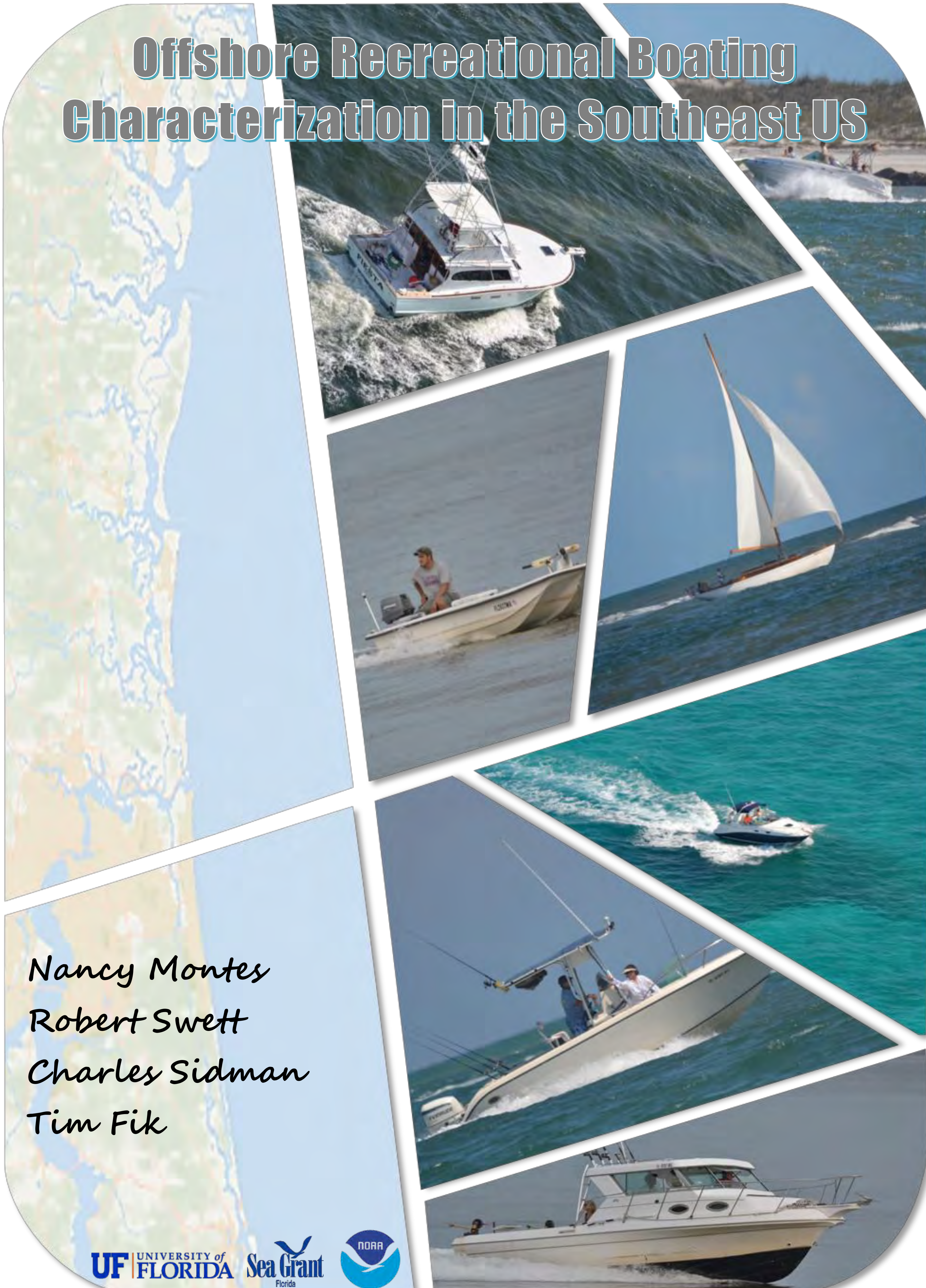
Offshore Recreational Boating Characterization in the Southeast US



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A publication of the University of Florida Sea Grant Program. The project was funded by the Southeast Regional Office NOAA Fisheries Services pursuant to National Oceanic and Atmospheric Administration Award number NAI00R4170079; by the University of Florida; by the Florida Sea Grant Program. The views expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, NOAA, or any of their sub agencies.

TP-226
December 2016

Offshore Recreational Boating Characterization in the Southeast US

by

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Acknowledgments

This initiative was implemented through a coordinated effort of local, state and federal agencies to help provide for enhanced recreational boating access to the coastal waters of northeast Florida and southeast Georgia. This multi-year project was funded by Southeast Regional Office NOAA Fisheries Services pursuant to National Oceanic and Atmospheric Administration Award number NAI00R4170079; by the University of Florida; and by the Florida Sea Grant Program.

The success of this project relied upon the individual contributions of various team members. Principal Investigator Robert Swett and Charles Sidman (Florida Sea Grant) were responsible for project administration, overall design of the questionnaire and correspondence, sample selection, the GIS database design, and reporting. Timothy Fik (Department of Geography, University of Florida) performed the statistical analyses. Nancy Montes conducted the spatial and abundance analysis of seasonal use. David Fann provided suggestions to improve the map layout and design. Maia Maguire (Florida Sea Grant agent), Captain Mike Getchell (harbor safety chair of Jacksonville Marine Transportation Exchange, Inc.), and Captain Jim Suber (Waterways coordinator and dock Master of the city of Jacksonville) provided suggestions for the mail survey questionnaire. Len Kreger, David Thrall, Jenna Manis, Scott Runnion, John Milio, Mason Smith, Rick Edwards, Howard Lawson, and Gordy Schleissing, Chris Swett, Katherine Malachowski, Althea Hotaling, Namyun Kil, and Daniel Soto spent long hours under rough conditions to record recreational vessels transiting the three main inlet of the study area. Chris Swett and Nancy Montes managed and processed spatial and attribute data from the returned surveys. Barb Zoodsma (NOAA), Timothy Gowan (FWC), Joel Ortega-Ortiz (FWC) and all people involved in the Early Warning System collected the spatial and temporal right whales and recreational vessel sightings that were used in the last part of this report.

We especially thank the many boaters who donated their time to complete and return the questionnaires. It is our intention that this work will provide information products and outreach support of benefit to boaters who use the offshore waters of the northeast Florida and southeast Georgia region.

Abstract

The recreational boating study described by this report resulted from a collaborative partnership between the NOAA Fisheries Southeast Regional Office, Florida Fish and Wildlife Conservation Commission (FWC), and the University of Florida Sea Grant College Program.

This report documents the methods, procedures, and findings of a map-based mail survey that was distributed (October 2012) to 5,034 boaters using the offshore waters of northeast Florida and southeast Georgia region. The study seeks to obtain seasonal and spatial information about boating preferences, use profiles, travel patterns, relative seasonal abundance. Additionally, we analyzed the relative probability of co-occurrence between the North Atlantic right whales and offshore recreational vessels in the study area using information provided by the Early Warning System (EWS).

Questionnaire recipients were asked to mark the start and end points of their two most recent recreational boating trips, draw the associated travel routes, and identify boating destinations and activities along these routes. They were also asked to mark destination points along with the described routes. Data collected from 958 returned surveys (19.03% overall return rate) were digitized into the ESRI ArcGIS geographic information system (GIS). This translated to a sample of 2,522 trip departure sites and travel routes and 1,881 boating destinations.
It is this spatial representation that serves to distinguish this study from previous efforts to characterize (i.e., profile and describe) boating patterns. Boaters drew hundreds of individual seasonal boating trips on provided maps. This spatial information and linked attributes were then entered into a GIS. Further descriptive data about the mapped trips, such as timing and vessel type, and independent data about the respondent's typical boating trips, including preferences determining departure sites and travel routes, and frequency, can be linked to the data within the GIS, for further analysis.

