fishery
Bait – net/cast net	—	—	—	—	—	—
Coastal demersals – gillnet	3	33%	—	—	3	33%
Coastal demersals – pole/handline	10	36%	3	35%	7	36%
Coastal demersals – spear gun	8	29%	7	31%	1	20%
Coastal demersals – trap	62	56%	16	33%	46	63%
Coastal pelagics – beach seine	7	56%	5	53%	2	63%
Coastal pelagics – troll/handline	4	11%	2	7%	2	15%
Conch – dive (free)	8	33%	2	35%	6	32%
Conch – dive (SCUBA)	9	69%	7	69%	2	70%
Demersal shelf/deep slope – pole/handline	47	36%	27	37%	20	34%
Demersal shelf/deep slope – trap	9	35%	5	34%	4	36%
Diamondback squid – light stick/hook & line	1	5%	—	—	1	5%
Lobster – dive (free)	3	25%	—	—	3	25%
Lobster – dive (SCUBA)	11	22%	6	24%	5	19%
Lobster – trap	34	28%	20	34%	14	20%
Ocean pelagics – troll/handline	36	51%	15	34%	21	64%
Shark – gillnet	2	21%	1	1%	1	40%
Shark – hook and line	2	4%	2	4%	—	—
Turtle – turtle net	4	20%	1	5%	3	25%

In an effort to better understand fishing effort on St. Kitts and Nevis, we examined the number of fisheries respondents participate in as well as the common target fishery combinations that occur. As seen in Table 11, over half of respondents participate in only one or two fisheries. An additional 28% of respondents participate in three fisheries. No respondent participates in more than seven of the 19 fisheries (species-gear type) considered in this study.

Table 11: Number of fisheries participated in

Number of fisheries	n=	% of total	Cumulative
One	31	27%	27%
Two	34	29%	56%
Three	32	28%	84%
Four	9	8%	91%
Five	3	3%	94%
Six	5	4%	98%
Seven	2	2%	100%
	116	—	—

[1] The number of respondents may be greater or less than the total number of fishers participating in a fishery as a fisher may have chosen not to answer this question or, similarly, may have chosen not to provide a shapefile for a fishery in which he participates.

Table 12 categorizes respondents based on the number of fisheries in which they participate and then summarizes the fishers participating in each fishery for a give category. For example, of the 31 individuals who participate in only one fishery, eight participate in coastal demersals – trap.

Table 12: Fishery participation

Number of fisheries	n=	Bait – net/cast net	Coastal demersals – gillnet	Coastal demersals – pole/handline	Coastal demersals – spear gun	Coastal demersals – trap	Coastal pelagics – beach seine	Coastal pelagics – troll/handline	Conch - dive (free)	Conch - dive (SCUBA)	Demersal shelf/d. slope – pole/handline	Demersal shelf/d. slope – trap	Diamondback Squid - light stick	Lobster - dive (free)	Lobster - dive (SCUBA)	Lobster - trap	Ocean pelagics – troll/handline	Shark - gillnets	Shark - hook & line	Turtle - turtle net
One	31	0	1	0	1	8	3	0	0	3	3	5	0	0	0	0	7	0	0	0
Two	34	1	0	5	1	18	0	1	0	1	15	6	0	1	1	9	9	0	0	0
Three	32	3	1	4	2	18	2	1	3	2	20	1	0	3	5	15	12	1	1	2
Four or more	19	6	0	1	6	15	1	1	3	4	17	4	1	1	4	14	13	0	2	2

There are a number of interesting points that can be taken from this table:

- Individuals participating in only one fishery target only eight of the 19 fisheries considered. Individuals participating in two fisheries target 12 of the 19 considered and those participating in three fisheries target 18 of the 19 considered.
- Coastal demersals – trap, demersal shelf/deep slope – pole/handline and ocean pelagics – troll/handline are popular fisheries across all categories.
- While the lobster-trap fishery is important for individuals participating in two or more fisheries, no respondent participating in only one fishery participates in lobster-trap.

Finally, we assessed whether there were specific fishery combinations that are more likely to occur within each category. The 31 respondents participating in only one fishery are most likely to target coastal demersals – trap (8) and ocean pelagics – troll/handline (7). That said, all eight coastal demersals – trap and six of the seven ocean pelagics – troll/handline respondents are from Nevis.

Respondents participating in two fisheries targeted a variety of combinations with the following being the most popular: coastal demersals – trap and lobster – trap (9 of 35), demersal shelf/d. slope – pole/handline and ocean pelagics - troll/handline (6 of 35). In both cases, while two fisheries are targeted, the gear type remains the same. Again, differences were seen between the two islands, with all but one of the coastal demersals – trap and lobster – trap (8), demersal shelf/d. slope – pole/handline and ocean pelagics - troll/handline (5) combinations being fished by Nevis fishers.

It is interesting to note that only nine of the 31 fishers (29%) targeting one species and 11 of 34 fishers (32%) targeting two species are from St. Kitts. In contrast, 13 of 19 fishers (68%) targeting four or more species are from St. Kitts

Respondents participating in trap fisheries were asked two additional questions:

- How many traps on average do you fish with?
- What is the average length of time each trap remains in the water?

The average number of traps used for both lobster and demersals shelf varied substantially between St. Kitts and Nevis, with respondents on St. Kitts using more traps (see Table 13). The average number of traps used on Old Road for lobster is substantially larger than other landing sites as two of the largest fishing vessels/operations are located within this site.

Table 13. Summary statistics for trap fisheries

		Lobster – trap		Coastal demersals – trap		Demersal shelf – trap	
	Landing site	Average number of traps	Average trap soak time (days)	Average number of traps	Average trap soak time (days)	Average number of traps	Average trap soak time (days)
St. Kitts	Basseterre	22	7	22	7	30	7
	Conaree	60	4	60	4	—	—
	Dieppe Bay	24	10	18	7	—	—
	Old Road	113	4	22	11	65	3
	Sandy Point	40	4	29	5	8	7
Nevis	Charlestown	23	4	31	5	28	4
	Jessups	28	2	28	2	—	—
	Cotton Ground	26	6	26	6	—	—
	Jones Bay	35	6	22	6	—	—
	Newcastle	20	7	26	6	—	—
	Long Haul	11	6	11	6	19	5
	Indian Castle	13	2	23	3	38	5
St. Kitts - TOTAL		42	7	27	6	46	5
Nevis - TOTAL		22	4	27	5	31	5
Federation - TOTAL		33	6	27	34	36	5

4.1.1 Qualitative responses

In addition to quantitative responses described previously, survey participants were also asked a series of qualitative questions including:

- How well are your fisheries doing?
- What things are impacting your fisheries?
- Are you aware of out-of-country fishers in your waters?

This section summarizes responses to these questions. Responses were coded into broad categories and reported accordingly.

Of the 88 individuals who responded to the question about how their fisheries are doing, only 11 (13%) responded positively. For the remaining 77 individuals, responses such as 'fair', 'up and down', 'not too good', 'declining' and 'getting harder' were common.

Responses to the question asking fishers what they perceived to be impacting their fisheries were varied (see Table 14). Of those who responded to this question (41 did not), the most popular response weather/ocean dynamics (17%). Other popular responses were poaching (12%) and other (12%), which included loss of reef, fewer educated people participating in fishing, high fuel costs, tourism, and fear of the sea by younger populations.

Table 14. Perceived impacts to fisheries

Coded category	Number of responses	Percentage of responses
Climate change	5	5%
Development	6	6%
Harvesting juvenile fish	5	5%
Hurricane	9	9%
Increased competition	5	5%
Mesh size regulations	9	9%
Overfishing	9	9%
Poaching	12	12%
Runoff	2	2%
Volcano	4	4%
Water temperature	4	4%
Weather /ocean dynamics	17	17%
Other	12	12%
No Response	41	–
TOTAL[2]	140	–

The majority of respondents reported that they do not see out-of-country fishers in St. Kitts and Nevis waters (see Table 15). Of the 16 individuals responding that they do see out-of country fishers, ten were from St. Kitts and six were from Nevis. St. Barts and Antigua were the countries reported as most frequently seen, with four fishers reporting siting of fishers from these two countries. Other countries reported included Redondo, Montserrat, Guadeloupe, St. Eustatis and St. Martin. Both the frequency of sightings and the types of species being targeted varied substantially among respondents.

Table 15. Summary of out-of-country fisher sightings

	Number of respondents	Percentage of respondents
Yes	16	14%
No response	40	34%
No	60	52%

[2] Fishers could provide multiple responses, therefore, the number of responses does not equal the number of respondents.

4.2 Map Products

Table 16 presents a summary of datasets or maps available for each commercial fishery by landing site, island and federation. A "✓" indicates that the fishing grounds datasets are available. It should be noted that only island and federation level maps (highlighted) were updated and submitted as final products. The fishery by landing site datasets made available July 2010 are considered final and no modifications were made to those datasets based on the in-country review that occurred in August and September 2010. Those dataset will be archived and considered an intermediary dataset. The fishery by island and Federation datasets available as of September 24th, 2010 have been updated based on the in-country review (Appendix A) and are considered final. In addition, Figures 1–3 show example maps at the island and federation level (St. Kitts and Nevis) for the coastal demersal – trap fishery.

Table 16. Summary of available map products

Fishery	Basseterre	Conaree	Dieppe Bay	Old Road	Sandy Point	Charlestown	Jessups	Cotton Ground	Jones Bay	Newcastle	Long Haul	Indian Castle	St. Kitts	Nevis	Federation
Bait – net/cast net	✓	✓	✓	✓		✓							✓	✓	✓
Coastal demersals – gillnet						✓						✓		✓	✓
Coastal demersals – pole/handline	✓		✓		✓	✓			✓			✓	✓	✓	✓
Coastal demersals – spear gun	✓	✓	✓		✓	✓							✓	✓	✓
Coastal demersals – trap	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coastal pelagics – beach seine	✓		✓	✓		✓		✓		✓			✓	✓	✓
Coastal pelagics – troll/handline			✓							✓		✓	✓	✓	✓
Conch – dive (free)	✓					✓	✓			✓		✓	✓	✓	✓
Conch – dive (SCUBA)	✓		✓			✓	✓			✓			✓	✓	✓
Demersal shelf/deep slope – pole/handline	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Demersal shelf/deep slope – trap	✓			✓	✓	✓				✓	✓	✓	✓	✓	✓
Diamondback squid – light stick/hook & line						✓							·	✓	✓
Lobster – dive (free)	✓					✓	✓		✓	✓			✓	✓	✓
Lobster – dive (SCUBA)	✓	✓	✓			✓			✓				✓	✓	✓
Lobster – trap	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Ocean pelagics – troll/handline	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓
Shark – gillnet									✓			✓		✓	✓
Shark – hook and line	✓		✓		✓								✓		✓
Turtle – turtle net					✓					✓		✓	✓	✓	✓

Figure 1

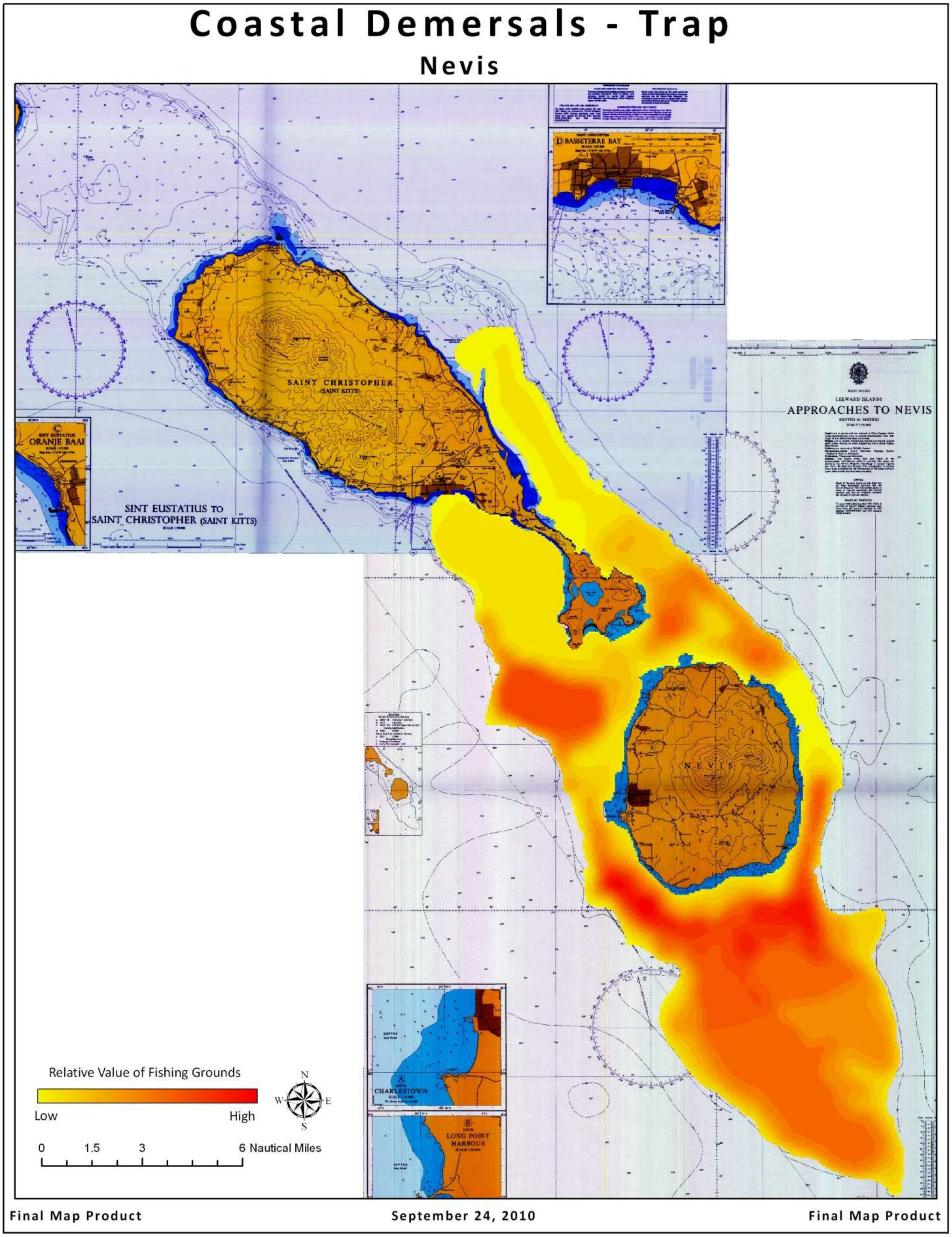
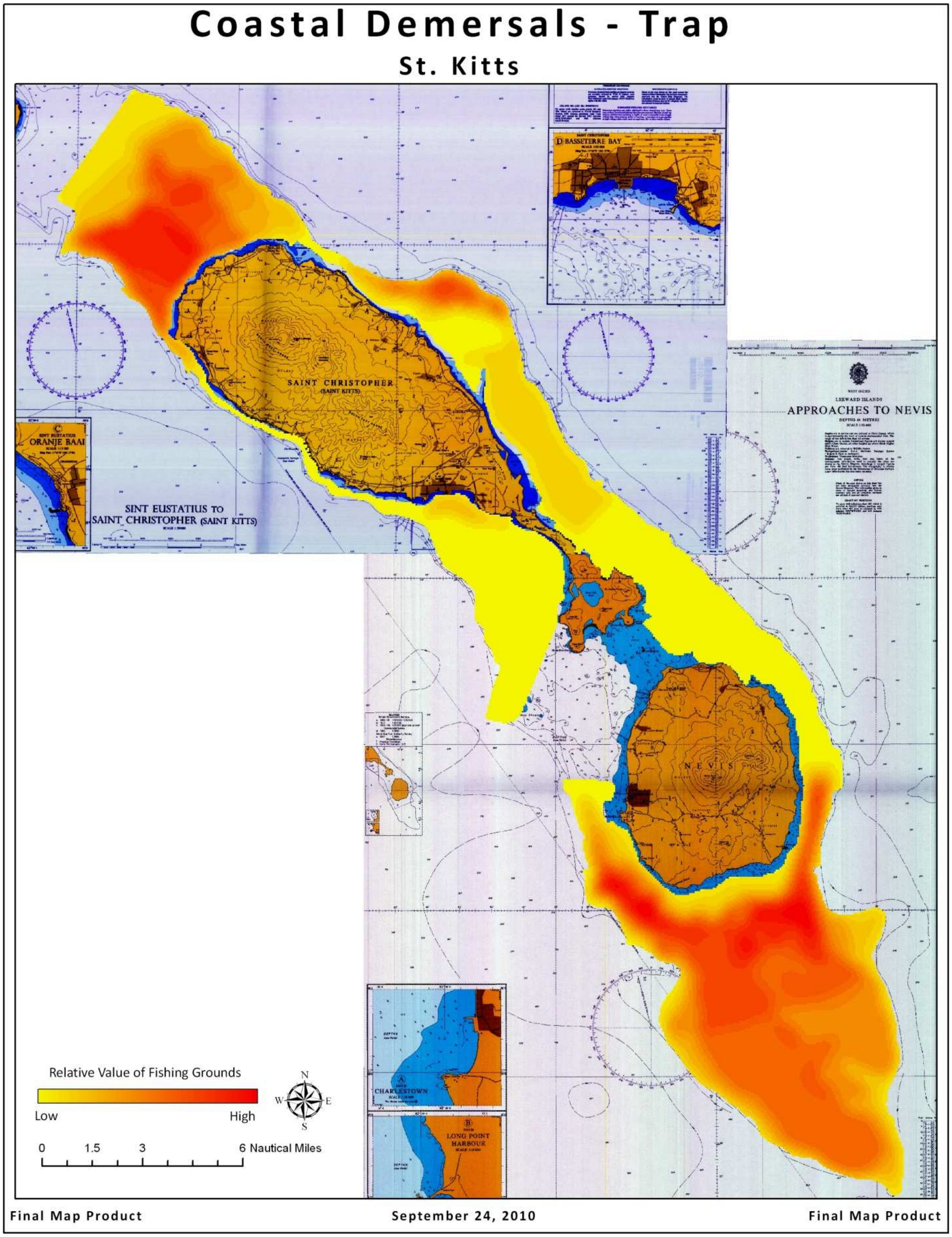
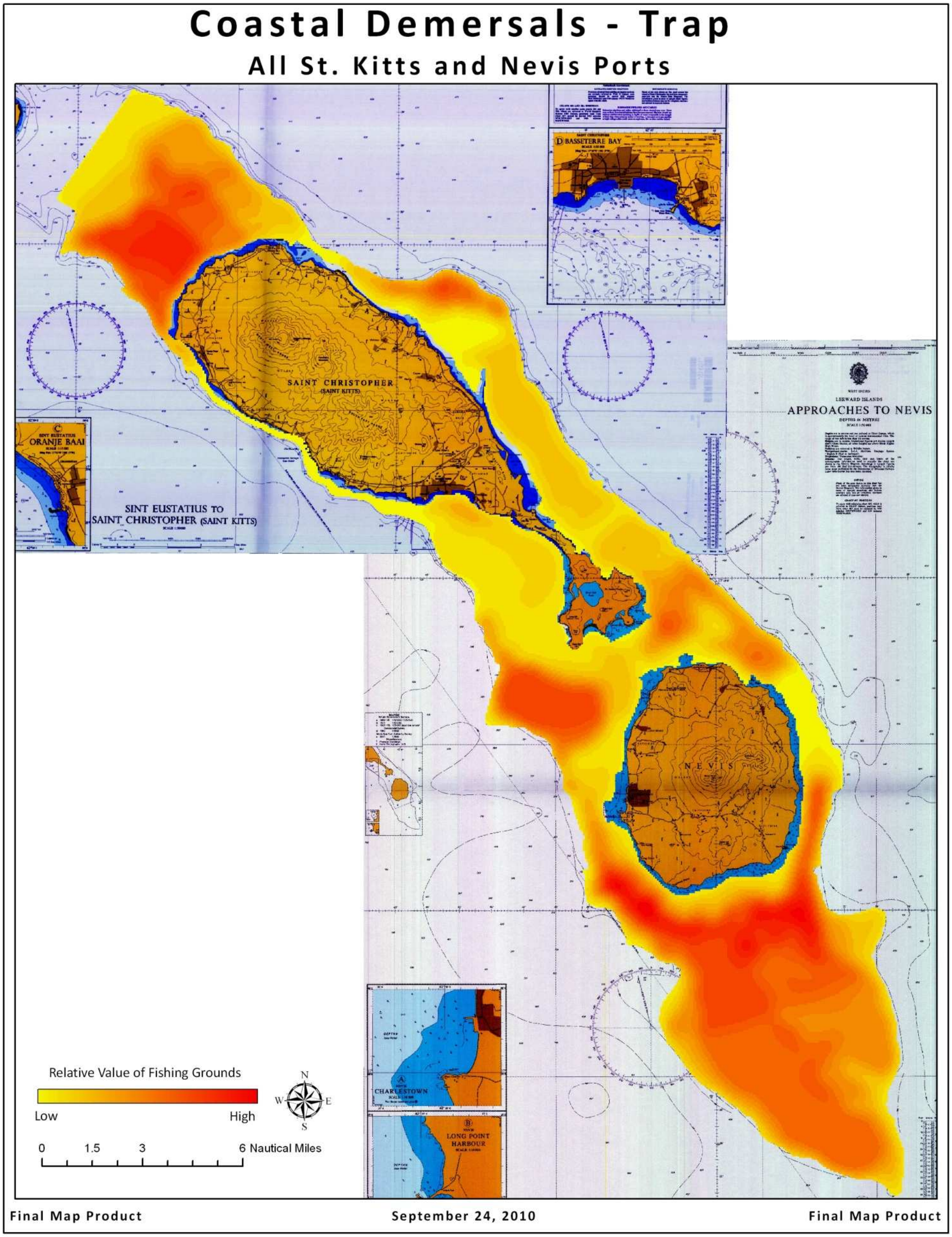

Coastal Demersals - Trap
Nevis
SAINT CHRISTOPHER
SINT EUSTATIUS TO
SAINT CHRISTOPHER (SAINT KITTS)
ORANJE BAAI
BASSETERRE BAY
APPROACHES TO NEVIS
NEVIS
CHARLESTOWN
LONG POINT
HARBOUR
Relative Value of Fishing Grounds
Low
High
0
1.5
3
6 Nautical Miles
N
S
W
E
Final Map Product
September 24, 2010
Final Map Product

Figure 2



Coastal Demersals - Trap
St. Kitts
SAINT CHRISTOPHER
(SAINT KITTS)
BASSETERRE BAY
ORANJE BAAI
SINT EUSTATIUS TO
SAINT CHRISTOPHER (SAINT KITTS)
APPROACHES TO NEVIS
NEVIS
CHARLESTOWN
LONG POINT
HARBOUR
Relative Value of Fishing Grounds
Low
High
0
1.5
3
6 Nautical Miles
Final Map Product
September 24, 2010
Final Map Product

Figure 3


Coastal Demersals - Trap
All St. Kitts and Nevis Ports
SAINT CHRISTOPHER
(SAINT KITTS)
SINT EUSTATIUS TO
SAINT CHRISTOPHER (SAINT KITTS)
ORANJE BAAI
BASSETERRE BAY
APPROACHES TO NEVIS
NEVIS
CHARLESTOWN
LONG POINT
HARBOUR
Relative Value of Fishing Grounds
Low
High
0
1.5
3
6 Nautical Miles
N
S
E
W
Final Map Product
September 24, 2010
Final Map Product

For the first round of deliverables, we provided a series of maps and two geodatabases. One geodatabase contained all of the raster data products created through the aggregation analysis. The data were created at the landing-site, island-wide, and federation-wide level. A map was created for each dataset—a total of 157 datasets/maps. The second geodatabase included all of the individual data collected from the fishers during the interview process. These data are provided in vector geodatabase. For the final round of deliverables, we are providing updated ArcMap projects and a raster geodatabase containing all of the fisheries at the island-wide and federation-wide levels—a total of 53 datasets/maps. All of the data provided include metadata conforming to the Federal Geographic Data Committee (FGDC) standards (http://www.fgdc.gov/standards). The Nature Conservancy will house all deliverables and manage the updating and confidentiality of data.

5 Discussion

This section reflects on several methodological and process lessons we learned in the hope of informing future iterations and/or applications of our approach.

5.1 Staffing

Trained field staff, either from Ecotrust or the client organization, are likely to play a key role in training and data collection phases of the project as well as overall project coordination. Findings from this project suggest that the overall project can be strengthened several ways. First, by having trained staff available (in-country) for several weeks after the training session to insure successful implementation—to conduct interviews to see if the set of questions and procedures work properly and/or to shadow the coordinator and work with field staff to conduct interviews until field staff are comfortable. Second, an in-country project coordinator is critical to the project's success, and if there are multiple islands/regions/cultures within the study area, it may be useful to consider having multiple project coordinators. Finally, by coordinating with relevant in-country agencies and organizations (including co-ops) —whose staff ideally are trained and have the capacity to conduct interviews if appropriate.

5.2 Existing Data

Increased focus on both the availability and role of existing data at the beginning of the project likely will help strengthen and streamline future projects. Suggested ways for increasing this focus include 1) creating a list of general data needs (for sample and survey design) for the project at the beginning to work from (e.g. checklist for what is and is not available, who is the gatekeeper, etc.); 2) characterize any existing data (e.g. how often are data collected, what do they represent, etc.); and 3) vetting existing data with in-country fishers early in the project. One finding was the importance to in-country agency staff and fishers of leveraging any existing data to minimize survey length and not duplicate efforts (e.g. modifying the survey to incorporate existing data). That said, as was later determined in this project, one of the better sources of information on who fishes were and where they fish came directly from the fishing community. Training field staff to use outreach meetings for investigative purposes—e.g., how many people fish from this port, what fisheries do they target, how many boats are there—as the information is both useful for the project and for subsequent outreach meetings—e.g., in Dieppe Bay, say, "I heard in Old Road they used to have seven net boats and now they have one. Are you having a similar experience here?" can help assess the usefulness of local knowledge data early on in the project. A better understanding of both the availability and role of existing data early on in future projects will help balance these types of considerations.

5.3 Survey Design

In addition to input, review, and feedback from the client and in-country agency staff, early review of the survey design by additional individuals in-country (e.g. fishers) will help minimize problems with the survey during implementation. Key points for consideration include: a) interview length; b) question framing; c) fishery names; and d) fishery groupings.

5.4 Tool/Interview/Post Interview Processing

Creating a more flexible mapping tool and streamlining post-interview data processing will likely help improve the quality of data received. In order to minimize the need to digitize hand-written surveys/notes, it should be confirmed early on that each field staff member has access to a laptop. However, hard-copy nautical charts and data sheets with the full suite of interview questions should be available at all times in case laptops are not available or if the situation calls for a hand-written interview. With a more flexible mapping tool, it will be possible to go backwards in an interview and review and verify shapefiles and other data at the end of an interview. Thus adjustments and corrections may be done immediately which reduces the possibility of error in post-interview data processing. Furthermore, creating a tool which captures all interview questions and shapefile notes will also streamline the need to digitize data and reduce the number of survey components the project coordinator will need to check for consistency and accuracy. The project coordinator may then focus more on coordinating and conducting interviews as less time is required to manage data. Ideally, the project coordinator would simply send data files directly to Ecotrust along with one document, which indicates which fishers were interviewed.

In summary, this type of research presented many challenges, yet we believe that the lessons learned in this project have been invaluable. Furthermore, we believe this project, and the lessons learned therein, can be leveraged to catalyze and inform other similar fisher mapping projects in the Caribbean and elsewhere. By nature, this type research has continued to evolve by attempting to transfer existing knowledge, methods, and tools to a new geography, different fisheries, and cultural settings. Much insight was gained on how to successfully adapt previous applications of this work so that they were informed by the local or regional context of St. Kitts and Nevis.

As stated in the introduction, we believe that this project has made a significant contribution to the marine knowledge base on St. Kitts and Nevis – not only by informing marine zoning efforts, but also by enhancing the public's and decision-makers' understanding of the importance of the coastal ocean to individual fishers and to coastal fishing communities. Likewise, we hope the engagement of the St. Kitts and Nevis fishing community in the marine zoning effort is now strengthened through this effort. This strengthened engagement, at a minimum, provides the foundation for future or long-term support for implementation of a zoning plan or inclusion in fisheries management. Through this project, fishers' collective knowledge can now inform current and future marine planning analyses and discussions, where the goal is to better understand and minimize conflict between user groups and optimally accommodate existing/future human uses while maintaining healthy marine habitats and ecosystems.

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Appendix A: Description of modification made based on in-country review

The following is a description of the data edits performed based on review comments from the fishers of St. Kitts and Nevis collected by Charles Steinback and Shawn Margles (TNC) during their review trip to St. Kitts and Nevis in August/September 2010.

1. **Coastal Demersal – Hand line:**
   a. **Nevis edits:** The fishing grounds on the backside of Nevis were connected into a larger area.
      - To complete this edit, we extended the existing shapes to connect and cover the area requested.
   b. **St. Kitts edits:** The area from Sandy Point to Black Rocks was edited to make the higher value area between 100ft and 250 ft deep.
      - To complete this edit, we used the contour lines to split the polygons at the appropriate depths and then adjusted the penny value to make sure the most value was between 100 and 250 ft.
   c. **Federation edits:** No specific edits were made to the Federation dataset. Any changes seen are due to the edits performed on the individual island datasets.
2. **Coastal Demersal – Spear gun:**
   a. **Nevis edits:** We extended the fishing grounds around the island to Butlers and up to Grid Iron Reef. The reef was also given additional value to emphasize its importance.
      - To complete this edit, we added two new shapes to the dataset. The first extended the area around the island up to Grid Iron reef; and the second was over the reef to give that area additional importance.
   b. **St. Kitts edits:** The reefs on the Atlantic side of the island were given some additional value to increase the importance from a lower value (yellow color) to middle level (orange color) importance.
      - To complete these edits, the penny value of the reefs was increased to make sure overall value was raised to a mid-level importance.
   c. **Federation edits:** No specific edits were made to the Federation dataset. Any changes seen are due to the edits performed on the individual island datasets.
3. **Coastal Demersal – Trap:**
   a. **Nevis edits:** We extended the high value fishing grounds on the backside of Nevis up to Butlers between 100ft and 250ft deep.
      - To complete this edit, we extended the existing data to match the requested edit.
   b. **St. Kitts edits:** The South Bank area (south of Nevis) was adjusted to have the same value as the Nevis Island dataset. The areas on the Atlantic side of the island between Black Rocks and Cayon were adjusted to have a similar level of importance as the St. Kitts Lobster – Trap dataset.
      - To complete this edit, we updated the attribute table to include all of the Nevis South Bank data in the St. Kitts dataset. We also copied and pasted the Lobster – Trap data from the Atlantic side to these data and then updated the attribute information so they would be included in this dataset.
   c. **Federation edits:** No specific edits were made to the Federation dataset. Any changes seen are due to the edits performed on the individual island datasets.
4. **Coastal Pelagic – Seine:**
   a. **Nevis edits:** An additional area of importance was added between Charlestown and Dogwood Point at the same depths as the original data. The area over Monkey Shoals was trimmed from a rectangle box shape to follow the contour line that encircles the shoals.

- To complete this edit, we drew a new area along the coast from Charlestown to Dogwood Point, and then we trimmed the area over Monkey Shoals to the contour.

b. **St. Kitts edits:** The area from Basseterre to Sandy Point was included and extended out to 1,200ft. The area was given similar value as the Atlantic side of the island.
   - To complete this edit, we copied an existing shape and adjusted it to match the requested edit.

c. **Federation edits:** No specific edits were made to the Federation dataset. Any changes seen are due to the edits performed on the individual island datasets.

5. **Conch – SCUBA Dive:**
   a. **Nevis edits:** The data were trimmed to a depth of 120ft and the area on the Atlantic side of the island was increased in value.
      - To complete this edit, we made a polygon with which we trimmed all of the data. We also adjusted the penny values in the table to emphasize the important area.

   b. **St. Kitts edits:** The data were trimmed to a depth of 120ft and the area on the Atlantic side of the island was increased in value.
      - To complete this edit, we made a polygon with which we trimmed all of the data. We also adjusted the penny values in the table to emphasize the important area.

   c. **Federation edits:** No specific edits were made to the Federation dataset. Any changes are due to the edits performed on the individual island datasets.

6. **Demersal Shelf/Deep Slope – Hand line:**
   a. **Nevis edits:** The value of the fishing grounds on the Atlantic side of the island was extended up to North Friar's Bay on St. Kitts. The areas between the South Bank and Butlers were connected.
      - To complete these edits, we extended and edited individual fishermen shapes and made them fit the requested edit.

   b. **St. Kitts edits:** The area from Sandy Point to Black Rocks was edited to make the higher value area between 350ft and 600 ft deep.
      - To complete this edit, we used the contour lines to split the polygons at the appropriate depths and then adjusted the penny value to make sure the majority of value was between 350 and 600 ft

   c. **Federation edits:** The data were trimmed to a maximum depth of 1,500ft around both of the Islands.
      - To complete this edit, we made a polygon with which we trimmed all of the data.

7. **Demersal Shelf/Deep Slope – Trap:**
   a. **Nevis edits:** The fishing grounds on the South Bank were adjusted to have a similar value representation as the Demersal Shelf/Deep Slope – Hand line data.
      - To complete this edit, we copied the Demersal Shelf/Deep Slope – Hand line data for the South Bank and updated it to reflect the correct fishery information. We then included the additional data in the analysis for Demersal Shelf/Deep Slope – Trap.

   b. **St. Kitts edits:** The fishing grounds on the South Bank were adjusted to have a similar value representation as the Demersal Shelf/Deep Slope – Hand line data.
      - To complete this edit, we copied the Demersal Shelf/Deep Slope – Hand line data for the South Bank and updated it to reflect the correct fishery information. The data were then included in the analysis for Demersal Shelf/Deep Slope – Trap.

   c. **Federation edits:** The data were trimmed to a depth of 200ft to 1,000ft and the highest value area was focused between 600ft and 1,000ft.

- To complete this edit, we made a polygon with which we trimmed all of the data.

8. **Lobster – Trap:**
   a. **Nevis edits:** More value was added to the South Bank area between 40–80ft.
      - To accomplish this edit, we queried all the lobster-trap data we had from both islands that was in or around the South Bank and updated the attribute table to make sure that the fishing data were used in the analysis for both islands.

   b. **St. Kitts edits:** The South Bank area was filled in to make it similar to Nevis—the areas on the Atlantic side were extended from Black Rocks to the south end of the Island; the areas along Nevis from Long Haul to South Bank were increased in value; and the area from the Salt Pond to Old Road was also increased in value.
      - To complete most of these edits, we updated existing data to be included in the processing for St. Kitts. Where this was not possible, we added additional shapes to the dataset that accomplished the edit requested.

   c. **Federation edits:** No specific edits were made to the Federation dataset. Any changes seen are due to the edits performed on the individual island datasets.

APPENDIX E

Marxan with Zones Analysis

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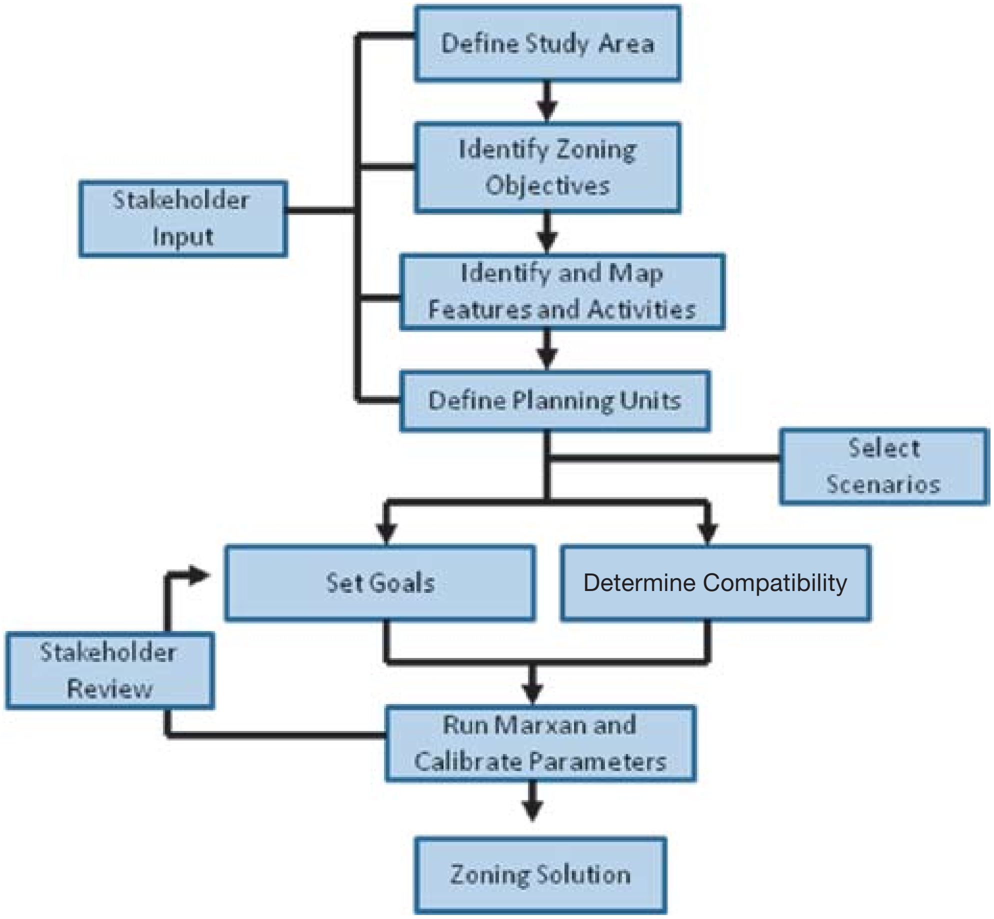

FIGURE E1. Flowchart of the process of implementing Marxan with Zones to generate possible zoning solutions.

INTRODUCTION

Marxan with Zones is an extension of the popular conservation planning decision support tool Marxan[1]. This free software allows users to consider a wide range of ecological and socioeconomic features when designing a portfolio of management areas or management approaches. Marxan is the most widely used conservation planning software in the world and it allows users to examine complex planning problems both on land and in the sea. The extension Marxan with Zones allows users to consider multiple features, objectives, or zones, within an analysis extent. In the case of multi-objective or multiple-use planning, this allows managers, decision makers, user groups, and stakeholders to spatially review tradeoffs in the planning process. Additionally, the systematic analysis allows key areas for each use or objective to be highlighted. Using Marxan with Zones in a participatory planning process illuminates important areas to each sector and facilitates the negotiation of tradeoffs in a zoning process.

Here we outline how Marxan with Zones was implemented in St. Kitts and Nevis in the eastern Caribbean to help inform the development of a multi-objective marine zoning design. We describe the inputs and parameters that were used in running the analysis and provide a brief discussion of model outputs. Figure E1 presents a flowchart of the process of implementing

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[1] Ardron, J.A., H.P. Possingham, and C.J. Klein, (Eds). 2010. *Marxan Good Practices Handbook, Version 2*. Pacific Marine Analysis and Research Association, Victoria, BC, Canada. 165 pages. www.pacmara.org.

Marxan with Zones to generate possible zoning solutions. We refer the readers to Section 3.5 of the main report for a description of how analysis outputs were used to facilitate discussions with key decision makers about tradeoffs.

Model Inputs and Parameters

A zoning analysis using Marxan with Zones requires the following elements:

1. Analysis boundaries
2. Potential zone types
3. A spatial unit for the analysis
4. A specification of quantitative goals and spatial information on where they can potentially be achieved
5. A metric that summarizes factors to avoid
6. Spatial objectives that guide appropriate location of zones

The following is a description of how each of the model inputs and parameters listed above were defined for this project:

1. Analysis boundaries

   In defining the boundaries or maximum analysis extent for this project, several factors were considered. These included the jurisdictional reach of government (e.g., exclusive economic zone [EEZ]), the practical reach for enforcement activities, the location of marine activities throughout the seascape, and the existence of spatial data on marine activities and characteristics (features). Although the need for a zoning plan that extends out to the limits of the country's EEZ was recognized by both the project team and the stakeholders, the analysis extent was set to the limits of the benthic habitat map, an area extending to the 30-meter depth contour line. This area was chosen because it contains equal and uniform information across all sectors considered, an essential component of any spatial modeling effort as it helps deliver unbiased results.

2. Potential zone types

   In order to set up a Marxan with Zones run, the zone types to implement need to be defined based on knowledge of the marine area in question. Ideally the number of zones should be limited and determined in consultation with stakeholders. During the first workshop (Table 2 in main report), the four main zone types for the waters of St. Kitts and Nevis were defined as follows: i) a fishing priority zone; ii) a conservation priority zone; iii) a tourism priority zone; iv) an industrial/transportation priority zone. The overall vision that would frame activities within each of these zones was also defined at the first workshop (Appendix A).

3. A spatial unit for the analysis (planning units)

   Marxan with Zones requires that each characteristic (feature) and activity in the seascape be summarized into planning units. Planning units are a pre-defined suite of areas, typically hexagons, that house all the necessary information for Marxan with Zones. These units permit the program to run and allow comparison and selection between candidate zoning areas. Planning units must capture all the areas that can possibly be selected as part of the zoning design, and their size should be at a scale appropriate for both the ecological and socioeconomic features used as model inputs. In general, planning units should be no finer in resolution than the characteristics or activities mapped and no coarser than is realistic for management decisions. Other considerations include the number of planning units based on computing power, and the size of planning units in relation to the reliability of the mapping data for features and activities. For this project, it was determined that hexagons five hectares in size were suitable based on the scale and complexity of the input data, the spatial extent of the study area, and the computational resources for executing the model. A total of 7,651 planning units were created, covering the study area extent to the 30-meter depth contour, and storing the abundance or intensity level for each sector feature or activity at that particular location (Figure E2).

4. A specification of quantitative goals and spatial information on where they can potentially be achieved.

   Specific characteristics (features) and activities that describe the study area in question within a Marxan with Zones platform and for which spatial data exist need to be selected as model inputs. Decisions on the amount of features or activity taking place in each zone (goals) also need to be made. Table E3 presents a list of spatial information selected to represent the study area in St. Kitts and Nevis. The choice of goals implemented in this analysis (Table E2) was guided by discussions with in-country partners, both at the first workshop outlined above and during informal meetings.

5. A metric that summarizes factors to avoid

   Different activities may affect each other, in addition to affecting ecosystem characteristics. These interactions are described in what is often called a cost matrix. The values in this matrix will ultimately influence where (i.e., which planning units) goals should be achieved. These values are used by Marxan with Zones to help identify and allocate an optimal selection of planning units to each zone, achieving the zone's goals at the minimum "cost." This optimal selection is referred to as the most efficient solution. For example, for a planning unit with a high cost of a specific activity, Marxan with Zones will try to avoid assigning a zone for that activity to that particular planning unit.

   Another way to consider these values is as a measure of potential conflict between marine features, activities, or interests. The cost, or in the St. Kitts and Nevis case, compatibility measures were generated at a stakeholder workshop (Table 2 in main report). Workshop participants reviewed each feature or activity to assess its compatibility with others. Based on group consensus, the interaction between each feature and/or activity was assigned one of four compatibility classes (Compatible, Somewhat Compatible, Rarely Compatible, and Incompatible) and entered into a compatibility matrix (Table 4 in main report). This matrix was used to create a series of GIS-based compatibility surfaces that were modeled for each marine-based feature and activity used in the project. These compatibility maps helped stakeholders visualize the level of compatibility between each feature or activity. For example, an area designated as a ferry route would have a low compatibility with a fishing area, while an area often used for snorkeling would have a higher compatibility score with coral reef conservation. Compatibility scores were assigned to each planning unit by taking the average value within the boundaries of the planning unit for each of the modeled compatibility surfaces. When attempting to meet the goals for each zone, Marxan with Zones uses the cost value of each planning unit as a

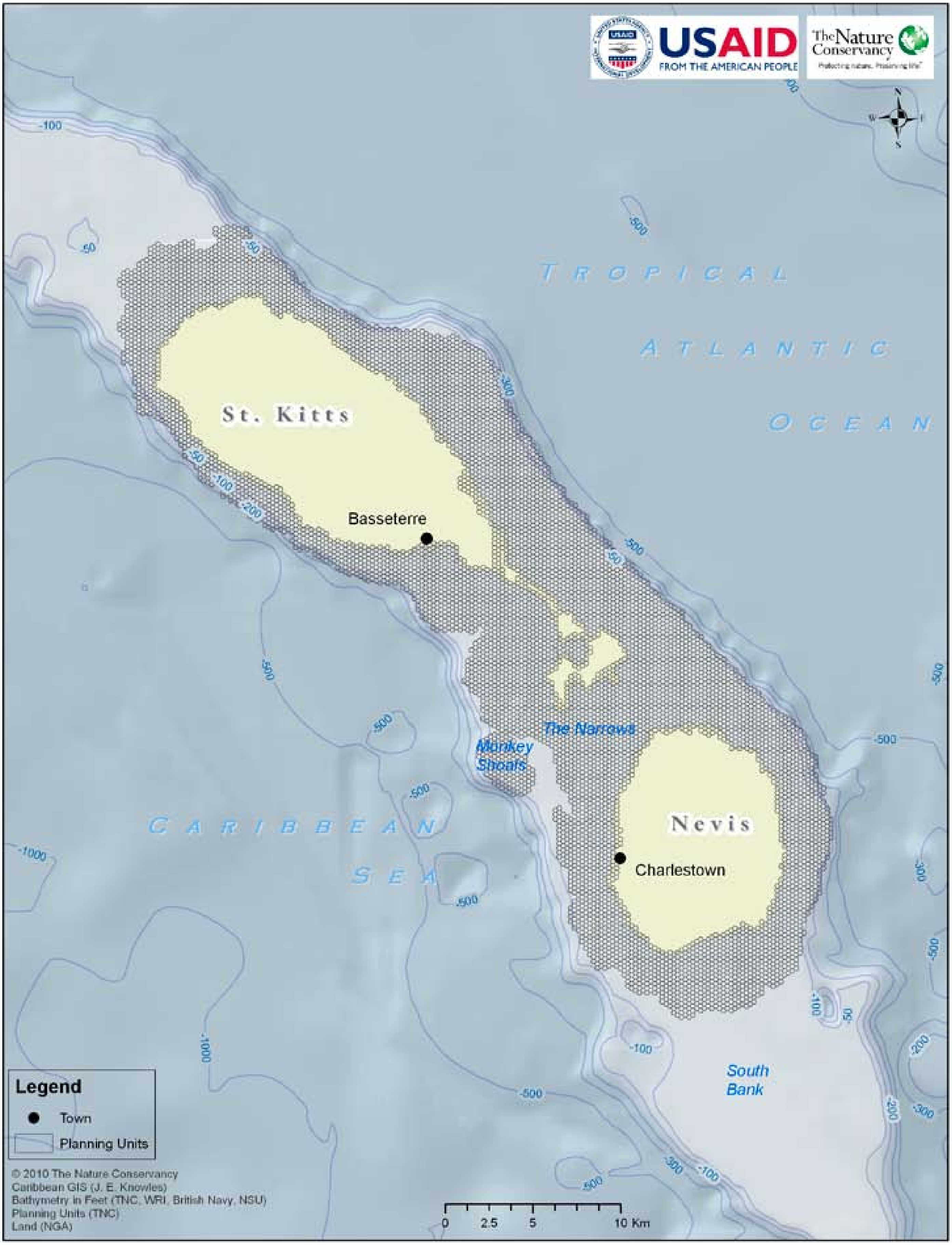


FIGURE E2. Planning units.

constraint for selecting the most optimal zoning configuration. In other words, the final zoning solutions represents an attempt to minimize the conflict by selecting the fewest planning units with the lowest total unit cost while meeting each of the pre-determined zone goals.

6. Spatial objectives that guide appropriate location of zones (zone boundary cost)

   How fragmented a specific zone is has an impact on how costly implementing that zone will be from both an ecological as well as management perspective. Exploring the impact of varying levels of fragmentation is achieved by calibrating a parameter representing compactness (zone boundary cost). Too little compactness leads to highly fragmented zones that are unmanageable. Too much compactness results in an overly large and inefficient zoning design. Calibration makes it possible to find the most mathematically efficient value for zone boundary cost. The zone boundary cost can also function to encourage further separation of conflicting uses or to cluster zones that share compatible management objectives. This can be useful when trying to buffer potential conflict between activities taking place in different zones such as conservation and fishing.[2] Optimal parameters for spatial compactness and buffering of zones were derived through a calibration process as described in the *Marxan with Zones User Guide*.[3]

TABLE E1. Zone boundary cost values used in all scenarios.

Zone Objective	Fishing	Conservation	Tourism	Industrial/ Transportation
Fishing	0			
Conservation	100000	0		
Tourism	300	300	0	
Industrial/Transportation	300	300	300	0

Scenarios

After calibration and in order to assess the impact of different decisions on the potential configuration of zones, some of the parameters described above were modified to generate different scenarios. Three zoning scenarios were implemented in this analysis, each with different zone-specific requirements as defined in Table E2. For each of the scenarios, Marxan with Zones was run using 100 repetitions, each repetition having 1 million iterations. These scenarios were chosen to represent a variety of potential planning perspectives, so as to best assist decision makers in considering trade-offs and variations in zoning design.

Scenario 1: Flat 30 Goal Lock. In the first scenario, a flat goal of 30% was assigned to both the fishing and conservation zones. This means the model was asked to locate the most optimal 30% of the fishing activities and benthic habitats based on the distribution of these features and corresponding underlying constraints. This scenario was an attempt to identify

[2] Watts, M. E., C.J. Klein, R. R. Stewart, I. R. Ball, and H. P. Possingham. 2008. Marxan with Zones (V1.0.1): Conservation Zoning Using Spatially Explicit Annealing, A Manual. University of Queensland, Brisbane. http://www.uq.edu.au/marxan.

[3] Watts, M. E., I. A. Ball, R. S. Stewart, C. J. Klein, K. Wilson, C. Steinback, R. Lourival, L. Kircher, and H. P. Possingham. 2009. Marxan with Zones: Software for optimal conservation based land- and sea-use zoning. Environmental Modelling & Software 24(12):1513–1521.

the highest priority fishing and conservation areas by constraining the model to identify the top 30% of fishing activities and benthic habitats for each zone. For this scenario, all tourism and industrial/transportation activities were "locked" into the best solution, since these activities are largely constrained to discrete locations (e.g., hotel areas, ferry lanes) and represent a relatively small spatial footprint on the marine environment. In other words, these areas were automatically assigned to their corresponding zones and not made available for possible selection into other zones. Because these planning units were locked into their respective zones, they were not considered candidate sites for meeting fishing and conservation goals.

Scenario 2: Flat 60 Goal No Lock. In the second scenario, no planning units were locked into predefined zones, permitting the model to freely choose among all planning units for allocating the optimal zone configuration based on a flat 60% goal assigned across all zone activities and features.

Scenario 3: Variable Goals Reduced Lock. In the third scenario, different goals were assigned to each activity or feature based on consultation with in-country partners and stakeholders during the first workshop and informal meetings. Many of the recommended goals were very high (i.e., 90-100%) and consequently the software had trouble finding a solution that would meet all goals. In order to allow the software to adequately meet the goals in the output solution, all goals that were 90% or above were reduced by 20%. As in the first scenario, both the tourism and industrial/transportation activities were locked in.

TABLE E2. Scenarios used in Marxan with Zones and associated run parameters.

