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The Our Florida Reefs Coastal Use Survey: An Online Survey to Support Stakeholder Management Recommendations for Southeast Florida

Amanda Rose Costaregni
Nova Southeastern University, AC1724@nova.edu

NOVA SOUTHEASTERN UNIVERSITY HALMOS COLLEGE OF NATURAL SCIENCES AND OCEANOGRAPHY

The *Our Florida Reefs* Coastal Use Survey: An Online Survey to Support Stakeholder Management Recommendations for Southeast Florida

By

Amanda Rose Costaregni

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Approved:

Thesis Committee

Major Professor: ____
Brian K. Walker, Ph.D.

Committee Member: ____
David W. Kerstetter, Ph.D.

Committee Member: ____
Manoj Shivlani, Ph.D.

Abstract

Coral reefs are an important resource world-wide. Unfortunately, coral reef conditions are declining in many areas due to both global and local stressors. The objective of this study was to survey stakeholders in southeast Florida to better understand reef use in the region. Stakeholders spatially identified where and how often they conducted their activities. These data were compiled and analyzed in GIS to determine spatial use patterns. Both location and intensity of use were analyzed to determine which areas may be under greater stress from recreational activities. It was found that reef use was not evenly distributed in the region, but clustered around inlets and piers. Reef use differed between user groups (i.e. SCUBA divers, fishers) and demographics. It was also found that use in the Broward-Miami Coral Reef Ecosystem Region was spread out over a wider spatial scale than the use in the regions north and south.

These data are important as they have the potential to inform the recommendations being made to improve coral reef management in southeast Florida. The study can provide a better understanding of human-environmental relationships and the trade-offs involved so that recommendations can better decrease user conflicts, maximize economic productivity, and preserve the environment.

Keywords

Spatial planning, survey, reef use, recreational use, GIS, Hot Spot Analysis, Point Density Analysis, habitat, southeast Florida

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List of Acronyms

- CWG- Community Working Group
- FDEP- Florida Department of Environmental Protection
- FWC- Florida Fish and Wildlife Commission
- GIS- Geographical Information Systems
- EIS- Environmental Impact Statement
- EBM- Ecosystem-Based Management
- MSP- Marine Spatial Planning
- NGO- Non-governmental Organization
- NOAA- National Oceanic and Atmospheric Association
- OFR- *Our Florida Reefs*
- SAC- Sanctuary Advisory Council
- SEFCRI- Southeast Florida Coral Reef Initiative
- TCM- Travel Cost Method

1. INTRODUCTION

Coral reefs are an important resource around the world. Unfortunately, coral reef conditions are declining in many areas due to both global and local stressors. Ocean warming and ocean acidification have been identified on a global scale. Elevated sea surface temperatures can cause coral bleaching, which in turn may result in catastrophic loss of coral cover in some locations and lead to altered coral community structure in many others, potentially influencing biodiversity (Baker et al., 2008). On a local scale, stressors may include fishing, pollution, sedimentation, habitat destruction, and invasive species. It is the combination of these global and local stressors that has contributed to unprecedented degradation over the last fifty years (Jaap, 1984; Lester et al., 2010; Smith et al., 2008; Walker et al. 2012).

High concentrations of anthropogenic activities in coastal regions have resulted in various pressures and associated impacts that adversely affect the coastal and marine environment (O'Mahony et al., 2009). Because many anthropogenic activities directly harm surrounding ecosystems, one of the main concerns today is the sustainability of the environment amidst increasing anthropogenic use (Douvere, 2008). Collective demand of resources and space in the marine environment has exceeded about three times that available in some parts of the world (Douvere, 2008). Ecosystem-based Management (EBM) has been implemented in many areas to maintain ocean health despite these high levels of stress placed on the environment. Rather than focusing on individual components, EBM focuses on the entire ecosystem. An ecosystem is a system formed by the interaction of a community of organisms with the physical environment (Slocombe, 1993), including humans and their interactions. EBM observes and manages this system as a whole so both environmental health and socio-economic prosperity are addressed (Koehn et al., 2013).

The EBM approach aims to achieve sustainable development and puts emphasis on management that maintains ecosystem health as well as human use. This type of management aims to benefit both current and future generations (Jennings, 2004). Through modified planning, management, policy, and decision-making activities, ecosystem-based management provides a framework and a research agenda that achieves environmental protection and economic development (Slocombe, 1993). The research agenda includes improved data collection for high-priority ecosystem interactions. This allows management to evolve toward a system in which indicators can be monitored for each ecosystem-based goal and objective (Pikitch et al., 2004). Goals and objectives are necessary to drive development of criteria to assess EBM programs (Slocombe et al., 1998). This adaptive management approach facilitates increased data richness and a better understanding of how ecosystems respond to alternative strategies (Arkema et al., 2006; Pikitch et al., 2004).

Many national and international bodies have called for the use of EBM as a more comprehensive way to manage the range of human activities that affect marine ecosystems (McLeod and Leslie, 2009). It consists of three key elements: connections, cumulative impacts, and multiple objectives. Cultures, economies, and institutions evolve with the ecosystem. Similarly, human activity affects these natural systems. These linkages have been referred to as "coupled social-ecological systems" and show the strong connections that are essential to EBM (McLeod and Leslie, 2009). Cumulative impacts are also an important element as EBM focuses on how human actions affect ecosystem services in these coupled systems. It concentrates on the range of benefits received from marine systems rather than single ecosystem services, demonstrating the importance of having multiple objectives. Ultimately, the idea of EBM is management of people's influences on ecosystems rather than the management of the ecosystems themselves (McLeod and Leslie, 2009). Ocean zoning is a critical component of EBM and regulates which type and level of human activity is permitted spatially and temporally (Pikitch et al., 2004).

In an effort to conserve natural resources and alleviate user conflict, many countries are using the spatially-focused approach to ecosystem-based management termed marine spatial planning (MSP) (Nutters and Pinto da Silva, 2012). MSP is an integrated planning framework that informs the spatial distribution of ocean activities. It aims to support current and future uses of ocean ecosystems while maintaining the delivery of valuable ecosystem services. Currently, governance of marine systems is primarily by sector (e.g. enforcement, fisheries, restoration), leading to fragmentation and spatial/temporal mismatches (Crowder and Norse, 2008). Unlike this form of sectoral management, MSP looks at cumulative effects of multiple activities in an area (Foley et al., 2010). Foley et al. (2010) state that the MSP process:

> Emphasizes the legal, social, economic, and ecological complexities of governance, including the designation of authority, stakeholder

> participation, financial support, analysis of current and future uses and ocean condition, enforcement, monitoring, and adaptive management. (p. 956)

With increased population growth along the coasts, resulting in likely increased conflicts between ocean health and ecosystem services, domestic policy makers in the United States began to consider MSP a viable strategy for managing human uses in federal waters (Foley et al., 2010).

In June 2009, an Interagency Ocean Policy Task Force consisting of representatives from ocean-related federal agencies was established and appointed to develop recommendations to enhance national stewardship of the ocean, coasts, and Great Lakes (The White House, 2010). The final recommendations of the Task Force consisted of nine priority objectives. The top two on this list were: 1) Ecosystem-based Management, and 2) Marine Spatial Planning. The Task Force noted that these priorities needed to be comprehensive, integrated, and more effectively coordinated with federal, state, tribal, local, and regional management, thus providing a bridge between the policy and specific actions required to meet the U.S. National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes (Interagency Ocean Policy Task Force, 2010). In July 2010 these Interagency Ocean Policy Task Force recommendations were adopted by Executive Order. Marine Spatial Planning subsequently accelerated at a remarkable pace with active steps being taken in Washington D.C. and nine regions around the United States (Gopnik et al., 2012).

Florida's fast population growth and subsequent coastal construction make it an appropriate region to implement marine spatial planning. Its vast and diverse coastline is popular for coastal and marine recreational activities. From 2000 to 2006, the increasing number of recreational boat registrations surpassed the population growth rate by three percent (Swett et al., 2009). In 2013, 896,632 vessels were registered in Florida alone (Florida DHSMV, 2014). With increased demands for space and resources, a comprehensive management plan is not an option but a necessity (Halpern et al., 2012). The reefs in Florida provide billions of dollars in revenue to the local economy (Lirman and Fong, 2007). In the year 2000 alone, it was estimated that the economic contribution from both natural and artificial reefs was $873.1 million for Monroe, Miami-Dade, Broward and Palm Beach counties combined (Johns et al., 2001). The reefs not only support various recreational activities such as fishing, diving, boating, and water sports, but they also protect coastlines from beach erosion caused by waves (Bhat, 2003; Wells and Ravilious, 2006). The benefits to humans provided by reefs demonstrate the strong coupling of social and ecological systems. It is thus important to incorporate these anthropogenic linkages with reef systems in MSP (Ban et al., 2011; Pomeroy & Douvere, 2008).

The Florida Keys National Marine Sanctuary ("the Sanctuary") was among the first examples of MSP implementation in Florida. In 1990, the mounting threats to the coral reefs in the Florida Keys provoked H.R. 5909 to enact the Florida Keys National Marine Sanctuary and Protection Act, (P.L. 101-605). The National Oceanic and Atmospheric Administration (NOAA) and the State of Florida, with management assistance by the Florida Department of Environmental Protection (FDEP), administers the Sanctuary.

In March 1995, NOAA released the FKNMS Draft Management Plan and Environmental Impact Statement (EIS) (Suman, 1997). This release was followed by public hearings in November 1995. A comprehensive management plan for the Sanctuary was developed in 1996 and the Secretary of Commerce in conjunction with the state of Florida, approved the plan in 1997 (Suman, 1997). The final plan included ten individual action strategies which aimed to protect the resources of the Florida Keys (Sleasman et al., 2009).

Although the marine spatial planning process was used in the Florida Keys to designate marine reserves as part of the Florida Keys National Marine Sanctuary, the northern 103 miles of the Florida Reef Tract (designated by the red boundary in Figure 1) lacks a comprehensive management plan to protect its reefs.

After the U.S. Coral Reef Task Force adopted the Puerto Rico Resolution calling for the development of Local Action Strategies by its seven U.S. states, territories and commonwealths, Florida Department of Environmental Protection (FDEP) and the Florida Fish and Wildlife Conservation Commission (FWC) formed the Southeast Florida Coral Reef Initiative (SEFCRI). SEFCRI is a local action strategy for collaborative action among government and non-governmental partners (DEP, 2004). It is SEFCRI's responsibility to identify and implement priority actions needed to reduce key threats to coral reef resources in southeast Florida (DEP, 2004). The region chosen for this initiative encompasses the northern portion of Miami-Dade County, Broward County, Palm Beach County, and the southern portion of Martin County.

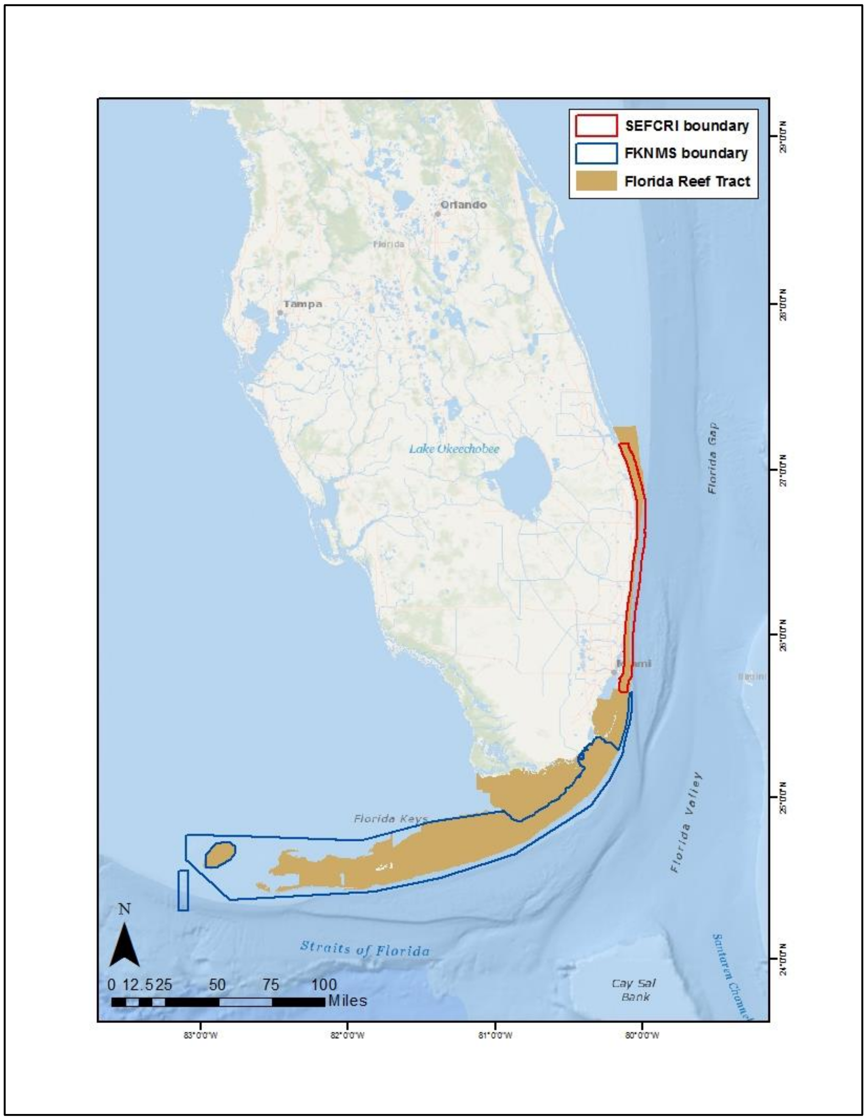

Figure 1. Map of the Florida Reef Tract (indicated in light brown) with the Southeast Florida Coral Reef Initiative (SEFCRI) boundary outlined in red and Florida Keys National Marine Sanctuary (FKNMS) boundary outlined in blue. Unlike the area within FKNMS boundary, the area within the SEFCRI boundary lacks a comprehensive management plan to protect its reefs

Frequent recreational use, declining reef health, and lack of a comprehensive management plan for southeast Florida's reefs led SEFCRI to begin a regional community marine spatial planning process called *Our Florida Reefs* (OFR) in June 2013 (Our Florida Reefs, n.d.). The goal of this effort is to engage local stakeholders in making management recommendations towards protecting southeast Florida's reefs for both environmental and economic reasons. The process was funded by a state and federal partnership through a cooperative agreement between the Coral Reef Conservation Programs of NOAA and FDEP. Two Community Working Groups (CWGs) were formed in 2014: a Northern group (Martin and Palm Beach counties) and a Southern group (Broward and Miami-Dade counties). These groups each consist of 25 representatives from various stakeholder groups including the general public, diving community, fishing community (recreational and commercial), academic community, NGOs, and government agencies. At the onset, the groups attended monthly meetings to learn more about the reefs and understand the current data that is available. The CWGs used this knowledge to develop a large list of recommended management actions (RMAs). Engaging stakeholders and allowing them to develop recommended management actions, elicits feelings of empowerment, legitimacy, and equity, producing a management plan that the community is more likely to support (McCall & Dunn, 2012).

It is important to identify a region's stakeholders within the MSP process. Stakeholders include any individual, group, or organization that can affect, be affected by, or perceives itself to be affected by, a project or program (MSP, 2011). They may participate in non-consumptive or consumptive forms of use, and oftentimes, engage in both. Some types of potential MSP process stakeholders include business owners, recreational anglers, commercial fishers, divers, and non-governmental organizations (NGOs). All of these groups have a vested interest in the reefs and thus, are important to include in developing a management plan. It is believed without stakeholder involvement, a plan will rarely succeed (Human & Davies, 2010; Mackinson et al., 2011; Maguire et al., 2012). Inclusion of stakeholder groups is one of the central principles of MSP and sets the guidelines for EBM (Nutters and Pinto da Silva, 2012). This is known as 'bottom-up' or collaborative planning. It strongly contrasts with the 'top-down' planning approach, where the government makes decisions without community input, a process which can be viewed as elitist and exclusionary (Human & Davies, 2010). It is also important that stakeholder involvement be initiated early in the process, often, and continuous throughout (Ban &

Bodtker, 2013; Gilliland & Laffoley, 2008; Maguire et al., 2012; Pomeroy & Douvere, 2008). A recent study found that many stakeholders in southeast Florida feel they are not given opportunities to make important decisions regarding the reefs; over half (58.45%) of their respondents felt they were “Never” given the opportunity to be involved in making decisions related to the management of coral reefs (NOAA, *in prep.*). One goal of the OFR process was to allow the public’s voice to be heard.

Within the OFR process, there were some necessary steps taken to gain community involvement and achieve transparency. Holding public meetings to inform the community about the planning process was one of the first steps. These meetings engaged the community and kept the stakeholders informed about the process. The next step was creating the representative stakeholder groups, referred to as Community Working Groups (CWGs), and asking them to develop recommended management actions.

Communication throughout the *OFR* process is crucial, as the stakeholders are fundamental in decision-making (Pomeroy & Douvere, 2008). Using the proper tools, the OFR community planning process can be transparent, comprehensive, adaptive, integrative, and ecosystem-based, giving the stakeholders a greater chance of developing successful management plans. Understanding the importance of interactive planning tools in the marine spatial planning process, an ecosystem-based consultant company named Point97, was contracted to develop a DST to meet the needs of *OFR*. The company has extensive experience creating marine planning software and has partnered with organizations such as the Mid-Atlantic Regional Council on the Ocean and the West Coast Governor’s’ Alliance to create open-source, intuitive tools, that aid in implementing a transparent and collaborative decision-making process (Point Nine Seven, 2015). These tools include the Marine Planner, an interactive mapping application that consolidates and displays available data in the region. They have developed surveys to fill data gaps, such as recreational use, that are fundamental to marine spatial planning. They have partnered with SeaPlan, the Northeast Regional Ocean Council, state coastal programs, marine trades associations, and others to conduct a recreational boating survey in the Northeast. They have also conducted recreational use surveys for the Northwest in partnership with The Surfrider Foundation (Point Nine Seven, 2015). Point97 was hired to tailor the Marine Planner for the *OFR* community planning process. Guided by Nova Southeastern

University and an *OFR* project planning team, Point97 coded the Marine Planner to serve as the *OFR* DST including an interactive data portal, a reef use survey, and a decision support program that utilizes grid filtering technology and the available data to aid the CWGs in making informed decisions.

Possessing the appropriate data is necessary to inform the MSP process. Although abundant data may be available on the spatial and temporal heterogeneity of natural features in the ecosystem, information on the heterogeneity of the human elements is often lacking, especially in the marine environment (Dalton et al., 2009). Social data are important, having potential to inform and improve MSP. According to Dalton et al. (2009):

> An improved understanding of the heterogeneity of human use patterns in the marine environment can highlight areas of intense use or areas where multiple activities are occurring, illustrate inequalities in resource use and access, and demonstrate how people are interacting with the natural environment and whether they are abiding by current spatial policies. (p. 309-310)

Social data provide a better understanding of human-environmental relationships and the trade-offs involved (Ban & Bodtker, 2013). With this information, the compatibility of multiple use objectives can be examined, areas of conflict can be identified, predicted and resolved, and existing patterns of interaction can be revealed (Pomeroy & Douvere, 2008). Enhanced understanding of human-environmental relationships, aids in developing a successful plan to decrease user conflicts, maximize economic productivity, and preserve the environment (Koehn et al., 2013; Lester et al., 2010).

In southeast Florida, anthropogenic reef use was identified as an OFR data gap. Although some reef use had been examined historically, those prior studies no longer reflected current use patterns, nor did they have the spatial resolution needed by the CWGs. A new spatial survey was therefore conducted to gather the necessary data. This new spatial survey also provided an opportunity to engage the community, allowing them to provide input and participate in the planning process.

Previous socioeconomic reef use studies in southeast Florida have been conducted but updated data will help identify how residents and visitors are currently using the reefs before a comprehensive management plan is formed. A study by Shivlani and Villanueva

(2007) compiled and compared social perceptions on reef conditions and use in southeast Florida. The data were collected differently depending on the stakeholder group. For example, fishermen were surveyed using in-person interviews while surfers were surveyed using a web-based survey program (www.surveymonkey.com). The study included demographic data, economic data, catch/use information, areas of use, and perception data for reef stakeholders. Using the Internet as a survey method for the surfer population was described as "an emerging medium" (pg. 194) in Shivlani and Villaneuva's report. Today, online surveys have become more prevalent. The results from this study are very important as they provide a spatial context of how stakeholders used the reef at that time. The surveys also provided insight on how the stakeholders viewed user conflicts, how their actions as well as other stakeholders' actions affect reef health, and how coral reef and water quality conditions have changed over the years. Over half of the fishermen interviewed, for example, believed coral reefs in the SEFCRI region were in worse condition than when they started fishing. Participants were also asked about their preferred form of management with options such as current, rights-based, less, interpretive, and enforcement-based. All stakeholders agreed that less management was the least preferred course of action. The information aided in understanding the perceptions of the different user groups and the extent of their use.

Another socioeconomic study of the reefs in southeast Florida was published by Johns et al. (2001), which determined the net economic value of both natural and artificial reefs to the local economies and reef users, as well as the willingness of reef users to pay to maintain the reefs. They looked at the reef-related expenditures per county. There was no spatial component of stakeholder use in this survey. A few years later, another socioeconomic study of the reefs was conducted by Johns et al. (2004) in Martin County, Florida. The same methods from the 2001 report were used. In both studies, it was clear that reef health is very important to all of the users by their willingness to pay to invest in, and maintain, the reefs. In Martin County, for example, reef users were willing to pay $1.1 million annually for that cause.

The data from these previous reports will not be directly comparable to the data from this study due to differences in data collection methodology, type of data collected, and resolution of data; however, past studies' findings will still be useful for qualitative comparisons and will provide a general measure of how stakeholder use extent has changed over the years. The data collection for the OFR reef use survey differed in that the participants submitted data online. In person interviews, phone interviews and mail back surveys were not used as they have been in past surveys. This method was used to make the survey accessible to more people and to make data collection and management automated. The OFR survey used a 200 m x 200 m grid to achieve a finer spatial resolution as well. Although the Shivlani and Villanueva (2007) study also collected spatial data, it was at a more course spatial resolution. The OFR study had a more complete list of activities for the participant to choose from; for example, instead of a generic "SCUBA diving" activity, users would select their method of entry such as "from shore" or "from a vessel." Participants would also indicate what activity they engaged in while diving. For example, as previous studies would simply note that the user engaged in SCUBA diving activity, this study would note that the user engaged in SCUBA diving activity from a vessel to spearfish. This produced more detailed data that could be analyzed individually or in groups according to different objectives.

2. STUDY OBJECTIVES

There were three main study objectives. The first was to understand reef user demographics in southeast Florida. The second was to investigate whether stakeholder groups utilize the seascape equally and are not spatially clustered. The third was to analyze intensity of use in addition to use location to observe if data cluster differently. This data will help develop and support the recommended management options generated from the OFR process. It will also be useful to understand implications that may result following the implementation of any management recommendations.

To achieve this objective, stakeholders were engaged to take an online, interactive survey. Respondents indicated which on-water activities they participated in during the past twelve months and spatially identified where they conducted the activities and how often they conducted the activities at each location. Non-spatial data in this survey included demographic data as well as expenditure data, which specifically requested that the participants provide an estimate of how much they spend on average per day engaging in their chosen activities. The spatial data were compiled by activity type and analyzed to determine spatial use patterns in southeast Florida. These data were then incorporated into multiple GIS layers referred to as "features" and integrated into the Marine Planner decision support tool to inform the OFR planning process. The participants were also asked to rate the usability of the survey and provide feedback on improvements that should be made to develop a more user-friendly survey and mapping tool in the future.

3. METHODS

3.1. Study area

The study area is located in southeast Florida in the shallow-water (< 40 m) coral reef system known as the northern extension of the Florida Reef Tract, henceforth referred to as the SEFCRI region (Figure 2). The northern-most limit of the area is Port St. Lucie Inlet in Martin County and the southernmost limit is the northern border of Biscayne National Park in Miami-Dade County. This area is heavily populated with 1,695 people per square kilometer, making it the eighth most densely populated area in the United States (Futch et al., 2011).

Since the county boundaries do not line up well with the offshore coral reef ecosystem, the survey data were displayed with the Coral Reef Ecosystem Region designations of Walker (2012) and Walker and Gilliam (2013) to help provide an understanding of use in each region (Figure 3 and Figure 4). Starting in the south, the Biscayne Region spans approximately 22 km of coastline bounded by the end of the SEFCRI area (south) and Government Cut (north). The Broward-Miami Region spans approximately 48 km of coastline bounded by Government Cut (south) and the Hillsboro inlet (north). The Deerfield Region spans approximately 15 km of coastline bounded by the Hillsboro Inlet and Boca Raton boundary. The South Palm Beach Region spans approximately 36 km of coastline from Boca Raton (south) to the Bahamas Fracture Zone (north). The North Palm Beach Region spans approximately 32 km of coastline from the Bahamas Fracture Zone (south) to southern Martin County just north of the Deep Ridge Complex (north). The Martin Region extends from this location north to the end of the mapped area (northern Martin County line) (Walker and Gilliam, 2013).

Walker (2012) provides a list of habitat types and their definitions in southeast Florida. These habitat types were used in the results and discussion of reef use distribution in this survey. The criteria for habitat classification were defined by their biologic communities, location, geomorphologic characteristics, and acoustic characteristics. The Deep Ridge is linear hardbottom habitat, often shore-parallel having low relief features that mostly occur in waters deeper than 25 m (Figure 3). The Nearshore Ridge Complex is a combination of shallow colonized pavement and ridges found near shore in 3-5 m depth (Figure 3 and Figure 4). It is solid carbonate rock with minimal relief. The Inner Reef is a distinct, relatively continuous, shore-parallel reef that consists of a rich coral reef community which crests in approximately 8 m depth (Figure 3 and Figure 4). The Middle Reef is a distinct, relatively continuous, shore-parallel reef that consists of a rich coral reef community that crests in approximately 15 m depth (Figure 3 and Figure 4). The northern terminus of this reef occurs offshore of the city of Boca Raton in Palm Beach County. The Outer Reef is also a distinct, relatively continuous, shore-parallel reef but crests in approximately 16 m depth. The Bahamas Fracture Zone, located south of Lake Worth Inlet, marks the northern terminus of this reef (Figure 3 and Figure 4).

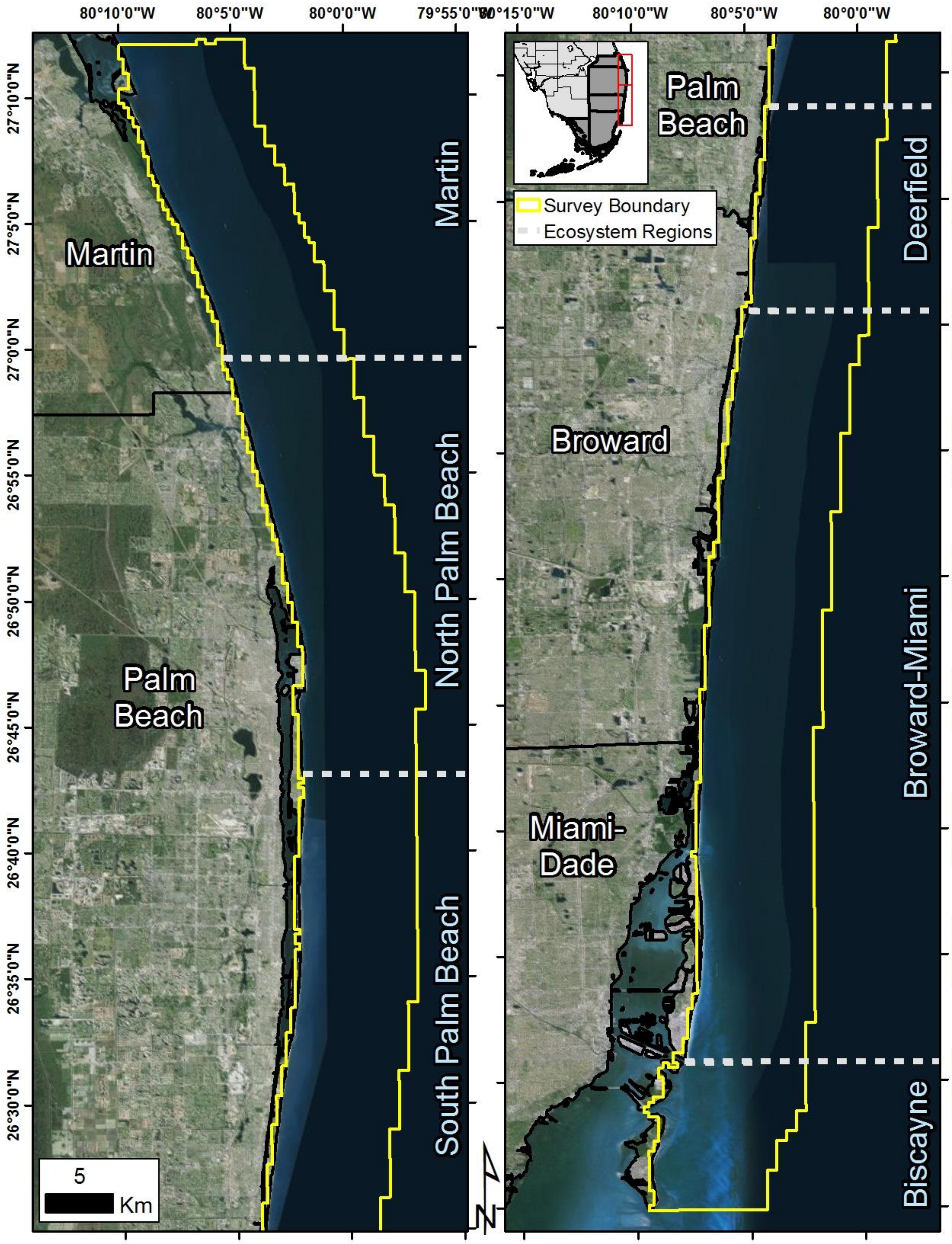

Figure 2. The OFR survey study area located in southeast Florida in the shallow-water (< 40 m) coral reef system known as the northern extension of the Florida Reef, henceforth referred to as the SEFCRI region. This map includes the county boundaries and coral reef ecosystem region boundaries. The coral reef ecosystem boundaries were used to display the survey results.

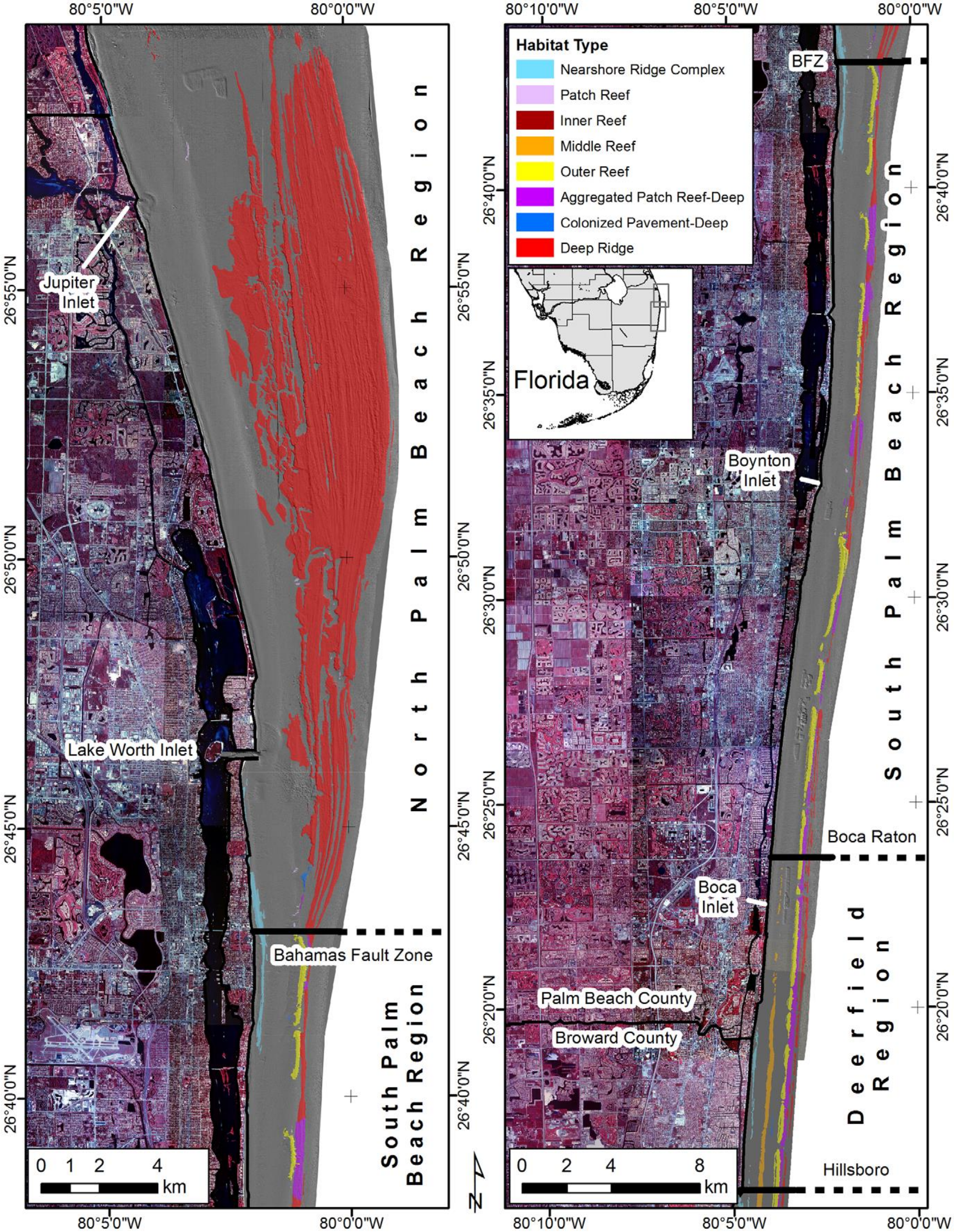

Figure 3. Maps displaying the coral reef habitat types in the North Palm Beach, South Palm Beach, and Deerfield coral reef ecosystem regions. These regions were used to describe reef use distribution in the OFR survey results (Walker, 2012).

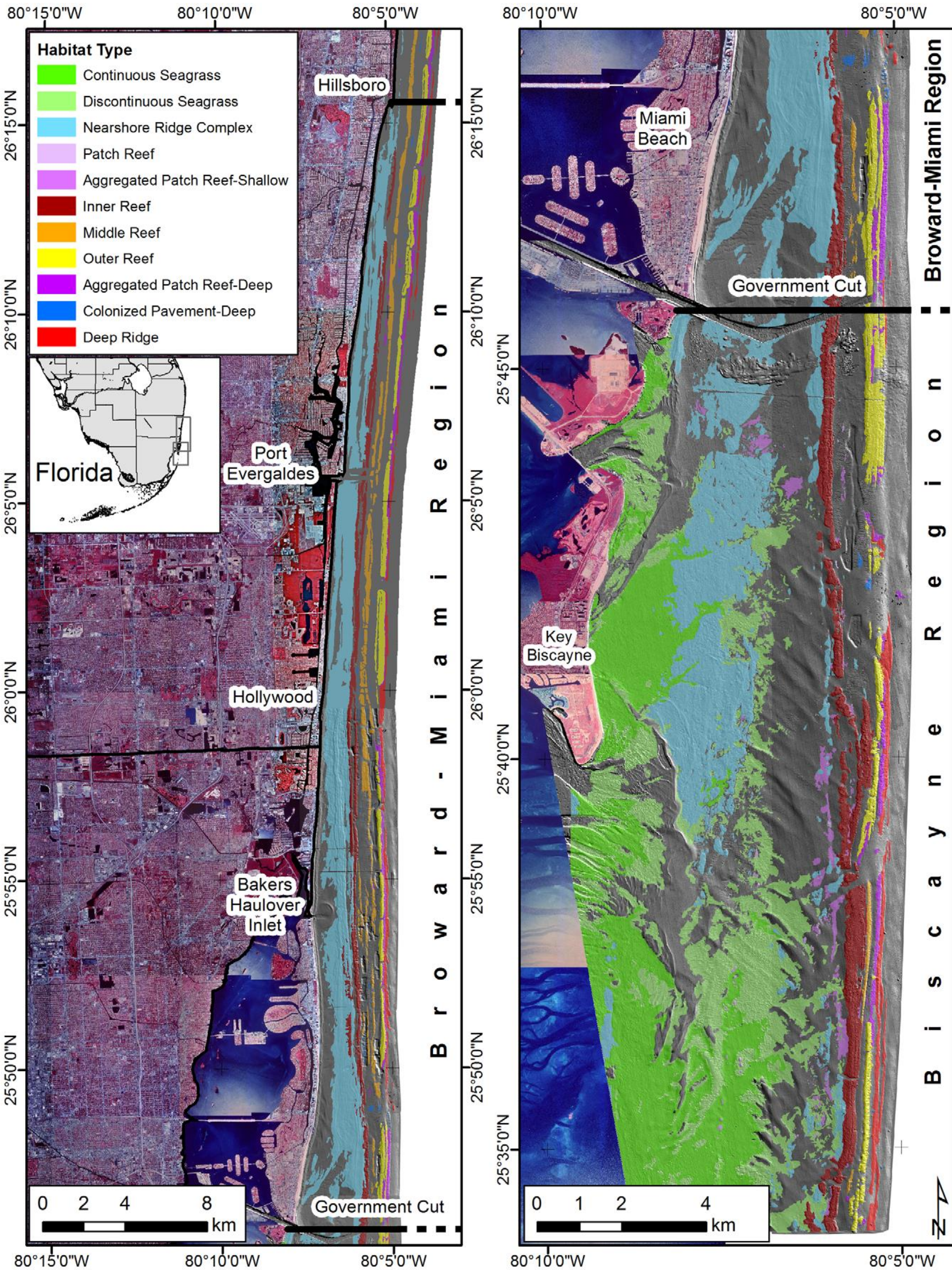

Figure 4. Maps displaying the coral reef habitat types in the Broward-Miami and Biscayne coral reef ecosystem regions. These regions were used to describe reef use distribution in the OFR survey results. (Walker, 2012).

3.2. Stakeholder-use Data collection Using Survey

3.2.1. Survey Design

An online spatial survey to obtain local knowledge using a participatory approach was conceptualized and designed by the *OFR* Project Planning Team and programmed by Point97, a third-party contractor in Oregon. A basic survey design was already in place as Point97 had designed surveys in the past while partnering with organizations aiming to collect similar data such as the Northeast Regional Ocean Council, SeaPlan, state coastal programs, and marine trades associations (Point Nine Seven, 2015). Point97 has also worked with The Surfrider Foundation, Monmouth University, and The Nature Conservancy to conduct a recreational ocean and coastal use study for the Mid-Atlantic. Similar to our survey, this survey included many recreational activities such as boating, surfing, diving, and kayaking. One of the main differences was the Mid-Atlantic survey's inclusion of beach activities. For the *OFR* survey, it was decided by the Project Planning Team that activities would be limited to the mean high water line and would not include activities such as shelling or sunbathing as these shore-based activities do not directly use or affect the reefs.

The *Our Florida Reefs* survey was designed using a non-probability based "opt-in" sample methodology (Crowther and Chen, 2015). An email authenticated registration process was used to minimize spam and improve security of the system. Following registration, survey respondents were emailed a unique survey link to access the survey. They were able to use this link to return to their saved survey at any time before final submission. Reminder emails to complete the survey were also sent in an effort to collect more surveys. All of the data was automatically added to a database so that no manual input was necessary. An online dashboard was created by Point97 to review high-level, real-time survey and demographic statistics. These statistics were used to monitor participation and target outreach activities.

Questions in the beginning of the survey were general and simple to build up respondents' confidence in the survey's objective, arouse their interest and participation, and reduce any doubt in their ability to answer questions (Iarossi, 2006). The first question asked whether respondents were a full-time resident, part-time resident, or visitor to southeast Florida. Full-time residents were defined as living in southeast Florida for six months or more. Part-time residents were defined as living in southeast Florida for less than six months. Visitors were defined as spending less than two months in southeast Florida. These definitions were chosen according to literature on seasonal residents in Florida, often referred to as "snowbirds". Snowbirds typically arrive in late fall and stay until late spring (Radcliff et al., 2005). This time frame is approximately four to five months. If the respondents selected the full-time or part-time resident option, they were then prompted to select the county in which they reside.

Next, respondents were asked to select the activities they participated in during the past twelve months. This time frame was chosen to include all seasons, as many reef-related activities are seasonal. Factors such as weather, fishing regulations, and fish migrations may dictate when people use the reefs. It was also chosen to be short enough for respondents to accurately recall their activities. Thirty-three activity options were available, including an "other" option that allowed respondents to manually enter their activity (Table 1). Due to the large number of activities offered, the webpage displayed the main headings and utilized dropdown subheadings to consolidate the large list. The main heading list had eight categories plus one "other" category. These main categories included more detailed activities within them; for example, spearfishing was found under multiple main categories such as the "SCUBA diving from shore (includes kayak)" category as well as the "SCUBA diving from boat" category. There was no limit to the number of selectable activities.

Table 1. List of selectable activities. Multiple activities could be selected in this question. Due to the large number of activities offered, the webpage displayed the main headings (bold) and utilized dropdown subheadings to consolidate the large list.

Activity Group	Activity
Boating	Motor
	Sail
	Kayak
	Personal Watercraft
	Research (boating)
Recreational fishing	Shore/pier
	Private vessel
	Charter vessel
	Research

Table 1. continued. List of selectable activities. Multiple activities could be selected in this question. Due to the large number of activities offered, the webpage displayed the main headings (bold) and utilized dropdown subheadings to consolidate the large list.

Activity Group	Activity
Commercial	Shore/pier
	Commercial/private vessel
	Charter vessel (Fishing Charter Captain)
	Charter vessel (Dive Boat Captain)
	Lobstering
	Research
SCUBA diving from shore (includes kayak)	Spearfishing
	Photography
	Pleasure
	Lobstering
	Collection for aquarium trade or personal tank
	Research
SCUBA diving by boat	Spearfishing
	Photography
	Pleasure
	Lobstering
	Collection for aquarium trade or personal tank
	Research
Snorkel/ freediving from shore (includes kayak)	Spearfishing
	Photography
	Pleasure
	Lobstering
	Collection for aquarium trade or personal tank
	Research
Snorkel/ freediving from vessel	Spearfishing commercial/recreational
	Photography
	Pleasure
	Lobstering
	Collection for aquarium trade or personal tank
	Research
Watersports	Surfing
	Kiteboarding
	Stand-up paddle boarding
	Windsurfing
Other	Respondent typed in activity

After respondents selected all appropriate activities, they were taken to an interactive map where they could indicate the locations of each of the selected activities . They were able to search the map using multiple methods. They could type in a city or popular dive site name, type in coordinates of a location, or they could manually pan along the map and use the zoom button. These methods yield more precise data at a finer spatial resolution. When mapping, the cursor changed into a 150 m diameter circle within which the activity should have occurred. Each 150 m diameter mapped location was then associated with an underlying 200 m by 200 m planning unit grid (Figure 5). The data entered were associated with all grid cells the cursor contacted yielding an area large enough to conceal specific reef locations, thus buffering the respondent's exact locations. This methodology was chosen to maintain an individual's location privacy while still gathering data at a meaningful scale.

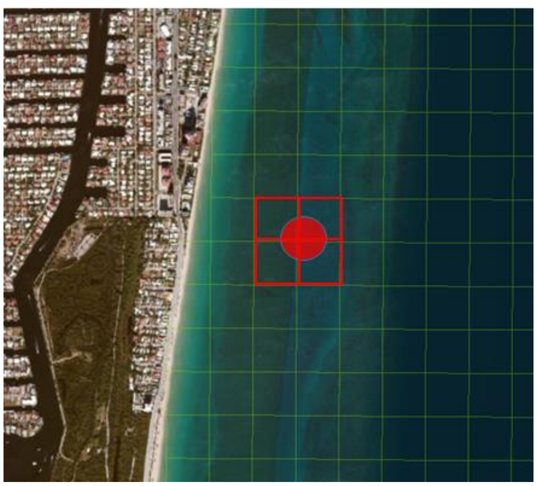

Figure 5. Example of survey activity mapping. Red circle is the 150 m wide circle cursor which selects any 200 x 200 meter planning units it intersects. This records a larger area, which conceals individual locations and retains privacy.

Since repetitive activities in the same location likely occur by some respondents (i.e., the individual visits the same spot multiple times per year), each mapped activity location required respondents to enter the number of days they visited the location in the past year, a value referred to as "activity-days." This value was used to weight the activity according to how many activity-days were spent to help understand the intensity of use without having the respondent enter the same location many times.

Once respondents finished mapping all activities selected, they were asked to indicate the estimated cost associated with each activity, including all expenses related to a day of doing that particular activity (e.g. fuel, bait, SCUBA tanks, food, charter costs, etc.). The travel cost method (TCM) is used to infer economic value of nonmarket resources and public goods (Cameron, 1992; Loomis et al., 2000). The travel cost considered must only be those costs associated with visiting the specific site (Loomis et al., 2000). Their choices were as follows: $0 - $50, $51-$100, $101-$500, $501-$1000, $1001-$5000 and $5001 or more. These bins were chosen to match the Villanueva and Shivlani 2007 study allowing a closer comparison of past and present economic data.

Next, the respondents were asked to select their favorite location using the interactive map. Unlike the previous mapping questions, this location did not have to be one that they had visited in the past year. Also unlike the previous mapping question, they were only permitted to choose a single location. Once the location was selected, respondents were asked to select from a list of choices why the location was important to them. They were permitted to choose as many options from this list as applied (Table 2). Finally, respondents were asked what their primary activity was at this location. For this question, only one answer was accepted (Table 3).

Table 2. List of reasons indicating why respondents chose their favorite location. Respondents were able to choose more than one reason for liking their favorite location.

Favorite Location Reason
Activity-based - The site is perfect for my particular activity (e.g. fishing area, dive site,
Beautiful - The site is beautiful or has striking natural features
Water Quality - The water is clean, clear and/or good to swim in
Marine Life - Marine life is abundant and diverse
Memories - I have a lot of memories from this place
Secluded - The site is secluded, away from crowds, and offers privacy
Educational- It is a place I can learn about, teach, or research the natural environment
Inspiring - This is a spiritual/inspiring place for me
Social - This is where my friends/family frequent
Livelihood - Professional purposes
Collecting - There are specific natural resources I like to collect here
Other

Table 3. List of activities respondents could select from indicating their primary activity at their favorite location. Only one answer was permitted.

Favorite Location Activities
Pleasure (diving by boat)
Pleasure (snorkel/freediving from shore)
Private vessel (recreational fishing)
Pleasure (diving from shore)
Research (diving by boat)
Motor
Photography (diving by boat)
Lobstering (diving by boat)
Pleasure (snorkel/freediving from vessel)
Shore/pier (recreational fishing)
Surfing
Research (snorkel/freediving from shore)
Research (diving from shore)
Spearfishing (diving by boat)
Photography (snorkel/freediving from shore)
Kayak
Spearfishing - commercial or recreational (snorkel/freediving from vessel)
Photography (snorkel/freediving from vessel)
Stand-up paddle boarding
Shore/pier (commercial fishing)
Sail
Research (snorkel/freediving from vessel)
Research (recreational fishing)
Lobstering (snorkel/freediving from vessel)
Lobstering (snorkel/freediving from shore)
Lobstering (diving from shore)
Collection for aquarium trade or for personal tank (diving by boat)
Other

After the favorite location question, the respondent was asked general demographic questions. The respondents' sex, ethnicity, age, education level and income level were used to determine the percentages of each group represented in the survey. Comparing these responses to demographic data collected by the United States Census Bureau determined whether the sample fairly represented the population in southeast Florida. Low participation by one demographic group could be a result of many factors. It is possible that the survey did not reach those groups or that those groups did not feel comfortable taking the survey. Low participation by a demographic group may also suggest that the group utilizes the reef less than another. These demographic data will provide insight on the characteristics and magnitude of the population using Florida's reefs.

The final two questions were used to receive feedback on the survey's usability and functionality. The first question was in multiple-choice format and asked whether the respondent found the mapping portion of the survey easy to understand and use. The second question was open-ended and asked the participant to provide any feedback to help improve the survey. It also asked: "Was there a specific section of the survey that you had trouble understanding? What would make it easier?"

The non-probability-based sample method engaged ocean and coastal recreation stakeholders by deploying targeted outreach strategies to solicit participation in an "opt-in" method of data collection. This method can provide many benefits. It gathers data from populations that are not well defined and within which a robust, probability-based sample cannot be established or collected in a practical way (Schillewaert et al., 1998). This method provides a participatory approach that engages and builds stakeholder investment. It also offers the ability to collect data and acquire larger sample sizes from specific user groups (e.g. SCUBA divers, kayakers, etc.) that are difficult to effectively capture in general population surveys (Schillewaert et al., 1998). Lastly, some research has suggested that this approach increases stakeholder trust in the survey results and therefore may lead to an acceptance of the data's use in subsequent policy-making processes (e.g., Lyons, 2012).

The nature of this survey does not allow these data to be either extrapolated to the general population or presumed to be a comprehensive representation of the activities being conducted offshore. The survey outcomes are entirely dependent on the survey participation and the information provided. For this reason, an extensive outreach campaign was conducted to solicit as many survey respondents as possible within the allotted time and project budget.

Engaging the southeast Florida community to take the online spatial survey was crucial in an effort to obtain robust data with a high statistical sample size. Advertisements, flyers, and other marketing material were used to inform the public of the *OFR* community planning process and the need for their involvement. Advertisements included radio and TV public service announcements as well as multiple newspapers (print and online) and the FWC fishing regulations pamphlet. Social media including Facebook, Twitter, and various diving and fishing forums were used as outreach tools as well. Several stakeholder clubs (e.g., dive clubs, underwater photography clubs, and fishing clubs) were contacted and presentations were given by OFR representatives during their meetings. This helped engage the members and educate them on the OFR community planning process and survey (Table 4). A list of local dive shops, tackle shops, and marinas were compiled and also visited by OFR representatives to personally ask stakeholders to take the survey (Table 5).

Table 4. Table of presentations given at club meetings and events to engage stakeholders to participate in the survey and inform them about the Our Florida Reefs community planning process.

	Name	**Type of Club**	**Type of Event**	**Date of Presentatio**	**County**	**Attendees**
1	Hollywood Hills Saltwater Fishing Science and Social Club	Fishing Club	Monthly meeting	10/1/2014	Broward/ Miami-Dade	45
2	SFAEP	Environmental Club	Conference/ Symposium	11/5/2014	Broward	50
3	Jupiter Drift Divers	Diving Club	Monthly meeting	11/6/2014	Palm Beach	30
4	Lighthouse Point Saltwater Fishing Club	Fishing Club	Monthly meeting	12/3/2014	Broward	60-70
5	Stuart Rod and Reel Club	Fishing Club	Monthly meeting	1/8/2015	Martin	50
6	South Florida Underwater Photography Club	Diving/ photography Club	Monthly meeting	1/13/2015	Broward	50
7	Dive in Lecture Series and SFUPS photo gallery opening	General public event	Special Event	1/14/2015	Broward	60
8	SFAEP Treasure Coast Chapter	Environmental Professionals Club	Monthly meeting	1/15/2015	Palm Beach	30
11	Active Divers Association	Dive Club	Spring Kick-off Event	3/21/2015	Broward	40
12	USA (Under Sea Adventurers) Dive Club	Dive Club	Monthly Meeting	3/5/2015	Broward	30

Table 5. Table of locations visited to engage stakeholders to take the survey and inform them about the Our Florida Reefs community planning process.

	Outreach Locations	**Location Type**	**Date Visited**	**County**
1	Grove Scuba	Dive	12/2/2014	Miami-Dade
2	Ocean Safari Diving Adventures	Dive	12/2/2014	Miami-Dade
3	Tarpoon Lagoon Dive Center	Dive	12/2/2014	Miami-Dade
4	Martin County Marina	Marina	1/26/2015	Martin
5	Stuart Dive Shop	Dive	1/26/2015	Martin
6	Pirate's Cove Marina	Marina/Fishing	1/26/2015	Martin
7	Jupiter Dive Center	Dive	1/26/2015	Palm Beach
8	Scuba Works	Dive	1/26/2015	Palm Beach
9	Florida Freedivers	Dive	1/26/2015	Palm Beach
10	Jim Abernathy's Scuba Adventures	Dive	1/26/2015	Palm Beach
11	Brownie's Palm Beach Divers	Dive	1/26/2015	Palm Beach
12	Bill Buckland's Fisherman's Center	Fishing	1/26/2015	Palm Beach
13	Pura Vida Divers	Dive	1/26/2015	Palm Beach
14	The Scuba Club	Dive	1/28/2015	Palm Beach
15	Wet Pleasures Dive Outfitters	Dive	1/28/2015	Palm Beach
16	The Scuba Center Delray	Dive	1/28/2015	Palm Beach
17	Boca Surf and Sail	Surf/Sail	1/28/2015	Palm Beach
18	Force E Boca Raton	Dive	1/28/2015	Palm Beach
19	Dixie Divers	Dive	1/28/2015	Broward
20	Scuba Network Deerfield	Dive	1/28/2015	Broward
21	South Florida Diving Headquarters	Dive	1/28/2015	Broward
22	Deep Blue Divers	Dive	1/28/2015	Broward
23	Scuba School and Dive Center	Dive	1/28/2015	Broward
24	Underseas Sports	Dive	1/28/2015	Broward

3.3. Activity Binning and Visual Display

The thirty-four activities in the survey were organized into six main activities requested by the community working group members to help inform the development of their recommended management actions. These include boating activity, SCUBA diving activity, recreational fishing activity, extractive diving activity, spearfishing activity, and water sport activity. An “All Activities” field that included all survey activities was created to show overall use distribution and intensity by all reef users. In addition, a “Diving and Angling Overlap” feature was created that displayed planning units where both diving and recreational fishing activities occurred. The raw survey data included the locations of every activity mapped in the survey. GIS polygon vector files (features) and maps depicting spatial patterns of use (extent and intensity of use) for these specific coastal recreational activities were created by summing the appropriate corresponding survey activities within these six activity categories and projecting them as activity features in ArcGIS.

The “Boating Activity” feature contained any activity that involved a vessel. These included:

- Charter vessel (dive boat captain)
- Charter vessel (fishing charter captain)
- Charter vessel (recreational fishing)
- Collection for aquarium trade or for personal tank (SCUBA diving by boat)
- Commercial/private vessel (commercial fishing)
- Lobstering (SCUBA diving or snorkel/freediving from vessel)
- Motor (boating)
- Personal watercraft
- Photography (SCUBA diving or snorkel/freediving from vessel)
- Pleasure (SCUBA diving or snorkel/freediving from vessel)
- Private vessel (recreational fishing)
- Research (recreational fishing)
- Research (boating)
- Research (SCUBA diving or snorkel/freediving from vessel)
- Sail (boating)

- Spearfishing - commercial or recreational (SCUBA diving or snorkel/freediving from vessel)

The “Recreational Fishing Activity” feature included:

- Private vessel (recreational fishing)
- Research (recreational or commercial fishing)
- Charter vessel (fishing charter captain)
- Charter vessel (recreational fishing)
- Collection for aquarium trade or for personal tank (diving by boat or from shore)
- Commercial/private vessel (commercial fishing)
- Lobstering (SCUBA diving or snorkel/freediving by boat or from shore)
- Lobstering (commercial fishing)
- Spearfishing - commercial or recreational (snorkel/freediving or SCUBA diving from vessel or shore)
- Shore/pier (recreational or commercial fishing)

The “SCUBA Diving Activity” feature included:

- Spearfishing (diving by boat or from shore)
- Photography (diving by boat or from shore)
- Pleasure (diving by boat or from shore)
- Lobstering (diving by boat or from shore)
- Collection for aquarium trade or personal tank (diving by boat)
- Research (diving by boat or from shore)

The “Spearfishing Activity” feature included:

- Spearfishing (diving by boat or from shore)
- Spearfishing (snorkel/freediving by boat or from shore)
- Spearfishing commercial/recreational (snorkel/freediving from vessel)

The “Extractive Diving Activity” feature included:

- Spearfishing commercial/recreational (SCUBA diving or snorkel/freediving by boat or from shore)
- Lobstering (SCUBA diving or snorkel/freediving by boat or from shore)
- Collection for aquarium trade or personal tank (SCUBA diving or snorkel/freediving by boat or from shore)

The “Watersport Activities” feature included:

- Surfing
- Stand-up paddle boarding
- Kiteboarding
- Kayaking
- Outrigger canoeing (Although not in the original list of activities presented to survey participants, outrigger canoeing was entered as an “other” submission and was thus added to the watersport activities layer.)

The CWG members requested a “Commercial Fishing Activities” feature; however, only one survey indicated commercial fishing. These data did not accurately depict commercial fishing activity in the southeast Florida region and therefore were not included in the requested data sets.

An “Angling and Diving Overlap” feature was created to determine areas where these activities occurred in close proximity. First, all recreational fishing activities by SCUBA and free diving (e.g., spearfishing, lobstering), were removed from the recreational fishing activity feature so that only angling activity was considered. These SCUBA and free diving fishing activities were added to the diving feature, which included all SCUBA and free diving activities. Unlike the original groupings, this was based on an activity-based perspective rather than a fisheries perspective. The main reason for this was to avoid overlap of component activities within the larger groups, as this overlap would lead to inaccuracies in the subsequent analyses. All planning units where both angling and diving did not occur were removed because use overlap did not occur in close proximity (within planning units). All activity day values in the angling category were made negative while the diving activity day values were kept positive. The two values (negative angling and positive diving) for each planning unit were then summed to create a negative to positive scale. Negative values indicated more angling than diving, values close to zero indicated fairly equal angling and diving, and positive values indicated more diving than angling.

The spatial use data were displayed by using the quantities, graduated colors symbology setting in ArcGIS10.3. All data layers were displayed using the same six classes of activity-days, binned as follows: 1-5, 6-20, 21-50, 51-100, 101-300, and 301 and greater activity-days. (Figure 6). These bins were chosen by using a five class Jenks Natural Breaks classification scheme. The bins were then adjusted to the nearest multiple of five, putting them in a simpler format that would appeal to a general audience (Brewer, 2006). For those features whose activity points did not reach 301, fewer bins are displayed in the legend. For example, extractive diving activity had fewer than 100 activity points therefore only 4 activity bins are displayed in the legend. A monochromatic color ramp was chosen to avoid interpretation difficulties. Color-blindness can become an issue in map readers as about 8% of men and 1% of women have one of the varied forms of red-green color vision deficiency (Brewer, 2006); Therefore, the color scale goes from a light yellow (RGB: 255, 255, 128), indicating a low number activity points, to a dark brown (RGB: 107, 6, 1), indicating a high number of activity points. The survey planning units that overlap land in some cases, is due to the nature of the grid design. The grid is snapped to the survey area outline, retaining the full 200 m by 200 m cells. It is important to note that these areas do not reflect activity on land but only on the area past the mean high water line as defined in the study area section as the survey boundary.