Information products generated from this study include:

1. A profile of boaters who access offshore and inlet areas in the northeast Florida and southeast Georgia region for recreation
2. A profile of the types of recreational vessels operated on offshore and at inlet areas in the study area
3. A description of boater preferences as to waterway access facility amenities
4. A summary of principal problems and needs perceived by offshore recreational boaters in the study area
5. An estimation of the relative seasonal abundance of offshore recreational vessels
6. Spatial data formatted within a GIS that can be used to map:
    a. service areas for boating facilities
    b. departure or launch sites
    c. water-based boating destinations
    d. distribution and overlap of recreational vessel with other maritime activities and\or wildlife
7. An evaluation of seasonal aspects for many of the information products listed above.

This report is divided into four parts. Part 1 discusses the survey design, mailing implementation, and data collection. Part 2 presents the results of a statistical analysis of survey questions and compares seasonal differences in use among survey respondents. Part 3 presents the results of spatial analyses of offshore and inlet use patterns. A GIS density function identifies travel corridors and boating destinations. Statistically significant “hot spots” and autocorrelations on the recreational boating trips are identified. A capture-recapture analysis is presented at the end of Part 2, which allows the estimation of the seasonal relative abundance estimate of offshore recreational vessel. Par 4 presents the result of the relative probability of co-occurrence between recreational vessels and the North Atlantic right whales using the sightings per unit effort (SPUE) method.

Part 1-Study Design

1.1 Introduction

Background

Boating is a key element in Florida's coastal lifestyle and growth phenomena. Florida ranks first in the nation in recreational boat registrations, with 901,969 registered in 2012 (FDHSMV, 2013). On average, this represents approximately one boat for every 21 residents. Coastal development, the ever-increasing number of boaters, and the diversity of recreational boating activities that now take place within Florida's coastal bays, estuaries, and waterways have had positive economic impacts, but have also profoundly altered the coastal estuarine environment (Letson, 2002; Antonini, Fann & Roat, 1999). As demand for the use of Florida's waterways increases, so does the need for enhanced public access, maintenance of waterway infrastructure, public safety, and environmental protection. There is, however, little information available to resource managers and planners that describes the actual use patterns and preferences of the offshore boating community.

The study area comprises the offshore waters of Nassau, Duval, St. Johns, Flagler, and Volusia counties in Florida and Camden and Glynn counties in Georgia. This area is noteworthy for its many water-based anthropogenic activities, including three major ports (Brunswick, Fernandina, and Jacksonville), two major naval stations (Mayport in Jacksonville and Kings Bay in St. Marys), and an unknown number of commercial and recreational vessels that use offshore waters. In addition to the 19,890 boats registered in the county[1], an unknown number of boaters travel to the area from other Florida counties, neighboring states, and from other countries (e.g., Canada).

The study area faces the difficult yet critical management challenge of sustaining economic viability while maintaining the integrity of coastal environmental resources. Over a million people[2] inhabit the five coastal counties of the study area (Census, 2012) and there were over 55,000[3] recreational boats registered in these counties in 2012 (FLHSSMV, 2013; GA Wildlife Resource Division, 2013). The study area has over one boat for every 23 residents.

The offshore waters of the southeastern United States (U.S.) provide the only known calving and nursing ground for the highly endangered North Atlantic right whale (*Eubalaena glacialis*), with an estimated population of 450 individuals (Kraus et al., 2005). Great efforts have been conducted to mitigate adverse effect of encounters between right whales and humans, especially ship collisions with whales, which have been identified as the whales' main cause of death (Kraus et al., 2005). Some studies have documented the probability of encounter between right whales and commercial ships (65 ft or greater) in the study area (Ward-Geiger et al., 2005; Fonnesbeck et al., 2008; Vanderlaan et al., 2008; Lagueux et al., 2011). However, information about the spatial distribution and overlap of recreational vessels (less than 65 ft in length) with right whales is limited (Hain et al., 1994). Nevertheless, quantitative estimates of

[1] Florida Fish and Wildlife Conservation Commission (myfwc.com/law/boating/), 2012.
[2] According to the Census Bureau the population estimate for 2012 for the 5 counties in the study area was 1,288,843.
[3] According to the Florida Department of Highway Safety and Motor Vehicles in 2012 there were 47,646 vessels registered in Nassau, Duval, and St Johns counties. According to the Georgia Department of Natural Resources in 2012 there were 132,424 vessels registered in Camden and Glynn counties.

whale/recreational vessel co-occurrence are scarce and little is known about their spatial distribution.

For optimum utility, science-based data pertaining to recreational boating patterns should include spatially referenced detail. For example, an analysis of boat trip origins that includes the type of access facility, facility location, and number of users is necessary for informed policy decisions as to siting infrastructure (e.g., public ramps). Spatial and temporal analyses of boat traffic as it relates to the distribution of other species (such as right whales) that identifies areas of overlap between whales and recreational vessel. A scientific approach provides information for rational and objective planning to assure that future economic viability and environmental protection needs are balanced.

Study Goals and Objectives

The goals of the study were to characterize the temporal and spatial patterns of recreational boating offshore and at inlets. Specific objectives included (1) the development of spatial data sets within a geographic information system (GIS) to map boating patterns, (2) the analysis of trip information provided by boaters to describe the preferences and behaviors of boaters who use the offshore waters of the study area, (3) to estimate relative seasonal abundance of offshore and at inlets recreational boaters, and (4) to map right whales and recreational vessel co-occurrence. Examples of the information products derived from the study are as follows:

1. A profile of boaters who use the offshore waters of the study area for recreation, and characteristics of their trips (e.g. timing, frequency, and duration);
2. A profile of the types of recreational vessels operated on offshore waters of the study area;
3. A compilation of spatial boating trip data within a GIS that can be used to map:
    a. departure or launch sites,
    b. offshore destinations,
    c. trip routes as reported by boaters;
4. A description of the main comments from respondents about their boating trips, boating facilities, waterway improvements, or information/actions that would increase boating enjoyment or help care for the boating environment;
5. An evaluation of seasonal aspects for many of the information products listed above;
6. An estimate of relative seasonal abundance of offshore recreational vessels;
7. Maps showing areas with high/low relative probability of right whale/human co-occurrence based on aerial sightings.

The study process involved (1) inlet observations to identify the characteristics and owners (name and mailing addresses) of vessels observed transiting the main study area inlets; (2) the development of a survey instrument and accompanying correspondence; (3) the identification of boater groups seasonally (winter, spring, summer, and fall); (4) the construction of spatial databases from returned mail surveys identifying trip departure sites, offshore destinations, and travel routes. The process was consistent with previous boating pattern studies conducted by

Florida Sea Grant and the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute for Tampa and Sarasota Bays (Sidman & Flamm, 2001; Sidman, Fik & Sargent, 2004); the Greater Charlotte Harbor (Sidman et al., 2005); Sarasota County (Sidman et al., 2006); Brevard County (Sidman et al., 2007); Bay County (Sidman et al., 2008); and Collier County (Sidman et al., 2009).

Study Region

The waters off the northeast coast of Florida (Nassau, Duval, St Johns, Flagler, and Volusia counties) and southeast coast of Georgia (Glynn and Camden counties) comprise the study area (Figure 1). The area corresponds with the southeastern portion of the calving and nursing ground of the North Atlantic right whale. Recreational boaters are attracted to this region's offshore waters, which provide excellent opportunities for fishing, diving, and nature viewing. Its proximity with the Caribbean Sea offers a route and destination for transit visitors to/from North and South America.

There are six inlets in the study area with different transiting capacities. St. Marys, St. Johns, St. Augustine, and Matanzas inlet are those most transited to access offshore waters. This area also has three major ports (Brunswick, Fernandina, and Jacksonville), and two major naval stations (Mayport in Jacksonville and Kings Bay in St. Marys).