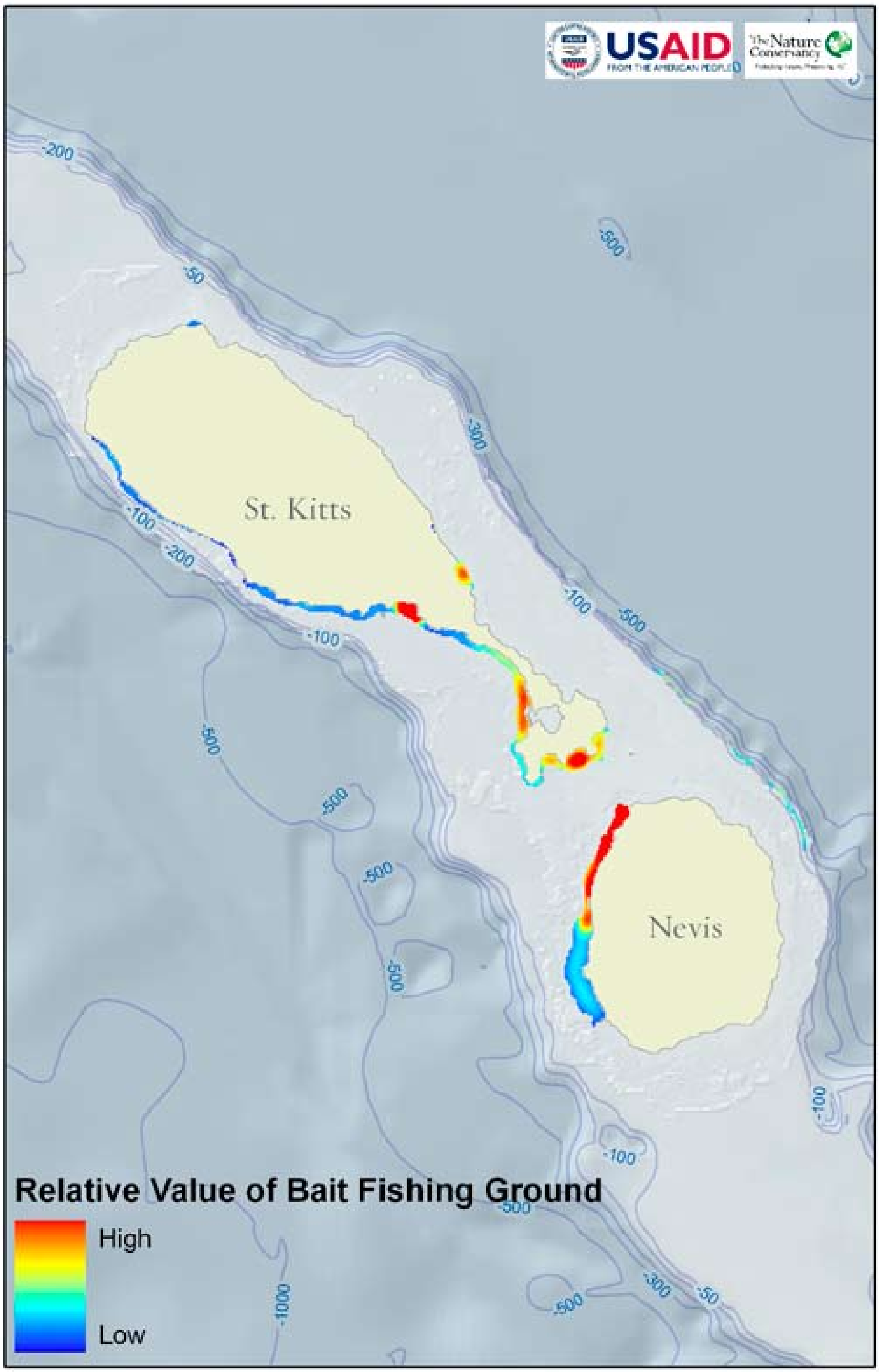
Scenario	# Runs	Goals	Locked	Goals Met?
1. Flat 30 Goal - Lock	100	30% for fishing and conservation objectives	Tourism and Industrial/ Transportation objectives	Yes
2. Flat 60 Goal - No Lock	100	60% for all objectives	No objectives locked	Yes
3. Variable Goals Reduced - Lock	100	Tourism Anchoring 50% Tourism Mooring 60% Tourism Swimming/Snorkeling 80% Tourism Scuba Diving 80% Tourism Jet Ski 80% Tourism Surfing 15% Tourism Kite Boarding 80% Tourism Wind Surfing 15% Tourism Bird Watching 70% Fishing Coastal Pelagics 70% Fishing Coastal Demersals 70% Fishing Demersal Shelf 70% Fishing Lobster 70% Fishing Conch 70% Fishing Bait 70% Conservation Coastal Lagoons 60% Conservation Coral Reef Good 80% Conservation Coral Reef Poor 30% Conservation Mangroves 60% Conservation Sandy Bottom 40% Conservation Seagrass Dense 20% Conservation Seagrass Sparse 20% Conservation Turtle Nesting Sites 70% Conservation Nursery Areas 60% Transportation Cruise Ship Port 20% Industrial Ports 20% Industrial Geothermal Vents 15% Industrial Sand Mining 15%	Tourism and Industrial/ Transportation objectives	Yes

BLM = Boundary Length Modifier, used for specifying the level of compactness of solutions.
# Runs = Number of repeat independent runs in Marxan using identical parameters. In other words, the number of solutions Marxan generates.

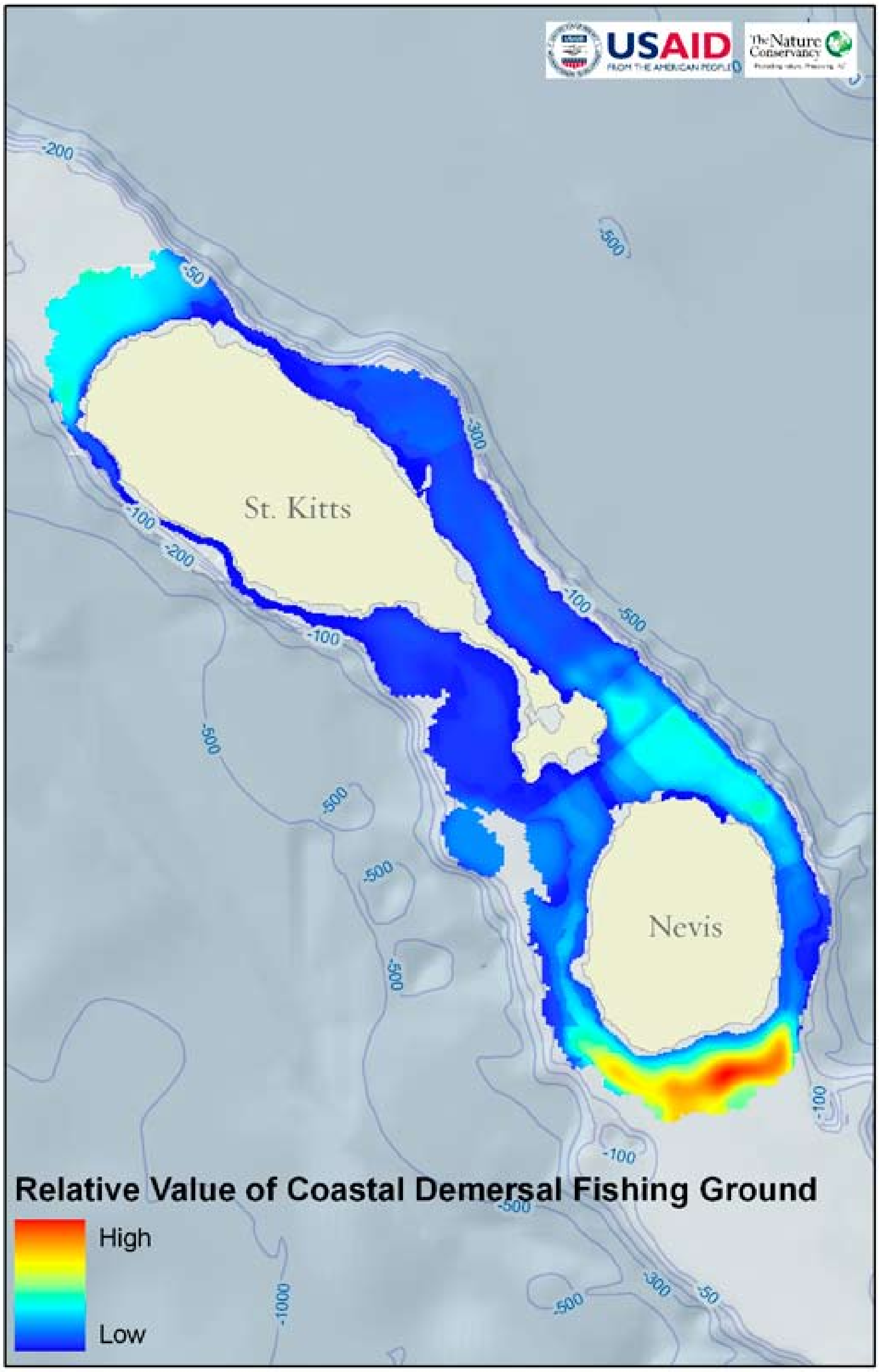
Data Inputs and Outputs

A Marxan with Zones analysis generates a number of mapped products and results, which are useful for understanding the complexity of interactions between uses and to assist the decision-making process. Here we include a series of maps that depict all model inputs and outputs (Figures E3-E7).

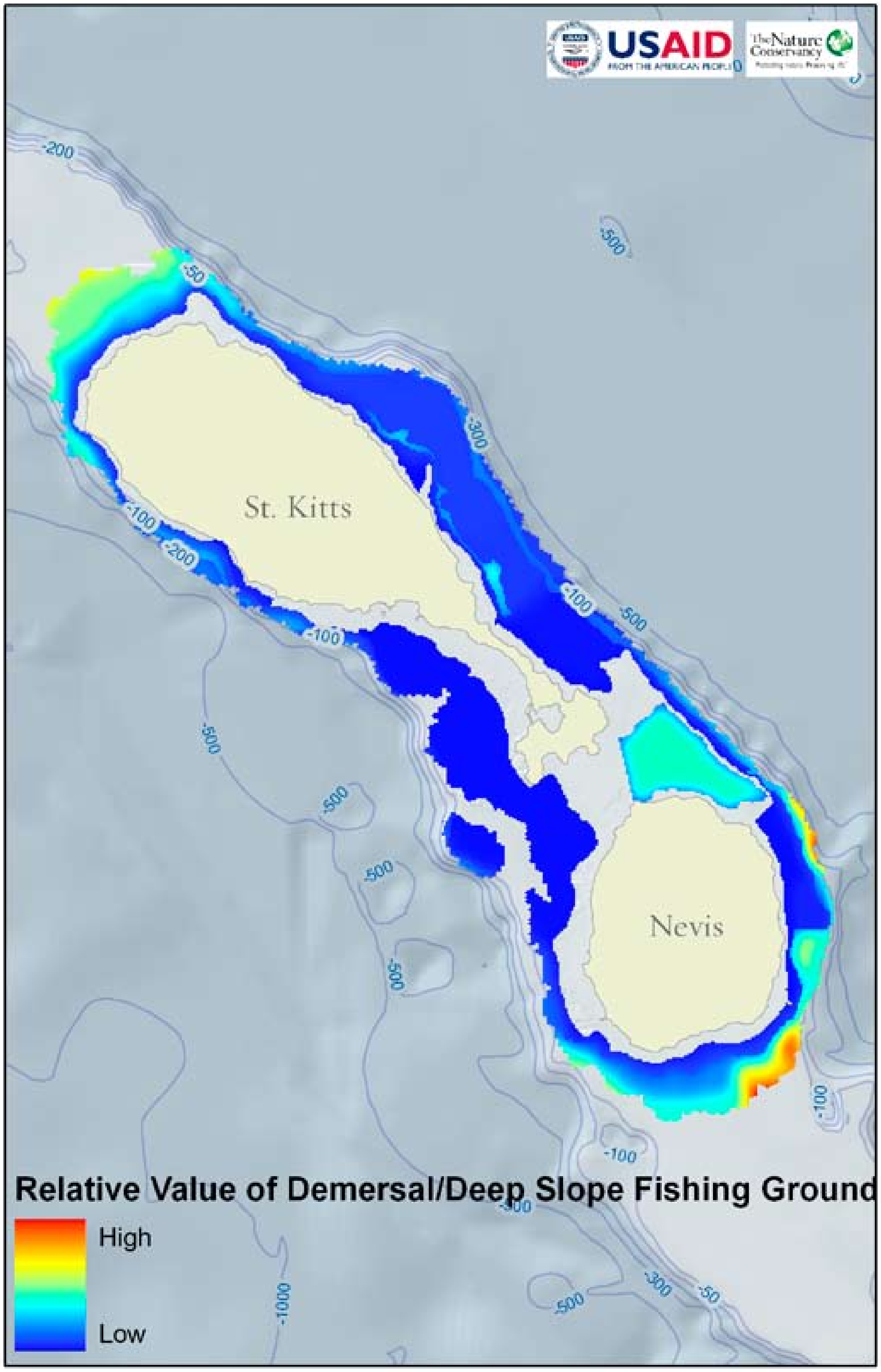
FIGURE E3. **Features and Activities:** These maps show the spatial distribution of all marine-based features and activities that were used in this analysis. These features and activities were summed at the planning-unit level for use in the model.



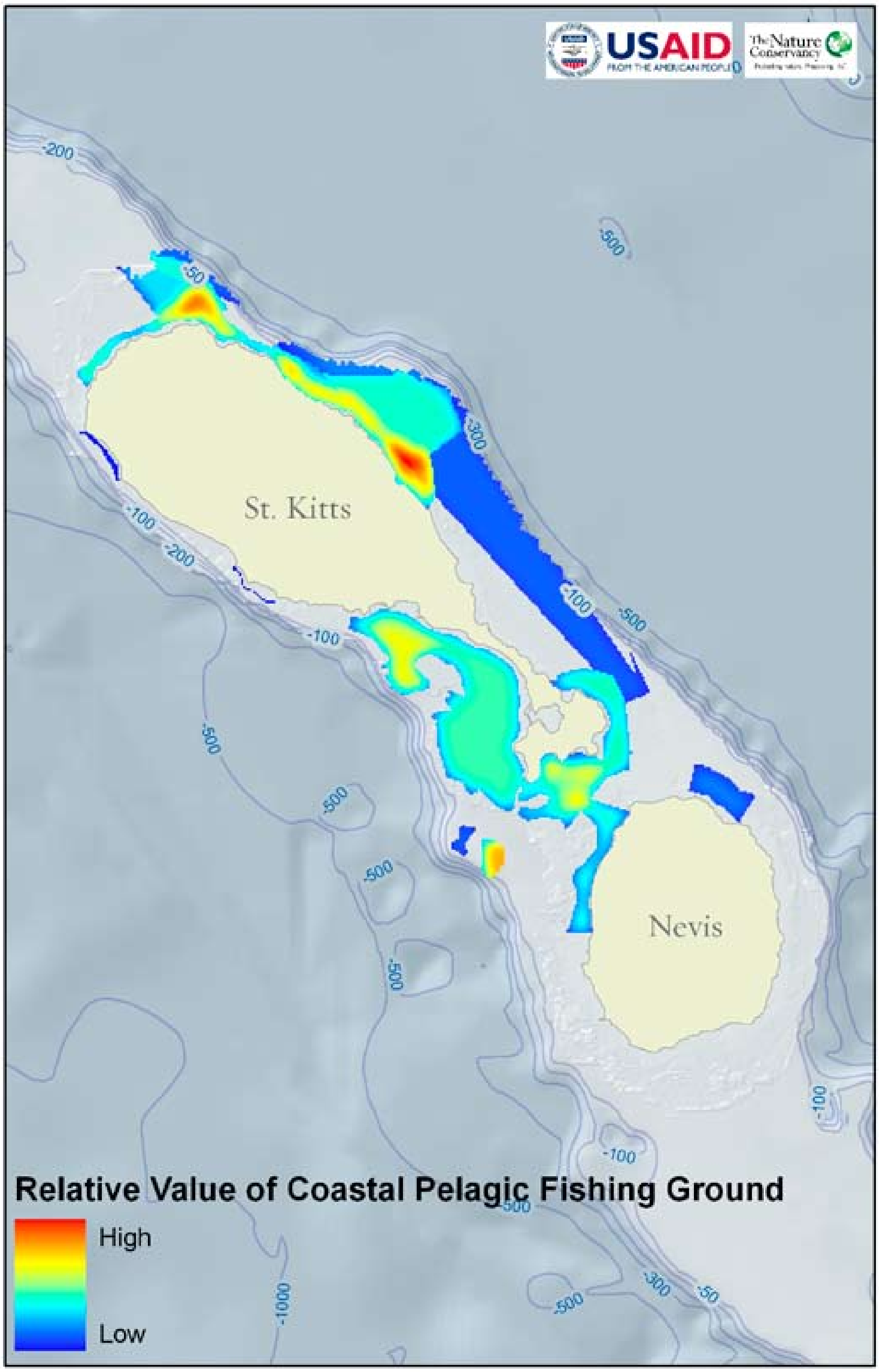
(a) Fishing Activity – Bait Fishing: The relative value of bait fishing grounds (based on fisher surveys) in St. Kitts and Nevis used for modeling fishing-priority zones. Areas in red and yellow indicate areas where bait fishing is most likely to take place.



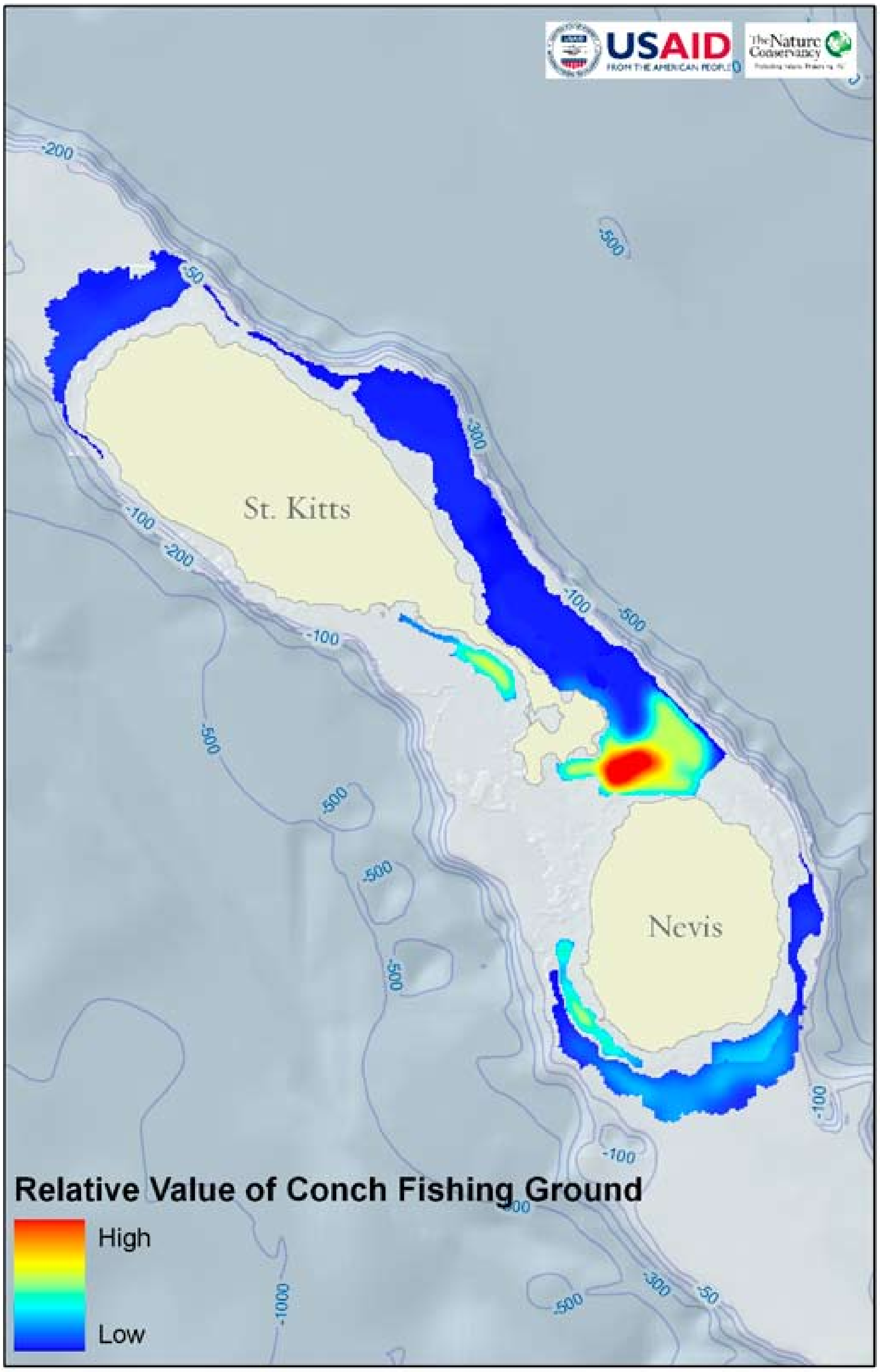
(b) Fishing Activity – Coastal Demersal Fishing: The relative value of coastal demersal fishing grounds (based on fisher surveys) in St. Kitts and Nevis used for modeling fishing-priority zones. Areas in red and yellow indicate areas where coastal demersal fishing is most likely to take place.



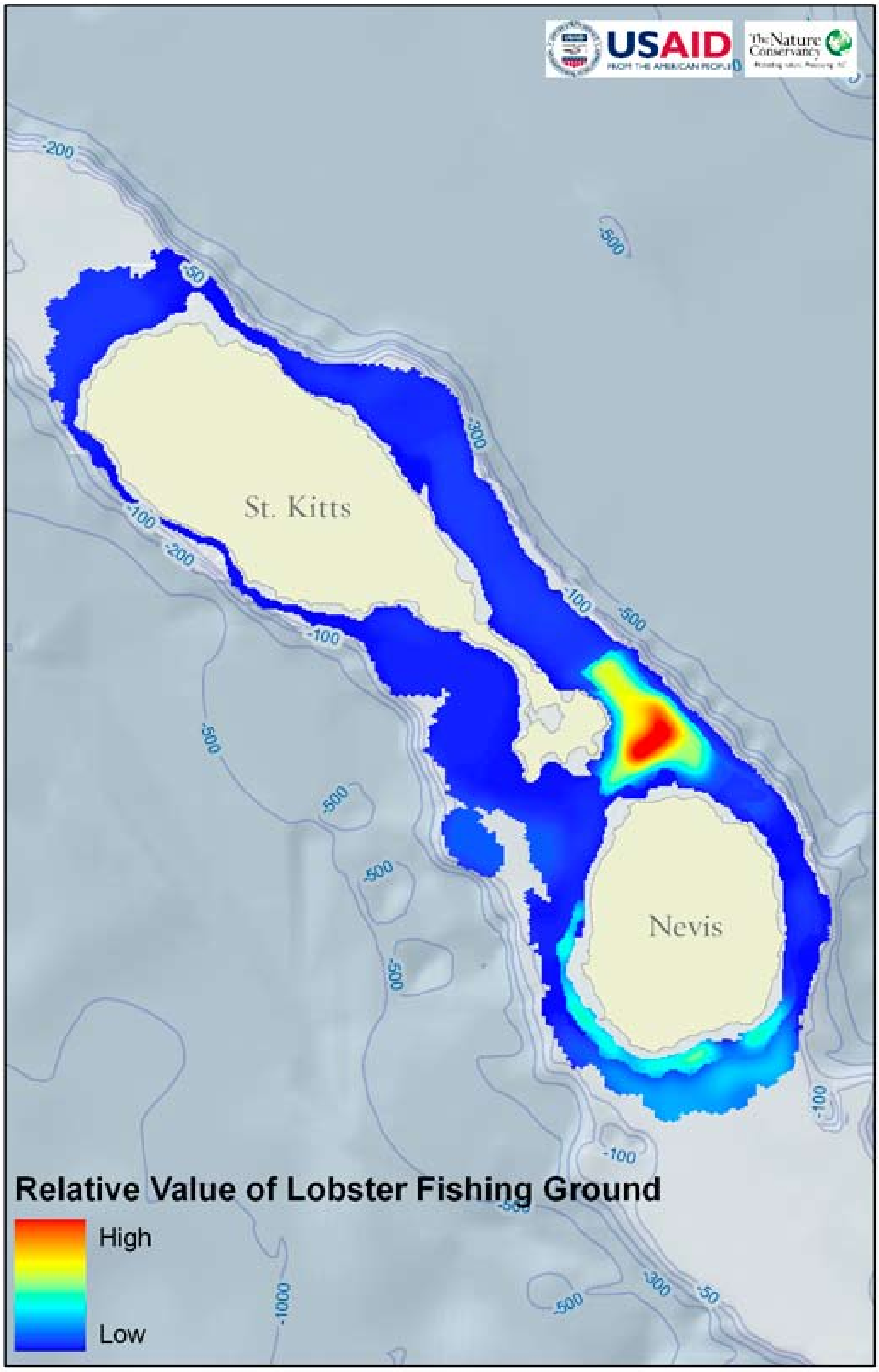
(c) Fishing Activity – Demersal/Deep Slope Fishing: The relative value of demersal/deep-slope fishing grounds (based on fisher surveys) in St. Kitts and Nevis used for modeling fishing-priority zones. Areas in red and yellow indicate areas where demersal/deep-slope fishing is most likely to take place.



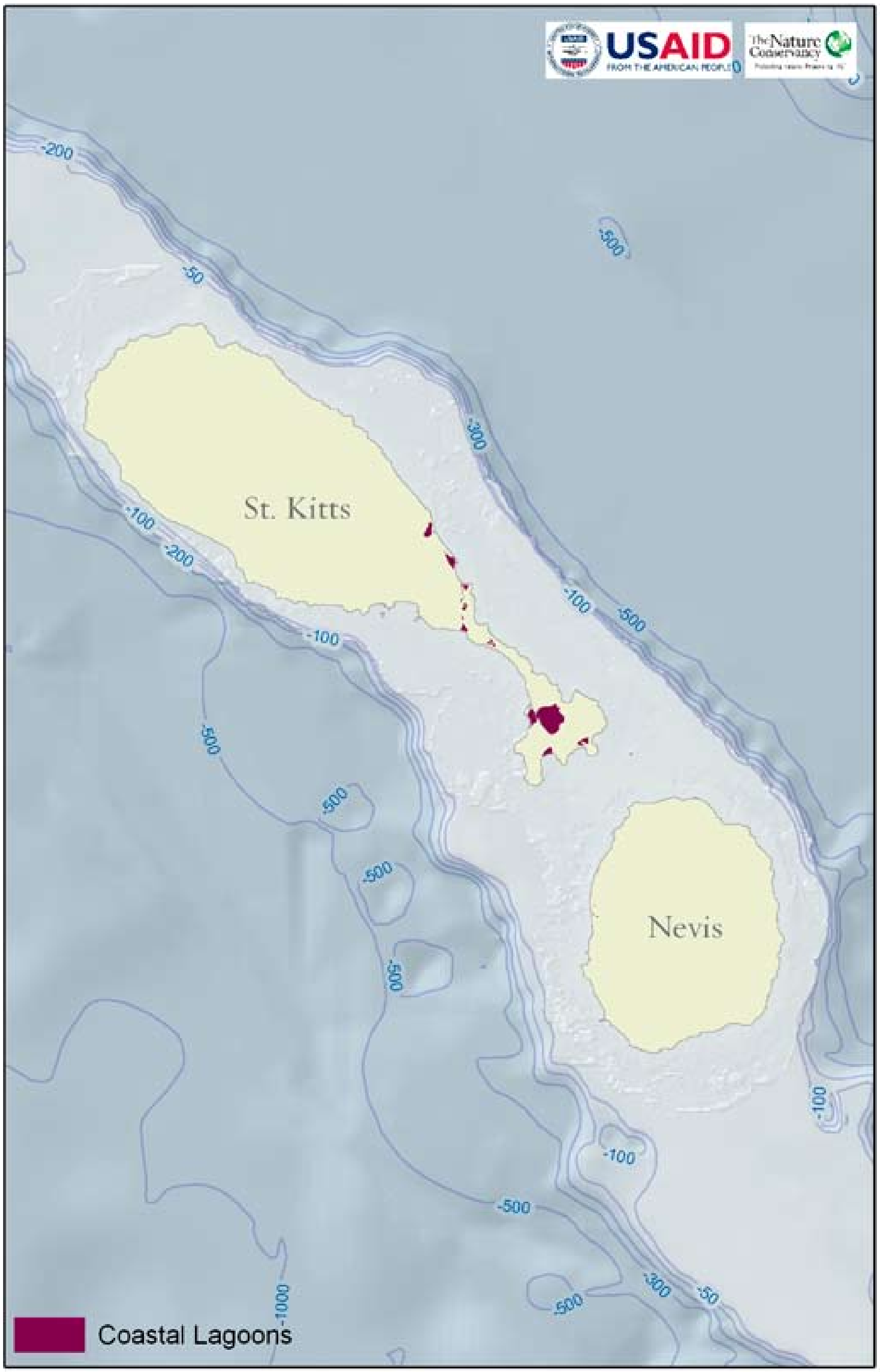
(d) Fishing Activity – Pelagic Fishing: The relative value of pelagic fishing grounds (based on fisher surveys) in St. Kitts and Nevis used for modeling fishing-priority zones. Areas in red and yellow indicate areas where pelagic fishing is most likely to take place.



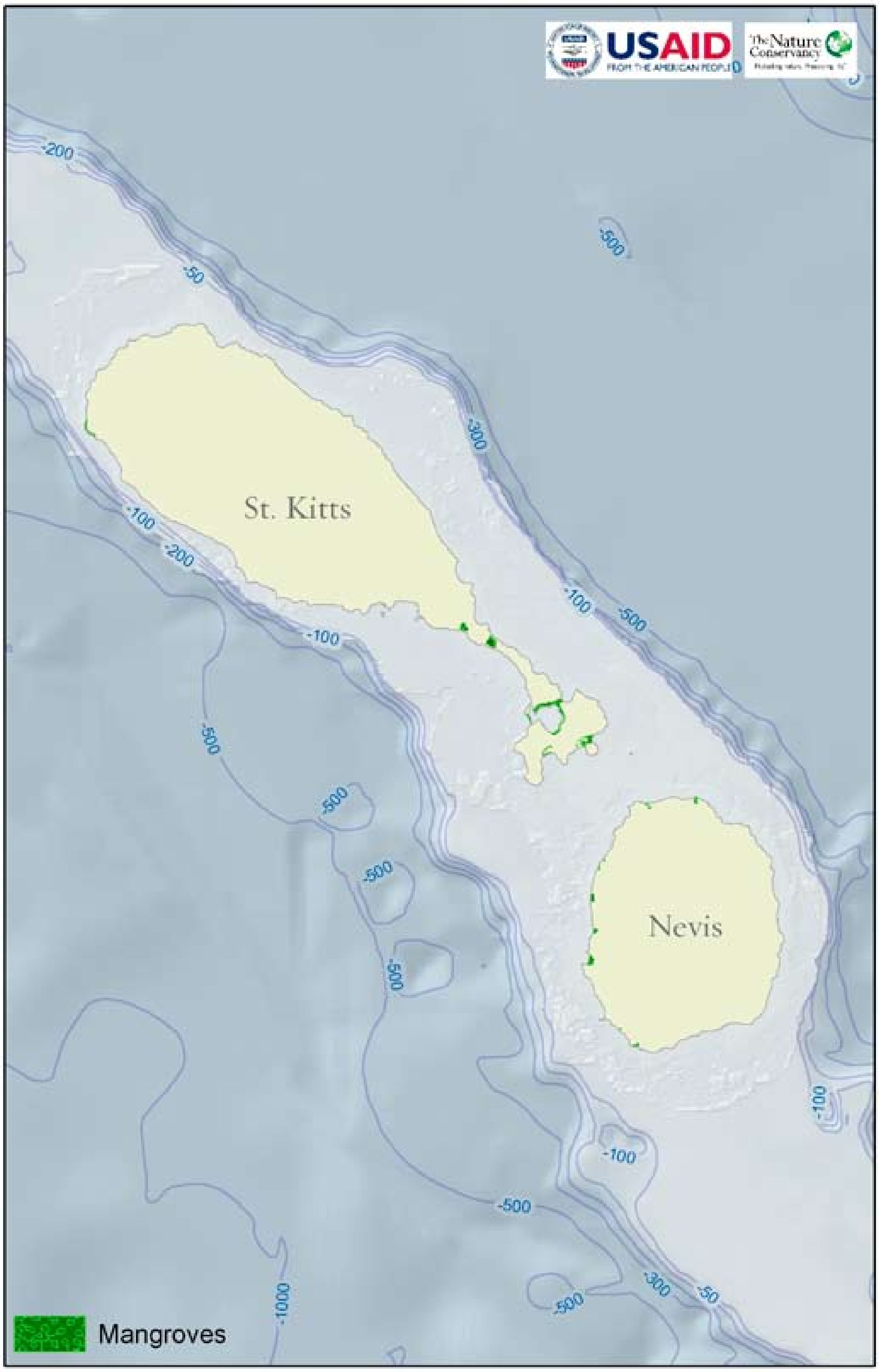
(e) Fishing Activity – Conch Fishing: The relative value of conch fishing grounds (based on fisher surveys) in St. Kitts and Nevis used for modeling fishing-priority zones. Areas in red and yellow indicate areas where conch fishing is most likely to take place.



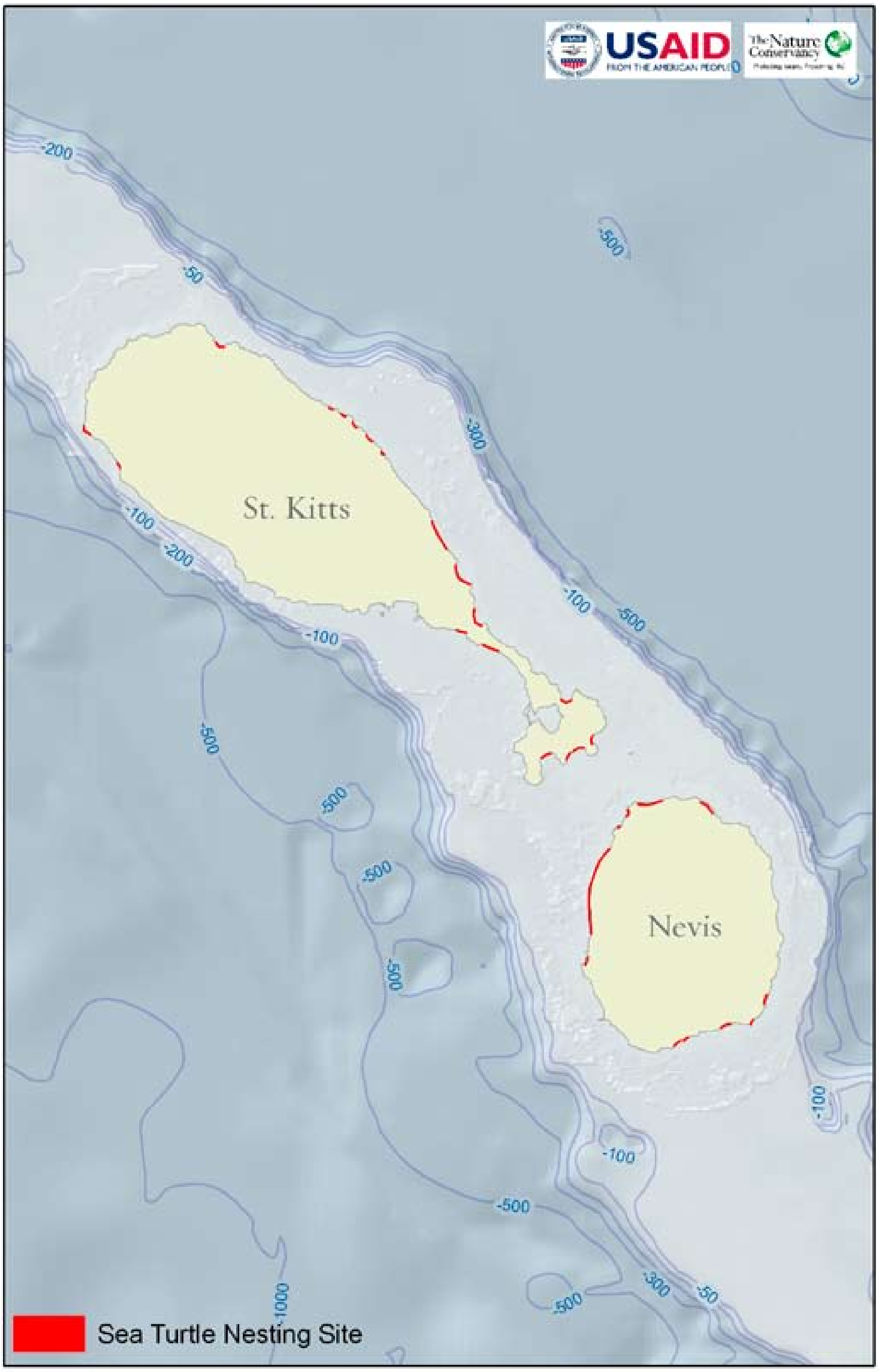
(f) Fishing Activity – Lobster Fishing: The relative value of lobster fishing grounds (based on fisher surveys) in St. Kitts and Nevis used for modeling fishing-priority zones. Areas in red and yellow indicate areas where lobster fishing is most likely to take place.



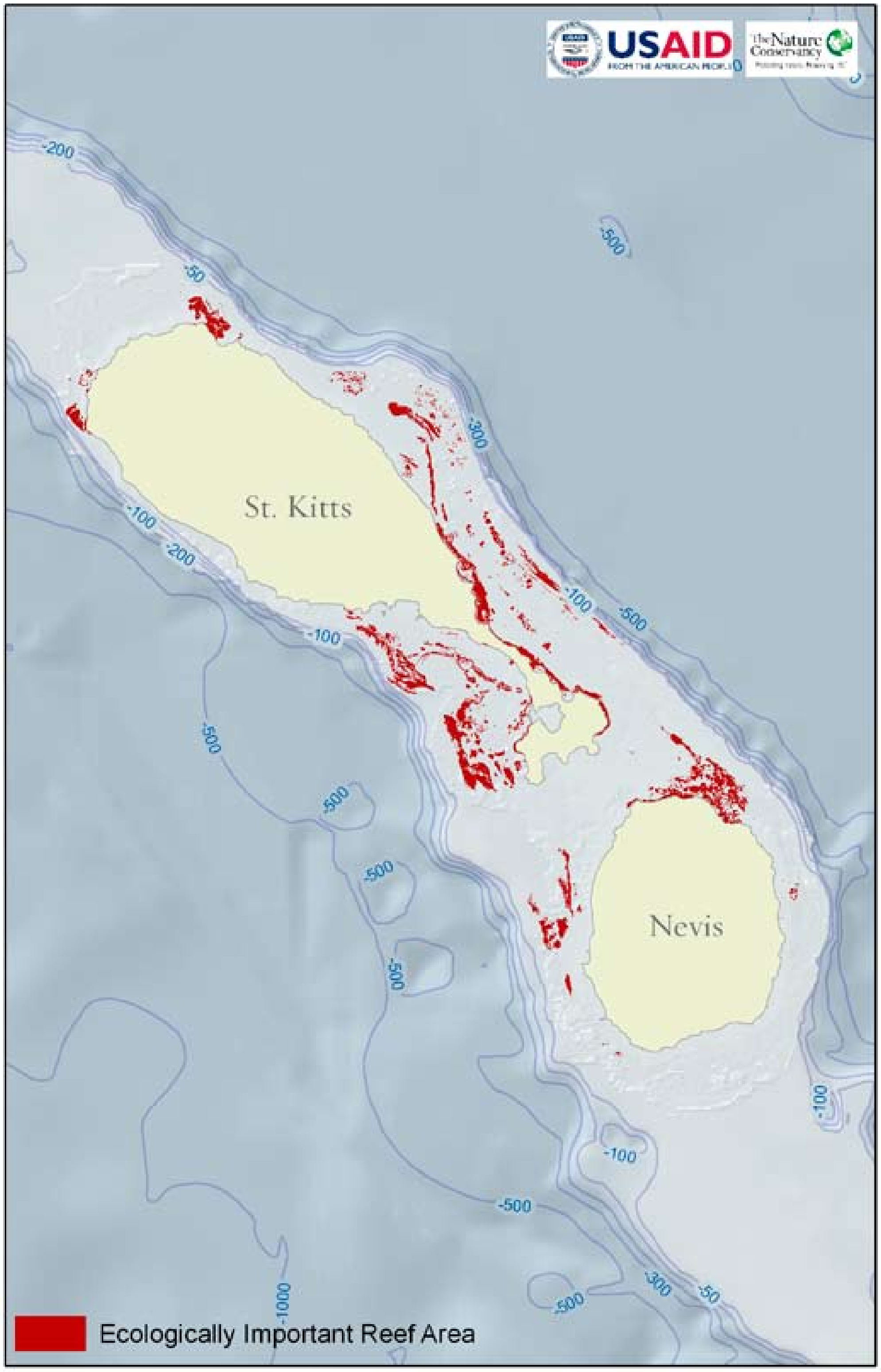
(g) Conservation Feature – Coastal Lagoons: Location of coastal lagoons in St. Kitts and Nevis.



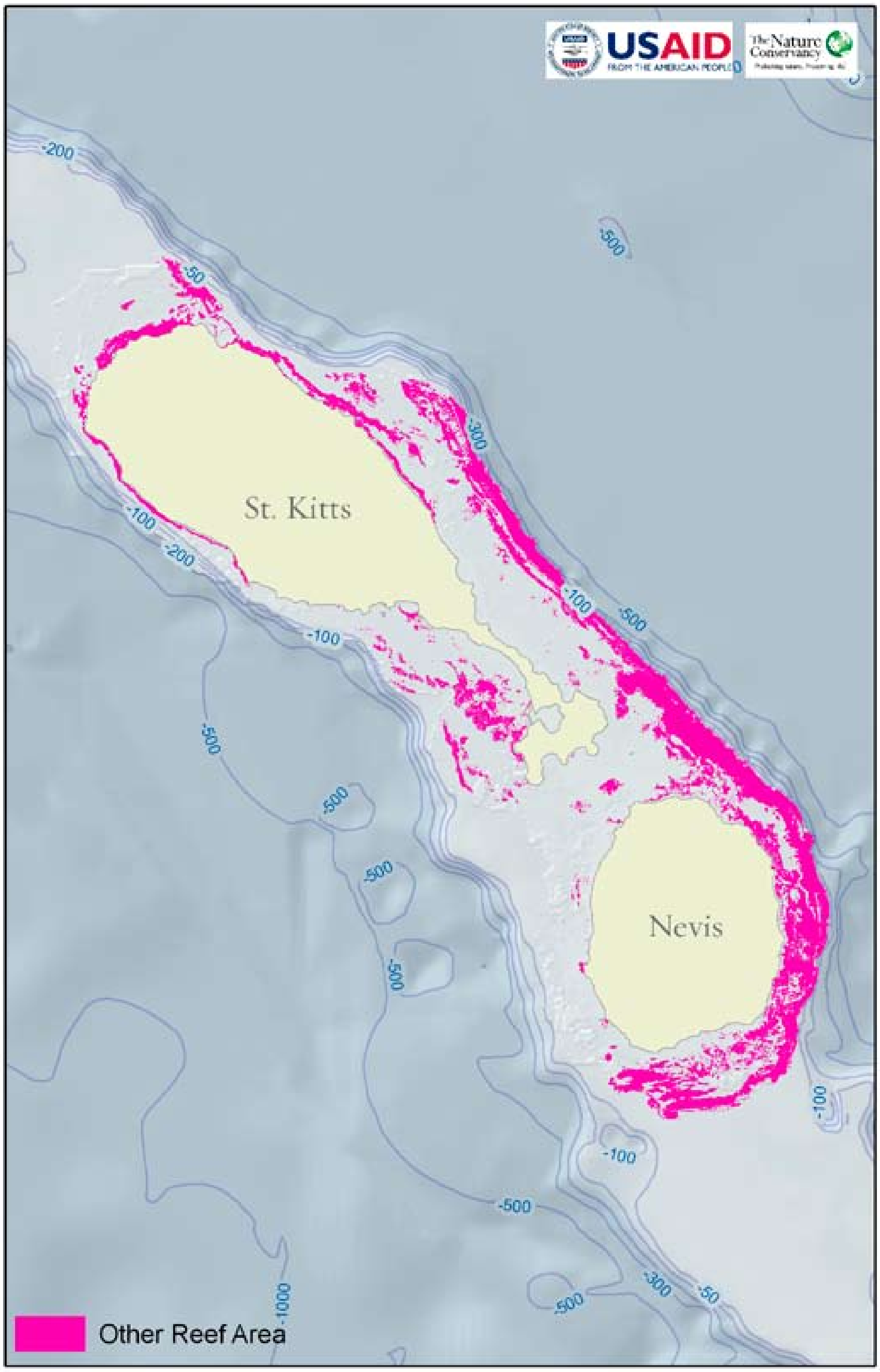
(h) Conservation Feature – Mangroves: Location of mangroves in St. Kitts and Nevis.



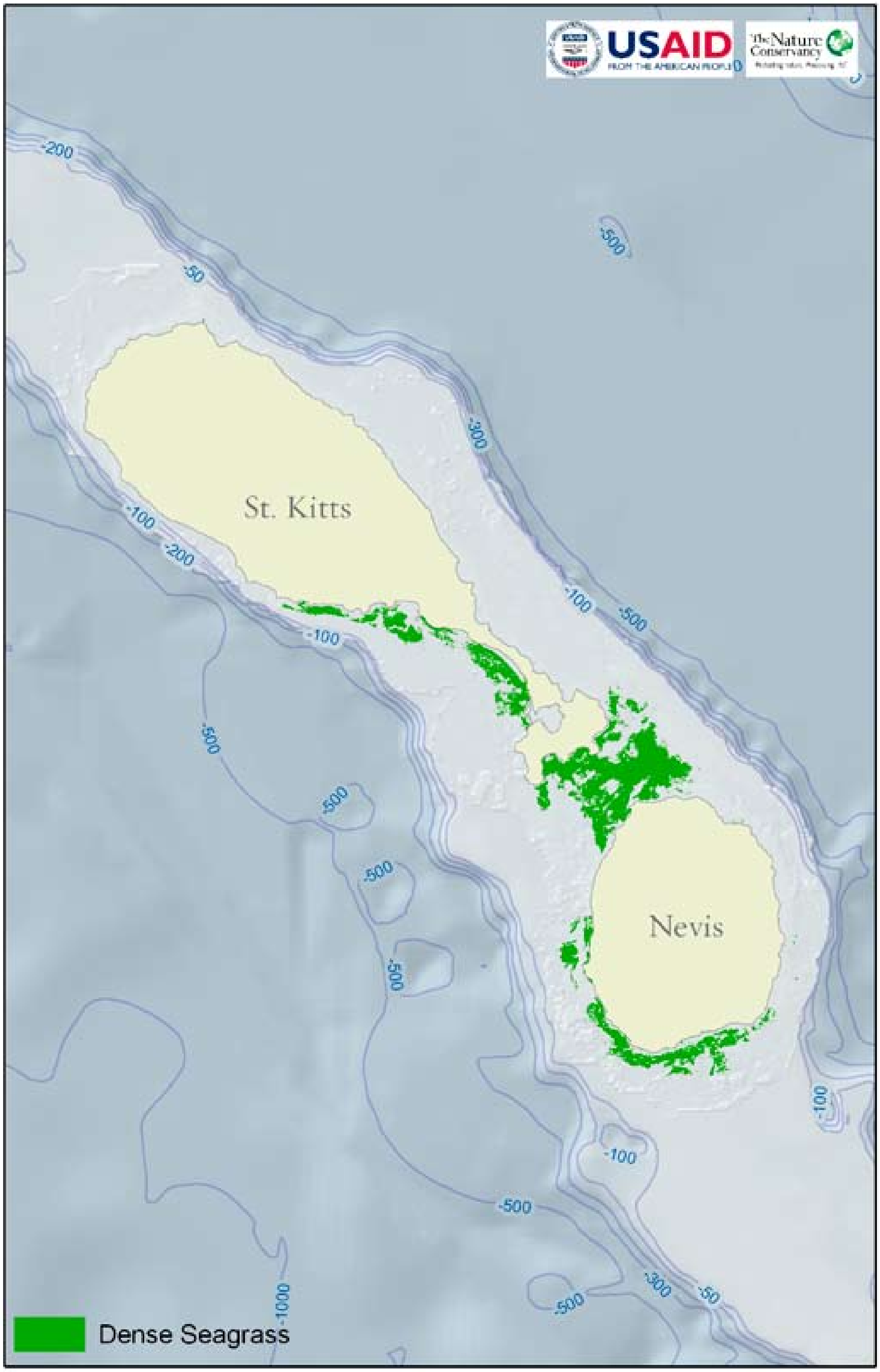
(i) Conservation Feature – Sea Turtle Nesting Sites: Location of important sea turtle nesting sites in St. Kitts and Nevis.



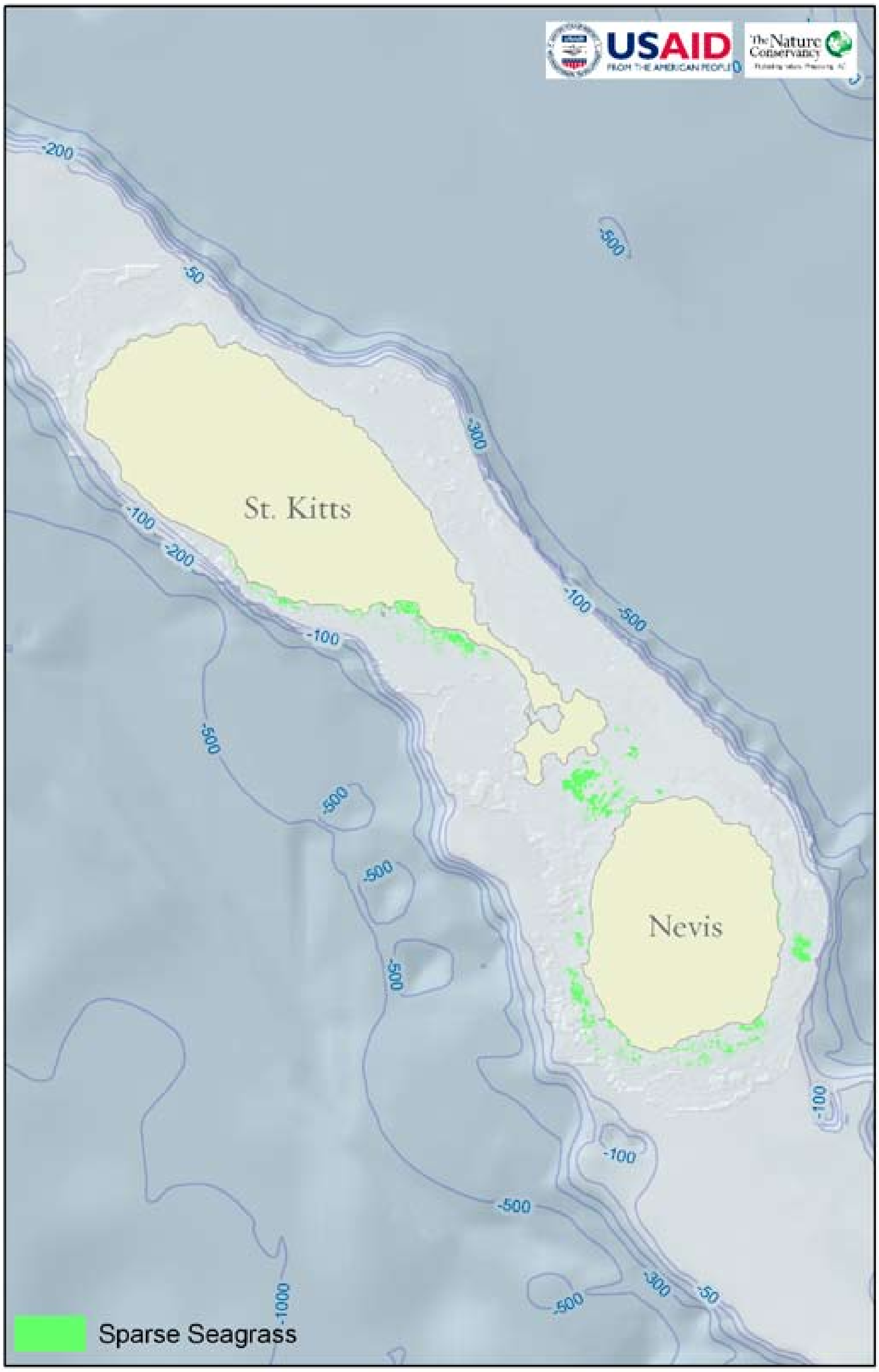
(j) Conservation Feature – Ecologically Important Reefs: Location of ecologically important reefs in St. Kitts and Nevis.