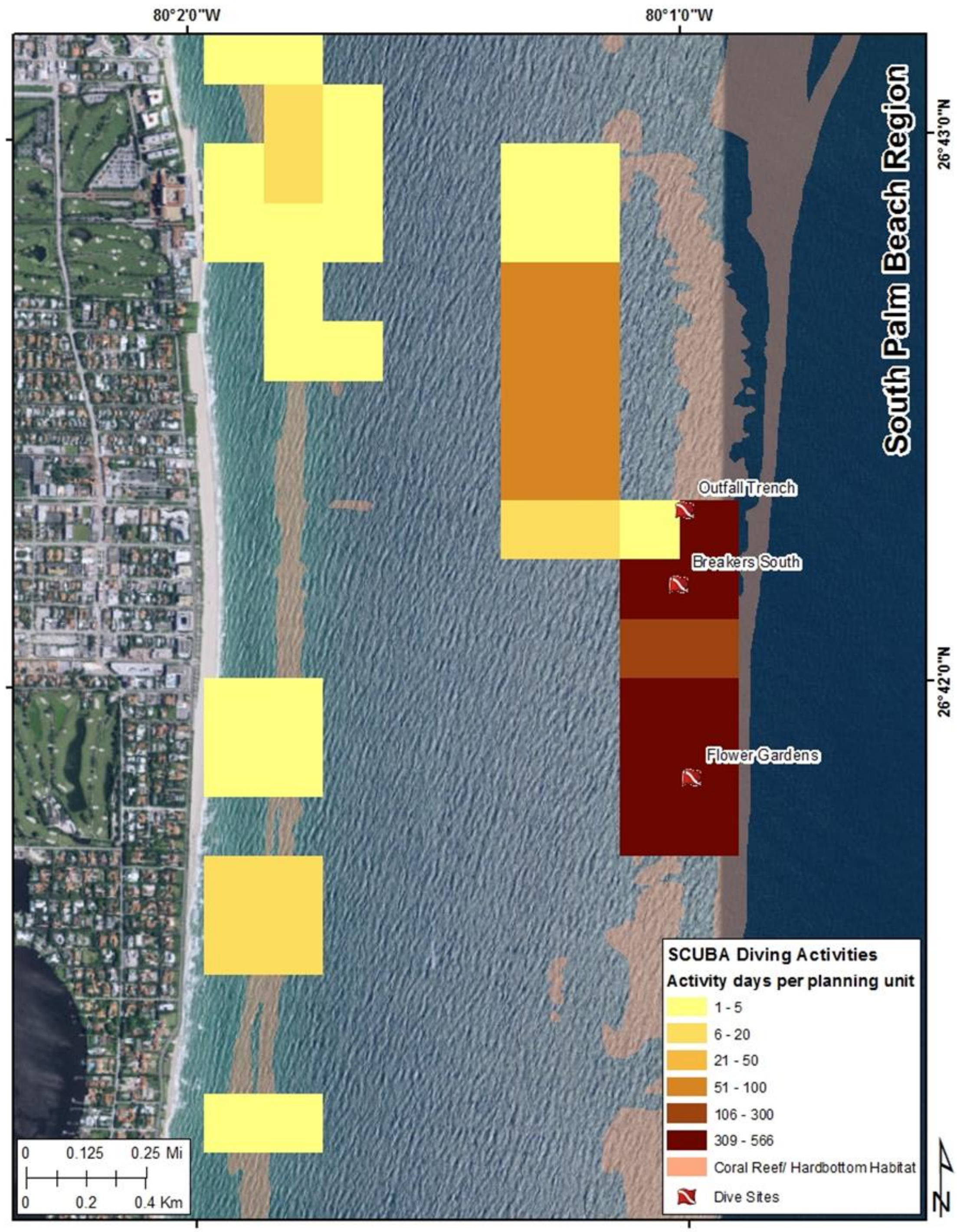

Figure 6. Example of color ramp bins for areas of SCUBA diving activity, including high activity (309-566 activity-days per planning unit) on coral reef and hardbottom on Breaker's Reef in Palm Beach.

The symbology for the “Angling and Diving Overlap” feature differed from that of the other activity features. Graduated colors under the quantities tab was selected, similar to that of the other activity features; however, seven classes were used with the following bin labels: High angling activity: -190 - -20, moderate angling activity: -20 - -6, equal angling and diving activity: -5 - 5, moderate diving activity: 5 - 200, and high diving activity: 200 - 643. The color bins for this feature are not monochromatic. Because this feature’s values run from negative to positive, two shades of red were used for the angling activity (designated by negative values), two shades of blue were used for the diving activity (designated by positive values), and yellow outlined with orange, was used for the equal fishing and diving activity (Figure 7).

The activity features were added to the OFR Marine Planner for the general public to view. They were also added to the OFR Marine Planner Designs, a decision support tool that filters out planning units by data values. The survey results data, in addition to many other southeast Florida spatial data sets, were associated with a 200 m by 200 m planning unit grid. This tool will assist the CWGs in making informed decisions regarding the siting of recommended management actions having a spatial component.

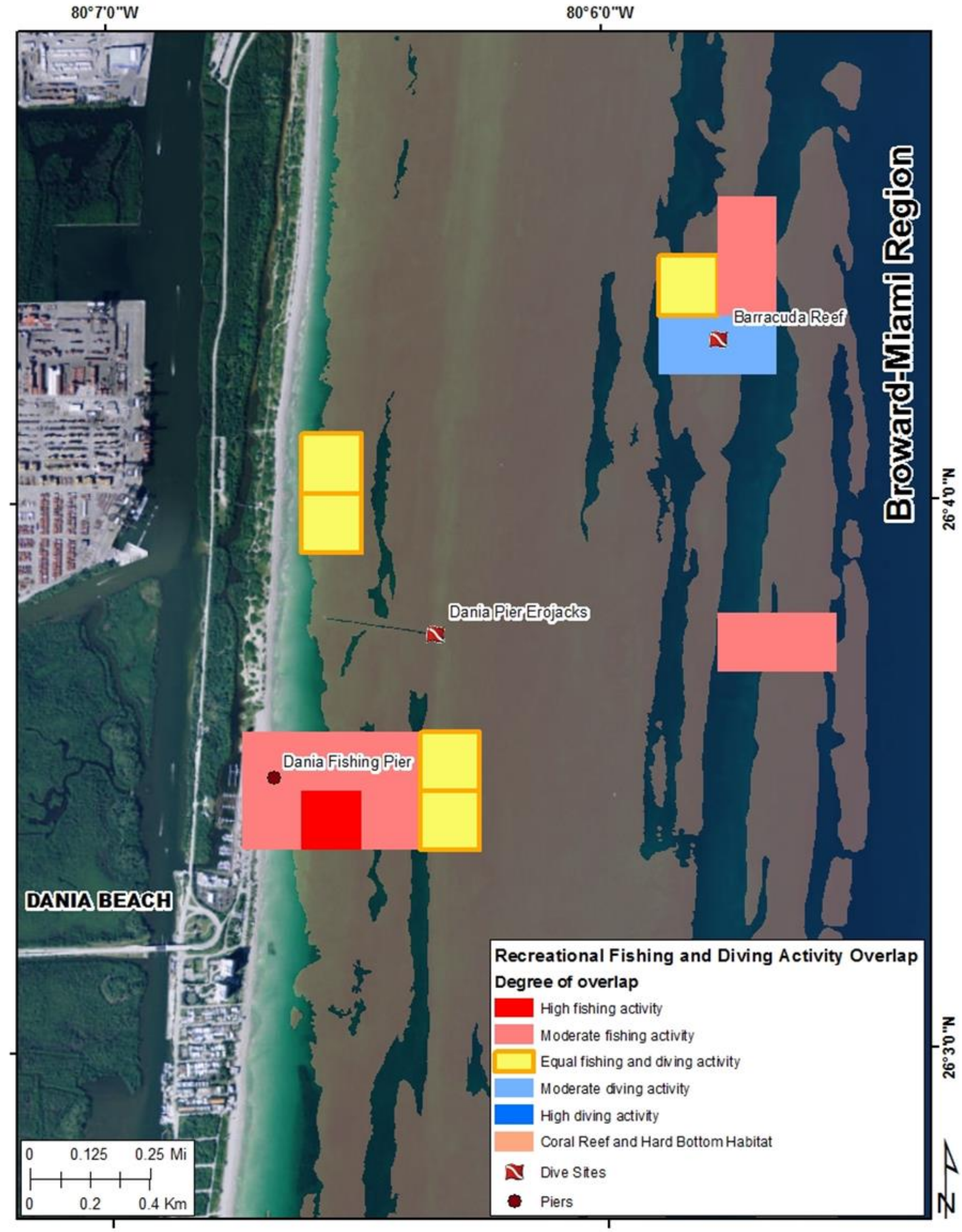

Figure 7. Example of color bins for the Angling and Diving Activity overlap feature in the Broward-Miami coral reef ecosystem region focusing on Hollywood and Dania Beach. The dive sites in this map are identified by the dive charter industry and are found in southeast Florida dive site books and websites.

3.4. Stakeholder-use data analyses

Spatial statistics were run in ArcGIS on four of the nine activity features. The chosen statics were point density analysis and hot spot analysis (Getis-Ord Gi*). Point density analysis showed where high numbers of unweighted features exist. Hot spot analysis identified statistically significant clustering of high and low use areas given a set of weighted features, using the Getis-Ord Gi* statistic which will be explained in further detail.

For both analyses, a fixed distance band with Euclidean distance was used as the conceptualization of spatial relationships to ensure each feature has at least one neighbor. This fixed distance band specifies a cut-off distance. Features outside this specified distance for a target feature were ignored in subsequent feature-specific analyses.

3.4.1. Determining the Fixed Distance Band

The incremental spatial autocorrelation was used to determine the correct fixed distance band for hot spot analysis. This technique analyzes spatial autocorrelation for a series of distances and creates a line graph of those distances as well as generating their corresponding Global Moran's I z-score value. Z-scores reflect the intensity of spatial clustering. Points on the line graph that showed statistically significant (> 0.05) peak z-scores indicated distances where spatial processes promoting clustering were most prominent. The Euclidean distance method with the default number of distance bands (10) was used for all analyses. The default beginning distance for each feature, the distance at which each feature in the dataset has at least one neighbor, was used to run this spatial statistic. The default increment distance, or the average nearest neighbor distance, was also used. This is the distance that correlated with the peak z-score for each of the four features in the hot spot analysis. (Getis and Ord, 1992).

The "All Activities", "Boating Activity", "SCUBA Diving Activity", and Recreational Fishing Activity" incremental spatial autocorrelation beginning distance, distance increment, first peak distance and corresponding z-score value, and max peak distance and corresponding z-score value can be viewed in Table 5.

Table 5. Table showing the incremental spatial autocorrelation beginning distance, distance increment, first peak distance and corresponding z-score value, and max peak distance and corresponding z-score value for "All Activities", "Boating Activity", "SCUBA Diving Activity", and Recreational Fishing Activity".

Feature	Beginning Distance (m)	Distance Increment (m)	First Peak Distance (m)	First Peak Z score value	Max Peak Distance (m)	Max Peak Z-score Value	Graph
"All Activities"	4,911	251.7	5,414.40	6.1	6,169.50	6.1	Figure 8
"Boating Activity"	4,403	308.2	6,560.50	6.6	N/A	N/A	Figure 9
"SCUBA Diving Activity"	5,020	291.2	5,311.20	6.6	N/A	N/A	Figure 10
"Recreational Fishing Activity"	4,401	308.1	5,017.30	4.6	6,557.90	5.3	Figure 11

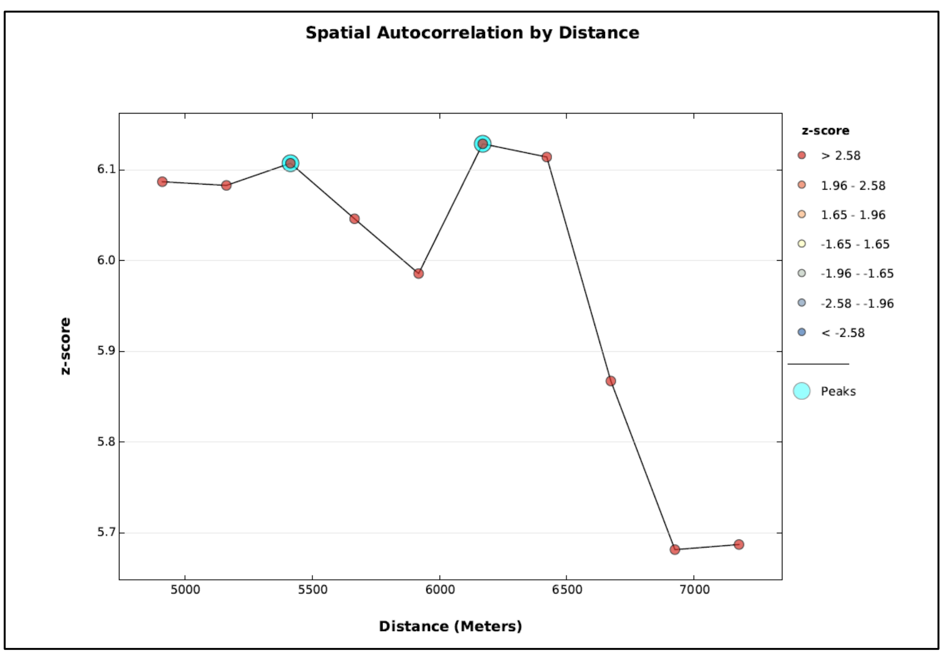

Figure 8. Incremental spatial autocorrelation by distance for "All Activities".

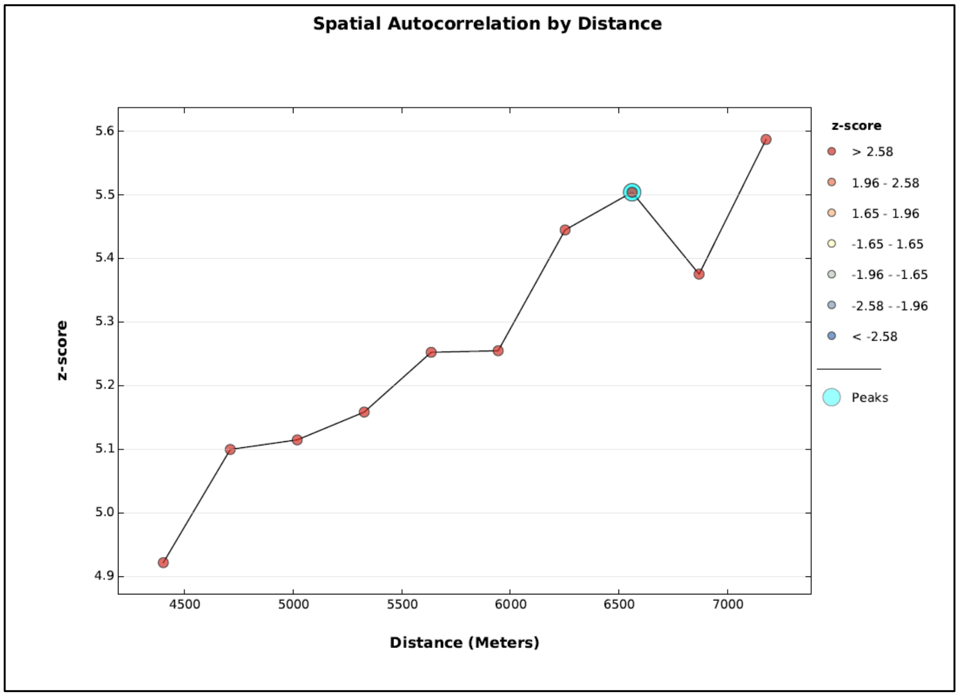

Figure 9. Incremental spatial autocorrelation by distance graph for "Boating Activity".

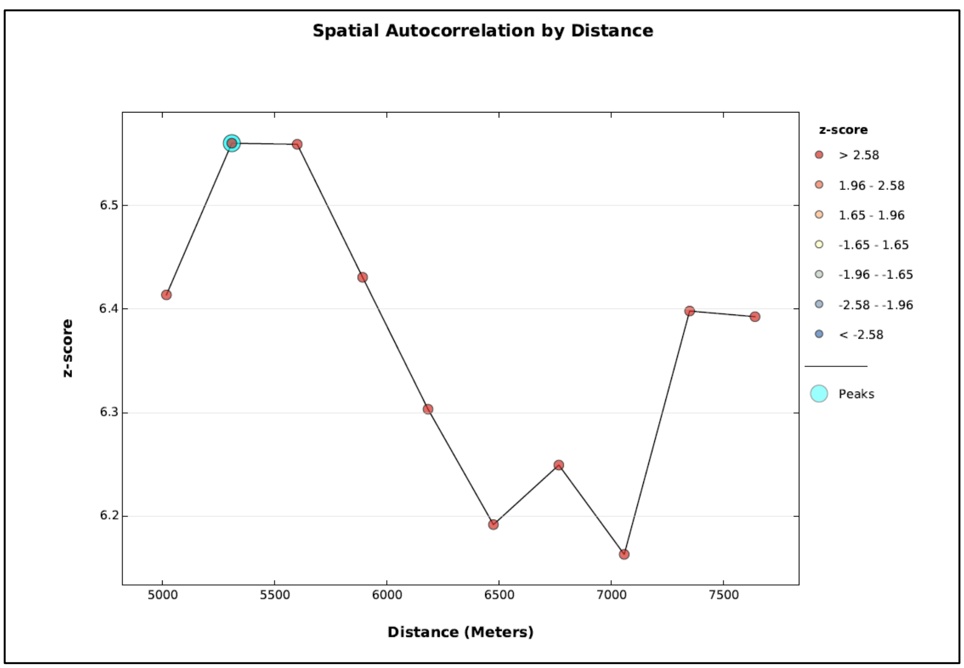

Figure 10. Incremental spatial autocorrelation by distance graph for "SCUBA Diving Activity".

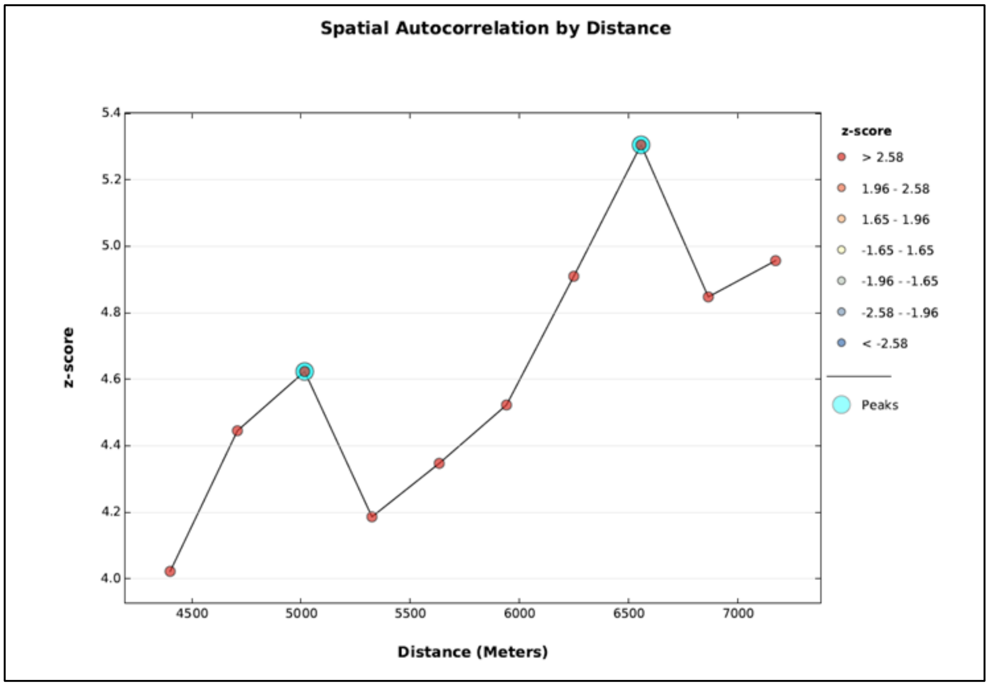

Figure 11. Incremental spatial autocorrelation by distance graph for "Recreational Fishing Activity".

3.4.1. Point Density Analyses

Point density analysis was run to determine if intensity of use was an important factor that would determine hot spot locations. The ArcGIS point density spatial analyst tool was used to analyze "All Activities", "Boating Activity", "SCUBA Diving Activity", and "Recreational Fishing Activity". This analysis was not weighted and the population field was left as the default "NONE". Running the analysis on the points themselves without a value associated with them eliminated the intensity of use and allowed visualization of areas where the most people visited. A circle with radius of 2000 km^2 was used for this analysis. A mask that incorporated only the survey area grid was also selected under the environments settings. The point densities are displayed in the legend as kilometers squared and the Jenks Natural Breaks classification was used with five classes and the exclusion of zero values. Jenks Natural Breaks has become a standard geographic classification algorithm and is the default classification method in ArcGIS (North, 2009). This classification scheme minimizes variation within classes and maximizes variation between classes so that units sharing a color are statistically more similar to each other than to units in other color classes (Brewer, 2006). Although the features' density values differed and thus used different break values according to their standard deviation, all features' densities were displayed using the same five colors. Low densities were represented by two shades of blue, the darker shade representing a lower density. Moderate density was represented by yellow. The high densities were represented by two shades of red, the darker shade representing a higher density.

Table 6 shows the minimum density, the maximum density, and the mean density in points per km^2, as well as the standard deviation used to run the point density analyses for "All Activities", "Boating Activity", "SCUBA Diving Activity" and "Recreational Fishing Activity."

Table 6. Table displaying the minimum density, maximum density, and mean density in points per km2, as well as the standard deviation, used to run the point density analyses for "All Activities", "Boating Activity", "SCUBA Diving Activity" and "Recreational Fishing Activity".

Feature	Min density (pts/km2)	Max Density (pts/km2)	Mean Density (pts/km2)	Standard Deviation
"All Activities"	0.06	14.32	14.32	1.91
"Boating Activity"	0.56	6.45	0.87	1.12
"SCUBA Diving Activity"	0.07	9.55	0.78	1.19
"Rec Fishing Activity"	0.07	3.5	0.4	0.52

3.4.2. Hot Spot Spatial Analysis

Hot spot (Getis Ord Gi*) spatial analysis was run to determine if incorporating use intensity in addition to use location would yield different results. This tool identified statistically significant spatial clusters of high values (hot spots) and low values (cold spots). The new Output Feature Class that was created had a z-score and p-value for each feature in the Input Feature Class. The z-scores and p-values are measures of statistical significance which provide guidance in deciding whether or not to reject the null hypothesis for each feature. These values indicate whether the observed spatial clustering of high or low values is more pronounced than would be expected in a random distribution of those same values. A high z-score and small p-value for a feature indicates a spatial clustering of high values. A low negative z-score and small p-value indicates a spatial clustering of low values. A z-score near zero indicates no apparent spatial clustering while scores that are higher or lower indicate more intense clustering (Getis and Ord, 1992).

Hot spot analysis was run for the "All Activities" feature, the "Boating Activity" feature, the "SCUBA Diving Activity" feature, and the "Recreational Fishing Activity" feature. The other activity features were not included in this analysis because they did not have large enough sample sizes to produce accurate results. Each analysis was set to Euclidean distance and a fixed distance band.

"All Activities" hot spot analysis was run with a fixed distance band of 6,169.52 m, "Boating Activity" was run with 6,560.52 m, "Recreational Fishing Activity" was run with 6,557.89 m and all "SCUBA Diving Activity" was run with 5,311.17 m.

Clustering of high use intensity (represented by red circles on the map) were points with Gi_bin values equaling 2 or 3 which correlated with points having Z scores greater than 2 and P values less than 0.05. Clustering of low use intensity (represented by blue circles on the map) were points with Gi_bin values of -2 or -3 which correlated with Z scores less than -2 and P values less than 0.05. Non-significant spots (represented by grey circles on the map) were points with Gi_bin Values between -1 and 1. These correlated with P values greater than 0.05.

3.4.3. Habitat Use Analyses

To determine the extent of use by survey participants on coral reef and hardbottom habitat in the SEFCRI region, the survey data layer and coral reef and hardbottom habitat data layer were joined in ArcGIS 10.3. This joined table was then exported into a new shapefile with an attribute table displaying all coral reef and hardbottom habitat data fields and all survey activity data fields. Two reports were run on this attribute table with the modifiers "habitat" and "type". The first generated report summed up the total number of reported survey activity points that fell on coral reef and hardbottom habitat and was divided by activity type. The activities included were "All Activities", "Boating Activity", “SCUBA Diving Activity”, and “Recreational Fishing Activity”. The second report looked at all activities and summed up the total number of activity points for each coral reef and hardbottom habitat type for the entire region. The coral reef and hardbottom habitat types included were Nearshore Ridge Complex, Inner Reef, Ridge, Outer Reef, Middle Reef, Aggregated Patch Reef, *Acropora cervicornis* Patch, Colonized Pavement, and Scattered Rock and Sediment (Walker, 2012).

4. RESULTS

4.1. Non-spatial Survey Results

4.1.1. Survey Summary Statistics

The survey was open from October 1, 2014 to March 31, 2015. During this time, participants were able to register and access the survey through a unique link sent via email. Over the 182-day period, a total of 1,101 users registered for the survey. Of these, 301 (27.3%) participants completed their survey, 432 (39.3%) began but did not finish the survey, and 368 (33.4%) registered for the survey but never started (*Table 7*). Participants entered a total of 1,969 activity points. The area of each point selected all 200 m by 200 m square planning units it touched. This selected a total of 2,993 planning units displayed in the map results (Table 8).

Table 7. Number of surveys by status including complete surveys, partial surveys, and surveys not started. The total number of surveys represents all users that registered for the survey and were sent a unique survey link.

Surveys Status	# Surveys	% Surveys
Complete	301	27.3
Partial	432	39.3
Not started	368	33.4
Total	**1,101**	**100**

Table 8. The number of 200 x 200 m planning units selected by activity. The sum does not equate to the total because some activities were included in more than one category. For example, SCUBA diving from vessel is included within "Boating Activity" and "SCUBA Diving Activity"

Activity	**Planning Units**
Total	2993
Boating	2232
SCUBA Diving	1508
Recreational Fishing	1033
Research	577
Extractive Diving	510
Watersport	389
Spearfishing	189
Fishing Diver Overlap	152
Commercial Fishing	1

4.1.2. Surveys by Residency

Full-time residents of Florida made up the majority of respondents at 280 surveys (93%), followed by visitors and part-time residents at 13 (4%) and 8 (3%) surveys, respectively (Table 9).

Table 9. Number of surveys by Florida residency status including full-time residents, part-time residents, and visitors of Florida.

Residency	**# Surveys**	**% Surveys**
Full-time Florida resident (6 months or more per year)	280	93
Visitor of Florida (less than 2 months)	13	4
Part-time Florida resident (less than 6 months per year)	8	3

Respondents who selected full-time or part-time Florida residency in the first question were also asked to indicate the county in which they resided. Of the 67 counties in Florida, 25 contained residents who participated in this survey. A majority (n=227) of the respondents from those 25 counties came from the four counties of southeast Florida. Almost half of the surveys (n=105) were submitted by Broward County residents; Palm-Beach County residents submitted 67 surveys, Miami-Dade County residents submitted 37 surveys, and Martin County residents submitted 18 surveys. From these, 46% of the activity points came from Broward County residents (898 activity points), 24% from Palm Beach county residents (474 activity points), 10% from Miami-Dade county residents (205 activity points), and 6% from Martin county residents (116 activity points) (Table 10).

Table 10. County of residence for respondents who indicated full or part-time Florida residency status. Counties in southeast Florida are indicated in bold font.

County	**# Surveys**	**% Surveys**	**# of Activity Points**	**% of Activity Points**
Broward	**105**	**36.5**	**898**	**46.8**
Palm Beach	**67**	**23.3**	**474**	**24.7**
Miami-Dade	**37**	**12.8**	**205**	**10.7**
Martin	**18**	**6.3**	**116**	**6.1**
Monroe	7	2.4	16	0.8
Pinellas	6	2.1	17	0.9
St. Lucie	6	2.1	20	1.0
Brevard	4	1.4	11	0.6
Charlotte	4	1.4	27	1.4
Collier	4	1.4	15	0.8
Hillsborough	4	1.4	21	1.1
Orange	4	1.4	14	0.7
Okaloosa	3	1	7	0.4
Seminole	3	1	12	0.6
Volusia	3	1	14	0.7
Alachua	2	0.7	6	0.3
Lake	2	0.7	13	0.7
Polk	2	0.7	10	0.5

Table 11. Continued. County of residence for respondents who indicated full or part-time Florida residency status. Counties in southeast Florida are indicated in bold font.

Columbia	1	0.3	2	0.1
Indian River	1	0.3	6	0.3
Lee	1	0.3	2	0.1
Leon	1	0.3	2	0.1
Manatee	1	0.3	3	0.2
Okeechobee	1	0.3	2	0.1
Pasco	1	0.3	4	0.2

4.1.3. Demographics

Among survey respondents who completed the survey, 59% (n=178) were males and 41% (n=123) were females (Table 12). Age results were classified into five age groups (Table 13). Eight of the respondents who completed the survey chose not to enter their age. Among those that indicated their age, most respondents were between the ages of 51 and 60 years old (76 respondents).

Table 12. Number of surveys by participant gender.

Gender	# Surveys	% Surveys
Male	178	59
Female	123	41

Table 13. Number of surveys by participant age. The participant was prompted to enter an integer for their age but these were then binned into the categories in the rows below.

Age Group	# Surveys	% Surveys
18-30	59	19.6
31-40	55	18.3
41-50	45	15.0
51-60	76	25.2
>60	58	19.3
No answer	8	2.6

All respondents that completed the survey chose to answer the education level question. For education level respondents were presented a list of five categories ranging from no formal education to a bachelor's degree or higher (Table 14). The majority (228) of survey respondents who answered this question indicated that they had received a bachelor's degree or higher.

Table 14. Number of surveys by level of education.

Education	**# Surveys**	**% Surveys**
Bachelor's degree or higher	228	75.7
Some college	55	18.3
High school	15	5
Less than high school	3	1
No formal education	0	0

For race, seven categories were listed (Table 15), including an "other" option. The majority (258) of respondents selected white as their race making up 85% of surveys. Ten percent of survey participants were Hispanic, Spanish, or Latino. The remaining five percent were Black or African American, Asian or Pacific Islander, American Indian or Alaska Native, other or they chose not to answer the question.

Table 15. Number of surveys by race.

Race	**# Surveys**	**% Surveys**
White	258	85.7
Hispanic, Spanish, or Latino	29	9.6
No Answer	4	1.3
American Indian or Alaska Native	4	1.3
Other	3	1
Black or African American	2	0.7
Asian/Pacific Islander	1	0.3

All respondents who completed the survey chose to answer the income level question. Respondents were able to select from 11 income classifications (Table 16). Survey counts had fairly even distribution between $25,000 and $124,999 income classifications; however, most respondents indicated that they were in the $25,000 to $49,000 income classification.

Table 16. Number of surveys by income.

Income	# Surveys	% Surveys
Less than $25,000	27	9.2
$25,000 to $49,999	46	15.6
$50,000 to $74,999	43	14.6
$75,000 to $99,999	44	14.9
$100,000 to $124,999	44	14.9
$125,000 to $149,999	27	9.2
$150,000 to $174,999	18	6.1
$175,000 to $199,000	5	1.7
$200,000 or greater	20	6.8
Don’t know	21	7.1

4.1.4. Surveys by Activity

The most commonly reported activities were SCUBA diving by boat for pleasure, snorkeling/free diving from shore for pleasure, and boating (motor), with 138, 132, and 125 surveys respectively (Table 17). Commercial fishing was the activity chosen the least. No respondents selected the shore/pier fishing and commercial lobstering activities within this commercial fishing activity category. In addition to the listed activities, 46 surveys chose “other” as their activity. In these cases, respondents manually typed in the activity. The most commonly typed “other” activity was “swimming”, followed by “beach”. These were not added to any other categories because the survey was focused on activities that occurred past the swim zone.

Table 17. Number of surveys by activity type. The sum of these numbers is higher than the total number of surveys because participants were allowed to select multiple activities. Motor boating had the highest number of surveys in this table (125).

Activity Group	**Activity**	**# Surveys**
Boating	Motor	125
	Sail	18
	Kayak	48
	Personal Watercraft	12
	Research (boating)	35
Recreational fishing	Shore/pier	47
	Private vessel	98
	Charter vessel	24
	Research	11
Commercial	Shore/pier	0
	Commercial/private vessel	1
	Charter vessel (Fishing Charter Captain)	2
	Charter vessel (Dive Boat Captain)	6
	Lobstering	0
	Research	3
SCUBA diving from shore (includes kayak)	Spearfishing	14
	Photography	55
	Pleasure	81
	Lobstering	22
	Collection for aquarium trade/personal tank	6
	Research	17
SCUBA diving by boat	Spearfishing	46
	Photography	93
	Pleasure	138
	Lobstering	70
	Collection for aquarium trade	10
	Research	41
Snorkel/ freediving from vessel	Spearfishing commercial/recreational	14
	Photography	28
	Pleasure	79
	Lobstering	27
	Collection for aquarium trade/ personal tank	0
	Research	16

Table 18 continued. Number of surveys by activity type. The sum of these numbers is higher than the total number of surveys because participants were allowed to select multiple activities. Motor boating had the highest number of surveys in this table (125).

Activity Group	**Activity**	**# Surveys**
Watersports	Surfing	32
	Kiteboarding	5
	Stand-up paddle boarding	53
	Windsurfing	2
Other	Respondent typed in activity	46

4.1.5. Last Completed Question

Not all respondents completed the survey. Understanding where they stopped can give insights into potential survey design problems, thus the last completed questions was tallied on the 432 partially completed surveys. The most common successfully last completed question was regarding activities respondents engaged in during the past twelve months. Of the partial surveys, 334 reached this question (Table 19). This indicates that those users continued to the activity-mapping question, but did not proceed further.

Table 19 Number of surveys by last complete question in the survey. Users may have progressed to the subsequent question, but the list below is the last saved question in the database, indicated by the participant clicking "Continue" on each page of the survey.

Last Completed Question	**# Surveys**
Residency	18
County	19
Activities Information	334
Activity Mapping	10
Activity Expenditures	16
Favorite Spot Mapping	24
Race	2
Income	2
Feedback	2
Comments	5

4.2. Spatial Survey Results

4.2.1. All Activities

In the Martin Coral Reef Ecosystem Region, the planning unit data for "All Activities" indicated the highest use, although low compared to other regions, was near the mouth of the St. Lucie Inlet and slightly north (Figure 12). Some of these planning units indicated as high as 135 activity-days but most of these planning units indicated anywhere from 1-100 activity-days. Point density analysis only showed moderate density of locations (2.76-5.62 per km^2) just north of St. Lucie Inlet (Figure 13).

In the North Palm Beach Coral Reef Ecosystem Region, the planning unit data showed high use (> 300 activity-days) offshore the city of Tequesta just north of Jupiter Inlet and at a popular dive site known as Jupiter Ledge (> 100 activity-days) (Figure 14). There were also planning units with more than 300 activity-days offshore Riviera Beach in the nearshore habitat. Most activity was in the nearshore areas, however, sparse activity also occurred on the Deep Ridge Complex (Figure 16). Point density was high at the mouth of Lake Worth Inlet and just north of the inlet with values between 5.63 and 9.66 points per km^2 (Figure 17). Moderate density occurred around Jupiter Inlet with values between 2.76 and 5.62 points per km^2 (Figure 15).

In the South Palm Beach Coral Reef Ecosystem Region, the planning unit data showed high use off the city of Palm Beach along the Outer Reef and nearshore hardbottom habitats. Many locations on the outer reef had over 300 activity-days corresponding to numerous dive sites including Breaker's Reef, Flower Gardens, and the Outfall Trench. Many activity locations concentrated around Boynton Inlet, although the activity-days indicated for each planning unit were lower. There was also an area with 100 activity-days offshore Boynton Beach in the deeper waters east of the Outer Reef (Figure 18). Point density analysis showed moderate location density around the North and South Palm Beach Coral Reef Ecosystem transition zone as well as around Boynton Inlet with values between 2.76 and 5.62 points per km^2 (Figure 17).

In the Deerfield Coral Reef Ecosystem Region, the planning unit data showed higher concentration of use around Boca Raton Inlet. Just over 100 activity-days were indicated on Middle Reef offshore Lighthouse Point (Figure 18). These activity-day values were lower in comparison to other regions. Point density analysis revealed only moderate point density between 2.76 and 5.62 points per km^2 around Boca Raton Inlet (Figure 19).

The Broward-Miami Coral Reef Ecosystem Region had the highest use in terms of both number of locations and activity-days. Many individual respondents used this area and concentrated on the reefs offshore Pompano and Fort Lauderdale. Higher use occurred specifically around Hillsboro Inlet with between 100 and 300 activity-days. Offshore of Anglin's Pier in Lauderdale-by-the-Sea, 5 planning units showed over 300 activity-days (Figure 18). There was a small area showing over 300 activity-days in the deeper waters east of Outer Reef offshore Dania Beach, although activity was generally much lower heading south from Port Everglades. Higher activity (275 activity-days) was present in the nearshore area offshore North Miami Beach. No other areas in Miami-Dade County showed similar use; however, there were some locations on the Middle Reef that had 20-50 activity-days (Figure 20). There were many areas along the reef tract in this region that displayed high density of individual locations from 5.63-14.32 locations per km^2, the highest areas (9.67-14.32 locations per km^2) being around Anglin's Pier and Dania Fishing Pier (Figure 19). Between Port Everglades and the Dania Fishing Pier, very high densities of 9.67 to 14.32 points per km^2 also occurred (Figure 21). The density decreased moving south down the Broward-Miami Region into the offshore areas of Miami.

In the Biscayne coral reef ecosystem region, use was generally low with most locations concentrated around Government Cut, along the shore of Key Biscayne, and on the Inner Reef. All values were under 100 activity-days (Figure 20). Point density analysis showed most areas in this region having low density except for the area around Government Cut, which had moderate density between 2.76 and 5.62 points per km^2 (Figure 21).

Locations demonstrating clustering of high use intensity for the southeast Florida region were at the St. Lucie Inlet as well as about 3.5 km north and down to about 10 km south of the inlet, mainly on the Nearshore Ridge Complex. This indicates that when activity-days were factored in, these locations showed high clustering of high activity-days. It also demonstrates that individuals who visited those locations did so more frequently and in a more concentrated area. Locations showing clustering of high use intensity were just below Lake Worth Inlet and continued through the southernmost part of the ecosystem region on the Nearshore Ridge Complex, the Deep Ridge Complex, the Outer Reef, and about one mile outside the reef. This showed that there were locations in this area with a high number of activity-days surrounded by other locations with high activity-days. Many users frequently visited the location throughout the year at these locations. These areas are thought to exhibit higher use intensity, which could potentially impose greater stress on the area. Two points located around 7.5 km^2 off Dania Beach, just south of Port Everglades were displayed as a cluster of high use intensity as well. Clustering of low use intensity occurred around Government Cut and off north Key Biscayne on the Nearshore Ridge Complex, Inner Reef, and Outer Reef (Figure 22). This indicates that users did not visit this area frequently throughout the year; so, although it is a location used by many people, the low number of activity-days indicates that stress on the reef should be lower here than in an area with clustering of high activity-days.

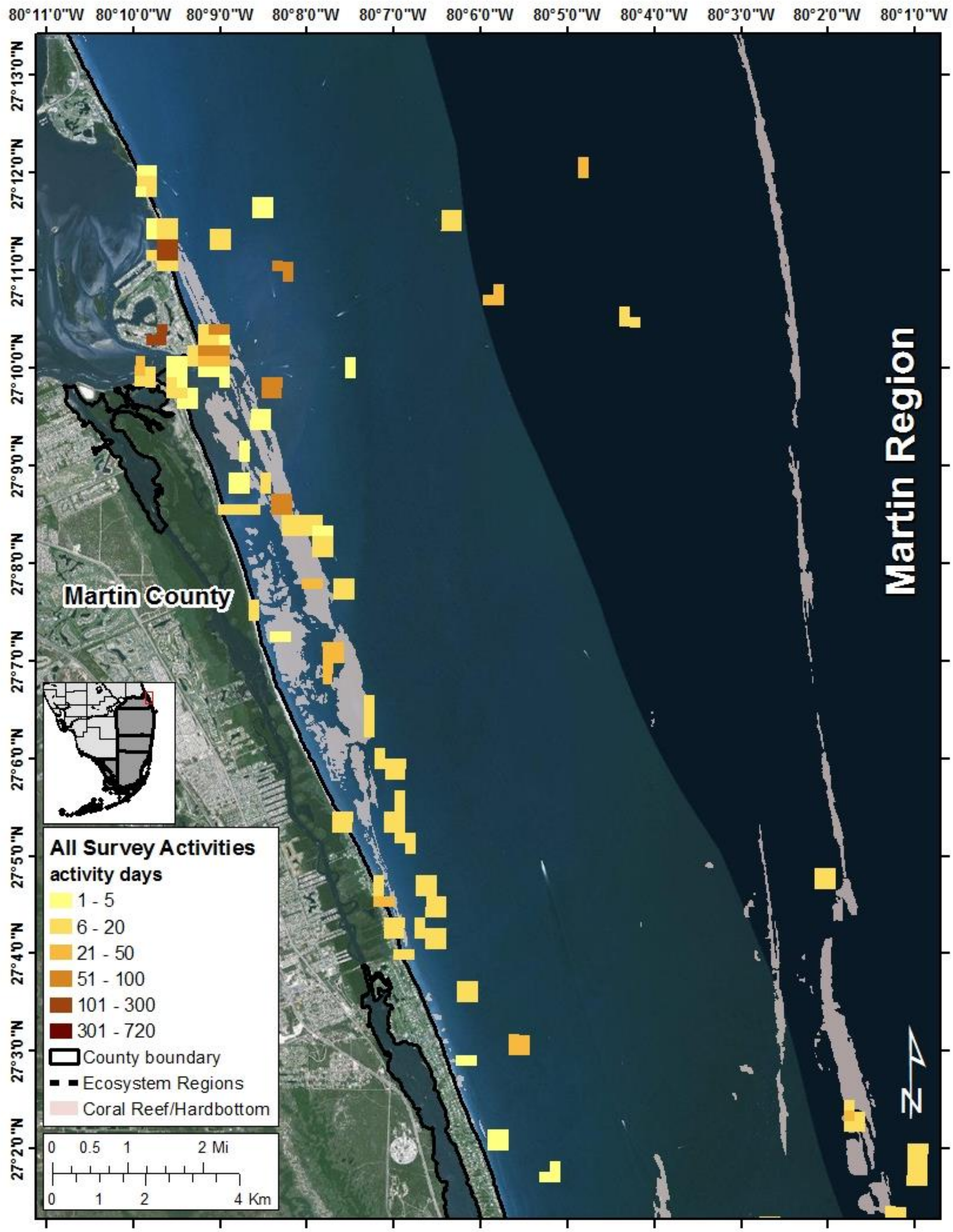

Figure 12. Map of final survey results displaying the total number of activity-days per planning unit for all activities within the Martin coral reef ecosystem region. Planning units with higher activity-days were around St. Lucie Inlet and slightly north of the inlet.

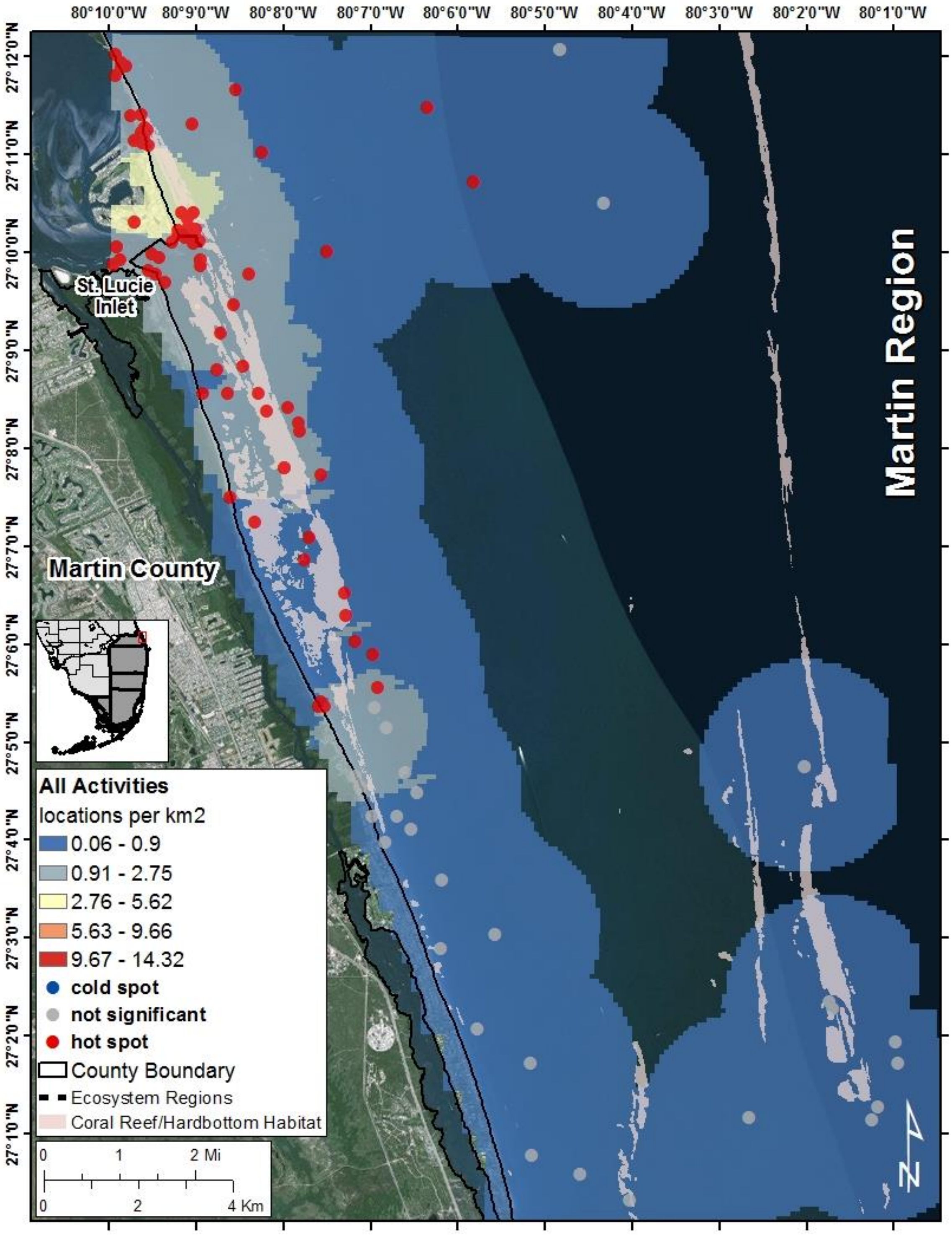

Figure 13. Map displaying results of point density analysis as well as hot spot analysis for all activities within the Martin coral reef ecosystem region. Moderate density of locations was just north of St. Lucie Inlet. Hot Spot locations were around St. Lucie Inlet, both north of the inlet and south of the inlet. Those hot spots south of the inlet concentrated on the Nearshore Ridge Complex.

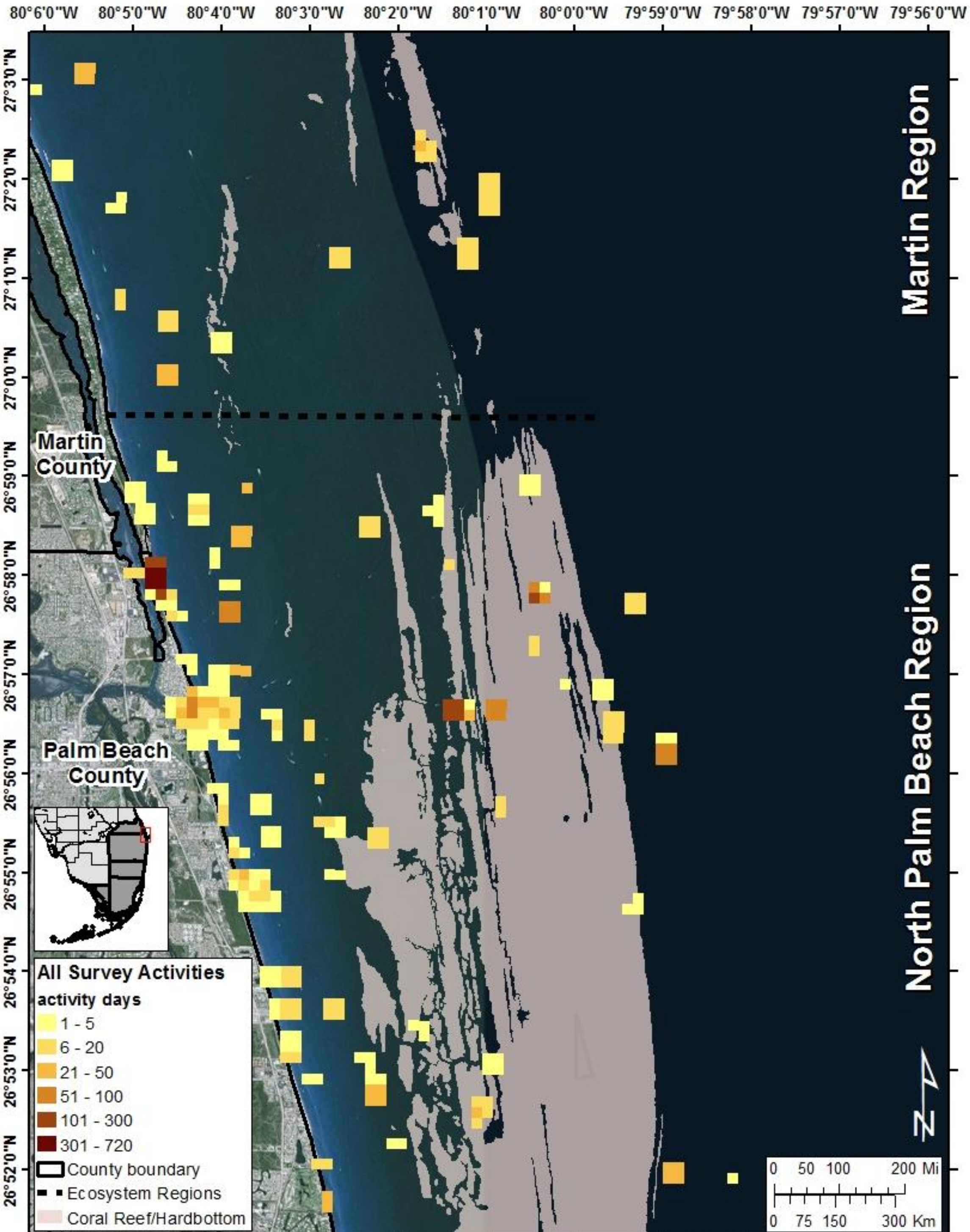

Figure 14. Map of final survey results displaying the total number of activity-days per planning unit for all activities within the Martin and North Palm Beach coral reef ecosystem regions. Planning units with high activity-days were in the nearshore habitat off Riviera Beach and on the Deep Ridge Complex. Clustering of locations with lower activity days are around Jupiter Inlet.

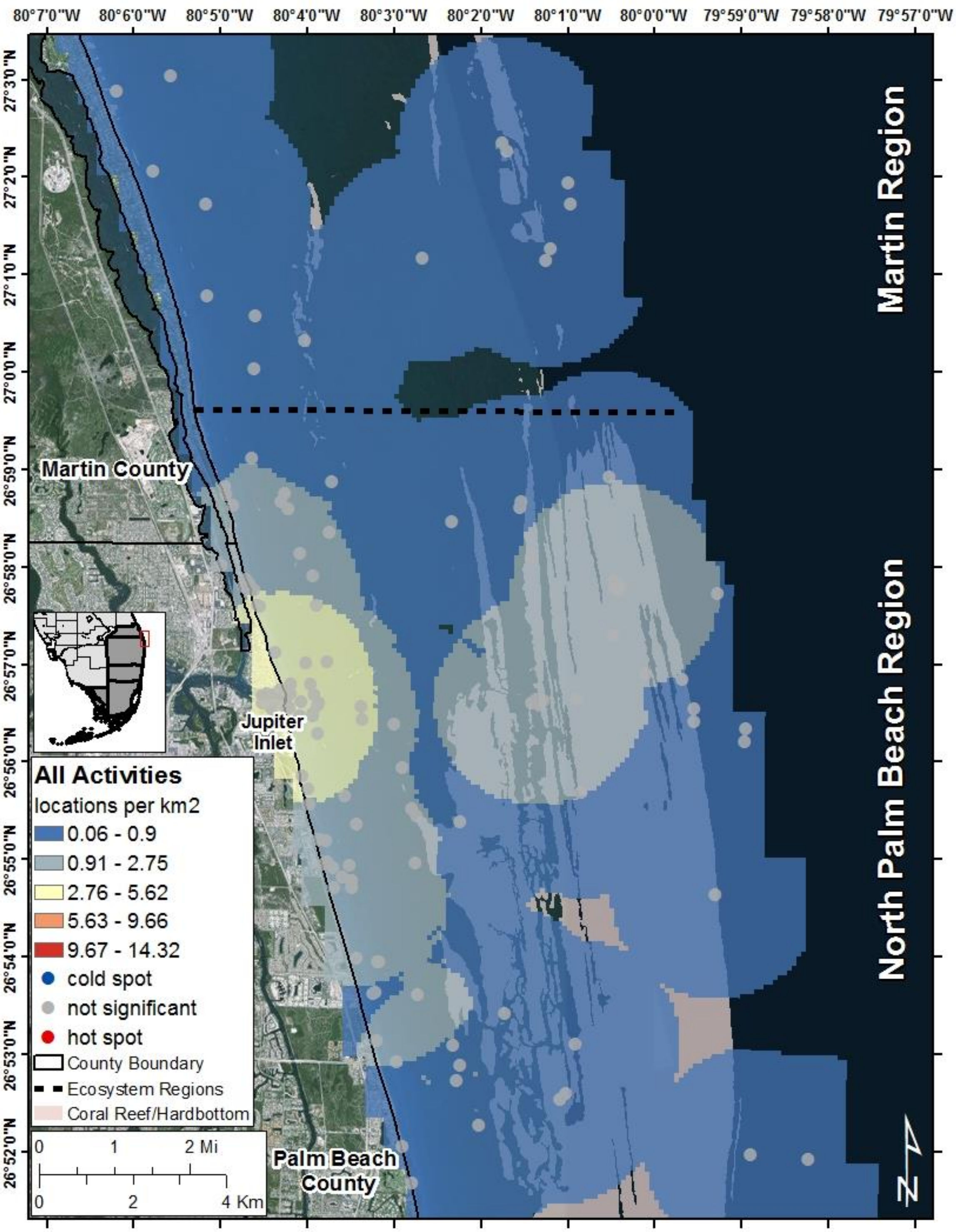

Figure 15. Map displaying results of point density analysis as well as hot spot analysis for all activities within the Martin and North Palm Beach coral reef ecosystem regions. Moderate density of locations was around Jupiter Inlet. No hot or cold spots were found in this region.

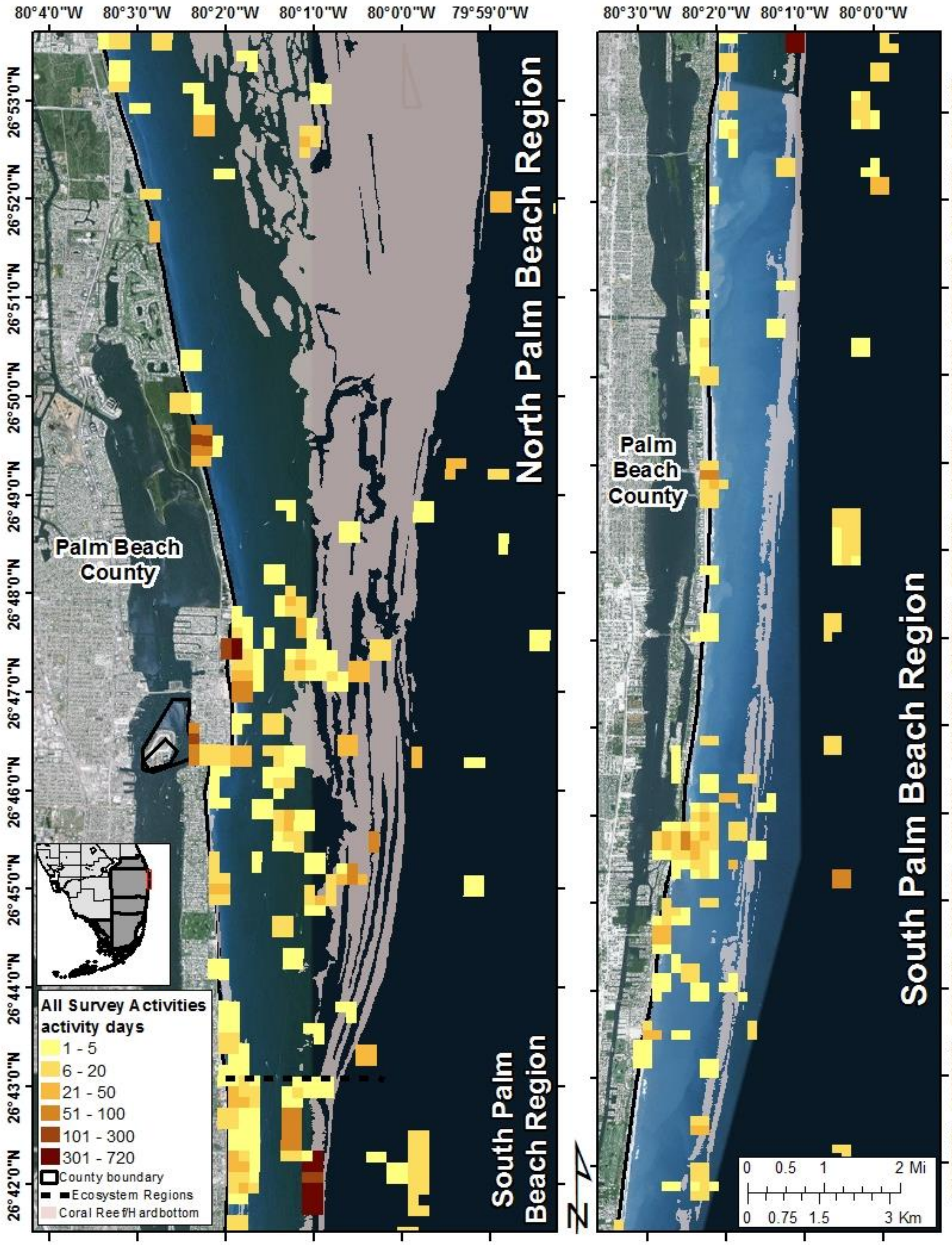

Figure 16. Map of final survey results displaying the total number of activity-days per planning unit for all activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions. Planning units with high activity-days were north of Lake Worth Inlet in the North Palm Beach Coral Reef Ecosystem Region and on the northern portion of the Deep Ridge Complex in the South Palm Beach Ecosystem Region.