Almost two million people inhabit the seven coastal counties of the study area (Nassau, Duval, St. Johns, Flagler, and Volusia in Florida and Camden and Glynn in Georgia (Census, 2012) and in 2012 there were almost 87,500 recreational boats registered in these counties (Table 1). However, no information exists about how many recreational boats access offshore waters in the study area (FLHSMV, 2012; Wildlife Resource Division, 2012).

Table 1. Population estimates by county (2012) and number of recreational vessels registered (2012) in the study area.

County	People 2012	Vessels 2012
Nassau	76,619	5,969
Duval	897,698	28,519
St Johns	217,919	13,158
Flagler	102,408	5,171
Volusia	507,531	27,125
Camden	52,027	2,846
Glynn	82,175	4,665
Total	1,936,377	87,453

Figure 1. The offshore waters of northeast Florida and southeast Georgia comprise the study area.

1.2 Mail Survey

Survey Instrument

The survey questionnaire for this study was patterned after that of similar, previous studies (Falk, Graefe, Drogin; Sidman & Flamm, 2001; Sidman, et al. 2004; West, 1982; Sidman, et al. 2007) and was designed (1) to capture spatial information regarding trip departure sites and intervening travel routes and (2) to characterize boaters with respect to the types of vessels owned and used, activity preferences, and the timing, frequency and duration of their recreational outings (see Appendix A for the survey instrument and associated correspondence).

The primary survey instrument was a two-sided 8.5 X 11 inch questionnaire and a 24 X 36 inch map (~1:254,000 scale) that folded to 8.5 X 11 inches. The questionnaire consisted of 16 questions divided into the following topical areas:

1. Description of the typical offshore boating trips by season (winter, spring, summer, and fall)
2. Description of typical departure sites
3. Description of survey respondent

The following additional items were included with each mailed questionnaire:

1. A cover letter that explained the study
2. A postage paid return envelope with postal permit indicium
3. A mailing envelope that included return address and postage permit indicium

In addition, a 4 X 6 card was mailed approximately two weeks after each mailing to remind survey recipients to complete and return the questionnaire. A copy of the survey map, with a thank you note, was delivered to over fifty percent of respondents (i.e., those who had requested one).

The questionnaire asked survey recipients to mark, on the map, the location of departure sites, travel routes, and offshore destination sites associated with their typical pleasure boating trips that they took during the most recent winter (Dec, Jan, Feb), spring (Mar, Apr, May), summer (Jun, Jul, Aug), and fall (Sep, Oct, Nov). In addition, survey recipients were to mark their offshore destinations along the routes. Complementary questions allowed recipients to characterize the trips that they drew on the map according to vessel type, the departure weekday, month and time, and the amount of time spent on the water. In addition, recipients were asked to characterize and name the departure sites for their last two trips and to rank reasons for departure site selection, where this differed from a home dock. A hypothetical scenario question asked participants how far upstream from the inlet they would be willing to go if an ideal departure facility was available for offshore trips. Respondents were asked to give the number of boating days per season. Finally, a series of questions sought to characterize the respondent in terms of age and boating experience. This section also included an open-ended question giving the boaters the opportunity to provide any comment about their boating trips, boating facilities, waterway improvements, or information/actions that would improve their boating experience.

Sample Design

The sample design was developed to include a diverse representation of offshore recreational boaters by targeting vessels transiting the three main inlets of the study area. The design was also intended to provide temporal and seasonal information that could be used to compare and contrast use patterns among days of the week and seasons.

Land-based inlet observations

This method provided information for 2 components of the study: a) the sampling frame for the survey and b) estimation of the relative abundance of recreational vessels offshore.

Based on exploratory visits to the six inlets within the study area and supporting information (i.e., population density and topographic maps, conversations with locals, and a literature review) land-based inlet observations were only conducted at the three main navigable inlets of the study area: St. Marys, St. Johns, and St. Augustine (Figure 1).

Field observers recorded information about boats transiting the St. Marys, St. Johns, and St. Augustine inlets (both incoming and outgoing boats) on 64 sampling days (at each inlet) over a 15-month period (from January 2011 to May 2012). Data was collected from sunrise to sunset on each sampling day. Previous studies on vessel traffic in Florida demonstrated that vessel abundance varies depending on the day of the week (Monday-Thursday, Friday and Sunday, Saturday, Holiday) and seasonally (Hain et al., 1994; Sidman et al., 2004, 2005, 2006, 2007). Therefore, each month, four days were randomly selected based on four pre-determined groups: a) Monday to Thursday, b) Friday or Sunday, c) Saturday, and d) Holidays (Figure 2). In some cases, previously selected random days changed due to hazardous weather conditions and small craft advisories that, generally, were broadcast 1 or 2 days in advance of a survey day. In those cases, another randomly available day was selected within the same pre-determined group for that particular month.

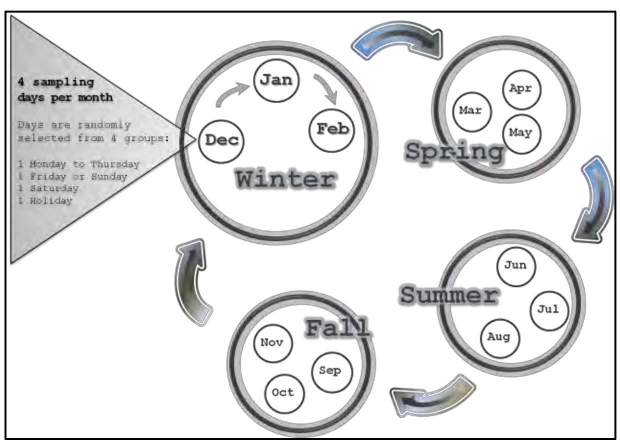


Figure 2. Land-based inlet observation sampling frame.

Data collection was conducted using 3 Nikon D3100 body cameras and 2 Nikon AS Zoom-Nikkor 70-300mm f/4.5-5.6G lenses and 1 Sigma APO 150-500mm F5-6.3 lens. Each vessel observed transiting a study inlet was photographed independently of its travel direction (outbound or inbound). Vessel registration numbers and/or vessel names and hailing ports, vessel type, vessel length, transit direction (out or in), and the date and time of transit was recorded directly was supported by a photographic record (at least 2 pictures per boat were taken). Field observers were trained to follow standardized guidelines. Appendix 2 shows the sampling schedule and the field sheet used for data collection during the inlet observations.

Previous research on recreational boating has used vessel type categories based on the propulsion method (motorized vs. non-motorized), length of vessel (small vs. large vessels), personal watercrafts, and other characteristics (Widmer and Underwood, 2004; Sidman et al., 2004, 2005, 2006, 2007; Gorzelany, 2008; Gray et al., 2011; Smallwood et al., 2011). The vessel type categories used in this study are illustrated in Figure 3.


Open fisherman (center console)

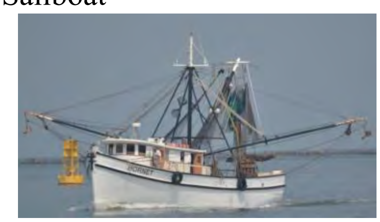

Runabouts (speed boats, cigarette, scarab)


Offshore boat

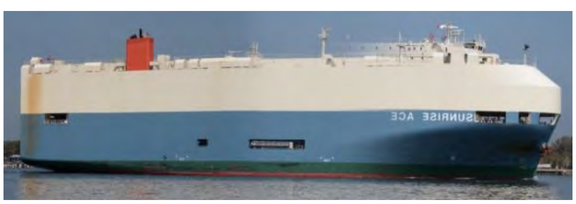

Sailboat


Yachts


Commercial: Head boat


Commercial: Shrimp boat


Commercial: Crab boat


Other: Cargo Ship


Other: Pilot boat


Other: Tug boat


Other: Governmental

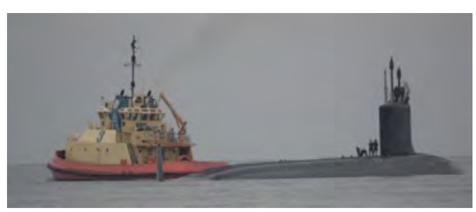

Other: Military

Figure 3. Vessel type classification use in this study.