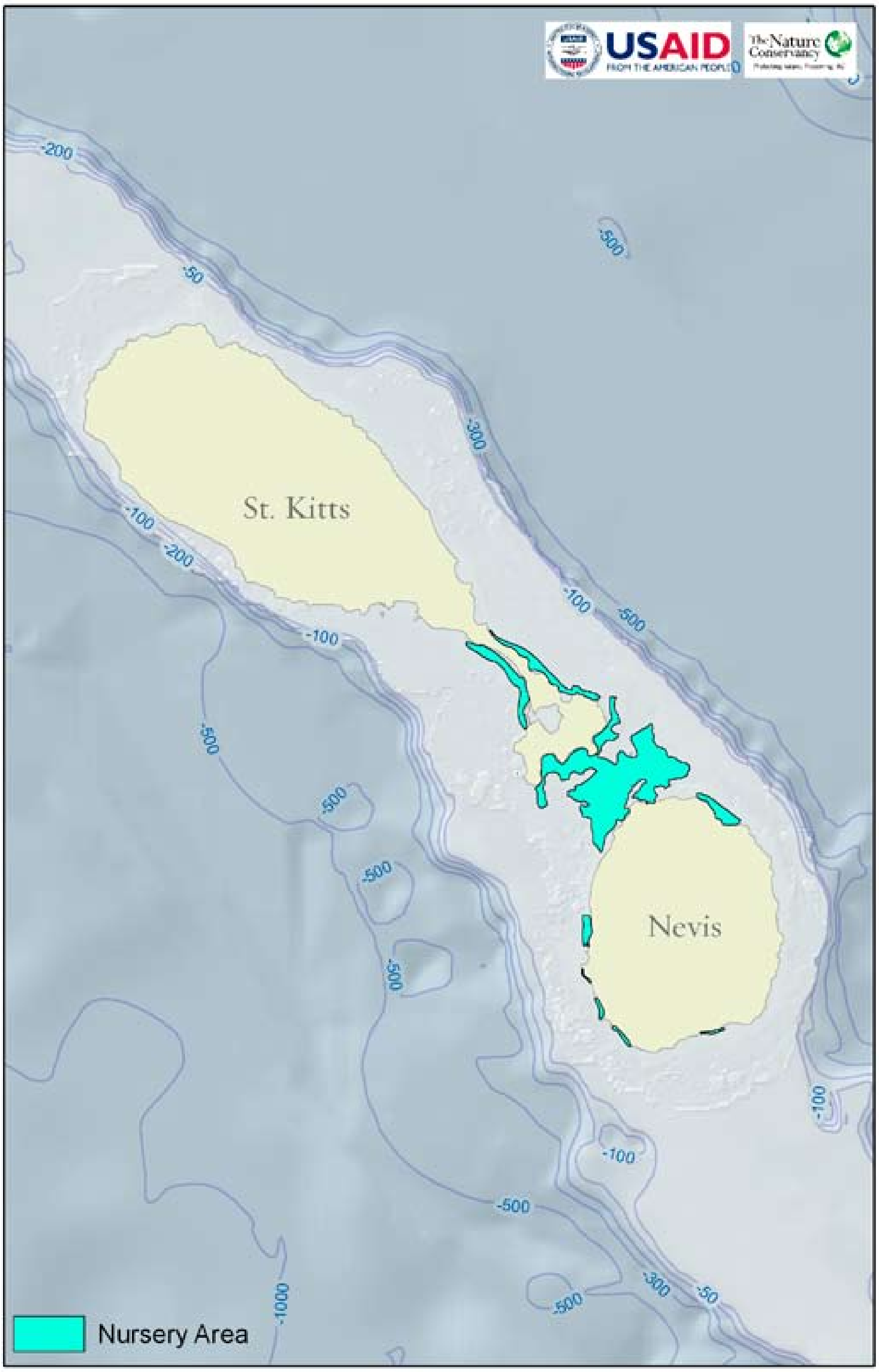
(k) Conservation Feature – Other Reefs: Location of other reef areas in St. Kitts and Nevis.



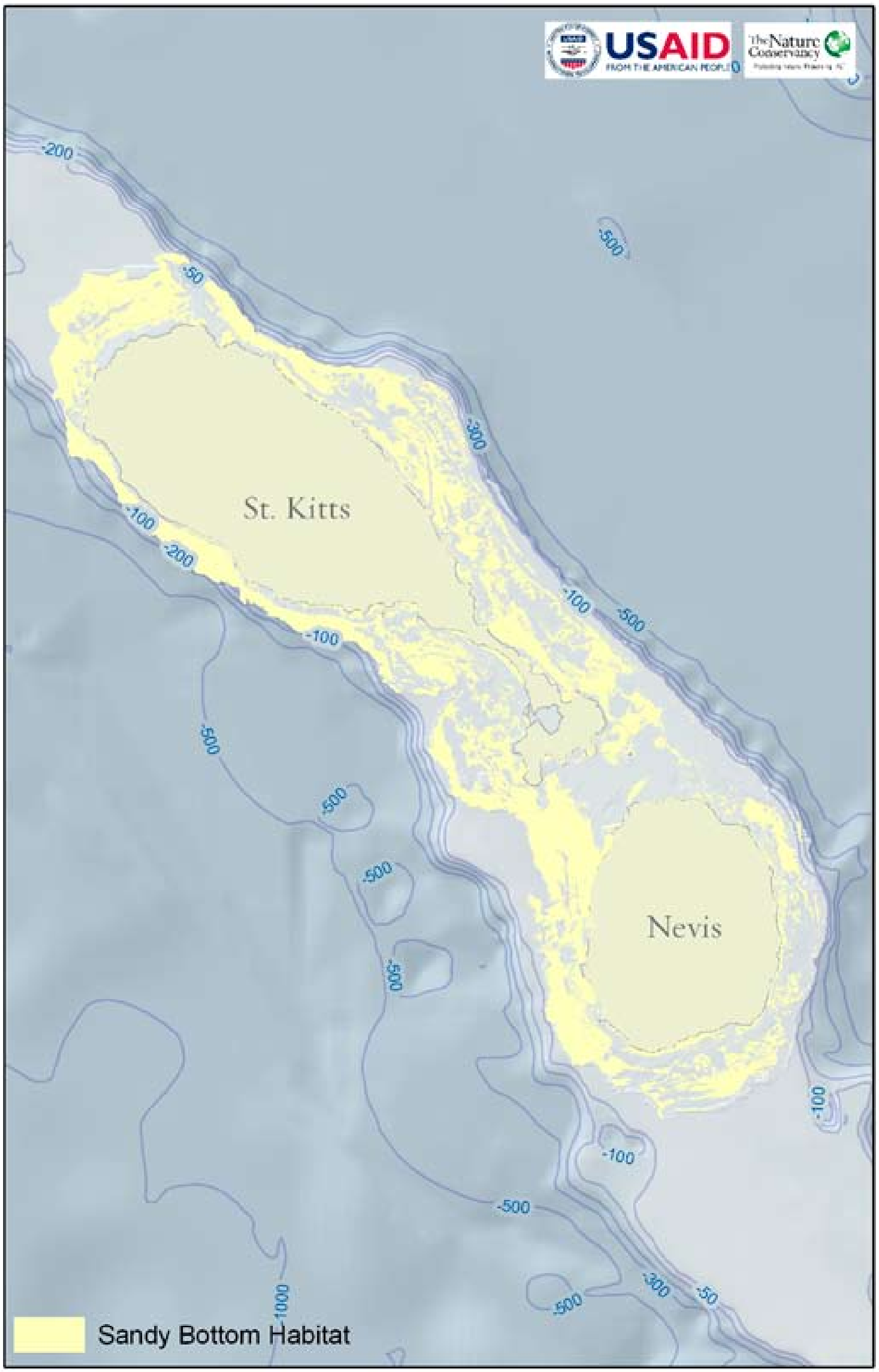
(l) Conservation Feature – Dense Seagrass: Location of dense seagrass in St. Kitts and Nevis.



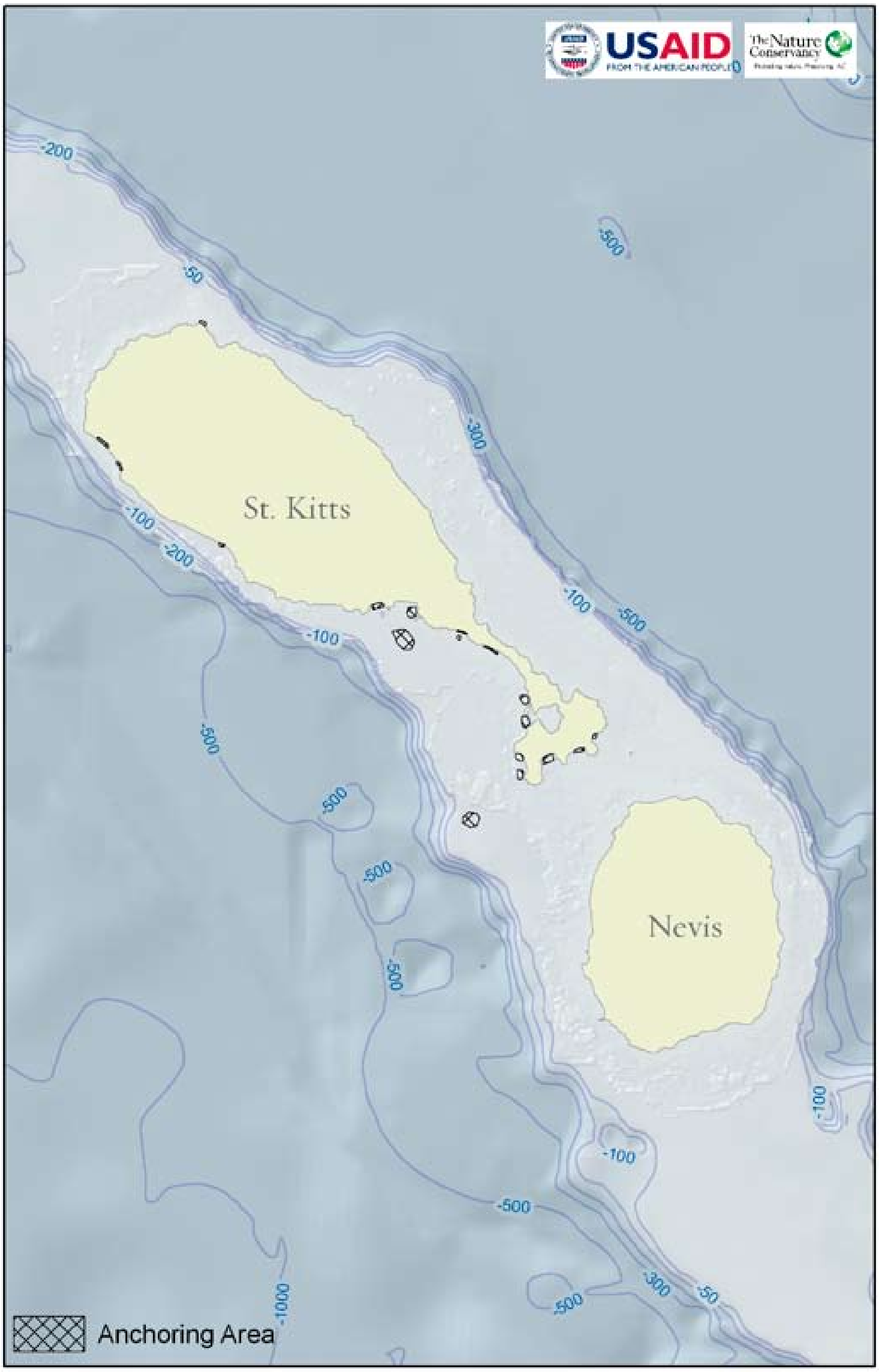
(m) Conservation Feature – Sparse Seagrass: Location of sparse seagrass areas in St. Kitts and Nevis.



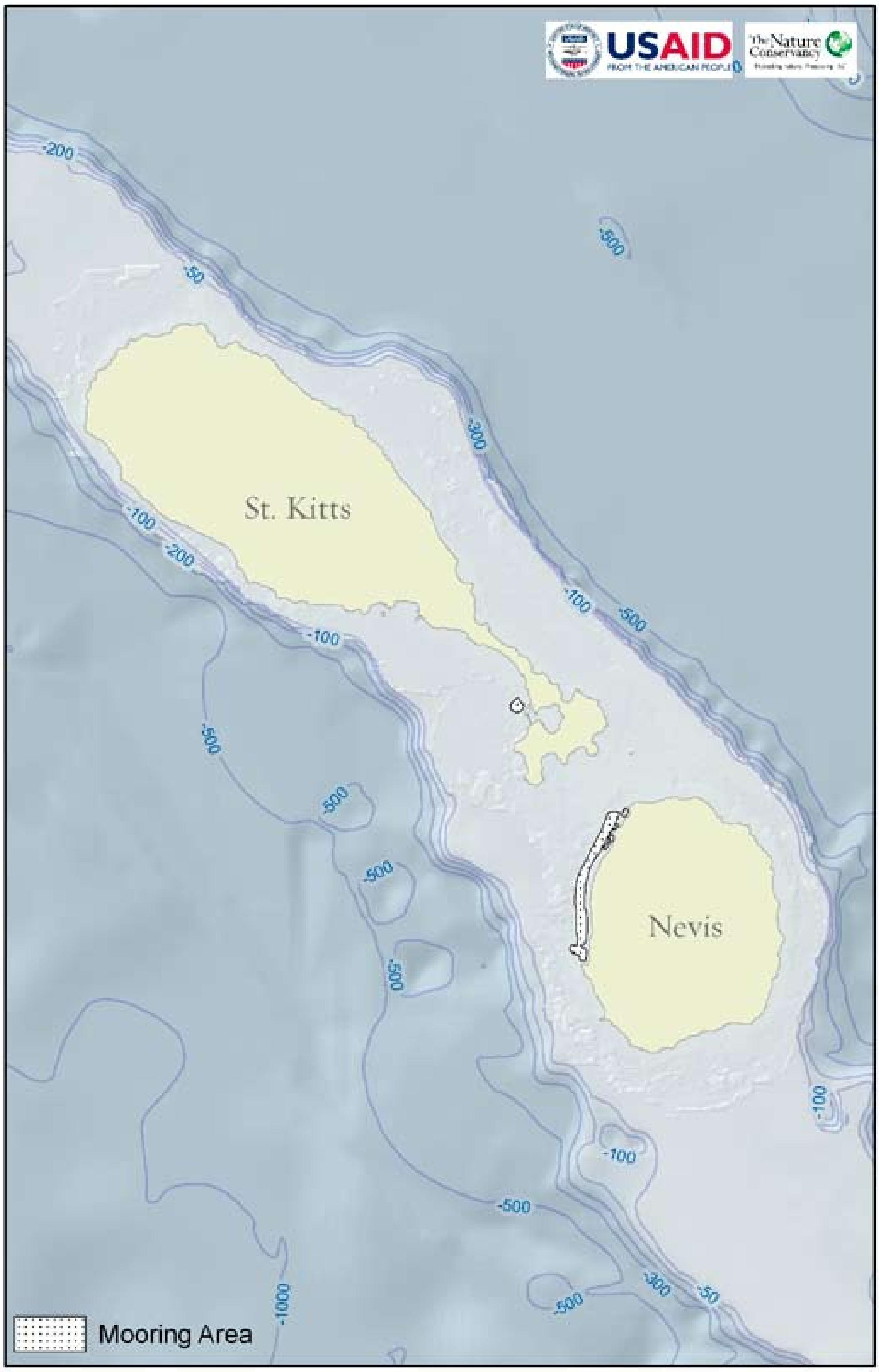
(n) Conservation Feature – Nursery Areas: Location of important fishery nursery areas in St. Kitts and Nevis.



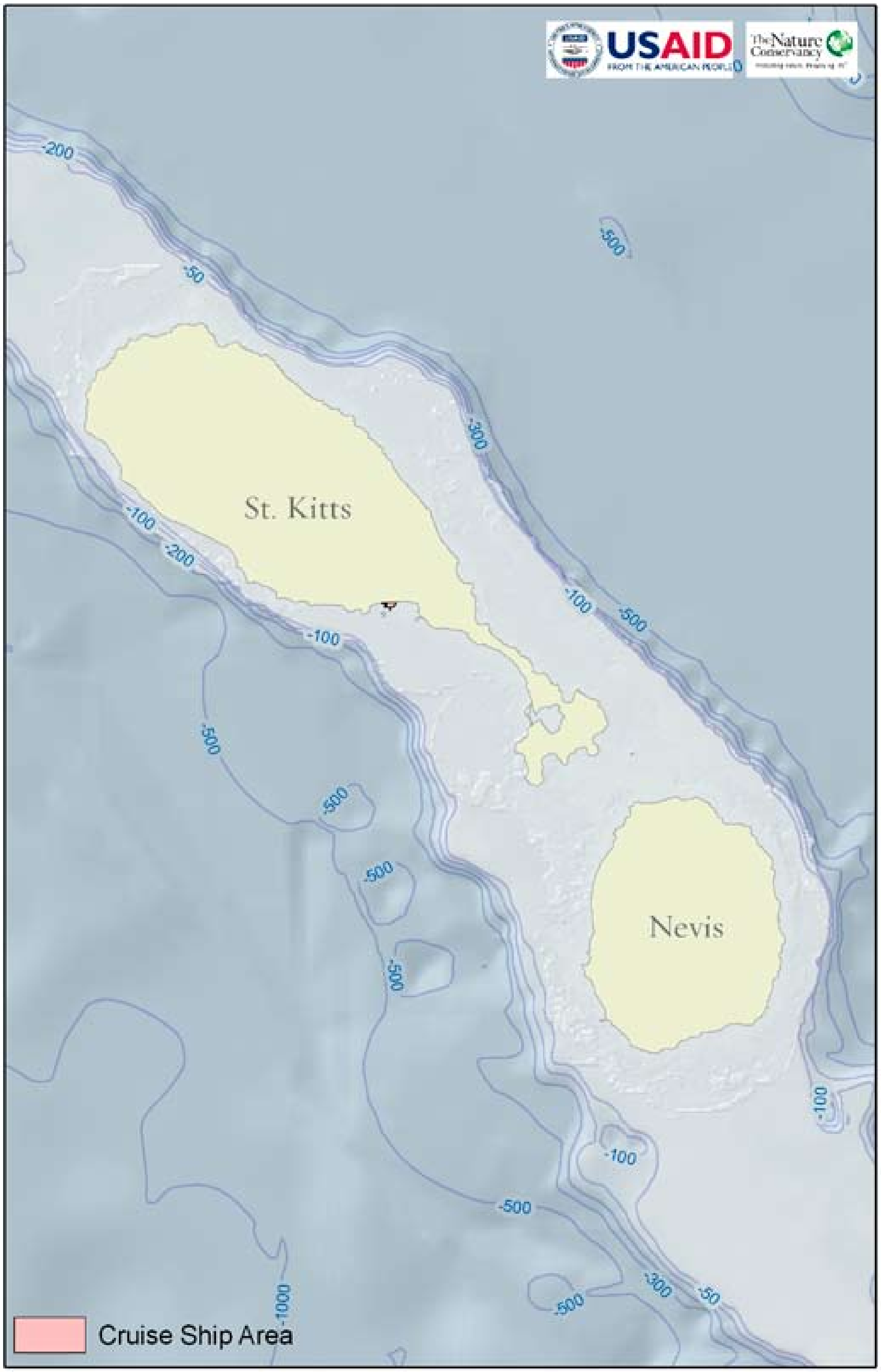
(o) Conservation Feature – Sandy Bottom: Location of sandy bottom areas in St. Kitts and Nevis.



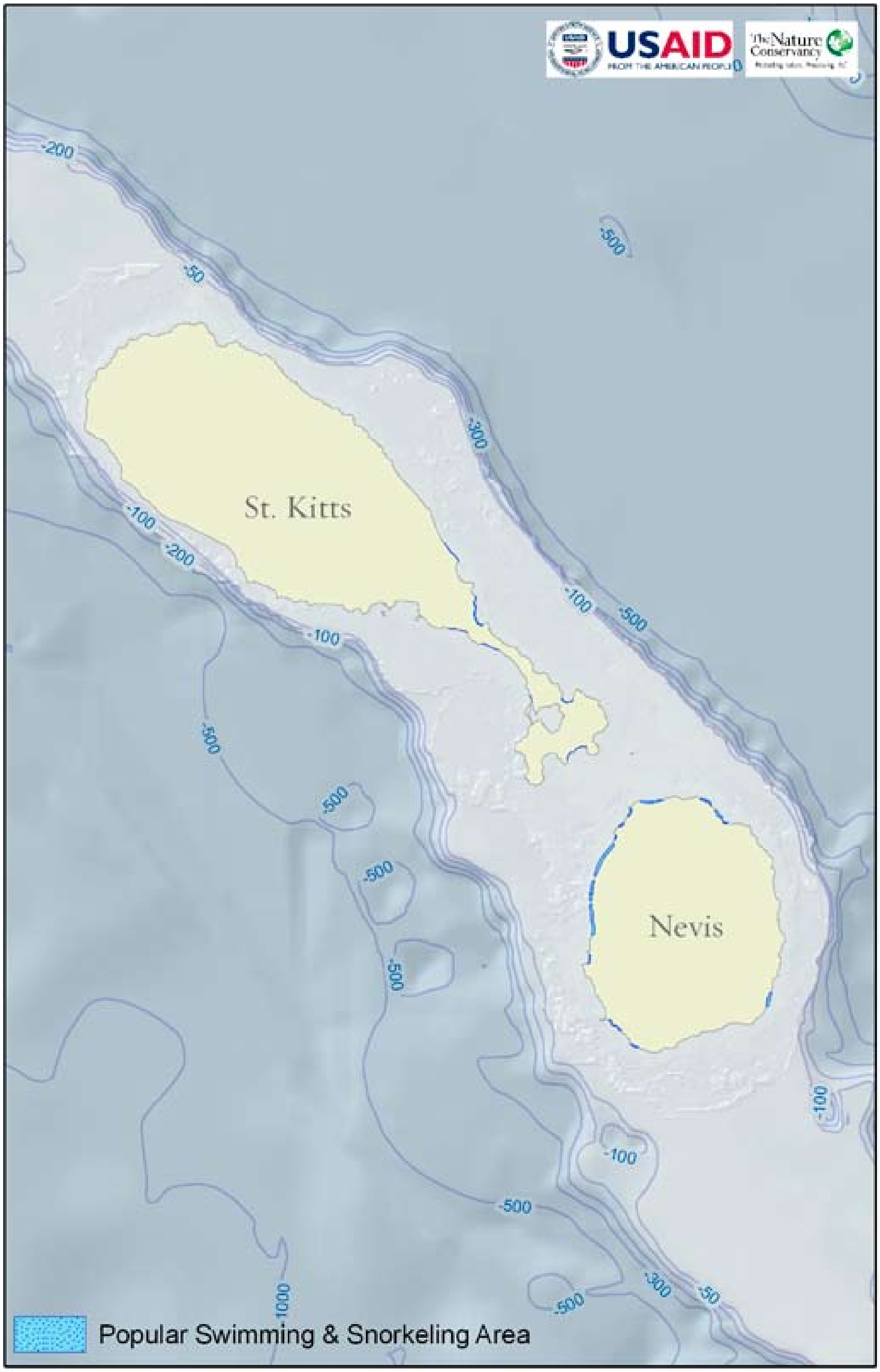
(p) Tourism Activity – Anchoring Areas: Location of popular anchoring areas in St. Kitts and Nevis.



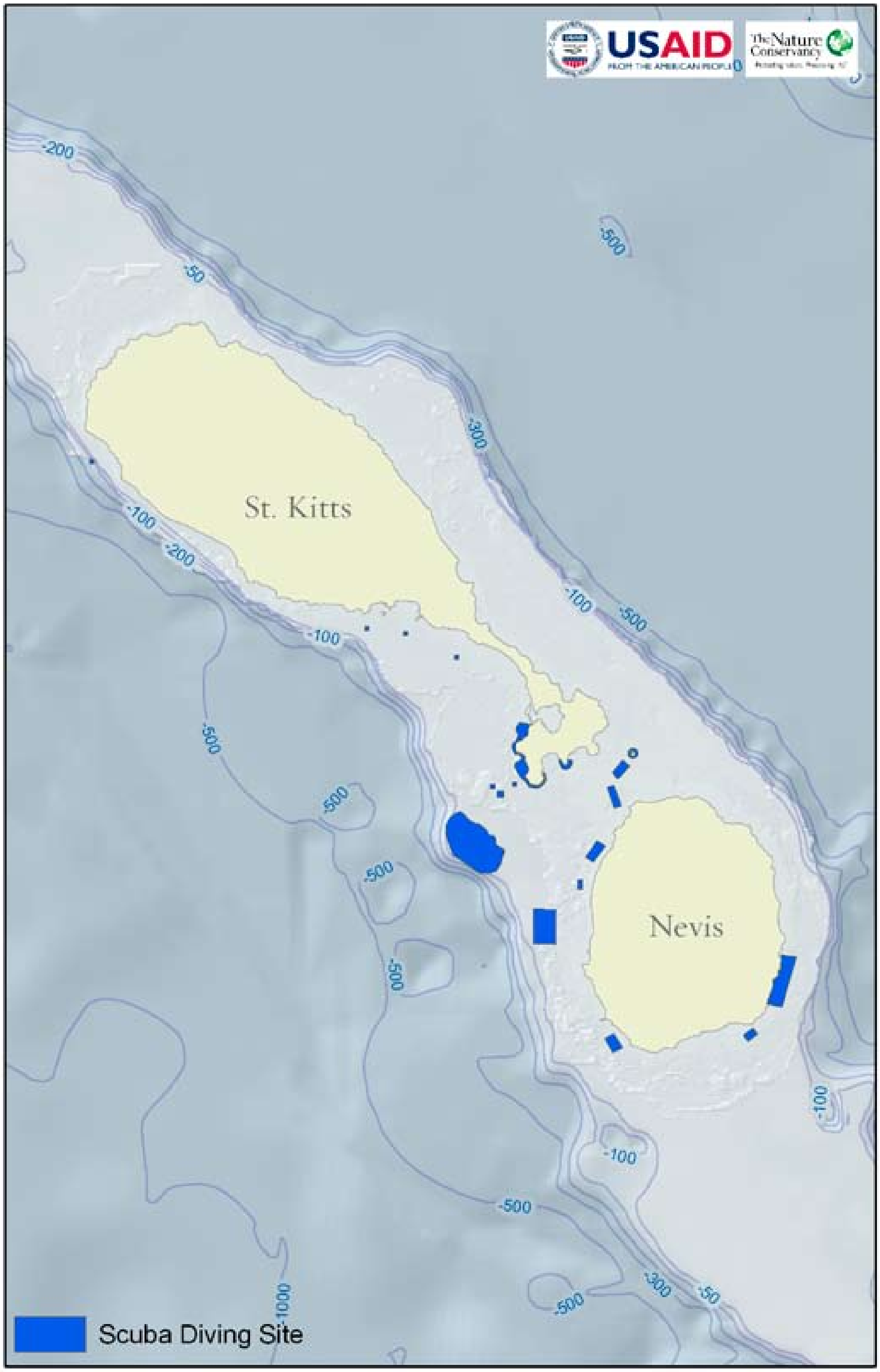
(q) Tourism Activity – Mooring Areas: Location of important mooring areas in St. Kitts and Nevis.



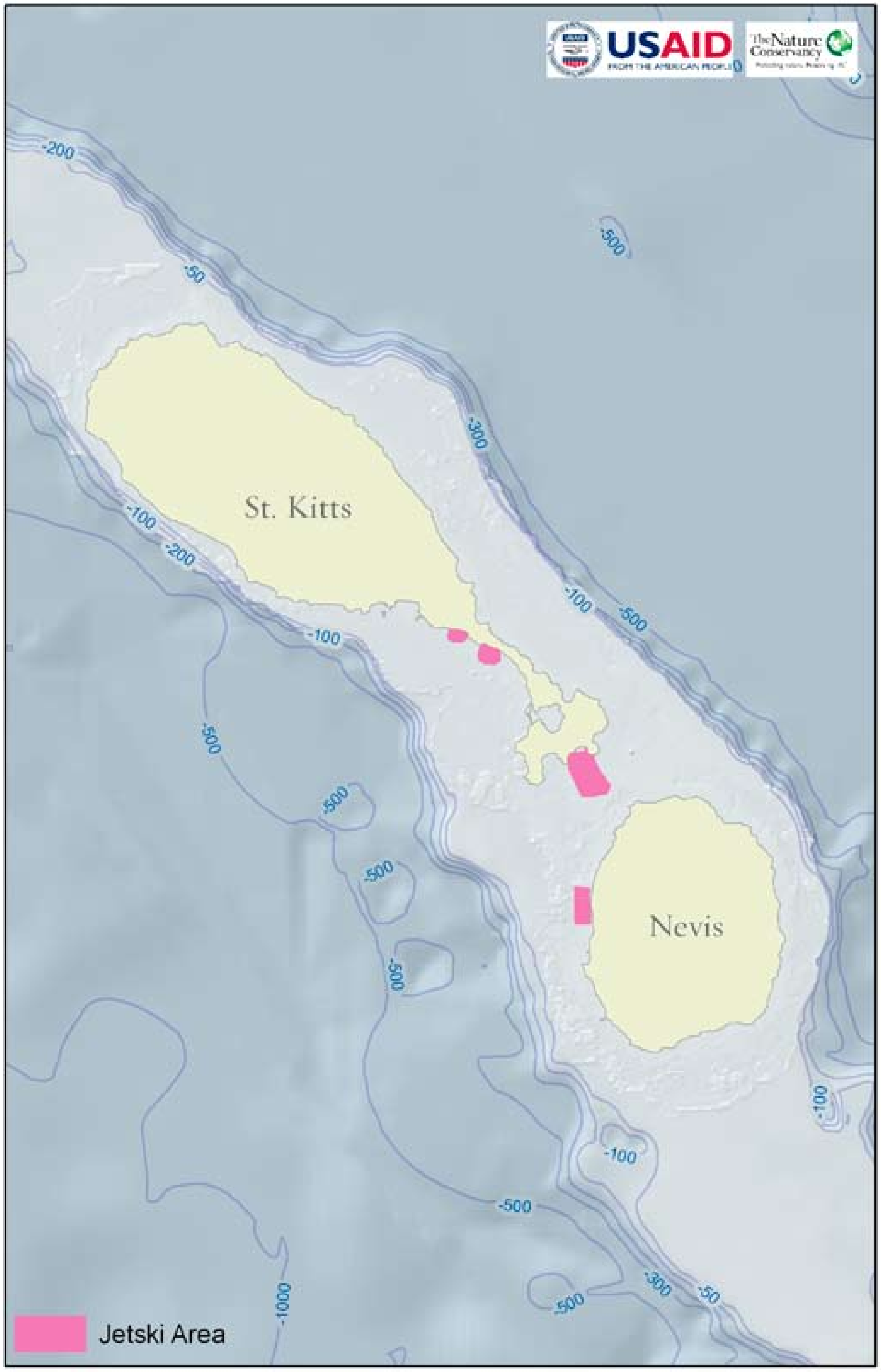
(r) Tourism Activity – Cruise Ship Areas: Location of important cruise ship areas in St. Kitts and Nevis.



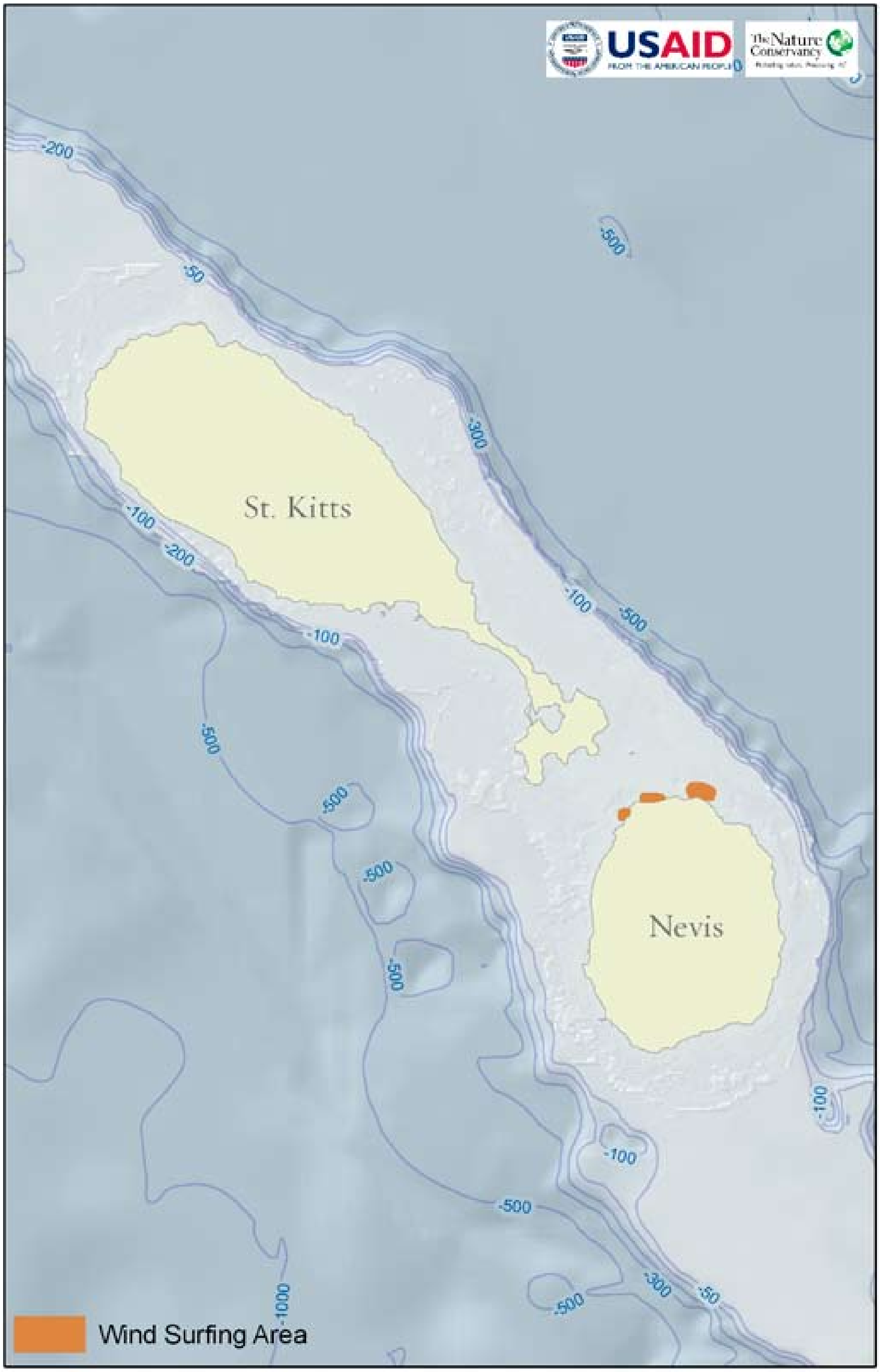
(s) Tourism Activity – Swimming & Snorkeling: Location of popular swimming and snorkeling areas in St. Kitts and Nevis.



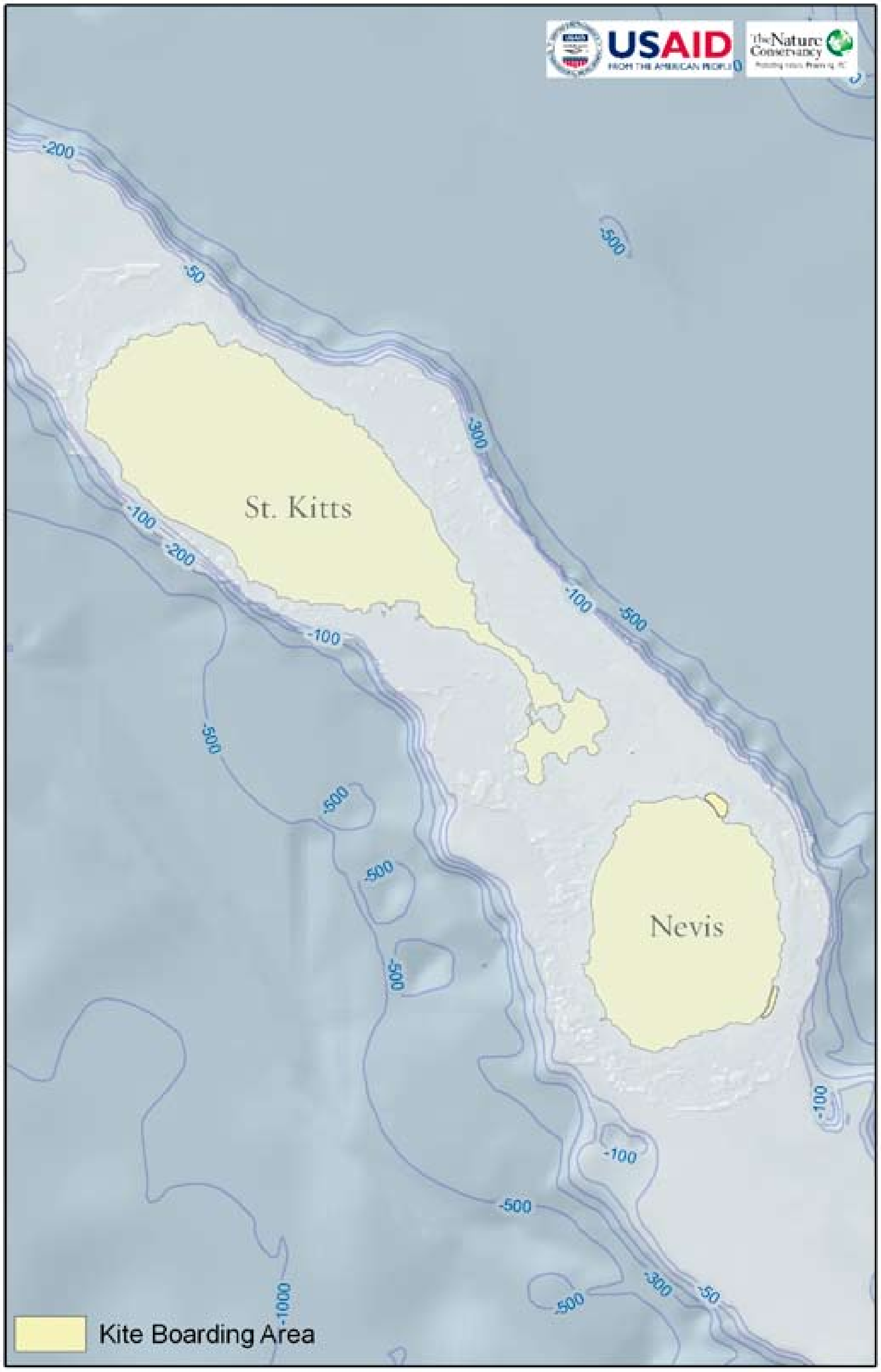
(t) Tourism Activity – Scuba Diving Sites: Location of popular scuba diving sites in St. Kitts and Nevis.



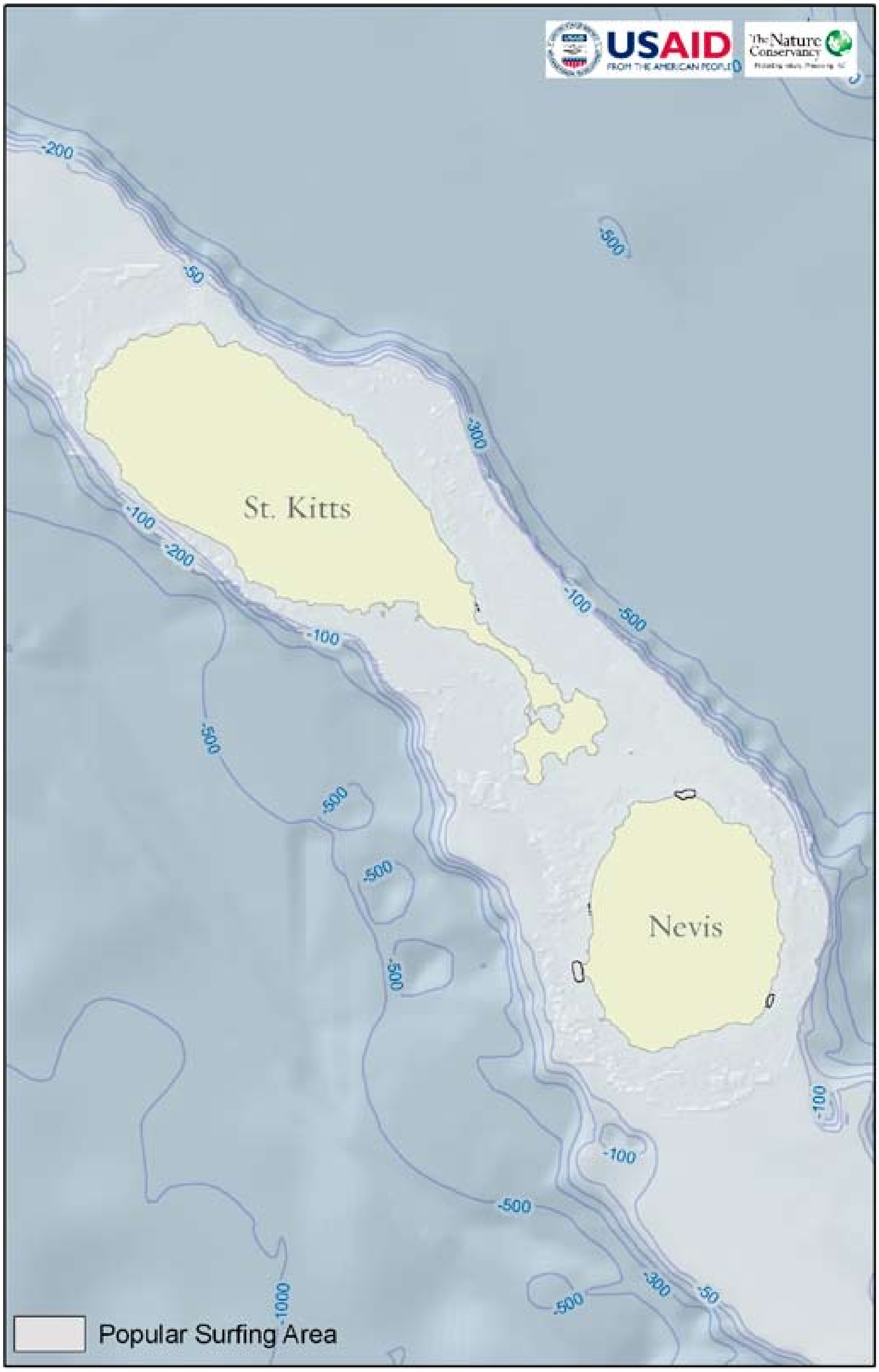
(u) Tourism Activity – Jet Ski Areas: Location of popular jet skiing areas in St. Kitts and Nevis.



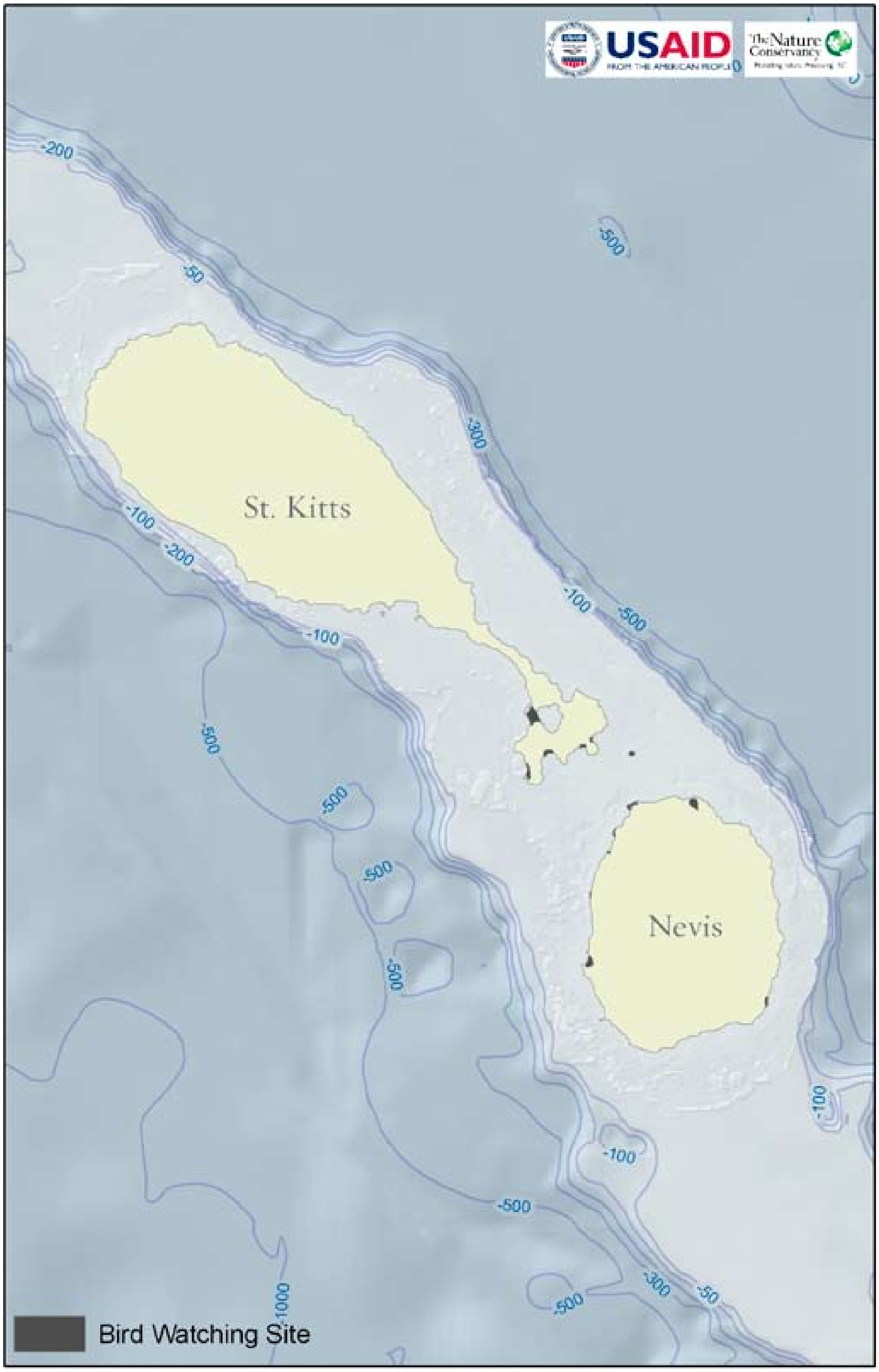
(v) Tourism Activity – Wind Surfing: Location of popular wind surfing areas in St. Kitts and Nevis.



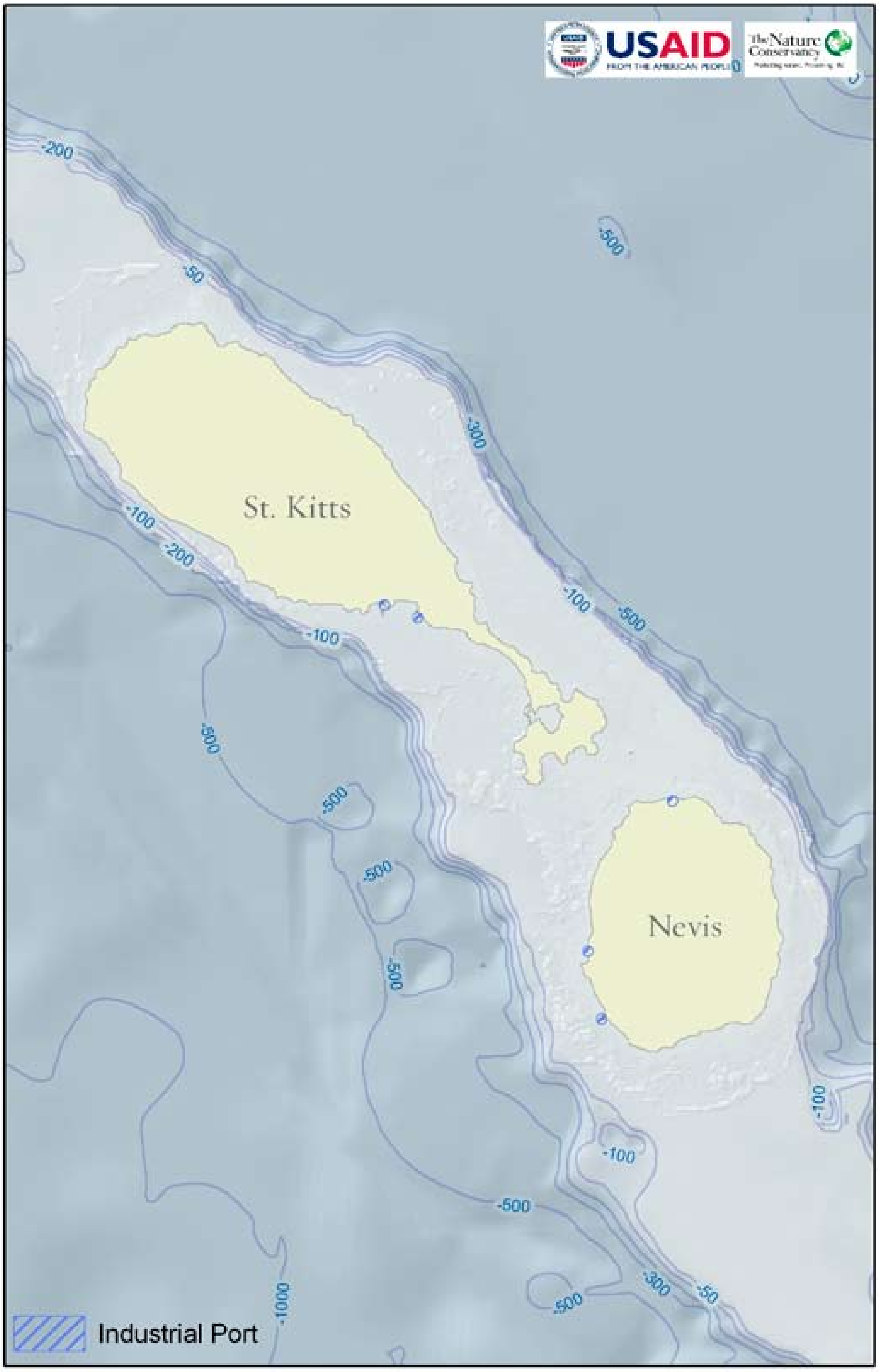
(w) Tourism Activity – Kite Boarding Areas: Location of popular kite boarding areas in St. Kitts and Nevis.



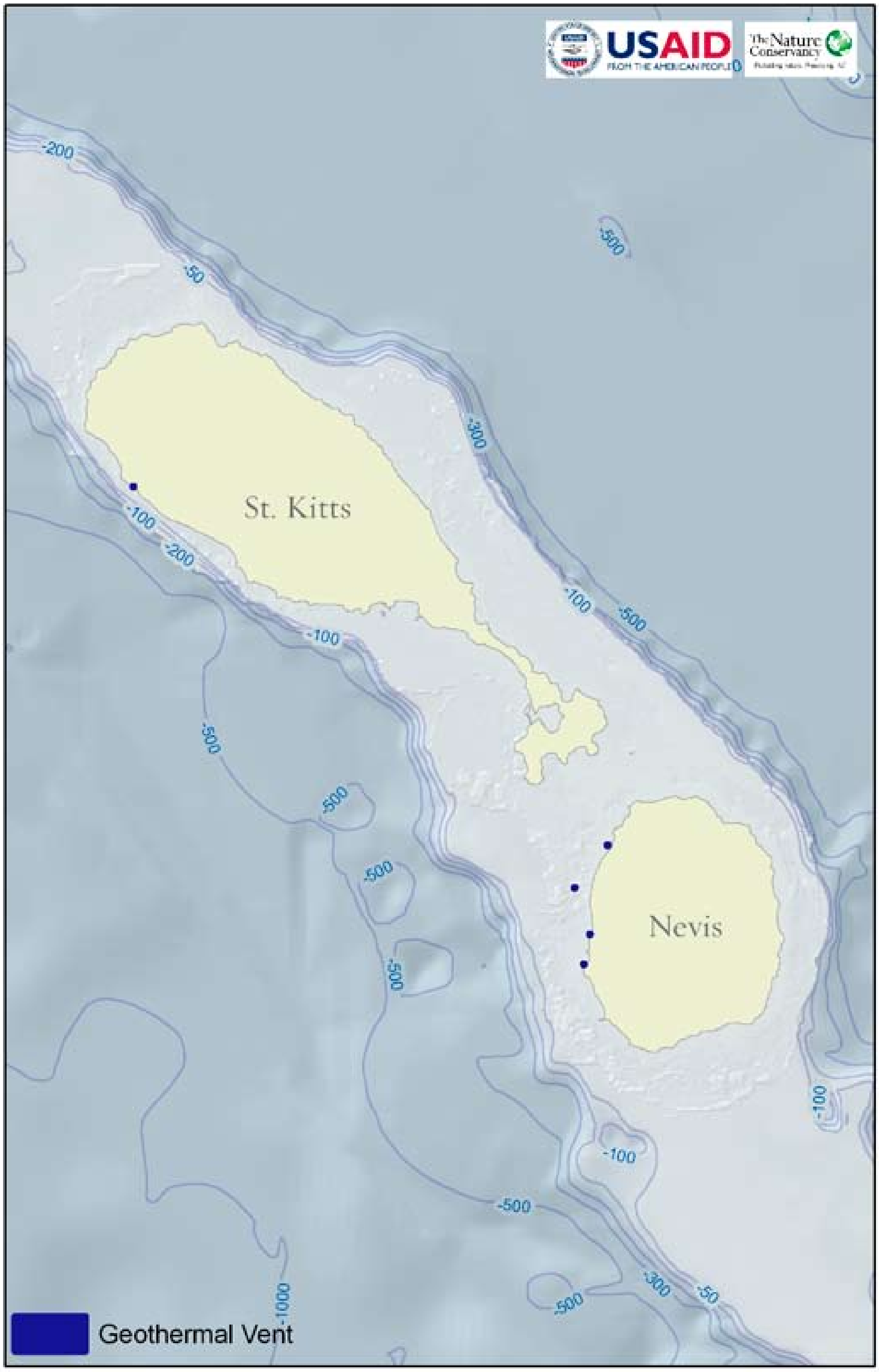
(x) Tourism Activity – Surfing: Location of popular surfing areas in St. Kitts and Nevis.