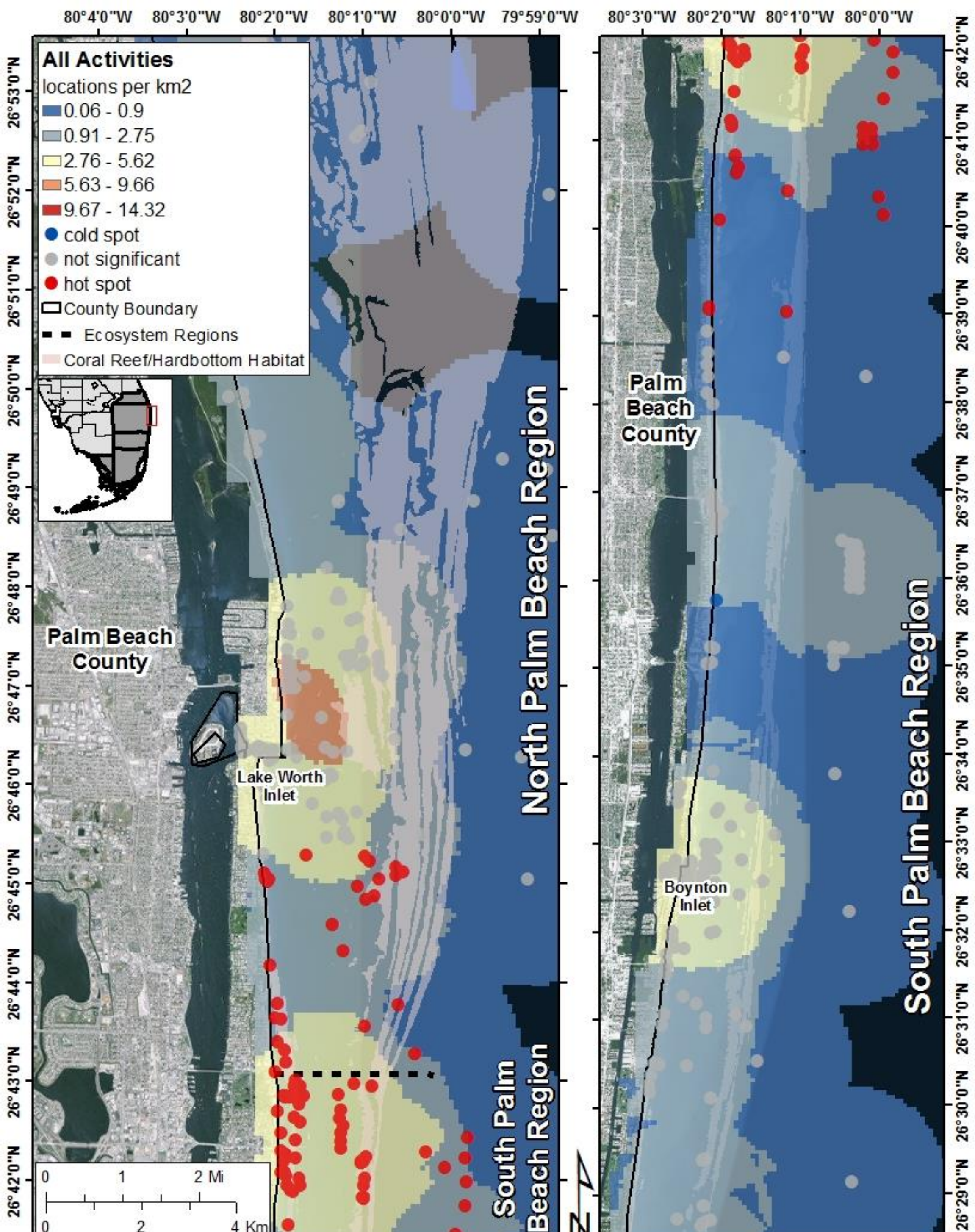

Figure 17. Map displaying results of point density analysis as well as hot spot analysis for all activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions. High density of locations was north of Lake Worth Inlet. Moderate density was in the northern portion of the South Palm Beach coral reef ecosystem region and around Boynton Inlet. Hot spots were south of Lake Worth Inlet, and continued down into the northern portion of the South Palm Beach coral reef ecosystem region.

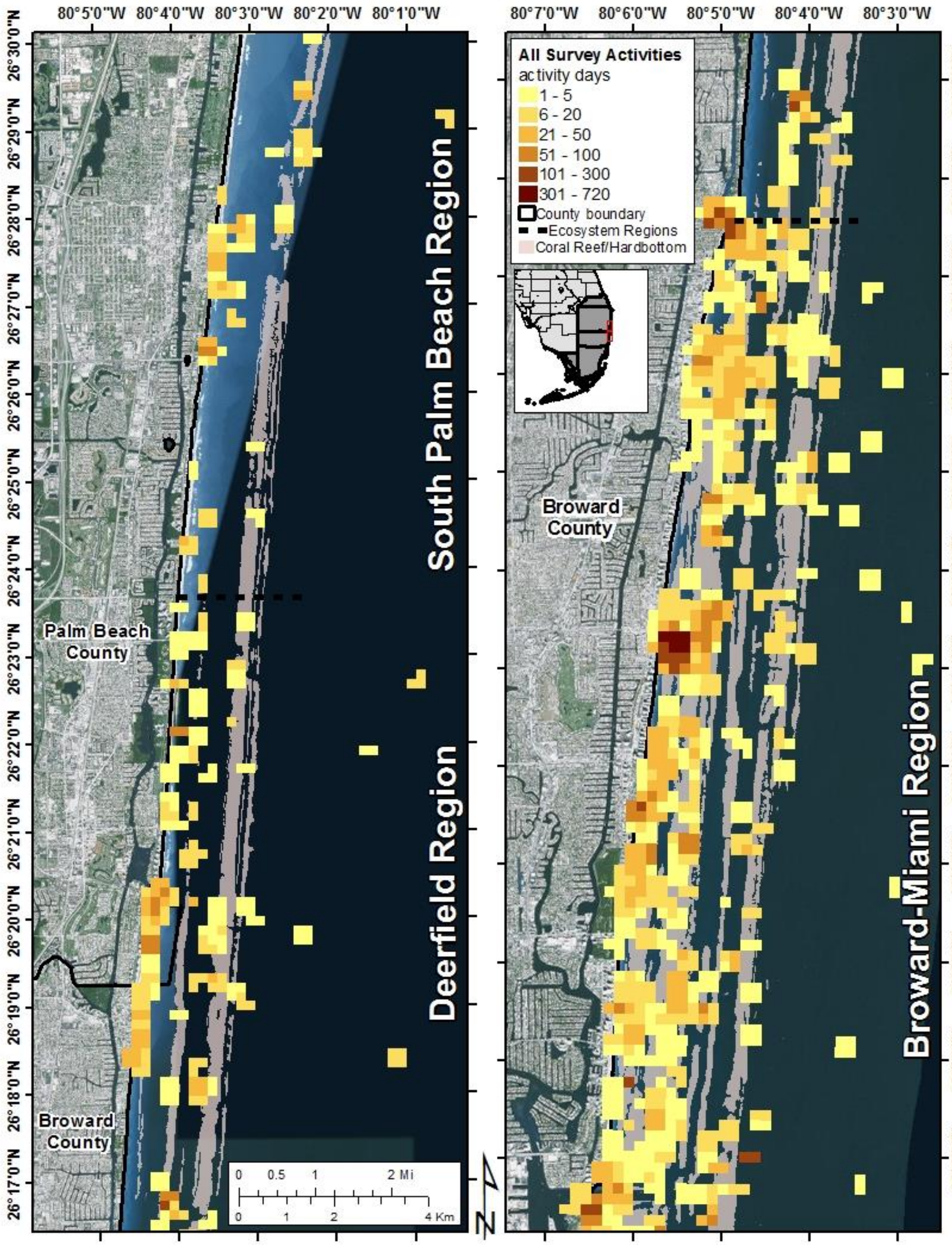

Figure 18. Map of final survey results displaying the total number of activity-days per planning unit for all activities within the South Palm Beach, Deerfield, and Broward Miami coral reef ecosystem regions. Planning units with higher activity days were around Hillsboro Inlet and Anglin's Pier. The Broward-Miami Region had a high density of planning units selected.

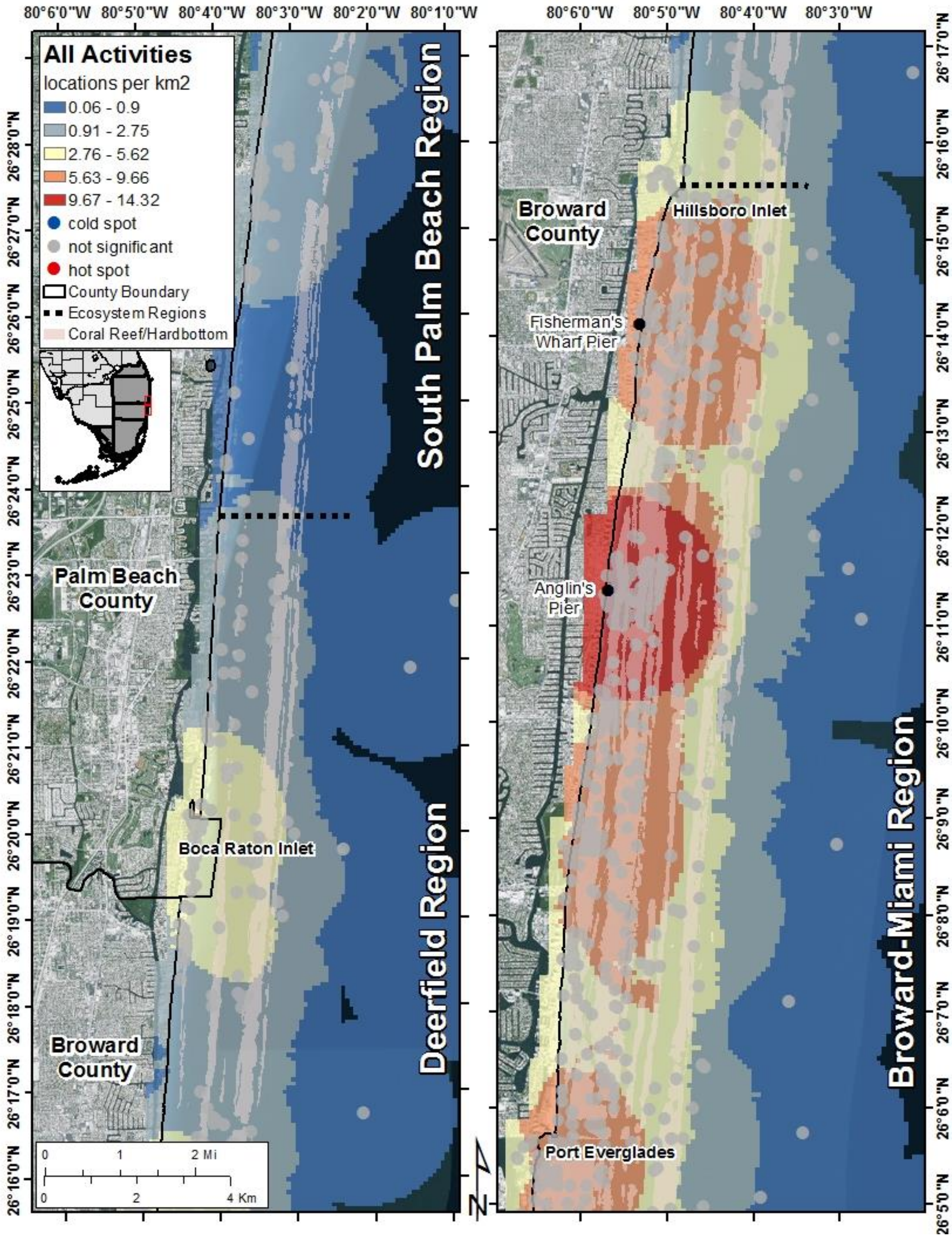

Figure 19. Map displaying results of point density analysis as well as hot spot analysis for all activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions. Very high density of locations was round Anglin's Pier and high density of locations was around Fisherman's Wharf Pier, south of Anglin's Pier, and around Port Everglades. Not hot spots or cold spots were found here.

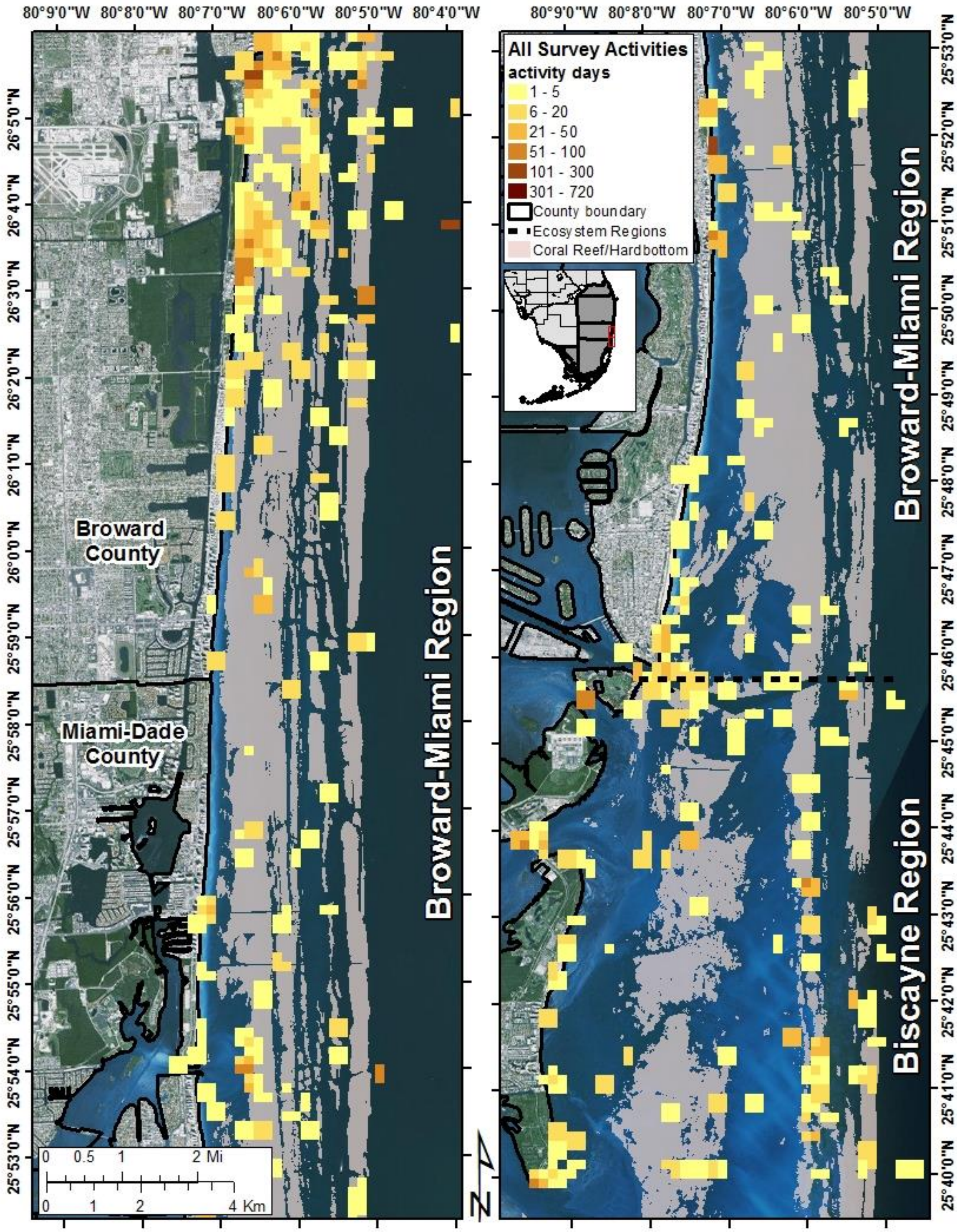

Figure 20. Map of final survey results displaying the total number of activity-days per planning unit for all activities within the Broward-Miami and Biscayne coral reef ecosystem regions. Planning units with high activity-days were around Port Everglades and Dania Fishing Pier.

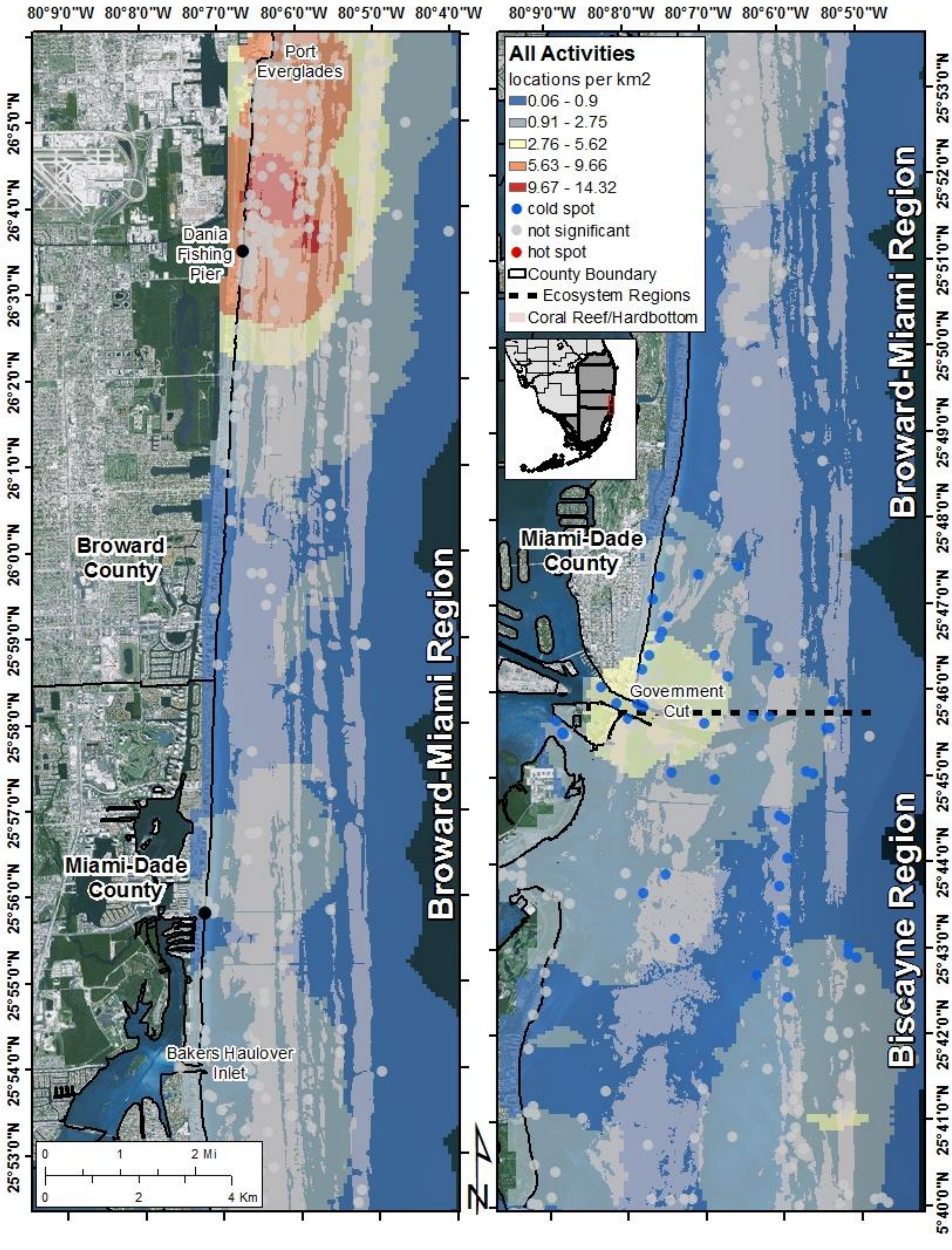

Figure 21. Map displaying results of point density analysis and hot spot analysis for all activities within Broward-Miami and Biscayne coral reef ecosystem regions showing cold spots around Government Cut and further south in the Biscayne Region. High density of locations was around Port Everglades and continued to Dania Fishing Pier. No hot spots existed in these regions but cold spots were around Government Cut.

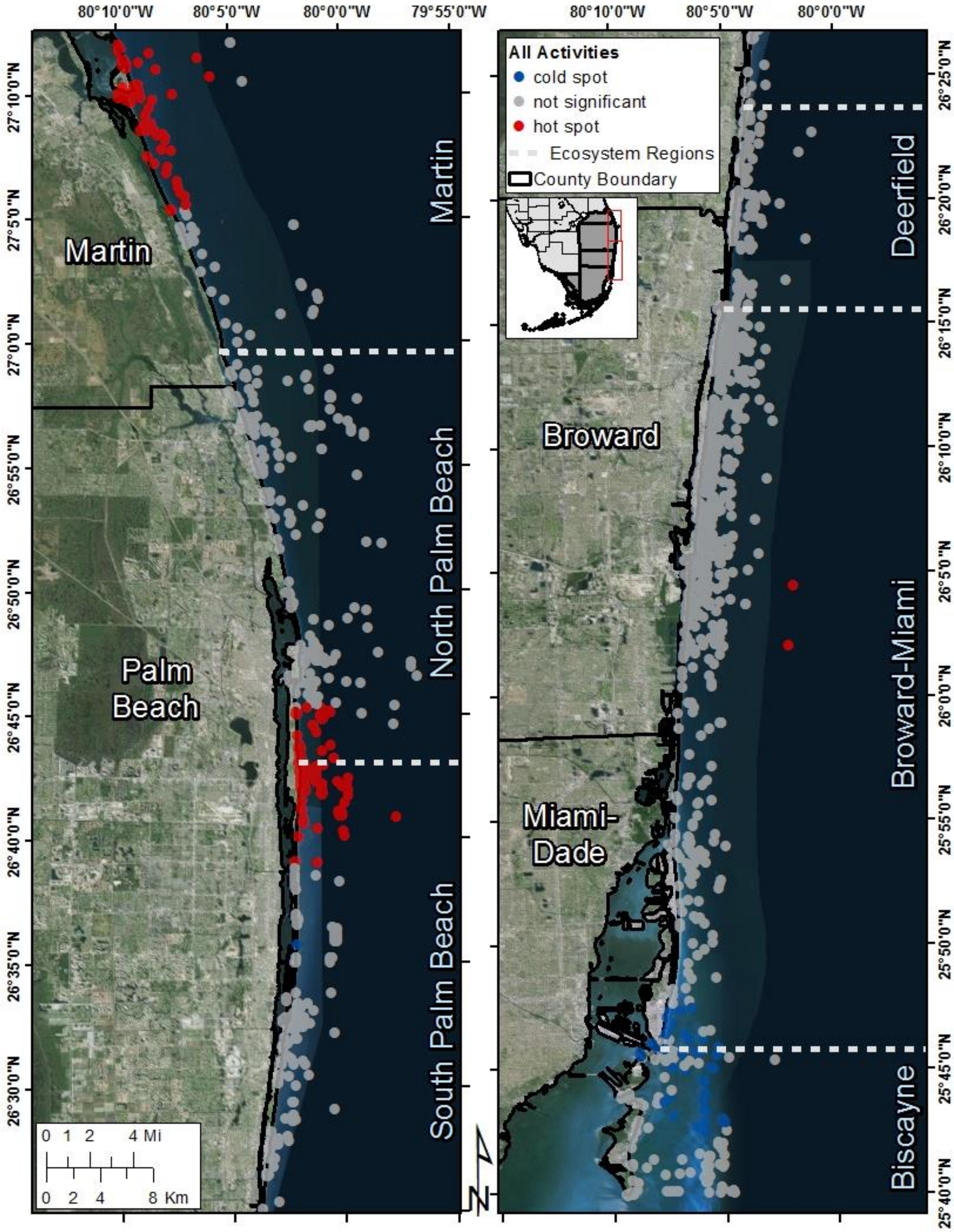

Figure 22. Hot spot analysis map of "All Activities" for the southeast Florida region showing hot spots in the Martin Coral Reef Ecosystem Region, between the North and South Palm Beach coral reef ecosystem regions, and further offshore in the Broward-Miami Coral Reef Ecosystem Region.

4.2.2. Boating Activity

The "Boating Activity" planning unit data showed between 20 and 100 activity-days in the Martin Coral Reef Ecosystem Region (Figure 23), with the most frequently visited areas around the St. Lucie Inlet and south along St. Lucie Reef. Point density analysis showed moderate density of locations at the mouth of St. Lucie Inlet, with values between 1.5 and 2.78 locations per km^2 (Figure 24).

In the North Palm Beach Coral Reef Ecosystem Region, the planning unit data showed Jupiter Ledge had over 100 activity-days and between 50 and 100 days at the Esso Bonaire III and Zion Train (Figure 25). There were high use areas along the Outer Reef offshore the City of Palm Beach where a lot of drift diving is known to occur. Some of these high-use areas reported between 100 and 400 activity-days. Although activity day values were lower, the area around Lake Worth Inlet had a high concentration of locations indicated as well (Figure 27). Point density analysis revealed moderate location density values, between 1.5 and 2.78 points per km^2, around Jupiter Inlet (Figure 26). High location density was located offshore Lake Worth Inlet between the inlet entrance and the Deep Ridge Complex, with values between 2.79 and 4.2 locations per km^2 (Figure 28).

In the South Palm Beach Coral Reef Ecosystem Region, the planning unit data showed high use of between 300 and 400 activity-days on the outer reef. These areas are also the locations of many popular dive sites such as Breakers Reef and the Flower Gardens (Figure 27). Point density analysis showed that respondent use was very high just off Palm Beach at the transition zone between the North Palm Beach and South Palm Beach regions, with values of 4.21 to 6.45 points per km^2. The area around Boynton Inlet had moderate location density of 1.5-2.78 locations per km^2 (Figure 28).

In the Deerfield Coral Reef Ecosystem Region, the planning unit data did not show any areas that had a very high number of activity-days. Boca Raton Inlet and the area on the Middle Reef off Lighthouse Point had the highest numbers indicated with values between 50 and 101 activity-days (Figure 29). Point density analysis showed high density for "Boating Activity" just outside of the Boca Raton Inlet spanning across the Middle and Outer Reefs. These values were between 2.79 and 4.2 locations per km^2 (Figure 30).

In the Broward-Miami Coral Reef Ecosystem Region, there was high activity near the mouth of Hillsboro inlet, some planning units showing between 101 and 300 activity-days. Planning units offshore Fisherman's Wharf Pier in Pompano Beach and Anglin's Pier in the City of Lauderdale-by-the-Sea showed between 51 and 100 activity-days. The Oakland Ridge mooring buoys also had planning units between 51 and 100 days (Figure 29). Close to 200 activity-days were indicated east of the Outer Reef just north of Port Everglades and north and south of Dania Beach Pier. Planning units having between 51 and 100 activity-days were located in various areas along the Nearshore Ridge Complex, many corresponding with mooring buoy and dive site locations. The planning units decreased moving south after Dania Beach. They increase again just outside of Baker's Haulover Inlet as well as east of the Outer Reef where activity-days were between 51 and 100 (Figure 31). Point density analysis showed very high location density from 4.21 to 6.45 locations per km^2 in the large 10 km stretch from Hillsboro Inlet to Anglin's Pier (Figure 30). There was also a very high density area around Port Everglades that spanned from Oakland Ridges south to Dania Fishing Pier. Moderate density from 1.5-2.78 km^2 was located offshore Baker's Haulover Inlet (Figure 32).

In the Biscayne Coral Reef Ecosystem Region, high use areas were located around Government Cut. Although high for this region, they were lower than other regions, with most areas showing under 50 activity-days (Figure 31). Point density analysis showed moderate density of 1.5-2.78 locations per km^2 around government cut and on the Inner and Outer Reef. One small area off Key Biscayne on the Outer Reef showed higher density from 2.79 to 4.2 km^2 locations per km^2 (Figure 32).

Locations demonstrating clustering of high use intensity for the southeast Florida region were around the mouth of the St. Lucie Inlet as well as along on the Nearshore Ridge Complex. This high clustering of locations with high activity-days shows that individuals who visited those locations did so more frequently and in a more concentrated area. Locations demonstrating clustering of high use intensity also occurred south of Lake Worth Inlet on the Nearshore Ridge Complex, the Deep Ridge Complex, and the Outer Reef down through the coral reef ecosystem transition area, south to about 8 km (Figure 28). One location demonstrating clustering of high use intensity was located almost eight kilometers off Dania Beach, just south of Port Everglades (Figure 32). Clustering of low use intensity locations were off Anglin's Pier, mainly on the Nearshore Ridge Complex and Inner Reef, but also on the Middle and Outer Reefs (Figure 28). They occurred off North Miami Beach

(Figure 32) and off north Key Biscayne on the Nearshore Ridge Complex, Inner Reef, and Outer Reef (Figure 33). Clustering of low use intensity around Anglin's Pier, demonstrated that many people visited this location for boating activities but only on occasion. Locations demonstrating clustering of low use intensity were also at the southern-most extent of the region. Further south, cold spots occurred offshore Key Biscayne. This was an area visited infrequently by several survey participants for boating activities. Although many users clustered at these locations, the low number of activity-days indicated by those users may cause this area to experience less stress. The locations indicate that those who used the location did not do so often so the intensity of use is presumably lower.

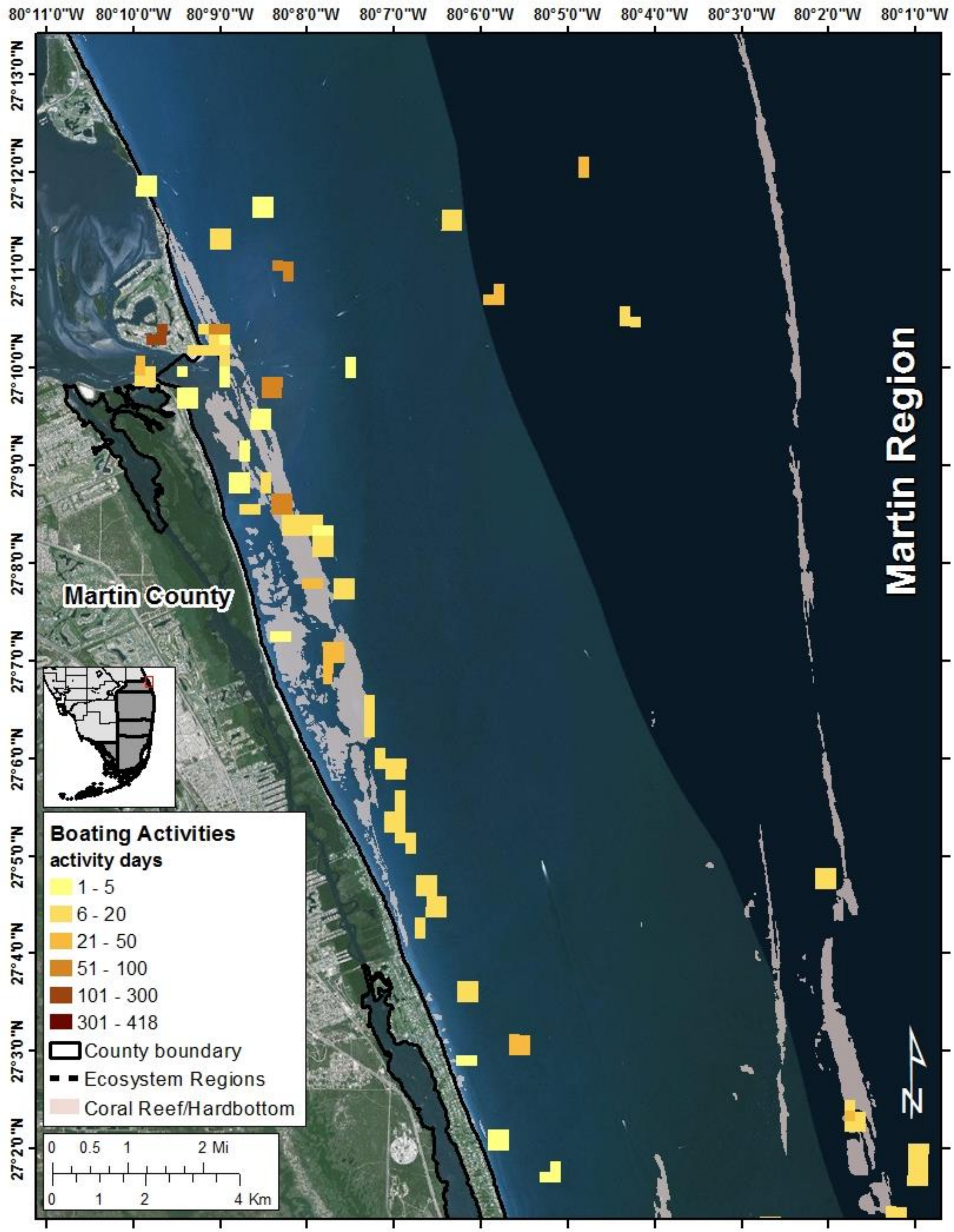

Figure 23. Map of final survey results displaying the total number of activity-days per planning unit for boating activities within the Martin Coral Reef Ecosystem Region. Planning units with higher activity-days were around St. Lucie Inlet.

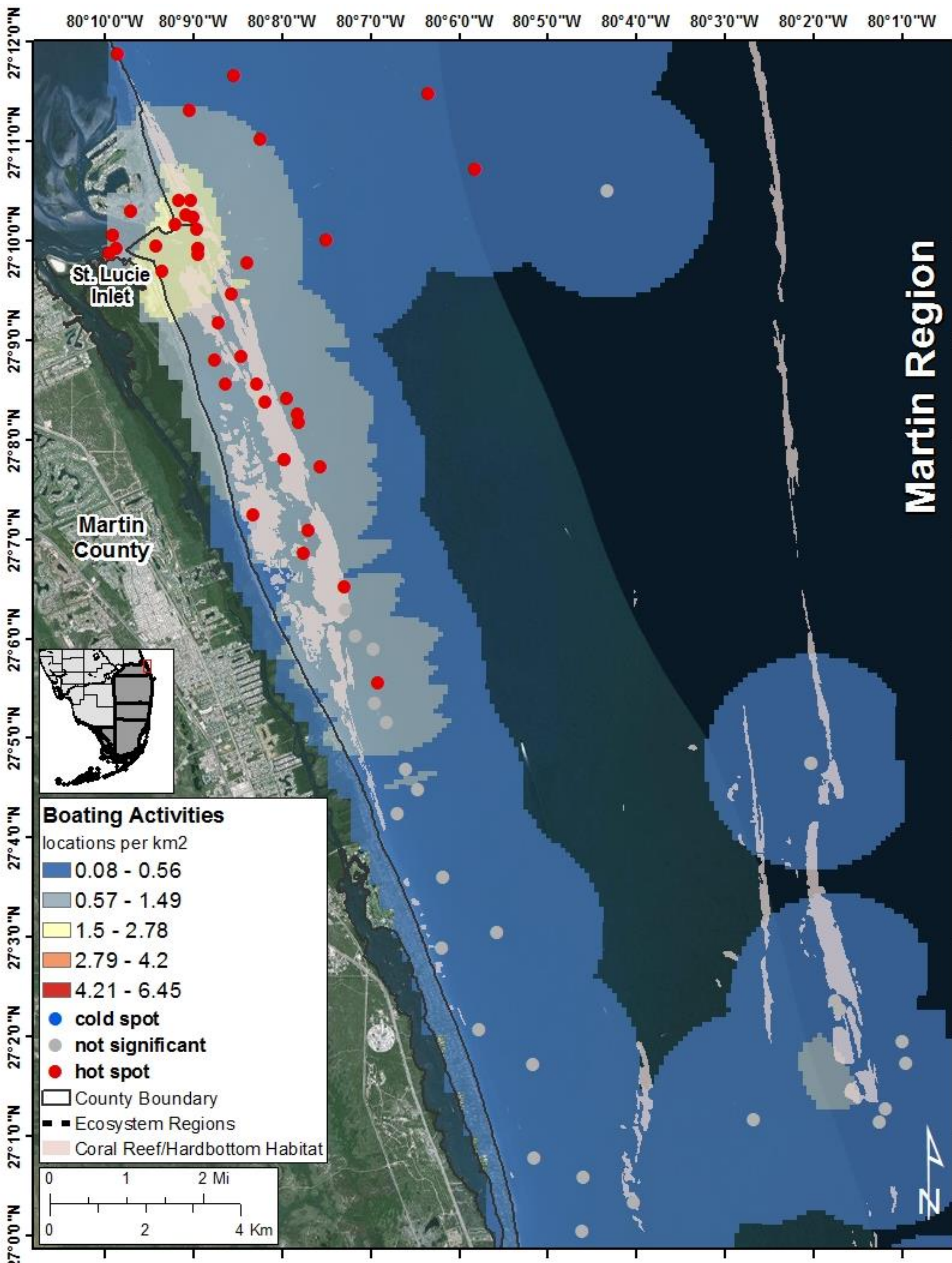

Figure 24. Map displaying results of point density analysis as well as hot spot analysis for boating activities within the Martin coral reef ecosystem region. Moderate density of locations and hot spots were around St. Lucie Inlet. Hot spots also continued down along the Nearshore Ridge.

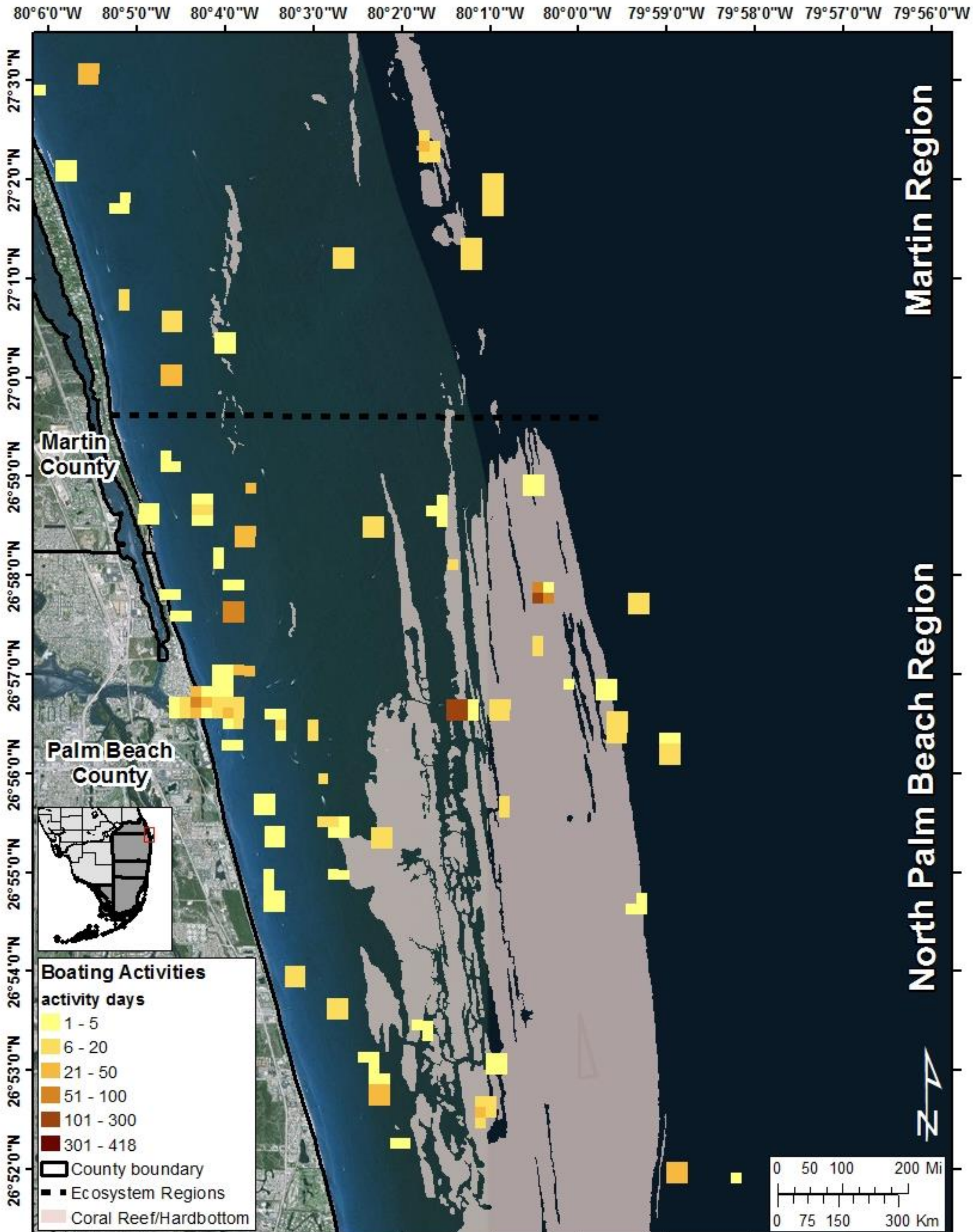

Figure 25. Map of final survey results displaying the total number of activity-days per planning unit for boating activities within the Martin and North Palm Beach coral reef ecosystem regions. Planning units with higher activity-days were around Jupiter Inlet and on the Deep Ridge Complex off Jupiter Inlet.

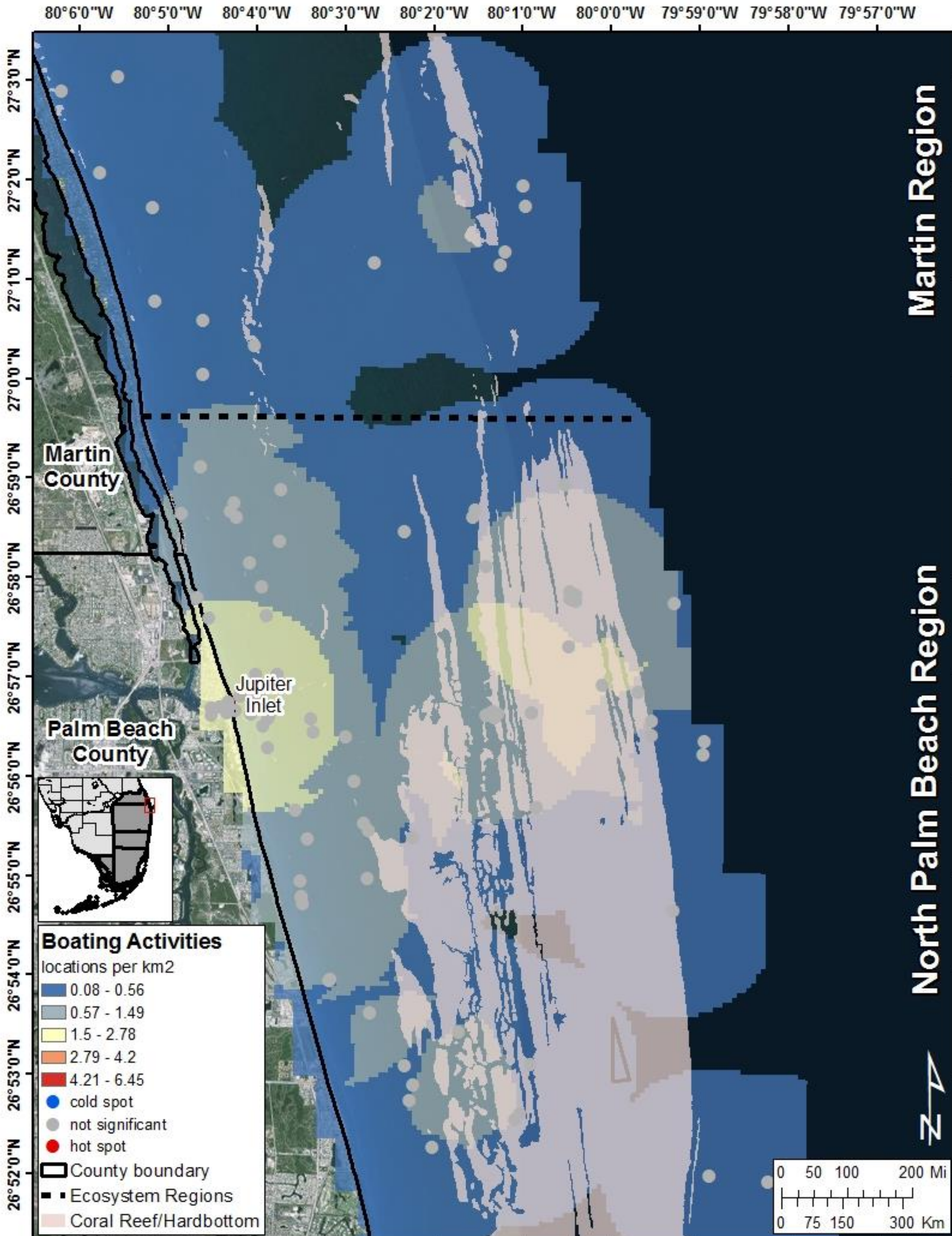

Figure 26. Map displaying results of point density analysis as well as hot spot analysis for boating activities within the Martin and North Palm Beach coral reef ecosystem regions. Moderate density of locations was around Jupiter Inlet. Not hot spots or cold spots were found.

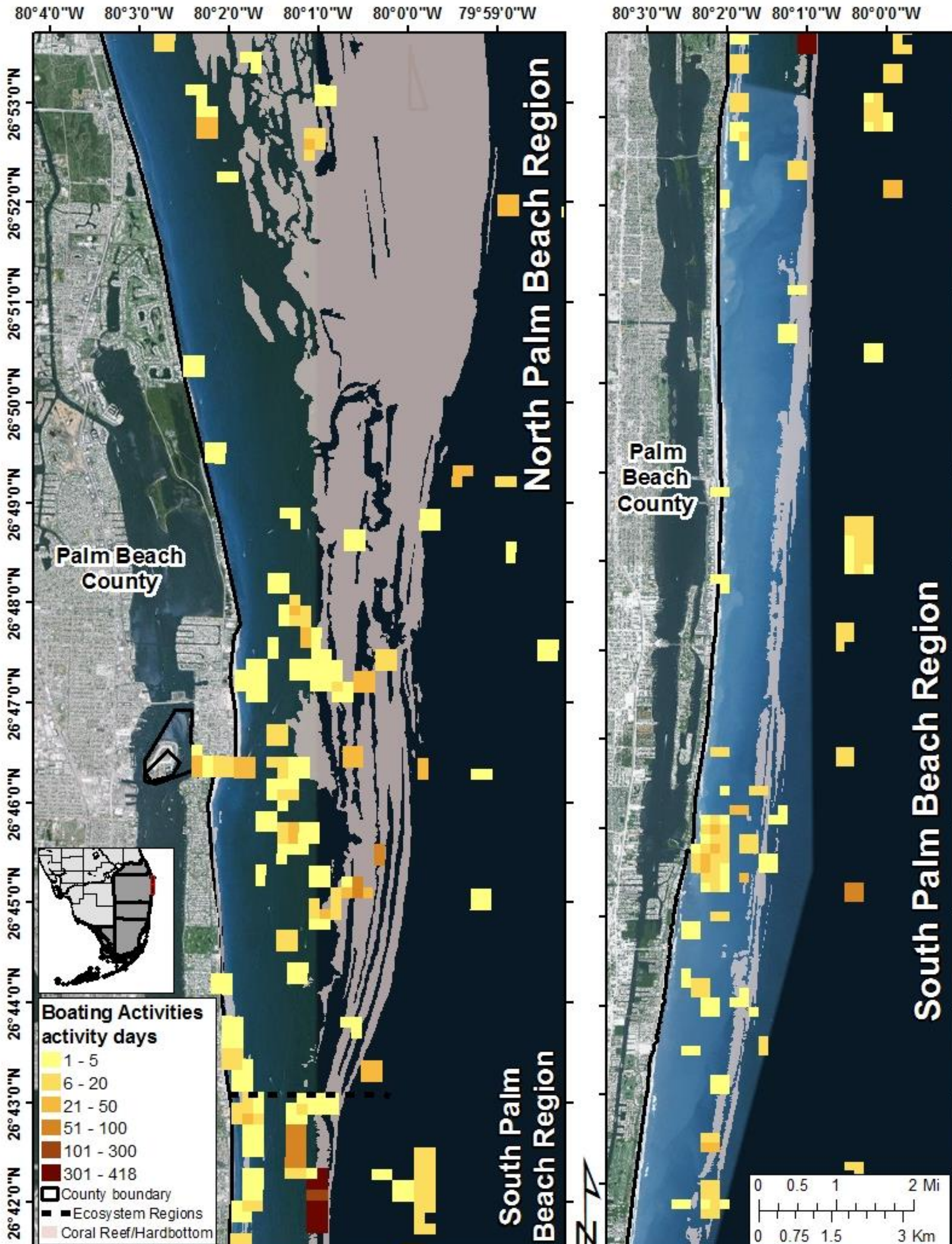

Figure 27. Map of final survey results displaying the total number of activity-days per planning unit for boating activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions. Planning unit with a high number of activity-days were on the Deep Ridge Complex in the northern stretch of the South Palm Beach Region.

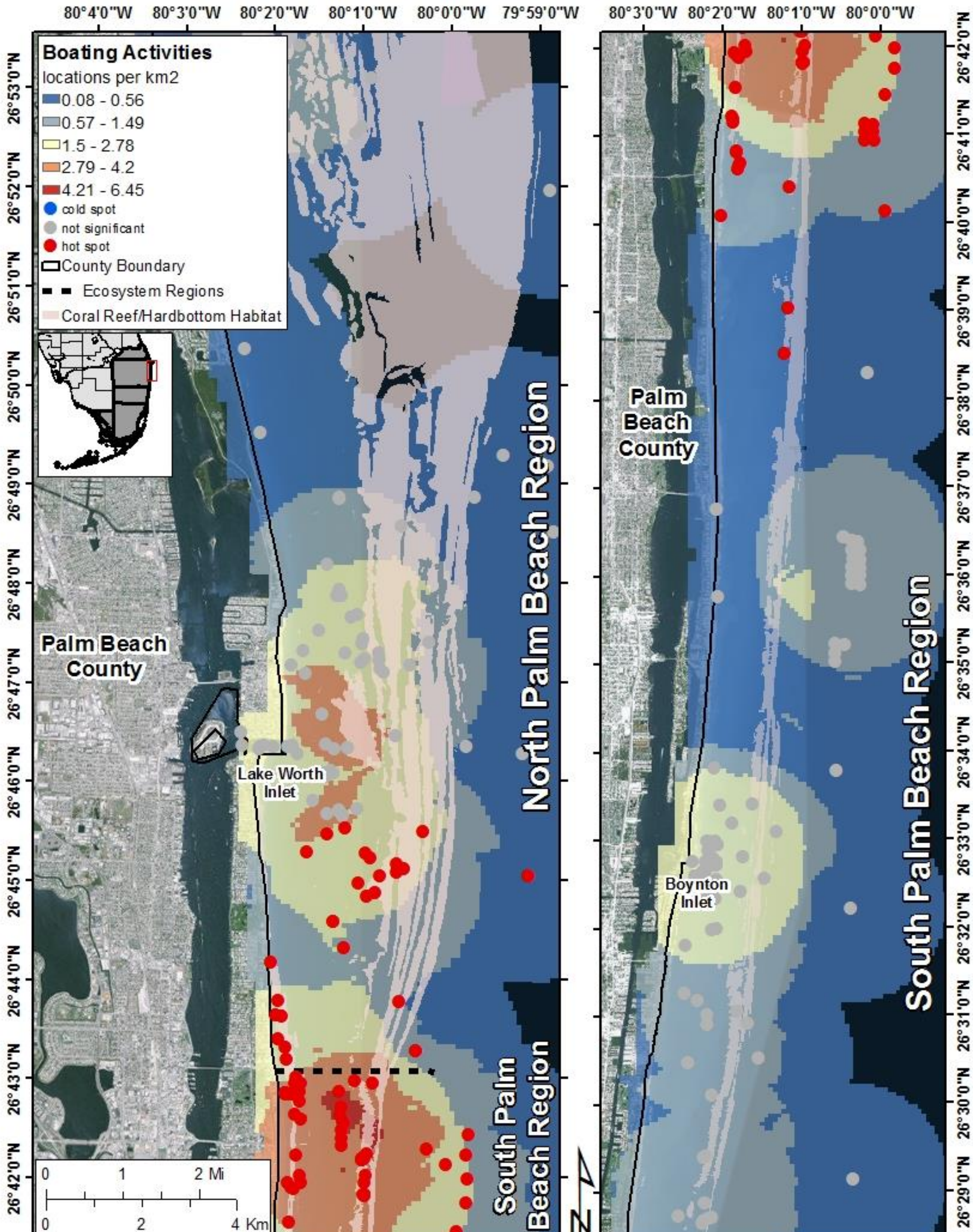

Figure 28. Map displaying results of point density analysis as well as hot spot analysis for boating activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions. High density of locations was outside Lake Worth Inlet as well as just south of the North and South Palm Beach Coral Reef Ecosystem transition zone. Hot spots were also around this transition zone.

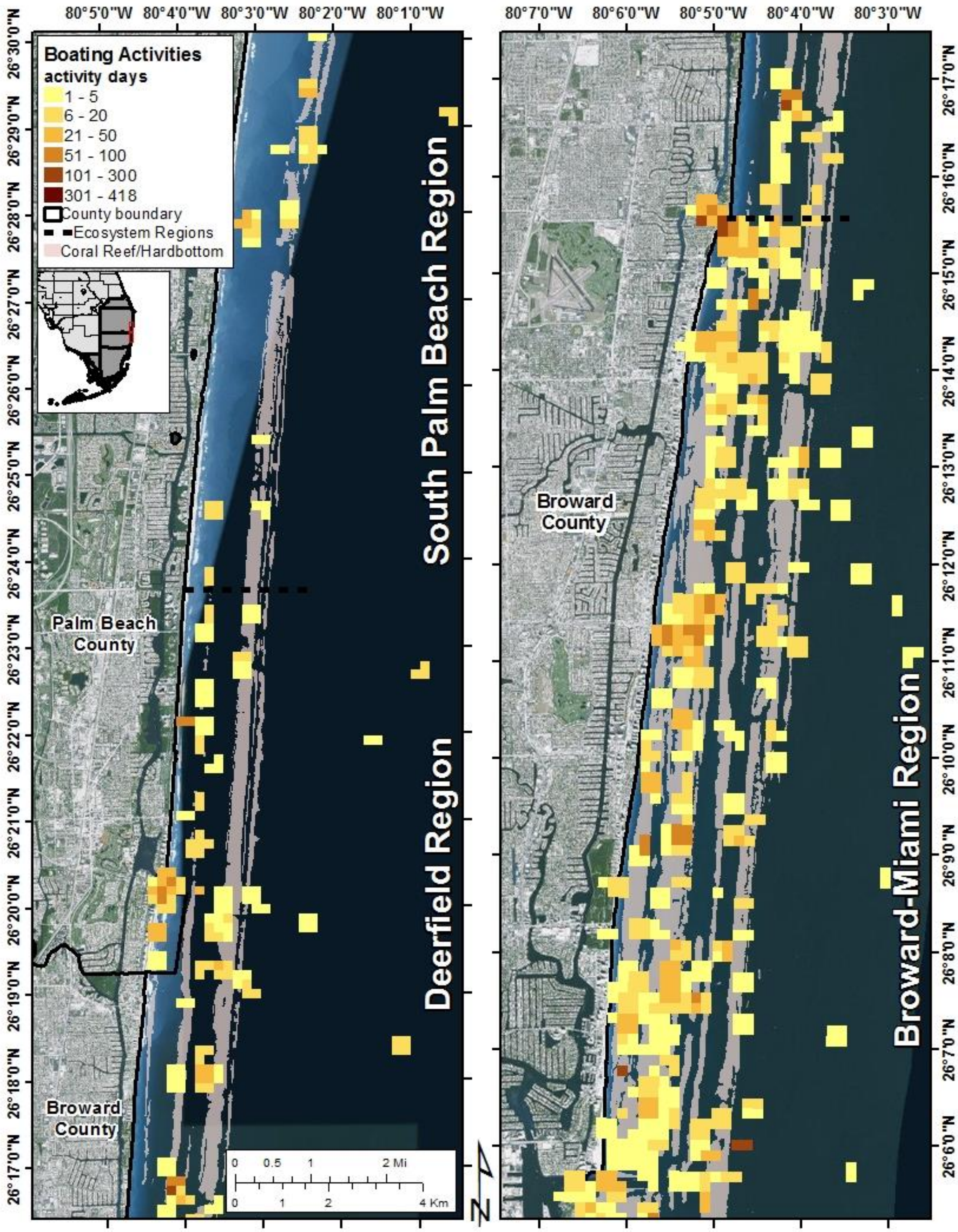

Figure 29. Map of final survey results displaying the total number of activity-days per planning unit for boating activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions. Planning units with high activity-days were around Hillsboro Inlet. Planning unit data showed that use was dense but also spread out along the reefs in the Broward-Miami Region.