A total of 7,645 unique vessel registration numbers (VRN) were identified, which were then linked with the Vessel Title Registration Systems (VTRS) of Florida and Georgia and the United States Coast Guard's (USCG) vessel database. Owner and address information for 5,034 VRN were identified. Identified addresses were certified and verified for mailing purposes. The survey was distributed to the identified boaters in October, 2012.

Survey Return

Surveys were distributed to 5,034 recreational boaters and 958 surveys were returned, which represents a 19.03% overall return rate. The identification of vessel owners using photo identification is not a perfect method. Fifteen percent of those who returned a survey were inshore boaters, 9% did not boat in the study area, and 9% returned a blank survey. The remaining 517 completed surveys were used in the analysis.

In 2012, there were 87,453 registered vessels in the seven counties of the study area. However, it is unknown how many of these boaters identify themselves as offshore recreational boaters. Furthermore, it is unknown how many non-residents vessels are visiting the study area. Therefore, there are no records about the size of our target population (offshore recreational boaters). If we assumed that our target population is no bigger than 87,500 boaters, we could roughly estimate the desired sample size based on the Dillman sample size equation (Vaske, 2008):

$$Completed\ sample\ size\ needed = \frac{(87{,}500)(0.5)(1-0.5)}{(87{,}500-1)\,(0.05/1.96)^2 + (0.5)(1-0.5)} = 382$$

For our estimate we assumed a 50/50 split in population (most conservative) that consisted of 87,500 boaters, a sample size of at least 382 is needed to be 95% confident that the sample estimate is within ±5% of the true population value (Vaske, 2008).

1.3. GIS Database Development

Spatial Database Design: Trip Origins, Travel Routes, and Boater Profile

Questionnaire recipients were asked to (1) mark the starting point of one boating trip for each season (winter, spring, summer, and fall) on a map, (2) draw their entire travel routes, and (3) identify destinations along those routes. Not all the returned surveys included spatial information or were of sufficient quality to be digitized. Data collected from 507 surveys were digitized into the ESRI ArcGIS geographic information system (GIS). This yielded a sample of 2,522 trip departure sites and travel routes (some respondents reported more than one trip per season), and 1,881 boating destinations (Table 2).

Table 2. Trip features digitized from returned surveys.

Trip Features	Winter trips	Spring trips	Summer trips	Fall trips	Season not specified by respondents	Totals
Origins	426	704	767	519	106	2,522
Travel Routes	426	704	767	519	106	2,522
Destinations	325	489	610	402	55	1,881

Spatial information was digitized using a Calcomp Drawing Board III digitizer tablet using the survey maps and ancillary data such as natural color Digital Orthophotograph Quarter Quadrangle (DOQQ) imagery, and the positions of marinas, ramps, navigation aids, and artificial reefs as background themes to enhance the accuracy of digitized data. Trip departure sites and destinations were digitized as point features, with each record coded with the survey control number, the trip number (i.e., first or second trip), and season. A marina or ramp origin was also coded as such, and identified with the map legend number for a given facility name.

Travel routes were digitized as line features and coded with the following attribute information: survey control number, trip number, season, individual root-mean-square error (RMSE) for each route, and trip features such as one-way vs. round trip, and whether or not the trip was confined to the study region. Off-map trip attributes included ultimate destinations and associated activities. In 98% of the cases the RMSE was between 0.04 and 0.09 (Mean=0.007; SD=0.001).

Reported summer travel routes within the St. Marys inlet boating region are displayed in Figure 5. Red lines represent travel routes digitized from returned surveys and green triangles represent digitized destination sites. The blue lines depicted in the GIS view represent 4 travel routes, origin, and destinations that were selected for display. The corresponding database records (origin and destinations) that are linked to the travel routes via the survey control number ID are shown in blue.

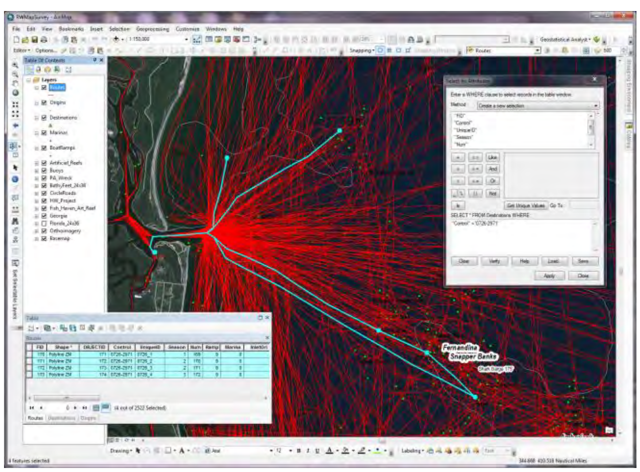


Figure 4. Example of GIS attribute query and display: Reported travel routes with their origins and destinations.

Part 2-Study Analysis

2.1. Boater-Group Characteristics

Overview

This chapter presents an evaluation and summary of responses to specific survey questions by boaters in the northeast Florida and southeast Georgia region. The sections of this chapter are divided according to themes that describe (1) seasonal offshore boating trips; (2) vessel characteristics; (2) offshore access characteristics; (3) trip characteristics; (4) boater profile; and (5) needs and barriers of survey respondents. It should be noted that while questions were arranged to follow a logical progression on the survey instrument, the following results and corresponding discussion sections are arranged thematically and, therefore, questions do not necessarily follow the order in which they appeared on the survey instrument. The descriptive analysis presented in this chapter is based on information obtained from N=515 surveys. Each survey typically describes one boating trip for each season, and, therefore, several questions embody more than one response, one for each trip. The number of survey responses to specific survey questions or combinations of questions varies from question to question, as does the sample size associated with the various user groups responding to those questions. For convenience, the sample sizes are listed within each summary table. A copy of the survey instrument is provided in Appendix A.

Season

The average number of trips during each offshore boating season varied significantly, ranging from a low of 3.3 trips during the off-peak season (winter) to a high of 8.2 trips during the peak season (summer). In addition, the number of reported off-shore trips was significantly higher during the spring and summer seasons than the fall or winter season (Table 3).

Table 3. Summary statistics for the number of reported "offshore" boating trips per season.

Trip/season	Average Number of Offshore trips	Standard Deviation	Min.	Max.	Median	95% confidence interval	N*
Winter	3.31	4.55	0	36	2.0	2.91 to 3.73	474
Spring	6.21	6.54	0	45	4.0	5.63 to 6.80	482
Summer	8.17	9.81	0	80	6.0	7.30 to 9.06	483
Fall	4.64	5.76	0	40	3.0	4.12 to 5.16	476

N* = the number of responses to question 7.

Vessel Characteristics

A summary of the vessels used by respondents in the offshore waters of the study area is given in Table 4. Reported trips of survey respondents were most associated with vessels that fell in the "**open fisherman**" category (a group that represented approximately 59% of reported trips by survey respondents in the study region). The "**off-shore fisherman**" category was associated with approximately 16% of reported trips, whereas the "**sailboat**" category accounted for 15% of reported trips. All in all, these three vessel categories account for approximately 88% of the trips reported by survey respondents in the study region.

Table 4. Type of boat/vessel associated with reported trips based on reported trips of N=511 responses to question 5.