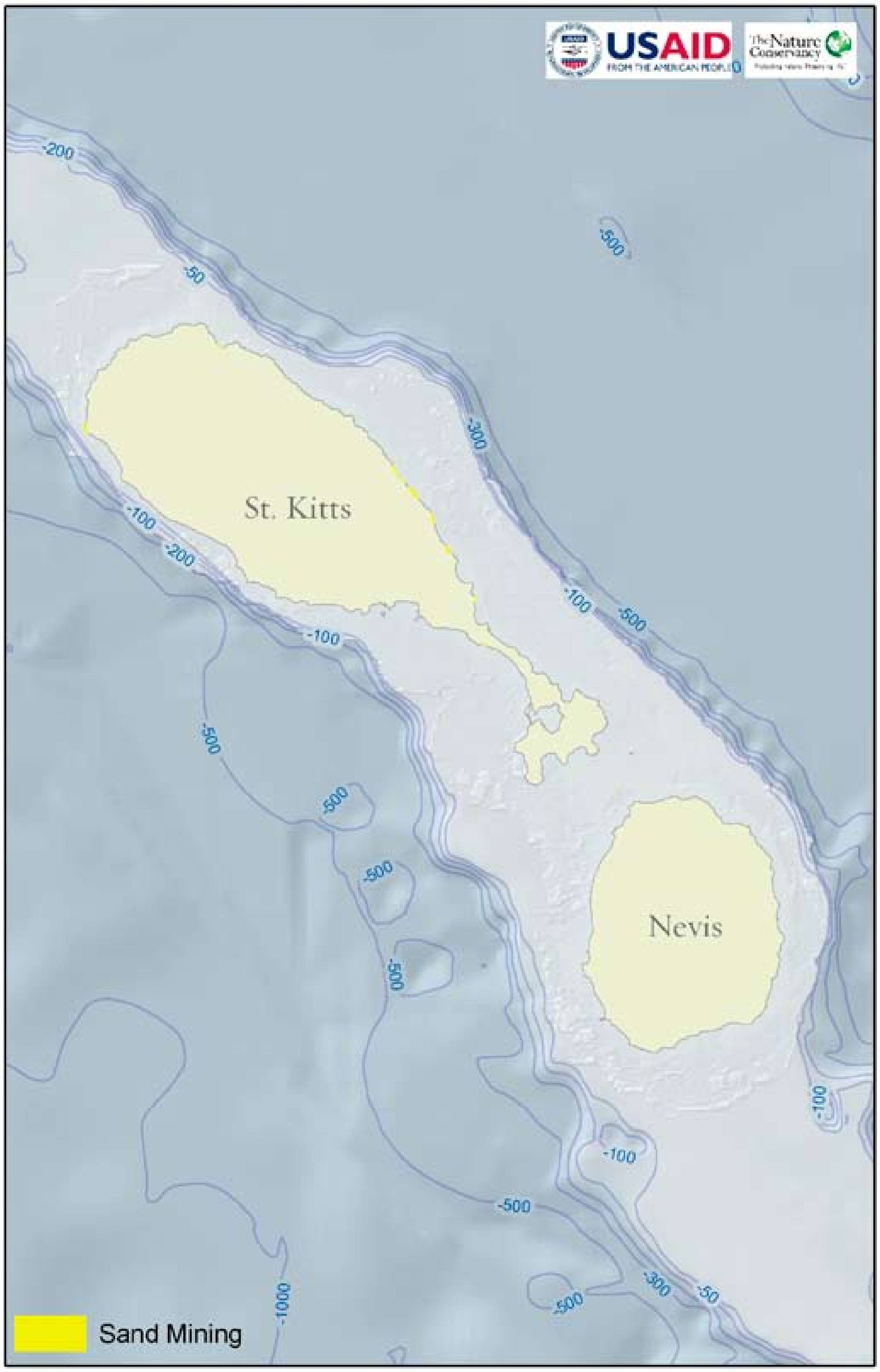
(y) Tourism Activity – Bird Watching: Location of popular bird watching areas in St. Kitts and Nevis.



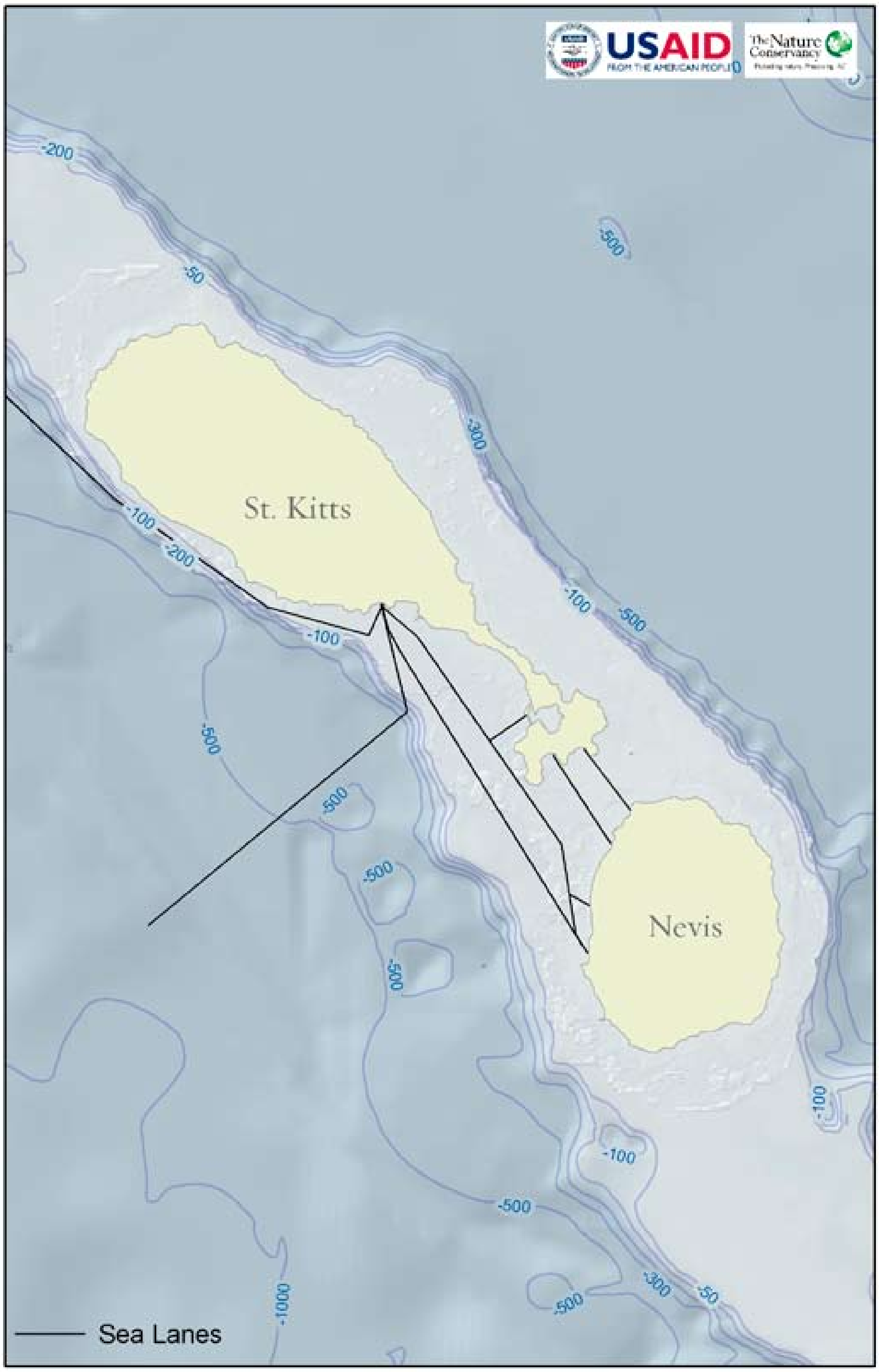
(z) Industrial Activity – Industrial Ports: Location of important industrial ports in St. Kitts and Nevis.



(aa) Industrial Activity – Geothermal Vents: Location of important geothermal vents in St. Kitts and Nevis.

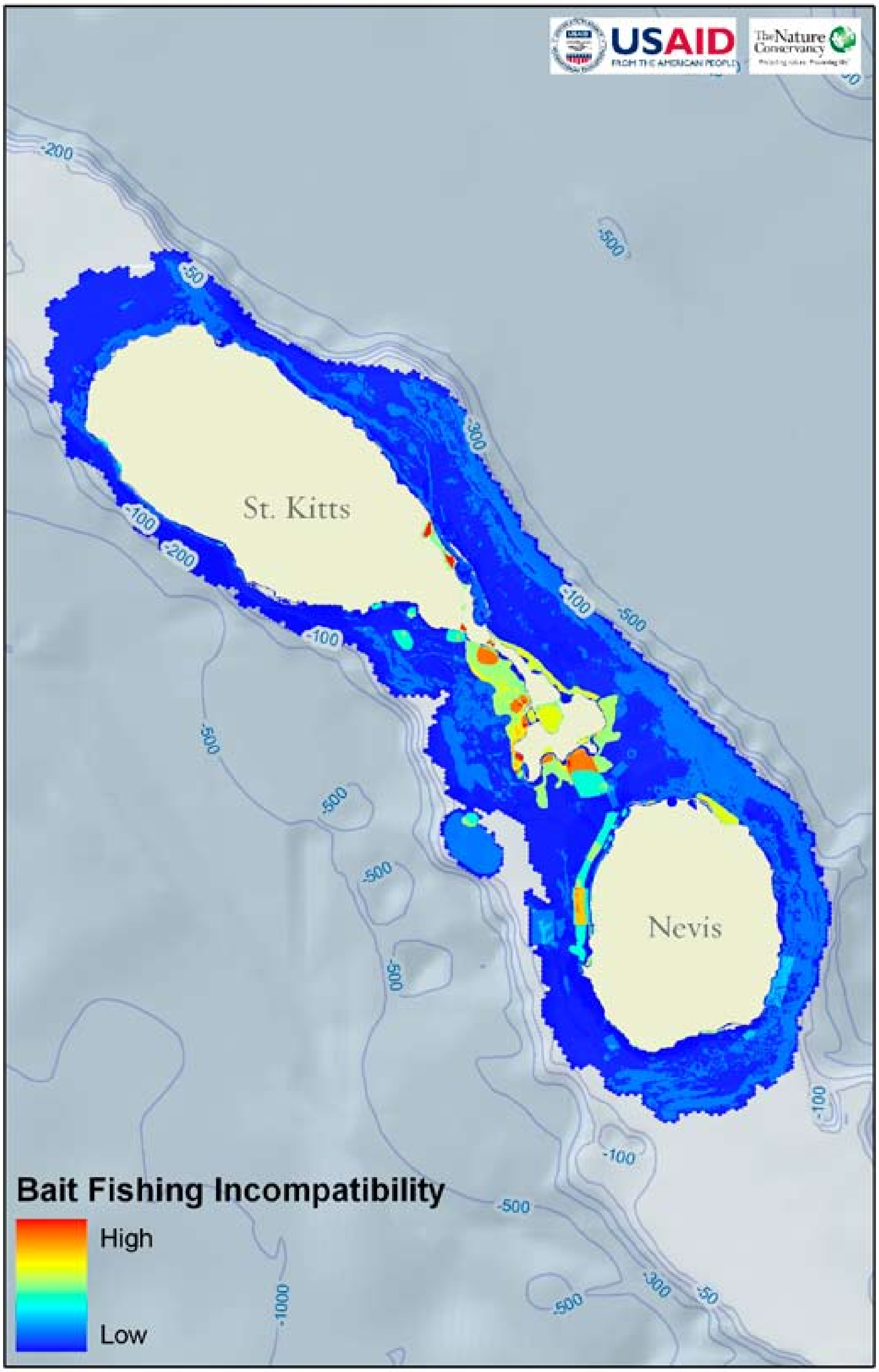


(bb) Industrial Activity – Sand Mining: Location of important sand mining areas in St. Kitts and Nevis.

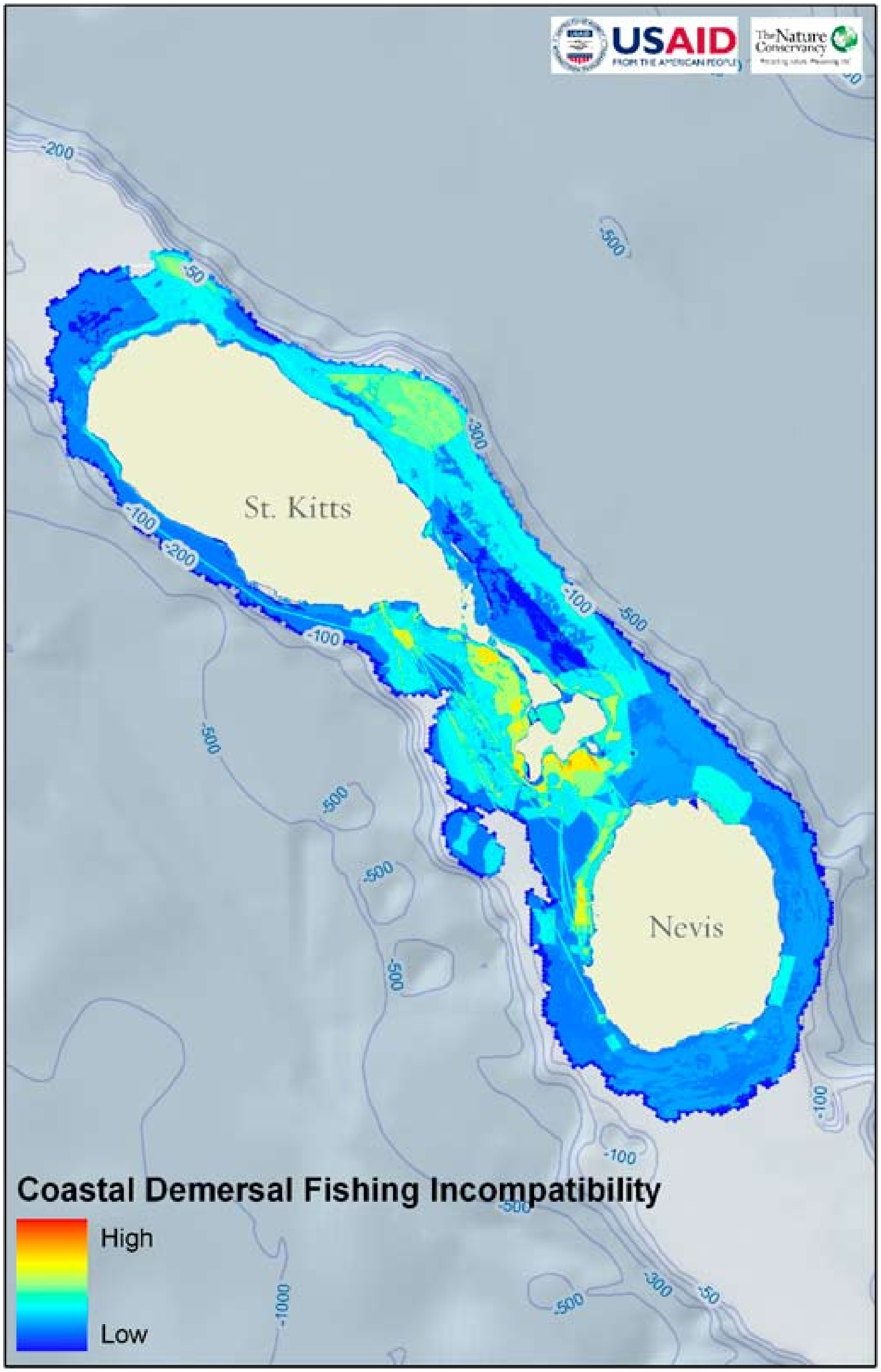


(cc) Transportation Activity – Sea Lanes: Location of important sea lanes in St. Kitts and Nevis.

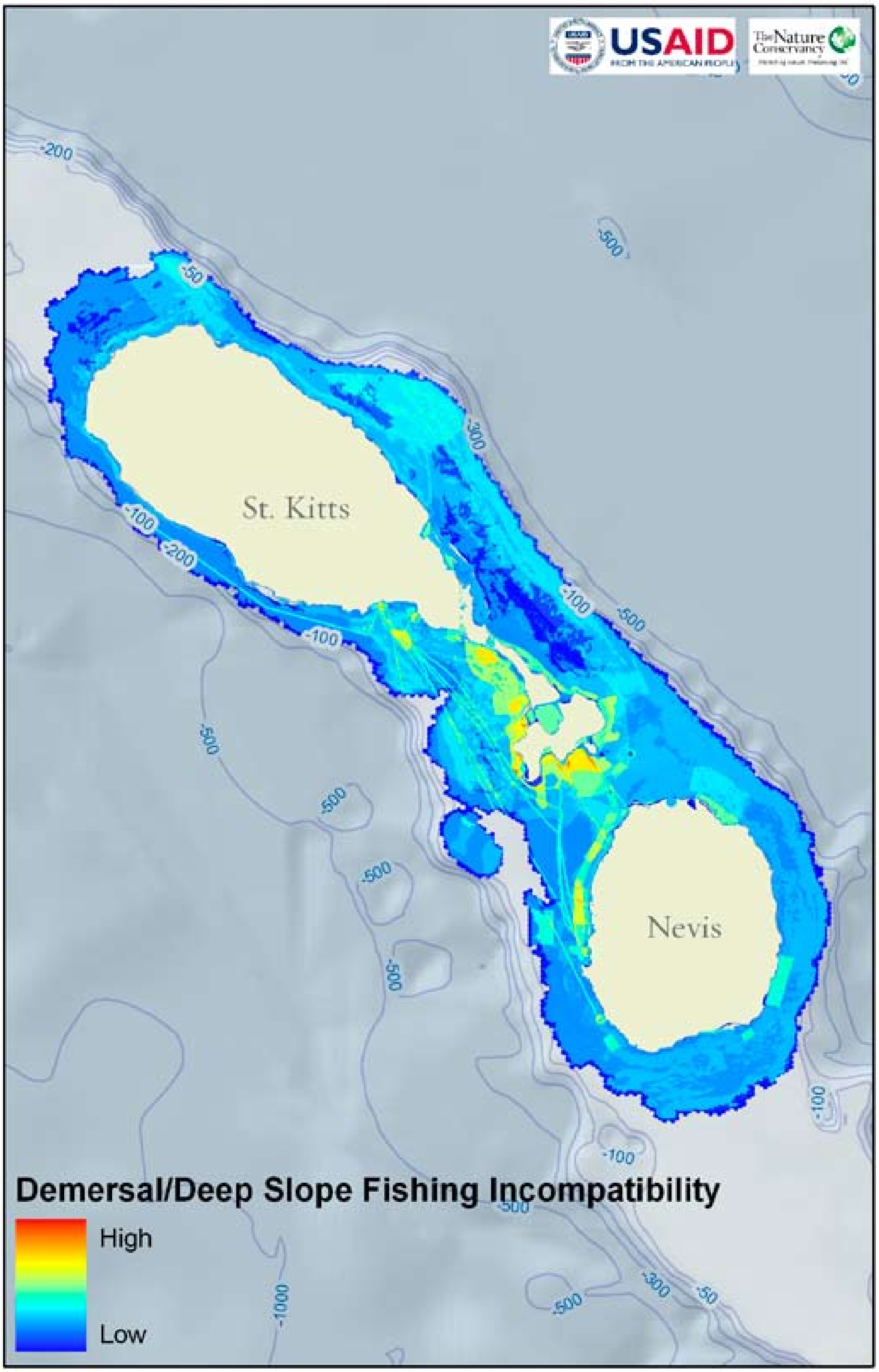
FIGURE E4. **Compatibility:** These maps are created from a compatibility matrix generated with stakeholder input during the second workshop. For each feature and activity, each map depicts the level of compatibility between that specific feature and all other features and activities. (Note that compatibility maps are described further in the main report.)



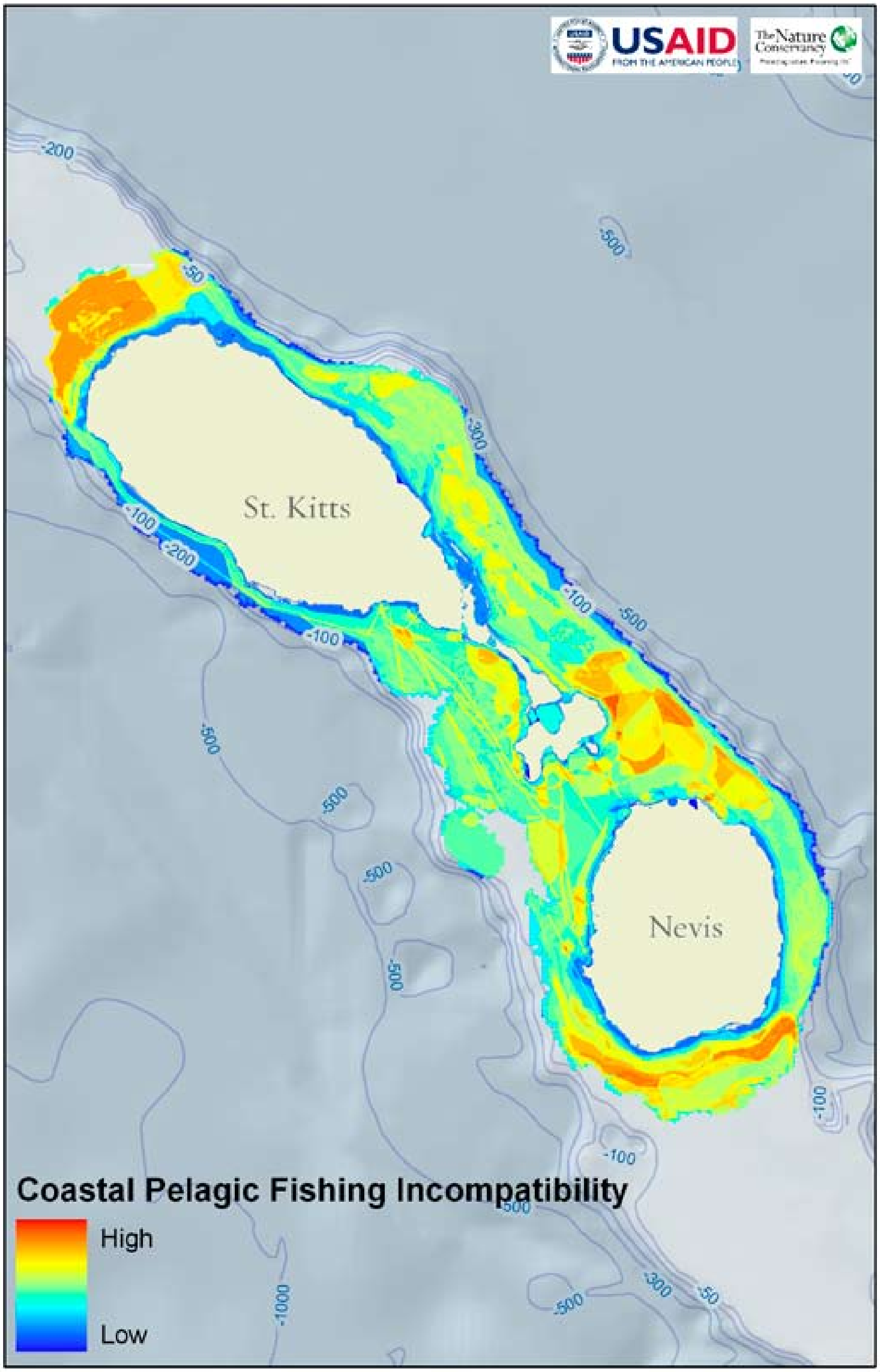
(a) Fishing Activity – Bait Fishing: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for bait fishing.



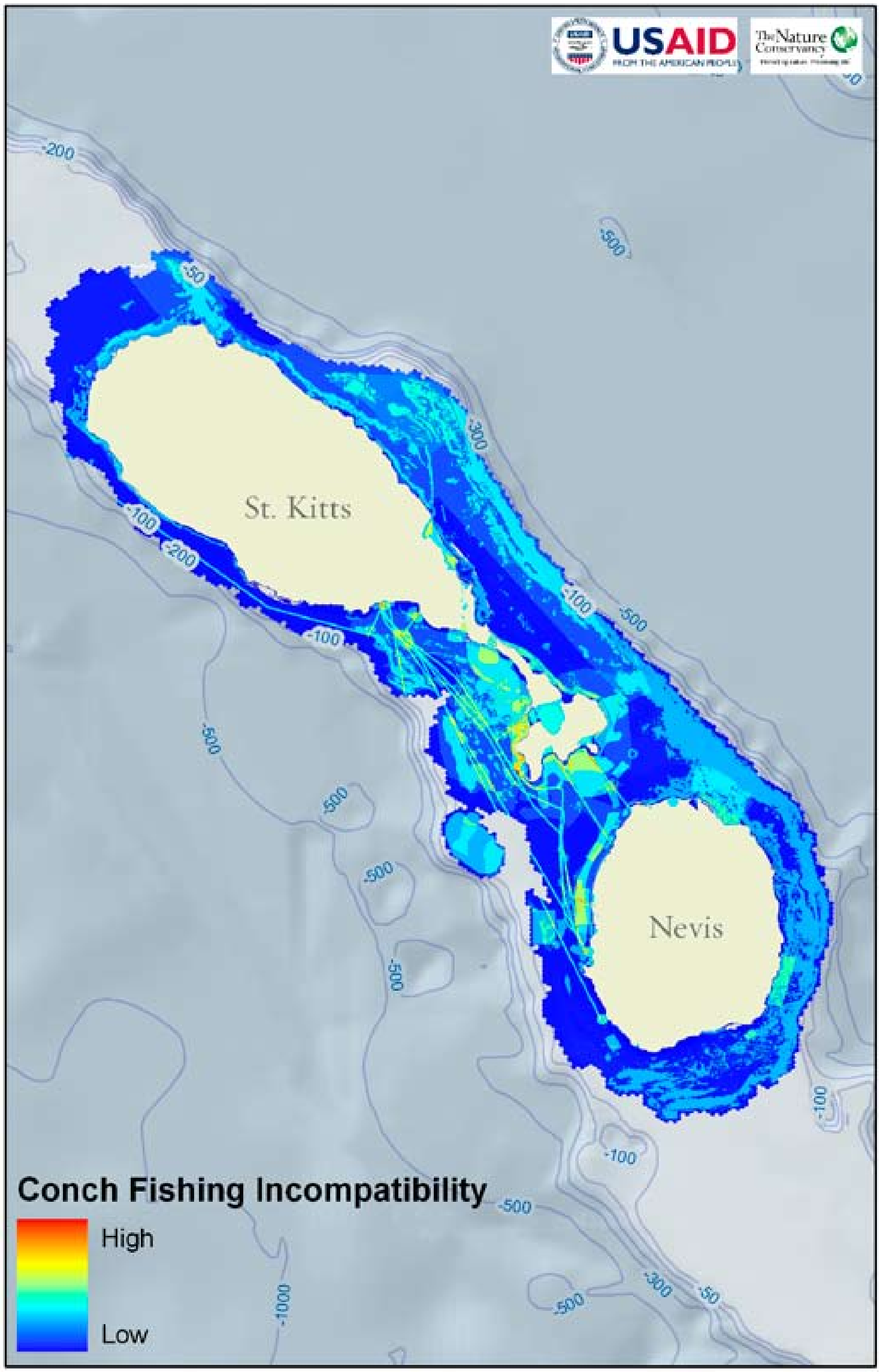
(b) Fishing Activity – Coastal Demersal Fishing: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for coastal demersal fishing.



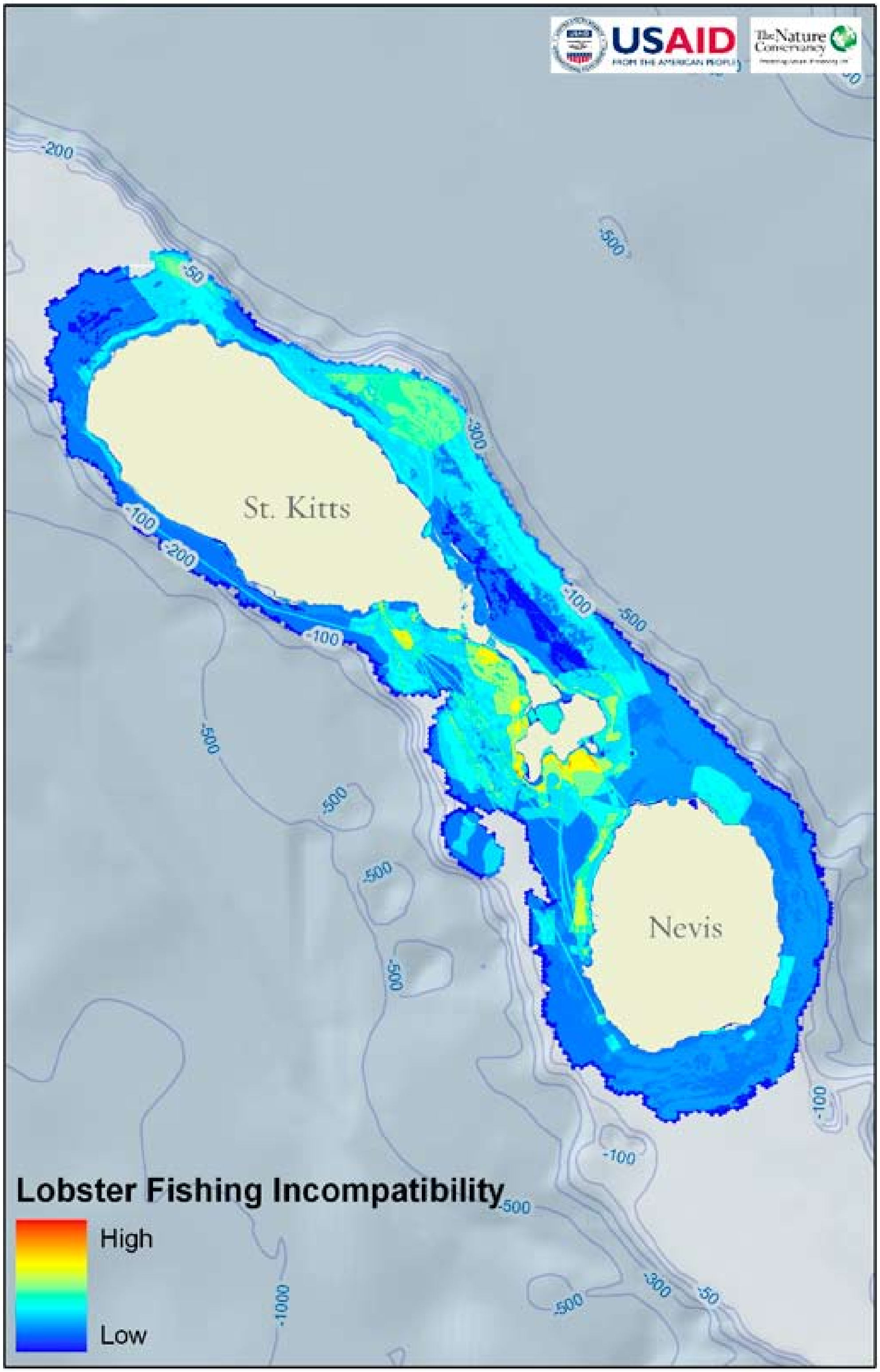
(c) Fishing Activity – Demersal/Deep Slope Fishing: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for demersal/deep-slope fishing.



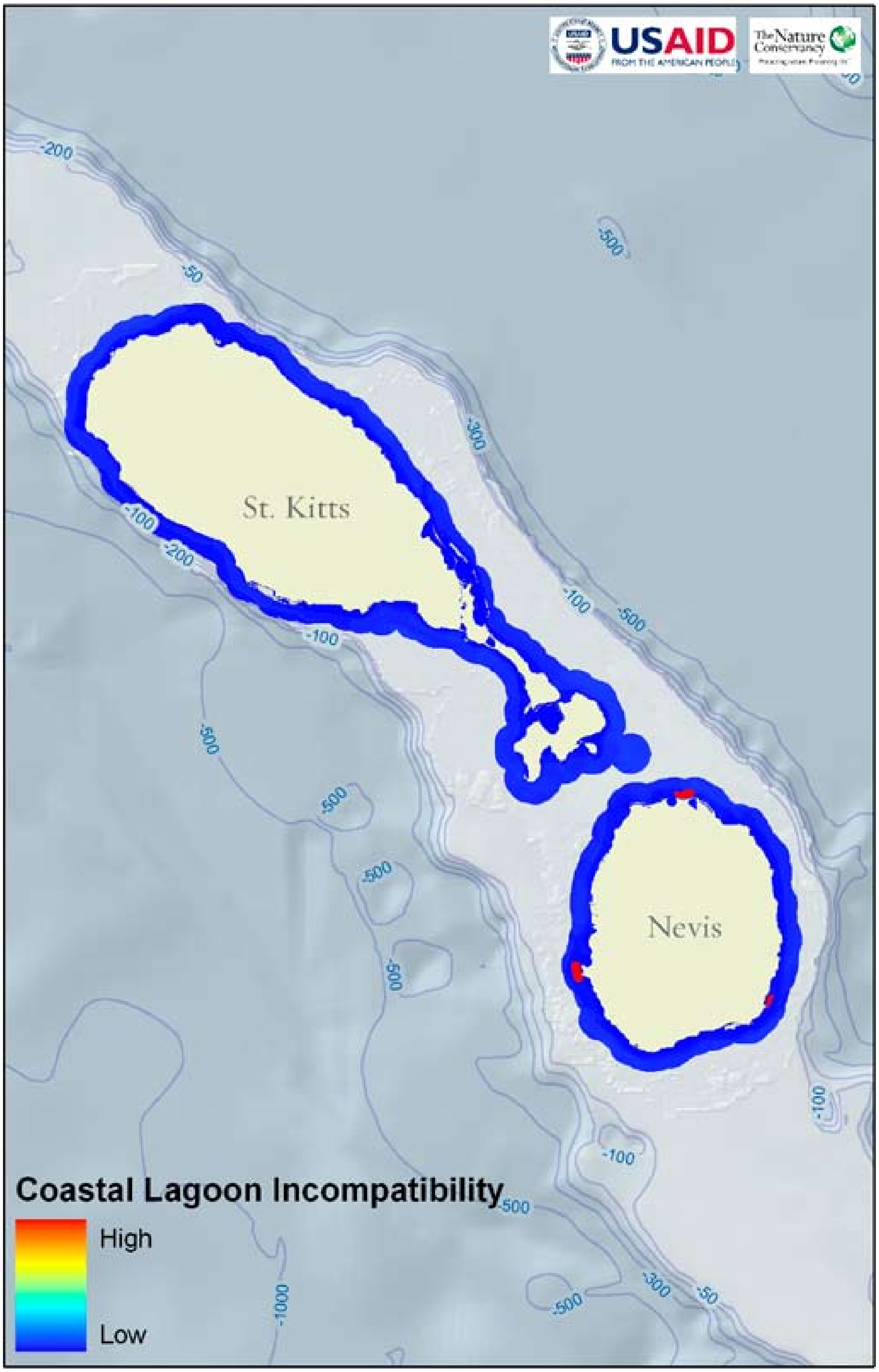
(d) Fishing Activity – Pelagic Fishing: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for pelagic fishing.



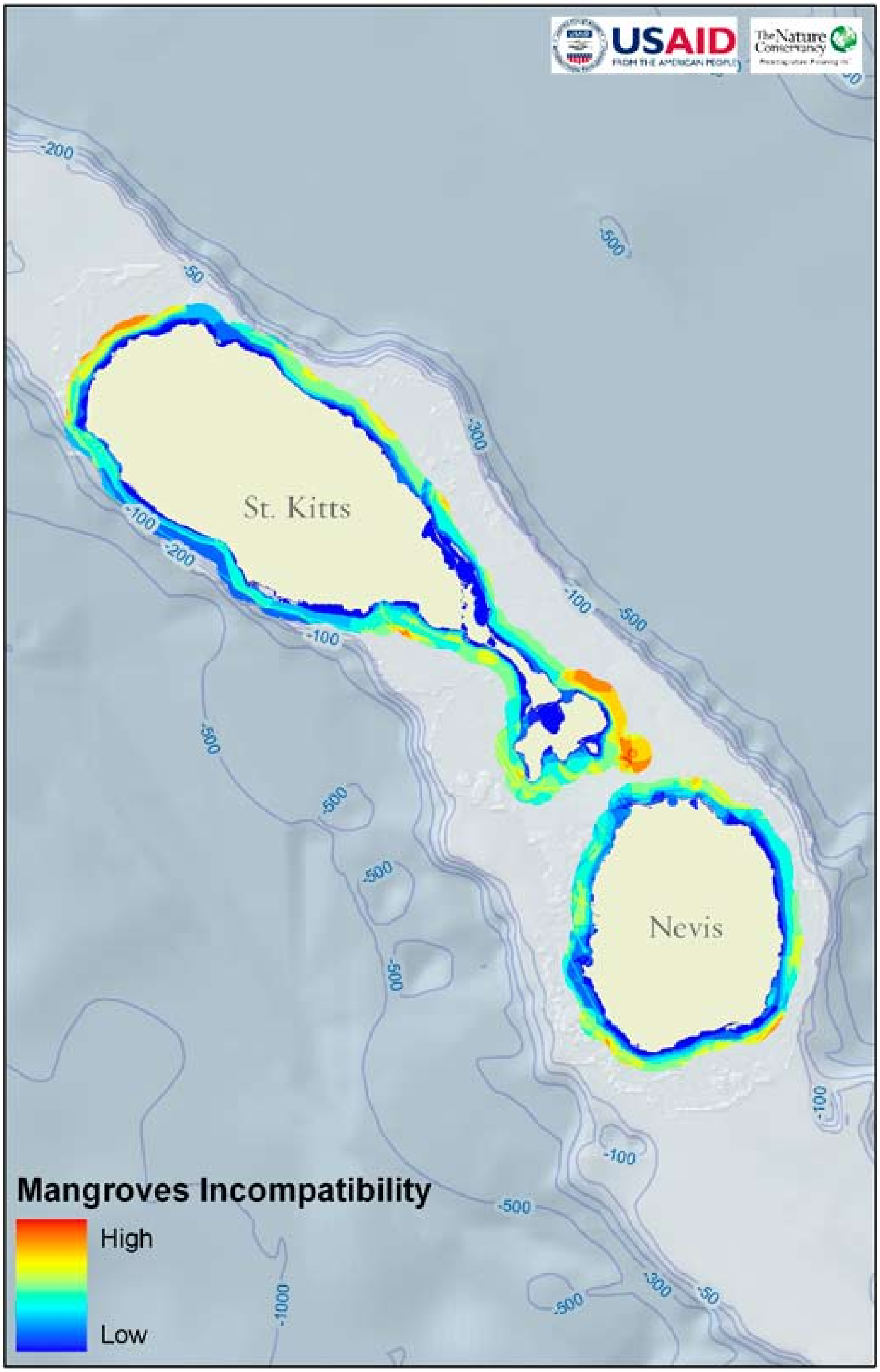
(e) Fishing Activity – Conch Fishing: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conch fishing.



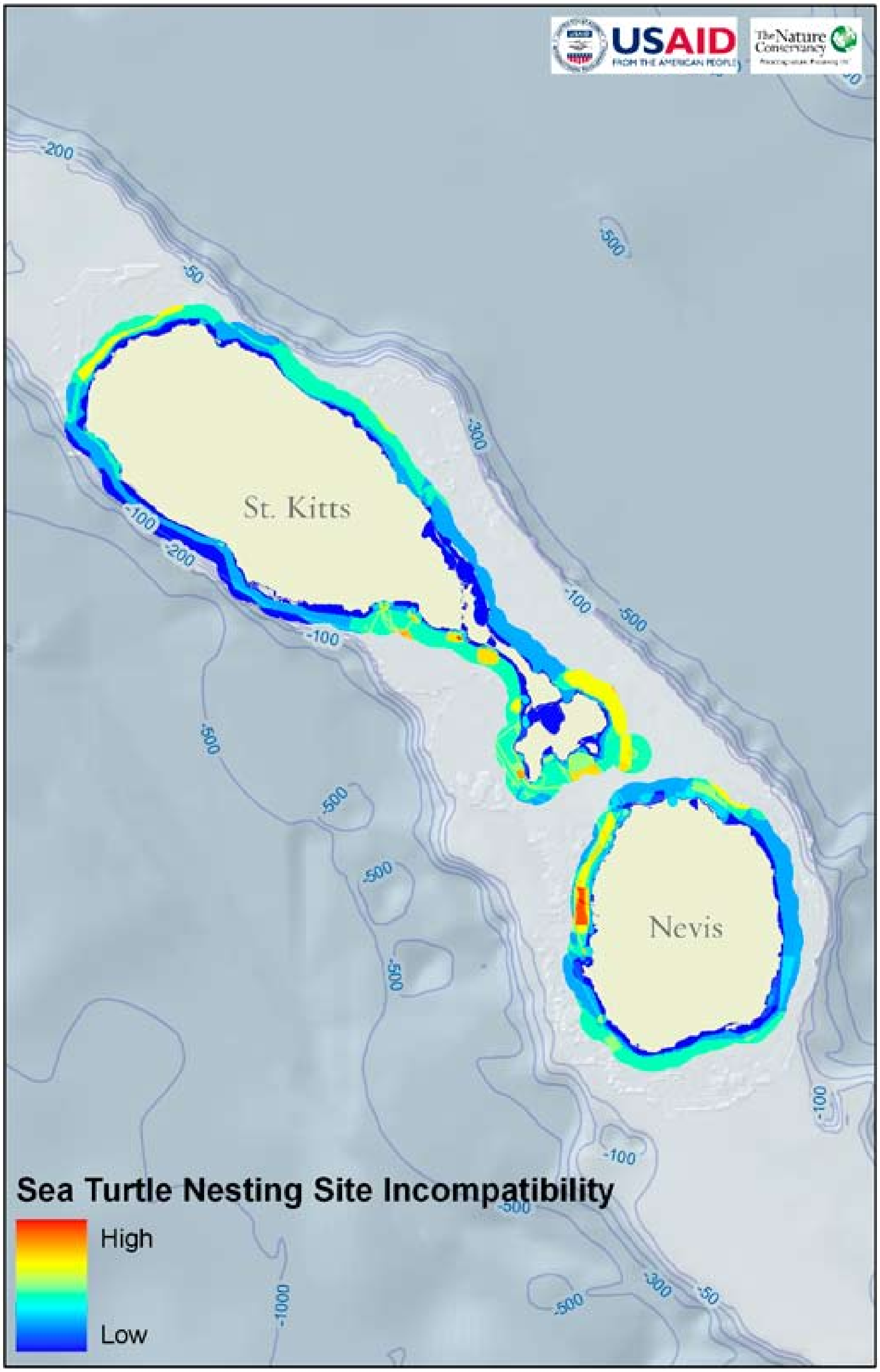
(f) Fishing Activity – Lobster Fishing: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for lobster fishing.



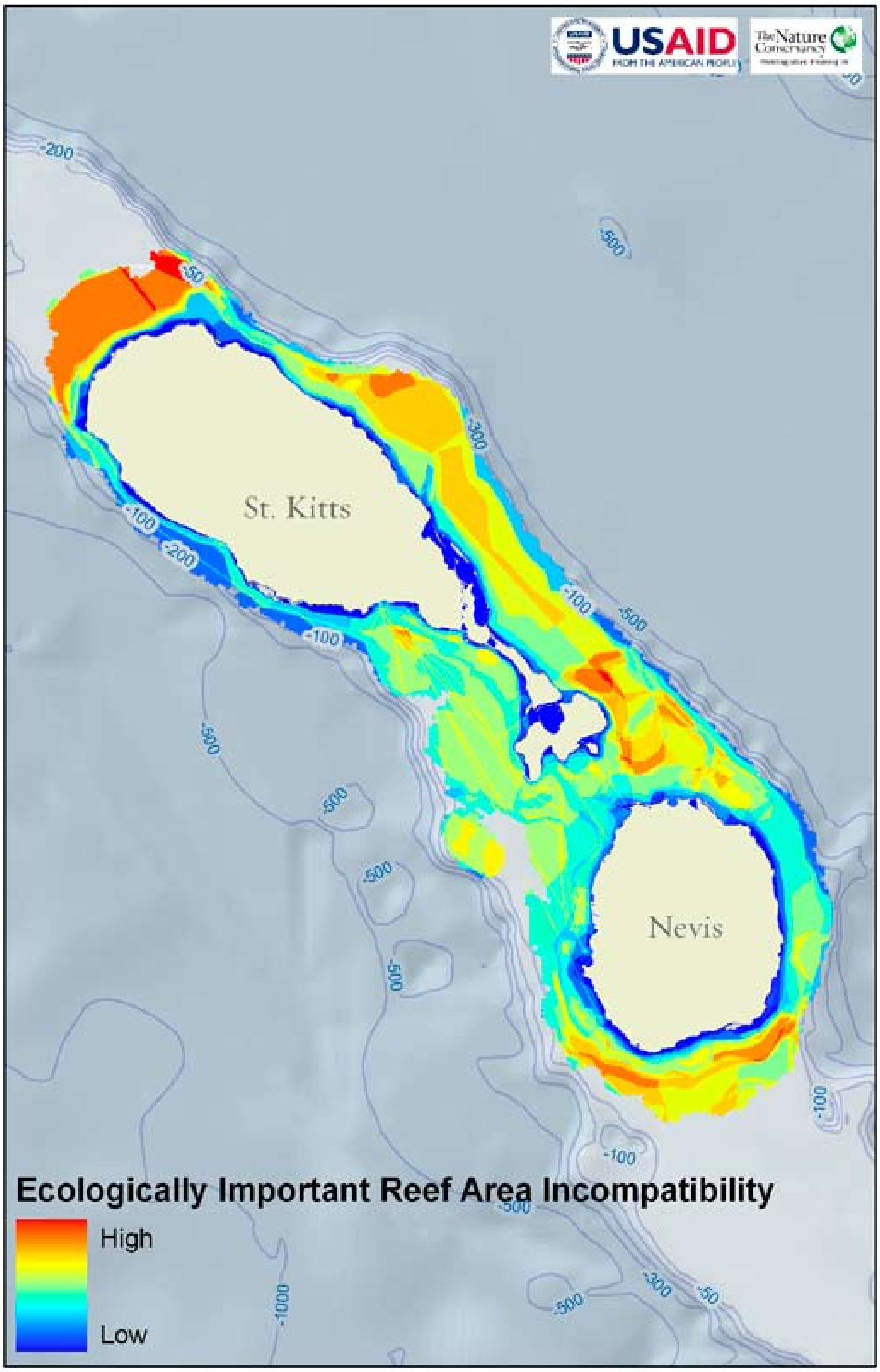
(g) Conservation Feature – Coastal Lagoons: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conserving coastal lagoons.



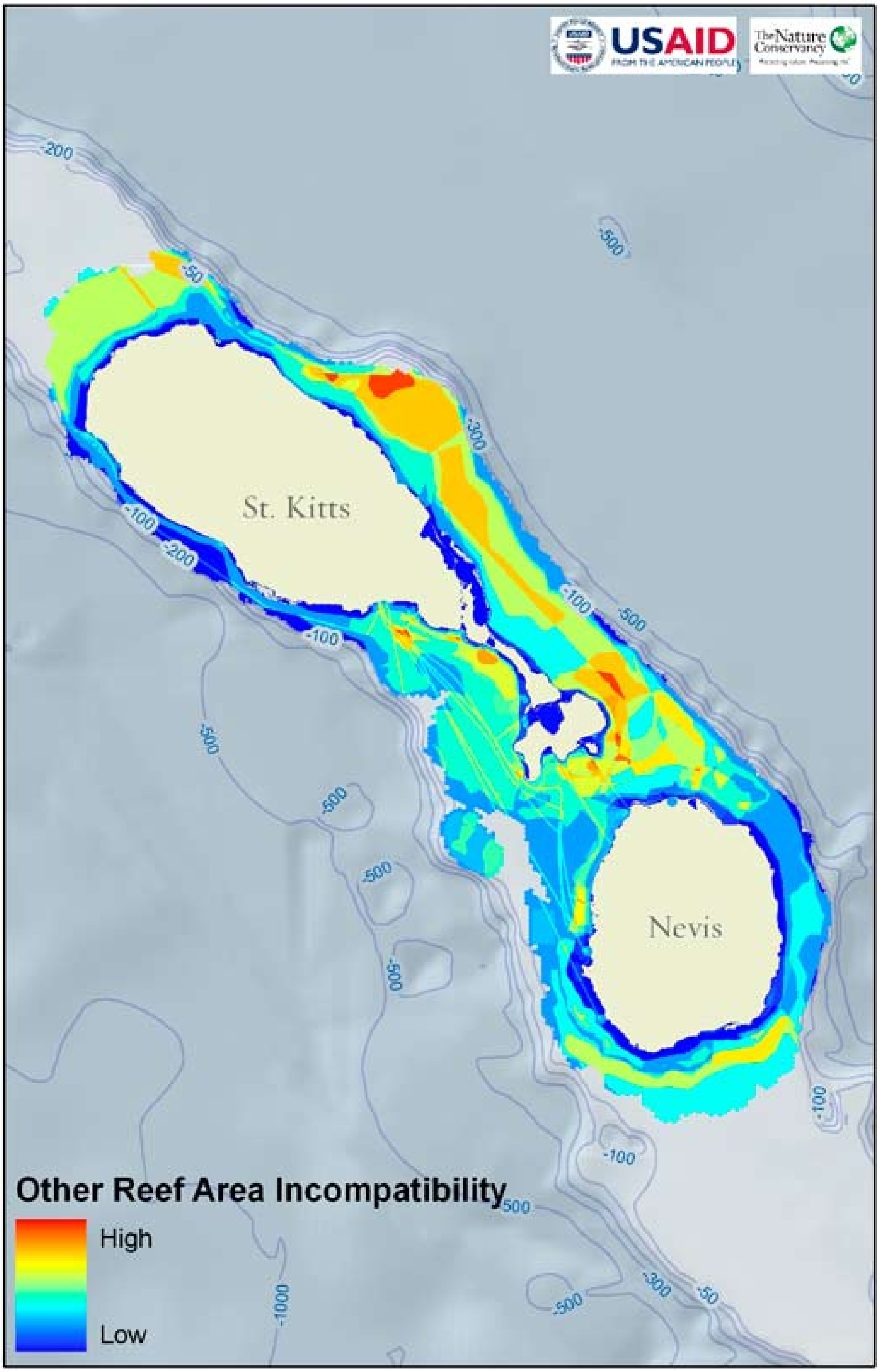
(h) Conservation Feature – Mangroves: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conserving mangroves.