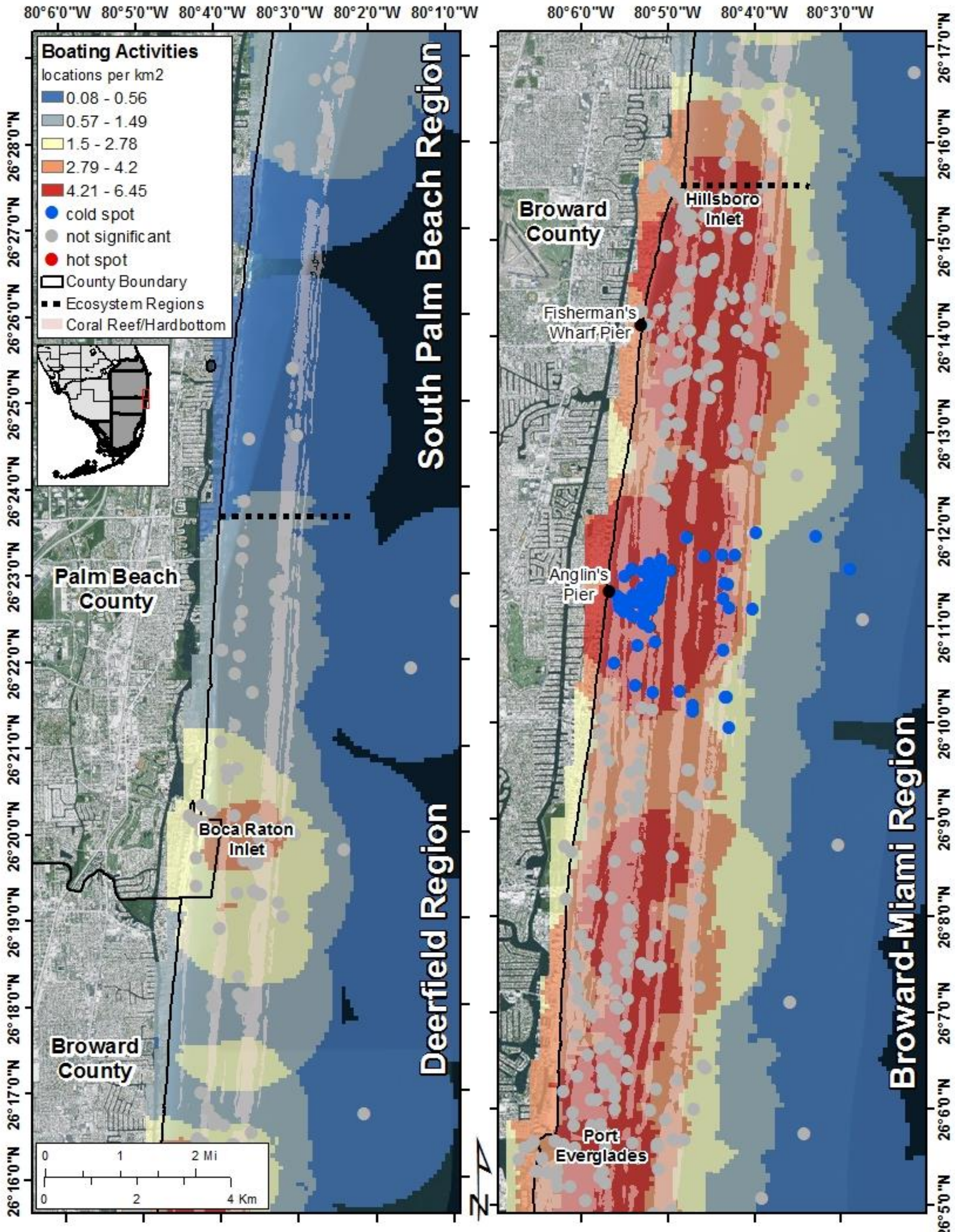

Figure 30. Map displaying results of point density analysis as well as hot spot analysis for boating activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions. Very high density of locations was in the area from Hillsboro Inlet to Anglin's Pier as well as North of Port Everglades. High density was around Boca Raton Inlet. Cold spots were around Anglin's Pier.

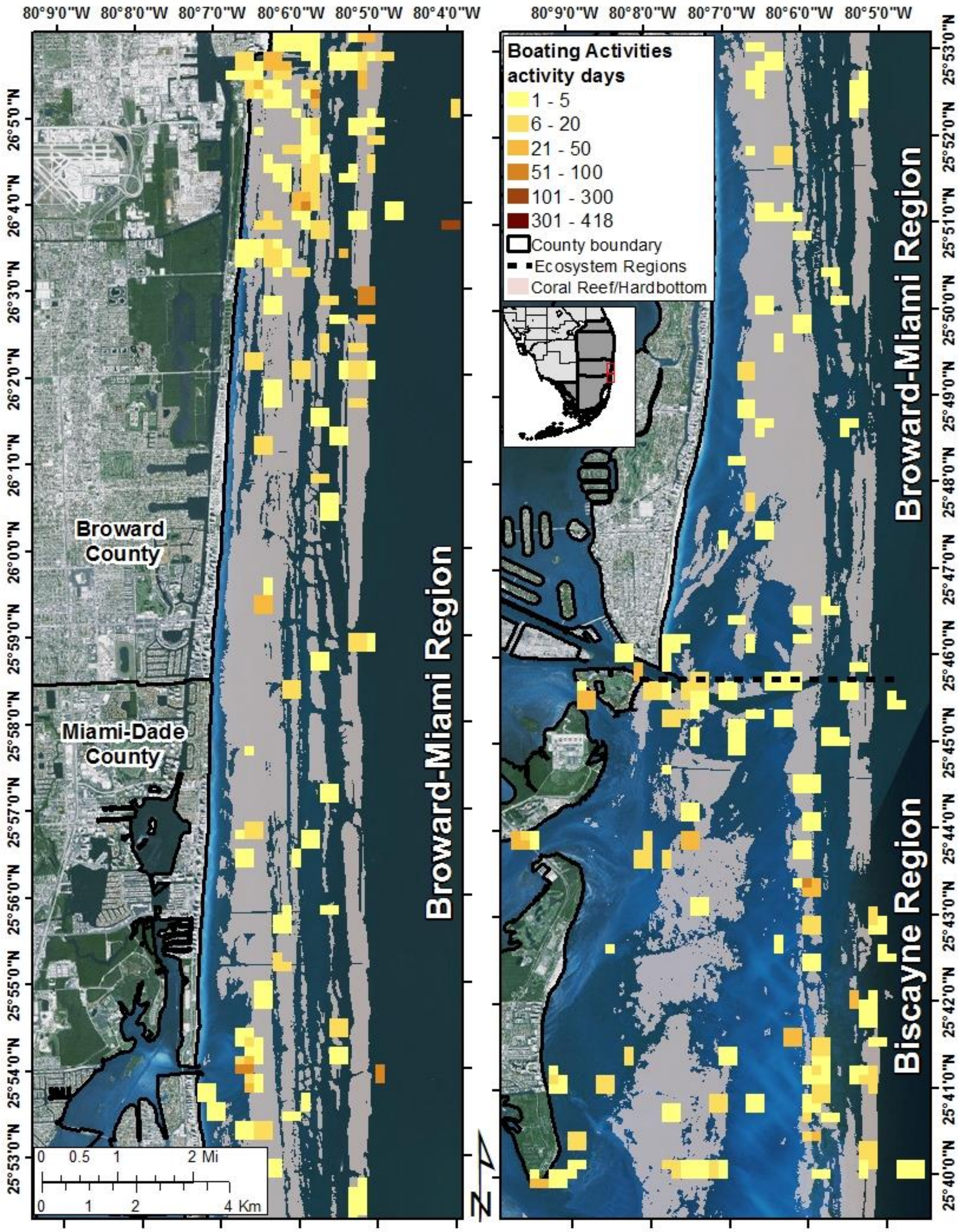

Figure 31. Map of final survey results displaying the total number of activity-days per planning unit for boating activities within the Broward-Miami and Biscayne coral reef ecosystem regions. Clustering of planning units was around Port Everglades but sparse throughout the regions.

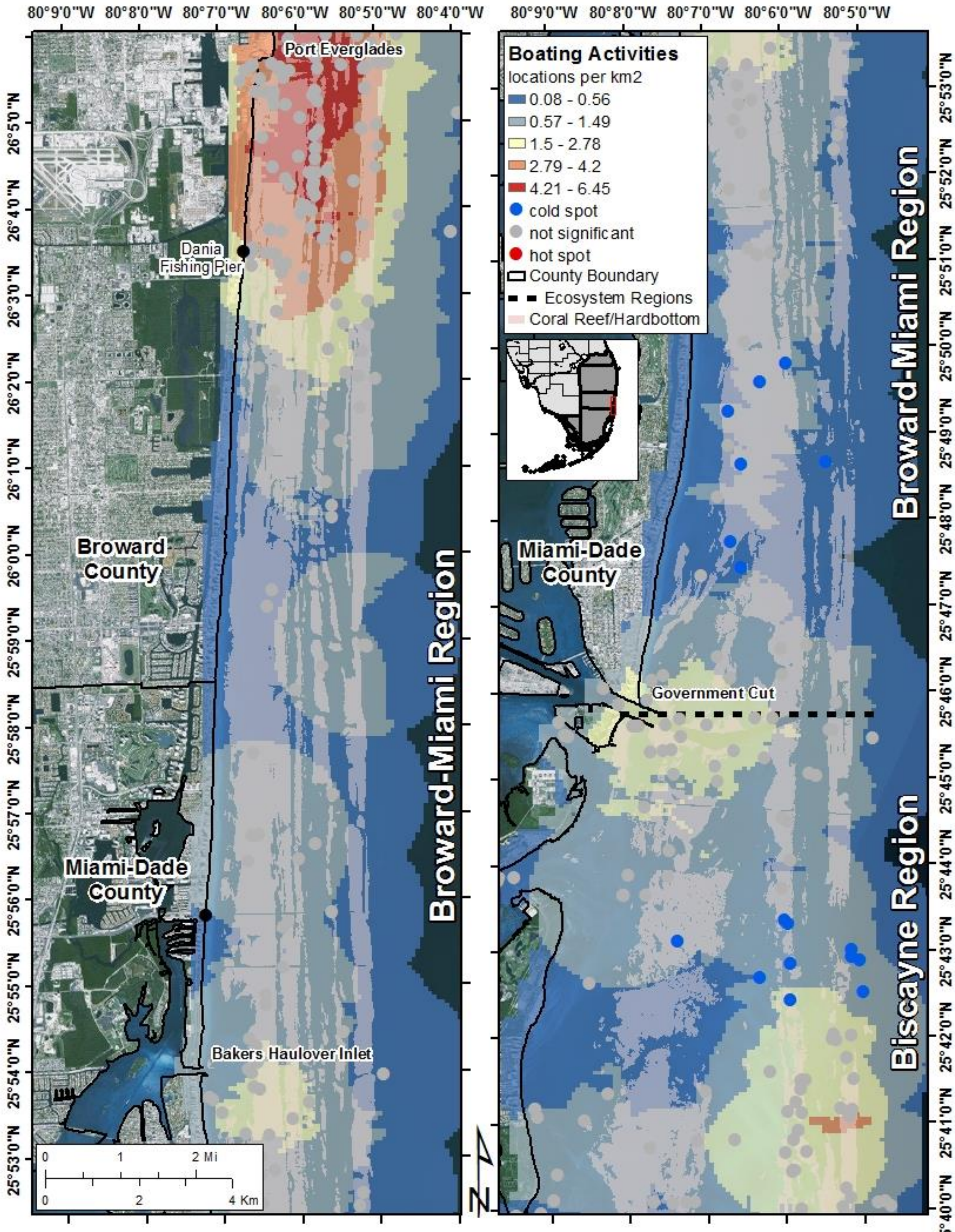

Figure 32. Map displaying results of point density analysis as well as hot spot analysis for boating activities within the Broward-Miami and Biscayne coral reef ecosystem regions. Very high density of locations was around Port Everglades and slightly south. Dania Fishing Pier had high density of locations. Cold spots were located above Government Cut and in the Biscayne Coral Reef Ecosystem Region.

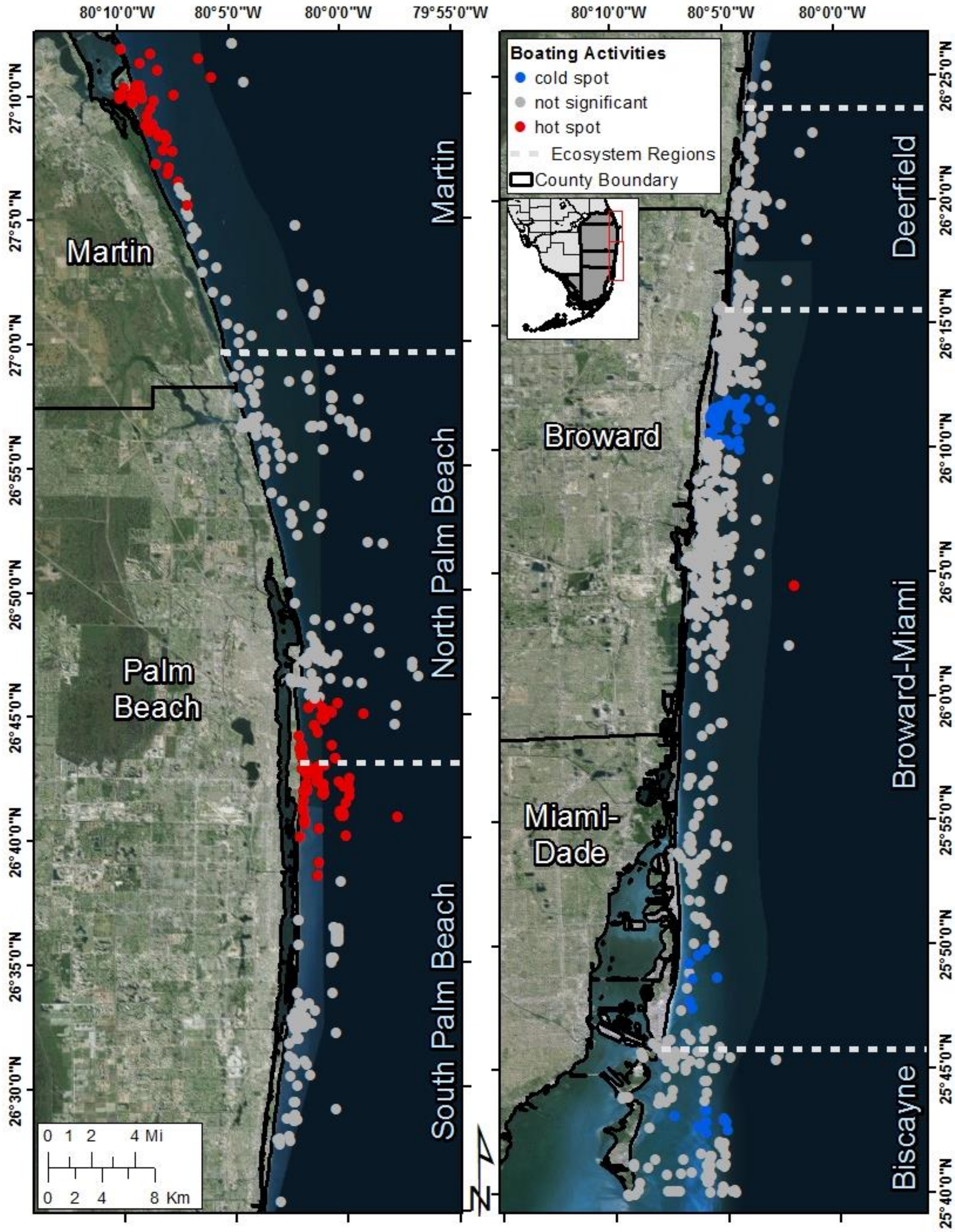

Figure 33. Hot spot analysis map of "Boating Activities" for the southeast Florida region. Hot spots were in the Martin Region, around the St. Lucie Inlet and the area of transition between the North and South Palm Beach regions. One hot spot was located far offshore in the Broward-Miami Region. Cold spots were in the northern portion of the Broward-Miami Region, north of Government Cut, and in the Biscayne Region

4.2.3. SCUBA Diving Activities

In the Martin Coral Reef Ecosystem Region, "SCUBA Diving Activity" was low. One area with 55 activity-days was indicated near St. Lucie Inlet, but most areas had 20 or less activity-days (Figure 34). Point density analysis showed only areas with low density of locations (1.65 locations per km^2 or less) (Figure 35).

In the North Palm Beach Coral Reef Ecosystem Region, "SCUBA Diving Activity" greater than 100 activity-days was on Jupiter Ledge (Figure 36). Planning units around the Esso Bonaire III and the Zion Train wrecks also had around 80 activity-days. Many locations offshore Lake Worth Inlet showed around 50 activity-days (Figure 38). Point density analysis showed moderate density of locations (1.66 and 3.33 locations per km^2) around Jupiter Inlet (Figure 37).

In the South Palm Beach Coral Reef Ecosystem Region, planning units with 300 plus activity-days were found along the Outer Reef and near shore hardbottom off of Palm Beach where many popular dive sites are located including Breakers, King Neptune, the Outfall Trench, and the Flower Gardens. Planning units with higher activity-days were also indicated offshore Boynton Beach, with one area consisting of 4 planning units having 100 activity-days (Figure 38). Point density analysis showed moderate density between 1.66 and 3.33 locations per km^2 at the northern stretch of the region where many popular dive sites are located (Figure 39). No high density areas were identified, however.

In the Deerfield Coral Reef Ecosystem Region, planning unit data showed locations around Boca Raton Inlet with just over 50 activity-days. Most other areas had 50 activity-days or less (Figure 38). Point density analysis showed an area of moderate density south of Boca Raton Inlet down to the North Deerfield Beach and Fishing Pier (Figure 39).

In the Broward-Miami Coral Reef Ecosystem Region, many planning units were selected throughout the northern portion of the region, especially nearshore and along mooring buoy locations. Extensive SCUBA diving activity was found near Anglin's Pier in the City of Lauderdale-by-the-Sea, with several planning units having over 100 activity-days and some having over 400 activity-days (Figure 40 and Figure 42). This high activity continued south along the Inner Reef in Fort Lauderdale (Figure 40). Many planning units were selected around Dania Fishing Pier. Continuing south, the number of locations decreased (Figure 42). High density of "SCUBA Diving Activity" locations were in the area around Fisherman's Wharf Pier and down past Anglin's Pier. These values ranged between 3.34 and 6.25 locations per km^2. Very high density was located within this area, at Anglin's Pier, with values of between 6.26 and 9.55 locations per km^2 (Figure 41). Dania Fishing Pier was also an area with high point density, ranging from 3.34 to 6.25 locations per km^2 (Figure 43).

In the Biscayne Coral Reef Ecosystem Region, higher activity was on the Middle and Outer Reef offshore Key Biscayne. Although high for Miami-Dade County, they were relatively low (< 30 activity-days) compared to other regions (Figure 42). Point density analysis showed moderate density of locations (1.66-3.33 points per km^2) offshore Key Biscayne on the Inner Reef, Outer Reef and Deep Ridge, where many popular dive sites exist (Figure 43).

Hot spot analysis for "SCUBA Diving Activity" in the southeast Florida region showed locations at the southern end of the North Palm Beach Coral Reef Ecosystem region, along the shallow colonized pavement. Two locations were also shown on the sand habitat before the Deep Ridge Complex (Figure 39). These locations showing clustering of high use intensity, continued into the South Palm Beach Region and spanned south to about 5 km. These spots were on the Shallow Ridge, Deep Ridge, Outer Reef, and in deeper waters past the reef. One location demonstrating clustering of high use intensity was just above the transition zone between the Deerfield and Broward-Miami region, as well as in the area between Hillsboro Inlet and Fisherman's Wharf Pier, on the Nearshore Ridge Complex, the Middle Reef, and the Outer Reef (Figure 41 and Figure 44). Clustering of high use intensity occurred at the southern-most end of the North Palm Beach Coral Reef Ecosystem Region, extending into the South Palm Beach region. This shows that many individuals engaged in SCUBA diving activity frequently in this area. Hot spot analysis showed clustering of low use intensity from Fisherman's Wharf Pier up to Hillsboro Inlet. This indicates that many individuals visited Anglin's Pier and the Dania Fishing Pier, but the number of activity-days, and thus the intensity of use, was not high.

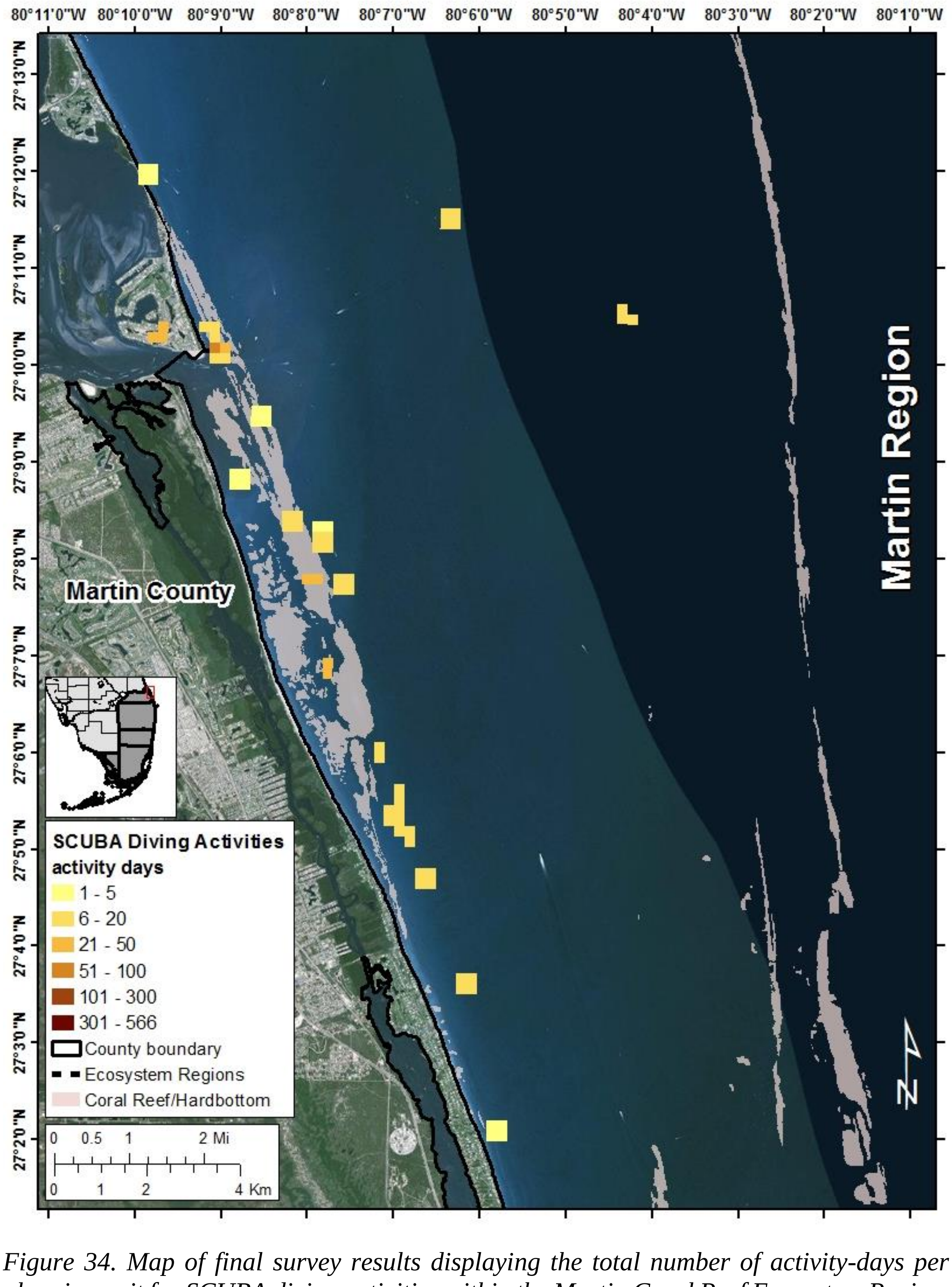

Figure 34. Map of final survey results displaying the total number of activity-days per planning unit for SCUBA diving activities within the Martin Coral Reef Ecosystem Region. Planning units with the highest activity-days in this region were on the north side of St. Lucie Inlet.

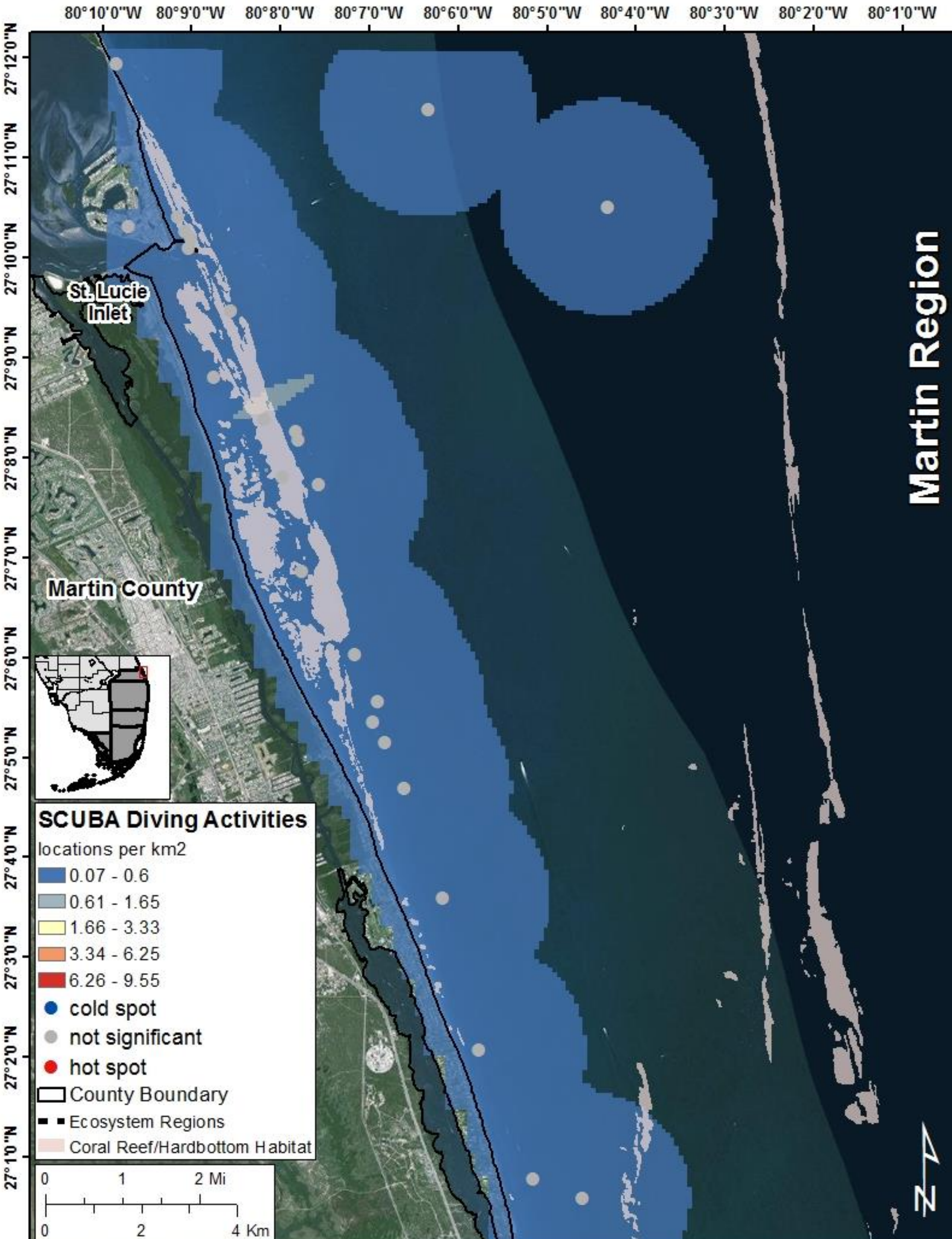

Figure 35. Map displaying results of point density analysis as well as hot spot analysis for SCUBA diving activities within the Martin coral reef ecosystem region. Point density analysis nor hot spot analysis revealed any notable areas.

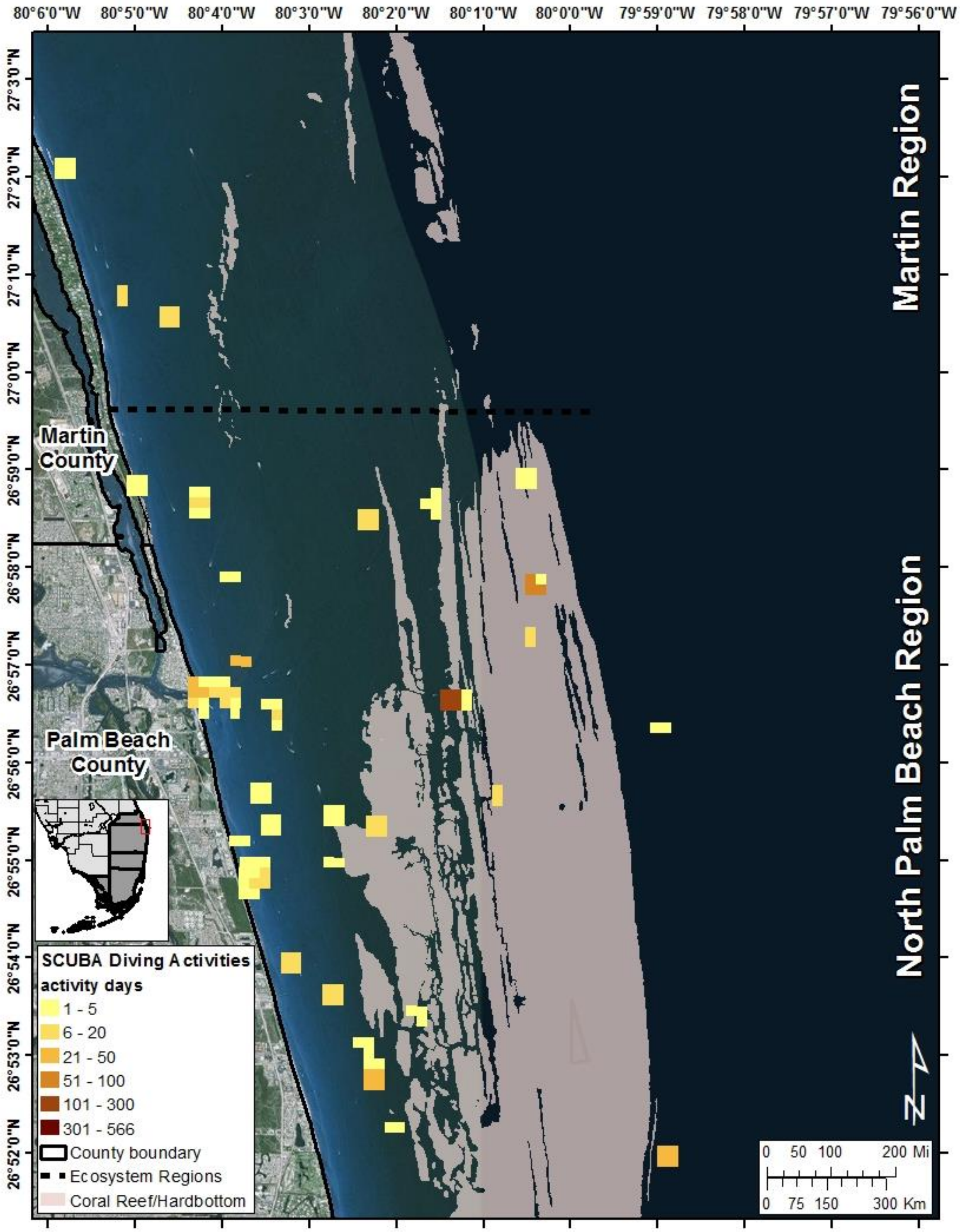

Figure 36. Map of final survey results displaying the total number of activity-days per planning unit for SCUBA diving activities within the Martin and North Palm Beach coral reef ecosystem regions. Sparse planning unit data were in the northern portion of this region. The highest number of activity-days was on the Deep Ridge Complex off Jupiter.

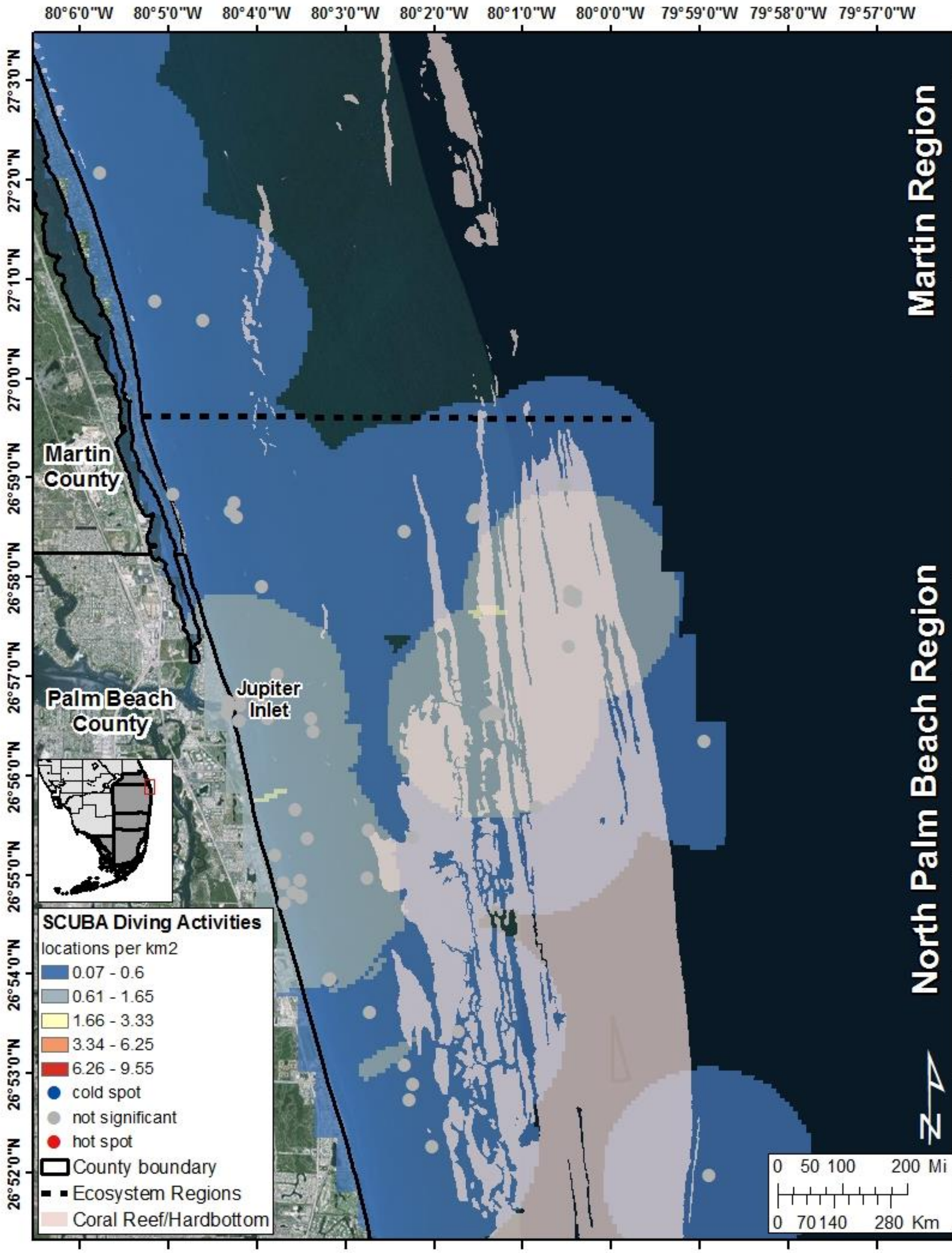

Figure 37. Map displaying results of point density analysis as well as hot spot analysis for SCUBA diving activities within the Martin and North Palm Beach coral reef ecosystem regions. Point density analysis nor hot spot analysis revealed any notable areas.

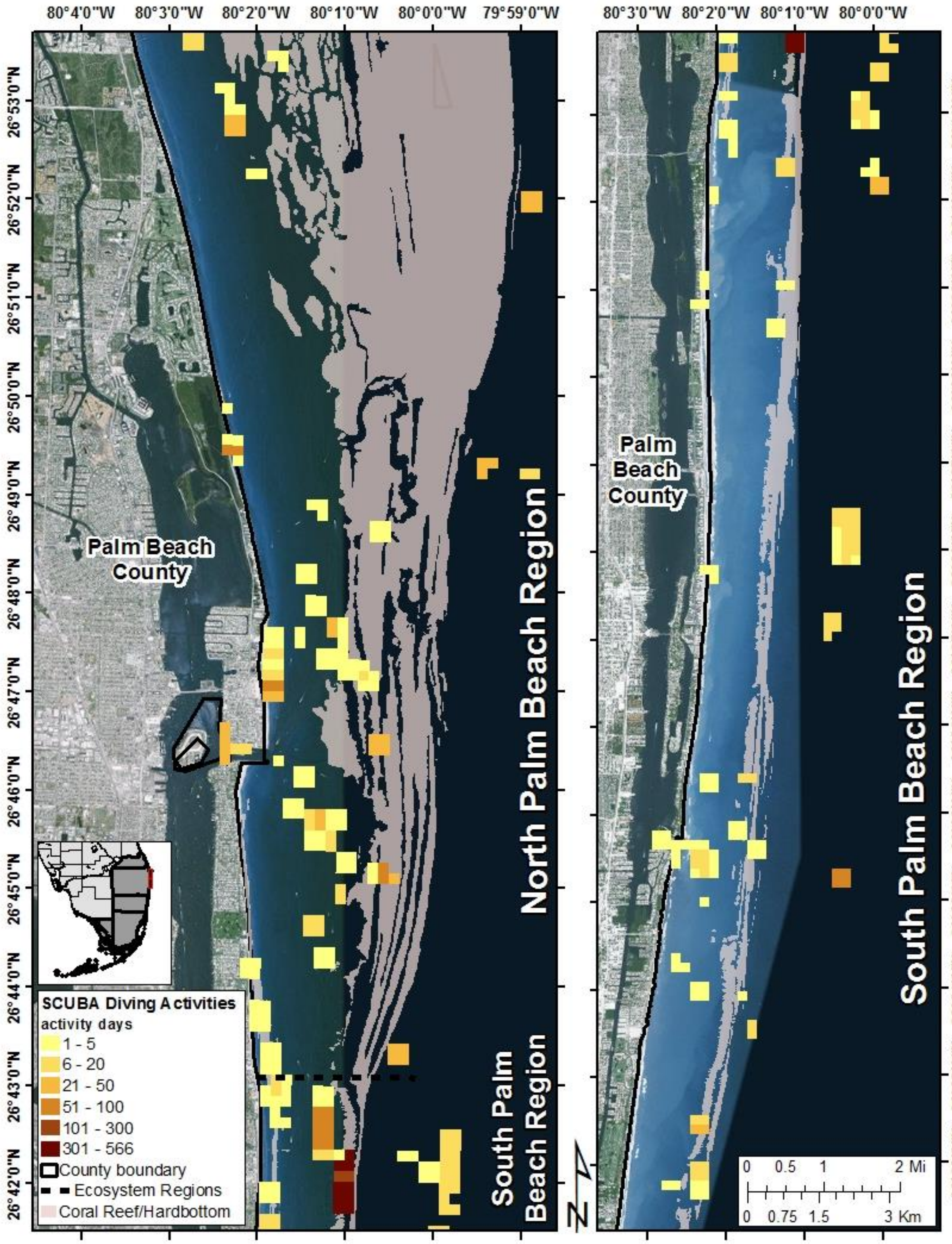

Figure 38. Map of final survey results displaying the total number of activity-days per planning unit for SCUBA diving activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions. Planning units with the highest number of activity-days in these regions were at the northern stretch of the South Palm Beach Region.

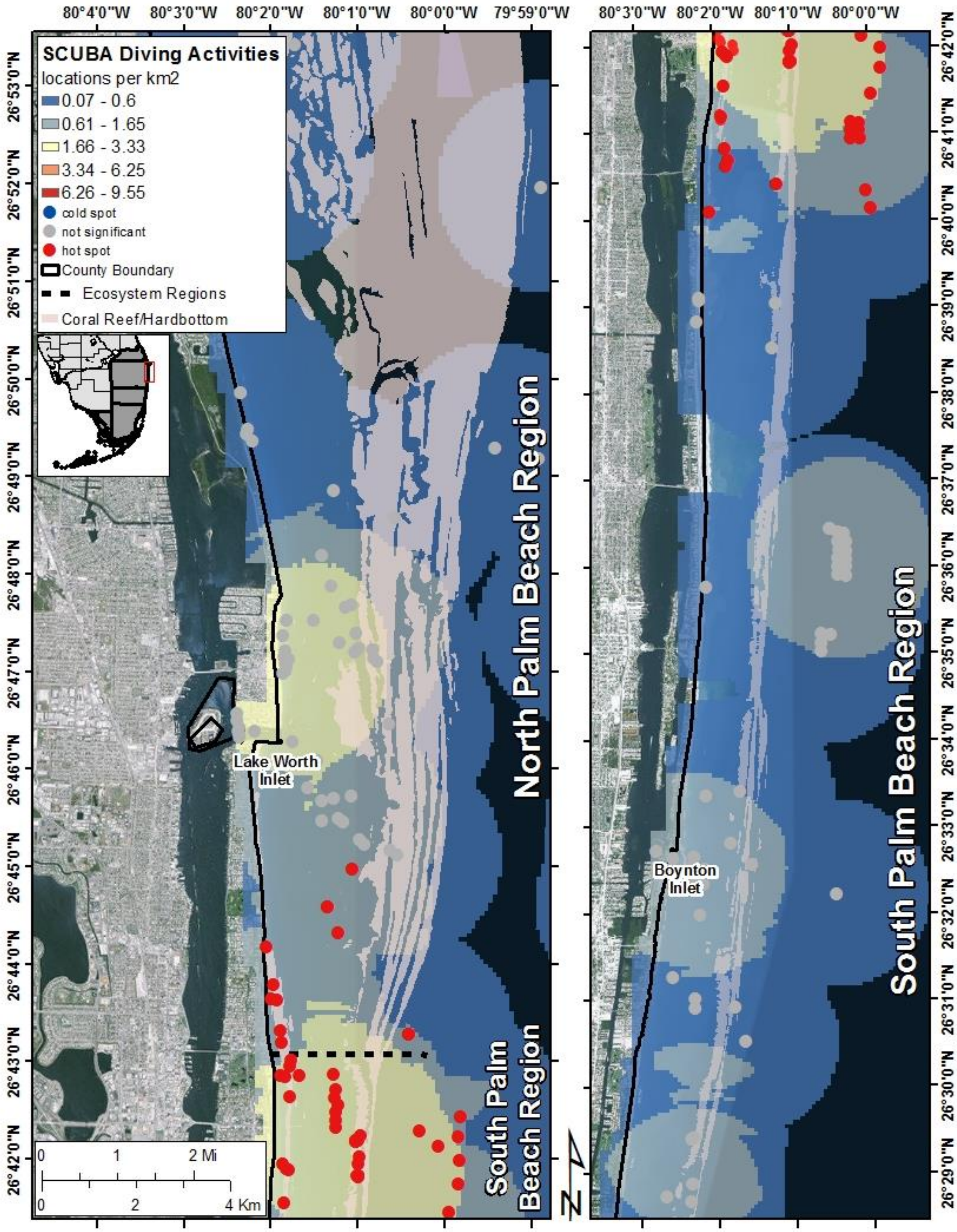

Figure 39. Map displaying results of point density analysis as well as hot spot analysis for SCUBA diving activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions. Moderate density of locations was around Lake Worth Inlet and in the northern portion of the South Palm Beach Coral Reef Ecosystem Region. Hot Spots were also in the northern portion of the South Palm Beach Coral Reef Ecosystem Region.

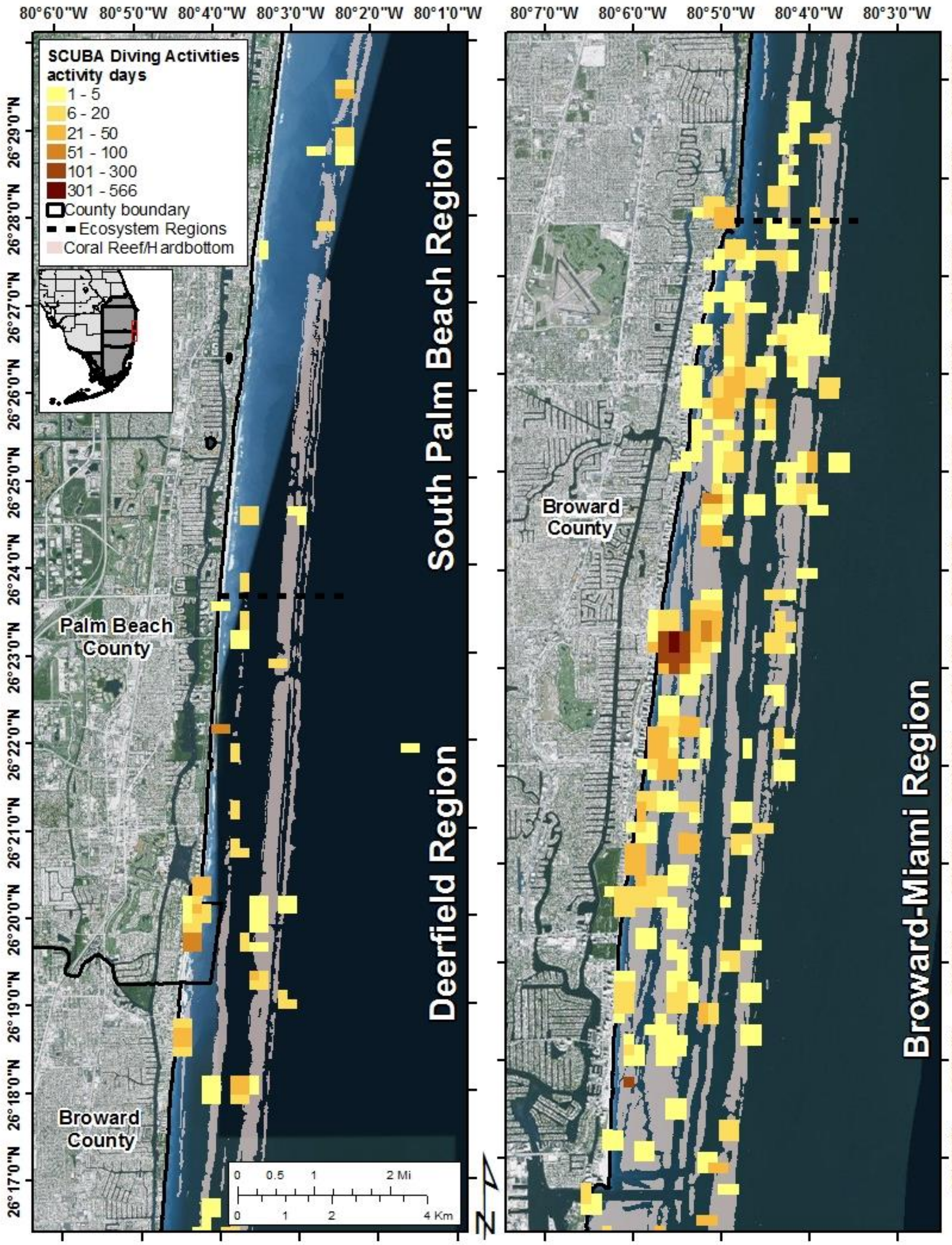

Figure 40. Map of final survey results displaying the total number of activity-days per planning unit for SCUBA diving activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions. Planning units with the highest number of activity days in these regions were around Anglin's Pier.

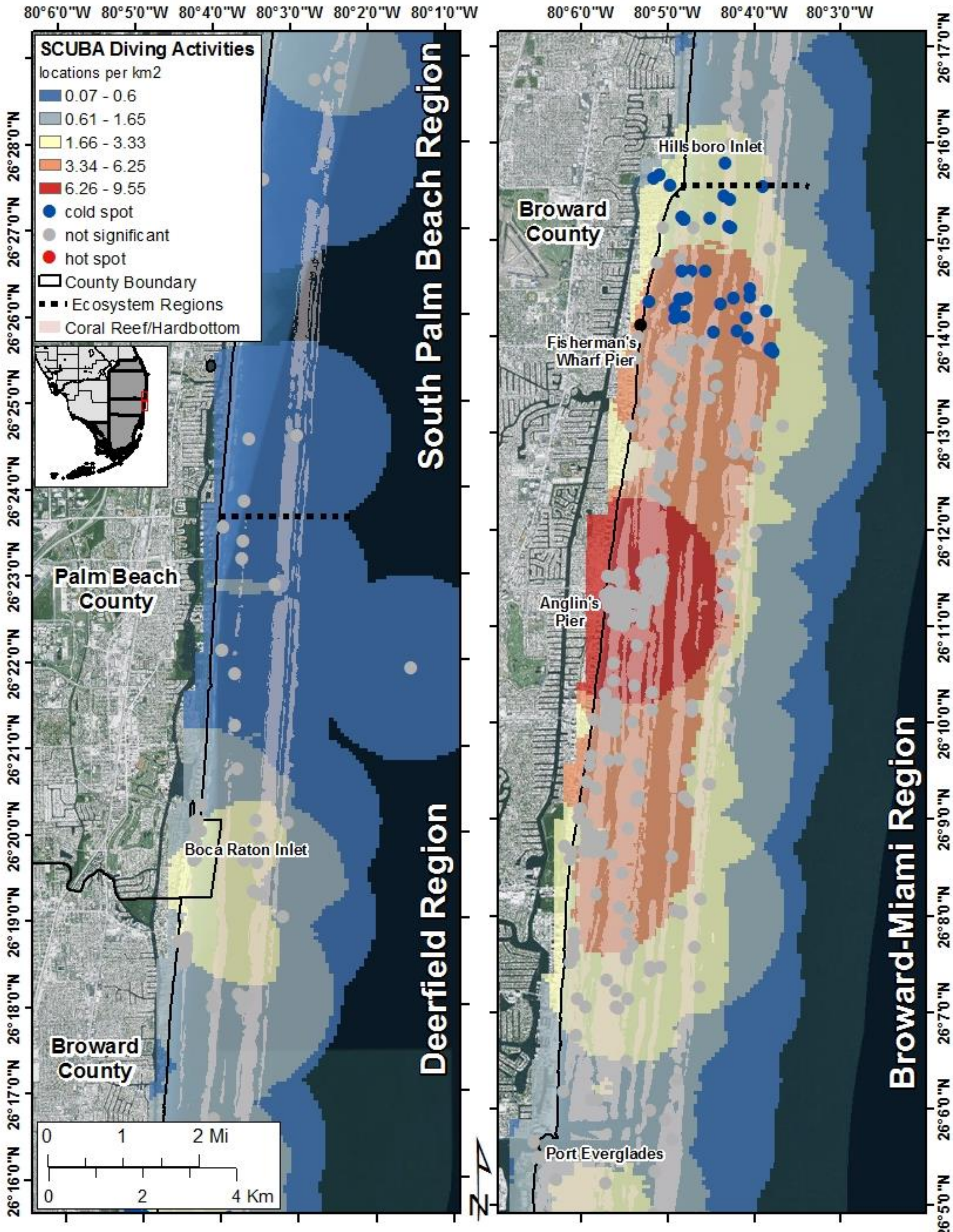

Figure 41. Map displaying results of point density analysis as well as hot spot analysis for SCUBA diving activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions. Very high density of locations was around Anglin's Pier and high density of locations was north and south of the pier. Moderate density was around Boca Raton Inlet. Cold spots were between Hillsboro Inlet and the Fisherman's Wharf Pier.

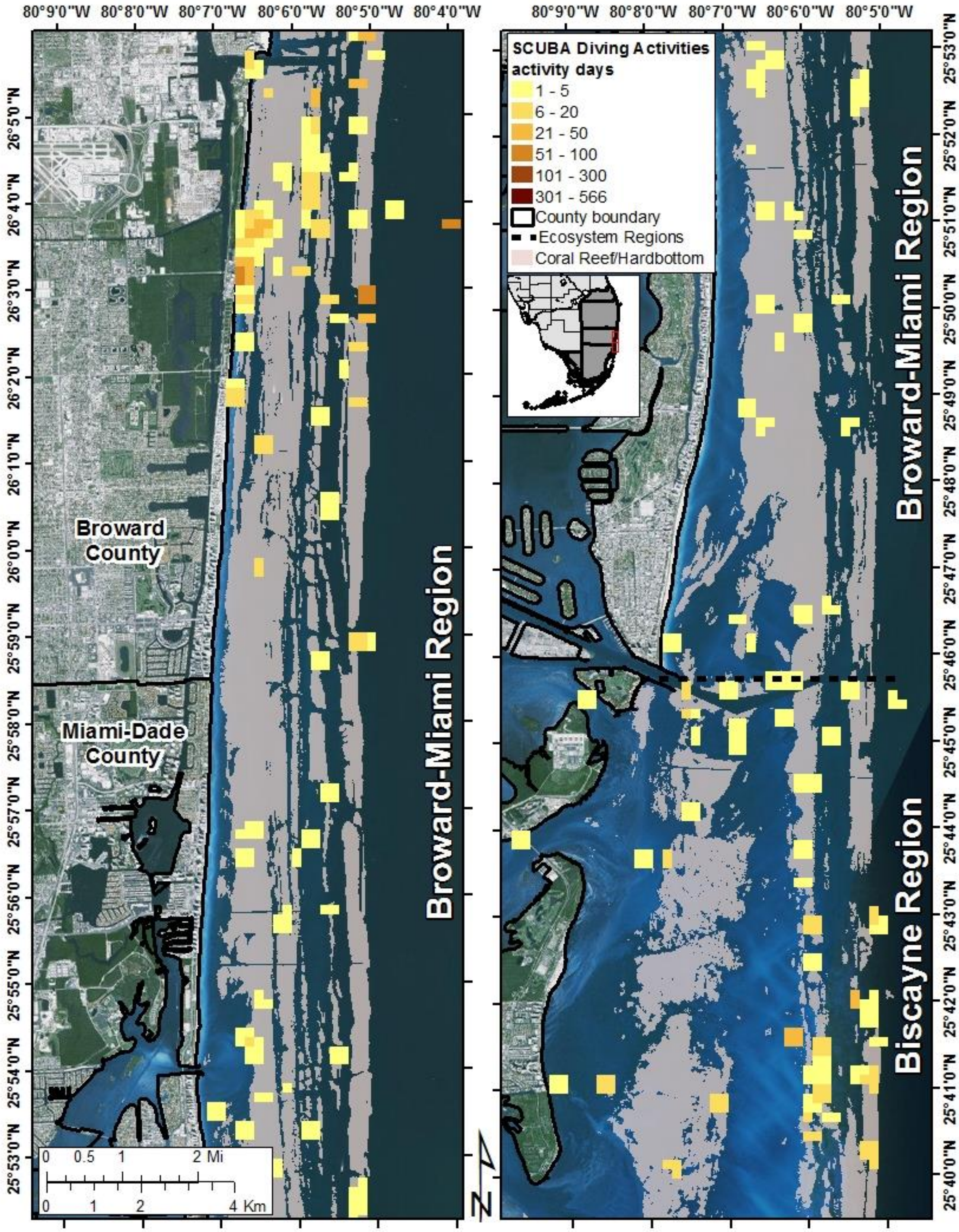

Figure 42. Map of final survey results displaying the total number of activity-days per planning unit for SCUBA diving activities within the Broward-Miami and Biscayne coral reef ecosystem regions. Planning units with the highest number of activity-days in these regions were around Dania Fishing Pier.

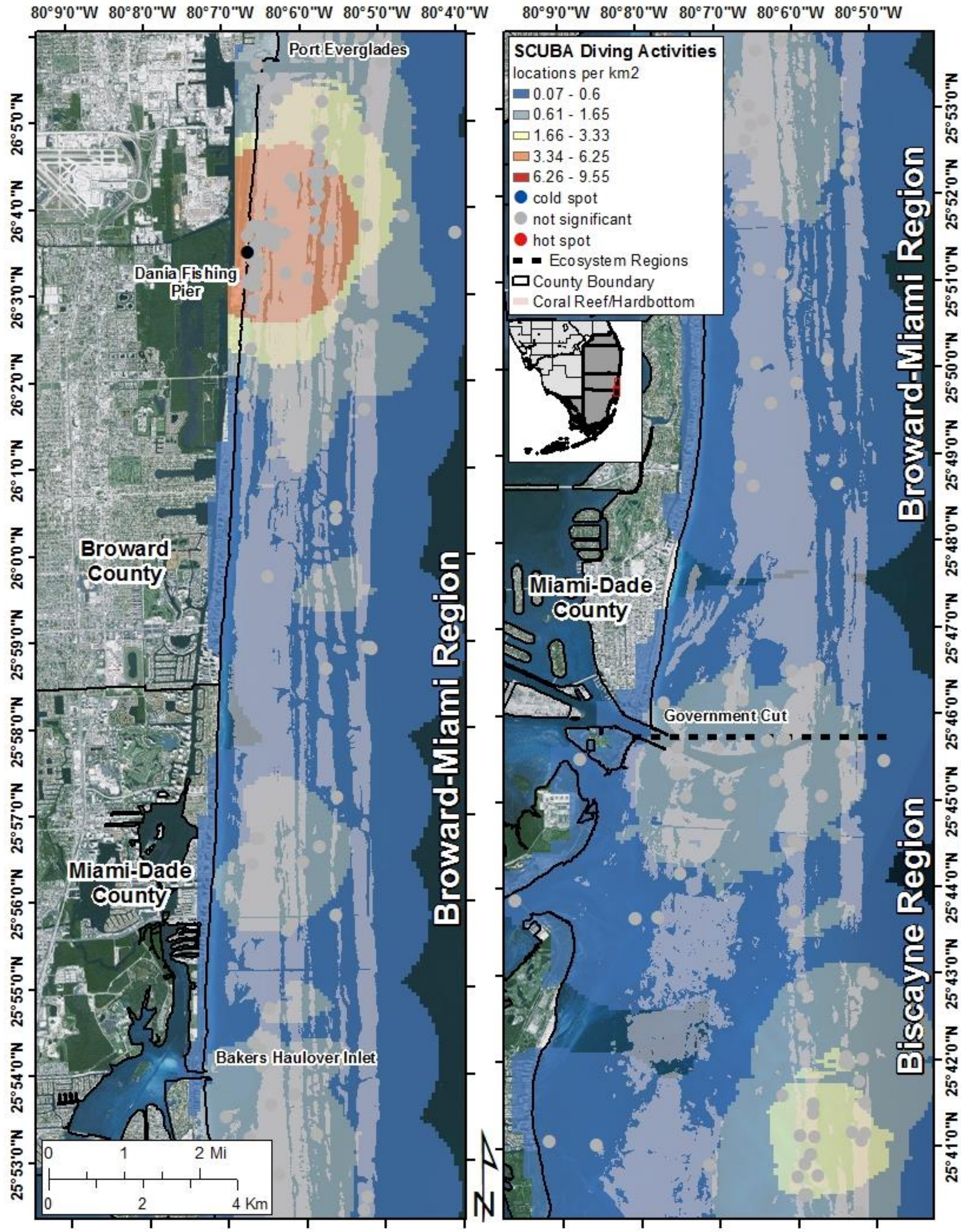

Figure 43. Map displaying results of point density analysis as well as hot spot analysis for SCUBA diving activities within the Broward-Miami and Biscayne coral reef ecosystem regions. High density of locations was around Dania Fishing Pier. No hot or cold spots were in these regions.