	Type of Boat/Vessel						
Season	**Open Fisherman**	**Offshore Sports Fisherman**	**Sailboat**	**Speedboat**	**Power Cruiser**	**Other**	**Total**
Winter	180	58	45	14	12	12	322
Spring	265	66	67	17	25	14	454
Summer	282	72	42	20	13	13	442
Fall	215	58	56	18	17	13	377
Total	942†	254	210	69	67	53	1595
Percentage	59.1%	15.9%	13.1%	4.3%	4.2%	3.3%	

† Open Fisherman category includes flats, skiffs, and center console boats

Average length statistics for vessels used in reported trips by survey respondents (question 6) are shown in Table 5. Survey results suggest that the average vessel length is approximately 27 feet, based on reported vessel types by survey respondents in the study area. The average vessel length was slightly lower for trips conducted during summer when compared with the other seasons.

Table 5. Boat length summary statistics for reported trips (in feet).

Trip/season	**Average Boat Length (feet)**	**Standard Deviation**	**Min.**	**Max.**	**Median**	**95% confidence interval (mean)**	**N***
Winter	27.3’	9.1’	14’	68’	24.5’	26.3 to 28.3	311
Spring	27.3’	11.2’	14’	127’	24.0’	26.2 to 28.4	443
Summer	25.1’	7.5’	14’	68’	23.0’	24.3 to 25.8	430
Fall	27.4’	11.3’	14’	127’	24.0’	26.2 to 28.6	368
Overall	26.8’						

*N = the number of responses to question 6.

Thirty-six respondents (7%) reported using more than one boat (N=507). A repeated measure ANOVA determined that the length of vessels used to access offshore water differed statistically significantly between seasons ($F=5.43$, $p < 0.05$). The size of the boat was significantly different among seasons with boaters using their smaller boats during spring (Table 6, Fig. 5).

Table 6. Boat length summary statistics for reported trips (in feet) when more than one boat was reported.

Trip/season	Average Boat Length (feet)	Standard Deviation	Min.	Max.	Median	95% confidence interval (mean)	N
Winter	31.58’	10.54	20	52	28.0	27.13 – 36.03	24
Spring	24.39’	8.02	17	60	22.0	21.44 – 27.33	31
Summer	26.37’	10.58	17	60	23.0	22.79 – 29.95	36
Fall	27.92’	9.21	13	52	25.5	24.6 – 31.24	32

There were 36 participants who reported using more than one boat; however, N varied because of the respondents’ frequency of use.

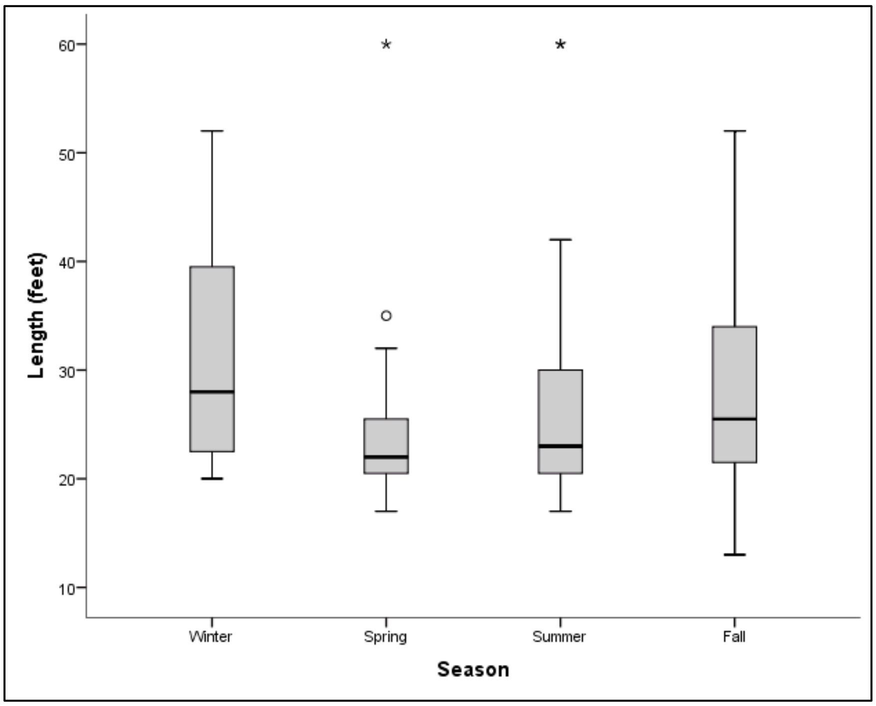


Figure 5. Box plots showing the length of the vessels used by participants who reported having more than one boat.

Offshore Access Characteristics

Frequency counts and percentage breakdown of survey responses by waterway access category are shown in Table 7. Survey results for question 4 suggest that the majority of trips reported by survey respondents originated from boat ramps (approx. 59%), followed by marina wet slips (approx. 22%). These two launch sites accounted for approximately 81% of all boating trip departure sites for reported trips in the study area.

Table 7. Survey response by waterway access category and season based on reported trips of N=507 respondents (question 4).

Season	Boat Ramp	Marina Wet	Marina Dry	Home/Condo Dock	Shoreline Causeway	Row Total	Row (%)
Winter	182	70	23	37	2	**314**	**19.8%**
Spring	260	104	31	47	5	**447**	**28.2%**
Summer	280	80	30	55	5	**450**	**28.4%**
Fall	209	89	27	43	6	**374**	**23.6%**
Column Total	**931**	**343**	**111**	**182**	**18**		
Column (%)	58.7%	21.6%	7.0%	11.5%	1.1%	**1,585 Total trips**	

A lower number of survey participants (33) used more than one type of waterway access throughout the year (6.5%). The most common combination of waterway access categories was Boat Ramp and Marina Wet.

The marinas and boat ramps listed in Table 8 are those departure sites that were used on the survey map. It also includes departure sites identified by respondents (question 8). The estimate for the on-the-water distance from a facility to the nearest inlet was obtained using the routes drawn for most of the departure sites. However, for those cases where the departure site was not cited by survey respondents, the distance estimate calculated based on the closest route to offshore waters.

Survey respondents identified 67 boat ramps and marinas that were used to access offshore water in the study area (Table 8). Survey results suggest that there are seven prominent launch/departure sites for recreational boating trips in the study region, based on information obtained from survey respondents on the launch locations associated with reported boating trips. The most popular boat ramps were Mayport, Vilano Boat Basin, and Dee Dee Bartels, Joe Calucci, Lighthouse Park, and Jim King Park (Table 8, Fig. 6). The most popular marinas were Camache Cove, Conch House Marina, Fernandina Harbour, and Amelia Island Yacht Basin (Table 8, Fig. 6).

Table 8. Frequency counts of departure sites identified by survey respondents for reported trips (N=507 respondents; 2,522 boating trips).