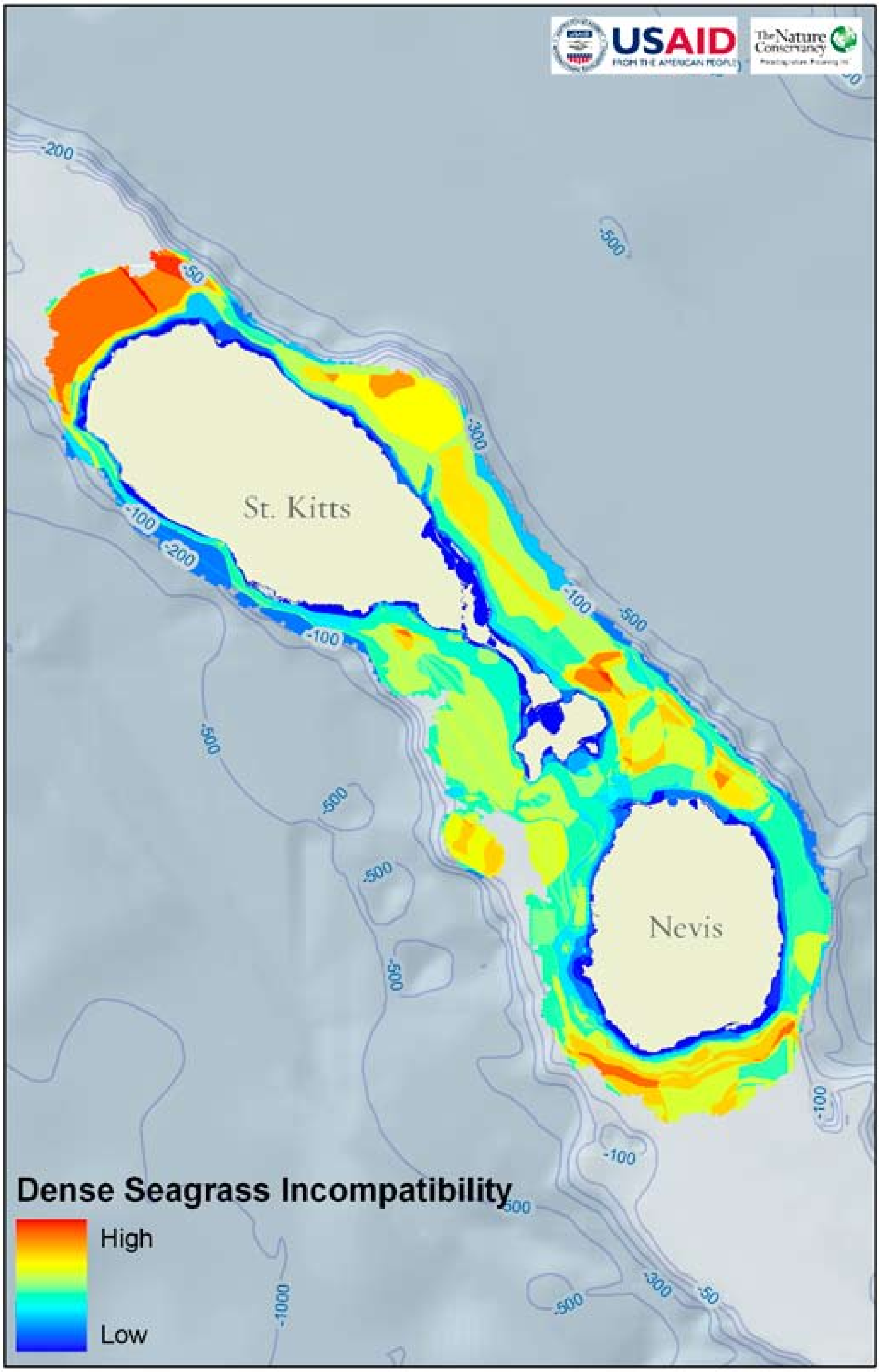
(i) Conservation Feature – Sea Turtle Nesting Sites: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conserving sea turtle nesting sites.



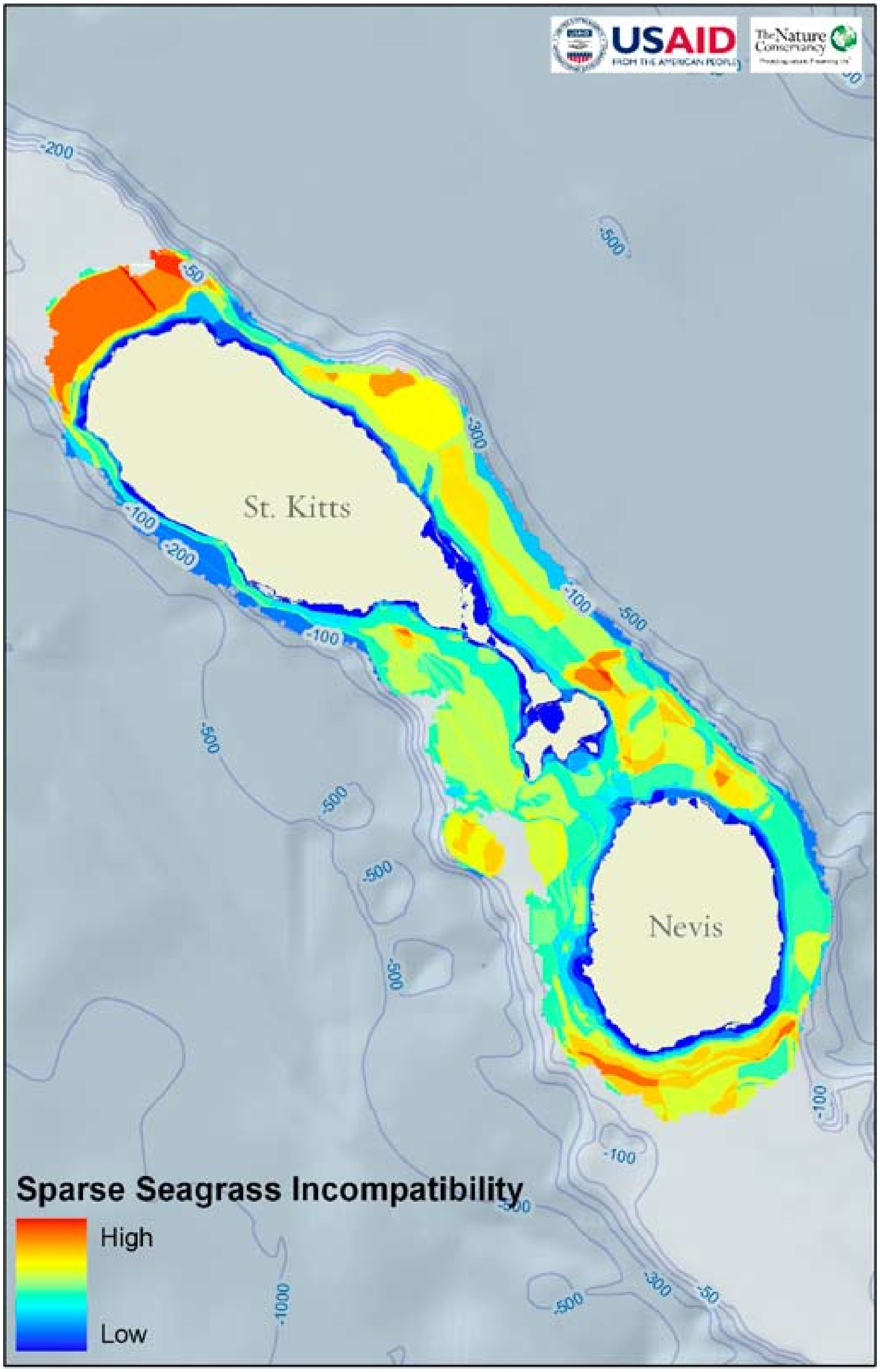
(j) Conservation Feature – Ecologically Important Reefs: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conserving ecologically important reefs.



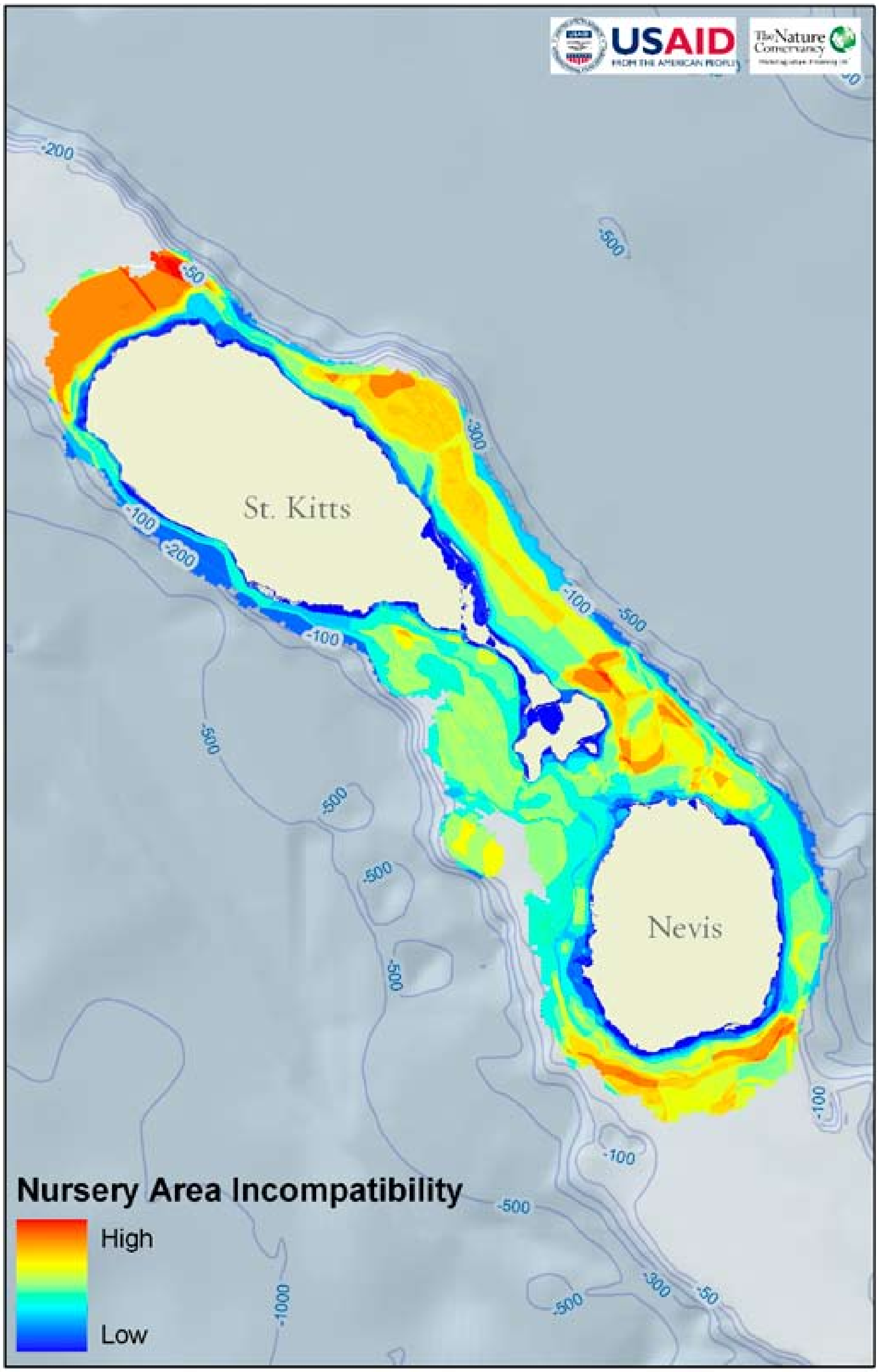
(k) Conservation Feature – Other Reefs: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conserving other reef areas.



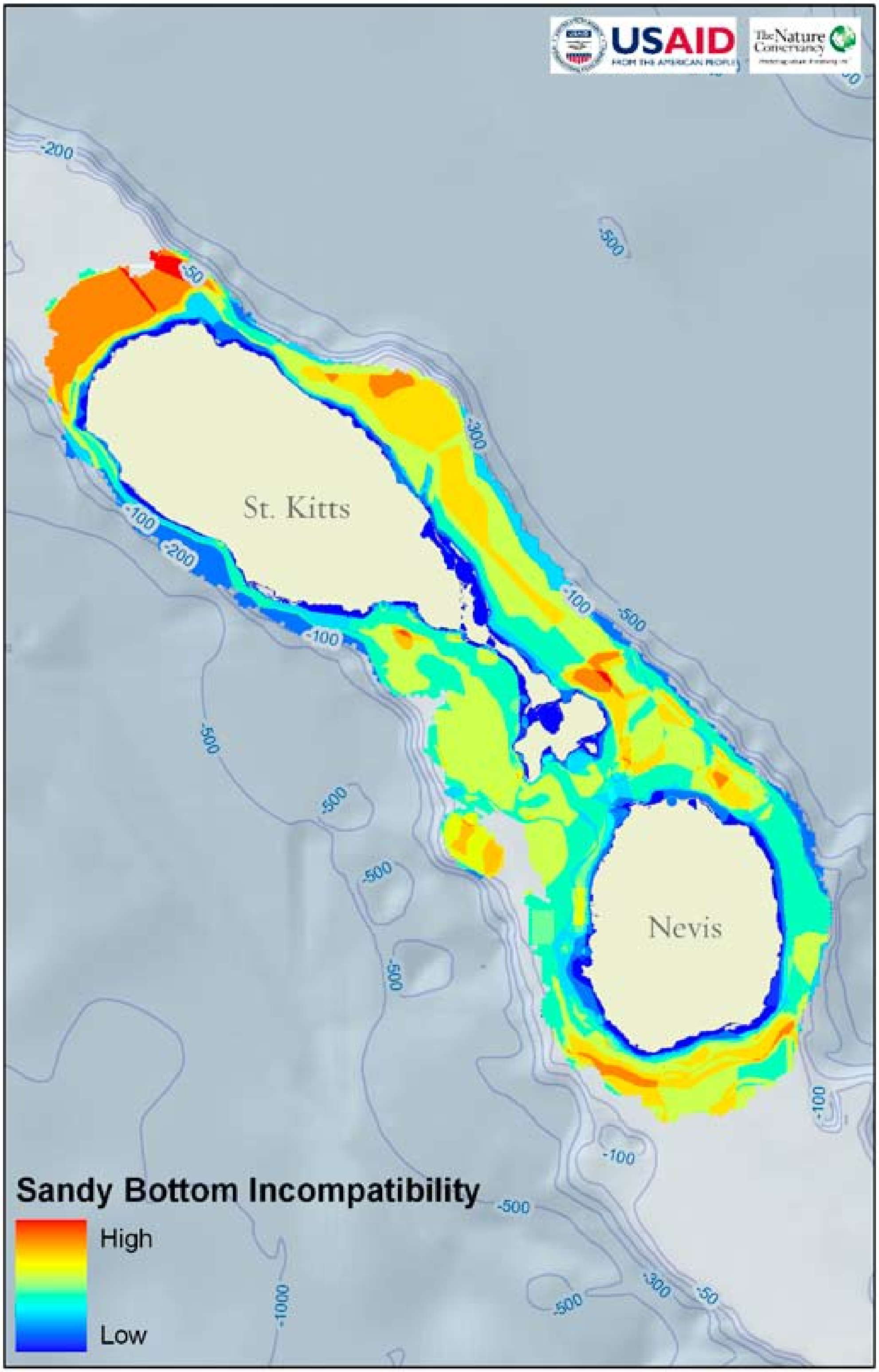
(l) Conservation Feature – Dense Seagrass: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conserving dense seagrass.



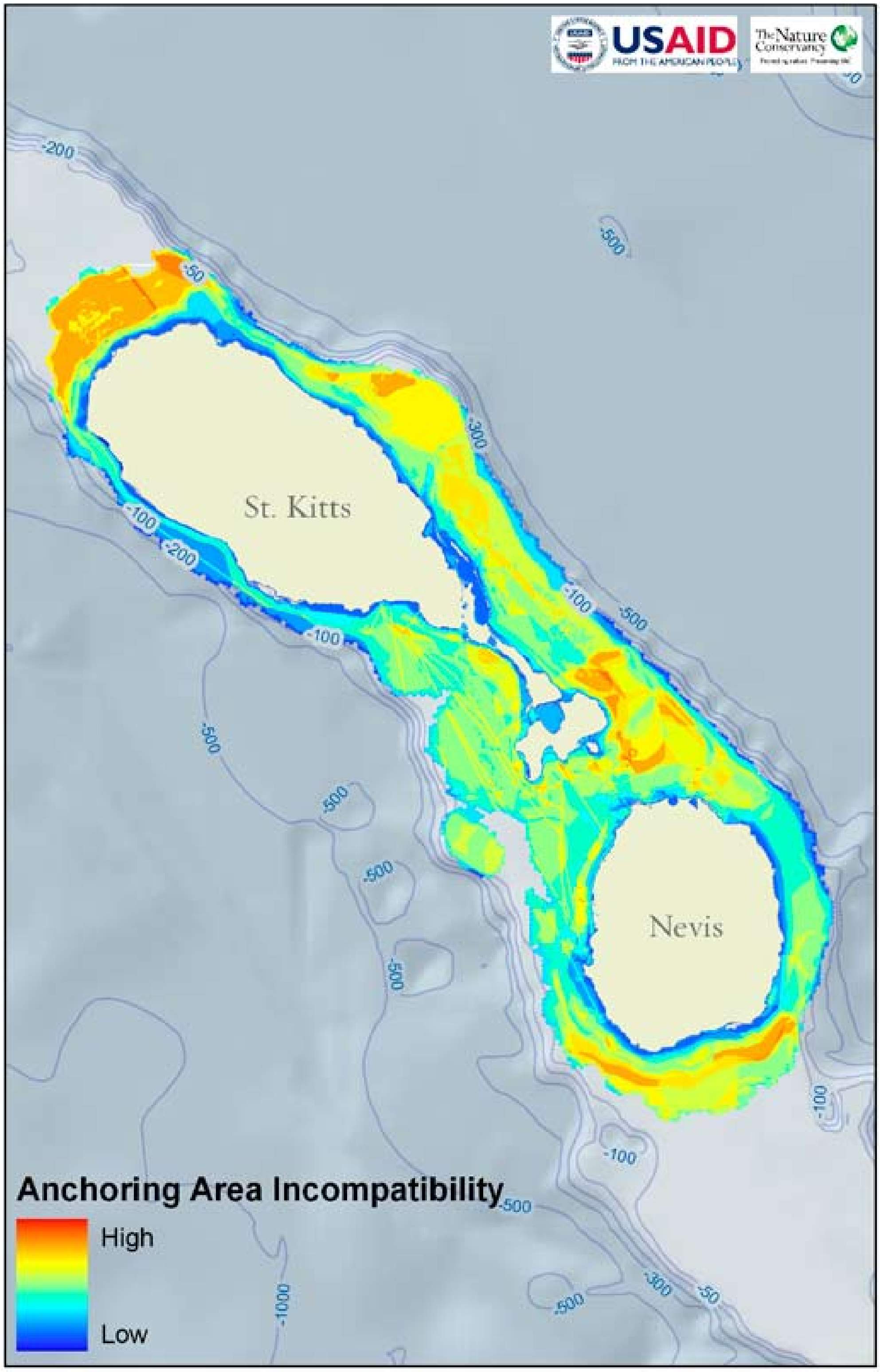
(m) Conservation Feature – Sparse Seagrass: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conserving sparse seagrass.



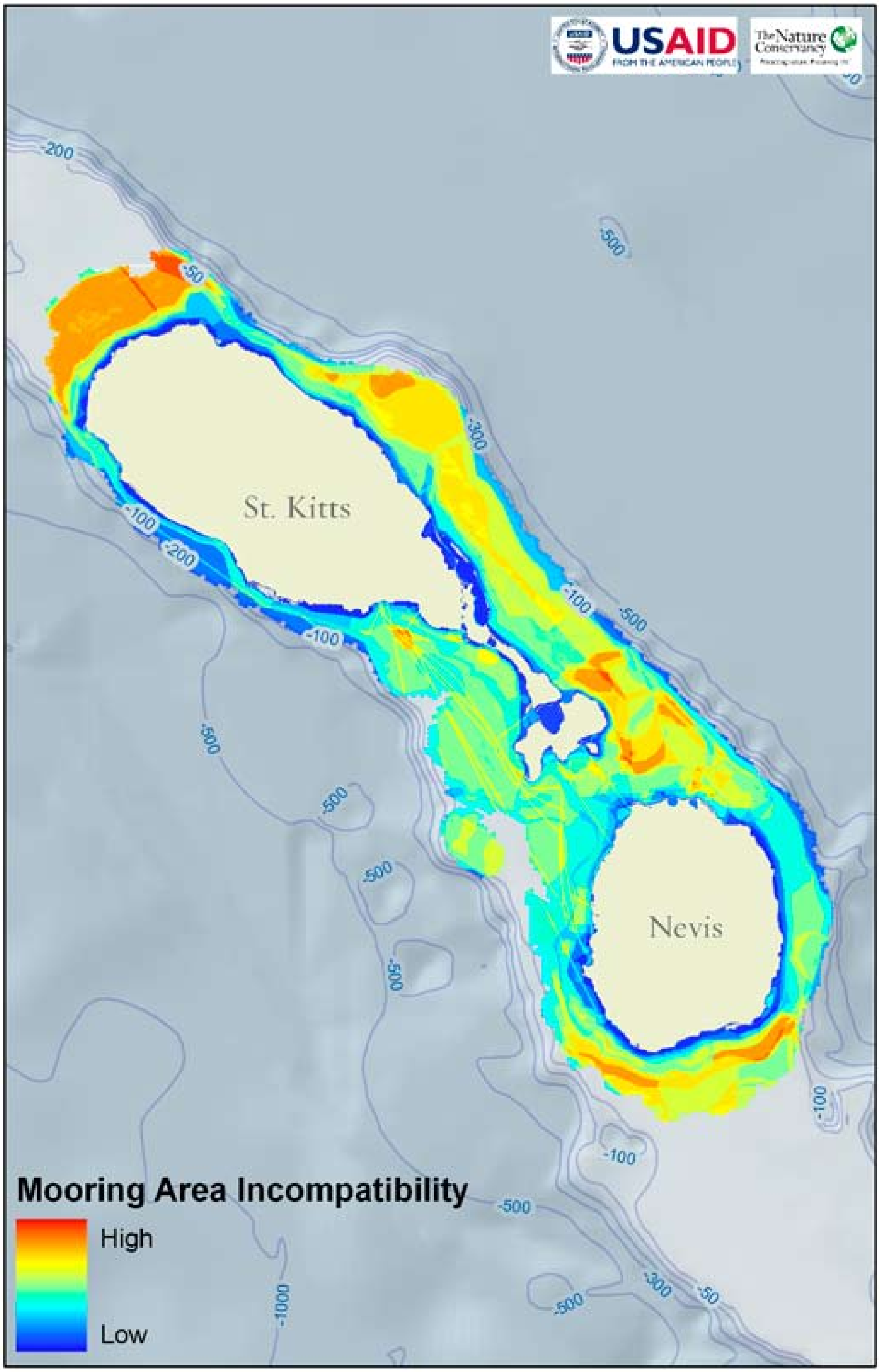
(n) Conservation Feature – Nursery Areas: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conserving fishery nursery areas.



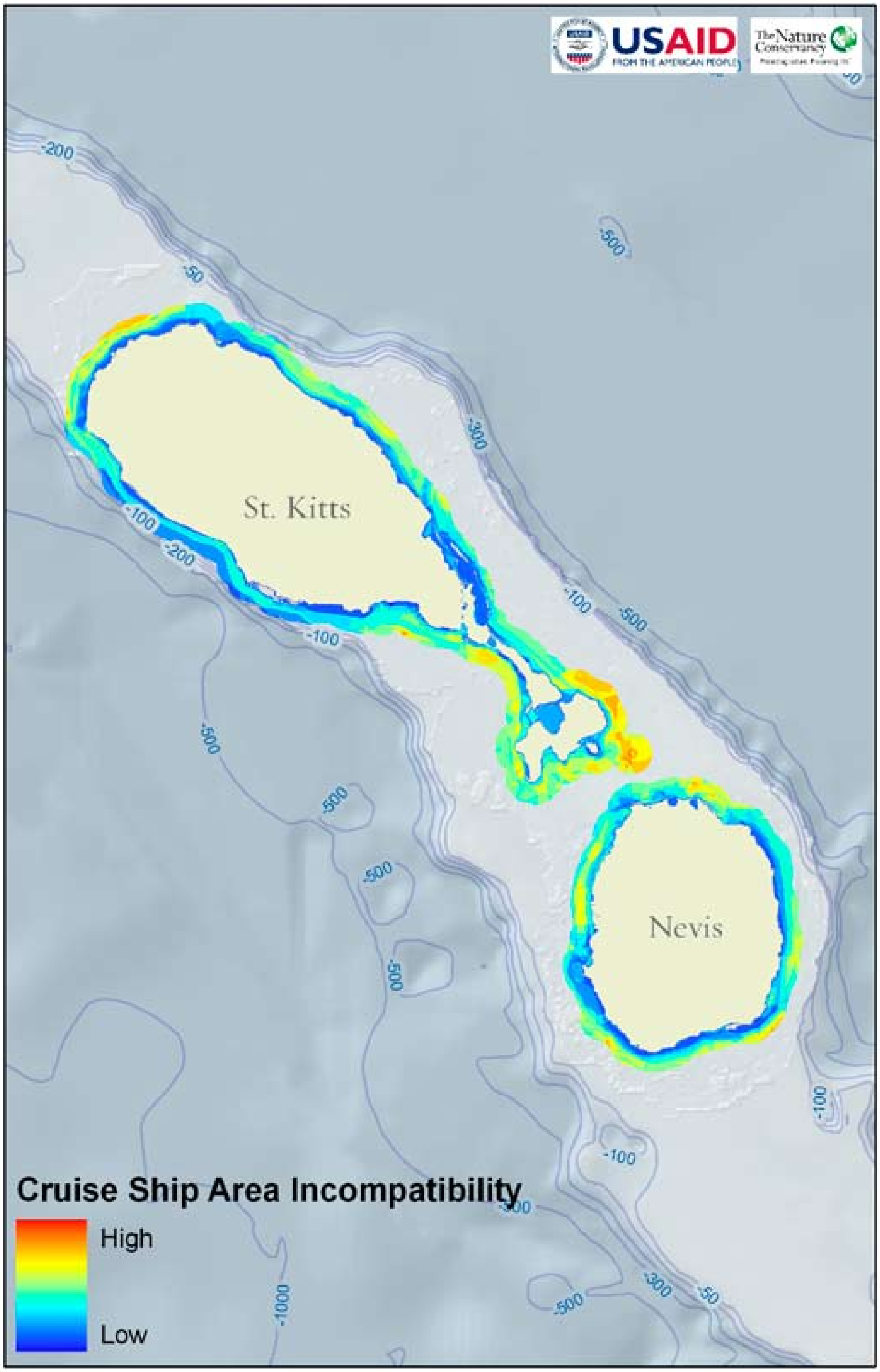
(o) Conservation Feature – Sandy Bottom: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for conserving sandy bottom areas.



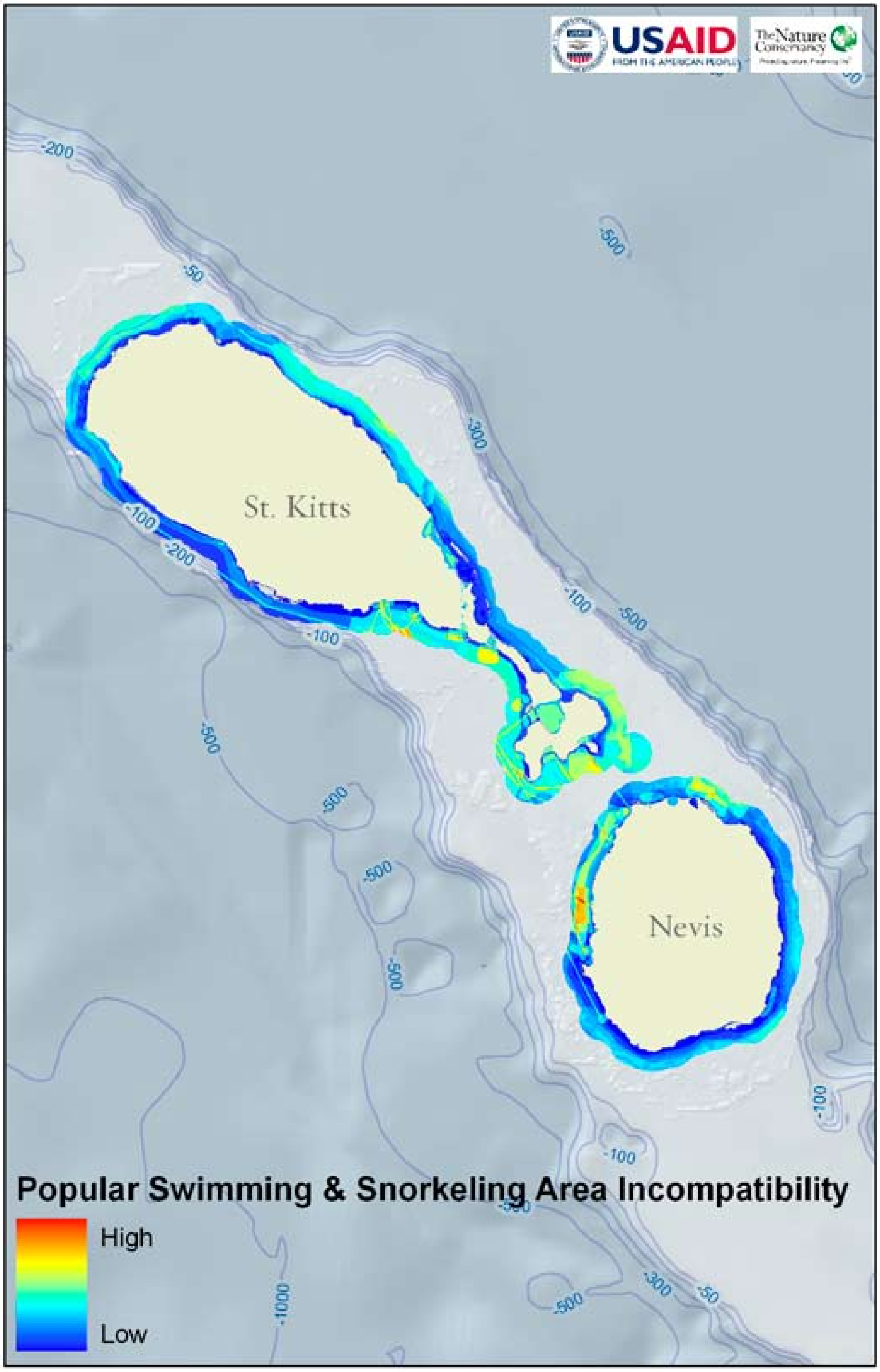
(p) Tourism Activity – Anchoring Areas: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for anchoring.



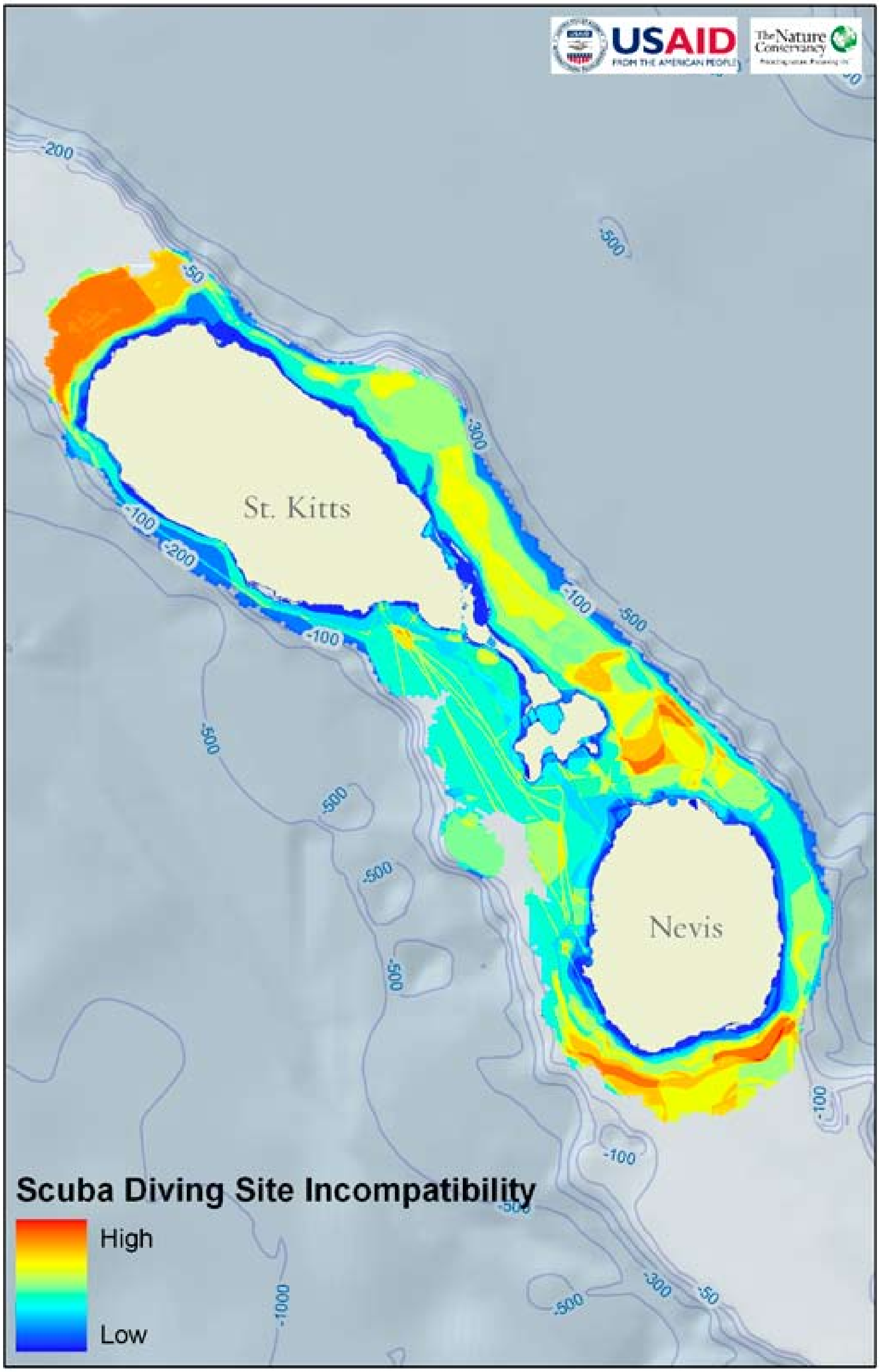
(q) Tourism Activity – Mooring Areas: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for mooring.



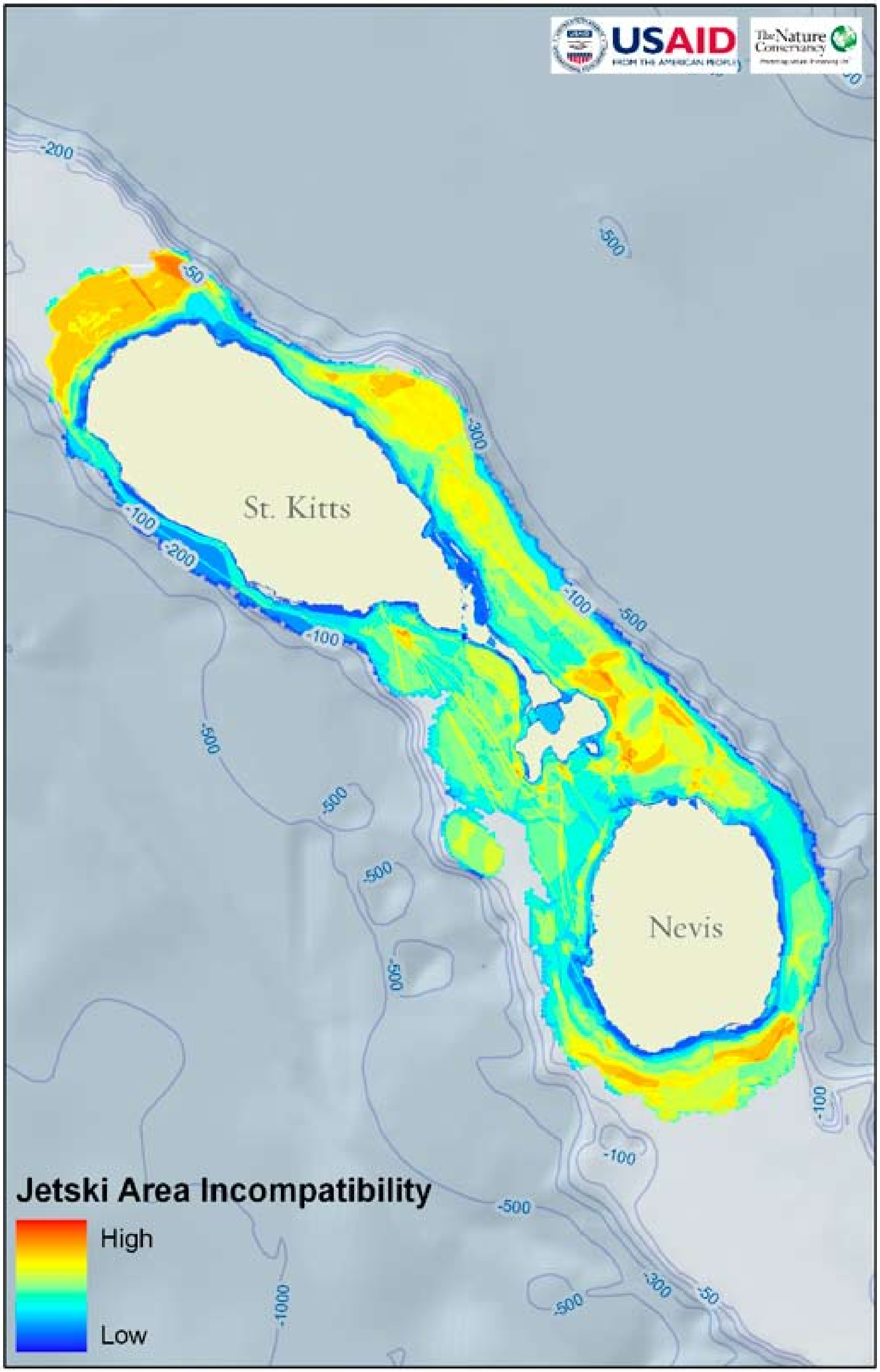
(r) Tourism Activity – Cruise Ship Areas: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for cruise ships.



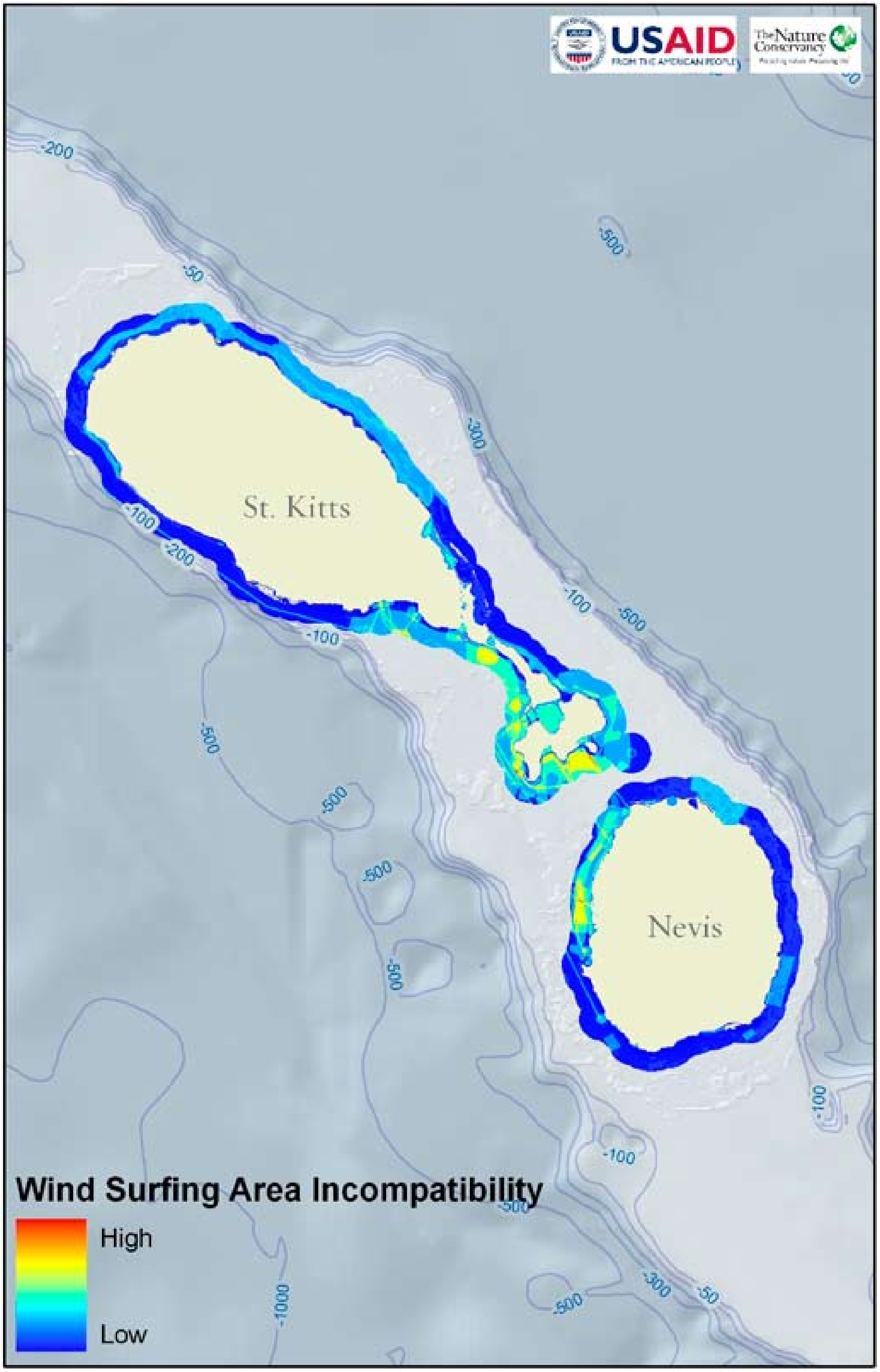
(s) Tourism Activity – Swimming & Snorkeling: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for swimming and snorkeling.



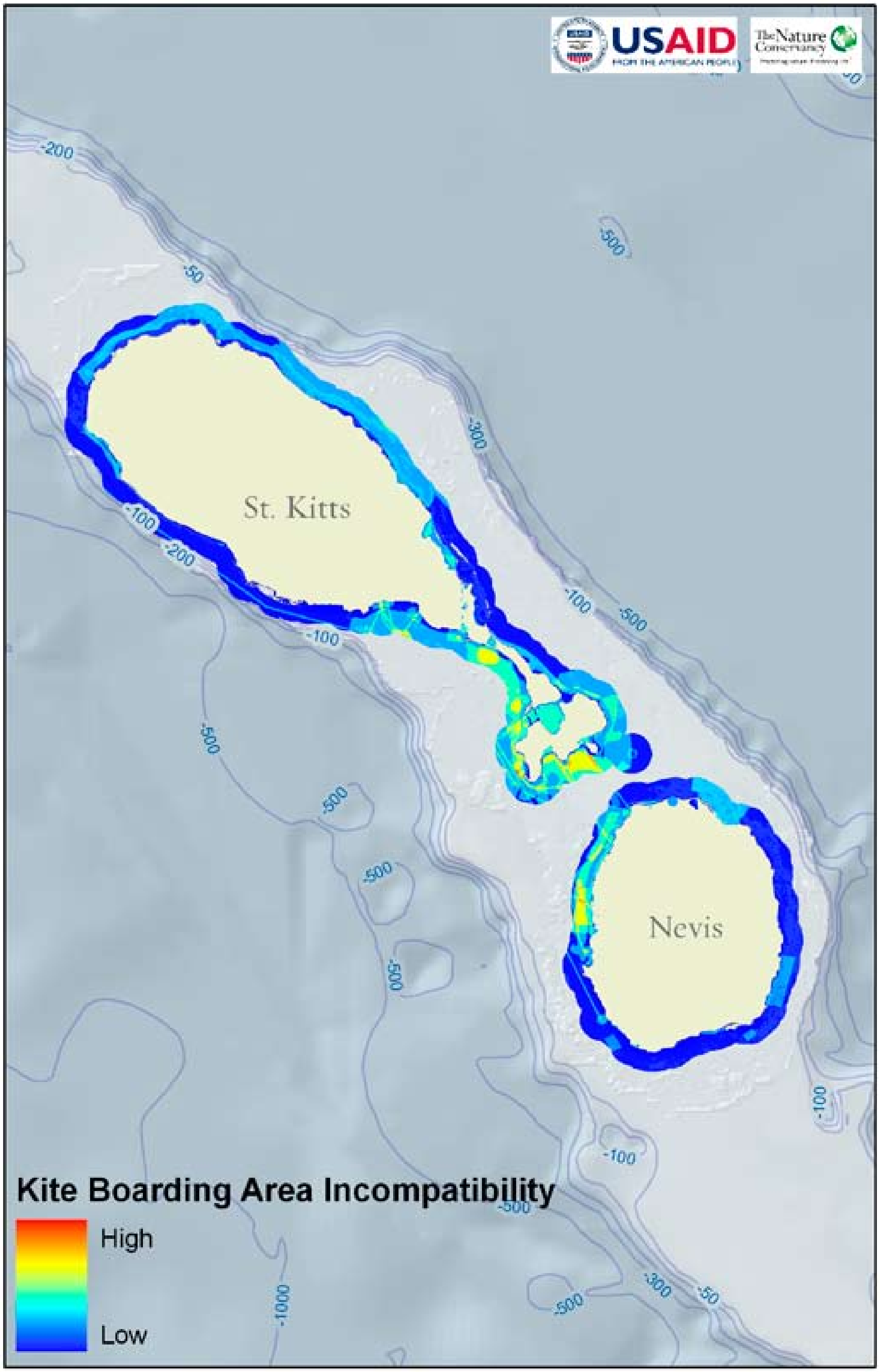
(t) Tourism Activity – Scuba Diving Sites: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for scuba diving.



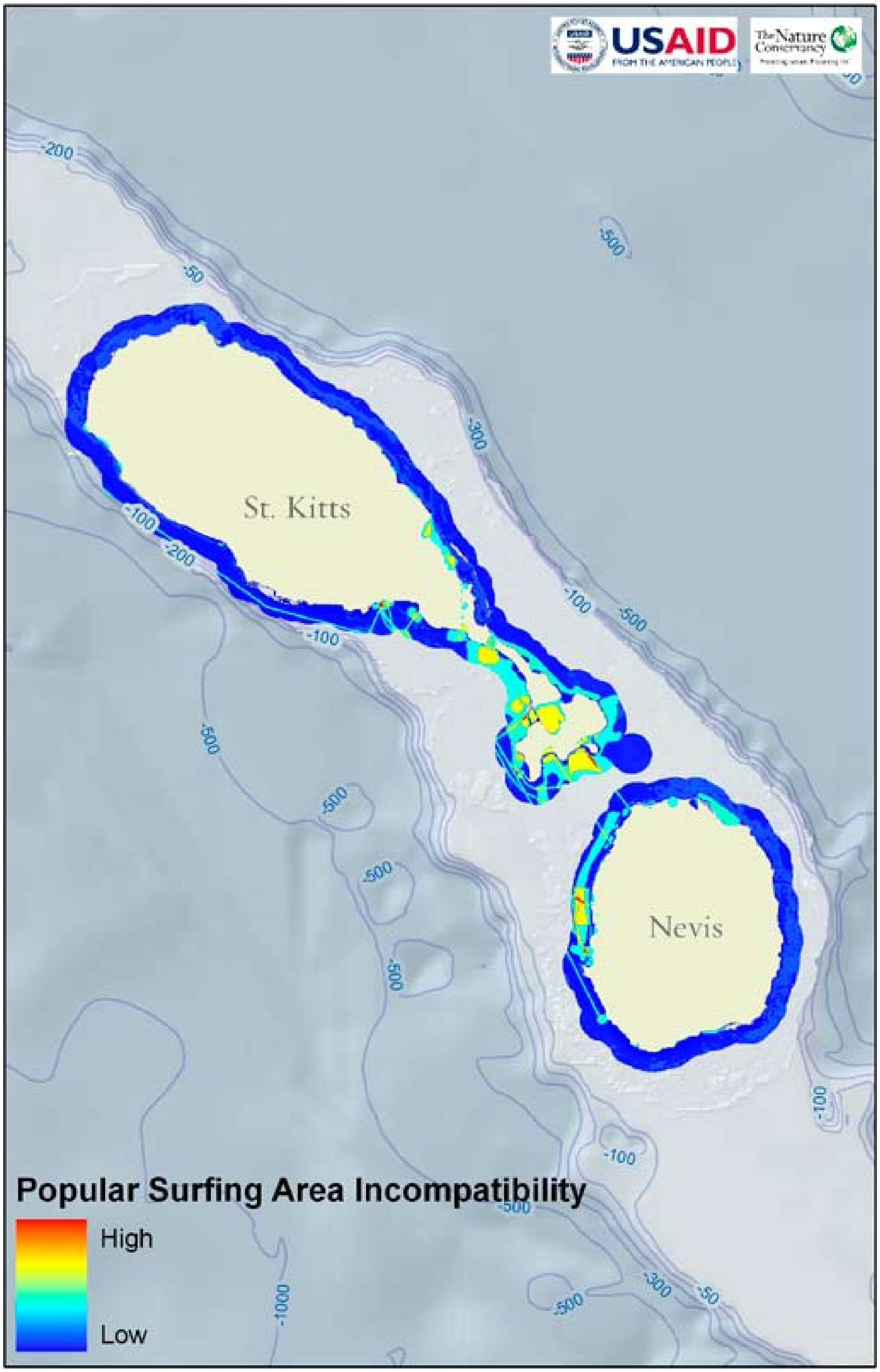
(u) Tourism Activity – Jet Ski Areas: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for jet skiing.



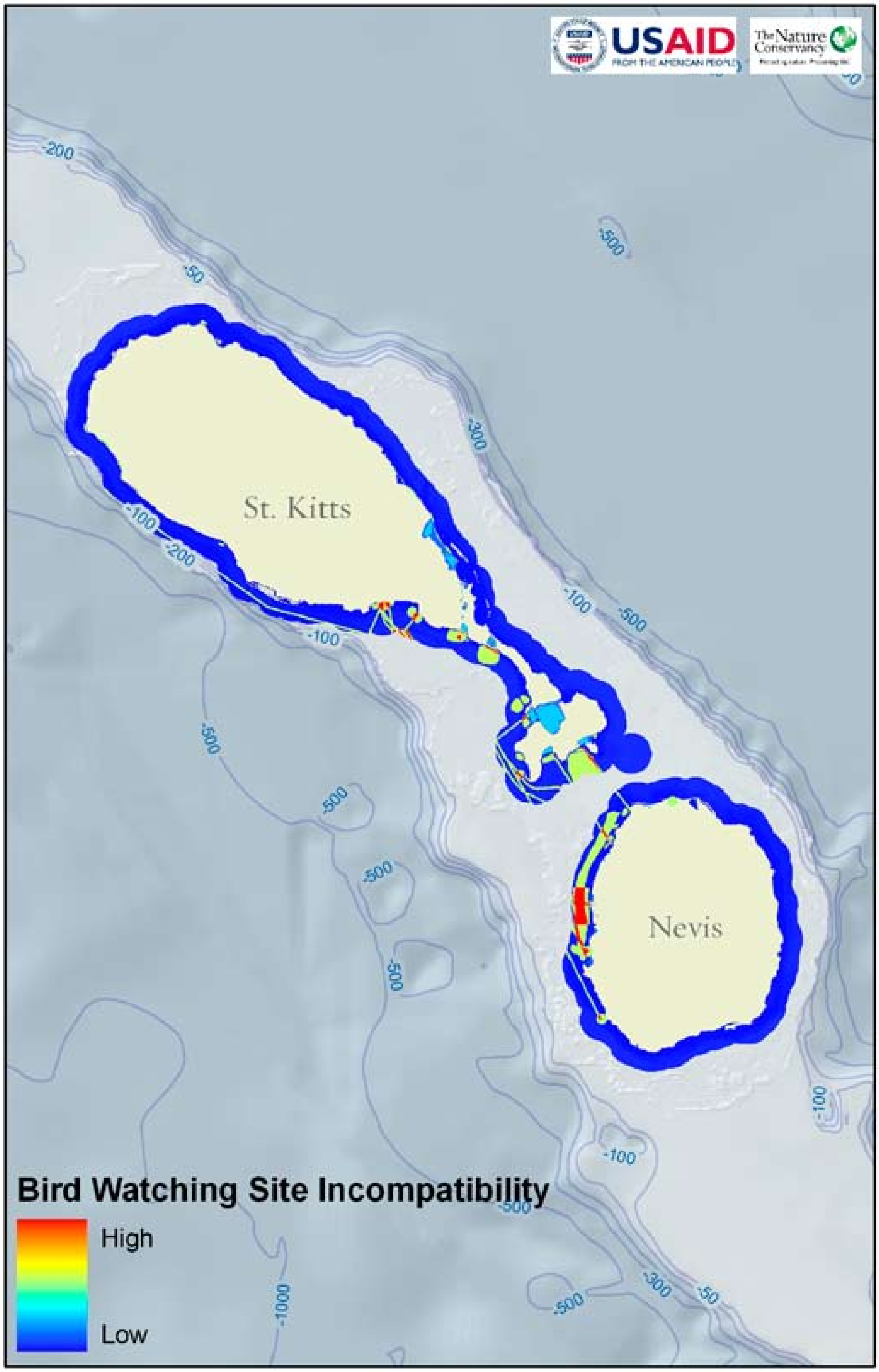
(v) Tourism Activity – Wind Surfing: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for wind surfing.