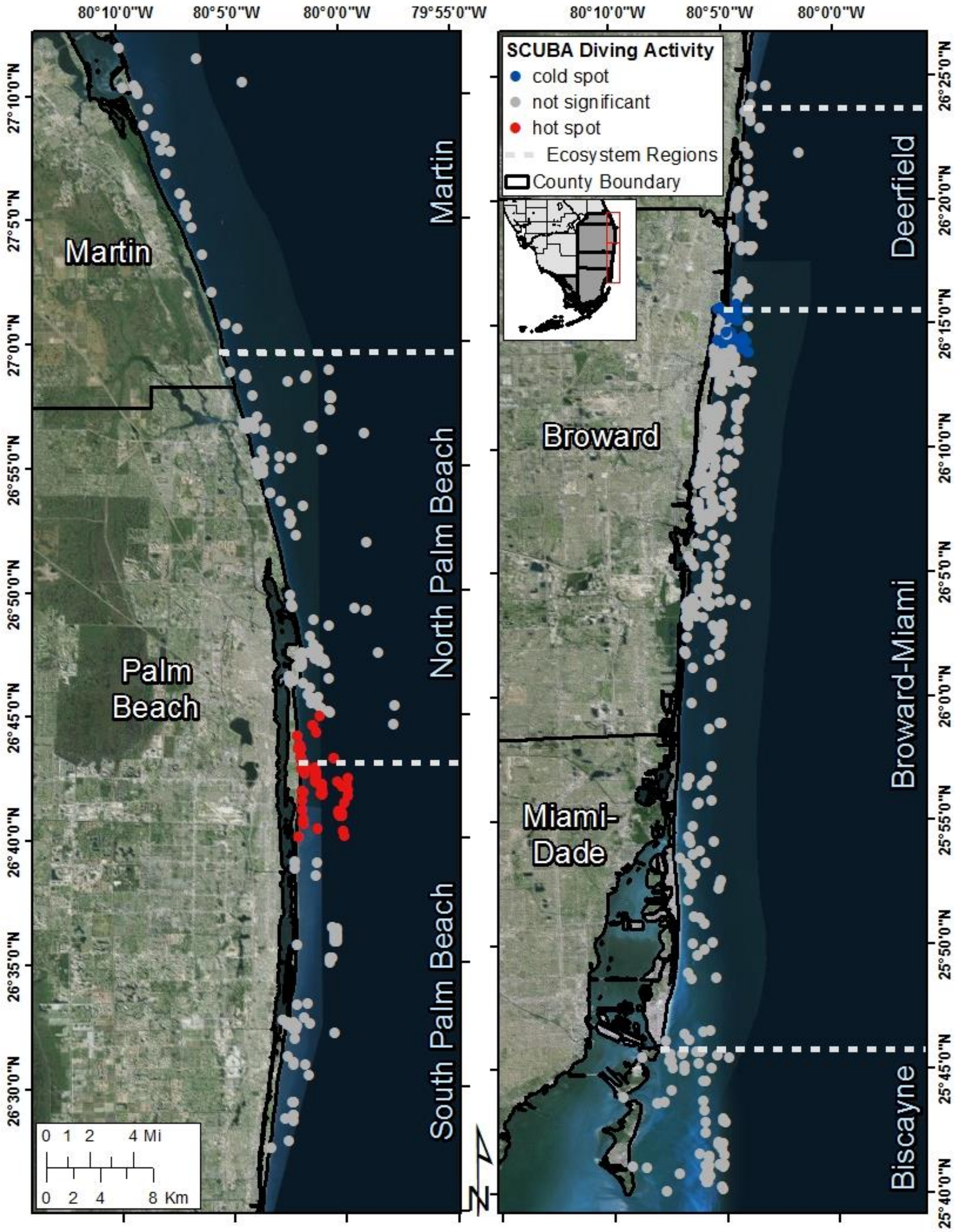

Figure 44. Hot spot analysis map of "SCUBA Diving Activities" for the southeast Florida region. Hot spots were in the North Palm Beach and South Palm Beach coral reef ecosystem transition zone. Cold spots were in the norther stretch of the Broward-Miami Coral Reef Ecosystem Region.

4.2.4. Recreational Fishing Activities

In the Martin Coral Reef Ecosystem Region, higher "Recreational Fishing Activity" occurred at the mouth of the St. Lucie Inlet and on St. Lucie Reef, with some planning units having activity-day values between 51 and 100 (Figure 45). Point density analysis showed moderate density of 0.7 to 1.43 locations per km^2 just outside of St. Lucie Inlet (Figure 46).

In the North Palm Beach Coral Reef Ecosystem Region, there were a few areas that had planning units with higher activity compared to other areas in this region. Values of 20-40 activity-days were offshore Jupiter Island. Other higher activity locations were evident in the nearshore area and Outer Reef offshore from Tequesta, just north of Jupiter Inlet (Figure 47). Higher fishing activity was indicated near the shore of Juno Beach and in the deeper area on Juno Ledge, with close to 50 activity-days. Some high fishing areas (~50 activity-days) were scattered along the southern portion of the Deep Ridge Complex near a number of popular dive locations including many artificial reefs and wrecks (Figure 49). Point density analysis showed a moderate density area (0.79-1.43 locations per km^2) around Jupiter Inlet (Figure 48) as well as just outside the Lake Worth Inlet (Figure 50).

In the South Palm Beach Coral Reef Ecosystem Region, planning units were shown in the northern and central portion of the region past the Outer Reef. These indicated activity-days between 6 and 20 days. Higher use was also located around Boynton Inlet, with planning units having 21-50 activity-days (Figure 49). A moderate density area, with values between 0.79 and 1.43 locations per km^2, was located around Boynton Inlet (Figure 50).

In the Deerfield Coral Reef Ecosystem Region, the planning unit data showed most recreational fishing activity in the northern part of the region occurring nearshore with very few areas selected on the Outer Reef and Deep Ridge Complex. These nearshore areas focused around Boca Raton Inlet, with activity-day values from 21-50 activity-days (Figure 51). Point density was moderate just outside of the Boca Raton Inlet, with values between 0.79 and 1.43 locations per km^2 (Figure 52).

In the Broward-Miami Coral Reef Ecosystem Region, many planning units offshore Fisherman's Wharf Pier were selected. Many popular dive sites and artificial reefs, as well as mooring buoys are located here. Some of these planning units indicated activity-days ranging between 21 and 50 days. “Recreational Fishing Activity” was relatively high at the areas known as Pompano Dropoff and Steve’s Ledge, showing around 20 activity-days. High recreational fishing (30 - 75 activity-days) was off Lauderdale-by-the-Sea, with many locations indicated on the coral reefs and hardbottom areas near Anglin’s Pier (Figure 53). Use was distributed amongst all reefs but focused in the shallower areas on the Nearshore Ridge Complex and Inner Reef. An area indicating between 101 and 190 activity-days was offshore Port Everglades, past the Outer Reef (Figure 51). Although this location stood out because of its high number of activity-days, recreational fishing activity was higher, in general, around Port Everglades and Dania Fishing Pier. Planning units with 21 to 50 activity-days were located offshore Hallandale Beach on the Shallow Colonized Pavement and Ridge. Planning units with higher activity-days were also selected around the Newport Fishing Pier. Participants indicated a high number of recreational fishing activity-days (80 activity-days) just outside the Outer Reef offshore Haulover Inlet as well (Figure 53). Very high point density, with values between 2.23 and 3.5 locations per km^2, extended from Hillsboro Inlet down to Anglin’s Pier. High density of locations also occurred just south of Port Everglades and around Dania Fishing Pier (Figure 52).

In the Biscayne Coral Reef Ecosystem Region, the number of selected planning units was low but focused around Government Cut. These planning units had 20 activity-days or less. Some areas with low number of activity-days (<5 days) were indicated on the Inner and Outer Reef offshore Key Biscayne as well (Figure 53). Point density analysis showed areas of moderate density (1.5-2.78 locations per km^2) around Government Cut and on the Inner Reef and Outer Reef sites offshore Key Biscayne that include many artificial reefs. One small area of moderate density from 0.79 to 1.43 locations per km^2 was located around Government Cut (Figure 54).

Locations showing clustering of high use intensity for the southeast Florida region occurred at the mouth of the St. Lucie Inlet and continued down along St. Lucie reef, on the Nearshore Ridge Complex. These results are similar to those found for boating activities. This is most likely because of the strong overlap of boating and fishing activities in this area. A great deal of the recreational fishing activity in this region occurred by boat and thus, was placed in both the “Boating Activity” feature and the “Recreational Fishing

Activity" feature. This demonstrates the importance of considering activity groupings according to the chosen objective before analysis. Locations demonstrating clustering of high use intensity were also at the southern end of the region, on the Deep Ridge Complex. Hot spot analysis also revealed one location just over four nautical miles off Martin County, on the Deep Ridge Complex. Three popular wrecks, the MG111 Barge, the Esso Bonaire III, and the Zion Train, are around this location. Locations demonstrating clustering of low use intensity were along the shore of Palm Beach (Figure 50). There were several locations showing clustering of low use intensity at the northern extent of the South Palm Beach Coral Reef Ecosystem Region, from Hillsboro Inlet to Anglin's Pier. These spots fell around many popular wrecks such as the Captain Dan Wreck and the Copenhagen Preserve (Figure 52).

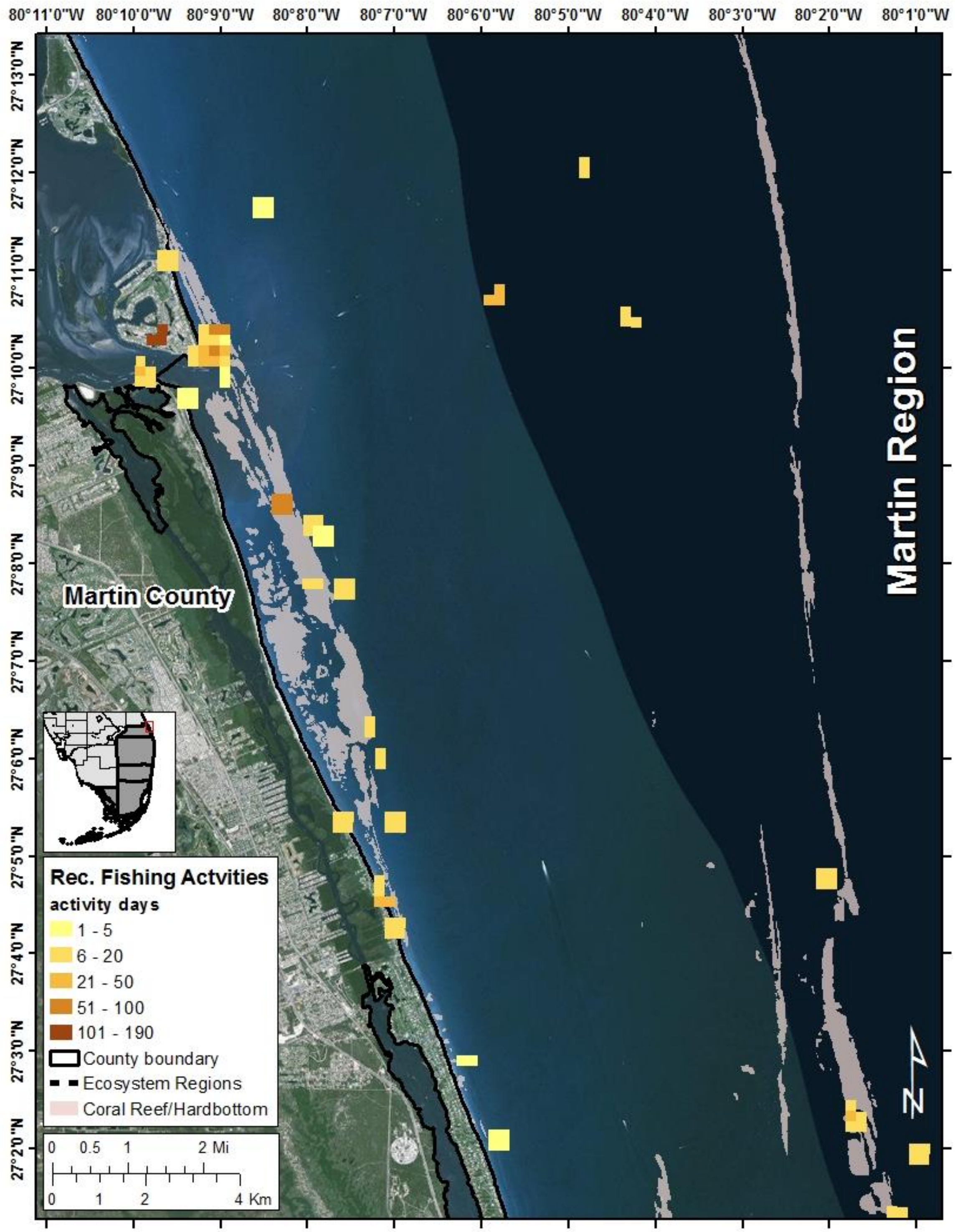

Figure 45. Map of final survey results displaying the total number of activity-days per planning unit for recreational fishing activities within the Martin Coral Reef Ecosystem Region. Planning units with the highest number of activity-days were around St. Lucie Inlet.

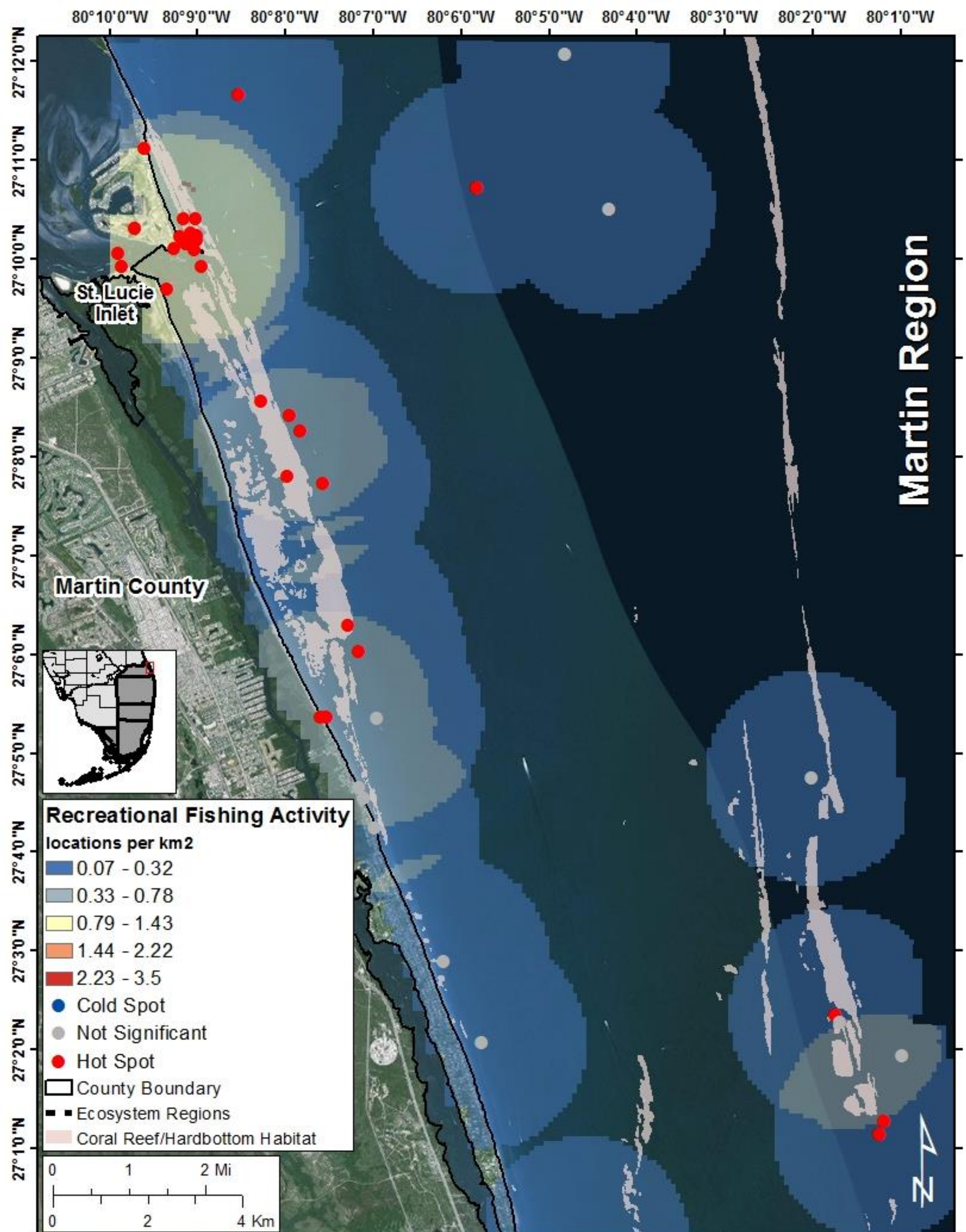

Figure 46. Map displaying results of point density analysis as well as hot spot analysis for recreational fishing activities within the Martin coral reef ecosystem region. Moderate density of locations was around St. Lucie Inlet. Hot spots were also around St. Lucie inlet and along the St. Lucie Reef.

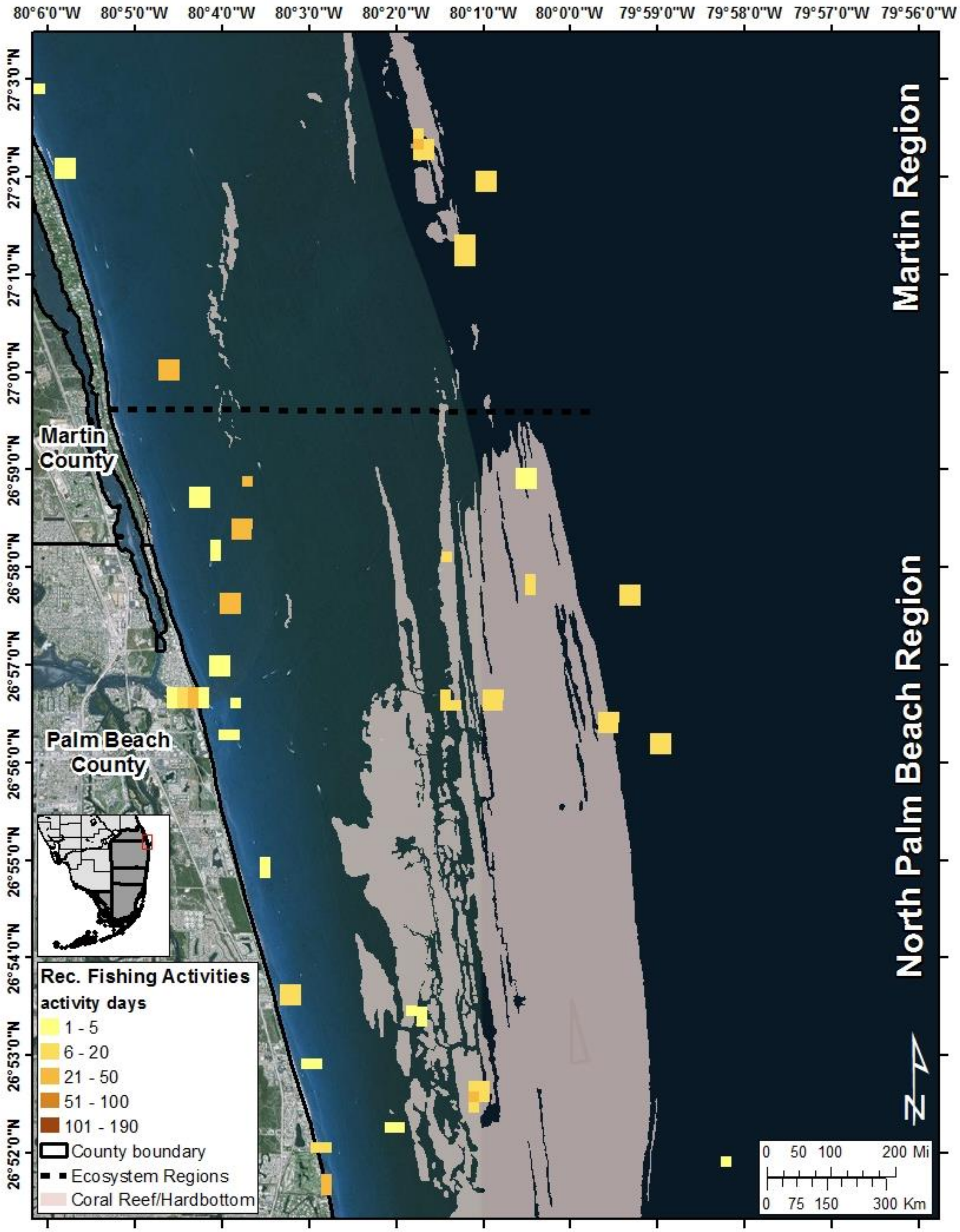

Figure 47. Map of final survey results displaying the total number of activity-days per planning unit for recreational fishing activities within the Martin and North Palm Beach coral reef ecosystem regions. Planning units showed the highest number of activity-days in this region were around Jupiter Inlet.

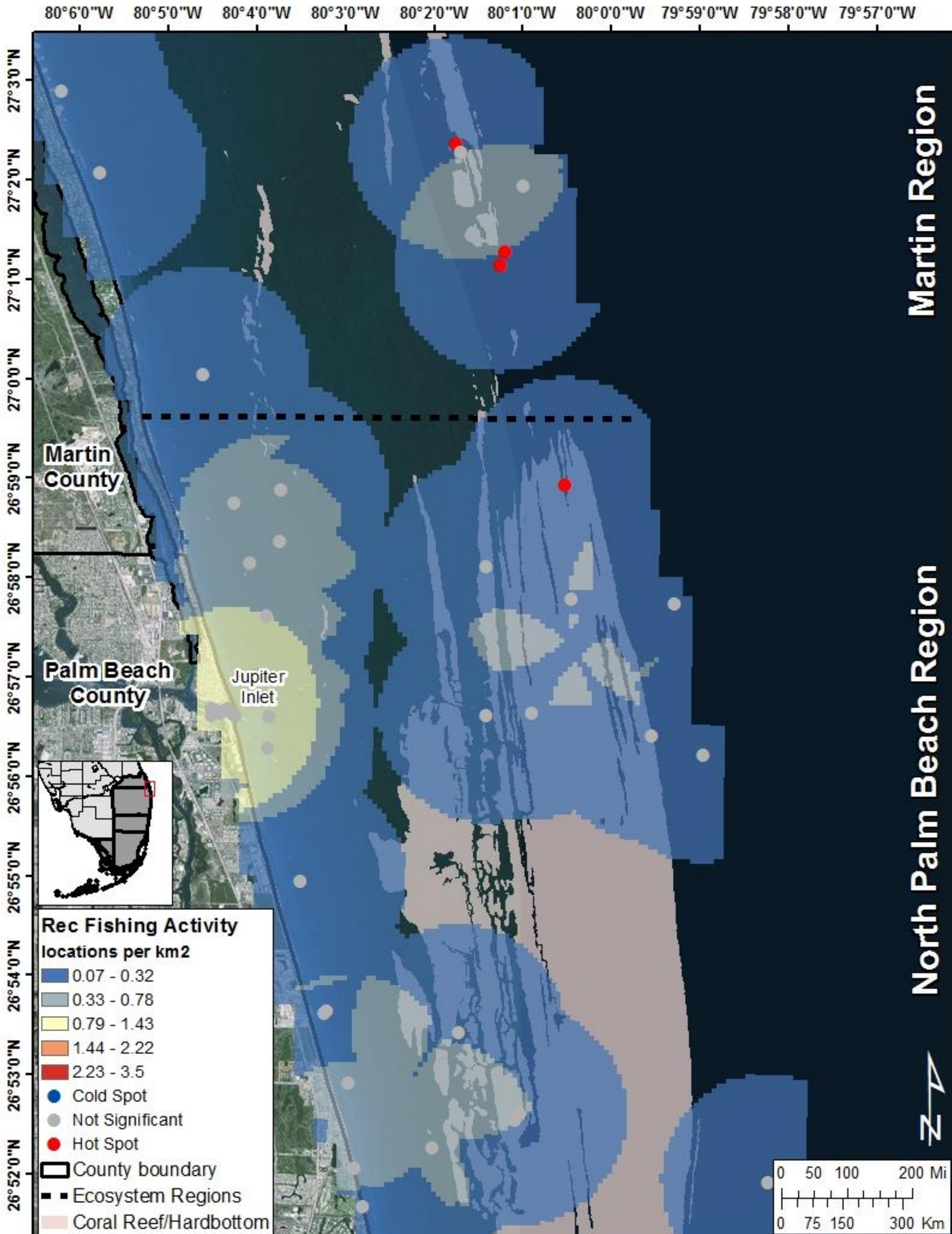

Figure 48. Map displaying results of point density analysis as well as hot spot analysis for recreational fishing activities within the Martin and North Palm Beach coral reef ecosystem regions. Location density was moderate around Jupiter Inlet. Three hot spots were located on the Deep Ridge Complex in the Martin Region and one was on the Deep Ridge Complex in the North Palm Beach Region.

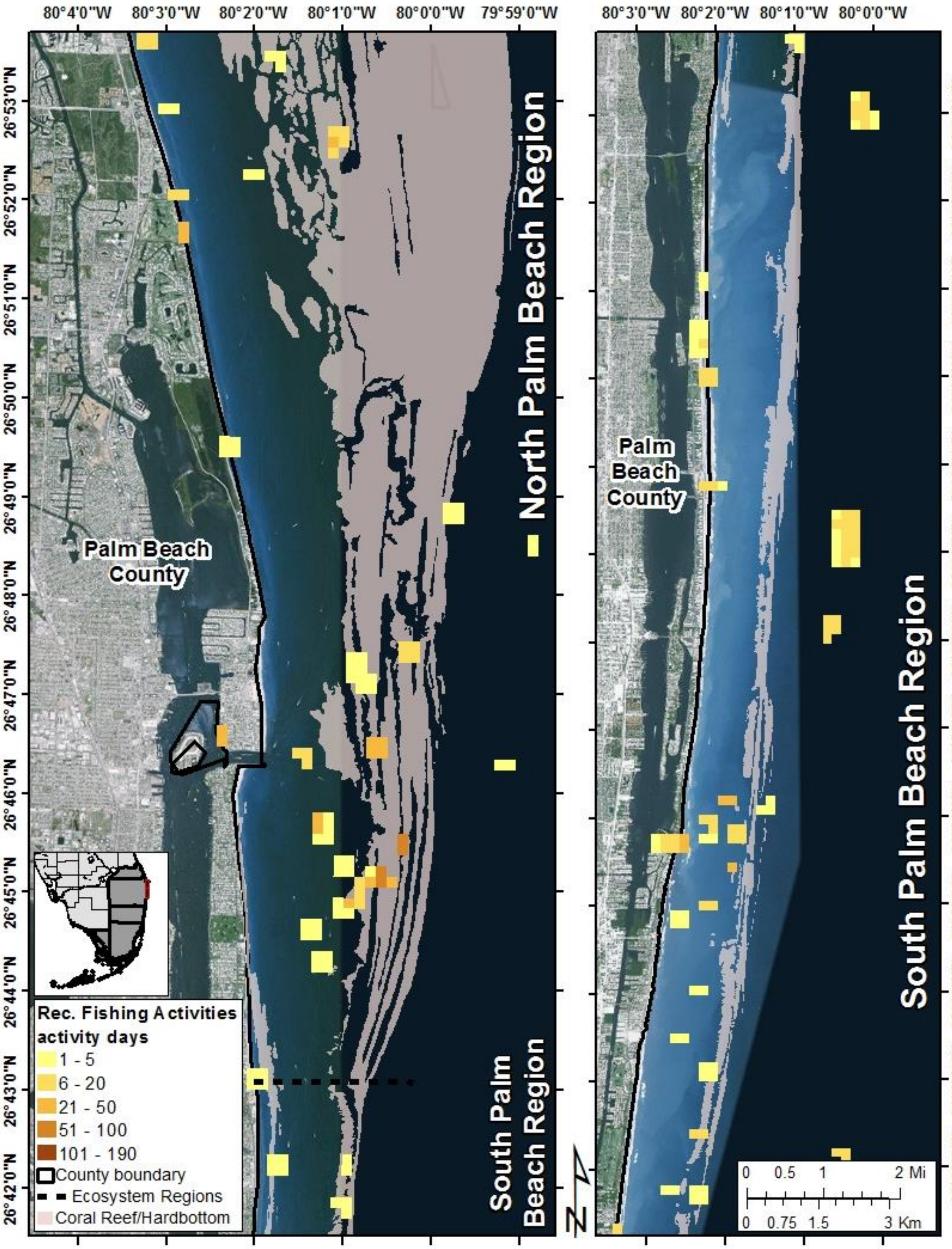

Figure 49. Map of final survey results displaying the total number of activity-days per planning unit for recreational fishing activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions. Planning units with higher activity-days were scattered along the southern portion of the Deep Ridge Complex and around Boynton Inlet. There were also some planning units past the Outer Reef.

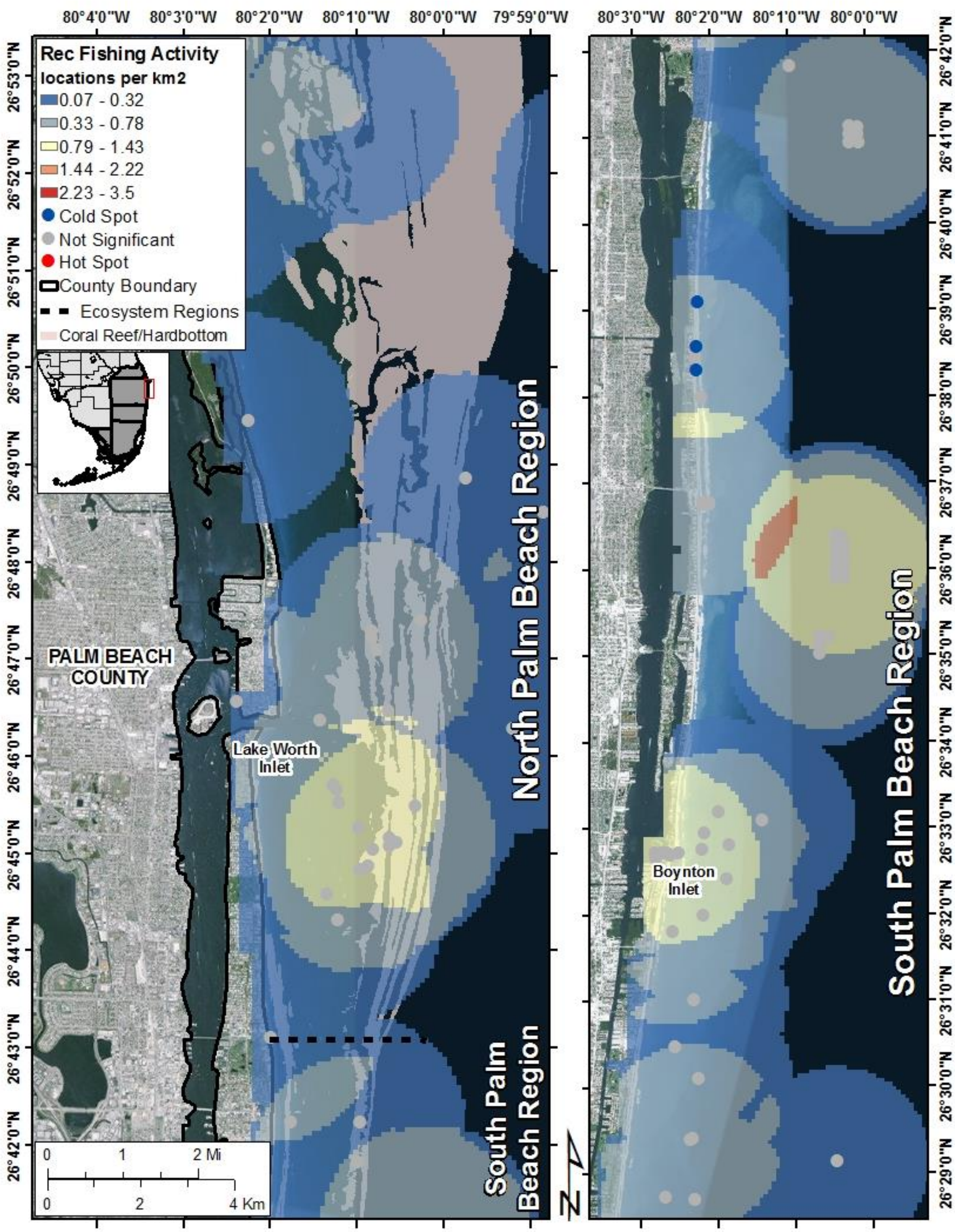

Figure 50. Map displaying results of point density analysis as well as hot spot analysis for recreational fishing activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions. Moderate location density was outside Lake Worth Inlet, around Boynton Inlet, and on the northern and central portion of the South Palm Beach region past the Outer Reef. Cold spots were along the shoreline in the northern portion of the South Palm Beach Region.

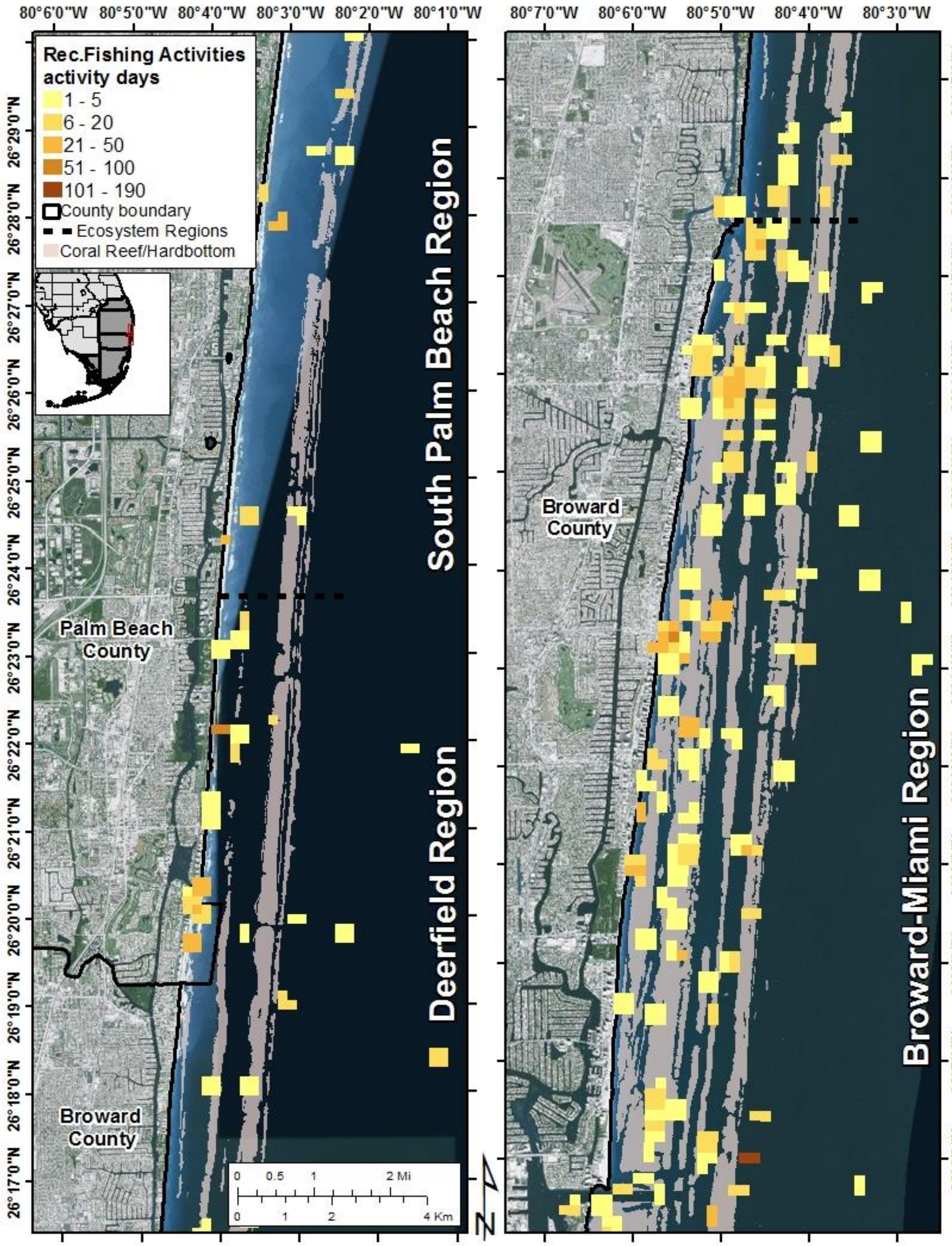

Figure 51. Map of final survey results displaying the total number of activity-days per planning unit for recreational fishing activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions. Planning units with high activity-days were around Fishermen's Wharf Pier and offshore of Lauderdale-by-the-Sea, near Anglin's Pier.

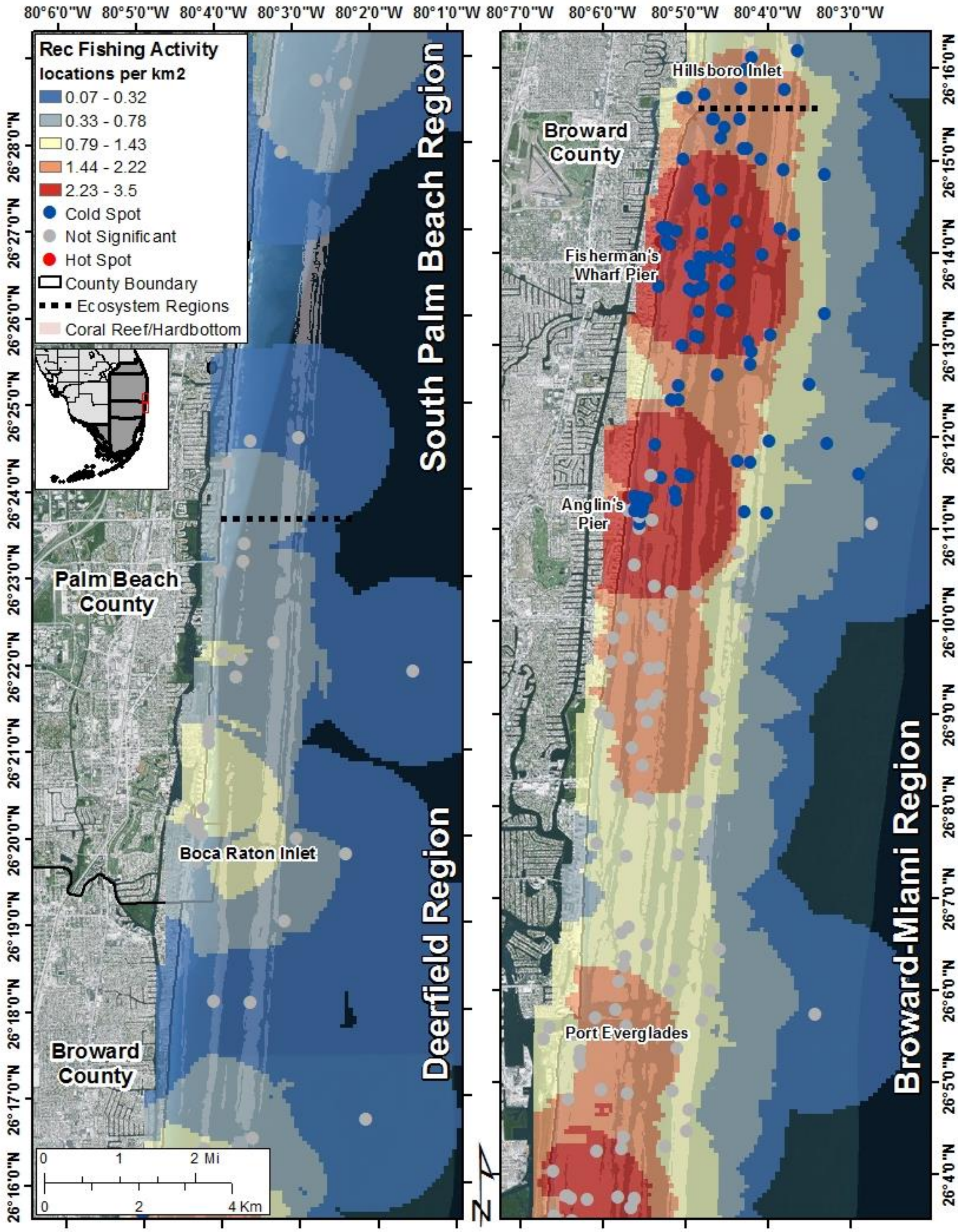

Figure 52. Map displaying results of point density analysis as well as hot spot analysis for recreational fishing activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions. Very high density of locations were around Fishermen's Wharf Pier and Anglin's Pier. High density of locations spanned from Hillsboro Inlet to south of Anglin's Pier. Cold spots were scattered from Hillsboro Inlet to Anglin's Pier.

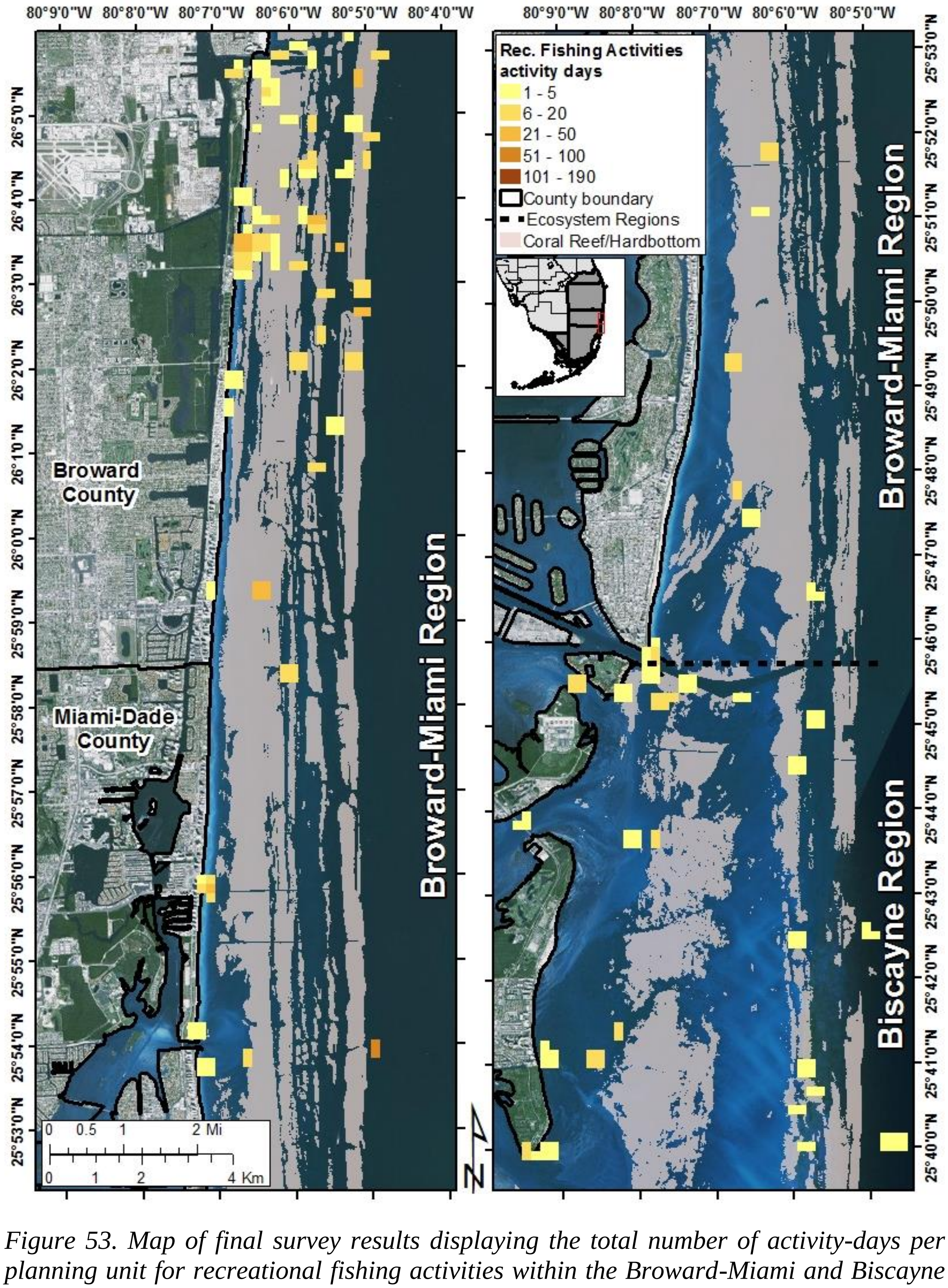

Figure 53. Map of final survey results displaying the total number of activity-days per planning unit for recreational fishing activities within the Broward-Miami and Biscayne coral reef ecosystem regions. Planning units with high activity-days were found from Port Everglades to Dania Fishing Pier and around Government Cut.

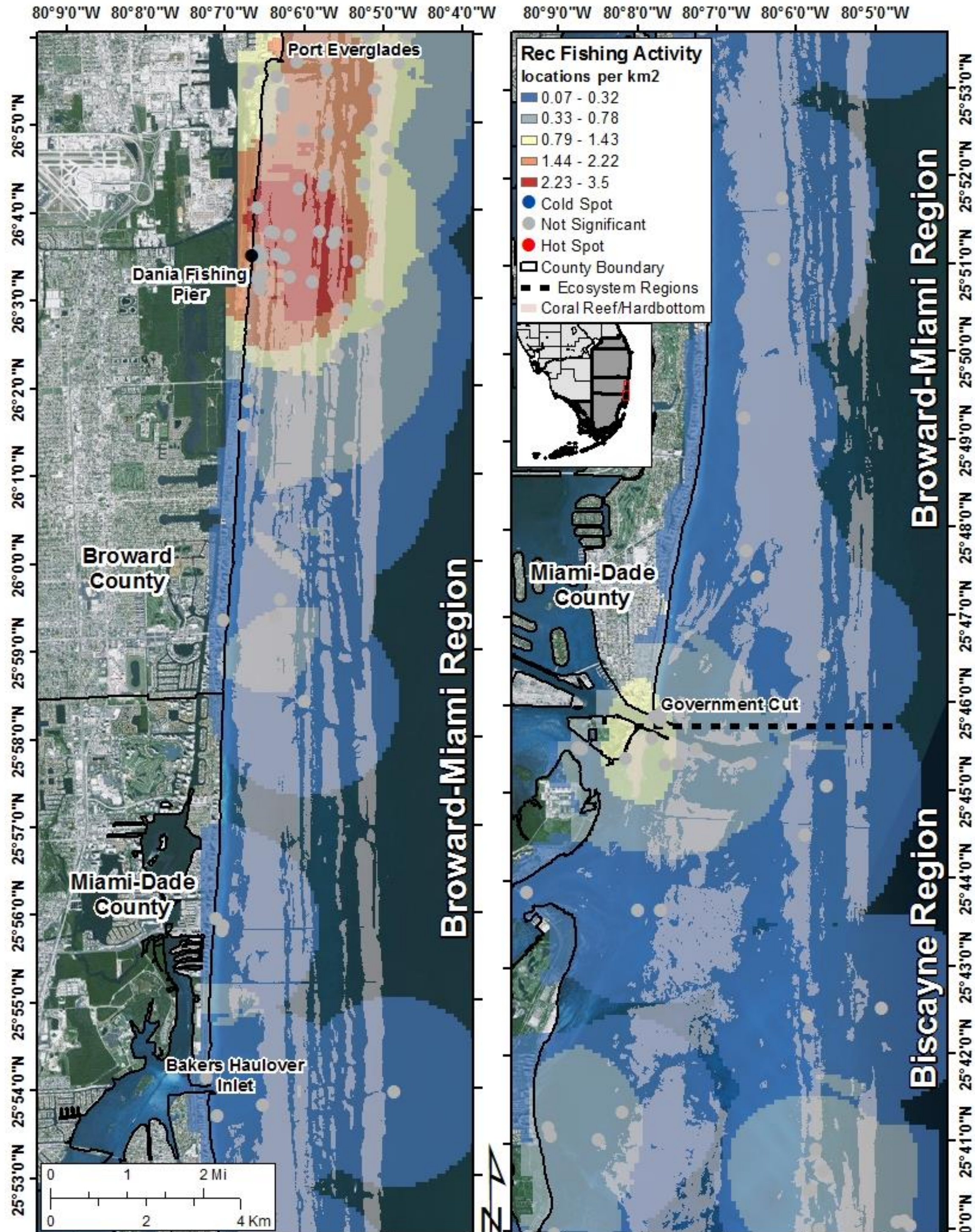

Figure 54. Map displaying results of point density analysis as well as hot spot analysis for recreational fishing activities within the Broward-Miami and Biscayne coral reef ecosystem regions. Very high density of locations was around Dania Fishing Pier, high density of locations was around Port Everglades, and moderate density of locations was around Government Cut. No hot spots or cold spots were found in these regions.

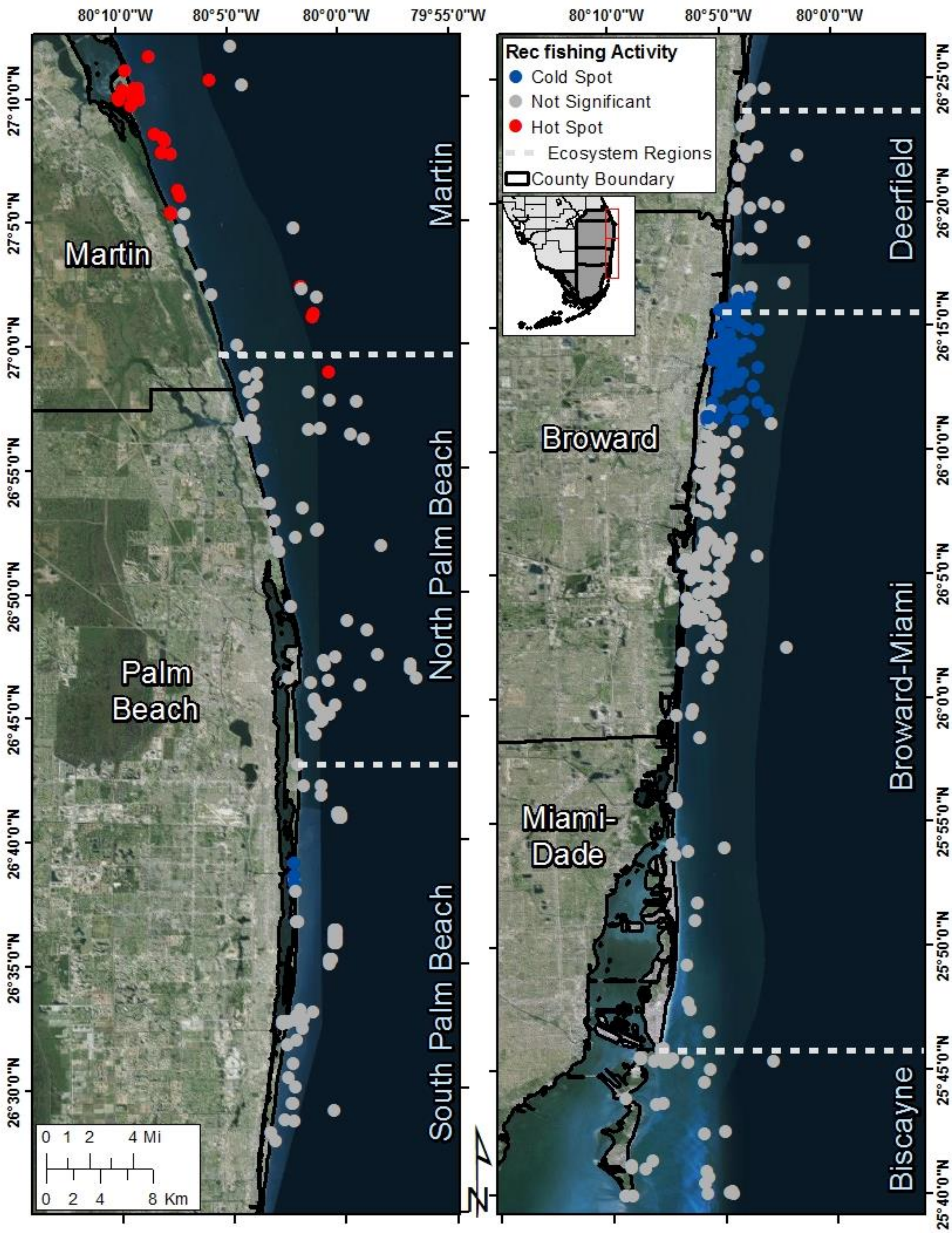

Figure 55. Hot spot analysis map of "Recreational Fishing Activities" for the southeast Florida region. Hot spots were found around the St. Lucie Inlet and along the St. Lucie Reef, as well as on the Deep Ridge Complex in the southern portion of the Martin Region and the Northern portion of the North Palm Beach Region. Cold spots were along the shore in the northern portion of the South Palm Beach Region and in the northern portion of the Broward-Miami Region.

4.2.5. Angling and Diving Activity Overlap

There were several areas in the southeast Florida region that showed overlap between recreational fishing and diving activity (Figure 56 and Figure 60). The results showed that most angling and diving overlap occurred near inlets, with the largest number of occurrences in Broward County.

In the Martin Coral Reef Ecosystem Region, angling and diving overlap occurred at the mouth of the St. Lucie Inlet. Areas here show high overlap. Most of these areas were dominated by angling, with some planning units having up to 75 more angling activity-days than diving activity-days. Other planning units showed slightly higher diving activity-days, with values of 42 more diving activity-days than angling activity-days (Figure 56). These may be areas of potential recreational activity conflict.

In the North Palm Beach Coral Reef Ecosystem Region, overlap of activity was located at the mouth of Jupiter Inlet where diving activity was moderately dominant over angling activity, having about 40 more activity-days in some areas. It is important to note that angling activity-days were less than 10 in these locations (Figure 57). Areas just north and south of Lake Worth inlet showed overlap. The majority of these locations had either equal angling and diving activity or slightly higher diving activity. Some areas here showed high activity-days for both diving and angling at between 20 and 25 days, while others showed low activity-day numbers of less than 5 days (Figure 58). At the Cross Current Barge artificial reef, just south of Lake Worth Inlet, equal activity overlap occurred with a higher number of activity-days indicated for both diving and angling. Here, diving activity-days were 25 and angling activity-days were 22. Overlap was moderate on the Deep Ridge Complex at a congregation of wrecks including St. Jacques, Shasha Boekanier, and Governor's River Walk. The survey data indicate that angling was more dominant west of the wrecks, with 20 activity-days, while diving only showed 1 activity day. Diving was more dominant to the east, with 51 activity-days, while angling showed 20 activity-days. Because these numbers are both high, this appears to be an area of potential conflict between anglers and divers (Figure 58).

In the South Palm Beach Coral Reef Ecosystem Region, overlap was indicated at Boynton Inlet and east near the Outer Reef. Anlging activity dominated diving activity, however, most planning units had a lower number of activity-days in general with values of 10 days or less. One planning unit did indicate that diving activity showed 17 days, while angling activity showed 47 days (Figure 58). Overlap occurred on the Outer Reef, where the dive sites Budweiser Bar, M/V Caster, and Genesis Reef are located. This overlap, although equal, was low with only two activity-days for both angling and diving shown (Figure 59).

In the Deerfield Coral Reef Ecosystem Region, overlap observed at the mouth of Boca Raton inlet was moderately dominated by diving activity. Relatively low activity-days were indicated here for both diving and angling, with values of 26 days and 7 days respectively. Outside of Hillsboro inlet, many areas of overlap were observed. This overlap was equal in both angling and diving activity and both activities showed a low number of days at these locations in general (Figure 59).

In the Broward-Miami Coral Reef Ecosystem Region, fairly equal angling and diving overlap was observed along the beach and out to the eastern edge of the Inner Reef off Pompano Beach. In areas that one activity did dominate over the other, it was only moderate and dominated by diving. There was diving-dominated overlap on the south side of Anglin's Pier in Lauderdale-by-the-Sea, with diving activity-days being over 598 and angling activity-days being 52. The high number of activity-days indicated for both activities shows that this is an area of concern for conflict. Overlap was observed in Fort Lauderdale on all three reefs, with diving dominating the Inner Reef and parts of the Middle Reef, and angling activity dominating the area of overlap on parts of the Outer Reef. The overlap was moderate with most locations showing between 5 and 50 activity-days for both recreational fishing and diving (Figure 59). Locations south of Port Everglades showed mostly equal angling and diving overlap but the activity-days for both were low in general. One location, just over one mile east from Port Everglades, had 50 diving activity-days and 24 fishing activity-days. Some locations around Barracuda Reef showed higher diving activity, but it is important to note that the activity-days indicated were low in general at eleven days or less. Overlap was also observed off Dania Beach Pier, with angling activity dominating diving activity by up to 22 days (Figure 60).

In the Biscayne Coral Reef Ecosystem Region, equal diving and angling overlap occurred at the mouth of Government Cut. Overlap was also in an area called Half Moon Preserve offshore the northern tip of Key Biscayne. The overlap was moderate and diving was the slightly more dominant activity, with eight diving activity-days and two angling activity-days. At the southern tip of Key Biscayne, near the Cape Florida Channel, there was moderate to equal overlap, diving being the slightly more dominant activity, with 40 activity-days and angling being low, with 12 activity-days (Figure 60).