Facility	Winter	Spring	Summer	Fall	No seasonal info	All Seasons	Distance from the departure site to the used inlet (nm)
Mayport Boat Ramp	68	138	173	114	19	**512**	3
Vilano Boat Basin	55	103	107	53	16	**334**	1
Dee Dee Bartels	30	34	57	24	5	**150**	3
Joe Calucci Boat Ramp	21	31	34	23	27	**136**	5
Lighthouse Park Boat Ramp	23	36	36	24	4	**123**	2
Camache Cove	16	23	26	22	3	**90**	1
Jim King Park Boat Ramp	12	21	19	17	0	**69**	6
Conch House Marina	15	21	18	15	0	**69**	1

Facility	Winter	Spring	Summer	Fall	No seasonal info	All Seasons	Distance from the departure site to the used inlet (nm)
Fernandina Harbour	10	23	13	12	5	**63**	4
Amelia Island Yacht Basin	10	9	14	9	0	**42**	8
Morningstar at Mayport	6	8	13	7	0	**34**	3
Palm Cove	6	5	18	5	0	**34**	11
Cat's Paw Marina*	6	10	11	6	0	**33**	4
North River Boat Ramp	3	6	11	4	0	**24**	7
St Augustine Municipal Marina	7	6	4	3	1	**21**	2
Devil’s Elbow	1	8	7	5	0	**21**	4
City of St Marys Boat Ramp	4	4	7	3	0	**18**	8
Mira Vista & Watersedge*	4	5	5	4	0	**18**	9
Beach Marine	4	5	4	2	1	**16**	11
Arlington Marina*	0	7	2	5	0	**14**	18
Brunswick Landing	2	5	2	3	0	**12**	8
Usinas	1	3	6	1	0	**11**	3
Egan's Creek Marina*	1	4	4	2	0	**11**	4
Tiger Point	1	4	2	3	0	**10**	2
Browns Creek		0	5	5	0	**10**	10
Lang's Marina	1	2	3	3	0	**9**	8
Cabana Club Boat Ramp	0	2	6		0	**8**	8
Oak Harbor Boat Ramp	0	2	1	4	0	**7**	7
Morningstar Marina at Golden Isles	3	1	0	3	0	**7**	3
Big Talbot Island State Park	3	2	0	1	0	**6**	2
Green Street Launch	2	1	3		0	**6**	4
Mandarin Holiday Marina*	1	2	2	1	0	**6**	38
NAS*	1	1	2	2	0	**6**	30
F&A Marine Const. Inc.*	1	2	2	1	0	**6**	5
Seafarers*	3	1	1	1	0	**6**	15
Fort George Island Marina	2	1	0	2	0	**5**	3
Oasis Boat Yard & Marina	2	1	1	1	0	**5**	4
Fish Island Marina	1	1	1	1	1	**5**	3
Jekyll Island Boat Ramp	2	0	0	2	0	**4**	4
Cedar Point Boat Ramp	1	1	1	1	0	**4**	8
Hershel King Park*	0	0	2	2	0	**4**	8
Boating Club Road*	0	0	0	0	4	**4**	3
Osprey Cove (Birdsong Trail)*	1	1	1	1	0	**4**	13
Blythe Island Regional Park	0	0	3		0	**3**	9
Intracoastal Waterway	1	0	1	1	0	**3**	11
Ocean Hwy (US HWY 17)*	1	1		1	0	**3**	22
Villages of Vilano		1	1	1	0	**3**	2
Intercoastal Marina	1	1	0	1	0	**3**	4
Queen's Harbour Yacht*	0	0	1	2	0	**3**	7

Facility	Winter	Spring	Summer	Fall	No seasonal info	All Seasons	Distance from the departure site to the used inlet (nm)
Ortega Yacht Club*	1	1	1		0	**3**	26
Anchorage Inn & Marina*	1	1	0	1	0	**3**	2
Crooked River Boat Ramp	1	0	0	1	0	**2**	16
Douglas C. Crane	0	1	1	0	0	**2**	4
Frank Butler Park	0	1	1	0	0	**2**	8
New Berlin Boat Ramp*	1	0	0	1	0	**2**	11
Clapboard Creek Marina	1	0	1	0	0	**2**	8
Ortega Landing*	0	0	1	0	1	**2**	26
Alimacani Boat Ramp	0	0	0	0	1	**1**	1
Palm Fish Camp Boat Ramp	0	1	0	0	0	**1**	8
West Palm Valley	0	0	1	0	0	**1**	16
Fellas Sport Boat Ramp*	0	1	0	0	0	**1**	15
St Simons Boating & Fishing Club	0	0	0	1	0	**1**	3
Jekyll Harbor Marina	0	1	0	0	0	**1**	4
Ocean Outboard	0	0	1	0	0	**1**	3
St Augustine Marine Center*	1	0	0	0	0	**1**	4
Gibson Dry Docks*	0	1	0	0	0	**1**	73
Lamb's Yacht Center Inc.	0	1	0	0	0	**1**	53
Home/Condo Dock or the departure site was outside study area	91	154	127	108	19	**499**	

*Departure site identified by respondents.

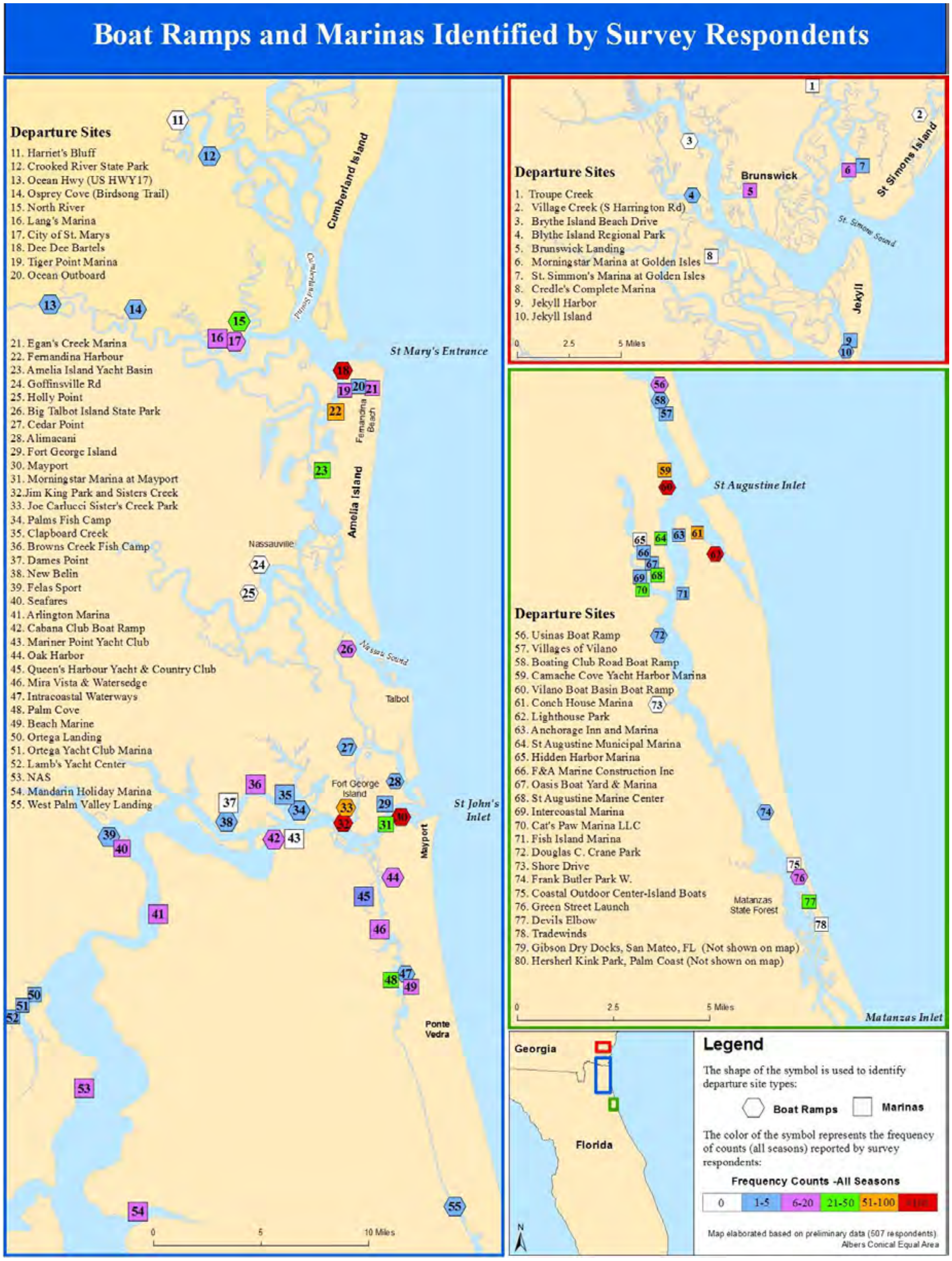


Figure 6. Boat ramps and marinas identified by survey respondents for reported trips (N=507; 2,522 trips).