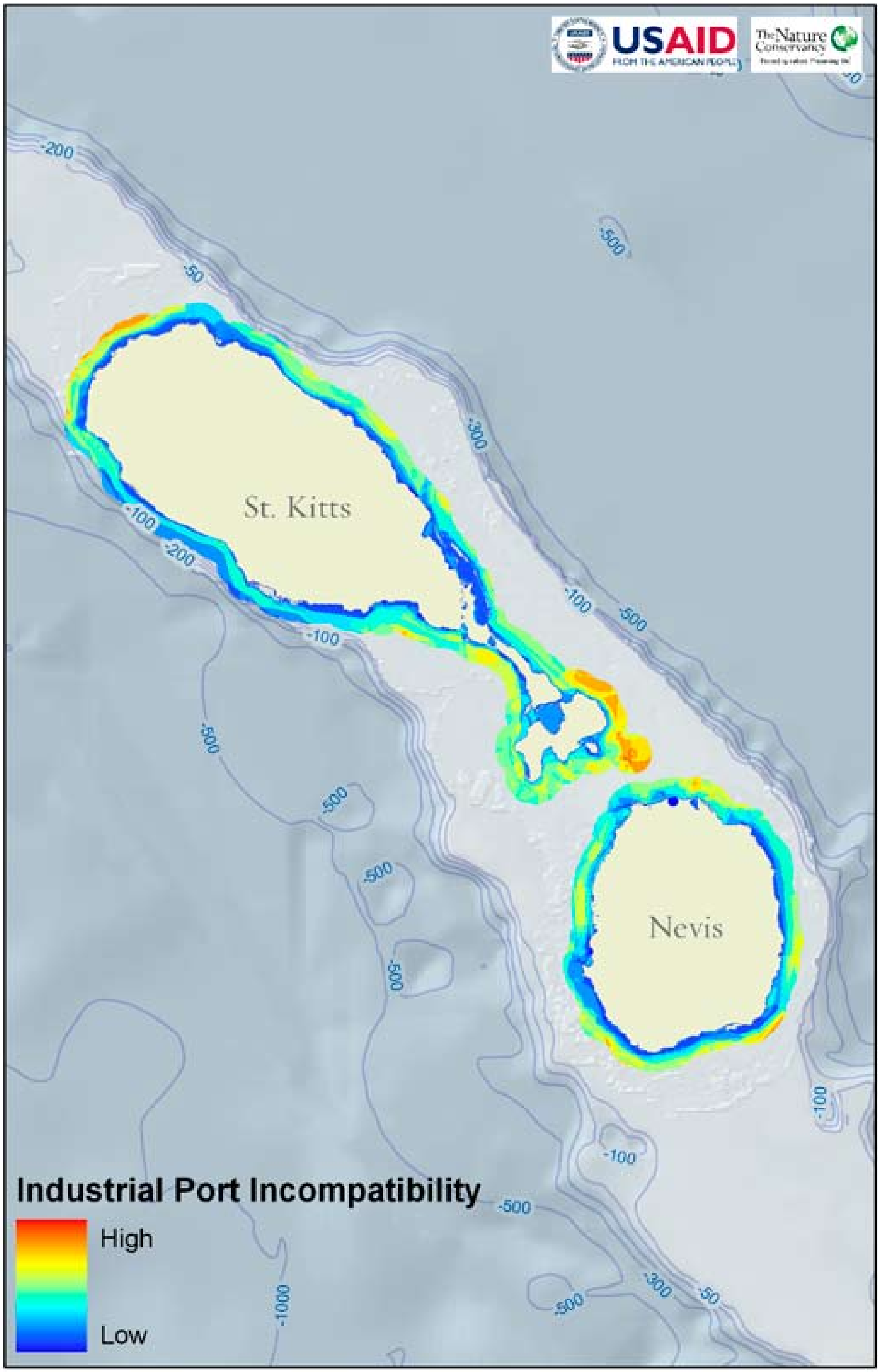
(w) Tourism Activity – Kite Boarding Areas: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for kite boarding.



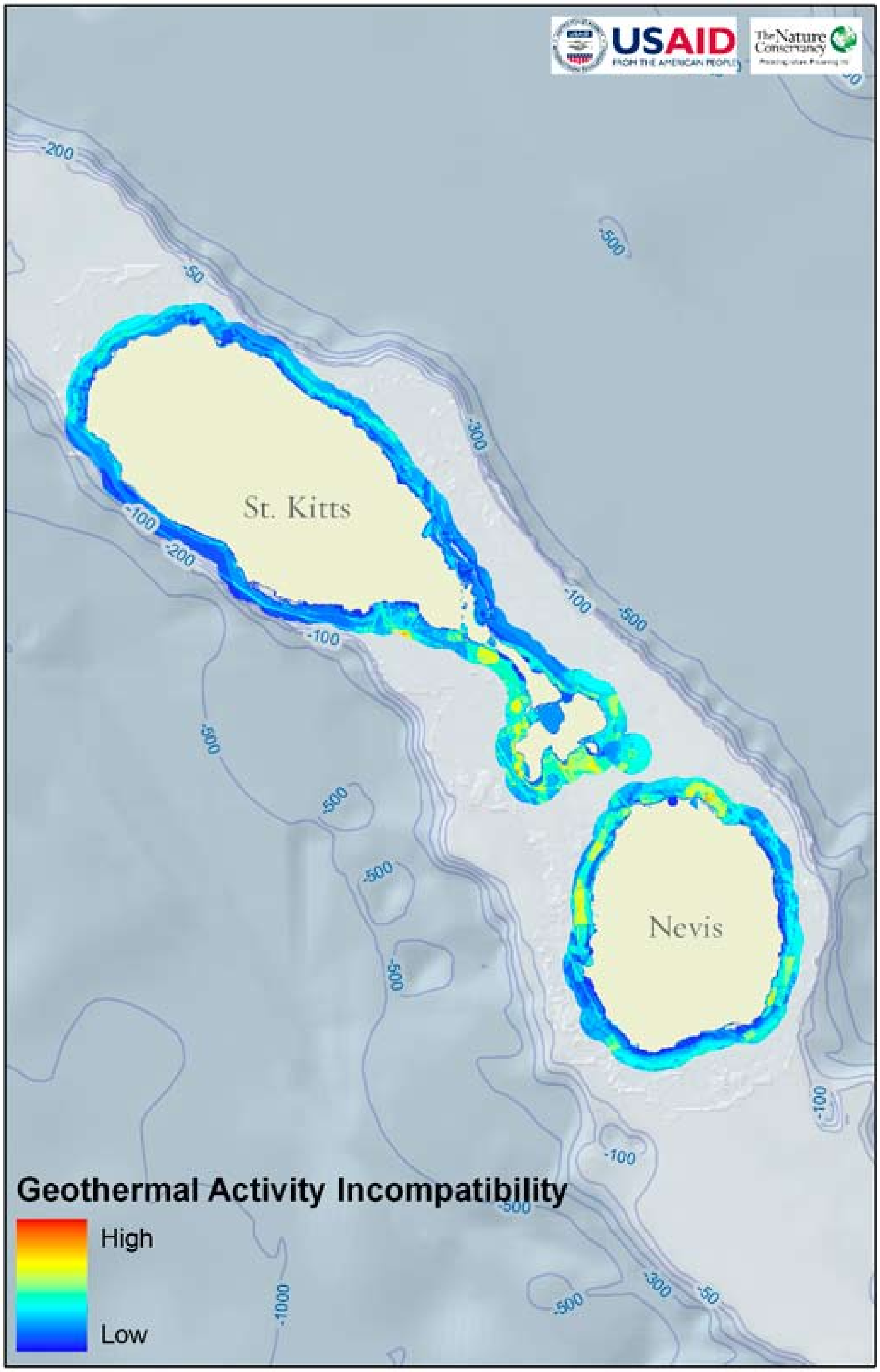
(x) Tourism Activity – Surfing: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for surfing.



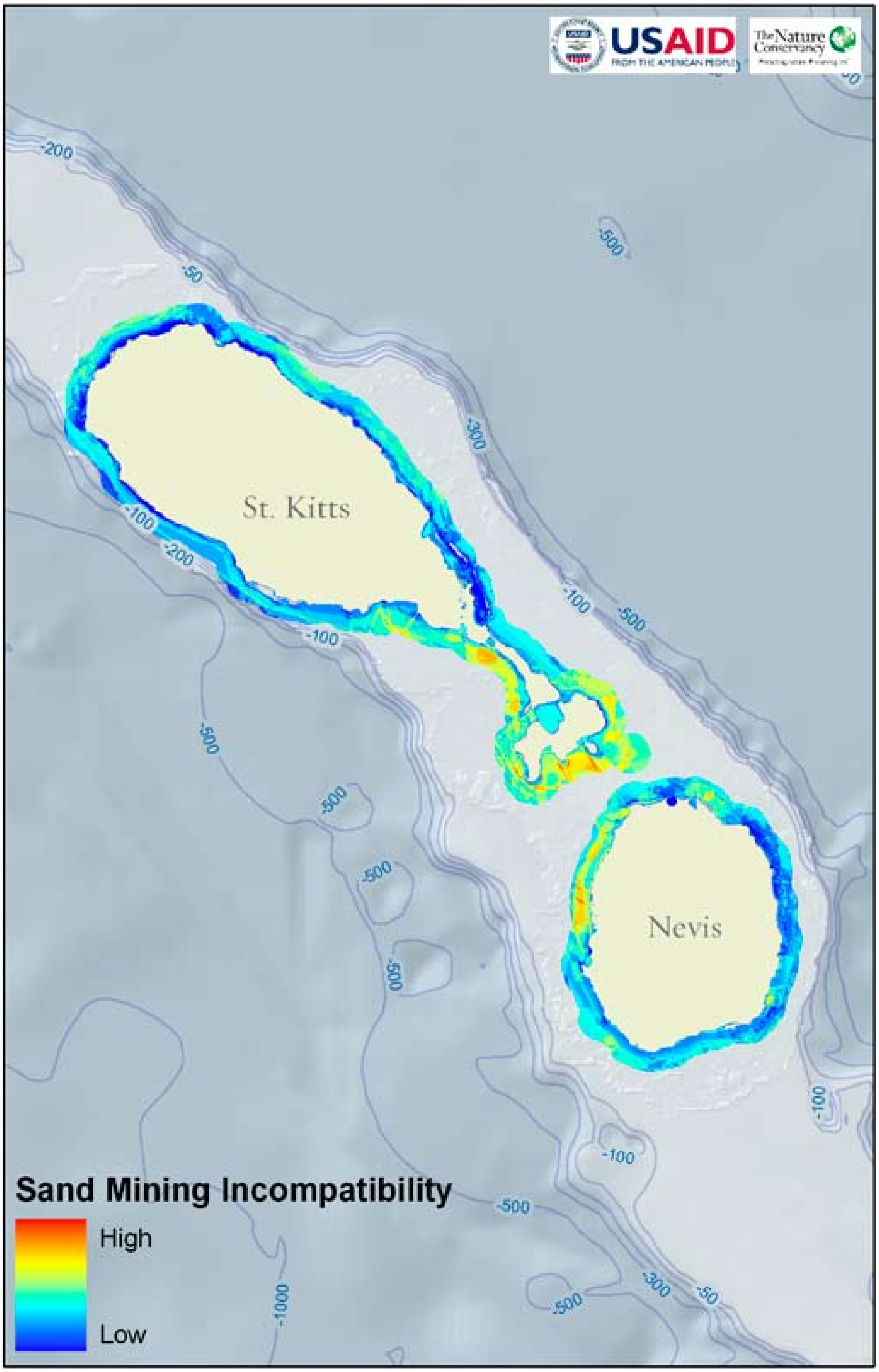
(y) Tourism Activity – Bird Watching: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for bird watching.



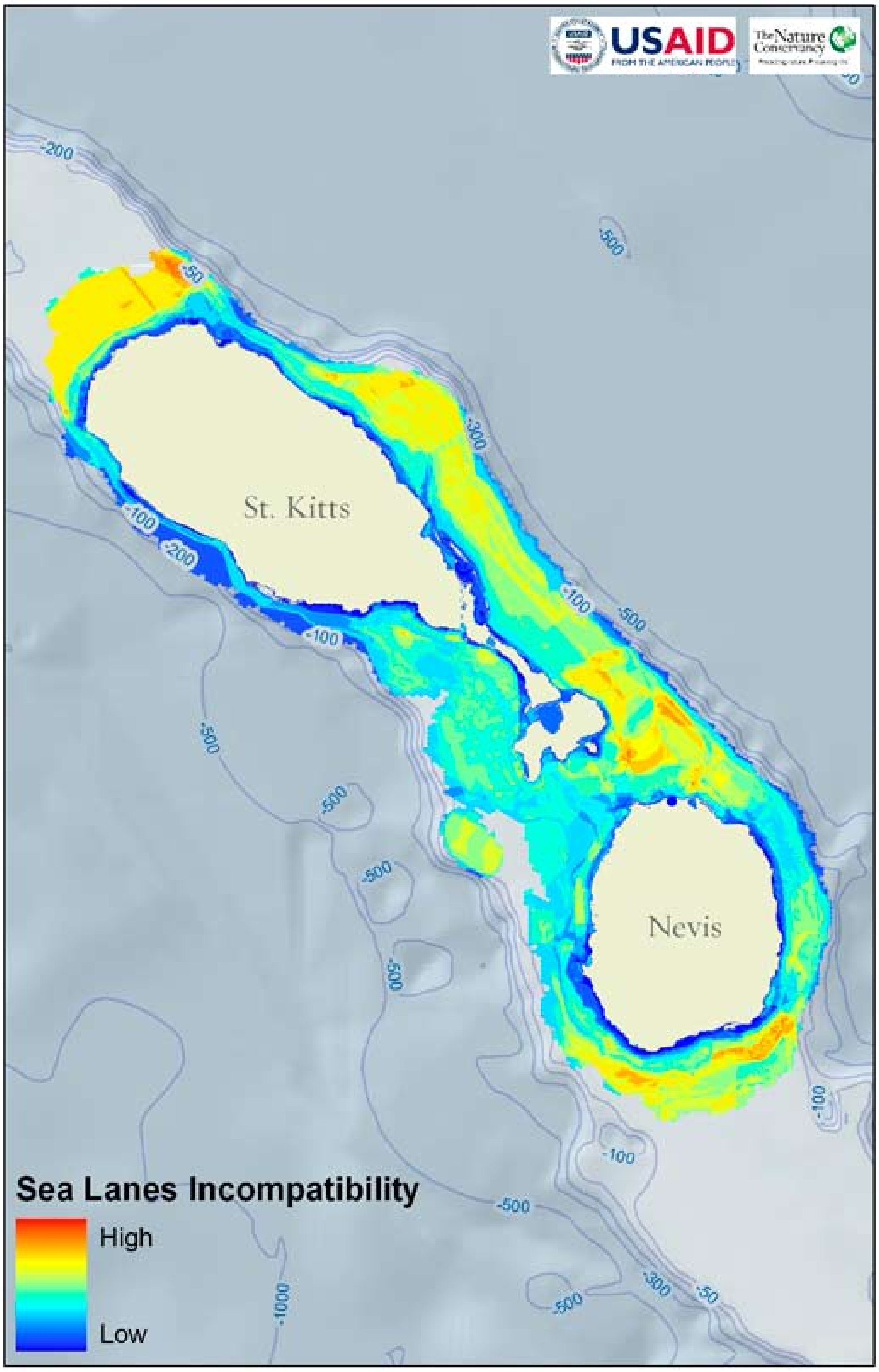
(z) Industrial Activity – Industrial Ports: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for industrial uses of industrial ports.



(aa) Industrial Activity – Geothermal Vents: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for industrial uses of geothermal vents.

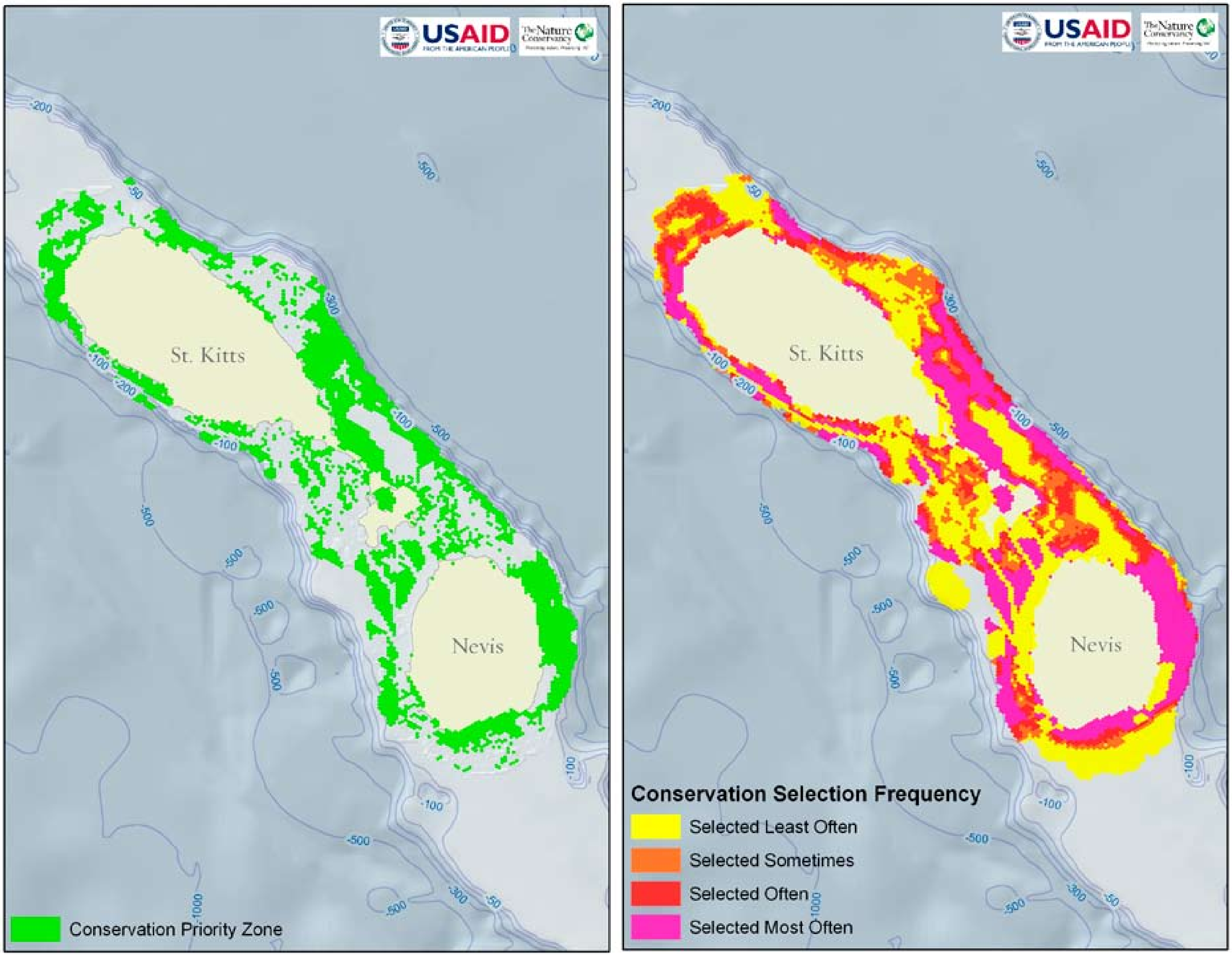


(bb) Industrial Activity – Sand Mining: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for sand mining.

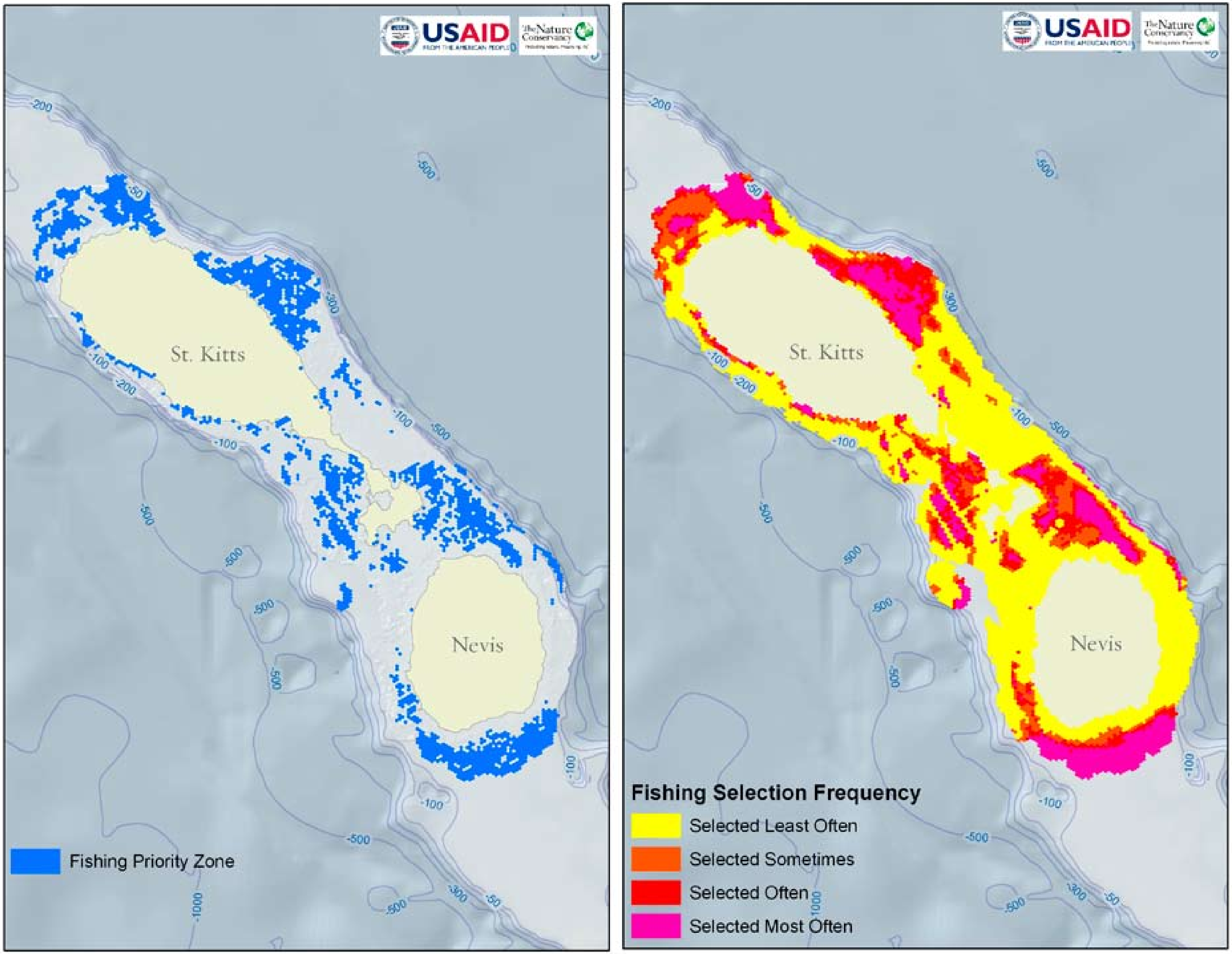


(cc) Transportation Activity – Sea Lanes: Areas in red and yellow indicate higher levels of incompatibility (or potential conflict) for sea lane traffic.

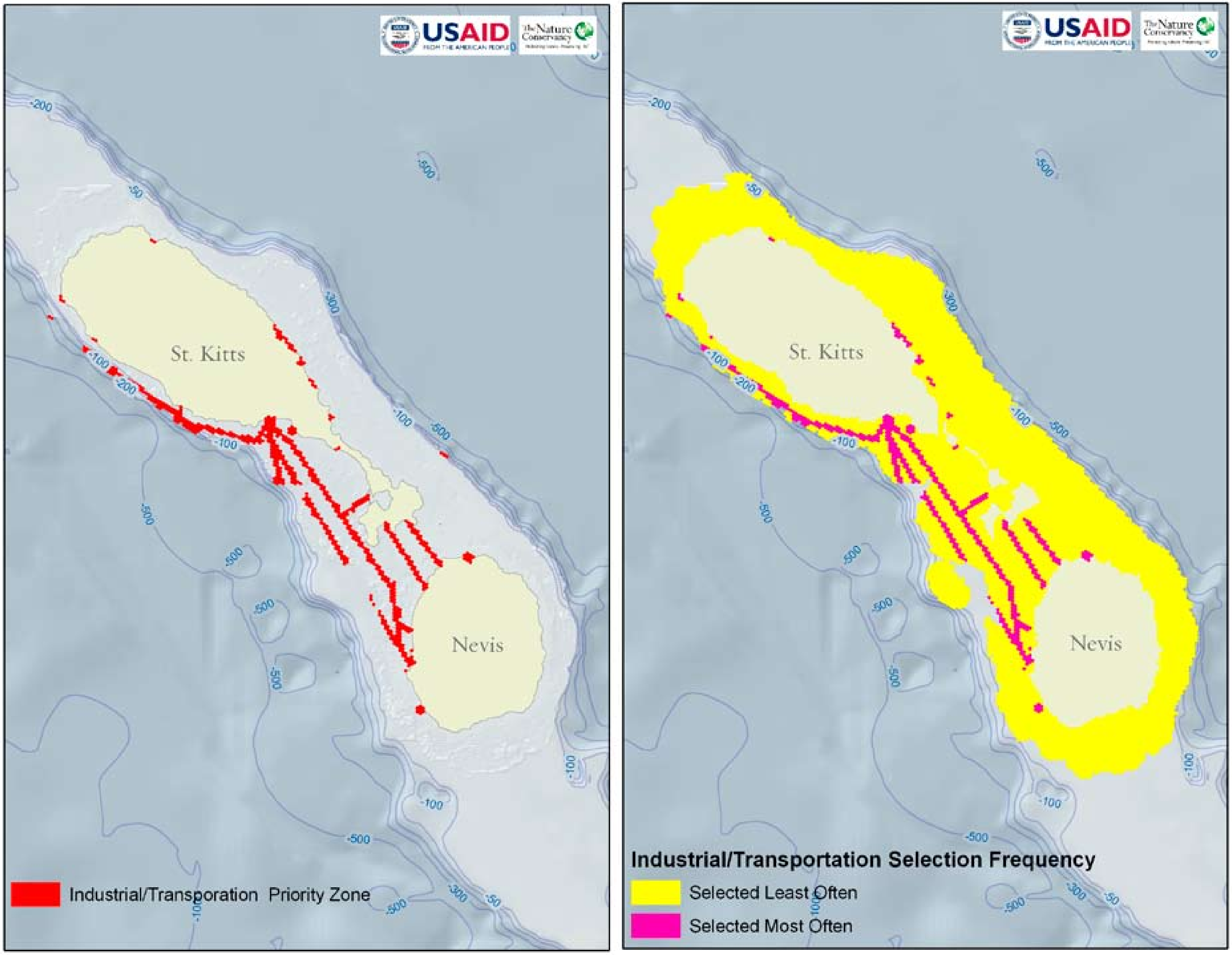
FIGURE E5. Selection Frequency: These maps represent information on how often each planning unit was assigned a specific zone based on 100 repetitions of the model. Higher numbers indicate higher value of that planning unit towards contributing to an optimal zoning configuration. These maps are useful to compare between runs in order to identify areas that are consistently assigned to specific zones. Areas that continually are assigned to the same zone, regardless of the run parameters, are important to meeting objectives of that zone.



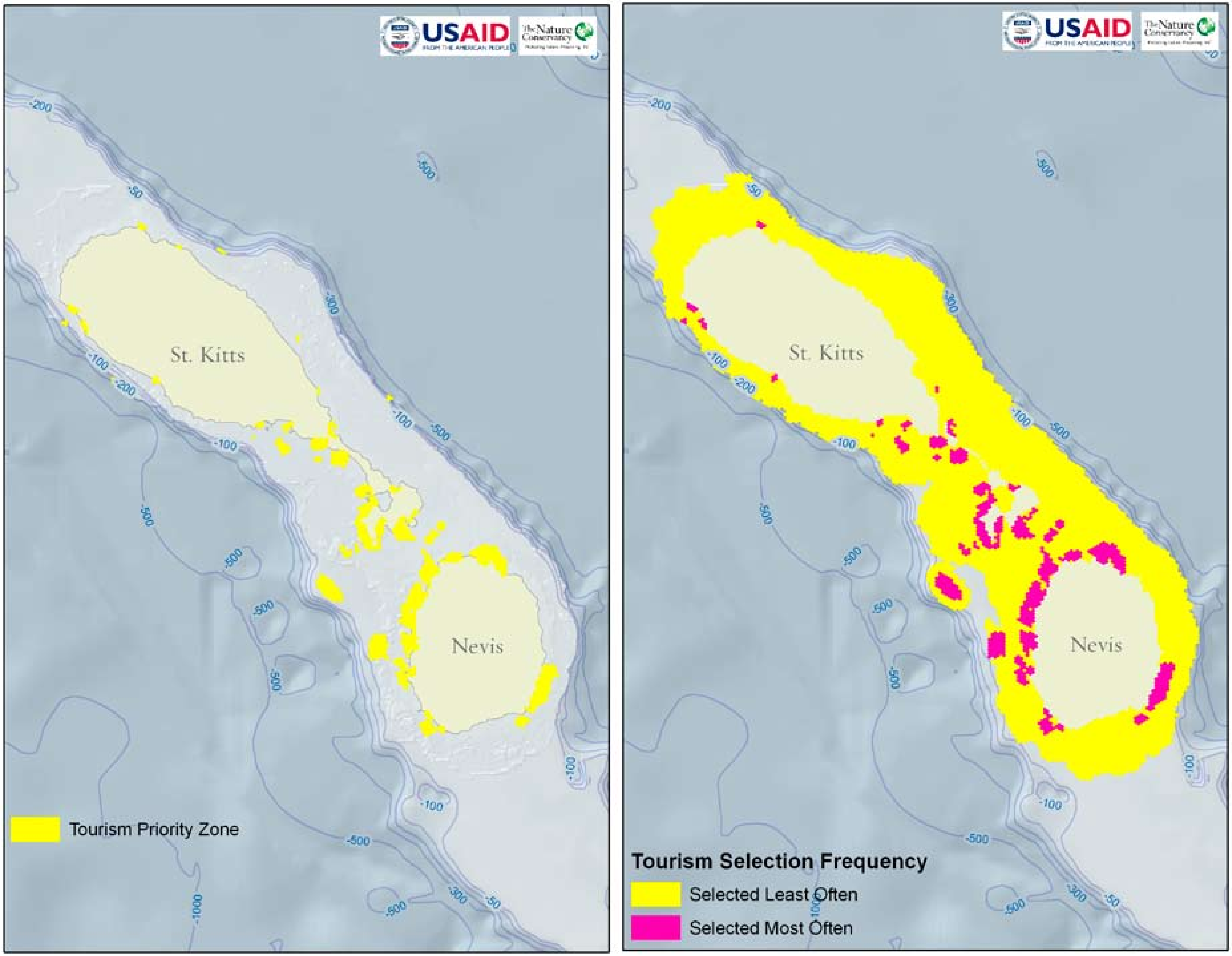
(a) Conservation: On the left are the high-priority conservation zone areas as modeled by Marxan with Zones, indicating an optimized solution for meeting conservation goals. On the right is the modeled selection frequency of the same solution showing the results in four classes of priority based on how often the areas were selected for inclusion in the solution.



(b) Fishing: On the left are the high-priority fishing zone areas as modeled by Marxan with Zones, indicating an optimized solution for meeting fishing goals. On the right is the modeled selection frequency of the same solution showing the results in four classes of priority based on how often the areas were selected for inclusion in the solution.

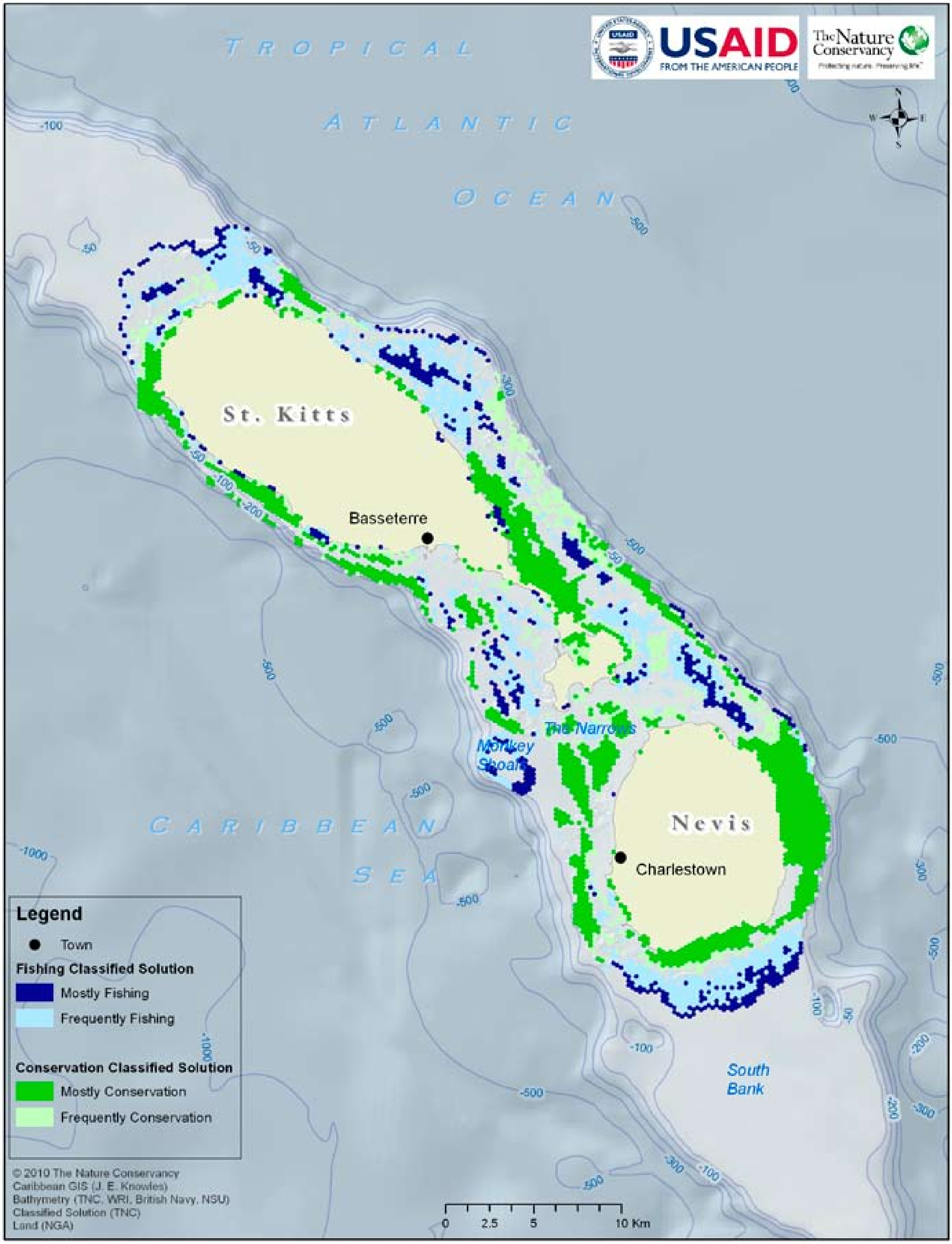


(c) Industrial/Transportation: On the left are the industrial/transportation areas that were locked into the zoning solution for the Flat Goal 30% and Variable Goals Reduced scenarios. On the right is the selection frequency of industrial/transportation areas showing locked (Selected Most Often) versus non-locked (Selected Least Often) locations.

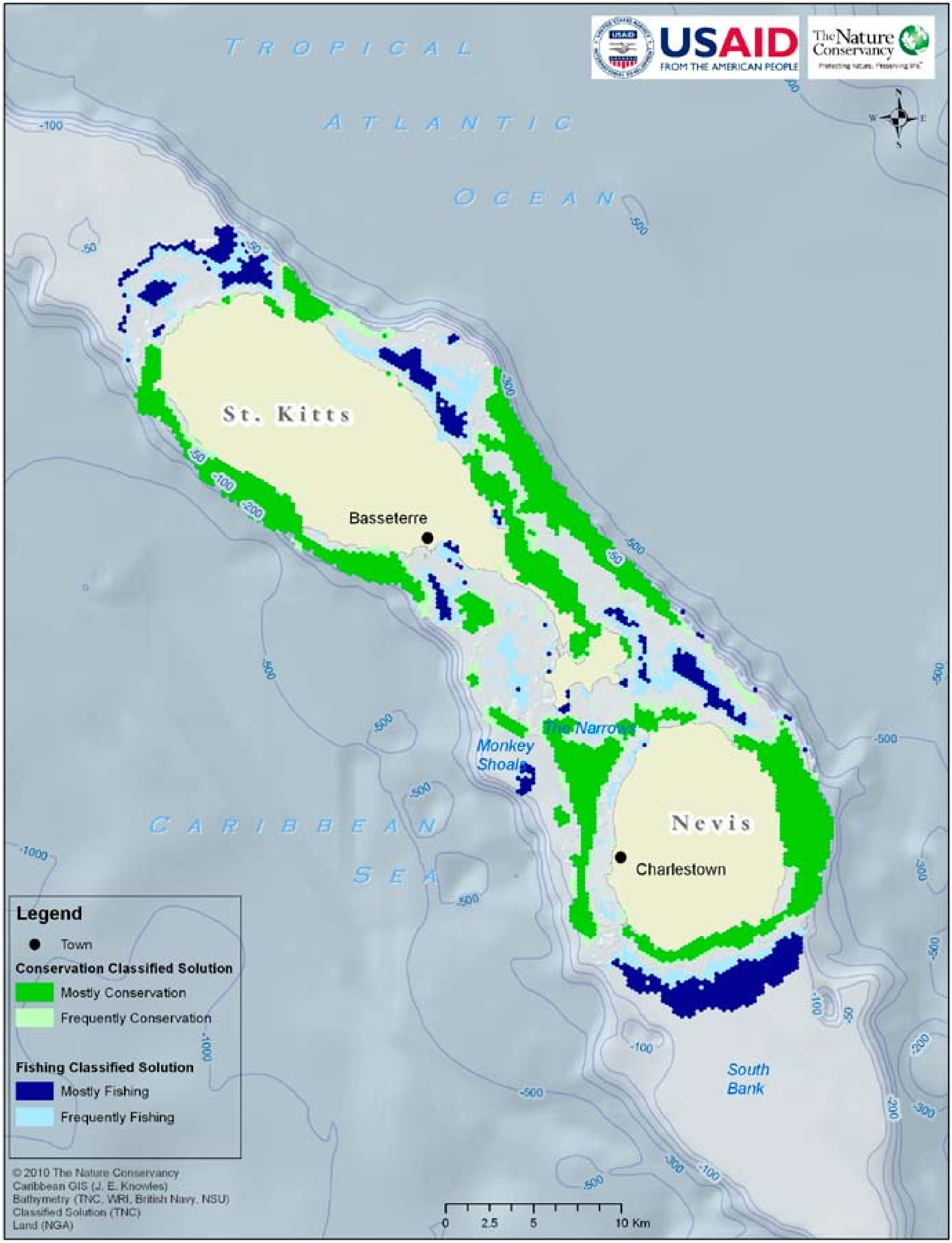


(d) Tourism: On the left are the tourism areas that were locked into the zoning solution for the Flat Goal 30% and Variable Goals Reduced scenarios. On the right is the selection frequency of tourism areas showing locked (Selected Most Often) versus non-locked (Selected Least Often) locations.

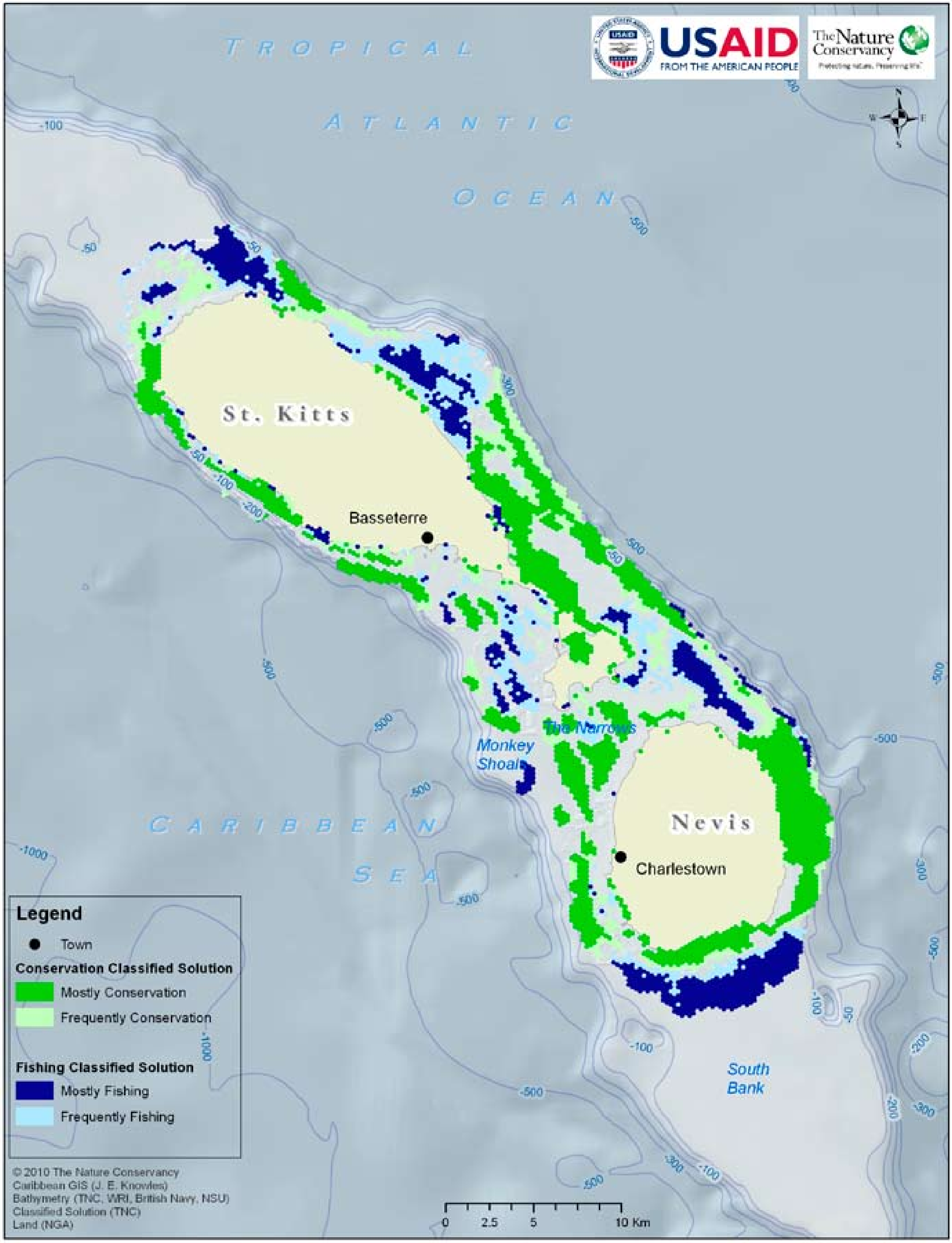
FIGURE E6. Classified Solution: These maps are similar to the selection frequency maps, but they integrate outputs for all four zones, categorizing each planning unit based on the number of times it was assigned or not assigned to each zone. In St. Kitts and Nevis, we focused on conservation and fishing, because tourism and industrial transportation had more fixed spatial distributions and limited footprints.



(a) Flat Goal 30% Lock: Fishing-priority and conservation-priority solutions based on the Flat Goal 30% Lock scenario using Marxan with Zones. Areas in dark blue indicate higher priority areas for reaching fishing goals, and areas in dark green represent higher priority areas for reaching conservation goals.

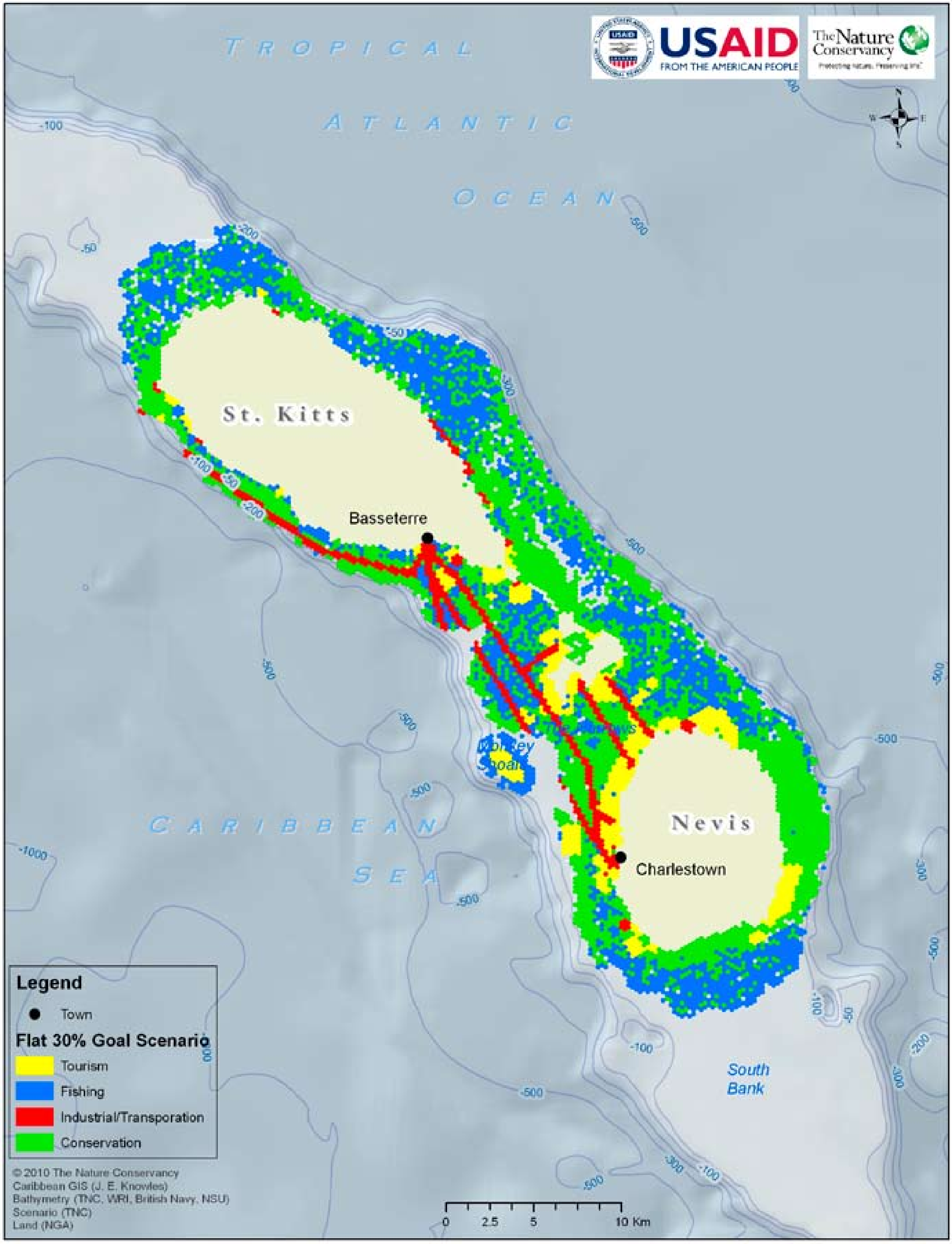


(b) Flat Goal 60% No Lock: Fishing-priority and conservation-priority solutions based on the Flat Goal 60% No Lock scenario using Marxan with Zones. Areas in dark blue indicate higher priority areas for reaching fishing goals and areas in dark green represent higher priority for optimally reaching conservation goals.

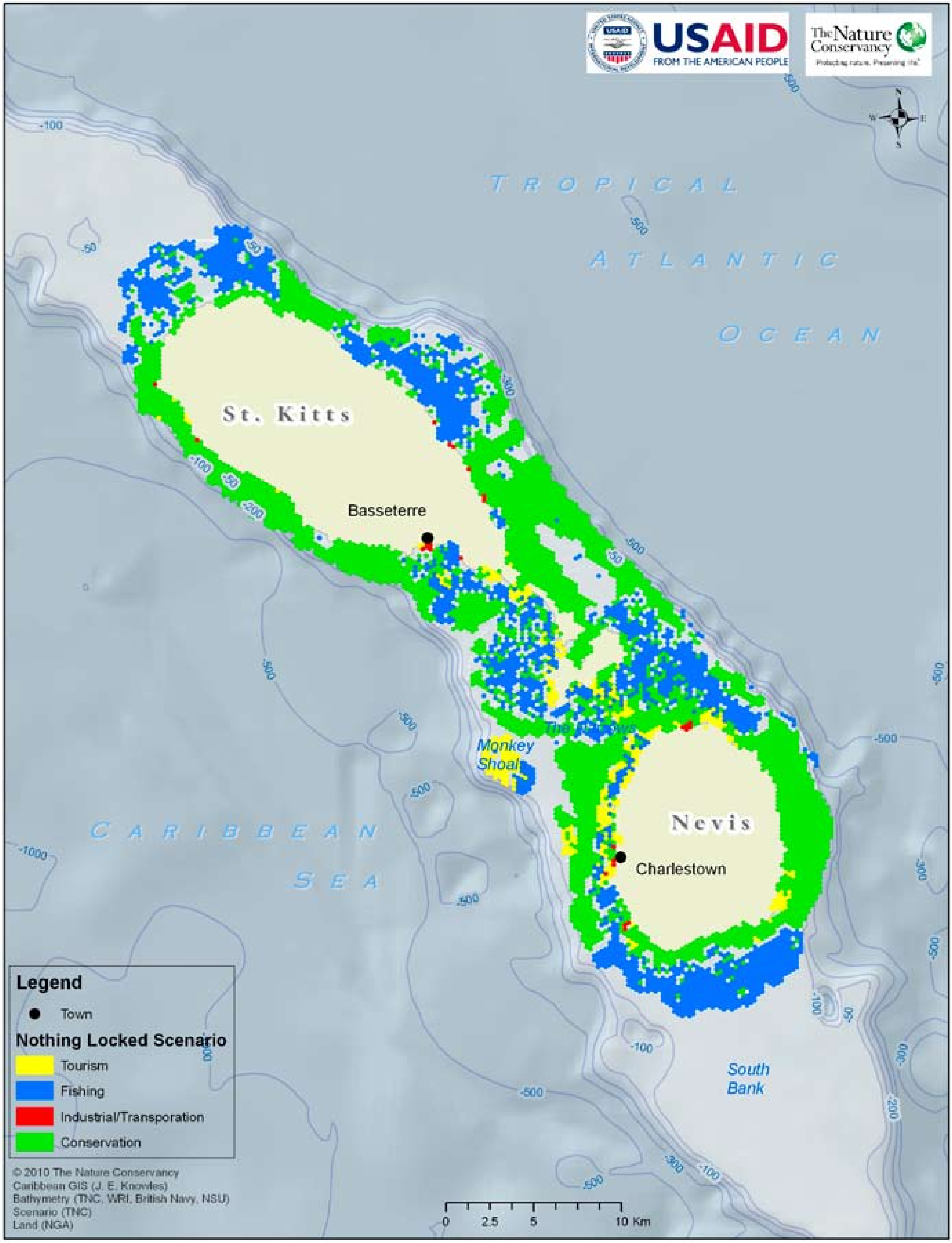


(c) Variable Goals Reduced Lock: Fishing-priority and conservation-priority solutions based on the Variable Goal Reduced Lock scenario using Marxan with Zones. Areas in dark blue indicate higher priority areas for reaching fishing goals, and areas in dark green represent higher priority areas for reaching conservation goals.