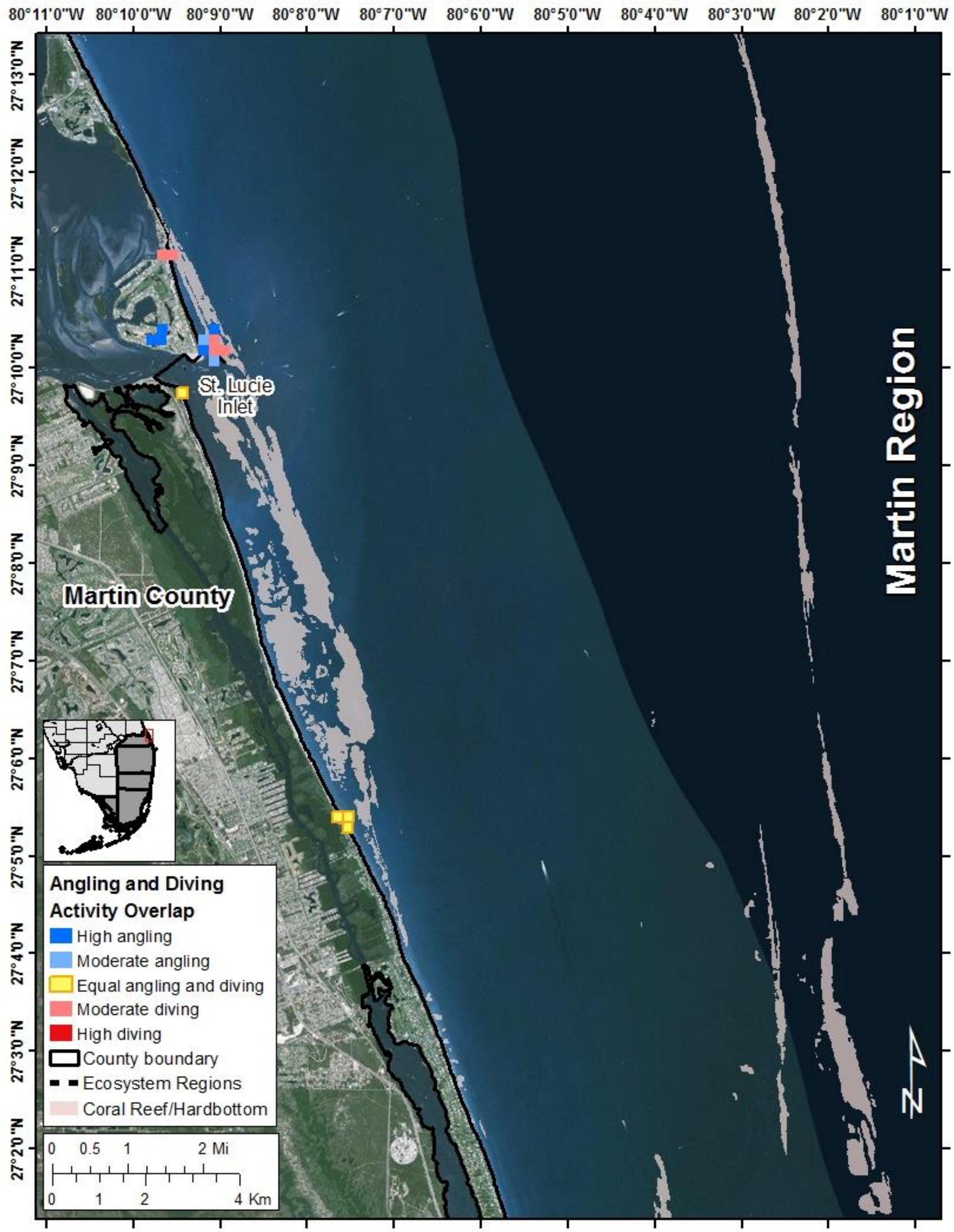

Figure 56. Survey results of angling and diving activity overlap in the Martin Coral Reef Ecosystem Region. Overlap occurred at the mouth of the St. Lucie Inlet. Most of these areas were dominated by angling however some planning units showed slightly higher diving activity-days.

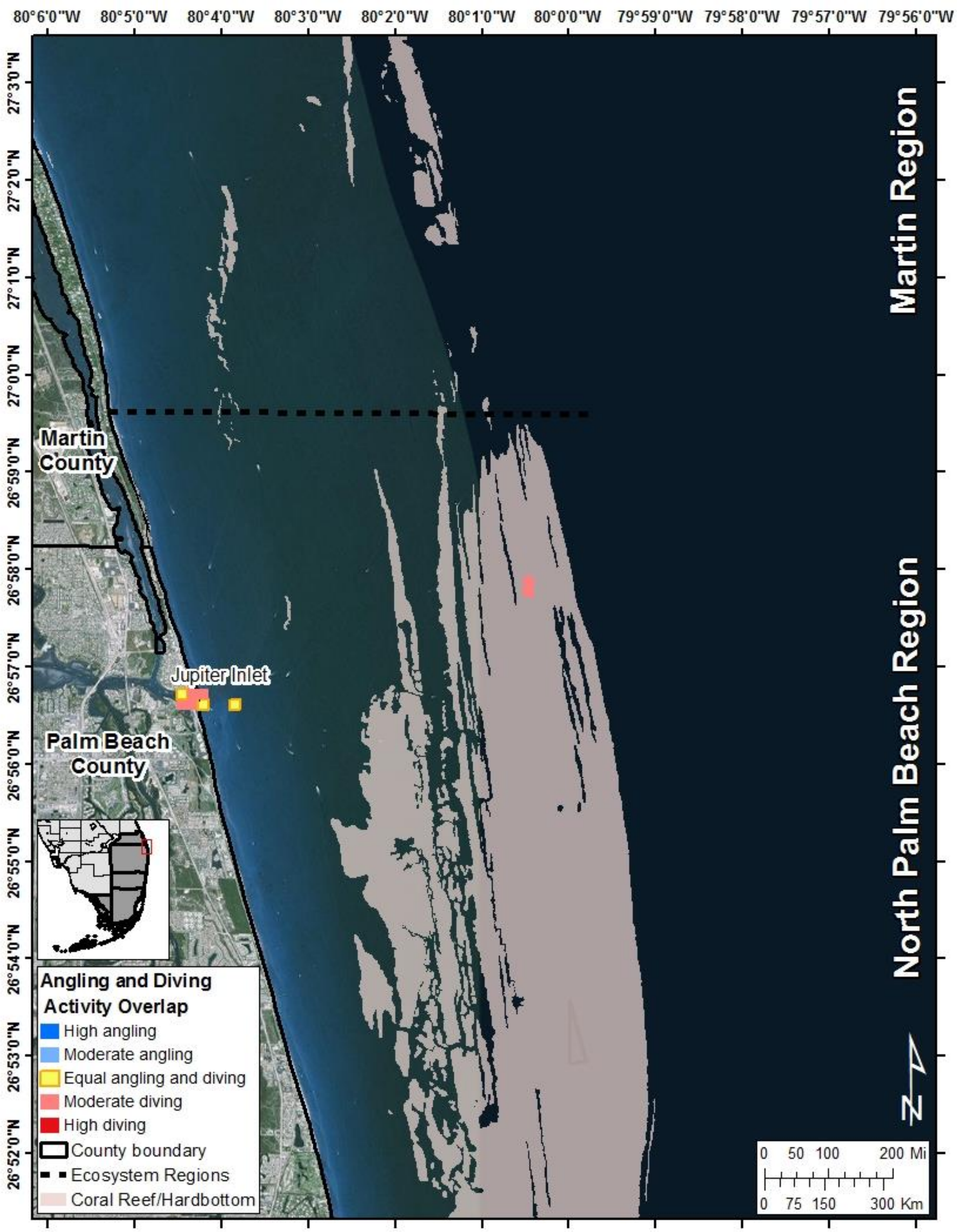

Figure 57. Survey results of angling and diving activity overlap in the Martin and North Palm Beach coral reef ecosystem regions. Overlap occurred at Jupiter Inlet and on the Deep Ridge Complex off the inlet, with diving activity moderately dominating angling activity in most cases.

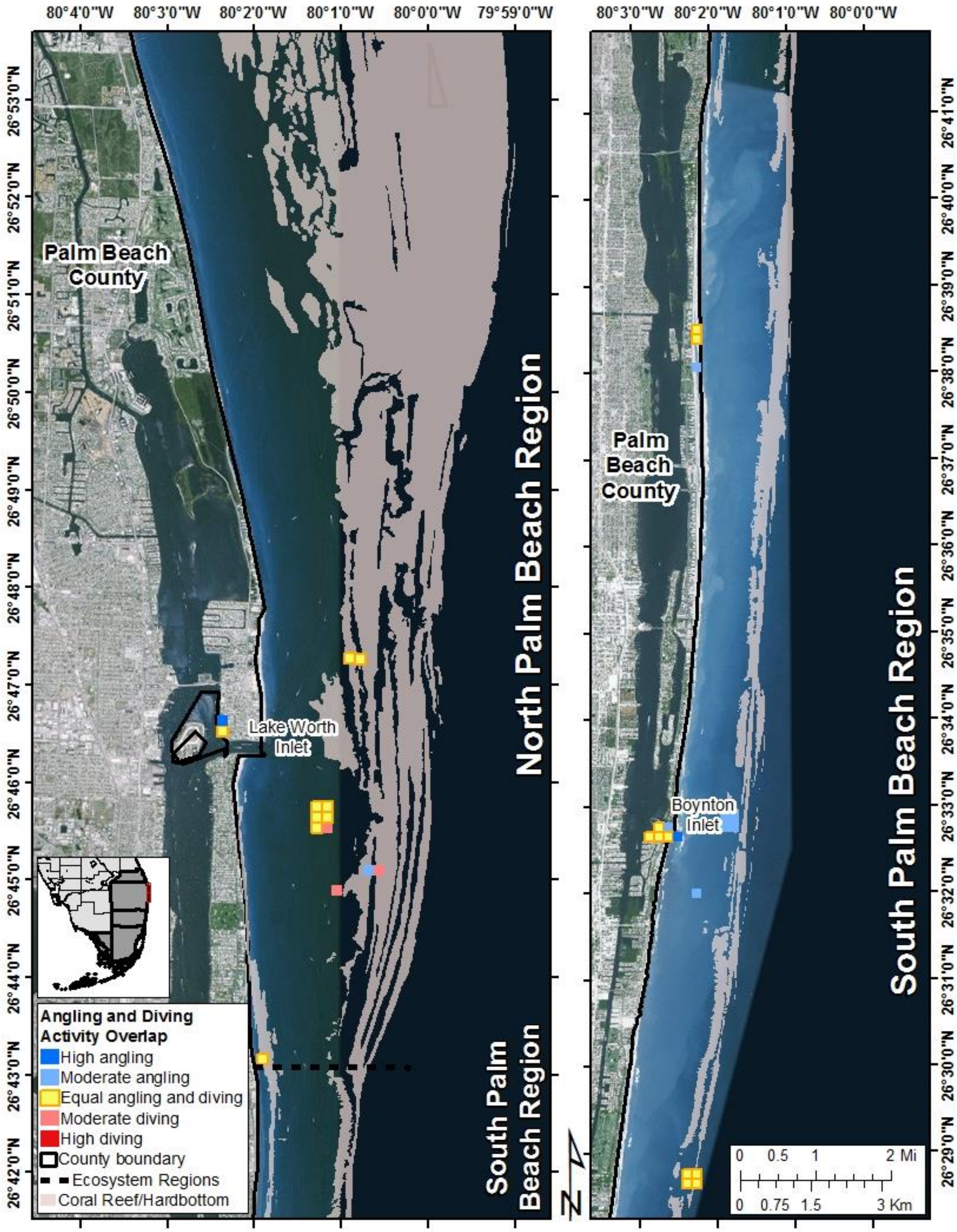

Figure 58. Survey results of angling and diving activity overlap in the North Palm Beach and South Palm Beach coral reef ecosystem regions. Areas north and south of Lake Worth inlet showed overlap as well as at the artificial reef, just south of Lake Worth Inlet. Overlap also occurred on the Deep Ridge Complex, at a congregation of wrecks and at Boynton Inlet and east of the inlet, near the Outer Reef.

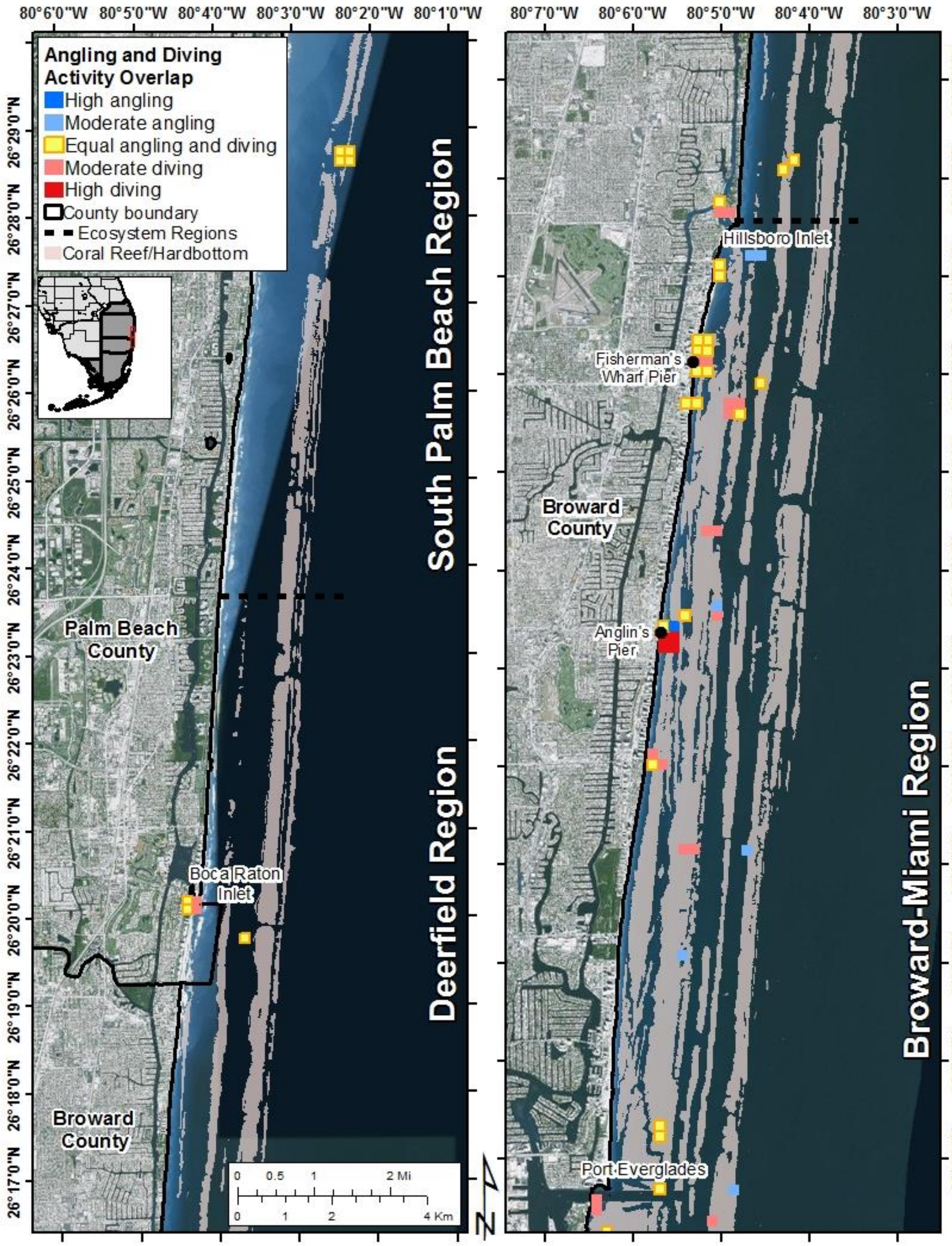

Figure 59. Survey results of angling and diving activity overlap in the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions. Overlap occurred on the Outer Reef, where the dive sites Budweiser Bar, M/V Caster, and Genesis Reef are located. It also occurred at Boca Raton Inlet, Hillsboro Inlet, and along the beach and out to the eastern edge of the Inner Reef off Pompano Beach. Diving-dominated overlap occurred at Anglin's Pier.

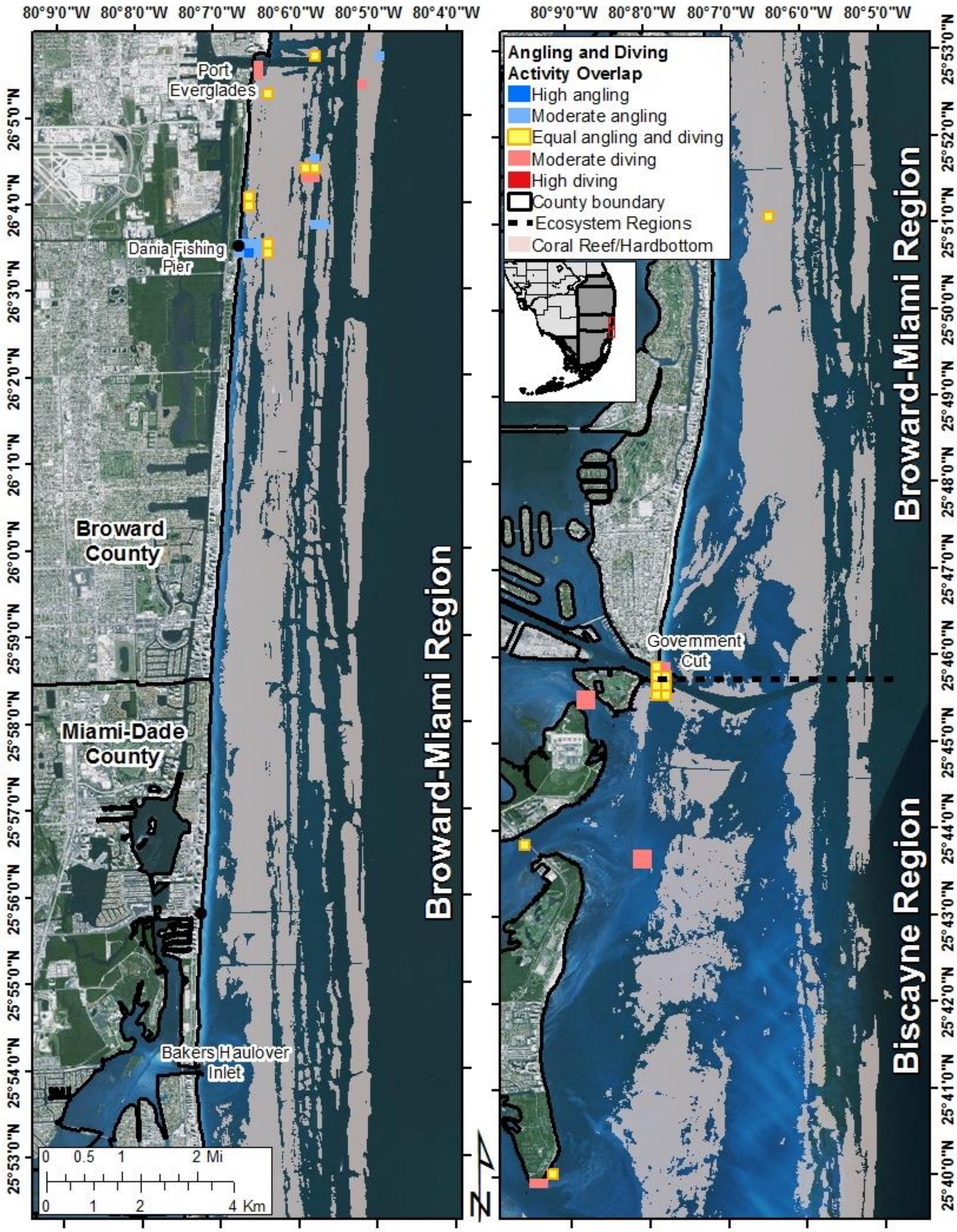

Figure 60. Survey results of angling and diving activity overlap in the Broward-Miami and Biscayne coral reef ecosystem regions. Overlap occurred from Port Everglades to Dania Fishing Pier. It also occurred around Government Cut and at the tip of Key Biscayne.

4.2.6. Favorite Location

A total of 336 respondents entered favorite locations, which corresponded to 810 planning units. Although 86.7% of the favorite locations (702/810) were associated with one planning unit, 108 locations had at least some partial overlap with another. Two favorite location planning units were overlapped by ten different respondents. The number of occurrences of favorite location overlap can be viewed in (Table 20) below. In the Martin Coral Reef Ecosystem Region almost all favorite locations were associated with St. Lucie reef (Figure 61). About one mile north of Jupiter Inlet, four participants chose overlapping planning units directly off the beach (Figure 62). Most of these respondents indicated that snorkeling/freediving from shore for pleasure was their primary activity here. Jupiter Ledge was chosen by five survey respondents who indicated that diving by boat was their favorite activity here (Figure 62). Of those, four dove there for pleasure and one dove to collect lobster. The area along John D. McArthur Beach State Park was six respondents' favorite for snorkeling/freediving from shore (Figure 63). Shallow Breaker's Reef was chosen by five respondents (Figure 63) for diving from a boat (3), snorkeling/freediving from shore (1) and boating (1). An area just south of Flower Gardens on the Outer Reef and Ridge was chosen by five respondents (Figure 63) for diving by boat for pleasure (3), for photography (1), and for catching lobster (1). Ten respondents' favorite location was the waters off Anglin's Pier (Figure 64). Diving from shore for pleasure (3), diving from shore for photography (1), pleasure snorkeling/freediving from shore (2), diving for research (3), and surfing (1) were the activities indicated. In Miami-Dade County, four respondents indicated the southern tip of Key Biscayne as their favorite and five respondents indicated Emerald Reef (Figure 65). On Emerald Reef diving by boat for research (1), snorkel/freediving by boat for pleasure (1), diving by boat for pleasure (1) and boating (1) were the primary activities.

In the North and South Palm Beach coral reef ecosystem regions, the favorite locations appear to be denser in the areas offshore Jupiter Inlet, North Palm Beach, Riviera Beach and Palm Beach (Figure 62Figure 63). In the Broward-Miami Coral Reef Ecosystem Region, apparent groups were offshore Pompano Beach, Lauderdale-by-the-Sea, and North Fort Lauderdale (Figure 64). In the Biscayne Coral Reef Ecosystem Region, favorite location data were denser offshore the southern tip of Key Biscayne. No grouping was apparent in the Martin region (Figure 65).

Table 20. Number of occurrences of favorite location overlap by the amount of favorite location overlap. A total of 810 planning units were chosen by respondents, of these 108 locations overlapped with at least one other.

Amount of Favorite Location Overlap	**Number of Occurrences**
1	702
2	71
3	21
4	6
5	5
6	2
7	1
8	0
9	0
10	2

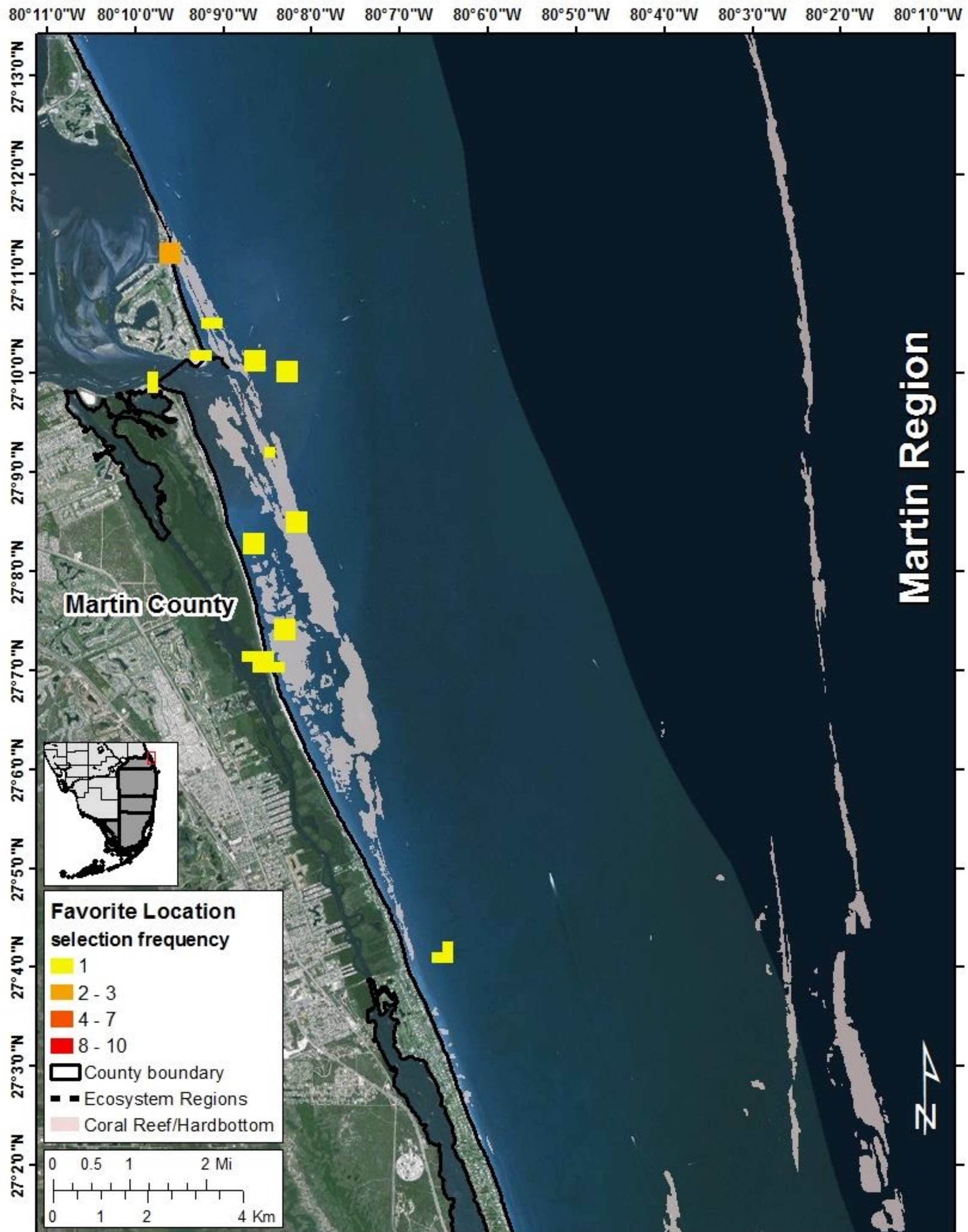

Figure 61. Map displaying the number of survey respondents who selected planning units in the Martin biogeographic region as their favorite or most valued location. Most favorite locations in this region were associated with St. Lucie Inlet and St. Lucie Reef.

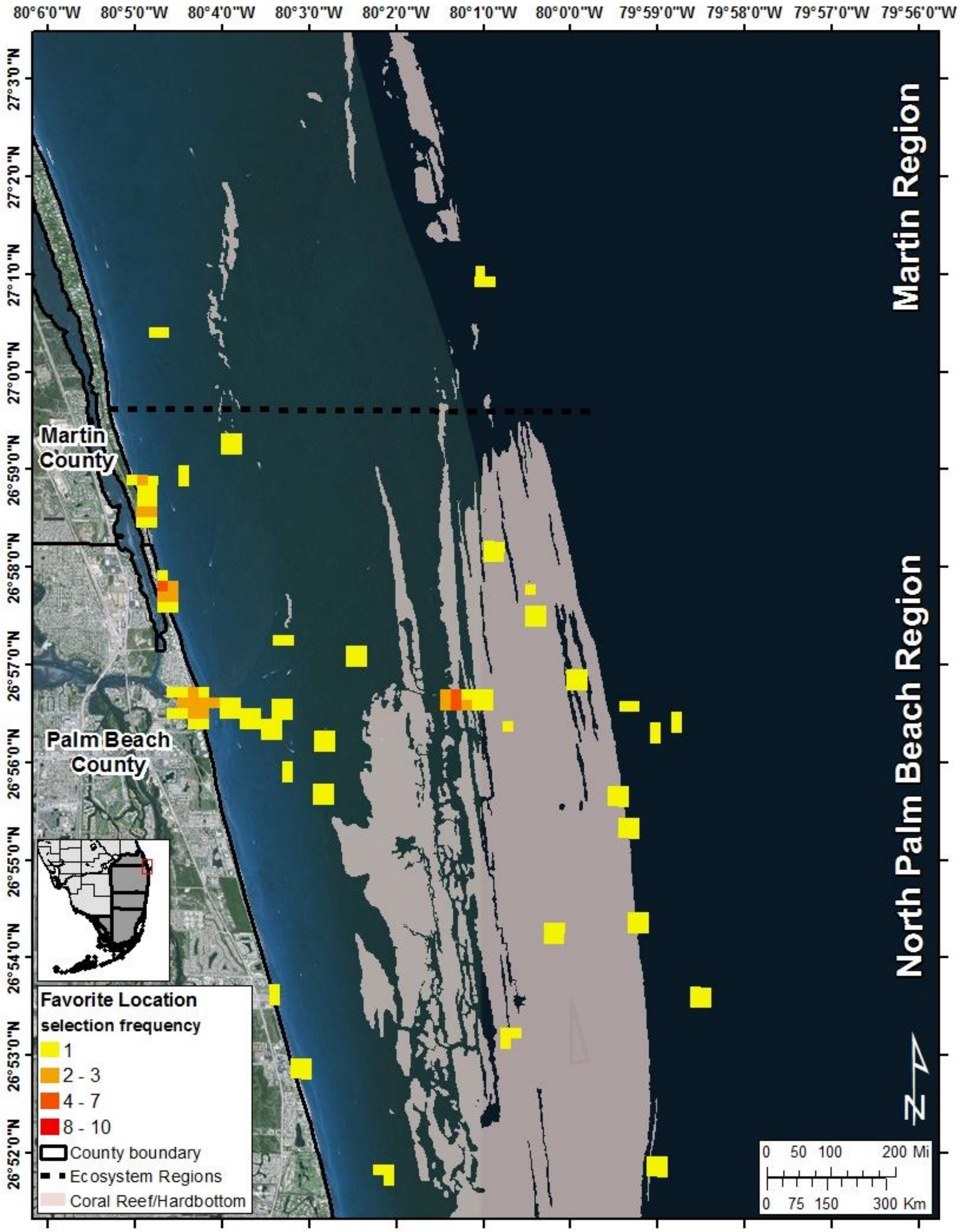

Figure 62.Map displaying the number of survey respondents who selected planning units in the Martin and North Palm Beach biogeographic regions as their favorite or most valued location. Favorite locations were chosen by four respondents, one mile north of Jupiter Inlet, directly off the beach. Jupiter Ledge was chosen by five survey participants.

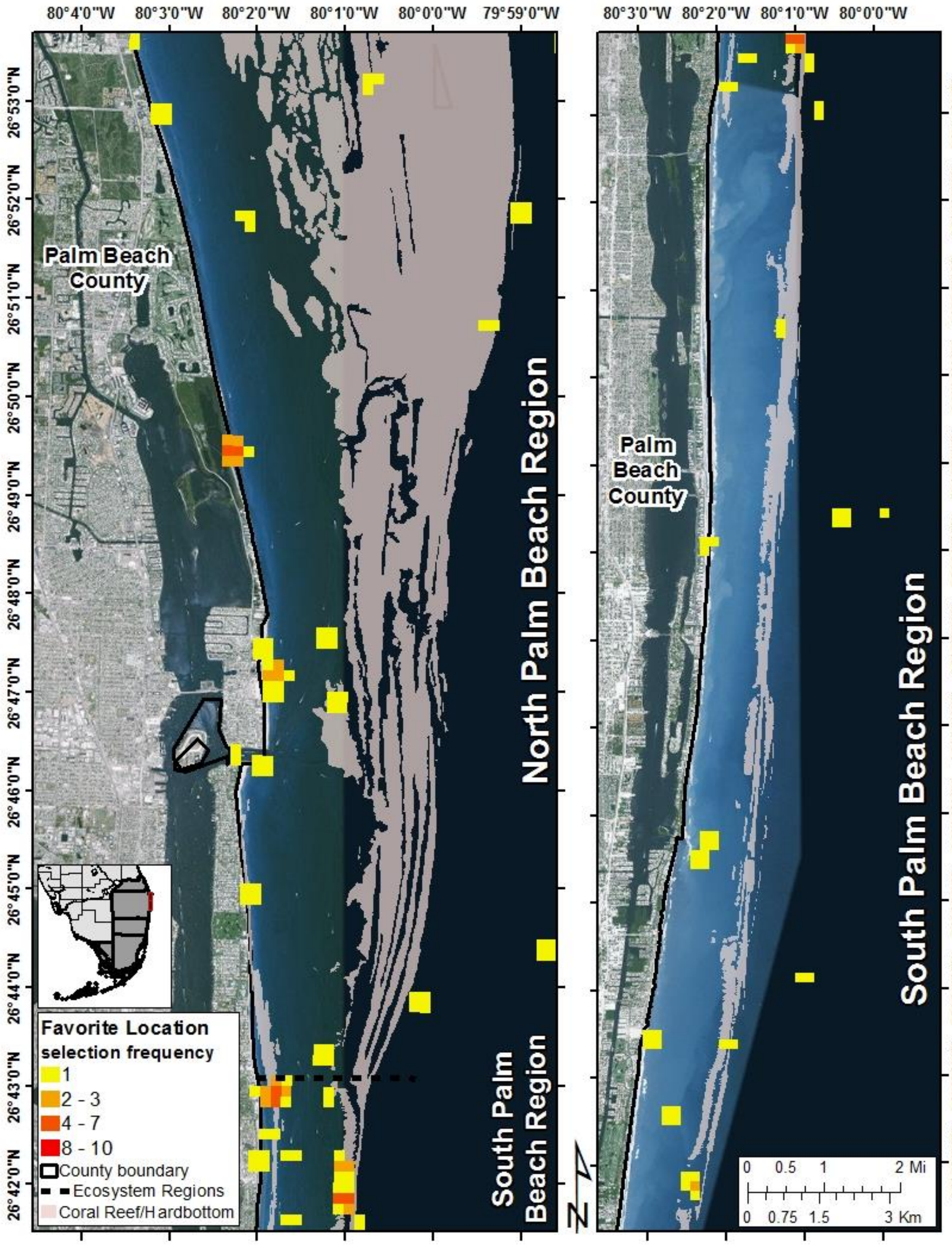

Figure 63.Map displaying the number of survey respondents who selected planning units in the North Palm Beach and South Palm Beach biogeographic regions as their favorite. The area along John D. McArthur Beach State Park was six respondents' favorite location. Shallow Breaker's Reef and an area just south of Flower Gardens on the Outer Reef and Ridge was chosen by five respondents.

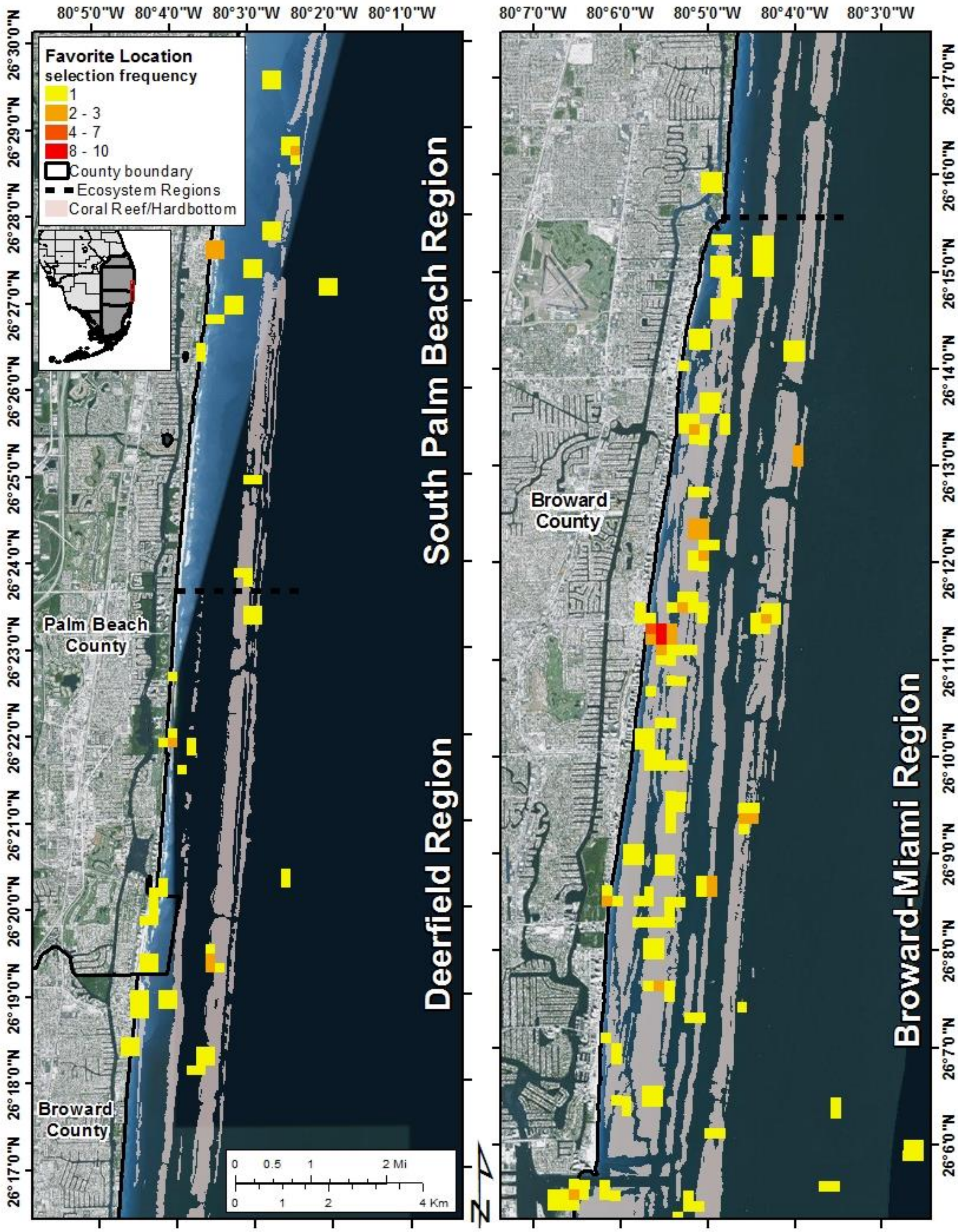

Figure 64. Map displaying the number of survey respondents who selected planning units in the South Palm Beach, Deerfield, and Broward-Miami biogeographic regions as their favorite or most valued location. Ten respondents' favorite location was the waters off Anglin's Pier.

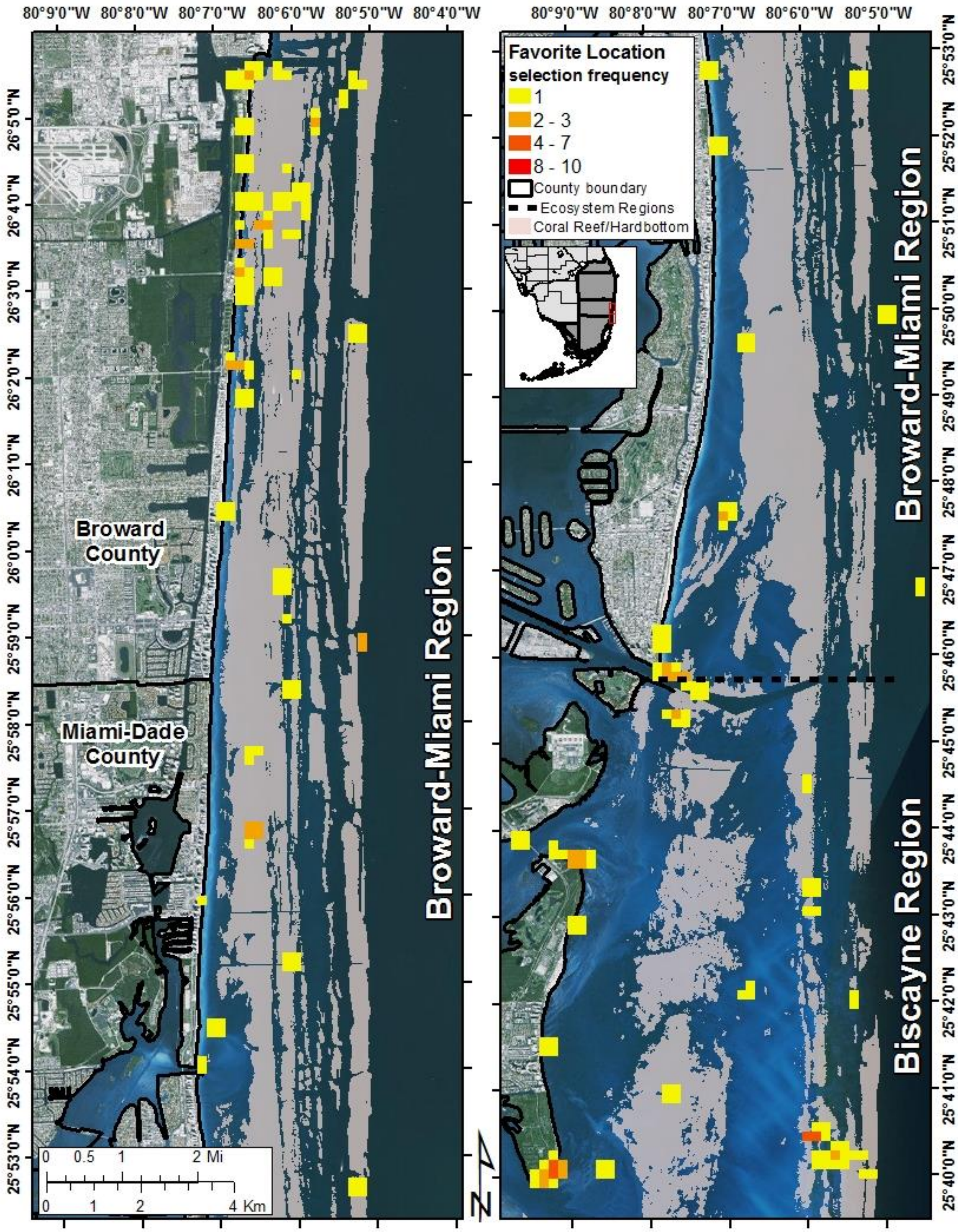

Figure 65.Map displaying the number of survey respondents who selected planning units in the Broward-Miami and Biscayne biogeographic regions as their favorite or most valued location. Four respondents indicated the southern tip of Key Biscayne as their favorite and five respondents indicated Emerald Reef.

The respondents' favorite location activities were numerous and varied (Table 21). Diving by boat for pleasure was the dominant activity, encompassing 59 of the favorite or most valued locations. Forty-one respondents chose snorkel/freediving from shore as the activity they engaged in at their favorite location. Recreational fishing from a private vessel was indicated by 32 survey respondents and diving from shore for pleasure was indicated by 24 survey respondents. All other activities were chosen by twenty or less respondents, including diving by boat for research (indicated in nineteen surveys). The remaining favorite location activities and the number of respondents who chose them are in Table 21.

Table 21. Number of surveys by primary activity at respondents' favorite location. Each survey respondent was only allowed to choose one primary activity for their favorite location. (Crowther and Chen, 2015)

Favorite Spot Activities	**# Surveys**
Pleasure (diving by boat)	59
Pleasure (snorkel/freediving from shore)	41
Private vessel (recreational fishing)	32
Pleasure (diving from shore)	24
Research (diving by boat)	19
Motor	16
Photography (diving by boat)	15
Lobstering (diving by boat)	14
Pleasure (snorkel/freediving from vessel)	11
Shore/pier (recreational fishing)	7
Surfing	6
Research (snorkel/freediving from shore)	5
Photography (diving from shore)	5
Research (diving from shore)	4
Spearfishing (diving by boat)	3
Photography (snorkel/freediving from shore)	3
Kayak	3
Spearfishing - commercial or recreational (snorkel/freediving from vessel)	2
Photography (snorkel/freediving from vessel)	2
Stand-up paddle boarding	1
Shore/pier (commercial fishing)	1
Sail	1
Research (snorkel/freediving from vessel)	1
Research (recreational fishing)	1

Table 20. Continued. Number of surveys by primary activity at respondents' favorite location. Each survey respondent was only allowed to choose one primary activity for their favorite location. (Crowther and Chen, 2015)

Favorite Spot Activities	# Surveys
Lobstering (snorkel/freediving from vessel)	1
Lobstering (snorkel/freediving from shore)	1
Lobstering (diving from shore)	1
Collection for aquarium trade or for personal tank (diving by boat)	1
Other	47

Favorite locations were chosen by respondents for various reasons; however, there were a few dominant ones. Activity-based was the top reason with 204 surveys indicating that the location was perfect for their particular activity. The location being beautiful was chosen by 177 survey respondents and good water quality was chosen by 137 respondents. Abundant and diverse marine life was also an important quality indicated by 129 surveys (Table 22). All other favorite location reasons were chosen by fewer than fifty respondents and can be seen below in Table 22.

Table 22. Number of surveys by the chosen reasons for a favorite location. Survey respondents could choose more than one reason for liking this location. The "other" responses were a type-in response that is not detailed here. (Crowther and Chen, 2015)

Favorite Location Reason	# Surveys
Activity-based - The site is perfect for my particular activity (e.g. fishing area, dive site, etc)	204
Beautiful - The site is beautiful or has striking natural features	177
Water Quality - The water is clean, clear and/or good to swim in	137
Marine Life - Marine life is abundant and diverse	129
Memories - I have a lot of memories from this place	48
Secluded - The site is secluded, away from crowds, and offers privacy	40
Educational- It is a place I can learn about, teach, or research the natural environment	39
Inspiring - This is a spiritual/inspiring place for me	38
Social - This is where my friends/family frequent	33
Livelihood - Professional purposes	15
Collecting - There are specific natural resources I like to collect here	10
Other	3

4.3. Activity Locations and Coral Reef/Hardbottom Habitat Association

Many activity locations were associated with coral reef or hardbottom habitat. Of 1,837 total survey locations, 687 (37.4%) occurred on coral reef or hardbottom habitat. Almost fifty percent of "SCUBA Diving Activity" locations and 36.3% of "Recreational Fishing Activity" locations occurred on coral reef or hardbottom habitat (Table 23 and Figure 66. Bar graph showing the percent of activity locations on coral reef/hardbottom habitat by activity type). Most activities were located on the Nearshore Ridge Complex, with 404 locations (58.8%) indicated by survey respondents. The Inner Reef had the next highest use with 92 (13.4%) activity locations indicated. The Ridge, Outer Reef, and Inner Reef all showed similar numbers in the 40s to 50s (8% or less) (Table 24 and Figure 67). The activity type not only differed by habitat, but also by region. Recreational fishing was the dominant activity in the Martin region with 40% of all activity being recreational fishing while SCUBA diving activity was the lowest in this region with only 27% of all activity. In both Palm Beach, Broward, and Miami-Dade counties, SCUBA diving activity was dominant (*Table 25*).

Table 23. Number of activity locations on coral reef/hardbottom habitat and percent of those activity locations on coral reef/hardbottom habitat by activity type

Activity Type	Total Locations	Locations on Coral Reef/Hardbottom	Percent on Coral Reef/Hardbottom
All Activities	**1837**	**687**	**37.4**
SCUBA Diving Activities	852	423	49.6
Boating Activities	1150	475	41.3
Recreational Fishing Activities	455	165	36.3

Table 24. Number of activity locations for all activities on coral reef/hardbottom habitat and percent of all activities on coral reef/hardbottom habitat by habitat type

Habitat Type	**Locations**	**Percentage of activities on Hardbottom**
Nearshore Ridge Complex	**404**	**58.8%**
Inner Reef	92	13.4%
Ridge	55	8%
Outer Reef	52	7.6%
Middle Reef	42	6.1%
Aggregated Patch Reef	22	3.2%
Acropora cervicornis Patch	11	1.6%
Scattered Rock and Sediment	6	0.9%
Colonized Pavement	3	0.4%

Table 25. Table of number of locations for "All Activities" by county, number of locations for "Recreational Fishing Activity" by county, percent of "Recreational Fishing Activity" compared to "All Activities" locations by county, Number of locations for "SCUBA Diving Activity" by county, and percent of "SCUBA Diving Activity" compared to "All Activities" locations by county.

County	**Martin**	**Palm Beach**	**Broward**	**Miami-Dade**
# of All locations	124	642	835	254
# of Rec Fishing locations	49	145	215	48
% Rec Fish of all activity	**40**	**23**	**26**	**19**
# of SCUBA Diving locations	34	271	446	107
% SCUBA diving of all activity	**27**	**42**	**53**	**42**

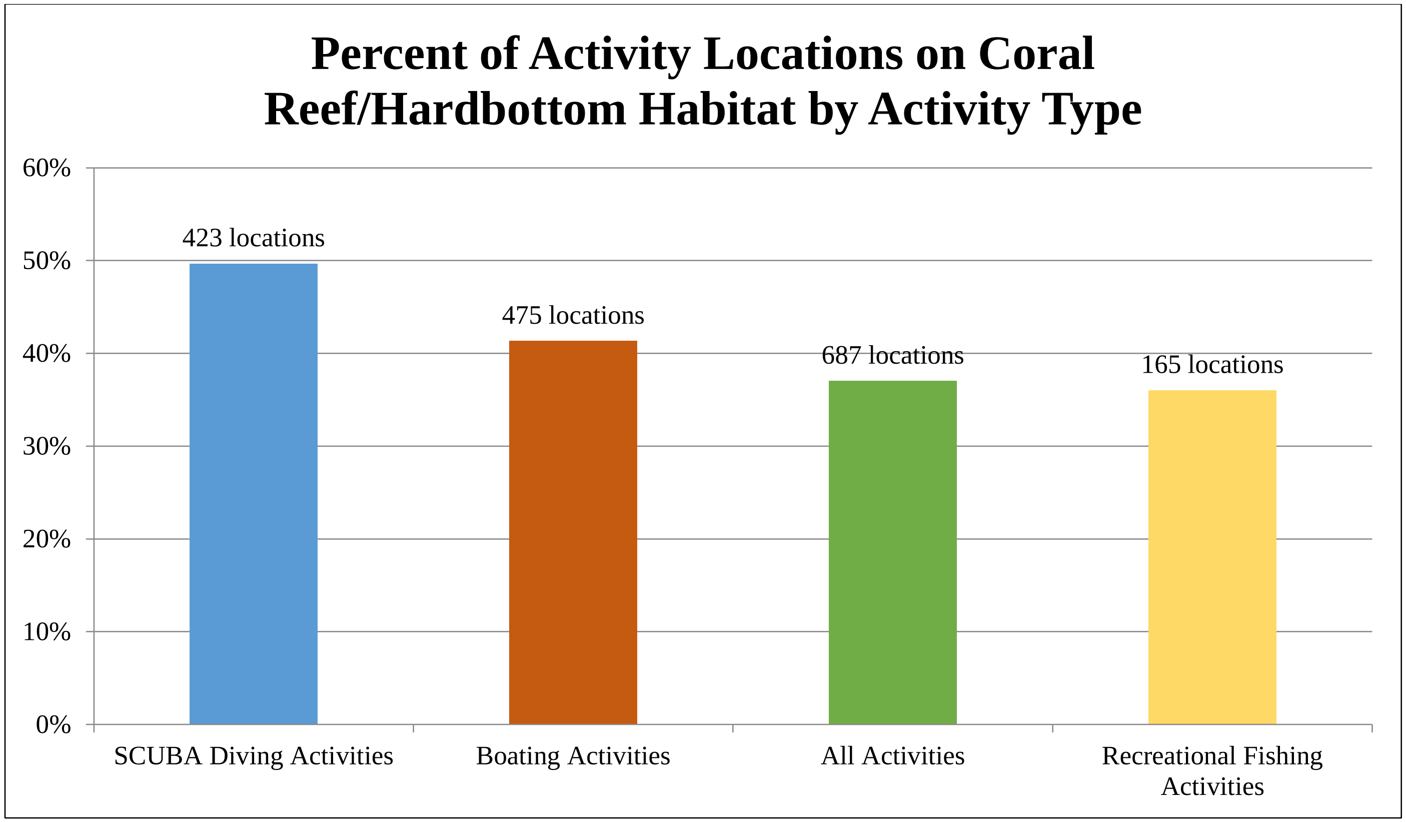

Figure 66. Bar graph showing the percent of activity locations on coral reef/hardbottom habitat by activity type

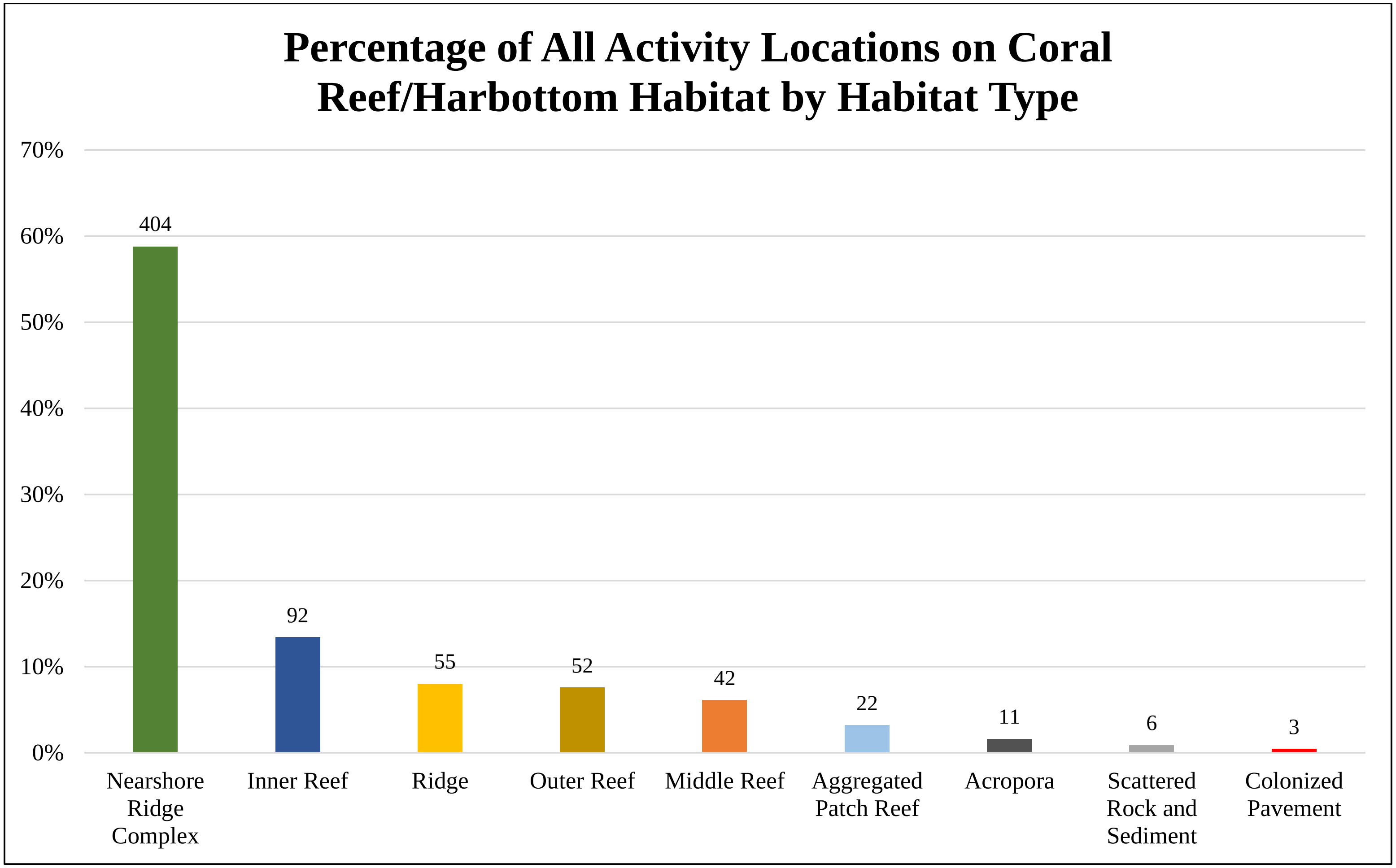

Figure 67. Bar graph showing the percent of activity locations for all activities on coral reef/hardbottom habitat by habitat type.

5. DISCUSSION

5.1. Interpretation of Spatial Results

The spatial results of the *Our Florida Reefs* survey are invaluable when making management recommendations for southeast Florida's reefs. They aid in understanding how, where and with what intensity people use the reefs in the region. High use areas may be areas where potential conflict could emerge in response to a management recommendation. Understanding where these areas are can allow planners to avoid them (Brody et al., 2004). This study not only provided information on reef use but also showed the importance of collecting data on both location and intensity of use. It was found that analyzing just location, rather than both location and activity-days, often yielded different results. Gathering both aspects of use helps to gain a more comprehensive understanding and helps to recognize which locations are under more pressure or which locations are more important to certain user groups.

The results show that the distribution of use in the SEFCRI region was not even among reef stakeholders. Instead, the distribution of activities was spatially clustered and occurred generally around inlets and piers. The planning unit survey data showed that the reefs in the Broward-Miami region were used over a wider spatial scale than those north or south. In these areas, the coral reef and hardbottom habitat is extensive, allowing respondent use to spread out over a larger area. Places where less reef habitat exist (e.g., Martin Coral Reef Ecosystem Region) showed use focused in smaller areas. Concentrated use locations could potentially lead to greater stress if the intensity of use is also high. The number of activity-days spent at a location was used as a surrogate for intensity in this case. Other studies have looked at intensity of use using number of people and number of days of activity per location as well. Zakai and Chadwick-Furman (2002) discussed the "diver carrying capacity" as a measure of the number of dives a site can sustainably support without becoming degraded. Similar to the data collected in the OFR survey, this measure looked at use using the number of people and number of days of activity per location. The study showed that a site having a limited, low frequency of recreational dives, retained a high percent cover of live corals and appeared to be in good condition relative to other, more impacted reef areas. The lower impact associated with sites having low frequency of recreational activity in the Zakai and Chadwick-Furman (2002) study illustrates the importance of understanding where activities occur as well as how often. Analyzing intensity of use in addition to location of use exhibited differences in clustering of the data. Some areas with low to moderate location density showed high use intensity clustering indicating that people more frequently visited locations that were in close proximity to each other. Because frequency of use may influence the degree of anthropogenic stress on the reef, these areas are still important to consider even if the number of people is lower. This demonstrates the importance of including both location and intensity in future surveys.

It is important to note that anthropogenic impacts on an area are not only dependent on the frequency of visitation but also on the type of activity. An activity such as snorkeling for pleasure would be expected to cause less stress than lobstering using SCUBA equipment as the latter is an extractive activity that involves closer contact with the benthic habitat and the removal of organisms. Non-extractive diving is often thought of as a low-impact activity relative to recreational or commercial fishing. Evidence has supported that intensive tourist use for diving could cause reef degradation as well (Thurstan et al., 2012; Zakai and Chadwick-Furman, 2002). In a risk-assessment conducted by Thurstan et al. (2012), a risk score of 3.5 on a scale of 0-4 (0 equaling no risk) was calculated for SCUBA diving. In addition, activities that involve boat anchoring would be expected to cause more damage than those that do not (Jameson et al., 1999; Lynch et al., 2004; Saphier and Hoffmann, 2005).