There were 13 departure sites shown on the survey map that were not reported by survey respondents (Table 9, Fig. 6).

Table 9. Departure sites shown on the survey map that were not reported by survey respondents.

Facility	Distance from the departure site to the used inlet (nm)*
Troupe Creek Marina	5
Village Creek Boat Ramp	12
Blythe Island Beach Drive	19
Credle's Complete Marina	6
Harriet's Bluff Boat Ramp	5
Goffinsville Road Boat Ramp	6
Holly Point Boat Ramp	8
Dames Point Marina	10
Mariner Point Yacht Club	11
Hidden Harbor Boat Ramp	7
Shore Drive Boat Ramp	27
Coastal Outdoor Center	5
Tradewinds Marina	3

*Distance estimation based on nearest route from the departure site to the nearest inlet.

Survey results for question 9 suggest that the most-important factors in the recreational boating experience, as indicated by survey respondents, are as follows (in descending order of importance, based on average ranking of responses):

(a) Proximity to inlet or nearness to off-shore waters;

(b) Adequate parking;

(c) Safe and secure parking areas;

(d) Convenient hours of operation; and

(e) Proximity to favorite boating destinations.

In addition, approximately 8% of survey respondents identified ramp/dock quality as an "other" factor of importance to them (Table 10).

Table 10. Reported importance of factors (ranked 1-5 Likert Scale: (1) Important; (2) Somewhat important; (3) Neutral; (4) Somewhat unimportant; and (5) Unimportant *Top Factors (with an average rank < 2.0).

Factor	N	Average Rank	Standard Deviation	95% Confidence Interval	
				Lower Bound	Upper Bound
Close to an Inlet* (near offshore waters)	**451**	**1.295**	**0.653**	**1.234**	**1.355**
No Launching or Parking Fees	441	2.086	2.425	1.954	2.219
Restroom Availability	450	2.209	1.275	2.091	2.327
Adequate Parking*	**447**	**1.539**	**1.159**	**1.431**	**1.647**
Close to my Home (shorter drive time)	447	2.208	1.303	2.087	2.329
Nearby Amenities (store, restaurant, hotel, etc.)	449	2.960	1.332	2.087	2.329
Safe and Secure Parking Area*	**448**	**1.629**	**1.100**	**1.527**	**1.732**
Close to my Favorite Boating Spots*	**447**	**1.877**	**1.162**	**1.769**	**1.985**
Availability of Fishing Supplies	447	2.868	1.391	2.739	2.997
Hours of Operation*	**448**	**1.732**	**1.101**	**1.630**	**1.834**
Gas, Pump Out, Maintenance Service	451	3.071	1.460	2.936	3.206
Other	**114**	**1.658**	**1.096**	**1.445**	**1.861**
Most Frequent Other*	**38**	**1.086**	**0.284**	**0.988**	**1.183**
Good Ramps/Docks; Ramp/Dock Quality					

Survey Results for question 10 suggest that the average on-water willingness-to-travel distance of survey respondents from a new launch facility to a nearby inlet with off-shore water access is approximately 7.6 nautical miles (or an average travel time of approximately 23 minutes). Based on the estimated 95% confidence interval for the mean, the average distance was somewhere between 7.2nm and 7.98nm (Table 11, Fig. 7).

Table 11. Descriptive statistics for responses to maximum on-the-water distance willingness to travel from a new facility/launch location (ramp, marina, dry stack) to a nearby inlet with off-shore water access.

Statistic	Distance (nm)	Distance (Minutes)
Average	7.59	22.77
Median	6.00	18
Std. Deviation	4.013	12.04
Minimum	2	6
Maximum	20	60
95% Confidence Interval	7.20 - 7.98	21.6 – 23.9
N	415	

Note: Travel distance in nm/minutes conversion assumes 20MPH speed; and hence, the number of minutes is equal to (3 x nm).

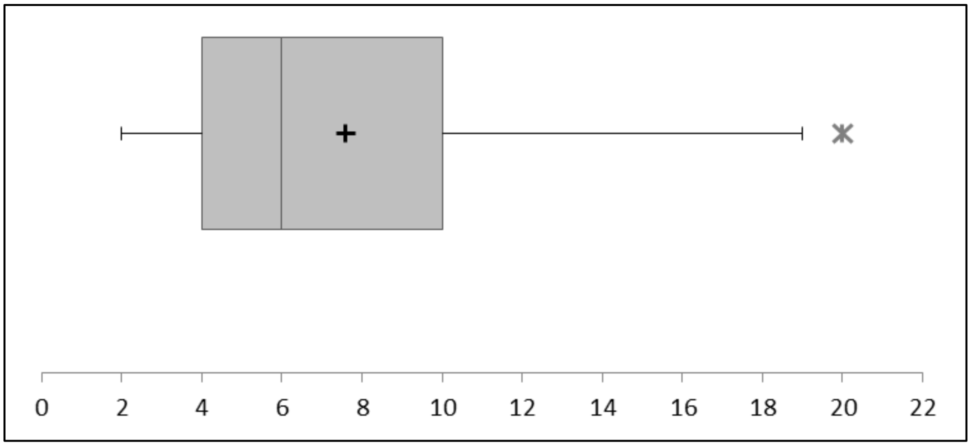


Figure 7. Box plot of the maximum on-the-water distance willingness to travel from a new facility/launch location to a nearby inlet with off-shore water access. Mean (+), Outlier (✳) (N=415).

Trip Characteristics

Survey results for question 1 suggest that recreational boating trips in the study region typically begin between 7:18AM and 7:42AM (depending on the season), and end somewhere in the vicinity of 4:00PM. The results also suggest that the typical boating trip is well over 8 hours in duration based on the reported start and end times of boaters who responded to the survey. The average boating trip duration for the Summer Boating Season was *significantly greater* than the average trip durations of other seasons at the 95% confidence level (Table 12).

Table 12. Average time when boating trips began and ended. Number of survey responses to question 1 is shown in parenthesis.

Trip Season	**Average Time When Boating Trip**		**Average Trip Duration**	**Standard Deviation**	**95% Confidence Interval**
	Began	**Ended**			
Winter	7:42AM (283)	3.57PM (283)	8hrs and 50min (281)	3hrs and 11min	8hrs_28min to 9hrs_13min
Spring	7.36AM (396)	4:02PM (394)	8hrs and 51min (392)	3hrs and 12min	8hrs_32min to 9hrs_11min
Summer	7.18AM (396)	4:09PM (395)	*9hrs and 17min †* (393)	3hrs and 06min	8hrs_58min to 9hrs_35min
Fall	7:40AM (327)	3:57PM (328)	8hrs and 48min (326)	3hrs and 16min	8hrs_26min to 9hrs_09min

† S*ignificantly greater* than the average trip durations of the other seasons at the 95% confidence level.

Survey results for Question 1 suggest that the average trip duration (for day trips – boating trips that are less than or equal to 24 hours in length) is approximately 9 hours, based on reported durations of individual trips taken and reported by survey respondents. Seasonal estimates range from approximately 8.5 to 9 hours, with trip duration being slightly longer during the summer boating season.

Survey results for Question 1 also suggest that for recreational boating trips exceeding 24 hours in length (i.e., over-night trips), the average trip duration ranges between 4.6 days during the summer to approximately 12 days during the winter boating season based on reported trips of survey respondents in the study area (Table 13). The mean boating trip duration for the summer and fall Boating Seasons, for trips that exceeded 24 hours in length, was significantly less than the average trip durations of the other seasons (i.e., the winter and spring) for trips exceeding 24 hours in length at the 95% confidence level. Note that far fewer overnight trips were reported by respondents; as overnight trips represented about 1 out of 8 trips reported.