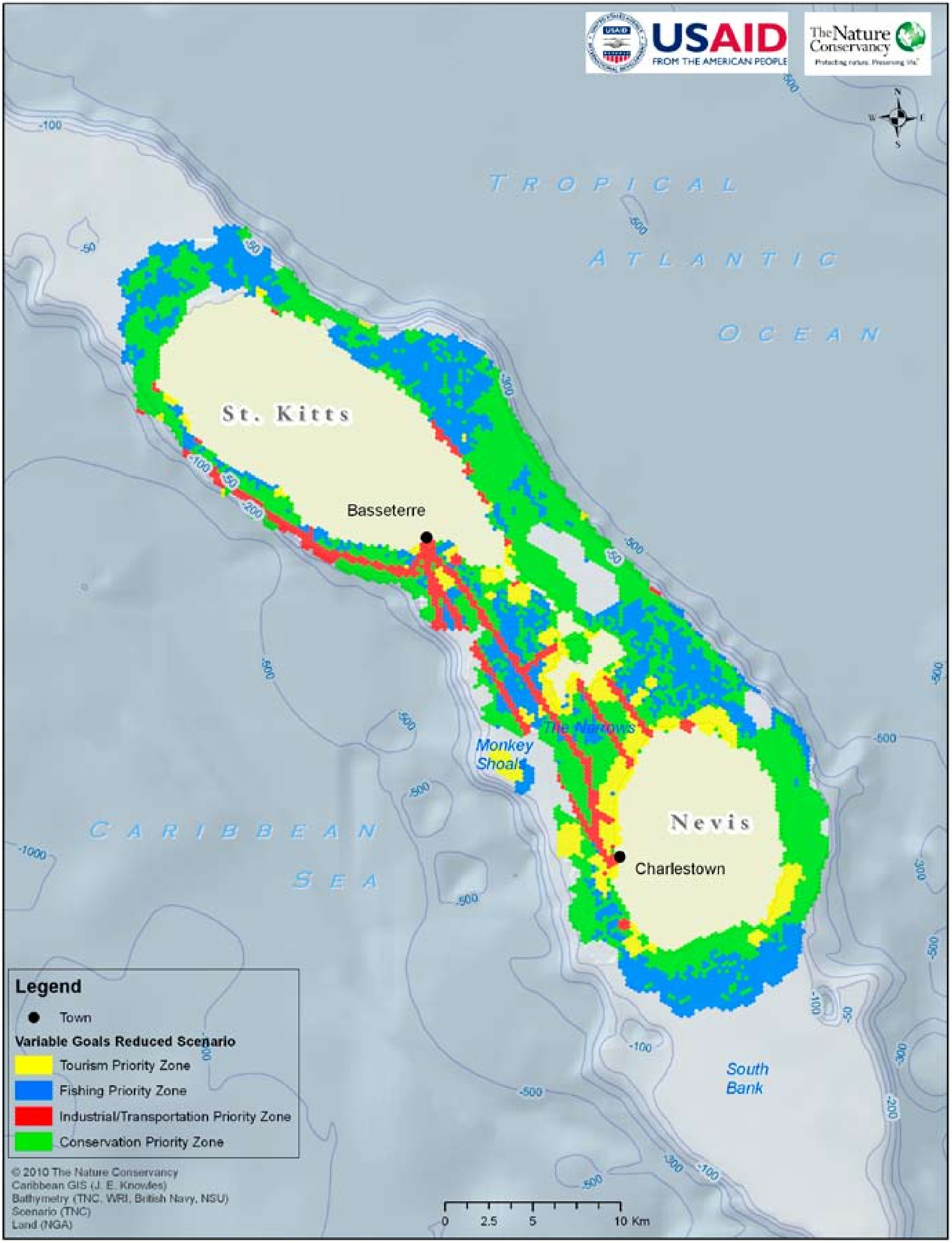
FIGURE E7. **Best Solution:** These maps represent the final, best (i.e., most compatible, least conflict) zoning configuration out of a set of 100 repetitions for each scenario. The "best solution" maps, often referred to as the most efficient solutions, represent the configuration of zones that best reduces overall conflict when trying to achieve zoning objectives and goals. It should be noted that the "best solution" maps represent only one solution amongst a set of different possible solutions. The terminology best and most efficient is linked to the mathematical efficiency of this solution, but should not be treated as an ideal scenario.



(a) Zoning Solution for the Flat Goal 30% Lock scenario: Optimized zoning solution for the Flat Goal 30% Lock scenario using Marxan with Zones. In this scenario, all features and activities for each zone were set to a 30% goal except for tourism and industrial/transportation uses that were locked into their respective zones.



(b) Zoning Solution for the Flat Goal 60% No Lock scenario: Optimized zoning solution for the Flat Goal 60% No Lock scenario using Marxan with Zones. In this scenario, all features and activities for each zone were set to a flat 60% goal and no planning units were intentionally locked into the solution.



(c) Zoning Solution for the Variable Goals Reduced Lock scenario: Optimized zoning solution for the Variable Goal Reduced Lock scenario using Marxan with Zones. In this scenario, all features and activities for each zone were set to goals defined in stakeholder workshops, except for tourism and industrial/transportation uses that were locked into their respective zones.

RESULTS AND DISCUSSION

Evaluating the Scenario Output Maps

A comparison of the best solution maps from each scenario reveals the location of core fishing and conservation areas, although the extent and size varies between scenarios. These areas represent the locations where fishing and conservation objectives can be met while minimizing conflict between uses. As an example of the type of analysis that could help support zoning decisions, we report below on the fishing intensity and habitat abundance for the four core fishing and five core conservation areas that were repeatedly identified in each of the model scenarios. Please note that the analysis reported here is by no means comprehensive; additional analysis should be implemented to continue to evaluate the scenario outputs generated.

Four core fishing areas emerged from the Marxan with Zones analysis (Figure E8):

1) northern bank (north of St. Kitts),

2) northeastern Atlantic side of St. Kitts,

3) southeastern Atlantic side near The Narrows, and

4) southern bank (south of Nevis).

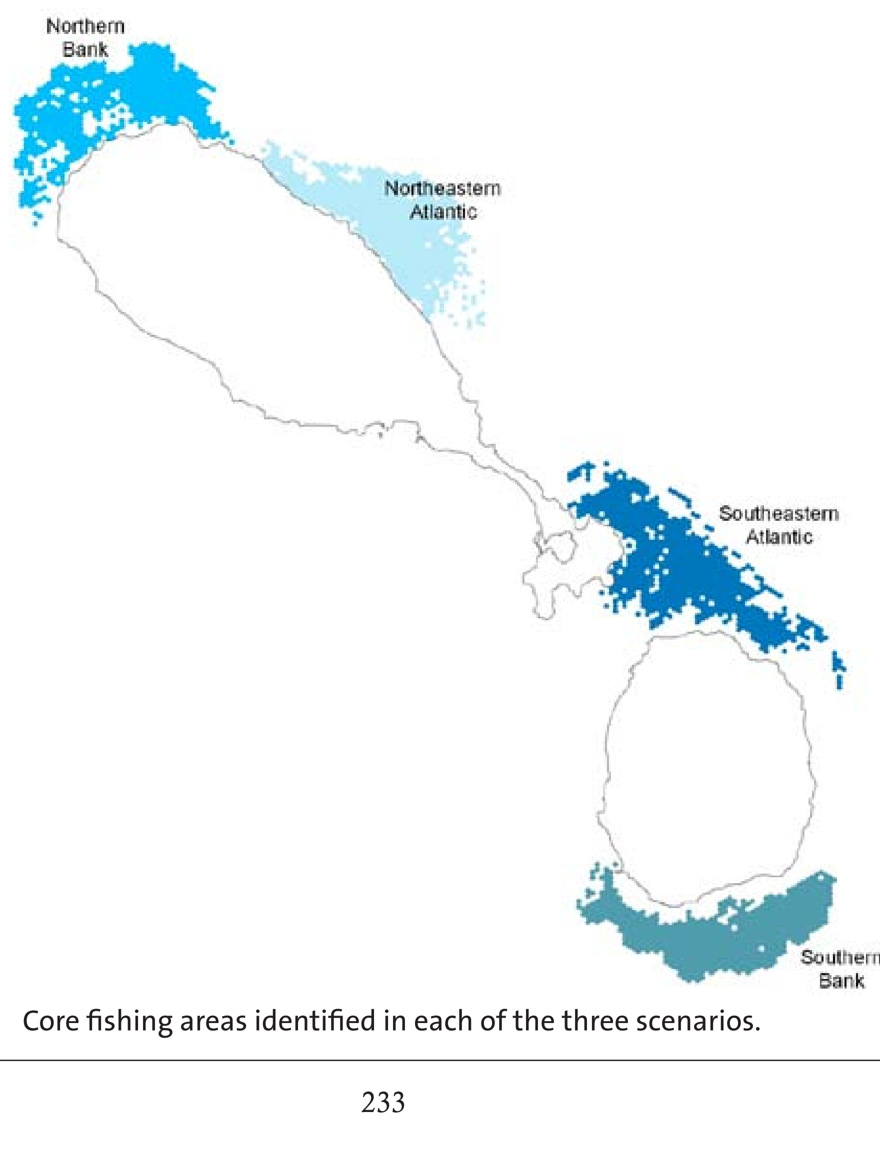


FIGURE E8. Core fishing areas identified in each of the three scenarios.

Similarly, five core conservation areas emerged (Figure E9):

1) western Caribbean side of St. Kitts,

2) northeastern Atlantic side of St. Kitts (off and to the north of Black Rocks),

3) eastern Atlantic side of St. Kitts,

4) eastern Atlantic side of Nevis, and

5) western Caribbean side of Nevis and the Narrows.

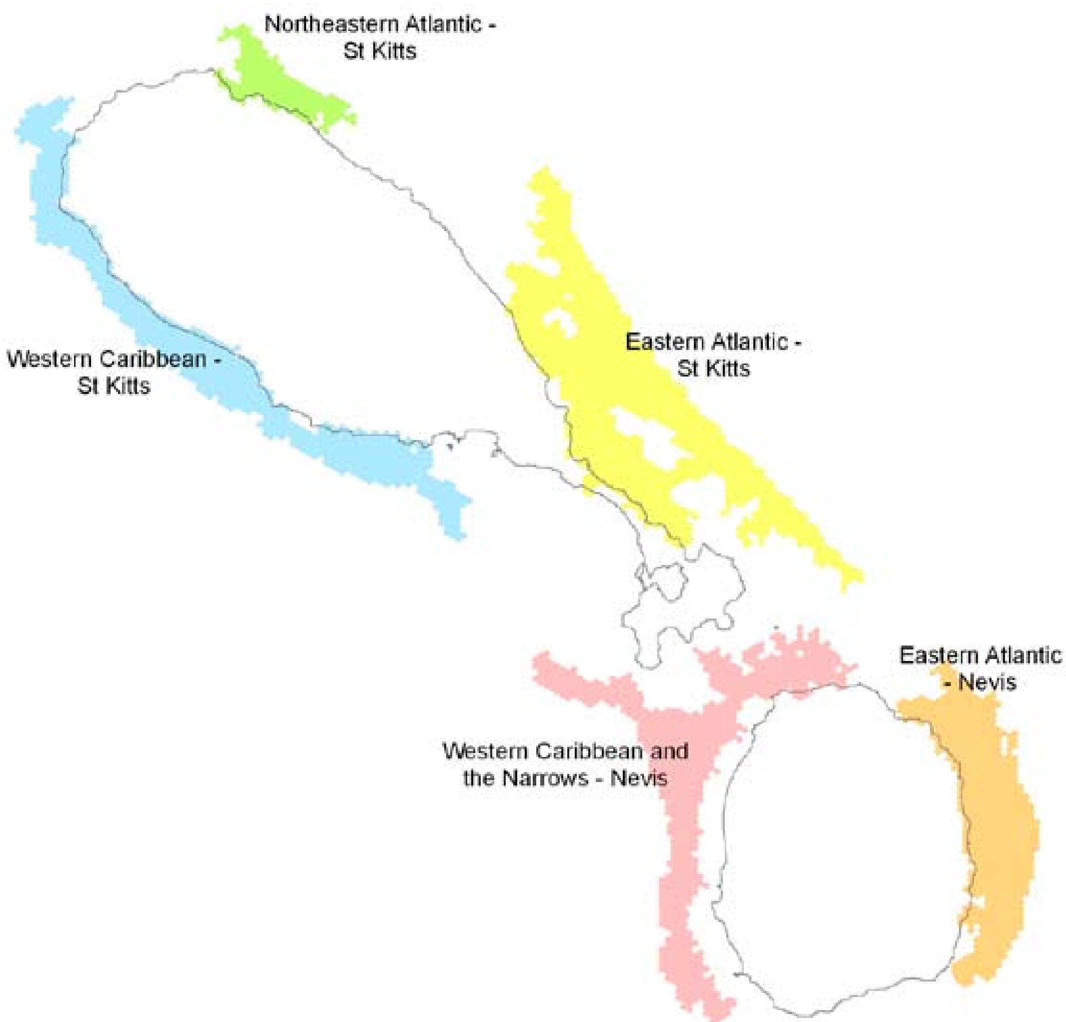


FIGURE E9. Core conservation areas identified in each of the three scenarios.

Fishing intensity, or the level of fishing activity as reported in the fishing surveys, can also be evaluated across scenarios for each of the four core fishing areas (Figure E10). This allows for an assessment of the relative importance of each area for specific fisheries. For coastal demersals, the southeastern area (0.65) and southern banks (0.68) achieved the highest intensity levels, while deep demersals had the highest representation in both the northern and southern bank (0.27) across all three scenarios. Overwhelmingly, coastal pelagic fishing reaches the highest intensity levels across all three scenarios in the northeastern area (0.50). Conch and lobster achieve high levels of intensity for both the southeastern and southern bank with the highest—0.28 for conch, 0.42 for lobster—being in the southern bank for Scenario 2: Flat 60 No Lock.

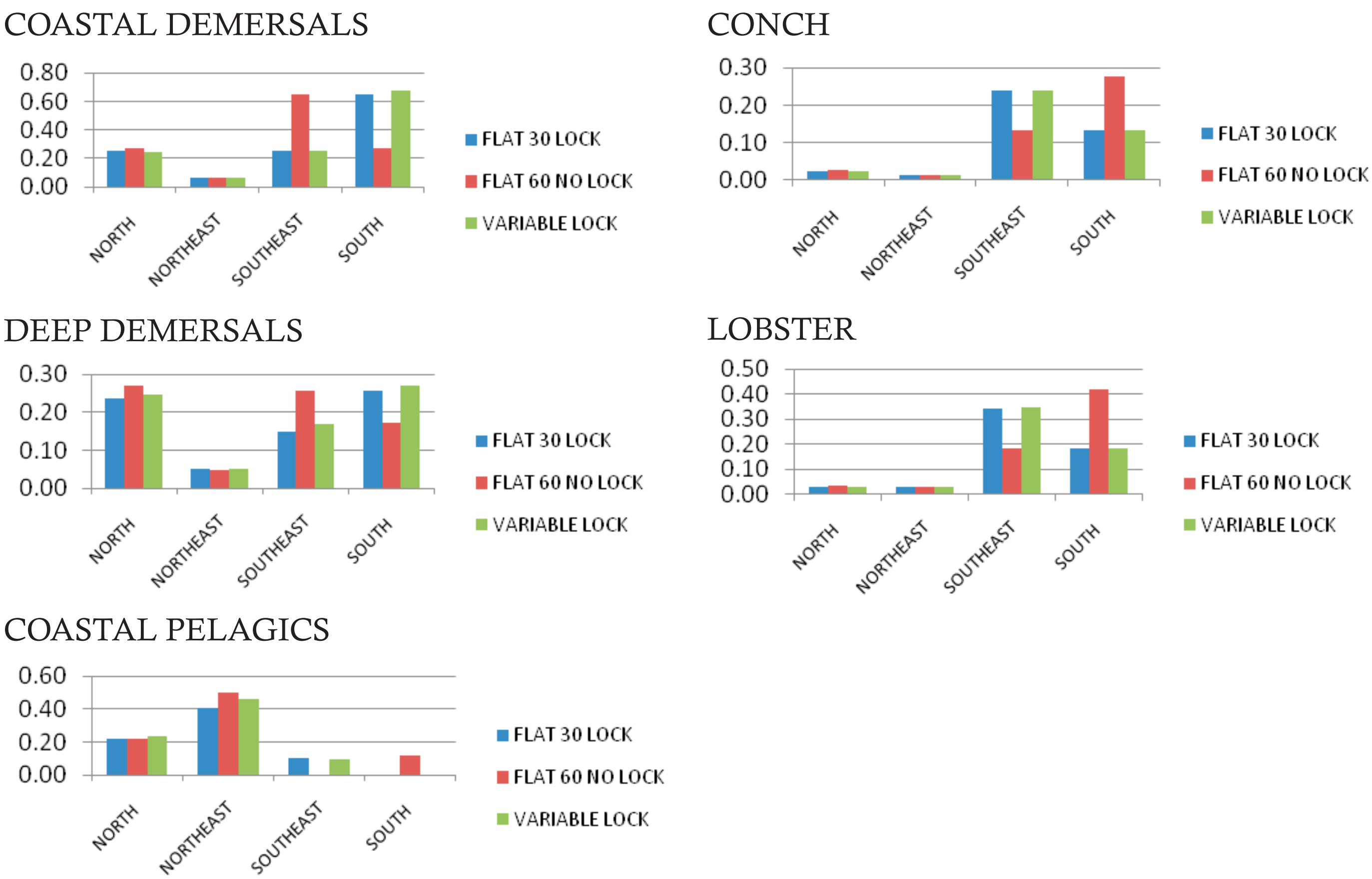
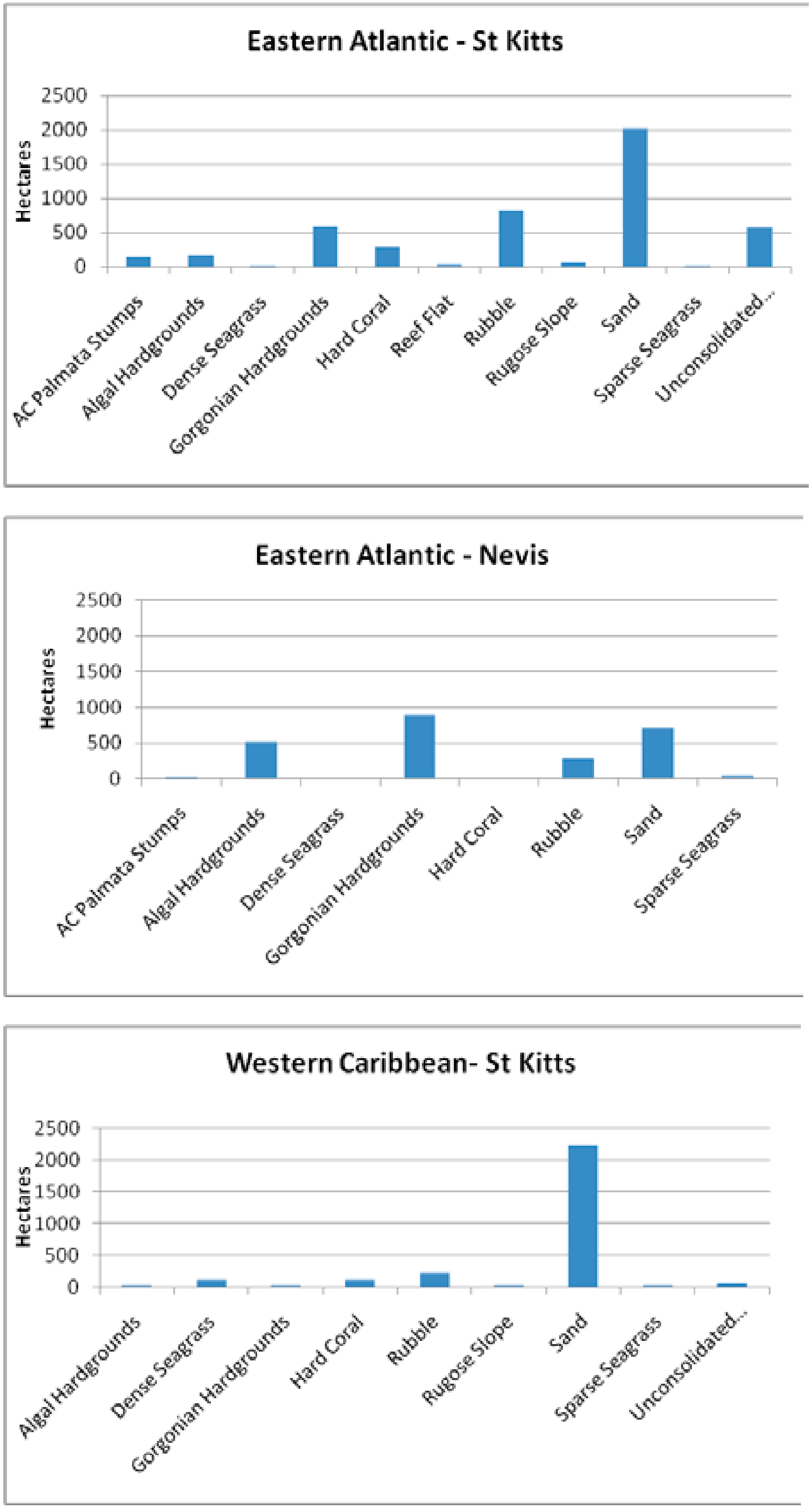


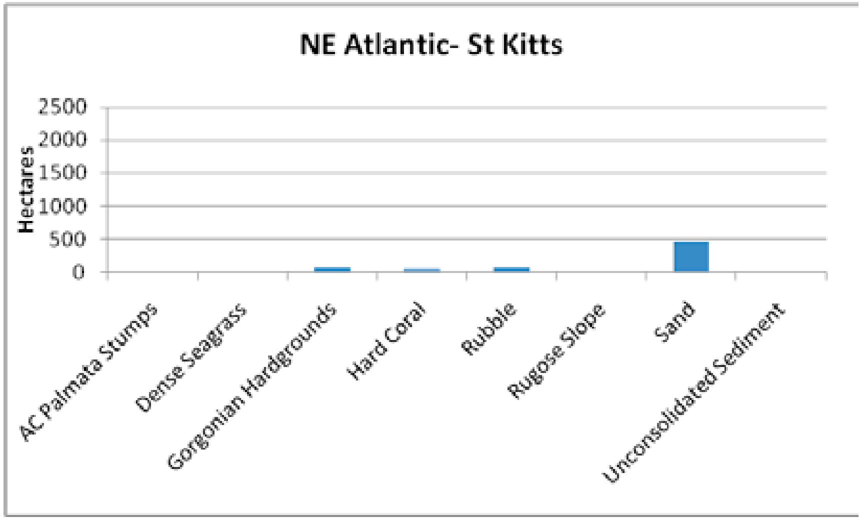
FIGURE E10. Fishing intensity values (0.0 is low and 1.0 is high) by fishery within each of four core fishing areas for each model scenario.

Similarly one can evaluate the amount by hectare of specific habitat types present in each conservation area and determine what areas are most important for the conservation of specific habitat types. As can be seen in Figure E11, the core conservation areas located on the eastern side of both St. Kitts and Nevis contain the highest variety of habitats when compared to the other conservation areas. Sand is usually present in the greatest quantity compared to other habitat types with the exception of the eastern side of Nevis, where gorgonian and algal hardground are present in similar quantities. Dense seagrass is present in larger quantities compared to the other conservation areas in the Western Caribbean and The Narrows conservation area near Nevis.



(continued on next page)

FIGURE E11. Amount of habitat by type in each of five core conservation areas.



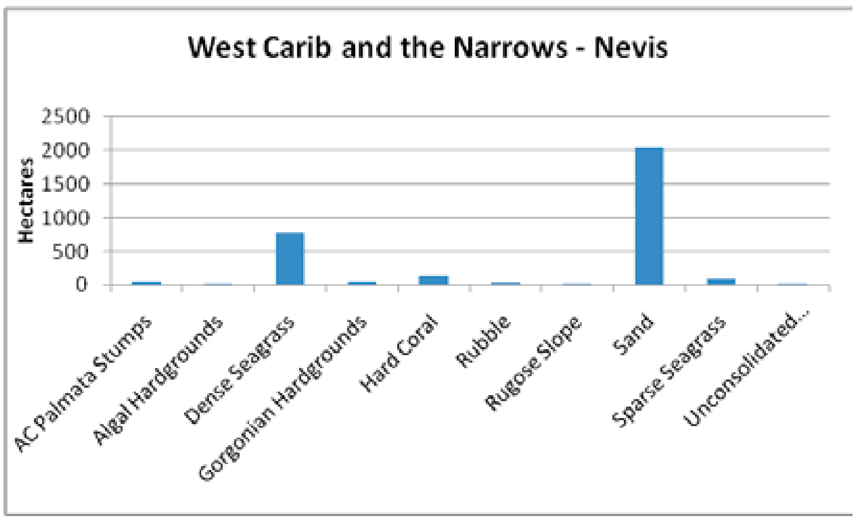


FIGURE E11 ***(continued).*** Amount of habitat by type in each of five core conservation areas.

Evaluating the Tabular Output

Marxan with Zones also produces tabular output for each scenario, reporting how much of the goal is achieved in the overall solution and the allocation of features or activities to each particular zone (usually in hectares for areas and kilometers for length). These tabular outputs are presented in Table E3. Note that while overall goals were met, not all of the individual zoning goals were met for each of the corresponding activities and features in each of the three scenarios. This may be attributed to certain planning units being unavailable because they are locked into a particular zone, the underlying constraints for a planning unit set by the assigned goal is too high, or the input scenario parameters constrained the model so not all goals could be achieved. The tables provide a way to assess gaps in goals achieved for each of the activities or features in a particular zone given the chosen input parameters, and they can be used to identify needs for either modifying goals or expanding zones to sufficiently achieve goals. They also provide a way to evaluate how much of each feature or activity is included in each zone given a zone configuration generated by a specific solution.

In reviewing model output, it is important to remember that Marxan with Zones provides decision support and is not the decision maker. The program does not provide the ultimate solution, and many of the input parameters require experimentation. Each output solution should be subject to visual inspection, and local knowledge should be incorporated to update and improve future model runs. Sensitivity analysis of parameters can improve the robustness of model outputs. Marxan with Zones was a useful tool to understand the complex spatial interactions of multiple uses and objectives within the marine shelf area of St. Kitts and Nevis. Additionally, the mapped inputs and outputs assisted in the visualization of zoned marine areas from the perspective of Kittitians and Nevisians (see Section 3.5 of main report). Using Marxan with Zones in a planning process is aligned with The Nature Conservancy's aim of choosing appropriate science-based tools to help communities make informed decisions to sustainably manage resources.

TABLE E3. Results of the three scenarios as summarized in the mvbest.txt output files from Marxan with Zones.

Scenario 1: Flat 30 Lock

Feature Name	Goal	Total Amount	Goal Met	Goal Tourism	Amount Held Tourism	Goal Met Tourism
Tourism_Anchoring	79.413	264.71	yes	132.355	184.14	yes
Tourism_Mooring	122.781	409.27	yes	204.635	325.73	yes
Tourism_Swimming_Snorklin	34.707	115.69	yes	57.845	105.69	yes
Tourism_Scuba_Diving	384.669	1282.23	yes	641.115	913.62	yes
Tourism_Jet_Ski	172.827	576.09	yes	288.045	339.78	yes
Tourism_Surfing	26.013	86.71	yes	43.355	85.71	yes
Tourism_Kite_Boarding	33.237	110.79	yes	55.395	110.79	yes
Tourism_Wind_Surfing	50.691	168.97	yes	84.485	164.06	yes
Tourism_Bird_Watching	30.018	100.06	yes	50.03	88.65	yes
				Fishing	**Amount Held**	**Goal Met**
Fishing_Coastal_Pelagics	287.456	958.185	yes	479.0926	479.1021	yes
Fishing_Coastal_Demersals	334.297	1114.32	yes	557.1612	557.1686	yes
Fishing_Demersal_Shelf	184.182	613.939	yes	306.9695	307.2624	yes
Fishing_Lobster	164.214	547.38	yes	273.69	274.3422	yes
Fishing_Conch	117.508	391.693	yes	195.8464	195.8928	yes
Fishing_Bait	23.2287	77.4291	yes	38.71455	13.8743	no
				Conservation	**Amount Held**	**Goal Met**
Conservation_Coastal_Lagoons	70.59	235.3	yes	117.65	118.74	yes
Conservation_Coral_Reef_Good	722.841	2409.47	yes	1204.735	853.05	no
Conservation_Coral_Reef_Poor	2484.74	8282.47	yes	4141.235	4141.3	yes
Conservation_Mangroves	27.006	90.02	yes	45.01	46.93	yes
Conservation_Sandy_Bottom	4905.87	16352.9	yes	8176.45	8176.98	yes
Conservation_Seagrass_Dense	929.835	3099.45	yes	1549.725	1241.84	no
Conservation_Seagrass_Sparse	110.799	369.33	yes	184.665	184.84	yes
Conservation_Turtle_Nesting_Sites	37.788	125.96	yes	62.98	32.82	no
Conservation_Nursery_Areas	709.506	2365.02	yes	1182.51	910.51	no
				Industrial Tranportation	**Amount Held**	**Goal Met**
Transportation_Cruise_Ship_Port	3.219	10.73	yes	5.365	10.73	yes
Industrial_Ports	29.433	98.11	yes	49.055	97.02	yes
Industrial_Geothermal_Vents	0.432	1.44	yes	0.72	1.4	yes
Industrial_Sand_Mining	7.815	26.05	yes	13.025	25.39	yes

Key:
Feature Name: The feature or activity for which a goal has been set. **Goal:** The total amount of hectares (for area) or kilometers (for length) that has been set for each feature or activity. **Total Amount:** This is the total amount of hectares or kilometers that the solution achieved. The Total Amount is compared to the pre-set goal to determine if the solution met the goal. **Goal Met:** "Yes" if the pre-set goal for this feature or activity was met. "No" if it was not met. **Goal Tourism/Fishing/Conservation/Industrial Transportation:** The total area (hectares) or length (kilometers) for this objective that Marxan is trying to achieve in the solution. For example, if the zone objective is tourism, this number represents the goal for hectares or kilometers of the feature or activity allocated to the tourism zone objective. **Amount Held Tourism/Fishing/Conservation/Industrial-Transportation:** This is the total area (hectares) or length (kilometers) that the Marxan with Zones solution included for an objective. This is compared to the goal to determine if the solution met the goal. **Goal Met Tourism/Fishing/Conservation/Industrial-Transportation:** "Yes" if the pre-set goal for this feature or activity was met. "No" if it was not met.

(continued on next page)

Scenario 2: Flat 60 No Lock

Feature Name	Goal	Total Amount	Goal Met	Goal Tourism	Amount Held	Goal Met Tourism
Tourism_Anchoring	158.83	264.71	yes	132.355	133.23	yes
Tourism_Mooring	245.56	409.27	yes	204.635	205.58	yes
Tourism_Swimming_Snorklin	69.414	115.69	yes	57.845	58.2	yes
Tourism_Scuba_Diving	769.34	1282.23	yes	641.115	641.23	yes
Tourism_Jet_Ski	345.65	576.09	yes	288.045	288.42	yes
Tourism_Surfing	52.026	86.71	yes	43.355	44.34	yes
Tourism_Kite_Boarding	66.474	110.79	yes	55.395	56.52	yes
Tourism_Wind_Surfing	101.38	168.97	yes	84.485	87.75	yes
Tourism_Bird_Watching	60.036	100.06	yes	50.03	51.4	yes
				Fishing	**Amount Held**	**Goal Met**
Fishing_Coastal_Pelagics	574.91	958.1851	yes	479.0926	479.1261	yes
Fishing_Coastal_Demersals	668.59	1114.322	yes	557.1612	557.1769	yes
Fishing_Demersal_Shelf	368.36	613.939	yes	306.9695	308.726	yes
Fishing_Lobster	328.43	547.38	yes	273.69	275.822	yes
Fishing_Conch	235.02	391.6928	yes	195.8464	196.0057	yes
Fishing_Bait	46.457	77.4291	yes	38.71455	38.7326	yes
				Conservation	**Amount Held**	**Goal Met**
Conservation_Coastal_Lagoons	141.18	235.3	yes	117.65	118.74	yes
Conservation_Coral_Reef_Good	1445.7	2409.47	yes	1204.735	1204.8	yes
Conservation_Coral_Reef_Poor	4969.5	8282.47	yes	4141.235	4141.76	yes
Conservation_Mangroves	54.012	90.02	yes	45.01	45.2	yes
Conservation_Sandy_Bottom	9811.7	16352.9	yes	8176.45	8176.69	yes
Conservation_Seagrass_Dense	1859.7	3099.45	yes	1549.725	1550.05	yes
Conservation_Seagrass_Sparse	221.6	369.33	yes	184.665	184.97	yes
Conservation_Turtle_Nesting_Sites	75.576	125.96	yes	62.98	63.3	yes
Conservation_Nursery_Areas	1419	2365.02	yes	1182.51	1258.96	yes
				Industrial-Tranportation	**Amount Held**	**Goal Met**
Transportation_Cruise_Ship_Port	6.438	10.73	yes	5.365	6.91	yes
Industrial_Ports	58.866	98.11	yes	49.055	49.79	yes
Industrial_Geothermal_Vents	0.864	1.44	yes	0.72	0.6	no
Industrial_Sand_Mining	15.63	26.05	yes	13.025	13.14	yes

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Scenario 3: Variable Goals Reduced Lock

Feature Name	Goal	Total Amount	Goal Met	Goal Tourism	Amount Held Tourism	Goal Met Tourism
Tourism_Anchoring	185.297	264.71	yes	132.355	184.14	yes
Tourism_Mooring	327.416	409.27	yes	204.635	325.73	yes
Tourism_Swimming_Snorkling	114.5331	115.69	yes	57.845	105.69	yes
Tourism_Scuba_Diving	1269.4077	1282.23	yes	641.115	929.2	yes
Tourism_Jet_Ski	57.609	576.09	yes	288.045	339.78	yes
Tourism_Surfing	21.6775	86.71	yes	43.355	85.71	yes
Tourism_Kite_Boarding	109.6821	110.79	yes	55.395	110.79	yes
Tourism_Wind_Surfing	25.3455	168.97	yes	84.485	164.06	yes
Tourism_Bird_Watching	70.042	100.06	yes	50.03	88.65	yes
				Fishing	**Amount Held**	**Goal Met**
Fishing_Coastal_Pelagics	670.72957	958.1851	yes	479.093	479.291	yes
Fishing_Coastal_Demersals	780.02561	1114.3223	yes	557.161	560.175	yes
Fishing_Demersal_Shelf	429.7573	613.939	yes	306.97	307.8811	yes
Fishing_Lobster	383.166	547.38	yes	273.69	273.7079	yes
Fishing_Conch	274.18496	391.6928	yes	195.846	196.9869	yes
Fishing_Bait	54.20037	77.4291	yes	38.7146	13.9805	no
				Conservation	**Amount Held**	**Goal Met**
Conservation_Coastal_Lagoons	188.24	235.3	yes	117.65	128.15	yes
Conservation_Coral_Reef_Good	2385.3753	2409.47	yes	1204.74	832.13	no
Conservation_Coral_Reef_Poor	4141.235	8282.47	yes	4141.24	4143.36	yes
Conservation_Mangroves	72.016	90.02	yes	45.01	45.2	yes
Conservation_Sandy_Bottom	9811.74	16352.9	yes	8176.45	8178.1	yes
Conservation_Seagrass_Dense	1239.78	3099.45	yes	1549.73	1371.34	no
Conservation_Seagrass_Sparse	147.732	369.33	yes	184.665	188.34	yes
Conservation_Turtle_Nesting_Sites	113.364	125.96	yes	62.98	34.84	no
Conservation_Nursery_Areas	1892.016	2365.02	yes	1182.51	997.86	no
				Industrial Tranportation	**Amount Held**	**Goal Met**
Transportation_Cruise_Ship_Port	4.292	10.73	yes	5.365	10.73	yes
Industrial_Ports	39.244	98.11	yes	49.055	97.02	yes
Industrial_Geothermal_Vents	0.216	1.44	yes	0.72	1.4	yes
Industrial_Sand_Mining	3.9075	26.05	yes	13.025	25.39	yes

APPENDIX F

Building a Legal Framework for Marine Zoning in the Federation of St. Kitts and Nevis, Notes for Policymakers

Building a Legal Framework for Marine Zoning in the Federation of St. Kitts and Nevis, Notes for Policymakers

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September 2010

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Executive Summary

Governmental regulation of land has been a feature in almost all of the world's legal systems since the beginning of history.[1] In the early twentieth century, governments in the United States and United Kingdom responded to increased urbanization and its associated conflicts and problems (congestion, disease, and poor sanitation, among others) by implementing comprehensive planning and zoning laws. Since that time, zoning has helped to guide development, and to preempt and manage conflicting uses of land.

Ocean zoning, in contrast, is in its infancy. Increasing pressures on marine resources and their inefficient management have made clear the need for new, ecosystem-based approaches to marine planning and regulation. Marine zoning is an effective tool for policymakers to plan for various ocean uses, organize and prioritize conflicts, and streamline management toward the goal of sustainability.

The case for marine zoning is particularly strong in the Small Island Developing States of the Eastern Caribbean where economies and public health depend on marine and coastal ecosystems and the biodiversity which they support. Lamentably, the Caribbean's large endowment of biodiversity-rich marine ecosystems is being lost at an alarming rate. A recent analysis published in *Science* noted that the Eastern Caribbean was among the five regions worldwide showing the highest cumulative human impact on marine ecosystems.[2]

Through the Marine and Coastal Biodiversity Threat Abatement in the Eastern Caribbean (BioTA) project, The Nature Conservancy (TNC) and partners will work to complement ongoing efforts in the region by developing scientific and regulatory frameworks that provide decision making tools, supporting improved environmental coastal and marine policies and legislation, and increasing awareness of decision makers, private industry leaders, and the public on key threats to marine and coastal biodiversity. Among the BioTA project's principal outputs is a marine and coastal zoning plan for the Federation of St. Kitts and Nevis. This paper aims to recommend a governance framework well-suited to the legal, institutional, and political context of St. Kitts and Nevis to implement this marine zoning plan and to develop marine zoning infrastructure that will continue to serve the government of St. Kitts and Nevis long after the running of the BioTA project cycle.

In furtherance of this goal, Part I of this paper surveys basic principles of marine planning and zoning, identifying various options for structuring a planning and zoning framework and exploring how its outputs may acquire the force of law. Part II identifies and describes laws and policies now in force in St. Kitts and Nevis that relate to marine resources management and maritime affairs. Part III analyzes those laws and policies that might support a marine planning and zoning framework and identifies several short and long-term implementation solutions.

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[1] JULIAN CONRAD JUERGENSMEYER & THOMAS E. ROBERTS, LAND USE PLANNING AND DEVELOPMENT REGULATION LAW 1 (2nd ed. 2007).

[2] Benjamin S. Halpern et al., *A Global Map of Human Impact on Marine Ecosystems*, SCIENCE, Feb. 15, 2008, at 948.

Conclusions

Marine zoning and its goals are consonant with the stated policies of the government of St. Kitts and Nevis. A planning and zoning framework would promote "the conservation of biological diversity, the mitigation of adverse effects of climate change and the maintenance of essential ecological processes and life support systems."[3] It would also help to clarify and rationalize the roles and responsibilities of national environmental agencies to maximize efficiency and accountability in management of the environment and natural resources,[4] and help to protect the cultural and natural heritage of St. Kitts and Nevis.

While existing law permits the government to meaningfully regulate activities in the coastal zone and to declare marine protected areas, it is inadequate to support the development and implementation of a comprehensive, integrated framework for ecosystem-based marine and coastal planning and zoning. Until a comprehensive marine planning and zoning framework is in place, policymakers in St. Kitts and Nevis can utilize existing legislative tools to protect the most sensitive coastal and marine areas. Specifically, the government could immediately adopt a coastal zone management plan under either the National Conservation and Environmental Protection Act (NCEPA) or the Development Control and Planning Act (DCPA) reflecting, to the extent possible, the zoning plan contemplated by the BioTA project's Component 1. The government could also designate marine reserves and protected areas under either the Fisheries Act or the NCEPA.

In the long term, however, implementation of a comprehensive marine planning and zoning framework will require the enactment of new legislation or the amendment of existing legislation. The new or amended legislation would establish the required planning and zoning infrastructure and include mechanisms for monitoring, evaluation, inter-agency coordination, inter-agency conflict resolution, public and inter-agency participation, and enforcement. A new framework would enhance the government of St. Kitts and Nevis' responsiveness to the complex challenges of preserving and conserving the marine environment by ensuring that the sum of all marine resource management decisions is oriented towards the goal of integrated, ecosystem-based management.

Part I. Marine Zoning

i. Introduction: The Case for Marine Zoning

In many parts of the world, a "hodgepodge of individual laws," implemented by "sector-based" agencies, has resulted in piecemeal management of ocean resources.[5] This approach to governance

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[3] St. Kitts and Nevis National Environmental Management Strategy and Action Plan 2005 – 2009, Principle 2, Strategy 2 (September 30, 2004) at 8.
[4] *Id.,* Strategies 6, 7 at 9.
[5] Pew Oceans Comm'n, America's Living Oceans: Charting a Course For Sea Change (2003), *available at* http://www.pewtrusts.org/pdf/env_pew_oceans_final_report.pdf.; *see also* Josh Eagle, *Regional Ocean Governance: The Perils of Multiple-Use Management and the Promise of Agency Diversity*, 16 DUKE ENVTL. L. & POL'Y

treats marine resources as collections of disconnected components, problems, and opportunities, overlooking the interconnectivity of the various sectors. This fragmentation is associated with inefficiencies and negative externalities.[6]

To address these effects, comprehensive marine planning and zoning seeks to enhance interagency, intergovernmental, and international communication and collaboration; maximize accountability in management of the marine environment and natural resources; and reduce conflicting uses of marine space.[7]

> Zoning is simple, straightforward, systematic and strategic. It results in regional maps, in which every watery space is categorized for a particular use or array of uses—from commercial activities to recreational ones, including strictly protected areas that are virtually off-limits.[8]

While conflicts would not disappear if zoning were implemented, it would help to minimize and resolve them.[9]

> In essence, ecosystem-based marine zoning attempts to blend the conventional terrestrial notion of separating incompatible uses with more contemporary [normative] concepts of integrated ecological management to form a new, more robust and enduring marine governance structure.[10]

Properly implemented, ecosystem-based marine zoning would help maintain a healthy, productive, and resilient ecosystem that can provide the services that humans need.[11] A marine zoning framework might also promote compliance with international obligations.

F. 143, 151 (2006); Kelly McGrath, *The Feasability of Using Zoning to Reduce Conflicts in the Exclusive Economic Zone*, 11 BUFF. ENVTL. L.J. 183, 199 (2004).

[6] For example: Reduced public participation in agency decision-making processes (Eagle, *supra* note 4, at 151); mismanagement of regulated resources due to lack of clarity in agency responsibilities (*id.* at 151); added negotiation costs and reduced possibility of efficient resolution of issues, especially when cross-jurisdictional cooperation required, (*id.* at 152; *see also* Andrew A. Rosenberg, *Regional Governance and Ecosystem Based Management of Ocean and Coastal Resources: Can We Get There from Here?*, 16 DUKE ENV. L. POL. FORUM 179, 180 (2006)); disregard for cumulative impacts; increased possibility for agency capture (James N. Sanchirico, Josh Eagle, Steve Palumbi & Barton H. Thompson, Jr., *Comprehensive Planning, Dominant-use Zones, and User Rights: A New Era in Ocean Governance*, BULLETIN OF MARINE SCIENCE, April 2010, at 8); and the inability to respond to complex challenges (Deborah A. Sivas & Margaret R. Caldwell, *A New Vision for California Ocean Governance: Comprehensive Ecosystem-Based Marine Zoning,* 27 STAN. ENVTL. L. J. 209, 244 (2008)).

[7] Sanchirico, *supra* note 6, at 5.

[8] Agardy, Tundi, *Is Ocean Zoning the Solution to Dying Marine Ecosystems?* SCIENTIFIC AMERICAN, June 30, 2009, at 1.

[9] Sanchirico, *supra* note 6 at 10.

[10] *See* Sivas, *supra* note 6, at 245; *see also* John Eagle, *The Practical Effects of Delegation: Agencies and the Zoning of Public Land and Seas*, 35 PEPP. L. REV. 835, 845 (2008).

[11] Sivas, *supra* note 6, at 245.

ii. Implementing a Zoning System, Generally

A zoning and planning framework requires a mandate to give its outputs the force of law. The specific tools available to policymakers to accomplish this will vary across jurisdictions, but options may include: networking existing legislation through an executive order or policy statement (or the Order-in-Council, its parliamentary equivalent); passing new legislation; amending existing legislation; and "hitchhiking" or "piggybacking" on substantively related bills before the legislature. Subsection (iii) below examines these options more closely.

Whatever the method, the mandate determines the specific character of the remaining steps in the implementation process. A major concern will be the zoning system's governance structure. This structure should assign administrative responsibility for marine planning and zoning, and provide for public and stakeholder input, enforcement and monitoring policies, planning practice, coordination mechanisms, and a conflict resolution process. Subsection (iv) below surveys two governance models.

Finally, the Pew Oceans Commission has suggested that marine zoning may proceed via a "building block" approach, under which policymakers would identify core sensitive areas in need of protection, designate them as marine protected areas (MPAs), and thus ensure that that they will be protected and buffered from areas with more intense uses.[12] More comprehensive regional planning and zoning could occur thereafter.[13]

iii. Legal Instruments, Conferring Legal Force

How marine zoning frameworks and their outputs acquire the force of law will depend on the implementing state's legal system. Each method explored below has associated benefits and drawbacks.

a. "Networking" Existing Legislation

"Networking" legislation refers to the repurposing of existing laws towards a common goal identified in an executive mandate, usually a policy statement or executive order (or Order-In-Council). The mandate could require agencies (or ministries) with regulatory responsibility for ocean resources and activities to coordinate their actions to realize management priorities identified in the instrument. A zoning plan would be the principle output of the coordinated activity. Under a "networking" arrangement, agencies or ministries would retain their traditional authorities but exercise them in accordance with the agreed-upon plan. The legal instrument would need to provide for: 1) an inter-agency coordination mechanism, 2) a conflict resolution process, 3) an information sharing framework, and 4) a lead agency. Because it does not involve passage of new legislation, "networking" is a "soft" approach to implementing a framework.

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[12] McGrath *supra* note 5, at 196, 205.
[13] *Id.* at 196.

Under a "networked" system each participating agency or ministry would pass regulations in order to realize the prescriptions of the zoning plans. Regulations would bind individual users. Because this process would implicate the regulatory process, when evaluating whether to proceed via new legislation or by "networking" existing laws, policymakers should bear in mind the time commitment that it might entail.

The Australia Oceans Policy (1998) and the United States Interim Framework for Effective Coastal and Marine Spatial Planning (2010) favor a networking approach to ocean planning and management. At the core of the Oceans Policy is the development of regional marine plans that bind all agencies of the Commonwealth.[14] Agencies carry out their respective regulatory duties in accordance with the plan. The United States' Ocean Policy Task Force recommends a similar model and explicitly identifies the source of binding authority as agreements between federal, state, and tribal "partners".

> Partner[s] participating in Coastal and Marine Spatial Planning (CMSP) would need to commit in good faith to: (1) a cooperative, open, and transparent CMSP process leading to the development and implementation of CMS Plans, acknowledging that each partner may have different authorities and non-discretionary mission objectives that must be fully addressed; (2) ensuring that consideration of the National Policy, national CMSP goals, objectives, and principles, and regional CMSP objectives are incorporated into the decision-making process of all the partners consistent with existing statutory, regulatory, and other authorities, and the critical needs of emergency response, and homeland and national security activities; and (3) dispute resolution processes that enable concerns and issues not resolved through the cooperative planning process to be resolved quickly, rationally, and fairly.[15]

The most notable benefit of the "networking" approach is the relative ease with which the government could issue a mandate. On the other hand, because under a "networking" approach the legal framework would be based on the initiative of the administration supplying the mandate, it may be subject to changing political circumstances that might result in its revocation. The durability of a networked framework may depend on executive term-length, agency strength, and agency motivation.

The greatest weakness of a zoning system driven by "networked" legislation is that it would be constrained by the authorities, procedures, and limitations of the underlying legislation it unites.

b. Special Legislation

The principal advantage of using new, specialized legislation to drive a marine planning and zoning framework is that new legislation provides a clear and unconditional mandate unfettered by other institutional arrangements, statutory mandates, etc. It is also more durable.

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[14] Australia's Oceans Policy (1998) at 2.

[15] *See* THE WHITE HOUSE COUNCIL ON ENVIRONMENTAL QUALITY, EXECUTIVE OFFICE OF THE PRESIDENT, INTERIM FRAMEWORK FOR EFFECTIVE COASTAL AND MARINE SPATIAL PLANNING INTERAGENCY OCEAN POLICY TASK FORCE 19-20 (2009).

There are notable disadvantages as well. First, navigating the political process can be time-consuming. Similarly, drumming up political support may be difficult because of the likelihood of deferred political benefit and the likelihood that any new ocean governance framework could strip agencies of existing statutory authorities (if, for example, new legislation vested full responsibility for ocean planning and zoning in a new agency, as under an Integrated Agency governance model, discussed below).

c. Amendment

Implementing a marine zoning system through amendment of existing legislation shares some of the advantages associated with new legislation (clearer authority, leadership, durability) and "networking" (relatively easier, politically, to accomplish).

A mandate coming via amendment, however, still implicates the political process and may be subject to some of its associated drawbacks. The resulting system may also require extensive coordination across agencies, which can be costly.

iv. Governance Models

This section explores two governance models that have been used in other countries to implement marine planning and zoning frameworks.

One scholar recommends that governance systems be evaluated according to four criteria of effectiveness and feasibility.[16] The criteria are: 1) integration; 2) comprehensiveness; 3) public accountability; and 4) political viability.[17] Integration refers to the extent that a system coordinates the activities of responsible agencies and mediates and resolves conflicts between them.[18] Comprehensiveness refers to the extent to which a system covers the entirety of a jurisdiction's waters.[19] Public accountability refers to the capacity of a system to ensure transparent decision-making, administrative appeals, and a role for the judiciary.[20] Finally, a system is politically viable if it stands a good chance of passing through the legislature and does not alienate or offend the interests of government and civil society stakeholders.[21]

Under the current "hodgepodge of individual laws," the public may be dissuaded from participating in ocean governance due to confusion concerning which agency is ultimately responsible for regulating the uses they are interested in. Councils or lead agencies reduce the number of "decision-making loci" and

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[16] Sivas, *supra* note 6, at 250.
[17] *Id.*
[18] *Id.*
[19] *Id.* at 252; Eagle, *supra* note 5, at 152 (explaining that when administrative jurisdictions do not match ecosystem boundaries there arises a "fractured authority" problem (with no agency or sovereign having the power to comprehensively manage resources across borders) characterized by higher transaction and negotiation costs and sub-optimal management).
[20] Sivas, *supra* note 6, at 252.
[21] *Id*. at 253.

serve as readily identifiable points of contact for interested parties.[22] This sort of streamlined, more transparent governance reduces costs and enhances public participation in the regulatory process.[23]

a. Integrated Agency Model

This model vests planning and implementation responsibility for the entire framework in one agency.

The Great Barrier Reef Marine Park in Australia employs an integrated agency model. The Great Barrier Reef Marine Park Act, its authorizing legislation, created the Great Barrier Reef Marine Park Authority and charged it with developing and implementing zoning and management plans, permitting uses, monitoring, and interpreting data within the Great Barrier Reef Marine Park.[24] Zoning plans developed by the Authority with public input[25] are legislative instruments.[26]

By maximizing "integration" this model minimizes transaction costs.[27] It is the most effective at resolving use conflicts and thereby arguably the best at promoting ecosystem health.[28] Some argue it also decreases the possibility of agency capture from concentrated interest groups.[29]

On the other hand, because it might strip authority from agencies with historic jurisdiction over marine and coastal resource management, the integrated agency model rates poorly regarding political viability.[30,31]

b. Master Zoning Plan Implemented by Multiple Agencies, Multi-Agency Management Model

As its name suggests, the essence of this model is agency consultation and collaboration toward the goal of coordinated management of the covered marine environment.[32] One scholar identifies four preconditions to its implementation. These provide a good starting point, but the list is not exhaustive:

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[22] Eagle, *supra* note 5, at 157.
[23] *Id.*
[24] *See* http://www.gbrmpa.gov.au/corp_site (follow "About Us" hyperlink).
[25] Great Barrier Reef Marine Park Act, 1975, art. 32C (Austl.).
[26] *Id*. at art. 35D (Austl.).
[27] Sivas, *supra* note 6, at 255.
[28] Sanchirico, *supra* note 6, at 9.
[29] *Id. But see* Sivas, *supra* note 6, at 251 (proposing that vesting authority in a single agency increases the possibility of agency capture by concentrating decisionmaking power in one place and results in a disregard for the full range of impacts on ecosystem function).
[30] *See* Sivas, *supra* note 6, at 255.
[31] It is worth noting that a model's political viability may depend its geographic scope. For example, the Great Barrier Reef Marine Park Act applies only to the limited area of sea space that comprises the Great Barrier Reef Marine Park. Within the Marine Park, the Authority has full regulatory control. Outside of the Marine Park, other agencies retain and exercise their historic authorities. This is perhaps more politically viable than an integrated framework that applies across the entire range of waters under a country's jurisdiction and strips agencies of their authorities across the board.
[32] *See* Sanchirico, *supra* note 6, at 8; *see generally* Rosenberg, *supra* note 6, at 179 (recommending an ecosystem-based management approach in lieu of the current sectoral approach to ocean management); *see also* Sivas, *supra* note 6, at 256.