Comparing the hot spot analysis and point density analysis for reef use reveals differences that arise when data on both location and intensity of reef use is collected rather than location alone, demonstrating the importance of both measures. For example, a location (Location One) used by five individuals only twice per year may experience less anthropogenic stress than one that is used by three individuals if those three individuals visit that location (Location Two) ten times per year. Likewise, if ten people visit the same location (Location Three) during a twelve month period on an average of three days each for that time period, the intensity of use could be similar to that at Location Two (Table 26).

Table 26. Example used to explain how intensity of use in addition to location can produce different results in the data. Although Location 2 and Location 3 have different numbers of people visiting them, the estimated use intensity at each locations is the same because the location with less individuals was visited more often by those individuals.

Location	**Number of people visiting a location per year**	**Average days spent at a location per person per year**	**Estimated use intensity**
1	5	2	10
2	3	10	**30**
3	10	3	**30**

5.2. Activity and Coral Reef/Hardbottom Habitat Association

Not only is it important to look at what locations are being used by stakeholders and with what intensity, but also the association of these activity locations with bottom habitat. Habitat association is useful to understand how intensity and location of activities may impact coral reef and hardbottom habitats. This will help identify areas that are not being used as heavily and thus may be better suited for conservation. Looking at which types of hardbottom habitat are most popular for certain activities may aid in developing management recommendations that correlate with these areas.

Stakeholder use was not evenly distributed among the benthic habitats in southeast Florida. Some activities occurred on hardbottom habitat more often than others (i.e., SCUBA diving activities), some activities occurred more often in some counties than others, and some habitat types were used more often than others. “Extractive Diving Activity” and “SCUBA Diving Activity” utilized coral reef and hardbottom habitat most often with almost 50% of activity on hardbottom habitat. Recreational fishing activity used hardbottom habitat less with only 36.3% of locations overlapping with coral reef and hardbottom habitat. Dive activities tend to be more focused on coral reef habitat. Although recreational fishing activities may target coral reef habitat for reef fish species such as grouper and snapper, pelagic species not associated with hardbottom habitat such as dolphin or tuna may cause the percentage of activity on hardbottom to drop.

The hardbottom habitat visited the most among all activities was the Nearshore Ridge Complex (58.8%), followed by the Inner Reef (13.4%). These habitat types are most likely used more often because they occur closest to shore and are more accessible to stakeholders.

The reefs in the Broward-Miami Region were used over a wider spatial scale than those north or south. This is most likely a result of the extensive reef habitat in this region. Regions such as the Martin Coral Reef Ecosystem Region, for example, have less hardbottom habitat which may concentrate use.

The activity type not only differed by habitat, but also by county. Within the sample, Martin County had more fishing activity than SCUBA diving activity while the other three counties (Palm Beach, Broward, and Miami-Dade) had more SCUBA diving activity than fishing activity. These differences in activity type by county corresponded to differences in habitat types by county. Martin County has considerably less coral reef and hardbottom habitat than the other three counties and thus, is not as desirable a location for SCUBA diving (Figure 68).

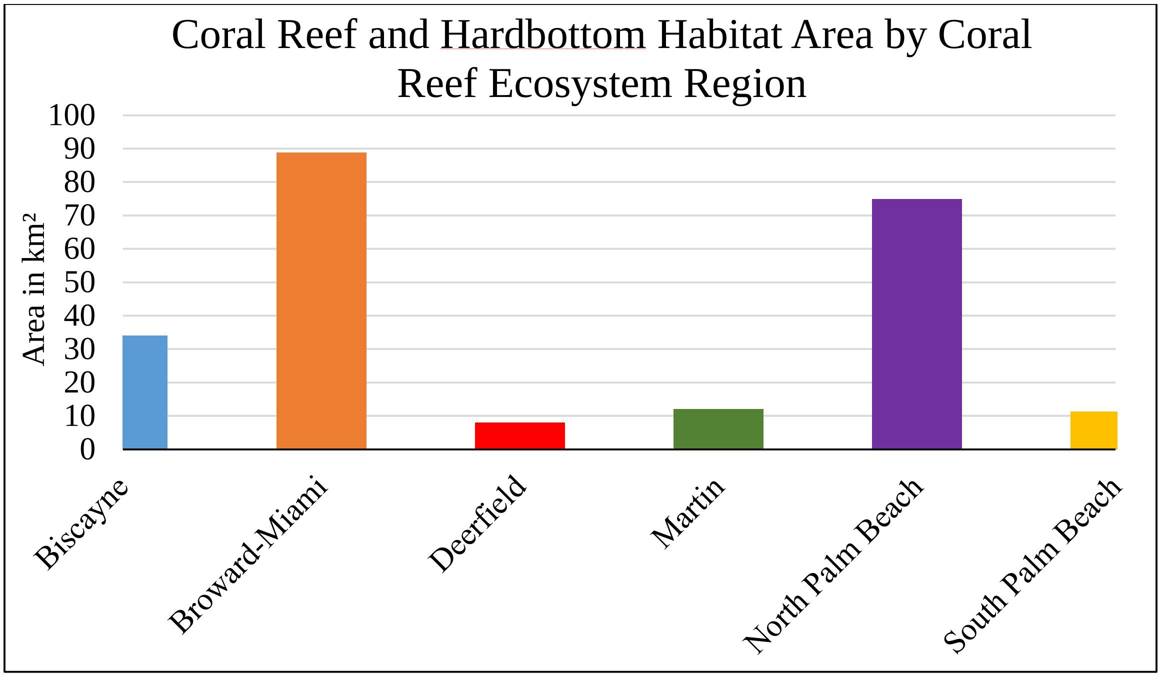

Figure 68. The area of coral reef and hardbottom habitat in km² for each coral reef ecosystem region.

5.3. All Activities

Analyses on "All Activities" in southeast Florida showed that the highest density of individuals visited locations in the Broward-Miami Coral Reef Ecosystem Region from Hillsboro Inlet to Port Everglades. The majority of these areas focused around inlets and piers. Inlets are popular locations for reef users because they are easily reached. Many users with smaller vessels are unable to travel far distances from these access points. The lowest density of individuals visited locations in the southern stretch of the Broward-Miami Region and the Biscayne Region. Areas that showed the highest clustering of intense use for all activities were around St. Lucie Inlet in the Martin Coral Reef Ecosystem Region and in the northern area of the South Palm Beach Coral Reef Ecosystem Region. St. Lucie Inlet is Martin County's only point of access to the Atlantic Ocean unlike the other three counties, which have multiple access points to choose from. This may be why a high number of individuals indicated locations here with a high number of activity-days. The northern area of the South Palm Beach Region may have had a high number of locations with high activity-days because it contains many popular dive sites and artificial reefs as well as mooring buoys. This area is different from those around it as it also correlates with an important geological feature known as the Bahamas Fracture Zone. It marks the northern terminus of the Linear Outer Reef and is also the point where the Florida Current extends further from shore (Walker and Gilliam, 2013). There is an obvious change in habitat morphology as well as differences in fish species richness on either side of this zone making it a unique and possibly desirable area to visit (Walker, 2012).

Comparing the location density analysis and hot spot analysis on “All Activities” demonstrated the importance of collecting data on both location and intensity in many cases. Locations demonstrating clustering of high use intensity were just below Lake Worth Inlet, outside the moderate density area. This indicates that many participants frequently visited the locations in that area even though the density of locations was not high compared to the entire region. The clustering of high use intensity at the northern extent of the South Palm Beach Coral Reef Ecosystem Region demonstrate that the area could potentially, be under greater stress. The clustering of low use intensity around Government Cut and off north Key Biscayne on the Nearshore Ridge Complex, Inner and Outer Reef were at areas of moderate location density. Users in this area did not visit this locations frequently throughout the year.

5.4. Boating Activities

Analyses on “Boating Activities” in southeast Florida showed that the highest density of individuals visited locations in the Broward-Miami Coral Reef Ecosystem Region from Hillsboro Inlet to Port Everglades. High density use throughout the region focused around inlets and piers. Within the Broward-Miami Coral Reef Ecosystem Region the frequency that individuals visited locations, was low, especially off of Anglin’s Pier where locations demonstrating clustering of low use intensity occurred. Areas that showed the highest clustering of intense use for boating activities were located around St. Lucie Inlet in the Martin Coral Reef Ecosystem Region and in the northern area of the South Palm Beach Coral Reef Ecosystem Region. The northern area of the South Palm Beach Region encompasses many popular dive sites, artificial reefs, and mooring buoys.

“Boating Activity” Analysis showed locations demonstrating clustering of high use intensity just south of Lake Worth Inlet, an area with moderate location density, but not at Jupiter Inlet, another area with moderate location density. These locations demonstrate clustering of high intensity use whereas the location density analysis showed only moderate use. This helps confirm the importance of gathering data on activity-days. In this case, if only location was taken into account, these two areas would be regarded as having the same use intensity when the intensity of use was actually higher near Lake Worth Inlet than near Jupiter Inlet. In the Deerfield Coral Reef Ecosystem Region, moderate to high density of locations was around Boca Raton Inlet, although no hot spots existed in this area. The moderate to high density of locations shows that this area was popular amongst many individuals however the lack of locations with clustering of high use intensity shows that it was not an area visited frequently throughout the year by these individuals. Hot spot analysis did not reveal any location showing clustering of high use intensity in the Broward-Miami Coral Reef Ecosystem Region, where high to very high density of locations for boating activities existed along the reef tract. Instead, several locations demonstrating clustering of low use instensity were around Anglin's Pier, revealing that many people visited this location for boating activities but only on occasion. This clustering of low intensity use locations paired with high location density exemplify the inaccuracy of data interpretation that could arise if both location and activity-days are not taken into account.

5.5. SCUBA Diving Activities

Analyses on "SCUBA Diving Activity" showed that the highest density of individuals visited locations in the Broward-Miami Coral Reef Ecosystem Region from Hillsboro Inlet to Port Everglades with the highest density around Anglin's Pier. This area offshore from the Town of Lauderdale-by-the-Sea was recognized as the Shore Dive Capital of South Florida by the Broward County Commission in 1997 (www.lauderdalebythesea-fl.gov). It is a shallow reef area that is easily accessible from shore as well as by boat from both Hillsboro Inlet and Port Everglades. This area was also reported as a popular dive use area by Shivlani and Villanueva in 2007 (Figure 69). They reported that the most popular ports listed by dive operators in southeast Florida were Hillsboro (19.6%) and Port Everglades (17.4%). There was high density of individual locations around Dania Fishing Pier, which is also easily accessible by shore or by boat via Port Everglades. The high concentration of dive shops and dive charters in these areas further support high diving activity. The map in the 2007 socioeconomic report by Shivlani and Villanueva supports the nearshore use characteristic of dive operations, as well as the focus within Broward County (Figure 69). They also point out that this concentration of use was a function of the highest concentration of dive operations in that county.

Density of SCUBA diving activity was lowest in the Martin Coral Reef Ecosystem Region. The low coral density and number of coral species in this region make it an undesirable area for SCUBA diving activity. There are also few dive charters in Martin County compared to the other three counties in southeast Florida. A previous socioeconomic study by Johns et al. (2004) noted that only seven percent of all boating activities in Martin County were for SCUBA diving activity. SCUBA diving activity was also lower in Miami-Dade County. Unlike Martin County however, Miami-Dade County has more coral reef habitat. The lower number of individuals SCUBA diving in this area may be because the population here does not use their reefs as much or perhaps that they travel further south past the SEFCRI designated boundary to Biscayne or Key Largo. Also, the number of dive shops and dive charter vessels in this county is lower than in Palm Beach or Broward counties.

High clustering of SCUBA diving activity locations with a high number of activity-days were found in the area of transition between the North Palm Beach and South Palm Beach Coral Reef Ecosystem Region. This area correlates with an important geological feature known as the Bahamas Fracture Zone, which marks the point where the Florida current extends further from shore (Walker and Gilliam, 2013). Due to this hydrographic difference, there are also clear differences in habitat morphology and fish species richness on either side of this zone (Walker 2012). Specifically, between North Palm Beach and South Palm Beach counties, Banks (2008) recorded 43 species exclusive to the north region and 56 additional species recorded in the south only. Kilfoyle et al. (2015) similarly reported that the South Palm Beach region, just south of the Bahamas Fracture Zone, could represent the greatest spatial overlap between the tropical and more temperate fish communities. These unique qualities, and distinctive fish assemblages, make the region popular for dive sites, artificial reefs, and mooring buoys, even though coral cover may not be as high here compared to regions further south (Gilliam et al., 2015).

In the North Palm Beach Coral Reef Ecosystem Region, locations demonstrating clustering of high use intensity occurred at the southern-most end of the region and extended into the South Palm Beach region. However, this area is not shown as a high use area according to location density. In the Broward-Miami Coral Reef Ecosystem Region, there were many areas along the reef tract from Anglin's Pier to Dania Fishing Pier, which displayed high to very high density of individual locations. Unlike the location density analysis, hot spot analysis did not display this region as a high intensity use area. Instead, locations demonstrating clustering of low use intensity were at the northern-most part of the region from Fisherman's Wharf Pier up to Hillsboro Inlet. This indicates that many individuals visited Anglin's Pier and Dania Fishing Pier but the number of activity-days, and thus the intensity of use was low. Although this is a popular area among reef users, the hot spot analysis paired with location density analysis show that the use is spread out over a larger area causing the intensity to be lower than would be expected looking at locations alone.

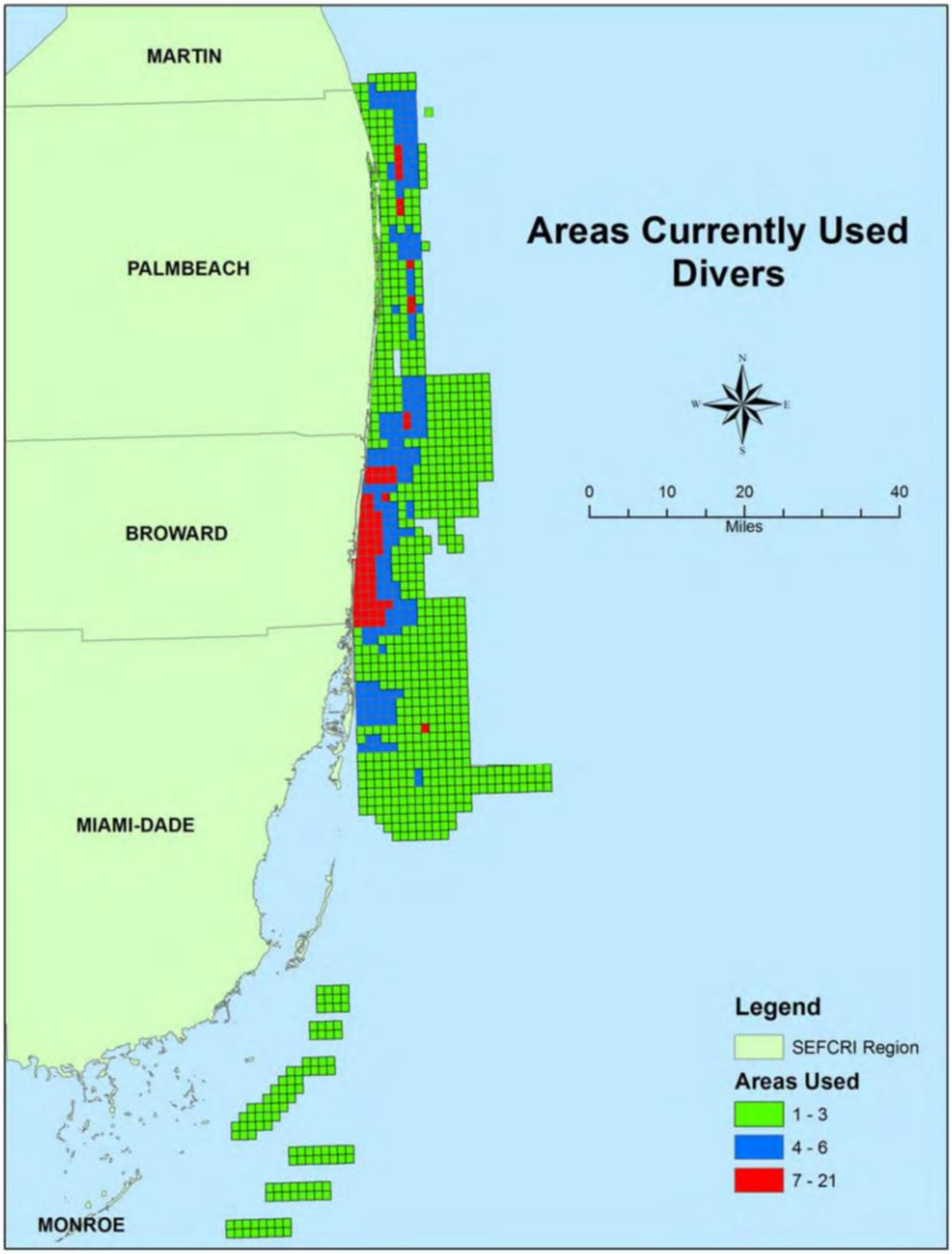

Figure 69. Map from Shivlani and Villanueva (2007) demonstrating the areas that were used by divers in southeast Florida when the survey was conducted in 2006.

5.6. Recreational Fishing Activities

Analyses of recreational fishing activities showed that the highest density of individuals visited locations in the Broward-Miami Coral Reef Ecosystem Region from Hillsboro Inlet to Dania Pier. Areas that showed the highest clustering of intense use were located around St. Lucie Inlet and in the southernmost area of the Martin Coral Reef Ecosystem Region on the Deep Ridge Complex. High concentration of fishing activity was also noted by Johns (2004) who found that 86% of boating activity reported in Martin County was for recreational fishing. This further demonstrates that recreational fishing is more popular among reef users than SCUBA diving activity in this region. This single point of access to the Atlantic Ocean may be why a high number of individuals indicated recreational fishing locations with a high number of activity-days here. The "Recreational Fishing Activity" hot spot analysis showed many locations demonstrating clustering of low use intensity within the very high location density area between Hillsboro Inlet and Anglin's Pier. This clustering of low activity-days paired with higher location density showed that although many individuals fished here, they did not do so frequently and thus may not impose as large of an impact to the area as would be expected if activity-days were higher.

Hot spot analysis did not show any clustering of high or low intensity use in the high density area between Port Everglades and Dania Pier. These analyses show that many people used this region for recreational fishing but the use was spread out along the reefs. Also, those who did fish in the area did not do so frequently.

5.7. Angling and Diving Activity Overlap

Areas of angling and diving overlap were assessed to see where potential conflict of activities could occur in southeast Florida. These activities may generate conflict for safety reasons, as it can be potentially dangerous for divers to swim around fishing equipment. The conflict could be philosophical in addition to actual, as both groups may desire exclusive recreational use of waters and abundant large fish (Lynch et al., 2004). Lynch et al. (2004) reported a conflict in Jervis Bay's northern headland that turned into a violent interaction reporting that dive boats were attacked with lead sinkers fired by anglers. The angler's viewpoint, however, was that the divers had been intentionally scaring the fish away. They contended that some formal delimitation of access rights may be needed.

Shivlani and Villanueva (2007) noted that boating activity associated with both recreational fishing and diving, rather than the fishing or diving themselves, is often the cause of conflict. Their study found that dive operations believed use conflicts may not impact their group with the possible exception of recreational boaters (Figure 70). Similarly, 32.9% of recreational anglers identified boating and other recreational fishing activity as a source of conflict, more often than diving. Angling and diving activities often occurred by boat causing a strong overlap of those features. This made it difficult to observe any conflict of boating activity with angling or diving activity. It is important to note that the respondent data from the previous survey was collected by interviewing individuals or asking them the direct question of where conflict occurred. In this study, however, the overlap of activities can only be observed through the spatial data and conflict then inferred.

The majority of angling and diving overlap occurred near inlets, with the highest degree of overlap being within the stretch of reef between Hillsboro Inlet and Port Everglades. These areas of overlap are consistent with high use areas for both recreational fishing and diving. Consistent with the high use areas for recreational fishing, although generally low, overlap in the Martin coral reef ecosystem region was dominated by angling activity. Overlap in both the North and South Palm Beach regions was also low, but overlap was mostly equal in areas where it did occur. In general, overlap in the Broward-Miami region was fairly equal. In areas within this region where the overlap between diving and angling activities was not equal, it was slightly dominated by diving activity in all locations except the area just south of Port Everglades.

Although overlap of SCUBA diving and angling activities did occur, it was difficult to know if it resulted in actual user conflict. Overlapping use by different groups does not always result in conflict. There was also no temporal component. For example, perhaps a site was dived in the morning and fished at night, or perhaps a spot was fished in the winter and dived in the summer. Shivlani and Villanueva (2007) also found that overlap of activities does not necessarily infer user-group conflict; during their in-person interviews, many users indicated that they did not feel that other users impacted their activity.

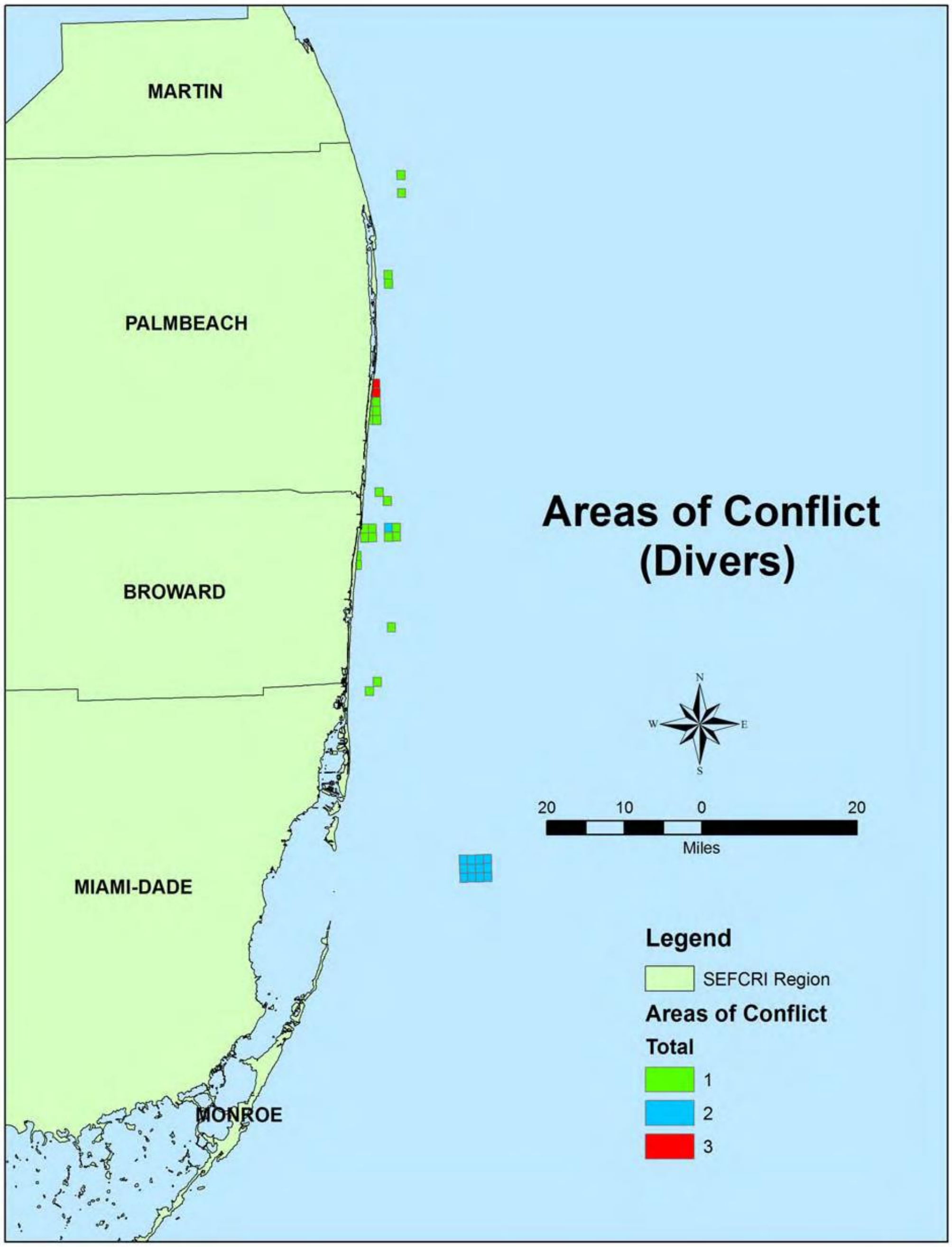

Figure 70. Map from Shivlani and Villanueva (2007) demonstrating the areas of conflict identified by divers at the time the survey was conducted in 2006. The area with the greatest conflict was in Palm Beach County. Both Martin County and Miami-Dade County had little conflict indicated.

5.8. Survey Participation

The *Our Florida Reefs* (OFR) Coastal and Ocean Use Survey reached 1,101 people in southeast Florida (Martin, Palm Beach, Broward, and Miami-Dade counties). This number is low in an area with an estimated population size over six million (www.census.gov). Although the population is large, reef users among this population are expected to be fewer simply because not all people have the desire or means to engage in reef-related activities. Low response rates are typically a result of non-response error, which can arise in two ways: non-contact of respodents and refusal to participate (Cornish, 2002). Noncontact error results from an inability to reach some individuals, thus indicating that more extensive outreach may be needed. Refusal to participate would have resulted if the survey reached reef users, but they chose not to provide information.

Many past socioeconomic survey efforts in southeast Florida have yielded low response rates (Johns, 2001; Johns, 2004; Shivlani, 2006; Shivlani and Villanueva, 2007). The southeast Florida socioeconomic study by Johns (2001) showed that among the 2,543 completed surveys from Monroe, Miami-Dade, Broward, and Palm Beach counties 34.8% indicated that they had not used the reefs in their county within the past year. It is important to note that their surveys were only mailed to boat owners. The percentage of non-reef users in some of these prior studies may have been higher had they been mailed to a group representative of the southeast Florida population. Unlike the Johns (2001) survey, the OFR survey did not include an option for respondents to indicate that they had not used the reef. The 368 people (33.4%) who registered but never started the survey likely included individuals who did not visit the reef in the past year. These respondents may have realized that they had not participated in any of the activities listed or within the time frame specified. Without a question in the survey addressing this issue, reasons why the registrant did not start the survey remain unknown. Other possible reasons could include an erroneous email address, lack of time, or lack of motivation to take the survey.

Although survey participation was low across the region as a whole, the participation varied by county. The number of completed surveys was not proportional to the population size in each county. Only 37 surveys logging 254 locations were completed by Miami-Dade County respondents. Although this county has the highest population size (approximately 2.6 million), it had the lowest number of activity locations proportional to population size (0.01%). Although Martin County had the lowest number of activity locations, it had the highest proportional to its population size (0.08%) (Table 27). Both Broward County and Palm Beach County had similar proportions of logged activity locations proportional to their population size (Table 27). The disparity in these numbers could be a result of lower outreach activity in Miami-Dade County. However, the outreach effort in Martin County was also low, yet it did not experience the same low participation compared to population size. These differences in response rates may mean that factors other than outreach efforts alone are driving these participation results. The socioeconomic survey by Shivlani and Villanueva (2007) also had low participation in Miami-Dade County compared to all other counties in southeast Florida. Of the 1,058 recreational fishermen who completed and returned surveys with associated zip codes, they reported that 31.1% were from Palm Beach County, 25.1% were from Broward County, 27.1% were from Martin County, and 16.7% were from Miami-Dade County.

Table 27. Table showing the population size, the number of activity locations, and the percent of those activity locations relative to the population size for each of the four counties in the southeast Florida region.

	Miami-Dade County	Broward County	Palm Beach County	Martin County
Population (July 2014)	2662874	1869235	1397710	153392
# of activity locations	254	835	642	124
% of activity locations relative to population size	**0.01%**	**0.04%**	**0.05%**	**0.08%**

The number of reef related businesses in each county could also be a factor affecting response rates. A list of dive shops located in the four counties was compiled using web-based dive shop lists as well as industry contacts. This list showed that both Broward County and Palm Beach County have the highest number of dive shops, schools, and charters (47 and 34 respectively) in the region and also had the highest number of SCUBA diving activity locations (Table 28). A large number of dive-related businesses in an area indicate a high demand and thus more activity. Miami-Dade County also borders Monroe County, which includes some of the most popular dive destinations in the continental U.S.

Although the population size of Monroe County is only 749,857 (U.S. Census Bureau, 2014), much lower than Miami-Dade, Broward, and Palm Beach counties, they have over thirty dive-related businesses. This demonstrates that Monroe County is a popular diving destination which may compete with diving activity in Miami-Dade. The Visitor Profile Survey for the Florida Keys found that 55 respondents (3.1%) had a second home in Florida (Insight, Inc., 2013). Of these 55 respondents, 22 (39.5%), had their second home in Miami. Also, Leeworthy et al. (2010) found Florida to be the number one origin of all visitors, with 18.71 percent of all visitors coming from Florida during the winter season, and 35.46% during the summer season. Of these visitors, south Florida was the dominant source, with Miami-Dade County ranking number one among all Florida counties. Any locations south of Key Biscayne were not in the survey boundaries, however, so it is difficult to be certain whether this was a factor that affected survey outcomes.

Table 28. Number of dive related businesses by county in the southeast Florida region.

Number of Dive-Related Businesses per county	Miami-Dade County	**Broward County**	Palm Beach County	Martin County
	29	**47**	34	4

The OFR survey had a high number of respondents (93%) who identified themselves as full-time residents. Because the survey was conducted during the winter and spring months, which are known for an increase in seasonal residents, it was thought that there would have been a higher number of part-time residents (Radcliff et al., 2005; Smith and House, 2006). However, these numbers are consistent with the findings in Shivlani (2006) that showed almost 91% of the survey respondents from Miami-Dade County and 93.5% of survey participants from Broward County identified themselves as full-time, southeast Florida residents.

The demographic results reveal that the majority of survey respondents were white and held a bachelor’s degree or higher. There were also more male than female survey respodents. This higher percentage of white males with an advanced education is consistent with many other coastal and ocean surveys. For example, the Johns et al. (2001)

socioeconomic survey showed the same statistics for reef users in southeast Florida. Demographic characteristics obtained from the resident boater survey and visitor boater survey conducted by Johns et al., (2001) showed that the typical reef user was a non-Hispanic, white male in his forties with an annual household income between $55,000 and $90,000. Another southeast Florida socioeconomic study by Shivlani (2006) noted having a sample that was over-represented by older, educated, Caucasian residents. In a study conducted the following year by Shivlani and Villanueva (2007), 95.3% of the sample identified itself as white. This demographic pattern was not only observed in southeast Florida, but in other states. The Washington Coastal Recreation Survey (Point Nine Seven, 2015) found that 57.3% of participants were male and 90.2% were white. Because survey participation was targeted rather than random, low participation by a demographic group does not necessarily indicate that the survey did not reach a demographic group (non-contact) but instead, that the demographic group may not be reef users or may not use the reef as intensely as another group. The high percentage of white male participants in this study and others (Johns et al., 2001; Shivlani and Villanueva, 2007) may show that this particular demographic uses the reef more often.

In addition to unequal survey participation between counties and demographics, there was also unequal survey participation between user groups. SCUBA diving activities were dominant over recreational fishing activities. Strong representation of this group could have been influenced by diving focused outreach, but also from the community connections divers have in southeast Florida. Shivlani and Villanueva (2007) recognized the strong and widespread, social networks that dive operations create and are part of within coastal communities. They point out:

> Unlike other user groups that are either limited to networks of their own groups (ex. recreational fishers) or are generally not linked to any other groups (ex. commercial fishers), dive operations in the SEFCRI region tend to be linked with national, regional, and local dive organizations, tourism groups, nongovernmental organizations, and chambers of commerce, among others. (p. 122)

The fishing community had low participation. The commercial fishing community was severely underrepresented with only 1 survey taken indicating 14 activity points.

Participation from commercial operators of recreational fishing boats were also very low with only two surveys. Commercial fishers were difficult to reach and was thus, not targeted as intensely as other user groups. A study in the Florida Keys alluded to the lack of participation by commercial fishers, stating that commercial fishers displayed a high degree of alienation from the public process (Suman et al., 1999). The independent nature and occupation of commercial fishers may explain this behavior. Shivlani and Villanueva (2007) describe the commercial fishing community as largely fragmented along an increasingly urbanized coastline of southeast Florida, with limited and costly dock space. They also point out that there was a substantial decline (40.4%) in state-issued commercial fishing licenses from 1995 to 2007. With the cost of coastal living continuing to increase, commercial fishing may not be a primary occupation for many people. It is difficult for commercial fishermen to compete with recreational fishermen, charter fishermen, and other non-fishing commercial users of harbor facilities (Schittone, 2001). A fisherman in the Florida Keys noted that charter fishing, diving, or sightseeing operations secure their money when they leave the dock. Commercial fishermen, in contrast, are not guaranteed any return when they go out, even though they may incur similar costs for fuel, mortgage payments, and boat maintenance (Schittone, 2001). In addition to commercial fishermen decreasing in numbers over the years, non-response error due to refusal to participate could have occurred. Although the survey was designed to keep locations private, confidentiality of both recreational and commercial fishing locations may have been a concern and thus a source for low survey participation.

There are a few considerations to be noted about the survey methodology that may have affected survey outcomes. These data cannot be extrapolated to the general population or be recognized as a complete representation of the activities being conducted offshore (LaFranchi and Daugherty, 2011). The survey outcomes are completely dependent on survey participation and the information that was provided.

Although an outreach campaign was conducted to solicit as many coastal users as possible within the allotted time and project budget, it was observed that some demographics and user groups showed higher participation and were thus represented more than others. This may be due to the outreach methods used to engage reef users. Methods used included event presentations, local stakeholder visits, emails, postcards, social media, and print media.

Survey outreach emails were sent to over 45 different groups targeting thousands of people. An FWC email list containing over 15,000 email address reached the greatest number of people. Efforts were also made to email all registered fishing license holders in south Florida totaling several hundred thousand emails but information privacy rules limited this effort. Social media included Facebook and Twitter account postings on various reef related group pages such as Florida's Coral Program, Protect Our Reefs, and Divers Direct. Articles were also posted on various internet-based forums such as *Scuba Board* and *Florida Sportsman*. Media groups also covered *Our Florida Reefs* and the survey including *The Sun Sentinel, The Fishing Wire,* and Nova Southeastern University's *Shark Bytes*.

The outreach method had a noticeable effect on the number of survey respondents. The highest peaks in survey participation occurred in 2014 on October 16, 22, and 23. The largest peak on October 23, 2014 accounted for the largest with 64 survey registrations. This date was associated with the Sun Sentinel media coverage. The second largest peak with 61 survey registrations was on October 16, 2014. This participation spike may be due to the social media posts created and shared that day. The FWC email to over 15,000 people on October 22, 2014 accounted for the third largest spike in survey participation with 45 survey registrations (Figure 71). Because the Sun Sentinel article and the FWC email occurred on consecutive days, it is difficult to determine which outreach effort actually produced more participation. In comparison to the OFR survey outreach, a World Wide Web survey study by Schillewaert et al. (1998) showed that on-line email databases yielded the highest number of respondents (35% of the total collected) and traditional media articles yielded the second highest number of respondents (31% of the total collected). In their study hyperlinks to the survey recruited the lowest number of respondents (14%). Survey collection numbers leveled off dramatically after mid-November. The first 500 surveys were collected in the initial three months between August 30th, 2014 and December 1st, 2014. The next two months (December and January) produced only 120 surveys (Figure 72). The cause of this drop in participation could be due to many factors and cannot be determined. Outreach effort was higher at the launch of the survey and was reduced toward the end of the survey. Also, those who were reached with initial outreach efforts may have been solicited again so subsequent outreach efforts may not have produced any additional surveys.

A website containing survey dashboard statistics was used to monitor registration numbers by date and time. Days showing increased participation were noted, as well as any outreach associated with that day. According to survey registration numbers by date, survey outreach may have been more successful if it were geared towards media and email outreach with less emphasis on in-person outreach. Visiting stakeholders personally may be a good way to engage survey participants because it makes them feel a stronger connection with the process, inspiring them to want to help make a difference. This outreach method was time-consuming, however, and did not result in the high number of participants that large group emails or print media did. Also, those groups who were given presentations may not make up a large proportion of reef users in southeast Florida. The socioeconomic study by Johns (2001) found that only 15-20% of the southeast Florida residents who participated in their survey belonged to a fishing or diving club.

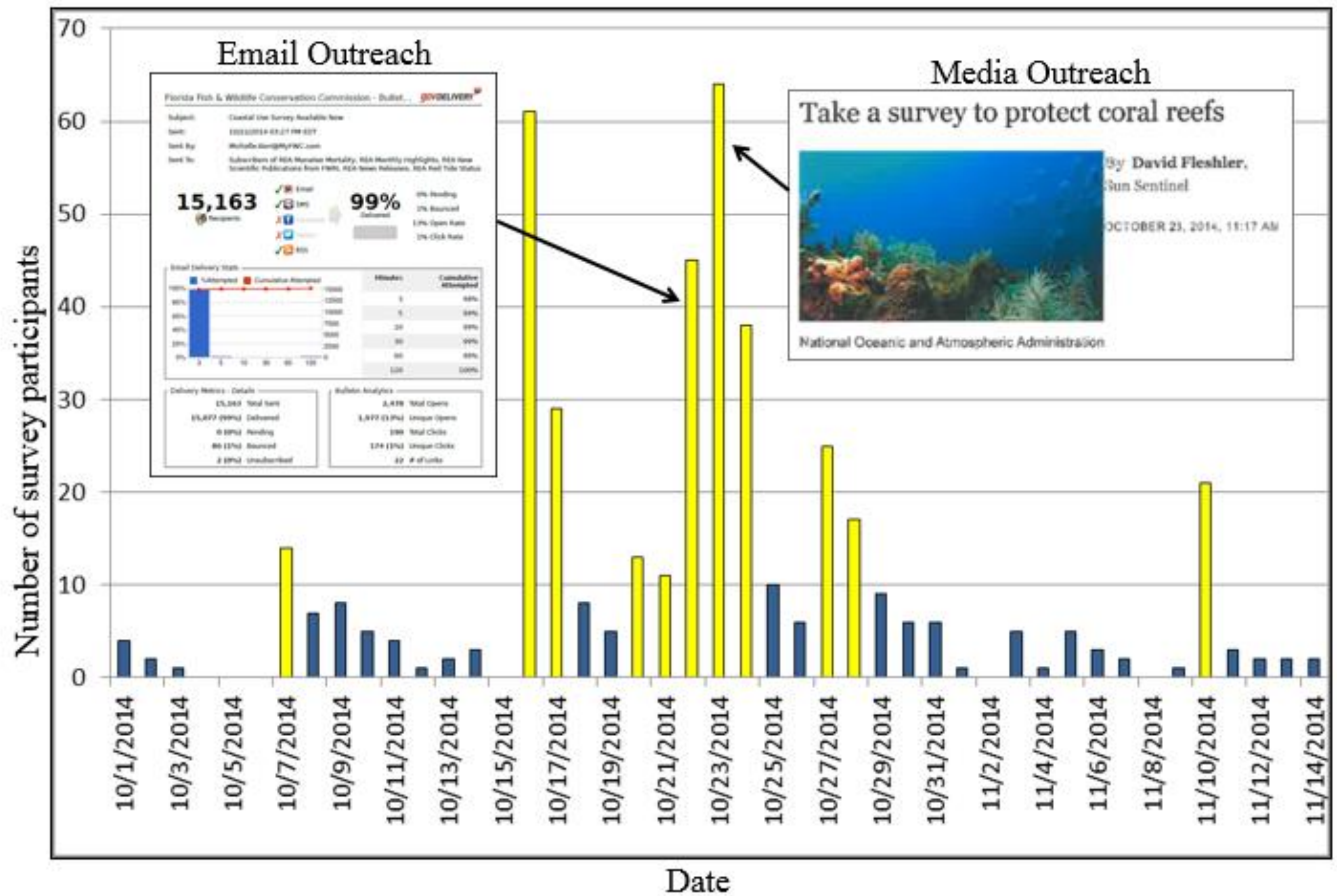

Figure 71. Graph of the number of participants who took the OFR survey from October when it opened to November 14th, 2014. These dates were chosen as they had the largest spikes in survey participation. The bars in yellow indicate that more than 10 surveys were taken that day. Within this date range, two outreach events caused large spikes, the FWC email to over 15,000 people on October 22nd, 2014 and the Sun Sentinel media coverage on October 23rd, 2014. The large spike on October 16th, 2015 may be due to the social media posts created and shared that day.

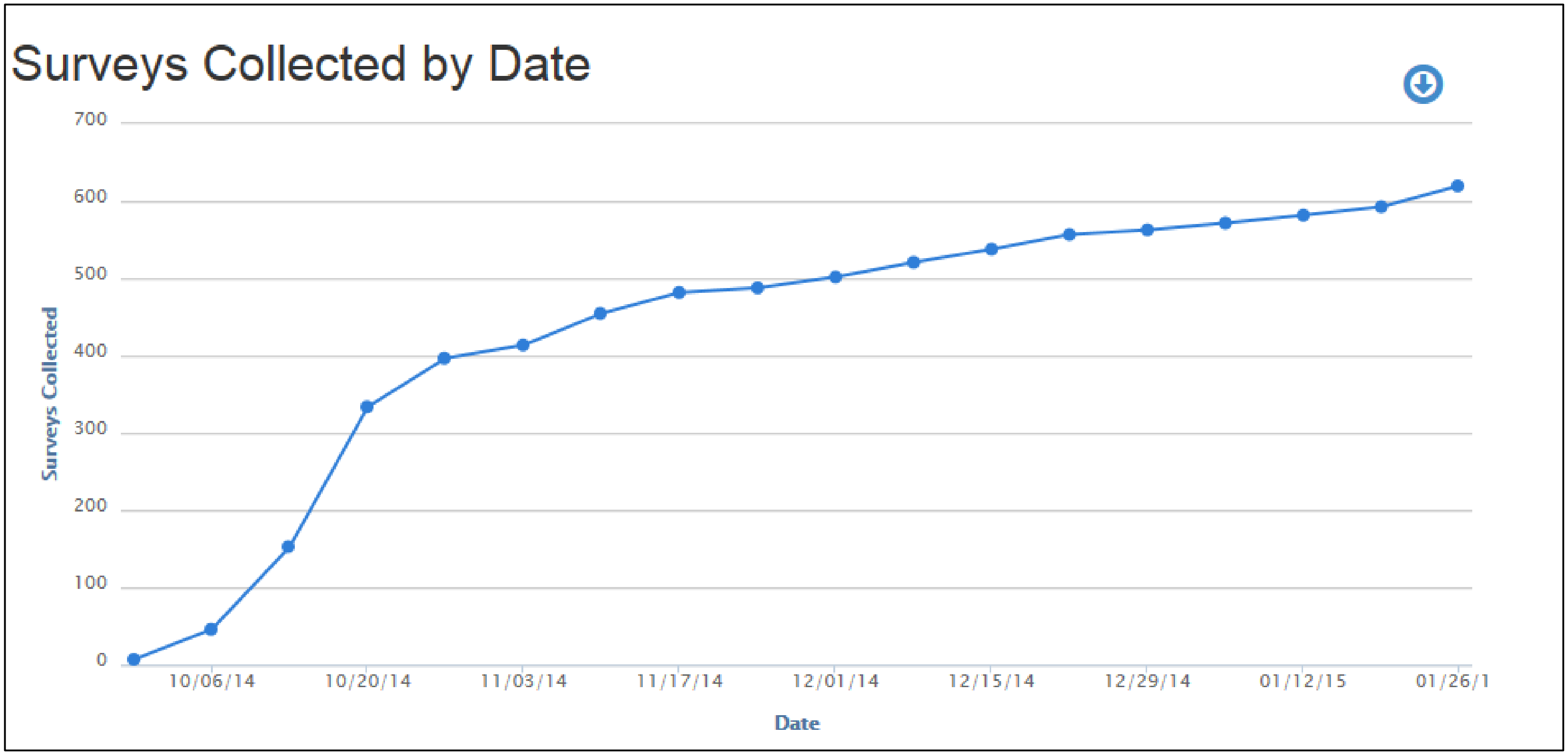

Figure 72. *Number of surveys collected by date from the start of the survey on August 30th, 2014 to January 30th, 2015. The first 500 surveys were collected in the first three months between August 30th, 2014 and December 1st, 2014. The next two months produced only 120 more surveys.*

5.9. Survey Method Considerations

The OFR survey was created as an internet-only survey for various reasons. Traditionally, survey methodologies have included face-to-face interviews, telephone interviews, and mail questionnaires (Fricker et al., 2005). The advancement of computer technology and rapid expansion of internet use, however, has caused internet surveys to rival these methods (Sills and Song, 2002; Fricker et al., 2005). They have a low cost, are easy to use, have fast delivery and response times, and simplify data management and analysis. Their design flexibility, geographic reach, anonymity, and minimized interviewer error often make them superior to telephone and mail delivery methods (Sills and Song, 2002).

These positive characteristics also come with some caveats. Web surveys may introduce confidentiality and internet security concerns as well as technological issues (Sills and Song, 2002). The main error types that need to be addressed in any survey are sampling error, non-coverage error, and non-response error. All of these error types introduce bias that is very difficult to eliminate in most real-world settings (Sills and Song, 2002) and some have speculated that they may be even higher in web-based surveys. Sills and Song point out that they offer relatively poor coverage of the general household population. Also, since the users are self-selected volunteers, response rates are impossible to calculate (Fricker et al., 2005).

Sampling error occurs when a selected subset of heterogeneous population does not accurately fit the population as a whole (Sills and Song, 2002). Non-coverage error occurs when the sampling frame does not cover all members of a population. These two types of errors were inherent in the OFR survey because it was a non-probability based survey. It did not aim to reach a representative subset of the population but instead aimed to gather information from a specific subset of the southeast Florida population who had used the reefs in the past year.

Non-response error results from the inconsistency between the observed participants and the entire population. Not all members in a population will respond to surveys and many studies have observed that younger and educated participants are overrepresented in internet-based surveys (Berrens et al., 2003; Boncheck et al., 1996; Kehoe & Pitkow, 1996; Pocewicz et al., 2012). Many studies have also pointed out that survey returns fall off at a rapid rate as a result of the fast-paced internet domain. If participants are going to complete the online survey, they do so within the first few hours or days (Crawford et al., 2001). For this reason, it was helpful to send email reminders shortly after the participant registered as well as on multiple occasions thereafter. Non-response error may also result from survey language or length. Sills and Songs (2002) points out that survey language and length may be important explanatory factors leading to survey abandonment and thus lower response rate. To avoid this, surveys must be carefully designed with clear and concise wording. It is also important to keep the survey short, while still collecting valuable data so that the participant does not lose interest or get frustrated and abandon the survey.

Survey participation outcomes could have been influenced by the aforementioned errors but also by the survey design. The survey was unique in that it allowed participants to provide locations using an interactive map. This gave the participants the opportunity to indicate a more specific location rather than having to describe a location or choose from a list of general locations. This method was used based on the premise that it would yield more accurate and detailed location results. The trade-off of this design was that it could complicated for some users and potentially lengthy depending on how many locations the participant had to log from the past year. These factors likely affected the number of completed surveys and the amount of data received. Participant comments relating to the survey design included "I only selected a small area of the areas we visit because it was going to be very time consuming to select each little grid", "Too many steps to add sites", and "Mapping was very tedious…" Many participants also found the mapping difficult to learn and counterintuitive. For example, participant comments included, "The mapping tool was a bit confusing" and "Mapping too clumsy". The difficult nature of the survey may have been a factor affecting the demographics of those who participated. Those who were more educated may have found the interactive map easy to learn and were thus more inclined to complete the survey. Descriptive statistics for the last completed survey question indicated that out of the 432 incomplete surveys, 334 of these had incomplete mapping questions, further demonstrating that mapping activity points may have been the most arduous for participants. Some participants with "Activities Information" as the final completed question did not begin the mapping question, while others entered locations but did not move on to the next question. It is important to note that although the mapping question was not saved in these surveys, these data were still available and used in the results summaries.

The interactive mapping could have been designed to allow users to select all planning units in which they conducted a given activity at one time however allowing participants to select point locations individually for each activity was chosen to collect use intensity data in addition to use location data. Requiring that the participant select individual point locations rather than multiple point locations allowed them to enter the number of days within the year that they visited that specific location for that specific activity as a proxy of use intensity. The importance of collecting the data this way was proven in the survey results. This design, however, may be more tedious and arduous for heavy users who have many points to enter. It was also problematic for those activities that were not necessarily associated with one place. For example, a drift dive along the reef, boating up and down the coast, or trolling for pelagic fish species are all activities that utilize a much larger area then could be indicated with this survey method. The participants had little guidance as to how to map such activities to accurately reflect their activity which may have resulted in incomplete surveys or inaccurate data. Some may have mapped multiple locations for one day's activity and some may have mapped one. These types of measurement errors are unknown. Despite the possible negative implications of this design, the benefits outweighed them.

Data was collected over a six month period, but the survey asked respondents to recall all activities they participated in within the past 12 months. This task may have been difficult for some, especially for those respondents who made many reef-related trips in the past year. Although a year-long period was chosen to include all seasons, it may have been more advantageous to collect data during two, six month periods, so that seasonal differences could be investigated. It was determined by Leeworthy et al. (2010), that visitors were significantly different across two different seasons in the Florida Keys. In their study, visitors were sampled January – April, for the winter season and June – August, for the summer season. Estimates from the two seasons were combined to also yield annual estimates.

5.1. Activity Grouping Effects on Results

Survey results are not only affected by coverage, nonresponse and measurement errors that may occur during data gathering but also by how the data are organized after they are gathered. The Community Working Groups chose groups of activities they felt would support their decision making process, however, there are other ways that these individual activities could have been grouped that may have altered the results. For example, the CWGs requested a recreational fishing activities group. For this group, it was decided that any fishing activity requiring a Florida fishing license (including spearfishing, lobstering, and collection for the aquarium trade) would be included. Often times these activities use SCUBA gear so they were accounted for in two groups, recreational fishing activities and SCUBA diving activities. When "Fishing Activity" only includes angling activity, and not fishing that occurs by SCUBA diving or freediving, the number of locations is reduced by 28.6% (Table 29). The number of data points as well as location of data points changes when the activities are grouped differently. The angling activity grouping shows points mainly around St. Lucie Inlet and on the Deep Ridge while the all recreational fishing activity grouping adds many data points that are nearshore and on St. Lucie Reef (Figure 73) due to the addition of fishing activity that uses SCUBA equipment. These activities tend to cluster closer to shore on hardbottom habitat.

Overlap of activities in multiple groups can also cause similarities in analyses. For example, in the Martin Coral Reef Ecosystem Region, the density of individual locations for "Recreational Fishing Activity" was moderate around the St. Lucie Inlet and along the Nearshore Ridge Complex where hot spot locations were also shown. These results are similar to those found for boating activities because of the strong overlap of boating and fishing activities in this area. A great deal of the recreational fishing activity in this region occurred by boat and thus was placed in both the "Boating Activity" feature and the "Recreational Fishing Activity" feature further demonstrating the importance of considering how to group activities according to the chosen objective before analysis.

Table 29. Example showing the difference in number of data points that results if recreational fishing activity is grouped differently

RECREATIONAL FISHING	
All Recreational Fishing Activities	329.0
Angling Activities	235.0
Difference	94.0
Percent Difference	**28.6%**

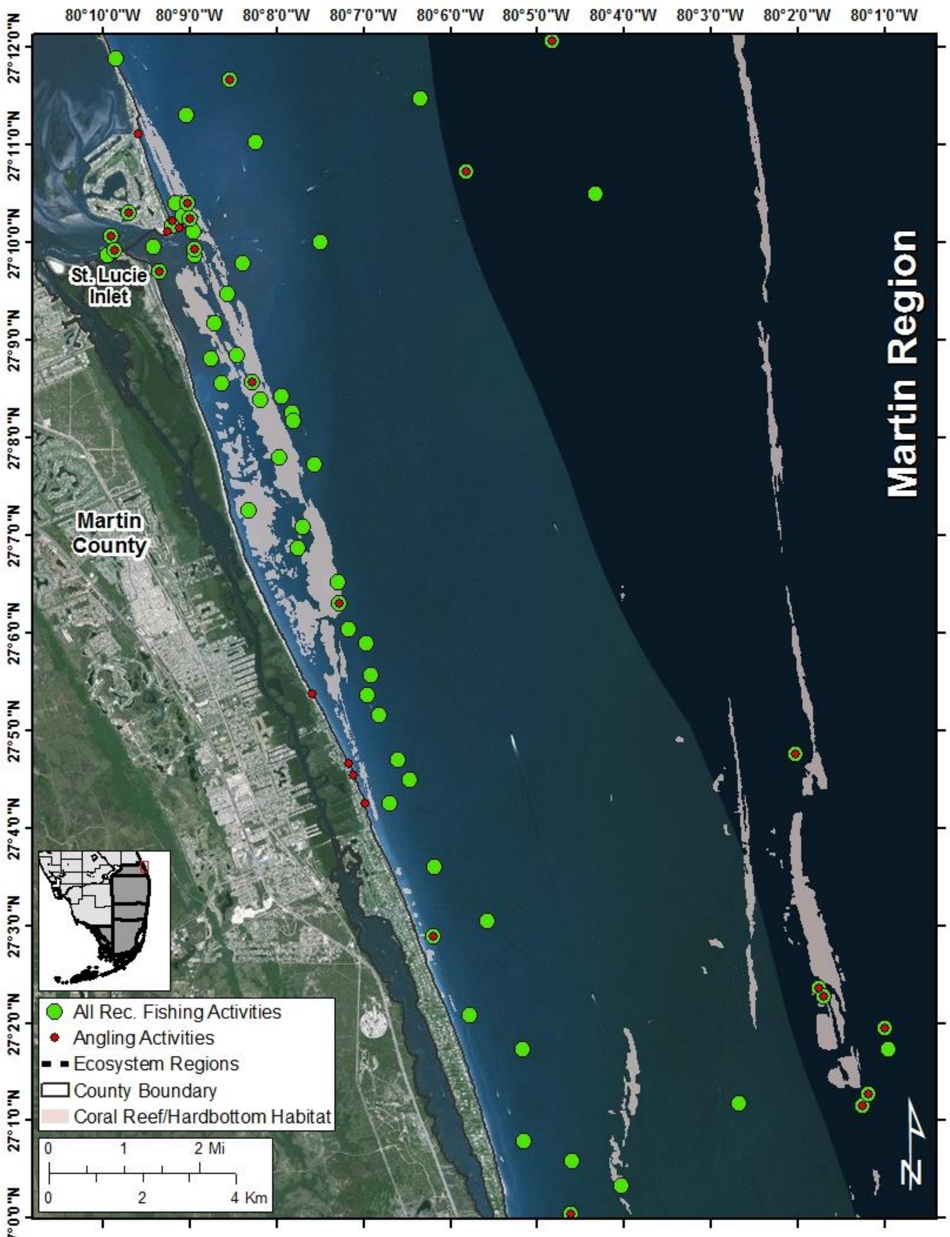

Figure 73. Map showing how the number and location of data points changes when individual recreational fishing activities are grouped differently.

For the SCUBA diving activities group, it was decided that only activities that used SCUBA equipment would be included, leaving out freediving and snorkeling activity. If the group did include freediving and snorkeling activity, 273 more locations would have been added to the group. These additional points could have affected the results of hot spot and point density analysis (Table 30). Johns (2001) noted that including snorkeling activity in addition to SCUBA diving activity also changed their survey results stating that:

> Overall, fishing activity on the reefs appears to dominate when snorkeling and scuba diving are compared separately. When snorkeling and scuba diving are considered together as diving activities, diving and fishing contribute about equally to total reef use in southeast Florida. (p. ES-3)

Ultimately, the groupings were chosen to best inform the development of recommended management actions, considering the objectives. Protection of the reefs was an important objective and thus it was important to consider activities that may cause stress to the reefs. Recreational fishing included all extractive fishing rather than just hook and line fishing because the groups wanted to look at activities that may cause impacts to the reef. Similarly, SCUBA diving activity was chosen over all diving activity because SCUBA diving allows user to get in close contact with the benthic habitat and thus may impose greater impacts than freediving or snorkeling. Divers can cause damage to marine organisms through direct physical contact with their hands, body, equipment and/or fins. Although the damage done by individuals is often insignificant, there is some evidence that the cumulative effects of these encounters can cause considerable localized damage (Rouphael and Inglis, 2001).

Table 30. Table showing how the number of data points changes depending on how individual activities are grouped.

DIVING	
All Diving Activities	1125
SCUBA Diving Activities	852
Difference	273
Percent Difference	**24.3%**

6. CONCLUSION AND RECOMMENDATIONS

The OFR survey gathered valuable data on reef use in southeast Florida that will be applied when developing management recommendations for the region. It showed that both where and how often activities are being conducted are relevant to the management of southeast Florida reefs. High use areas may be areas where potential conflict could emerge in response to a management recommendation. Understanding where these areas are can alert policy makers to avoid them or to design a process that includes conflict management and resolution techniques (Brody et al., 2004).

The results showed that the distribution of use in the SEFCRI region was not even among reef stakeholders. It was spatially clustered and occurred generally around inlets and piers. It also showed that the reefs in the Broward-Miami Coral Reef Ecosystem Region were used over a wider spatial scale than those north or south. In these areas, the coral reef and hardbottom habitat is extensive allowing use to spread out over a larger area. Regions with less reef habitat showed more concentrated use.

The results showed that use was not evenly distributed among user groups or between habitats. Some activities such as SCUBA diving occurred on hardbottom habitat more often than others, some activities occurred more often in some counties than others, and some habitat types were used more often than others. It was also found that the Nearshore Ridge Complex hardbottom habitat was the most-visited among all activities. The activity type not only differed by habitat but also by county. Recreational fishing was the dominant activity in Martin County while SCUBA diving activity was the lowest in this region. In both Palm Beach and Broward counties, recreational fishing activity and SCUBA diving activity was fairly equal. Similar to Martin County, Miami-Dade County was dominated by recreational fishing activity.

Based on the success of this spatial survey and the lessons learned, the following are a list of recommendations for future surveys:

1. Repeat a similar survey after management actions are implemented to understand how activities spatially change in response to the management action.
2. Develop the survey so it can be downloaded as a smart phone application with GPS and tracking capabilities so participants could log their location instantly and

accurately. This way may yield more data as participants would not need to go back later to log a location from memory.

3. Be designed for both one-time and daily users as well as users who cover large areas.
4. Continue to collect data on both location and intensity of reef use.
5. Continue to provide detailed activity options so all users are represented.
6. Include an opt-out option or an option that indicates they did not qualify to take the survey (e.g. no use in survey area within timeframe).
7. Engage certain stakeholder groups (e.g., commercial fishers) more intensely.
8. Include a video tutorial to show participants how to use the mapping interface to find and select their locations.
9. Possibly break up the survey into two six month time frames, rather than one year, to understand seasonal differences in reef use.

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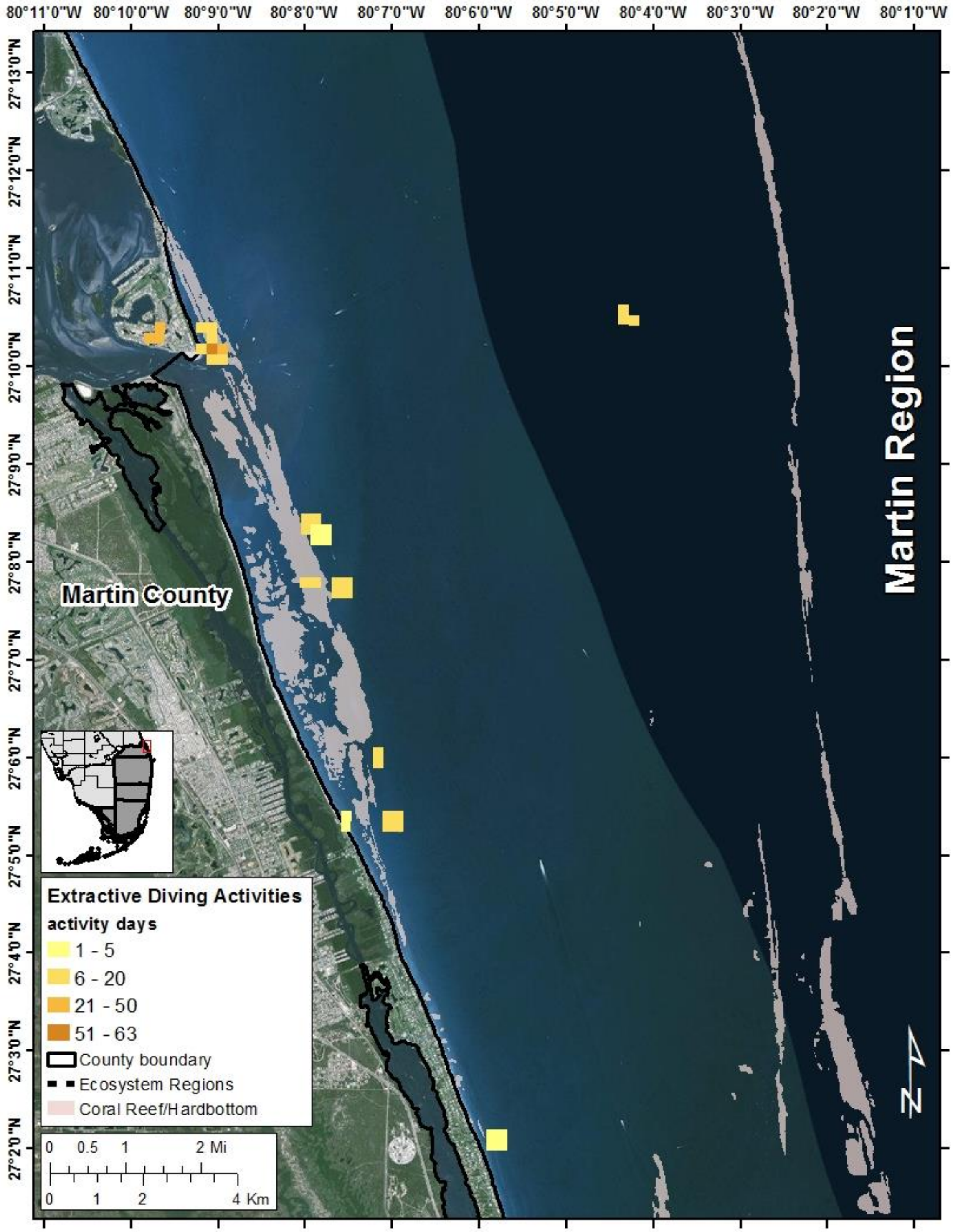
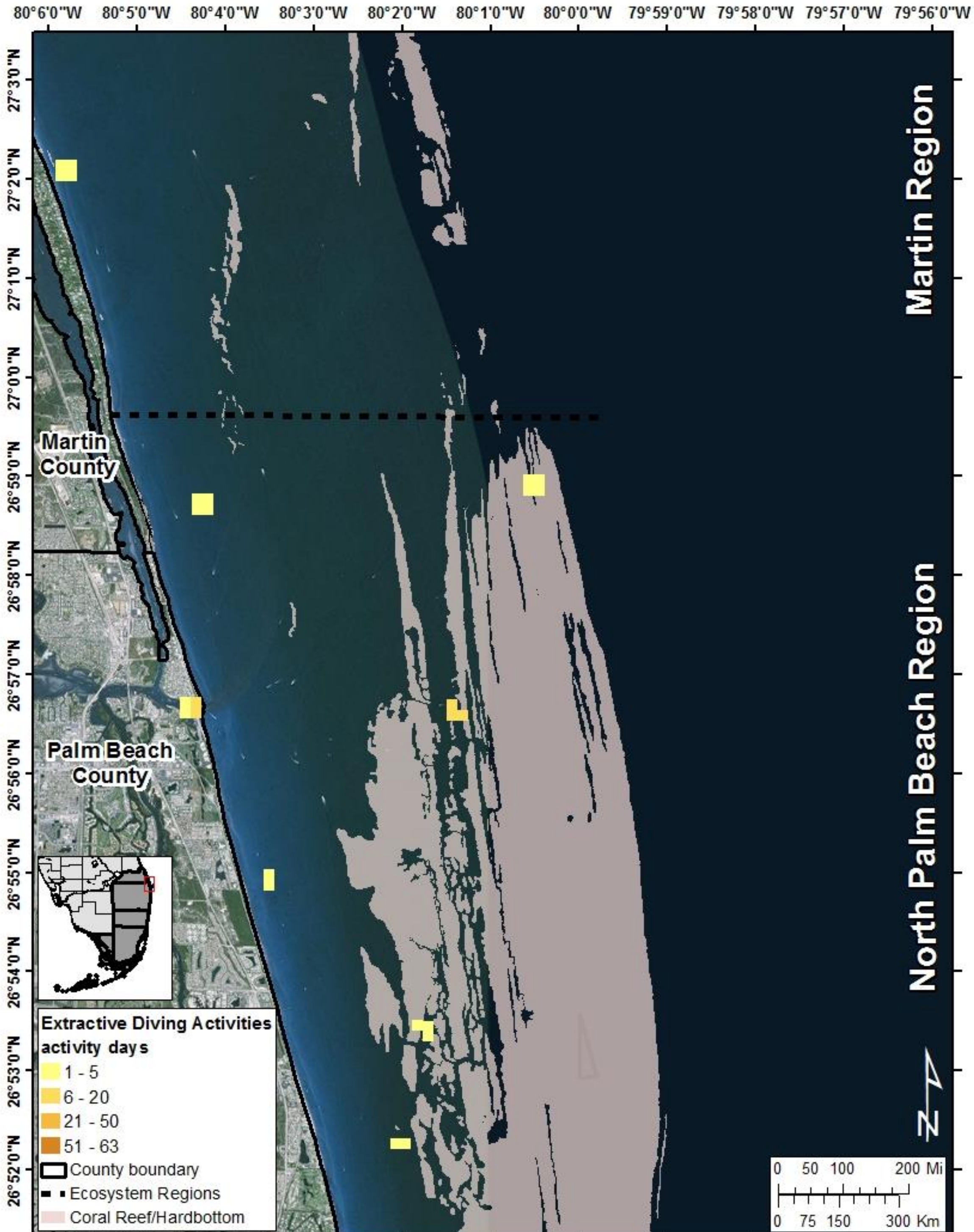
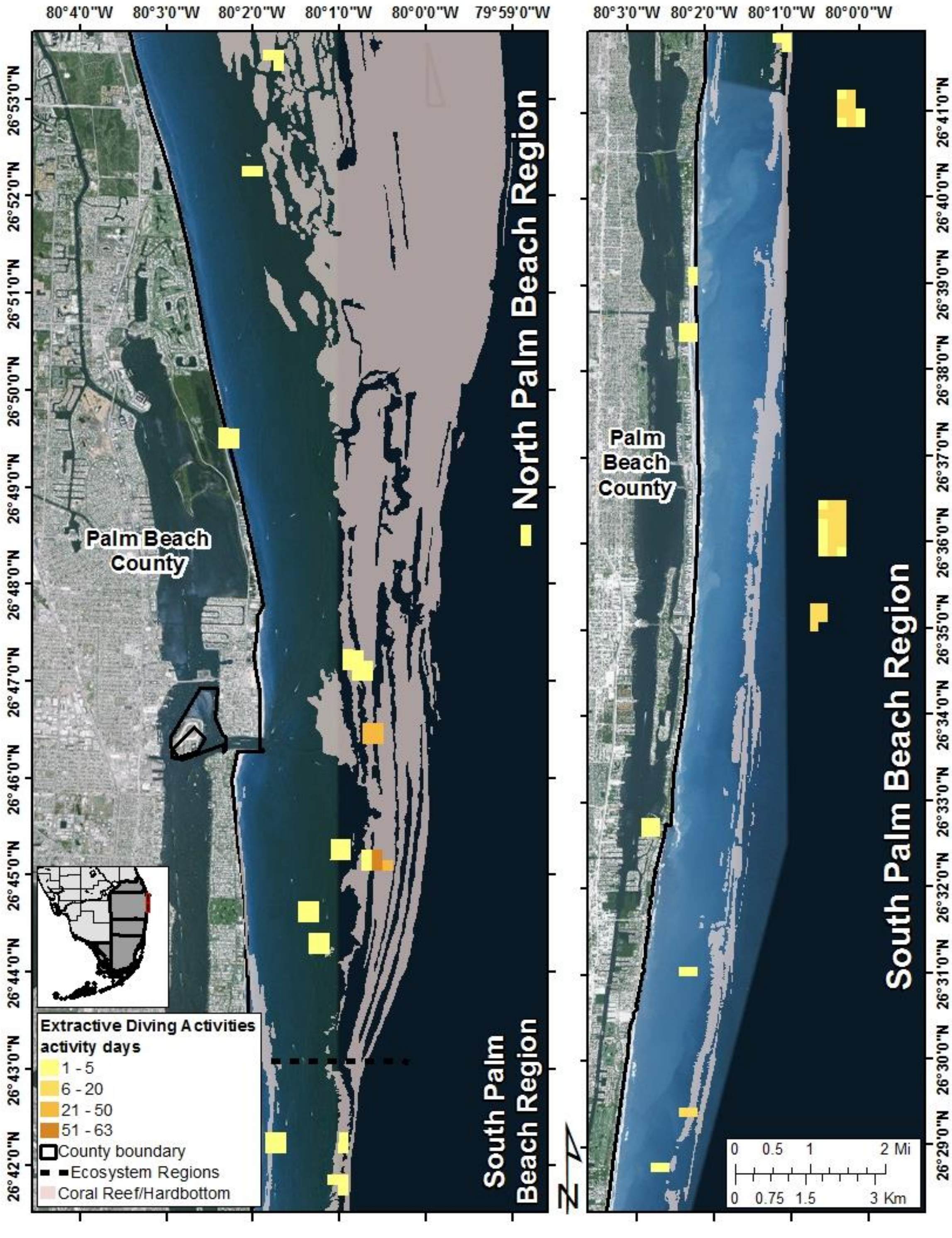
Appendix A Extractive Diving Activities



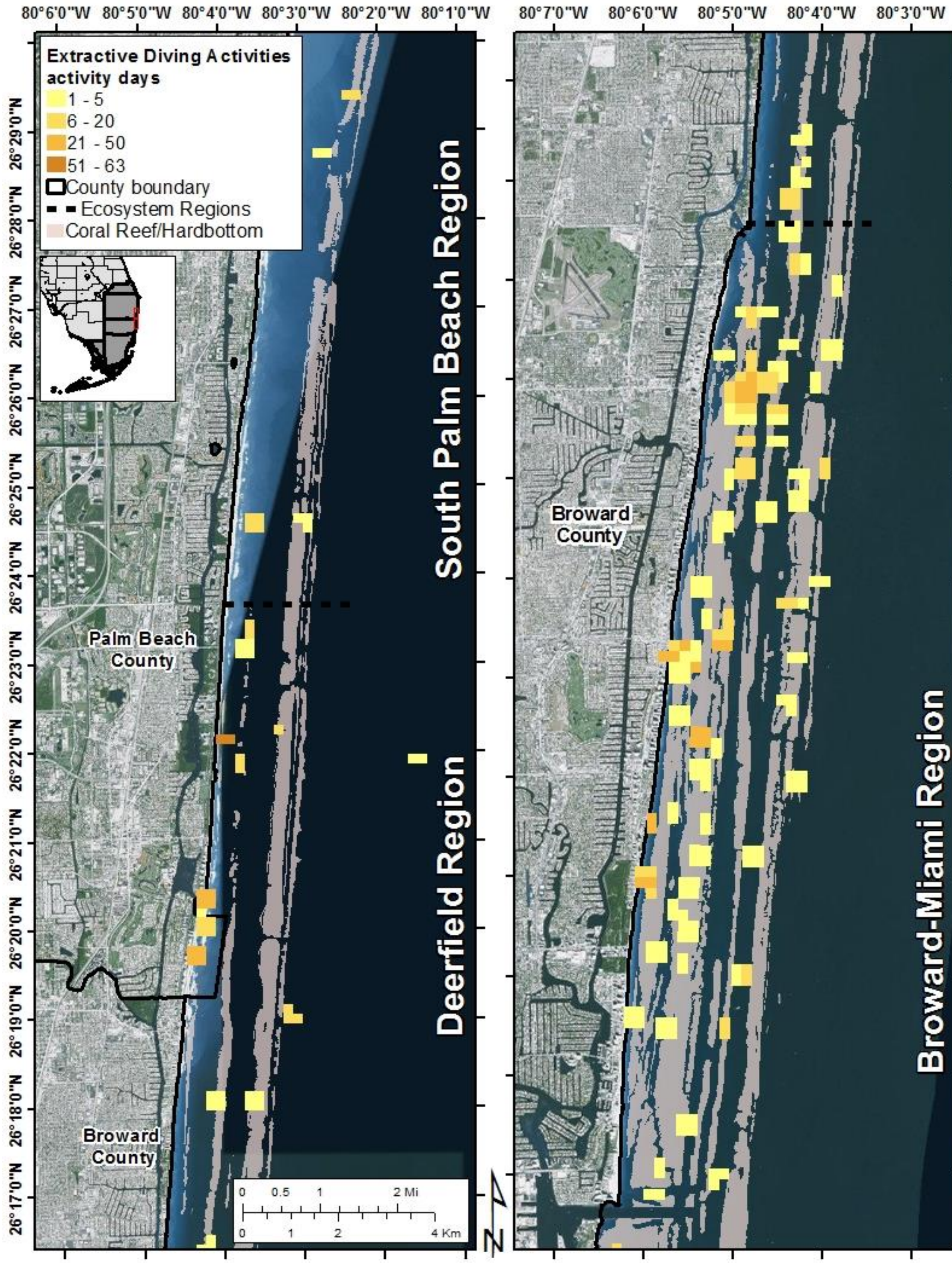
A- 1. Map of final survey results displaying the total number of activity-days per planning unit for extractive diving activities within the Martin coral reef ecosystem region.



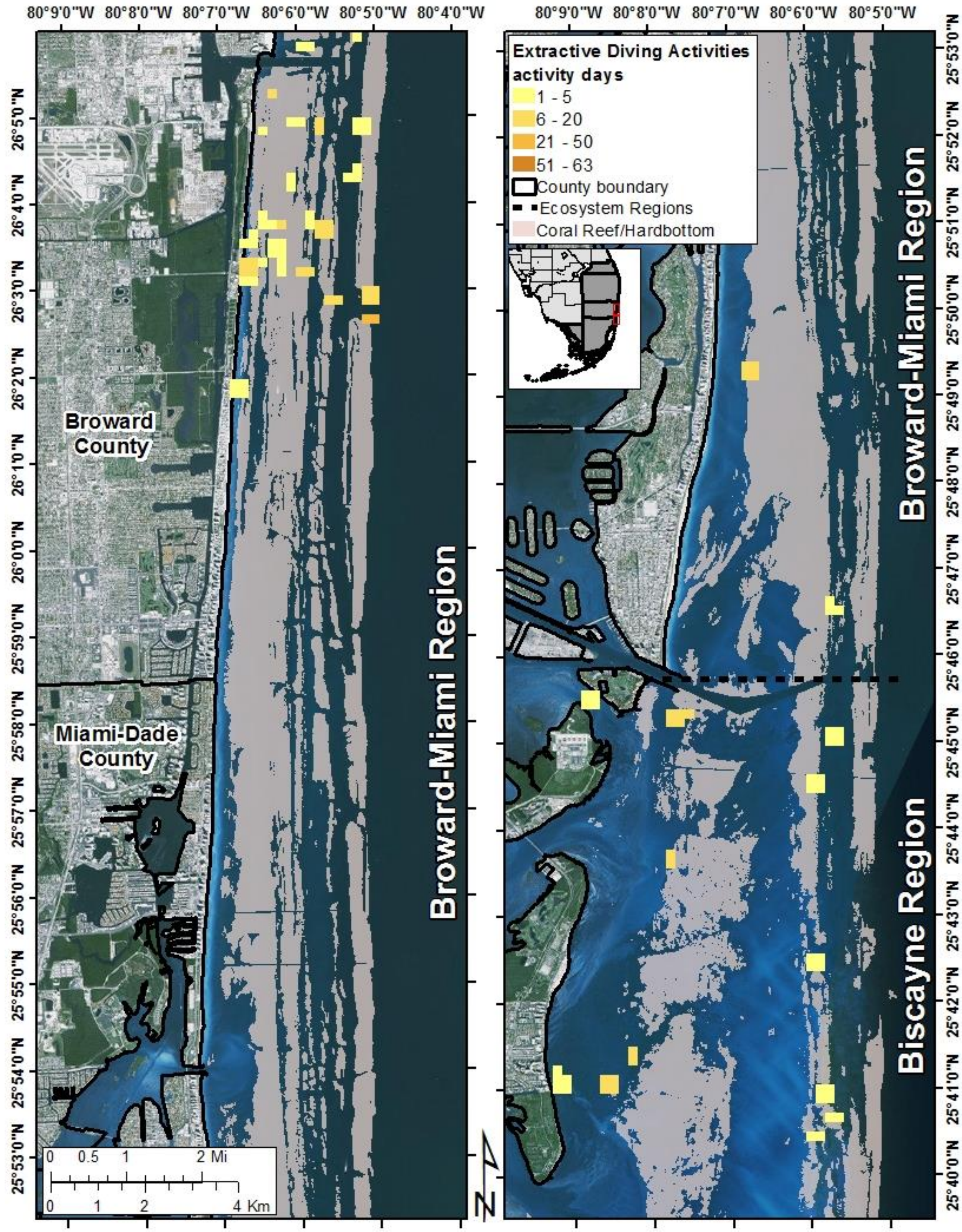
A- 2. Map of final survey results displaying the total number of activity-days per planning unit for extractive diving activities within the Martin and North Palm Beach coral reef ecosystem regions.



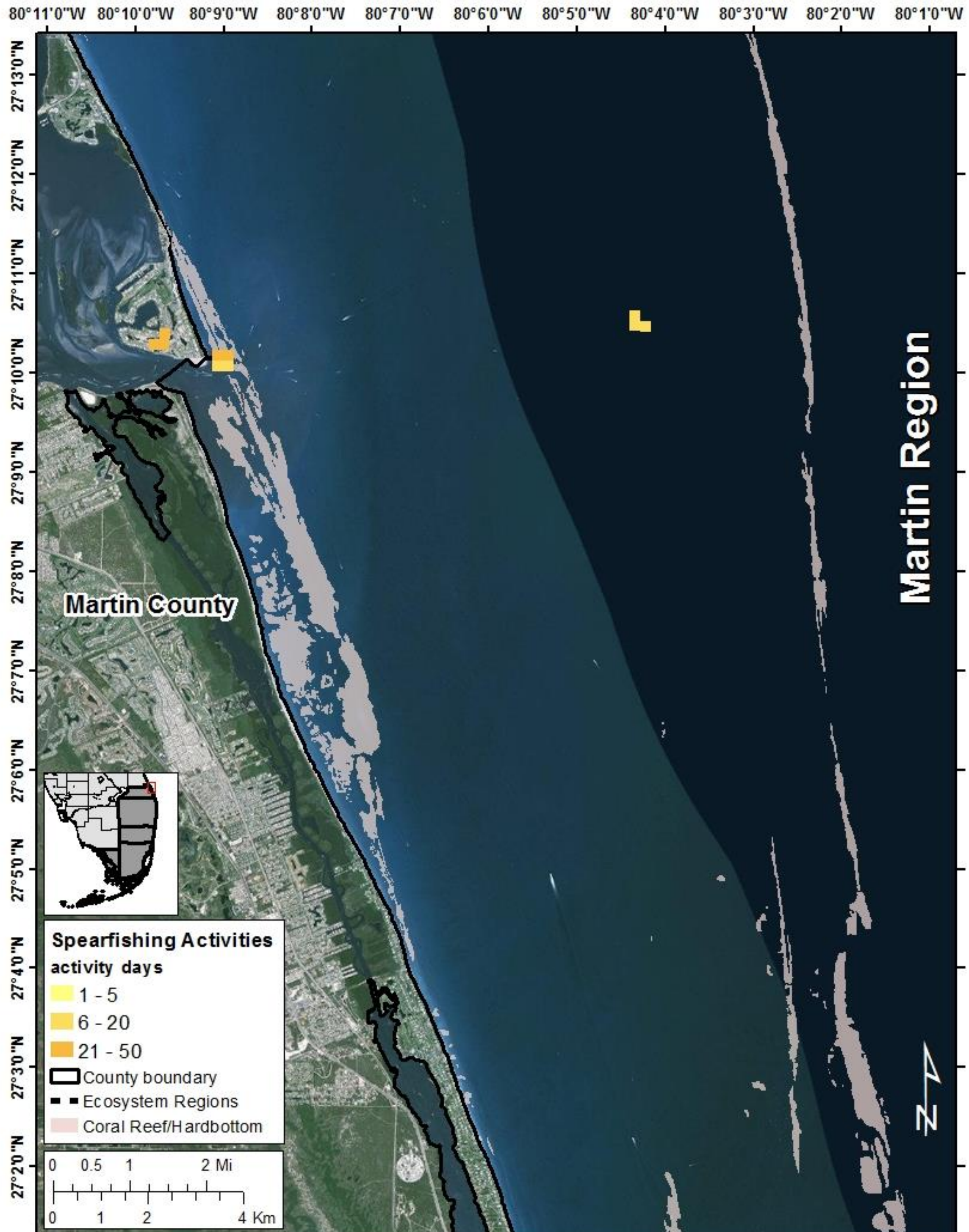
A- 3. Map of final survey results displaying the total number of activity-days per planning unit for extractive diving activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions.



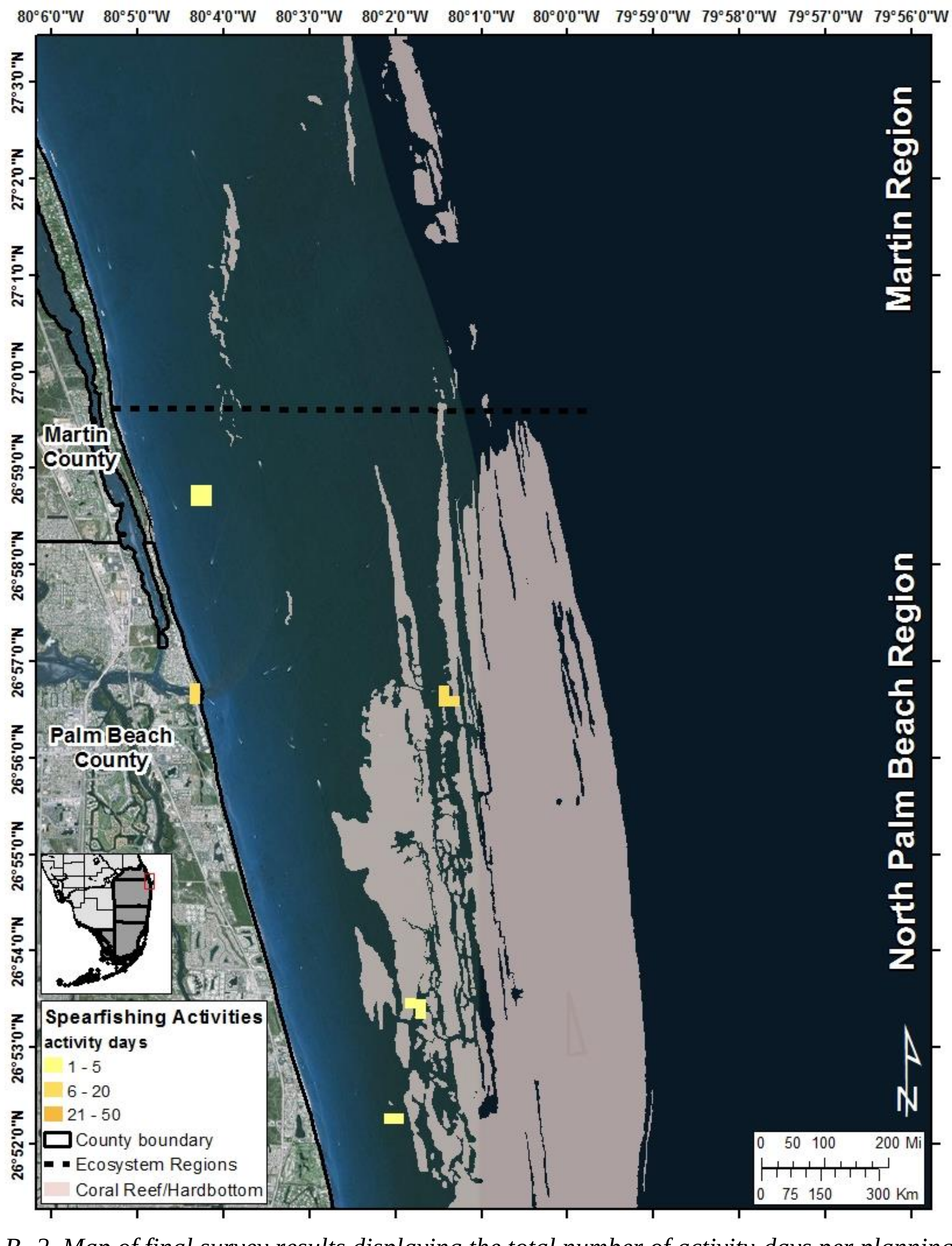
A- 4. Map of final survey results displaying the total number of activity-days per planning unit for extractive diving activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions.



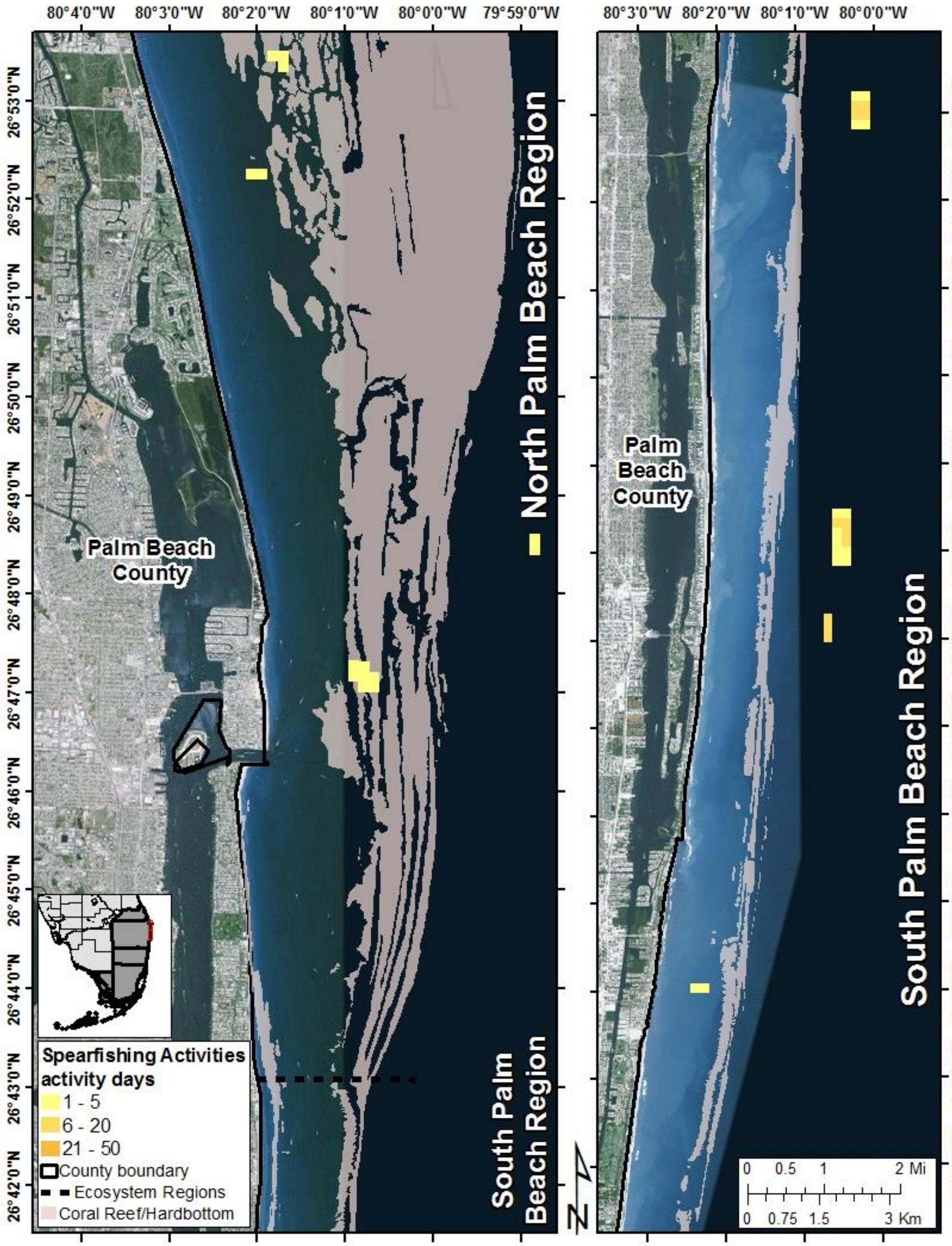
A- 5. Map of final survey results displaying the total number of activity-days per planning unit for extractive diving activities within the Broward-Miami and Biscayne coral reef ecosystem regions.



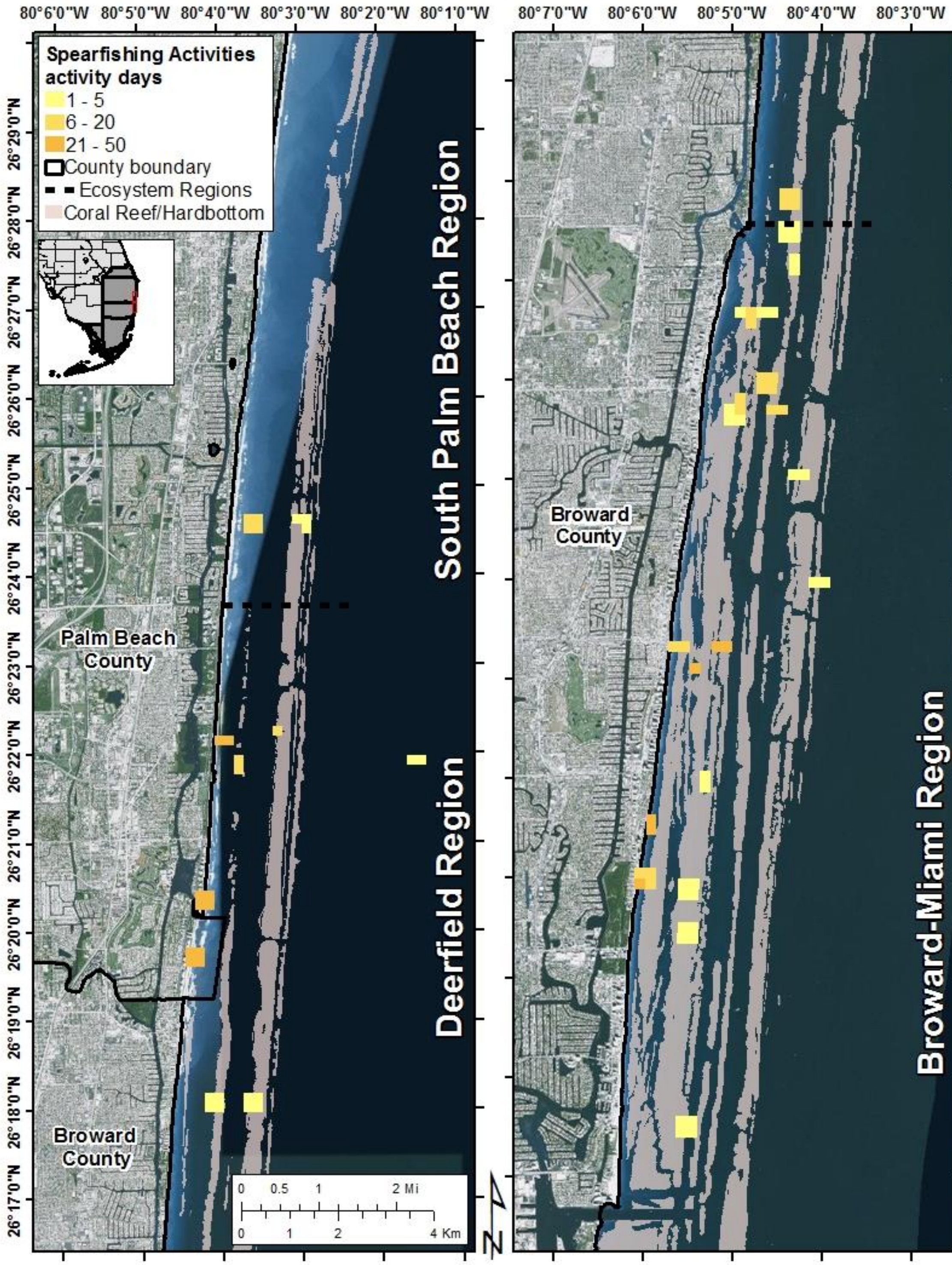
B- 1. Map of final survey results displaying the total number of activity-days per planning unit for spearfishing activities within the Martin coral reef ecosystem region.



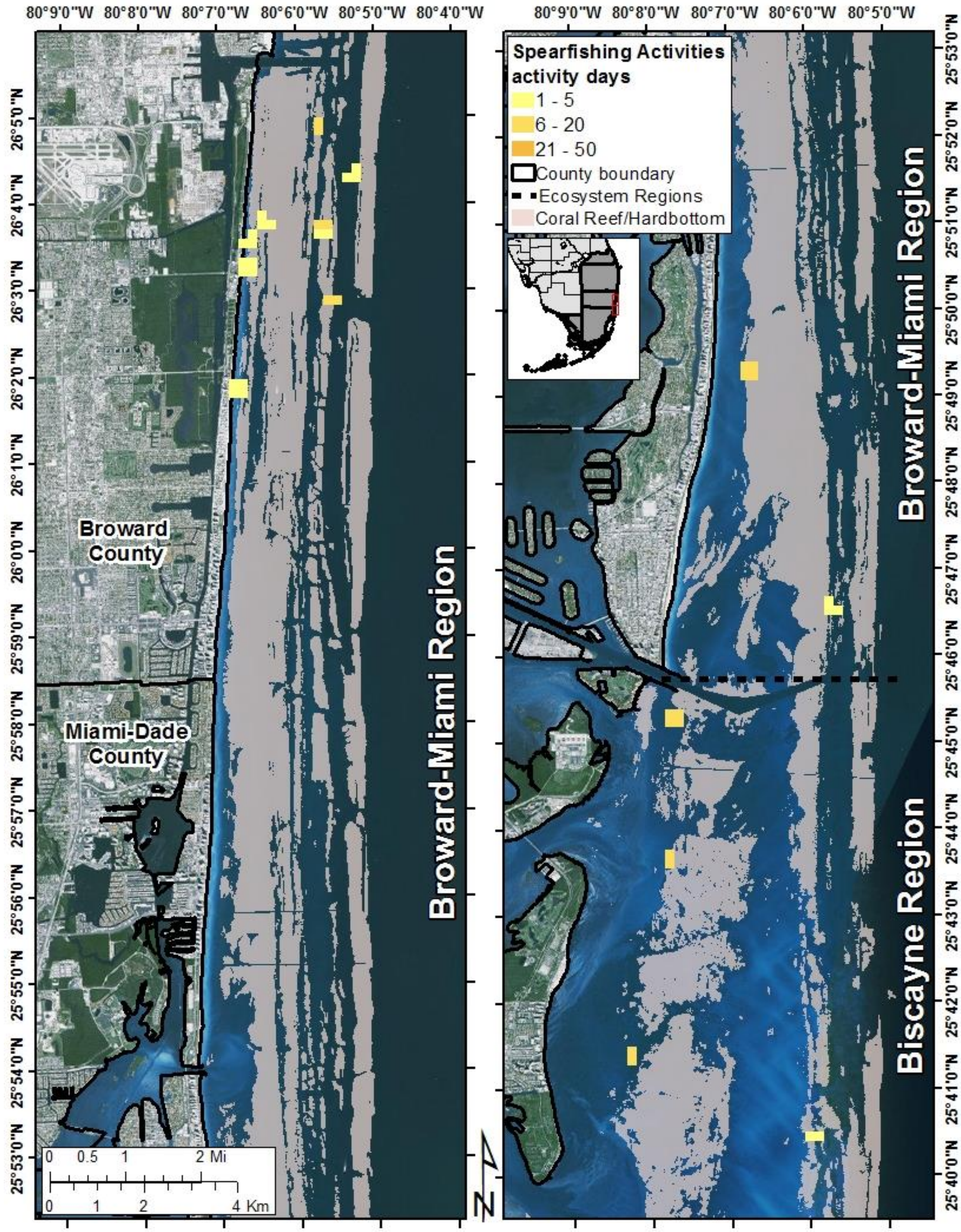
B- 2. Map of final survey results displaying the total number of activity-days per planning unit for spearfishing activities within the Martin and North Palm Beach coral reef ecosystem regions.



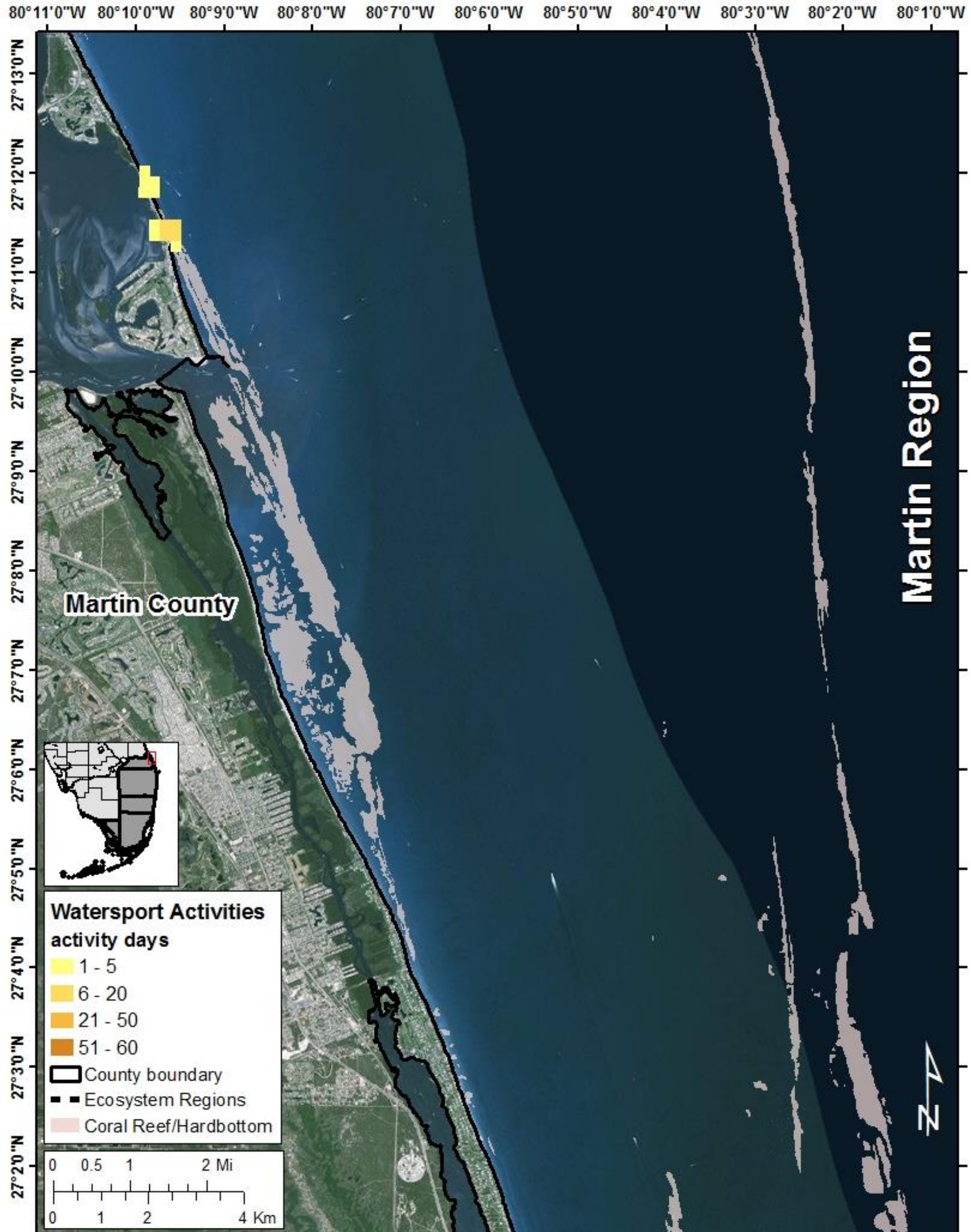
B- 3. Map of final survey results displaying the total number of activity-days per planning unit for spearfishing activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions.



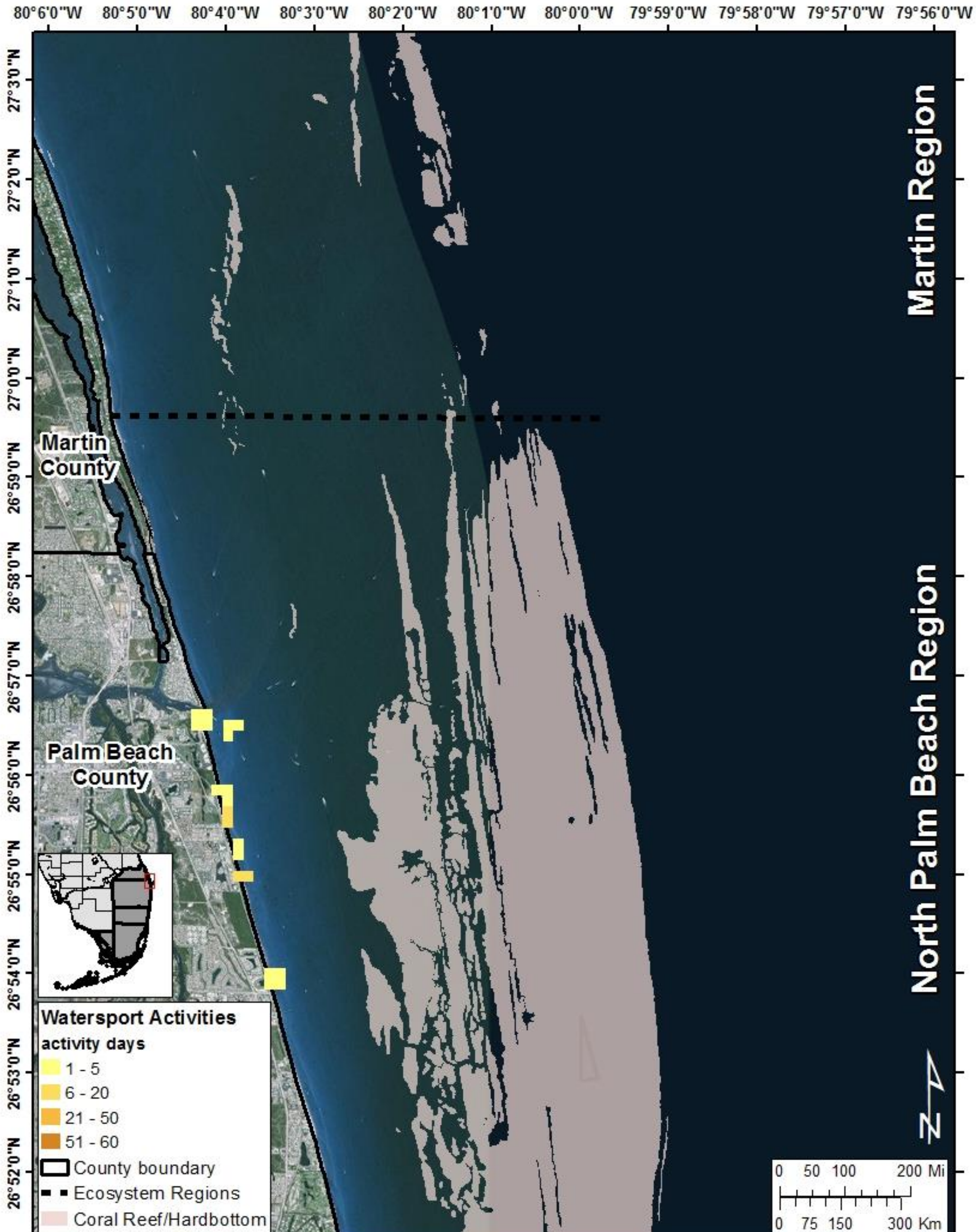
B- 4. Map of final survey results displaying the total number of activity-days per planning unit for spearfishing activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions.



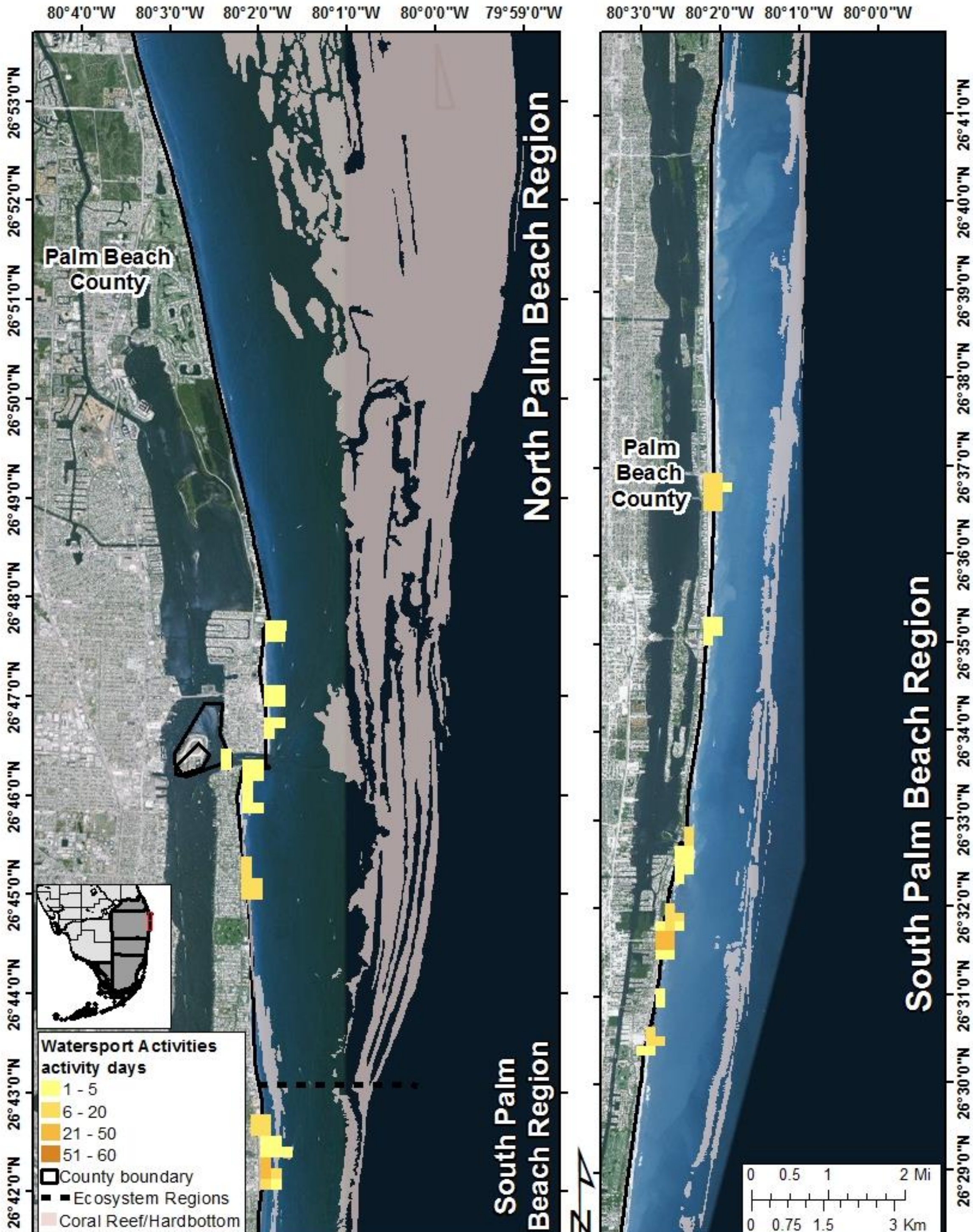
B- 5. Map of final survey results displaying the total number of activity-days per planning unit for spearfishing activities within the Broward-Miami and Biscayne coral reef ecosystem regions.



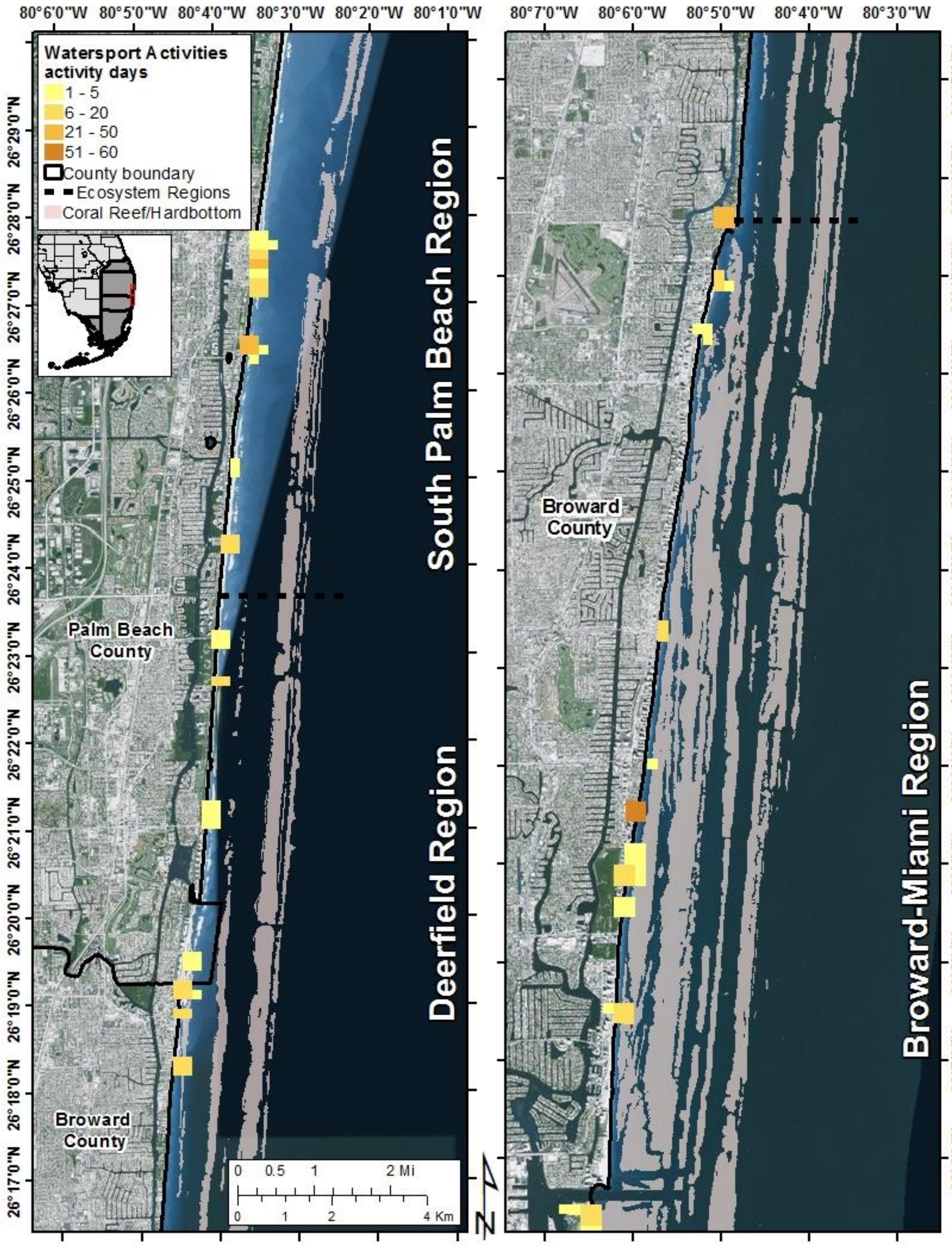
C- 1. Map of final survey results displaying the total number of activity-days per planning unit for watersport activities within the Martin coral reef ecosystem region.



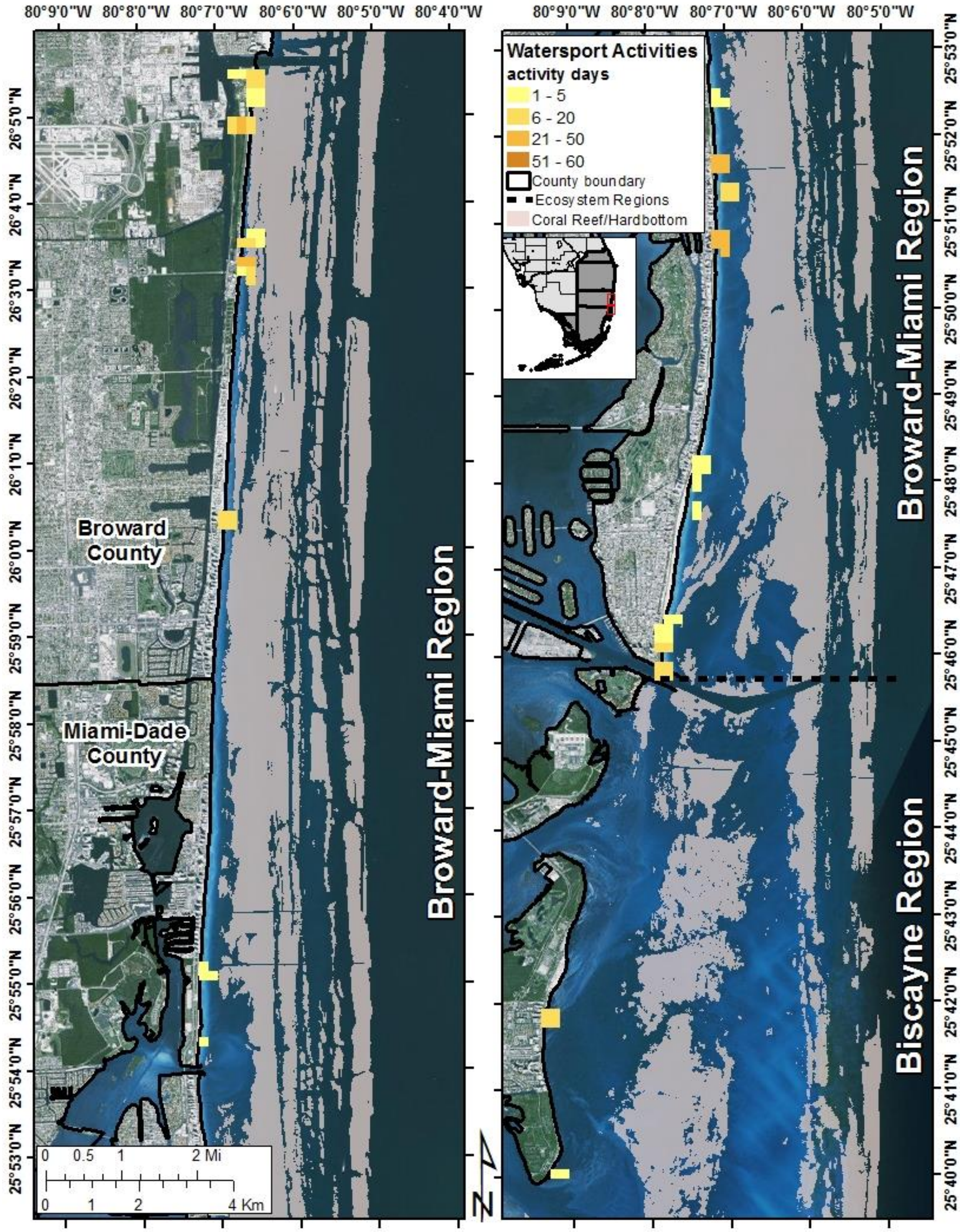
C- 2. Map of final survey results displaying the total number of activity-days per planning unit for watersport activities within the Martin and North Palm Beach coral reef ecosystem regions.



C- 3. Map of final survey results displaying the total number of activity-days per planning unit for watersport activities within the North Palm Beach and South Palm Beach coral reef ecosystem regions.



C- 4. Map of final survey results displaying the total number of activity-days per planning unit for watersport activities within the South Palm Beach, Deerfield, and Broward-Miami coral reef ecosystem regions.



C- 5. Map of final survey results displaying the total number of activity-days per planning unit for watersport activities within the Broward-Miami and Biscayne coral reef ecosystem regions.