(1) a national mandate; (2) a forum that takes into account the interests of the public, industry, etc.; (3) a set of principles for making tradeoffs (because a new framework would determine rights, how allocative decisions are reached will have to relate to a set of principles for making these tradeoffs); and (4) data sharing across regional borders.[33] A lead agency (or "council") with support from other agencies is also important, as is a system for resolving differences among coordinated agencies.[34]

This model has a number of distinct benefits. Depending on their composition, councils might exercise jurisdiction over all resource uses within a defined space.[35] This well reflects the interrelationships between the component parts of the marine environment,[36] and promotes the goals integrated management and reduced conflicts among users. Also, because agencies retain historic authorities, this model is more politically viable than an integrated agency model.[37] Finally, diffusion in decision-making power may also reduce the likelihood of single agency capture.[38]

Multiple agency management is favored by the Pew Oceans Commission (2003). Under the Pew model, federal legislation would create "Regional Ocean Ecosystem Councils" consisting of federal, state and tribal authorities with jurisdiction over space and resources.[39] Councils would develop and oversee enforceable regional plans to protect marine ecosystems.[40] Plans would include performance goals and indicators, be binding on all parties, and meet federal standards established in the legislation.[41] Agency actions would have to be consistent with regional plans.[42] Standing advisory committees to the councils would obtain the advice of fisherman, scientists, environmental organizations, local governments, and other interested parties.[43]

The US Commission on Ocean Policy (2004) also called for[44] a multiple agency management governance approach based on the division of US waters into a series of large marine ecosystems (LMEs).[45] Councils for each LME would be made up of government and industry representatives and would agree to plans

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[33] Rosenberg, *supra* note 6, at 185.
[34] *Id.* at 183.
[35] Eagle, *supra* note 5, at 157.
[36] *Id*. at 158
[37] Sivas, *supra* note 6, at 256.
[38] *Id*. *But see* Eagle, *supra* note 5, at 160 (proposing that a multi-use management approach also presents a problem of "diffuse – concentrated" interests, which may facilitate dominant interest groups prevailing upon the lead agency). The idea is that by giving various resource management agencies unlimited discretion in allocating resources among user groups, dominant interests and concentrated groups are better able to advocate and lobby for optimal results. For example, a diffuse group of casual sport fishermen who travel to the sea only occasionally are unlikely to put forth a coordinated effort to advance their interests.
[39] Pew, *supra* note 5, at 33; *see also* Eagle, *supra* note 5, at 156.
[40] Pew, *supra* note 5, at 33.
[41] *Id.*
[42] Eagle, *supra* note 5, at 156-7.
[43] Pew, *supra* note 5, at 34.
[44] WHITE HOUSE, *supra* note 15.
[45] Eagle, *supra* note 5, at 154

that would allocate uses in marine space.[46] The Commission on Ocean Policy did not call for a super agency or detract from existing agency authorities.[47]

The multiple agency management model also has a number of potential drawbacks. Because some uses cannot be balanced there may be a tendency to "average" and apply middle-of-the-road management strategies, which may ultimately have a negative impact on the managed ecosystem.[48] Also, the process of consulting and coordinating within zones involves significant costs.[49] Finally, because the councils or lead agencies balance more uses and interests, achieving conservation goals under this model may be more difficult, especially if you assume that existing multi-use frameworks are ineffective at realizing objectives.[50] Similarly, relying on the development of a comprehensive management plan that pre-designates specific areas for all existing and anticipated uses may be unworkable in light of scientific uncertainty and the multiplicity of possible uses.[51]

v. Other Considerations of Governance

Regardless of the governance model chosen, a marine planning and zoning framework should provide for extensive public input, monitoring, and enforcement. Each of these features is examined more closely below.

a. Monitoring

"Monitoring and evaluation provide the link that enables planners and managers to learn from experience and helps governments and funding agencies at all levels to monitor the effectiveness of marine spatial management performance."[52] Clear management objectives give monitoring meaning. These objectives should be identified in the mandate authorizing the framework or in management plans. In the land use planning context, monitoring data are used in the periodic adaptation and review of land use plans. Review promotes dynamism and continuity. Similar provision should be made in marine zoning laws.

There are two types of monitoring.[53] One type assesses the state of the biodiversity within a management area.[54] The other assesses the performance of management systems and measures.[55] Monitoring of the first order may include a range of activities, such as modeling, laboratory and field

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[46] *Id*.
[47] *Id.* at 155.
[48] *Id*. at 159.
[49] Sanchirico, *supra* note 6, at 9.
[50] Eagle, *supra* note 5, at 147.
[51] Sivas, *supra* note 6, at 256.
[52] UNESCO Intergovernmental Oceanographic Commission [IOC], *Marine spatial planning: A step-by-step approach toward ecosystem-based management*, at 87, IOC Manual and Guides, No. 53, ICAM Dossier No. 6 (2009).
[53] *Id.* at 86.
[54] *Id.*
[55] *Id.*

research, time-series measurements in the field, quality assurance, and data analysis, synthesis, and interpretation.[56] Both types of monitoring are critical to system effectiveness.

b. Enforcement and Compliance

"Mechanisms to ensure public accountability should . . . occupy a central place in any ocean governance reform plan."[57]

Voluntary compliance with the framework and its outputs can be promoted through education, agreements with stakeholders, technical assistance, self-regulation of stakeholder groups, and effective physical demarcation (such as buoys or landmarks demonstrating restricted or important areas).[58] The use of recognizable shapes in marine zoning maps can also promote compliance.[59]

Government enforcement can take the form of inspections, negotiations with non-compliant persons, and legal action.[60] Inspection can draw on high-resolution photography, vessel monitoring systems, transponders, night vision equipment, and global positioning systems. Clear zoning regulations and permitting and licensing requirements will also optimize compliance.[61]

Accountability can be created both through institutional structure design (e.g. transparent decision processes, administrative appeal systems, etc.) and by ensuring that the judiciary maintains its traditional role as the ultimate backstop for the protection of public trust resources.

Australia's Great Barrier Reef Marine Park Act has an elaborate enforcement and liability regime. Inspectors appointed by the Authority are empowered to enforce its civil and criminal provisions.[62] The law enumerates offenses, including unpermitted fishing or mining, operation of a vessel causing damage in the marine park, unauthorized discharge of waste, and others.[63] Zoning plans themselves may also specify certain prohibited conduct and provide civil and criminal penalties.[64]

The Great Barrier Reef Marine Park Act makes a number of remedies available to the government. They include undertakings,[65] enforceable Directions,[66] emergency directions,[67] remediation orders,[68] vessel monitoring directions,[69] directions limiting access to the marine park,[70] and injunctions.[71]

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[56] *Id.* at 87.
[57] Sivas, *supra* note 6, at 252.
[58] UNESCO, *supra* note 46, at 85.
[59] McGrath, *supra* note 5 at 217.
[60] UNESCO, *supra* note 51, at 84.
[61] *Id.*
[62] Great Barrier Reef, *supra* note 25, at art. 43 (Austl.).
[63] *See generally id.* at art. 38.
[64] *Id.* at art. 38BA.
[65] If a person is thought to have contravened a civil penalty provision then he may give a written undertaking in which he commits to take specified actions to prevent, repair or mitigate harm of a specified kind in the park; not to engage in offensive conduct; or to pay a fee to prevent or mitigate harm. Breach of an undertaking permits the Ministry to apply to the federal court for an order directing compliance.
[66] Great Barrier Reef, *supra* note 25, at art. 61ADA.

c. Public Participation

Whichever governance model is chosen, public participation in the process is critical to ensuring transparency and viability of a marine planning and zoning system. Where and when it will occur will depend on the instrument and the governance model policymakers ultimately select.

Part II. Legal and Policy Context in St. Kitts and Nevis

Implementation of a comprehensive marine zoning framework will require due recognition and consideration of the authorities, obligations, and institutions currently in place in St. Kitts and Nevis that govern marine and coastal planning and resource management. The source of obligations and authorities may be statutes, treaties, or policies. This section surveys domestic and international laws in force in St. Kitts and Nevis that govern or relate to marine and coastal resources management and maritime affairs. It also surveys important national policies. Part III then analyzes the laws and policies that might support the development and implementation of a marine and coastal planning and zoning framework.

i. Regional and Extra-regional Obligations

The Federation's accession to international treaties and its membership in regional institutions such as the Caribbean Community (CARICOM) and the Organization of Eastern Caribbean States (OECS) has given rise to obligations in various sectors of relevance to marine and coastal planning and zoning, including pollution control, fisheries management and conservation, and protection of endangered species and their habitats. Because the prescriptions of regional and extra-regional obligations would drive and inform target and goal setting, a marine and coastal planning and zoning framework would promote compliance with regional and extra-regional obligations.

The following section surveys a handful of the most important obligations, emphasizing those that may be of direct relevance to marine and coastal planning and zoning.

a. Regional – CARICOM

- Caribbean Regional Fisheries Mechanism (CRFM). Member countries signed the Agreement Establishing the CRFM on February 4, 2002 to promote and facilitate "the responsible utilization of the region's fisheries and other aquatic resources for the

[67] *Id.* at art. 61ACA.
[68] *Id.* at art. 61AHA.
[69] *Id.* at art. 61AAA.
[70] *Id.* at art. 61AEA.
[71] *Id.* at art. 61AGA.

economic and social benefits of the current and future population of the region."[72] Conservation and protection of fish stocks and ecosystems is a priority objective of the CRFM. Strategic, Medium-Term, and Annual work plans guide activities of participating countries. These targets could inform the goals of a zoning system.

b. Regional – OECS

- St. George's Declaration. The St. George's Declaration (2000) is the benchmark environmental management framework in the Organization of Eastern Caribbean States (OECS) region. It is structured around twenty one principles. The St. George's Declaration is implemented by OECS member countries at the national level through the National Environmental Management Strategy (NEMS). For more information on specific principles, refer to the section below treating the St. Kitts and Nevis NEMS.

c. Extra-regional – UN Convention on Law of the Sea

Under the United Nations Convention on the Law of the Sea (UNCLOS), coastal states have obligations to conserve marine living resources and protect and preserve the marine environment.[73] The Convention does not qualify this obligation.[74] It requires coastal states to take all measures necessary to prevent, reduce and control pollution from any source, as well as to protect and preserve rare or fragile ecosystems, the habitats of depleted, threatened or endangered species, and other forms of marine life.[75]

The obligation to conserve marine living resources applies within each coastal state's territorial sea, its exclusive economic zone (EEZ), and on the high seas (where all states must cooperate in conserving and managing living resources).[76]

d. Extra-regional – Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena de Indias (Colombia), 1983)

The Cartagena Convention is "a comprehensive, umbrella agreement for the protection and development of the marine environment" providing the "legal framework for cooperative regional and national actions" in the wider Caribbean region.[77]

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[72] *See* http://www.caricom-fisheries.com/WhatisCRFM/AboutCRFM/tabid/56/Default.aspx (last visited October, 26, 2010).
[73] United Nations Convention on the Law of the Sea (UNCLOS), arts. 246, 252, December 10, 1982, 1833 U.N.T.S. 397.
[74] Lee A. Kimball, *International Ocean Governance: Using International Law and Organizations to Manage Marine Resources Sustainably*, at 10, IUCN, Gland, Switzerland and Cambridge, UK. xii + 124 pp (2001).
[75] UNCLOS, *supra* note 72 at art. 194.
[76] Kimball, *supra* note 73 at 25.
[77] http://www.cep.unep.org/cartagena-convention.

The Convention requires the adoption of measures aimed at preventing and controlling pollution from ships and from seabed activities.[78] It also requires parties to take appropriate measures to protect and preserve fragile ecosystems.[79] In fulfilling their obligations, participating countries must "ensure sound environmental management, using for this purpose the best practicable means at their disposal . . . in accordance with their capabilities."[80]

e. Extra-regional – Convention on Biological Diversity and the Jakarta Mandate on Marine and Coastal Biological Diversity

The Convention, signed in 1992 by 150 countries, commits member nations to protect and maintain the earth's "ecological underpinnings as we go about the business of economic development."[81] The three objectives of the Convention are: "the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources."[82]

The conservation of marine and coastal biodiversity was an early priority of the Conference of the Parties (COP).[83] At the second COP in November 1995, the parties adopted a new global consensus on coastal and marine conservation which would become known as the Jakarta Mandate.[84] The mandate is an agreement on a plan of action for implementing the Convention.[85] Its five principal themes or focal areas – integrated marine and coastal area management, marine and coastal living resources, marine and coastal protected areas, mariculture, and alien species – are reflected in the program of work that the COP adopted in 1998 and the updated program elaborated in the annex to Decision VII/5.[86] The program of work sets goals and objectives for marine and coastal conservation, and identifies activities that will aid in their achievement.[87] Primary implementation responsibility for these activities rests with national governments, with the assistance of regional and international bodies, where appropriate.[88]

Objectives of specific relevance to marine zoning include:

1. Encouraging the "application of the ecosystem approach, promot[ing] integrated multidisciplinary and multi-sectoral coastal and ocean management at the national level, and

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[78] *Id.*
[79] Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, art. 10, March 24, 1983, 1506 U.N.T.S. 157.
[80] *Id*. at art. 4.
[81] *See* https://www.cbd.int/convention/guide/ (last visited October 26, 2010).
[82] Convention on Biological Diversity, art. 1, December 29, 1993, 1760 U.N.T.S. 79.
[83] *See* https://www.cbd.int/marine/pow.shtml (last visited October 26, 2010).
[84] *See* https://www.cbd.int/marine/pow.shtml (last visited October 26, 2010).
[85] *See* www.biodiv.org/jm.html (last visited October 26, 2010); *see also* http://www.un.org/Depts/los/general_assembly/contributions_texts/scbd.pdf (last visited October 26, 2010).
[86] https://www.cbd.int/marine/resources.shtml (last visited October 26, 2010)
[87] Convention on Biological Diversity, Conference of the Parties Decision VII/5 at 10.
[88] *Id*.

encourag[ing] States in developing ocean policies and mechanisms on integrated coastal management.[89]

2. The establishment and strengthening of "national and regional systems of marine and coastal protected areas integrated into a global network and as a contribution to globally agreed goals."[90]

ii. Domestic Laws and Policies

a. Policies

The goals of a marine and coastal planning and zoning framework are consistent with a range of existing national policies. Like treaty obligations, national policies may inform priority- and target-setting. This subsection explores the policies in place in St. Kitts and Nevis that might inform the goals and objectives of a marine zoning framework.

1. National Environmental Management Strategy and Action Plan (2005 – 2009)

The St. Kitts National Environmental Management Strategy (2005 – 2009) (NEMS) sets out actions and strategies to guide agencies in implementing the principles of the St. George's Declaration (2000), the benchmark environmental management framework in the Organization of Eastern Caribbean States region. The NEMS sets out 48 environmental management strategies arranged in sections corresponding to seventeen of the Declaration's twenty one principles, as well as specific activities that support these strategies and the agencies responsible for implementing them. The NEMS is intended to "guide programmes in environmental management over the long term."[91] At the end of its five-year period of applicability, agencies are expected to review progress on implementation and plan for another five-year cycle.[92]

Objectives of relevance to marine zoning include:

1. Integration of environmental considerations into national development policies, plans and programs,[93] specifically:
    a. Pursuit of "sustainable development policies aimed at . . . the conservation of biological diversity, the mitigation of adverse effects of climate change and the maintenance of essential ecological processes and life support systems."[94]
2. Improvement of legal and institutional frameworks,[95] specifically:

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[89] *Id*. at 11.
[90] *Id.* at 15.
[91] St. Kitts and Nevis National Environmental Management Strategy and Action Plan 2005 – 2009, *supra* note 3, at 5.
[92] *Id*. at 6.
[93] *Id.* Principle 2 at 8.
[94] *Id.* Principle 2, Strategy 2 at 8.
[95] *Id.* Principle 3 at 9.

   a. The clarification and rationalization of regional and national environmental agencies – and the creation of new agencies where necessary – to maximize efficiency and accountability in management of the environment and natural resources;[96] and
   b. The development, integration, strengthening, and enforcement of environmental legislation to implement the Principles of the St. George Declaration.[97]
3. Protection of cultural and natural heritage[98], specifically:
   a. The institution of "appropriate measures, including legislation, to provide for the researching, documenting, protecting, conserving, rehabilitating and management of . . . areas of outstanding scientific, cultural, spiritual, [and] ecological significance."[99]

2. Medium Term Economic Strategy

The Medium-Term Economic Strategy Paper (MTESP) sets out policies and approaches which the Government of St. Kitts and Nevis will pursue to sustain growth and development. The plan identifies tourism as the "main engine of economic growth."[100,101] It also notes that the government is wholly committed to sustainable development and that there is a need for legislation that will address coastal zone and watershed management.[102]

Medium Term Objectives of relevance to marine zoning:

- Promotion of sound environmental practices through enforcement;[103]
- Adherence to all international environmental conventions;[104]
- The institutionalization of greater capacities at the Department of the Environment;[105]
- With regard to fisheries, the development of an effective monitoring, surveillance, and enforcement programme;[106] and
- Also with regard to fisheries, the promotion of scientific research.[107]

3. The National Biodiversity Strategy and Action Plan

The National Biodiversity Strategy and Action Plan identifies gaps in information about ocean organisms as an issue requiring attention in St. Kitts and Nevis.[108] It also identifies a gap in conservation policies

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[96] *Id*. Principle 3, Strategies 6, 7 at 9.
[97] *Id.* Principle 3, Strategy 9 at 10.
[98] *Id*. Principle 12 at 20.
[99] *Id*. Principle 12, Strategy 37 at 20.
[100] St. Kitts and Nevis Medium-Term Economic Strategy Paper 2003 – 2005, at 38.
[101] Marine reserves and protected areas provide stable foundations for nature-based recreation and tourism activities. Because a marine zoning framework would likely promote the designation of marine reserves and other classes of marine protected areas, it likely would promote the interests of tourism and tourism-related sectors.
[102] *Id*.
[103] *Id.* at 40.
[104] *Id.* at 41.
[105] *Id.*
[106] *Id*. at 32.
[107] *Id.*

aimed at marine life preservation and a lack of enforcement legislation.[109] A marine planning and zoning framework would address these gaps.

b. Federal Coastal Zone Management Laws

This section identifies existing federal laws that govern the various marine sectors, among them coastal planning and management, marine protected areas, fisheries, transit, and pollution control. Together these laws permit the government to regulate meaningfully activities in the sea and coastal zones and to declare marine protected areas.

1. Maritime Areas Act (1984)

The Maritime Areas Act (1984) defines the inland waters, territorial sea, contiguous zone, and exclusive economic zone (EEZ) of St. Kitts and Nevis and sets out the various rights and responsibilities of the government with respect to these areas. The act asserts the government's sovereign rights in the territorial sea and the sovereign right to conserve and manage resources in the EEZ.[110] The government also has jurisdiction to protect and preserve the marine environment within the EEZ.[111]

The Maritime Areas Act authorizes the Minister of Foreign Affairs to enact regulations[112] for the protection and preservation of the marine environment of both the territorial sea[113] and the EEZ,[114] and for the exploration and exploitation of the EEZ for economic purposes.[115]

2. National Conservation and Environmental Protection Act (NCEPA)(1987)

The National Conservation and Environmental Protection Act (NCEPA) is a comprehensive environmental statute providing for, *inter alia*, 1) the establishment and management of protected areas; 2) preparation of coastal zone management plans; 3) forestry, soil, and water conservation; and 4) the protection of wild animals.[116] A 1996 Amendment provides for the entry into force of various international agreements and conventions.[117] Those of potential relevance to marine zoning are the Convention on International Trade in Endangered Species of Fauna and Flora, the UN Convention on Climate Change, the UN Convention on Biological Diversity, and the Basel Convention on the control of Trans-boundary Movement of Hazardous Waste.

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[108] National Biodiversity Strategy and Action Plan for St. Kitts and Nevis (2004) at 79.
[109] *Id.* at 81.
[110] The Maritime Areas Act, 1984, No. 3 of 1984 (St. Kitts and Nevis) (August 30, 1984) at Part III, §12.
[111] *Id.*
[112] *Id*. at Part VII, §29.
[113] *Id.* at Part VII, §29(2)(b).
[114] *Id.* at Part VII, §29(3)(b).
[115] *Id.* at Part VII, §29(3)(d).
[116] *See generally* The National Conservation and Environment Protection Act, 1987, No. 5 of 1987 (St. Kitts and Nevis) (April 27, 1987).
[117] The National Conservation and Environment Protection (Amendment) Act, 1996, No. 12 of 1996 (St. Kitts and Nevis) (April 9, 1996).

The NCEPA mandates the preparation of a coastal zone management plan and regulations to control development in the coastal zone.[118] Administrative responsibility for the act lies with the Minister responsible for the Environment, in consultation with the Conservation Commission.[119]

Under the act, the coastal zone extends two kilometers seaward of the mean low water mark, and includes the foreshore and floor of the sea.[120] The coastal zone management plan may declare protected beaches and, within areas covered by the declaration, prohibit fishing, anchoring of boats and docking of cruise ships, disposal of waste, water skiing, sand mining or dredging, or removal of "treasure or artifact" from the sea.[121] It is noteworthy that Section 33 preserves any "vested rights enjoyed by fisherman engaged in fishing as a trade in or over any beach."[122]

3. Development Control and Planning Act (2000)

The purpose of the Development Control and Planning Act (DCPA) is to assist in the orderly, efficient, and equitable planning, allocation and development of the resources of St. Christopher.[123,124] The DCPA's definition of land includes submerged land extending to seaward limit of territorial sea, which the Maritime Areas Act sets at 12 miles seaward of a landward baseline.[125] Thus, development occurring thereon may only proceed with permission of the Development Control and Planning Board created by the Act.[126]

The Development Control and Planning Board is also responsible for preparing development plans.[127] Development plans may provide for zoning,[128] allocate land for the protection of marine life,[129] and/or protect the coastal zone[130] (defined as extending to seaward limit of the territorial sea).

In carrying out its duties (i.e. producing development plans), the Board may designate comprehensive planning areas for conservation and other purposes[131] and may designate environmental protection

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[118] National Conservation and Environment Protection Act, *supra* note 115, at Part VI, §25.
[119] It is uncertain whether a Conservation Commission was ever convened.
[120] *Id*. at Part I, §2.
[121] *Id*. at Part VI, §31.
[122] *Id.* at Part VI, §33.
[123] The Development Control and Planning Act, 2000, No. 14 of 2000 (St. Kitts and Nevis) at Part I, §4(d).
[124] The Constitution of St. Kitts and Nevis reserves to the Nevis Island Administration responsibility for land use planning. However, it does not address the Nevis Island Administration's responsibility for marine or coastal zone planning.
[125] *Id.* at Part I, §2.
[126] *Id.* at Part IV, §20.
[127] *Id.* at Part II, §6(3)(c).
[128] *Id*. at Schedule 2, Part III.
[129] *Id*. at Schedule 2, Part IV.
[130] *Id*.
[131] *Id*. at Part III, §11(5)(e).

areas.[132] For both, in consultation with Minister Responsible for NCEPA, the Board is responsible for developing management plans.[133]

Management plans may contain special resource and use areas in which the Minister (in consultation with the minister responsible for NCEPA) may permit and prohibit certain activities, such as designating protected swimming and surfing areas; designating anchoring, mooring, and beaching areas; and designating where water-skiing, wind surfing, or other water sports may occur.[134] Management plans may also arrange for protection of marine flora and fauna, and specifically provide for the regulation of hunting and fishing to achieve this purpose.[135]

4. National Conservation and Environmental Management Act (NCEMA) (not yet enacted)

The NCEMA would update and modify the NCEPA. Among other things it provides for the development of coastal zone management plans. Section 38 of the NCEMA requires the department responsible for the environment to prepare a coastal zone management plan which "indicat[es] the strategy which the Department proposes to adopt for the management of land and marine areas within the coastal zone."[136]

The coastal zone includes any area of land less than 15 meters above mean sea level within a limit of one kilometer landward of the mean high water mark, and the foreshore and the seabed with a limit of two kilometers seawards of the mean low water mark."[137]

Coastal zone management plans, the Act specifies, should illustrate the coastal zone management strategy,[138] and allocate land or marine areas or combination thereof as protected areas.[139]

Within the coastal zone, activities may be prohibited or regulated, including the capture or killing of marine plants or animals, including fish; drainage of wetlands; removal of vegetation from a beach; removal of sea barriers; sand mining or dredging; anchoring of pleasure boats and other vessels, including cruise ships; water skiing; the driving of all-terrain vehicles; and the disposal of waste matter.[140]

[132] *Id*. at Part III, §12(1).
[133] *Id.* at Part III, §13(1).
[134] *Id.* at Part III, §13(3).
[135] *Id.* at Part III, §13(2)(a).
[136] The National Conservation and Environment Management Act, No. __ of 2009, (St. Kitts and Nevis) (not yet enacted) at Part IX, §38(1).
[137] *Id*. at Part I, §2.
[138] *Id.* at Part IX, §38(3).
[139] *Id.* at Part IX, §38(3)(a).
[140] *Id.* at Part IX, §38(5)

c. Federal Marine Protected Areas Laws

1. NCEPA (1987)

The NCEPA allows the Minister responsible for Environment to designate marine areas as a) national parks, b) nature reserves, c) botanic gardens, d) marine reserves, e) historic sites, or f) scenic sites in order to, inter alia:

- Sustain natural areas important for the protection and maintenance of life-support systems and basic ecological processes;
- Preserve biological diversity that may be of special concern and the land and marine habitants upon which survival of species depends; and
- Protect selected natural sites of special scientific or ecological value.[141]

Management and administration of declared MPAs is the responsibility of the Minister (along with the Conservation Commission).[142] The Conservation Commission must develop management plans for protected areas and may prescribe certain activities within protected areas.[143] Plans require the approval of Minister and must be revisited at least every five years to account for new information.[144] Regulations may set out prohibited activities and prescribe the manner of protected area operation.[145]

2. Fisheries Act (1984)

The Fisheries Act authorizes the Minister to declare, by order, marine reserves and fishing priority areas in any area of fishery waters (the entire extent of EEZ, territorial waters, and internal waters).[146]

Fishing priority areas are places where the Minister feels special measures are necessary to ensure that authorized fishing is not impeded.[147]

Marine reserves are areas where the Minister feels that special measures are necessary to protect the flora and fauna of the designated areas; preserve breeding grounds and habitat; allow for natural regeneration of life; promote scientific research; or to preserve and enhance natural beauty.[148] Within these areas, it is illegal to take fish, destroy flora and fauna other than fish, dredge, pollute, or build without prior authorization.[149]

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[141] National Conservation and Environment Protection Act, *supra* note 115, at Part II, §4.
[142] *Id*. at Part III, §7.
[143] *Id*. at Part III, §13.
[144] *Id*.
[145] *Id.* at Part X, §56.
[146] The Fisheries Act, 1984, No. 4 of 1984 (St. Kitts and Nevis), Part III.
[147] *Id*. at Part III, §21.
[148] *Id*. at Part III, §23.
[149] *Id*. at Part III, §§23(2),(3).

Regulations can set out rules for the management and protection of marine reserves and fishing priority areas.[150]

3. NCEMA (not yet enacted)

The NCEMA would update the NCEPA. It allows the Minister responsible for the Environment, in consultation with the Conservation Commission, to designate protected areas.[151] Schedule 1 lays out the various classes of protected areas and their purposes. Part IV sets out requirements for management of protected areas.

The Commission would assist in the selection of protected areas and the maintenance and development of the national parks in St. Kitts and Nevis.[152]

The Act also calls for the Department of the Environment's collaboration with the Department of Physical Planning and Development Control to develop strategies to promote environmentally sound and sustainable development in areas adjacent to protected areas.[153]

d. Federal Laws, Other Sectors

If implemented, a marine and coastal zoning and planning framework may affect management of resources and activities governed by other statutes, e.g. placement of navigational aids, shipping lanes, undersea telecommunications and electricity cables, etc. This section identifies several important statutes and authorities that a marine zoning plan likely will implicate.

1. Merchant Shipping Act, 2002

Of particular relevance to marine zoning, the Act provides for registration of vessels;[154] prevention of collisions and safety of navigation;[155] the establishment and management of aids to navigation;[156] and prevention of pollution from ships[157].

2. Fisheries Act, 1984

The Fisheries Act of 1984 aims to provide an institutional framework for the "management, planning, development, and conservation of fishery resources."[158] Administration of the Act is the responsibility of the Chief Fisheries Officer, and if one is not appointed, then the Chief Agricultural Officer.[159] Section

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150 *Id*. at Part V, §40(2)(p).
151 The National Conservation and Environment Management Act, *supra* note 135, at Part II, §3.
152 *Id*. at Part III, §4(3).
153 *Id*. at Part VIII, §31.
154 The Merchant Shipping Act, 2002, No. 24 of 2002, (St. Kitts and Nevis) at Part I, §6.
155 *Id*. at Part VI.
156 *Id*. at Part VI, §162.
157 *Id*. at Part VII, §169.
158 The Fisheries Act, *supra* note 145, Preamble.
159 *Id*. at Part II, §§3(1)-(3).

4 requires the Chief Fisheries Officer to "prepare and keep under review a plan for the management and development of fisheries in the fishery waters."[160]

The Act allows for and anticipates regional cooperation in the regulation of fisheries, e.g. the Caribbean Regional Fisheries Mechanism. It allows the responsible Minister to enter into agreements with other countries or organizations in the region to collaborate in developing a uniform licensing system, enforcement mechanisms, and other fisheries management systems.[161] Any agreement entered into should be published as an order in the Gazette and then approved by Parliament.[162]

Section 25 lists prohibited fishing methods.[163] Section 40 authorizes the Minister to make regulations for the management, development, and conservation of fisheries.[164]

The Act also lists offenses, including prohibited fishing methods, and associated punishments. In order to enforce the provisions of the Act, the Minister can designate any persons to enforce the Act. This may include "members of the enforcement authority of any country or of any regional or sub-regional marine enforcement entity."[165]

3. Fisheries Regulations, 1995

The Regulations contain conservation measures for lobster, turtles, conch, coral, sponges, marine algae, sea stars, and aquarium fish.[166] The regulations also affirm that in fishery waters, no person or company may introduce pollutants, poisons, or other harmful substances.[167]

4. The Port Authority Act, 1981

The Port Authority Act creates the Saint Christopher and Nevis Port Authority,[168] which is responsible for developing an integrated system of lighthouses, ports, and port services, and regulating navigation to the ports.[169]

The Port Authority, with the approval of the Minister of Finance, has the authority to make regulations concerning the

> [. . .] (c) controls and prohibitions on the doing or omission of any thing or class of things within the limits of any port; (d) the regulation, restriction and control (without prejudice to the conduct of navigation) of the depositing of any substance, solid matter,

[160] *Id*. at Part II, §4.
[161] *Id*. at Part II, §§6(1)(a)-(g).
[162] *Id*. at Part II, §6(2).
[163] *Id*. at Part III, §25.
[164] *Id*. at Part V, §40.
[165] *Id*. at Part III, §27.
[166] The Fisheries Regulations, 1995, No. 11 of 1995 (St. Kitts and Nevis) at Part VI, §§18-22.
[167] *Id*. at Part VII, §38.
[168] The Port Authority Act, 1981, No. 8 of 1981 (St. Kitts and Nevis) at Part 1, §3(1).
[169] *Id*. at Part II, §§17(1),(3).

article or thing polluting or likely to cause pollution of the waters of any port; and (e) the regulation of traffic and navigation of ships within the limits and approaches to a port and all matters relating to the protection of life and property.[170]

5. The Maritime Areas (Establishment of Safety Zones Around Installations) Regulations, 1995

These regulations prohibit ships and other vessels from anchoring in the safety zone around Skantel submarine cables.[171]

e. Nevisian Laws

The 1983 Constitution of the Federation of St. Kitts and Nevis reserves certain powers to the Nevis Island Administration.[172] Of relevance to marine zoning is the power to regulate fisheries.[173] The following ordinances appear to reflect this power and are also relevant.

1. The Nevis Coastal Protection Levy Ordinance

The Nevis Coastal Protection Levy Ordinance[174] allows the member of the Administration responsible for the Environment to appoint an Advisory Committee to inform him or her on:

- Measures for protecting Coastal Areas against the ravages and any other natural or man-made disasters;
- Protection and preservation of the marine environment; and
- The causes, nature, extent and prevention of damage to the Coastal Area.[175]

2. Zoning Ordinance (1991)

The Nevis Zoning Ordinance provides for the establishment of marine parks in Nevis.[176]

3. Nevis Fisheries Law

The Nevis Island Administration's Fisheries Department operates using the federal Fisheries Act of 1984. Nevis does not have a separate fisheries ordinance.

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170 *Id*. at Part VI, §59(1).
171 The Maritime Areas (Establishment of Safety Zones Around Installations) Regulations, 1995, No. 13 of 1995 (St. Kitts and Nevis) at §2.
172 FED. OF ST. KITTS AND NEVIS CONST.,ch. X, §106(1)
173 *Id*. at §106(1)(d).
174 The Nevis Island Coastal Protection Levy Ordinance, 2002, No. 3 of 2002 (Nevis Island).
175 *Id*. at §4.
176 *See* http://www.fao.org/fi/oldsite/FCP/en/KNA/profile.htm.

Part III. Analysis and Recommendations

Sufficient authority exists in St. Kitts and Nevis to regulate meaningfully activities occurring in the coastal zone and to declare marine protected areas. Until a comprehensive marine and coastal planning and zoning framework is in place, policymakers in St. Kitts and Nevis can utilize these legislative tools to protect the most sensitive coastal and marine areas.

Some have referred to this as the "building block" approach to comprehensive marine and coastal planning. Of the legislative tools available for the interim protection and management of the coastal zone, the clearest authority exists in the NCEPA (mandating coastal zone management plans and permitting declaration of various classes of MPAs); the Fisheries Act (authorizing declaration of marine reserves); and the DCPA (authorizing the Planning Board to develop management plans for environmental protection areas which can designate protected swimming and surfing areas; anchoring, mooring, and beaching areas; and where water-skiing, wind surfing, or other water sports may occur).[177] The broadest authority rests in the Ministry of Foreign Affairs under the Maritime Areas Act, which authorizes the Minister to enact regulations for the protection and preservation of the marine environment of the territorial sea and EEZ, though this authority is largely dormant.

Furthermore, existing laws could support many of the specific prescriptions of the marine zoning plan contemplated by Component 1 of the BioTA project. For example, the plan targets anchoring, jet-skiing, kite boarding, siting of marinas, mooring, SCUBA diving, surfing and wind-surfing, swimming, and snorkeling, *inter alia*. Within environmental protection areas the DCPA may permit or prohibit anchoring, mooring, and beaching of boats, as well as water-skiing, wind surfing, or other water sports. Similarly, under NCEPA coastal zone management plans may identify protected beaches and prohibit the anchoring of boats and docking of cruise ships, water skiing, and sand mining or dredging in these areas. Annex 1 identifies how various other prescriptions could be given immediate effect under existing laws.

While these management tools are both useful and powerful, alone they provide insufficient foundation for a dynamic marine and coastal planning and zoning framework. For example, current laws do not provide an infrastructure for coordinating interagency decision-making across sectors or provide a set of ecosystem-based principles to guide agency actions. Nor do they provide for comprehensive, science-based marine planning, the yield of which may be a zoning plan. These gaps are characteristic of the "hodgepodge of individual laws" implemented by "sector based" agencies that results in piecemeal management of ocean resources and the inability to respond to complex marine management challenges.

A marine and coastal planning and zoning framework is consonant with the stated policies of the government of St. Kitts and Nevis. A marine and coastal planning and zoning framework would promote "the conservation of biological diversity, the mitigation of adverse effects of climate change and the maintenance of essential ecological processes and life support systems." It would also help to clarify

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[177] There is notable overlap of authority in several areas under the existing legal framework. A marine zoning framework would rationalize existing laws and clearly define agency responsibilities.

and rationalize national environmental agencies to maximize efficiency and accountability in management of the environment and natural resources and help to protect the cultural and natural heritage of St. Kitts and Nevis.

Government officials discussing the best way to develop and implement a zoning and planning framework at a workshop at Basseterre on July 19 and 20, 2010, concluded that only new or amended legislation would generate the clout a new system would require to function. It was unclear whether participants believed a "networking" approach would supply sufficient clout, though "networking" too should be considered as a way of conferring legal force. The preference of those attending the workshop was to amend the Fisheries Act or the National Conservation and Environmental Management Act (NCEMA) (currently under review in parliament) to allow for a marine and coastal planning and zoning framework that would be implemented in a decentralized fashion by multiple agencies. Amending the DCPA was not fully discussed at the workshop, but it too merits consideration. Participants definitively ruled out the "Integrated Agency" model due to its lack of political viability.

The analysis below explores four options for implementing a new marine and coastal resources management framework.

i. Amending DCPA to Allow for Marine Planning and Zoning

The DCPA defines "land" as the submerged land extending to seaward limit of territorial sea (12 nautical miles), and it permits the development of management plans for environmental protection areas. Within these areas the planning board may set out where water-skiing, wind surfing, or other water sports, swimming, surfing, anchoring, mooring, and beaching may occur. The Board may also plan for the protection of marine flora and fauna, and regulate hunting and fishing in order to accomplish this. The act thus allows for small-scale marine and coastal planning. Despite the apparent usefulness of this tool, officials in the Department of Physical Planning have suggested the DCPA is principally a land-use management statute, and that the Department has always viewed the high-water mark as the limit of the Board's jurisdiction.

a. Planning

To implement a marine planning and zoning framework under this approach, an amendment would expand the Planning Board's existing authority to include the creation of marine management and zoning plans. The Planning Board would have sole lead responsibility for developing zoning plans, though the amendment would provide explicitly for the participation of other interested agencies and the public through committee meetings, public hearings, and opportunities for public comment at important points in the process. This approach capitalizes on existing planning infrastructure and institutional knowledge.

The DCPA creates a strong terrestrial planning infrastructure. It creates the Development Control and Planning Board responsible for preparing and periodically reviewing and amending development plans. The Board and agency house institutional knowledge and experience of developing terrestrial zoning plans. The marine planning process would be similar in important respects and this knowledge and experience would be of great value.

b. Conferring Legal Force

The amendment would need to set out how plans would bind agencies and users. Zoning plans would ideally be legislative instruments carrying the force of law. If not, plans could acquire the force of law through the regulatory process. In the latter case, each agency with responsibility for regulated activities would pass regulations to implement the marine and coastal zoning plans developed by the DCPA.

c. Implementation

As noted, implementation would occur at the agency level. An amendment would authorize the Planning Board to comprehensively plan marine space. Agencies would implement and enforce the plans by incorporating the objectives and principles of the plan into their decision-making processes consistent with their existing statutory and regulatory authorities.

d. Miscellaneous

If this approach were taken, there would need to be an increase in the budget allocation to the Planning Board for new staff, resources, and equipment.

ii. Convening an Ocean Planning and Management Council Responsible for Ocean Management Planning by Networking Existing Legislation

Under this model, the authorizing mandate (issued by the Prime Minister or the Cabinet) would set out ecosystem based priorities for management of ocean resources, identifying zoning plans as a means of accomplishing these priorities. It would require agencies with regulatory responsibility for ocean resources and activities to realize priorities identified in the instrument by complying with zoning plans produced by a Planning Council.

a. Planning

A Planning Council comprised of representatives from various agencies with marine resource management portfolios would develop zoning plans. While the Planning Council would have sole lead responsibility for developing zoning plans, the authorizing instrument would provide explicitly for the participation of the public through committee meetings, public hearings, and opportunities for public comment at important points in the process.

b. Conferring Legal Force

Under this model, the executive would issue a policy statement to bind the actions of line ministries. Workshop attendees noted that in St. Kitts and Nevis a Cabinet Decision would be the appropriate tool. In the United States the analogous tool is the Executive Order.

The policy statement would bind agencies to do as directed. In this case, the executive would direct them to develop a marine zoning management plan and to coordinate their activities to ensure that it was implemented faithfully. To realize the objectives and goals of the plans, agencies would ensure that their prospective actions and activities are compatible with the plan. This may require the drafting of new regulations. For example, if the plan were to identify a need to curb or ease fishing in a particularly sensitive spawning area, and existing rules permitted uncontrolled fishing in the area, the agency would be required to issue a regulation to ban or control fishing in the area identified to achieve the purposes of the plan.

While a mandate housed in a policy statement offers a quicker route to implementation, it may subject the framework to changing political circumstances. Also, it does not provide the same clarity of authority that new legislation would.

c. Implementation

Under this arrangement, agencies or ministries would retain their traditional authorities but exercise them consistent with the agreed-upon plan. In addition to the standard compliment of management tools (i.e. enforcement and monitoring infrastructure), the legal instrument would need to provide for 1) an inter-agency coordination mechanism, 2) a conflict resolution process, 3) an information sharing framework, 4) a lead agency, and 5) public participation.

d. Miscellaneous

Users would ultimately be bound by regulations implementing the management or zoning plans.

Also note that a similar framework could be implemented legislatively.

iii. Amending NCEMA to Allow for Marine Planning and Zoning

Marine zoning and the NCEMA share a number of goals. For example, the NCEMA aims to assign administrative responsibility for environmental management within the Federation, and

> "[to] conserve[e] and [ensure the] sustainable use of the natural heritage of Saint Christopher and Nevis, including the conservation of biological diversity, the protection of threatened and endangered species and their habitats, [. . .] and the conservation of significant terrestrial and marine ecosystems[. . .]."[178]

[178] The National Conservation and Environment Management Act, *supra* note 135, at Part I, §3.

Furthermore, participants at the July 20 workshop recommended implementing a marine zoning framework by "piggy-backing" on the NCEMA law currently before parliament; expanding the powers delegated in the Act to the Conservation Commission to include marine planning. This approach has several advantages. Principal among them is its procedural convenience.

Compared to the Planning Board, however, the Conservation Commission would not have the institutional knowledge or experience of planning or leading a comprehensive planning effort, making this option relatively less appealing than amending the DCPA.

a. Planning

The NCEMA would establish a twelve-member National Conservation Commission[179] responsible for advising the Department of the Environment on the selection of protected areas, and the control, maintenance and development of the national parks, botanical gardens, and beaches of Saint Kitts and Nevis. An amendment could broaden the scope of the Commission's duties to include the development of marine zoning plans. The Commission could also coordinate implementation. Thus the Conservation Commission could assume a lead agency role or function as a Secretariat for the marine planning and zoning framework. Alternatively, rather than the Conservation Commission, the amendment could authorize the Ministry of Marine Resources to undertake these functions.

While the Conservation Commission would surely represent a diverse range of interests and a good deal of knowledge and expertise, as NCEMA is written, it is not composed entirely of government representatives. While public participation in the marine planning process is critical, the initial development of marine zoning plans by a group comprised of government and civil society stakeholders would be inefficient and unproductive. Essential planning functions are traditionally the province of government agencies. The Conservation Commission could be convened to serve an advisory function after plans are developed.

b. Conferring Legal Force

The amendment would need to set out how plans would bind agencies and users. Zoning plans would ideally be legislative instruments carrying the force of law. If not, plans could acquire the force of law through the regulatory process. In the latter case, each agency with responsibility for regulated activities would pass regulations to implement plans.

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[179] *See id*. at sch. 9, §2(3)(The Director of Physical Planning; the Director of Environment; one representative of non-governmental organizations operating in St. Kitts and one from Nevis; one representative from the Water Department; three representatives from the business community with interests in recreational or tourism activity in connection with the country's parks and protected areas, including but not limited to the marine, hotel, restaurant, taxi, travel, fishing, and dive industries; and four people knowledgeable or experienced in one or more of the fields of environmental management, ecology, environmental health, engineering, natural resources economics, and law.)

c. Implementation

Individual agencies would implement the plan according to their historic authorities. Agencies would conform their actions and activities to the rules elaborated in plans.

d. Miscellaneous

New or amended legislation would establish the required planning and zoning infrastructure and include mechanisms for monitoring, evaluation, inter-agency coordination, inter-agency conflict resolution, public and inter-agency participation, and enforcement.

iv. Amending NCEPA or NCEMA[180] to Permit Multi-Use Zoning of Marine Protected Areas

The NCEPA currently provides for the declaration and administration of various classes of marine protected areas. The NCEPA explicitly requires the Conservation Commission to develop management plans for areas so declared. One way to implement the zoning plans contemplated by Component 1of the BioTA project may be to amend the NCEPA (or NCEMA, currently under consideration in parliament) to authorize multi-use zoning within protected areas. The amendment might also amplify the purposes for which a marine protected area can be declared to include, for example, ecosystem-based management and conservation of marine resources, as well as widen inter-agency and stakeholder participation in the MPA selection and planning process. The amendment would also need to provide for periodic system-wide reviews by a central body. The result is something more akin to a marine protected area network than a comprehensive marine planning and zoning framework.

Proceeding in this way would provide sufficient authority to implement marine zoning plans, as those produced by the science team and partners under Component 1 of the BioTA project.

This model would likely require all of the effort typically associated with amending existing legislation and yield a sub-optimal framework because it favors area-by-area regulation of marine space and complicates the implementation and compliance picture. Agencies and stakeholders alike would need to be mindful of several plans.

a. Planning

This model would rely on an expanded version of NCEPA's existing planning framework, which is designed to assist in the selection and designation of marine protected areas rather than to comprehensively plan the entire extent of federal waters. Once a protected area is declared, the amendment would provide that a zoning plan would have to be developed within a certain timeframe. The current NCEPA planning framework gives the Conservation Commission (comprised of government and civil society stakeholders) a consultative role in the selection and administration of marine reserves.

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[180] The NCEPA and NCEMA do not differ materially in their coverage or treatment of marine protected areas declaration, administration, or management.

The amendment would need to widen inter-agency and stakeholder participation in the planning process. Planning would be most simply conducted by a central authority with input from agencies with marine interests and stakeholders.

b. Conferring Legal Force

The amendment would need to set out how plans would bind agencies and users. Zoning plans would ideally be legislative instruments carrying the force of law.

c. Implementation

Implementation would occur at the agency level consistent with marine zoning plans developed by a central planning authority. Agencies would implement and enforce the plans by incorporating the objectives and principles of the plan into their decision-making processes, consistent with existing statutory and regulatory authorities.

v. A Note on Federalism

Because marine resources and maritime management is largely a federal prerogative, in most material respects a marine zoning framework as elaborated above would not derogate the powers reserved to the Nevis Island Administration or present significant federalism or jurisdictional issues. One important area, however, requires consideration. §106(1) of the 1993 Constitution of the Federation of St. Kitts and Nevis vests the power to regulate Nevis Island fisheries in the Nevis Island Administration. Because a federal marine zoning plan would likely make some provision for how fisheries are managed in Nevis, and because of the above-noted reservation of power to the Nevis Island Administration, a federal mandate alone is insufficient to bind the Administration's actions as they relate to fisheries.

Importantly, if a marine zoning framework were implemented, the Nevis Island Fisheries department would retain most of its jurisdiction. The models described above contemplate decentralized implementation of a centrally-developed zoning plan. If adopted, the Nevis Island fisheries authority would surrender some planning control to the central planning entity, but would retain its historic authority to implement the new plans. There would be no effect on the Nevis Island Fisheries Authority's actions in areas not covered by the plan.

A possible solution to this quandary would be for the Nevis Island Administration and/or Fisheries Department to contract with the federal government. The agreement would need to explicitly require compliance with plans.

Part IV. Conclusions

Marine zoning is consistent with the policies of the government of St. Kitts and Nevis.

Implementation of a comprehensive marine and coastal planning and zoning framework likely will require the enactment of new legislation or amendment of existing legislation. New or amended legislation would establish the required planning and zoning infrastructure and include mechanisms for planning, monitoring, evaluation, inter-agency coordination, inter-agency conflict resolution, and enforcement. The new framework would ultimately enhance responsiveness to pressing marine issues and improve the government of St. Kitts and Nevis' ability to respond to complex challenges to the integrity of marine ecosystems.

Short of enacting new legislation, there are things that government and policymakers could do to improve marine management. The Government should consider immediately adopting a coastal zone management plan under either the NCEPA or the DCPA that reflects, to the extent possible, the zoning plan contemplated by Component 1 of the BioTA project. Similarly, the Government should consider immediately designating marine reserves or protected areas to preserve highly sensitive areas under either the NCEPA or the Fisheries Act reflecting, to the extent possible, the zoning plan contemplated by Component 1.

Annex 1

St. Kitts and Nevis Marine Planning and Zoning Framework

Existing Regulatory Authorities

Target	Law(s)	Specific Provision
Tourism-Related		
Anchoring, mooring	DCPA, NCEPA, Port Authority Act	Management plans for special use areas may specify anchoring, mooring, and beaching areas. DCPA §13(3). Coastal zone management plans may prohibit anchoring of boats and docking of cruise ships in certain areas. NCEPA §31. PAA §59A(1)(f) permits the Port Authority to regulate the mode and place of mooring, anchoring, and berthing of ships. The Fisheries Regulations of 1995 Part VII, §37(2) forbids anchorage in fisheries priorities areas, except in cases of emergency.
Water Sports (Jet-Skiing, kite boarding, e.g.)	DCPA, NCEPA	Management plans may contain special resource and use areas where water-skiing, wind surfing, or other water sports may occur. DCPA §13(3) Coastal zone management plans may declare protected beaches and, within areas covered by the declaration, prohibit water skiing, *inter alia*. NCEPA §31.
SCUBA diving	Fisheries Act, Fisheries Regulations	The Minister responsible for fisheries may regulate the use of SCUBA gear. Fisheries Act

		§40(2)(g) The use of SCUBA or HOOKAH gear for fishing without the written approval of the Chief Fisheries Officer is prohibited. Fisheries Act (Regulations, 1995) §26.
Swimming, snorkeling	DCPA	Within environmental protection areas, the Planning Board may designate swimming areas. DCPA §13(3)(a).
Siting of marinas	DCPA	Construction of marinas implicates the DCPA like any other building or development project.
Fishing-Related		
Coastal Pelagics	Fisheries Act	
Coastal Demersals	Fisheries Act	
Deep Slope/Shelf Demersals	Fisheries Act	
Lobster	Fisheries Act (Regulations)	Section 18 prohibits the taking of undersized, moulting, and egg-carrying lobsters. It also prescribes acceptable and unacceptable methods of capture. Fisheries Act (Regulations, 1995) §18.
Conch	Fisheries Act (Regulations)	The taking, sale, or purchase of immature conch is prohibited. Fisheries Act (1995 Regulations) §20.
Bait fish	Fisheries Act	Among the aims of the Fisheries Act is the “management, planning, development, and conservation of fishery resources.” (Preamble to Fisheries Act 1984) Section 40 authorizes the Minister to make regulations generally for the management and development of fisheries. Action has not yet been taken under this authority to regulate bait fisheries.
Transportation/Industrial		
Geothermal energy production	DCPA	Construction of geothermal energy production facilities implicates the DCPA like any other building or development

		project. It is unknown whether additional laws govern energy production, specifically.
Port siting	Port Authority Act	The Port Authority Act vests in the Port Authority the power to develop a coordinated and integrated system of ports, lighthouses and port services. Port Authority Act §17(1).
Sand mining	NCEPA, Fisheries Act	Coastal zone management plans may declare protected beaches and, within areas covered by the declaration, prohibit sand mining or dredging. NCEPA §31. A permit must be obtained prior to taking or mining of sand within marine reserves. Fisheries Act §27.
Cruise ship areas	NCEPA, Port Authority Act	Coastal zone management plans may declare protected beaches and, within areas covered, prohibit anchoring of boats and docking of cruise ships, *inter alia*. NCEPA §31 The Port Manager may direct where any ship shall be berthed, moored or anchored and the method of anchoring within the port. He or she may also regulate the moving of ships within the port and the approaches. PAA §52
Ferry routes	Port Authority Act	The Port Authority Act at §59(1) authorizes the regulation of traffic and navigation of ships within the limits and approaches to a port.
Conservation-Related		
Coastal Lagoons	NCEPA	
Coral Reefs	DCPA, Fisheries Act, Fisheries Act (Regulations)	Management plans may provide for protection of marine flora and fauna. DCPA §13(3). §40(2)(p) of the Fisheries Act

		authorizes regulation of taking of coral and shells. Fisheries Act §40(2)(p). Regulations prohibit collection and possession of coral, sponge, and sea stars without the written permission of the Chief Fisheries Officer. Fisheries Act (Regulations, 1995) §21
Mangroves	DCPA, Fisheries Act	Management plans may provide for the protection of marine flora and fauna. DCPA §13(3). Marine reserves are areas where the Minister feels that special measures are necessary to protect the flora and fauna of the designated areas; and to preserve breeding grounds and habitat. Fisheries Act §23. Without prior authorization, it is illegal to . . . destroy flora. Fisheries Act §23 (2),(3).
Sandy Bottoms	Unknown.	Unknown.
Dense Sea Grass	DCPA, Fisheries Act	Management for special use areas plans may provide for protection of marine flora and fauna. DCPA §13(3) Marine reserves are areas where the Minister feels that special measures are necessary to protect the flora and fauna of the designated areas; and to preserve breeding grounds and habitat. Fisheries Act §23. Without prior authorization, it is illegal to . . . destroy flora. Fisheries Act §23 (2),(3).
Sparse Seagrass	DCPA, Fisheries Act	Management for special use areas plans may provide for protection of marine flora and fauna. DCPA §13(3) Marine reserves are areas where the Minister feels that special measures are necessary to

		protect the flora and fauna of the designated areas; and to preserve breeding grounds and habitat. Fisheries Act §23. Without prior authorization, it is illegal to . . . destroy flora. Fisheries Act §23 (2),(3).
Turtle Nesting, Nursery Areas	Fisheries Act (Regulations)	Taking of turtle eggs and undersized turtles. It also prohibits interference with nests or nesting turtles. Fisheries Act (Regulations, 1995) §19.