Table 13. Length of overnight boating trips: Number of days (where trip length >24 hours).

Trip Season	**Average Overnight Trip Duration**	**N***	**Standard Deviation**	**95% Confidence Interval**	**Maximum**
Winter	11.98 days	34	22.73 days	4.06 days to 19.91 days	90 days
Spring	10.61 days	68	17.02 days	6.49 days to 14.73 days	65 days
Summer	*4.60 days†*	40	9.41 days	1.58 days to 7.68 days	60 days
Fall	*6.37 days†*	51	13.32 days	2.62 days to 10.12 days	90 days

N* = Number of survey responses to question 1, part C. † S*ignificantly less* than the average trip durations of the other seasons (i.e., the Winter and Spring) for trips exceeding 24 hours in length at the 95% confidence level.

Survey results for question 2 suggest that the average time spent at boating destinations is approximately 4 hours for reported boating trips taken by survey respondent in the study area. This is a statistic that is relatively consistent (i.e., does not vary significantly) across the boating seasons. Note that overall the reported mean time spent at boating destinations is approximately 3 hours and 54 minutes; an estimated value that is not significantly different from a value of 4.0 hours at the 95% confidence level (Table 14).

Table 14. Length of time spent at boating destinations.

Trip Season	**Average Time Spent at Destinations**	**N***	**Standard Deviation**	**95% Confidence Interval**	**Maximum**
Winter	3 hrs and 43 min	235	2 hrs &10 min	3hrs_27min to 4hrs_00min	8hrs
Spring	3 hrs and 50 min	308	2 hrs &10 min	3hrs_36min to 4hrs_02min	8hrs
Summer	4 hrs and 03 min	326	2 hrs &13 min	3hrs_47min to 4hrs_18min	8hrs
Fall	4 hrs and 00 min	256	2 hrs & 00 min	3hrs_45min to 4hrs_26min	8hrs

N* = Number of responses to question 2.

Survey results for 1uestion 3 suggest that approximately 55% of reported trips took place during the weekend (Saturday or Sunday), whereas 45% took place on weekdays (Monday through Friday). Summer and Spring boating trips accounted for 30% and 28% of all reported trips, respectively; and 58% of all trips overall (Table 15).

Table 15. Frequency of boating trips by day of the week based on N=515 reported trips (question 3).

Trip Season	Day of the Week Reported Trip(s) Began							Row Total	Row (%)
	M	T	W	Th	F	Sat	Sun		
Winter	27	29	30	39	78	178	71	425	(19.2%)
Spring	36	52	53	61	103	245	111	661	(28.1%)
Summer	41	45	51	61	115	274	116	703	(29.9%)
Fall	27	31	38	52	86	207	95	536	(22.7%)
Column Total	131	157	172	213	382	904	393	2352 total trips	
Column %	5.5%	6.7%	7.3%	9.1%	16.2%	38.4%	16.7%		

There were no statistically significant differences in trip durations by seasons (F=0.638, p=0.59 for Mon-Thu group and F =2.5, p=0.06 for Fri-Sun group) or by day (Mon-Thu vs. Fri-Sun).

Table 16. Trip duration (≤48 hours) by day of the week and by season.

Season	Trips reported only between Monday-Thursday			Trips reported only between Friday-Sunday		
	Mean (SD)	N	95% CI	Mean (SD)	N	95% CI
Winter	10.60 (7.2)	38	8.22-12.98	9.29 (4.8)	197	8.61-9.96
Spring	11.16 (9.9)	56	8.50-13.82	10.81 (8.8)	260	9.73-11.88
Summer	11.77 (10.5)	46	8.65-14.90	11.20 (8.7)	275	10.17-12.23
Fall	13.99 (13.1)	35	9.49-18.48	11.16 (9.7)	235	9.91-12.41

SD= standard deviation. CI= confidence interval

Boaters Profile

Survey results for question 13 suggest that the average age of survey respondents was approximately 55 years (Table 17, Fig. 8). There were no significant differences between respondents' age by departure site (F=1.26, p>0.05).

Table 17. Descriptive statistics for age of survey respondents (all survey respondents).

Statistic (N=499)	**Boaters' Age (years)**
Average (overall)	**55.18 years**
Standard Deviation	10.94 years
Minimum	16 years
Maximum	88 years
Median (overall)	55 years
95% Confidence Interval	54.22–56.14 years

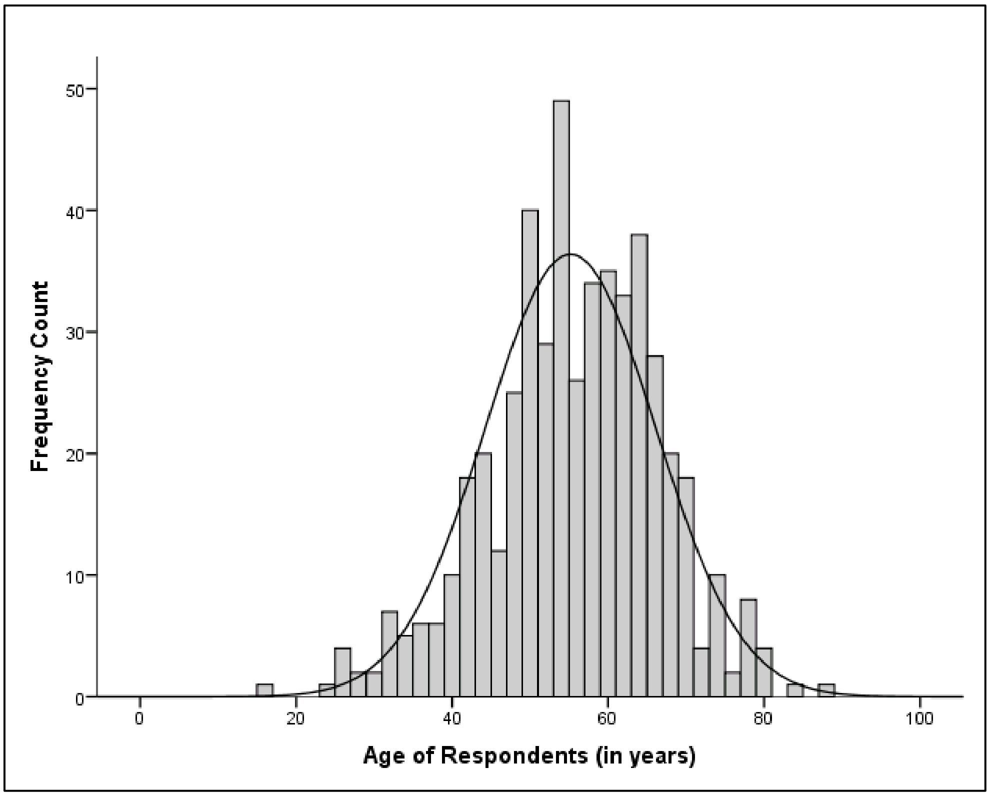


Figure 8. Histogram showing the age of survey participants.

A breakdown of respondents' age by vessel type is given in Table 8. Boaters who used Power Cruisers, Sailing Boats, and/or Other Category of vessel tend to be significantly older ($F=5.9$, $p < 0.05$) than respondents who used Open and Offshore Fishing Boats and/or respondents who have more than one type of vessel to access offshore waters (Table 18).

Table 18. Age of survey participants (years) by vessel type based on N=498 responses to questions 5 and 13.

Vessel Type	Frequency Count	Mean of Age (years)	Standard Deviation	Min	Max	95% Confidence Interval	
						Lower Bound	Upper Bound
Power Cruiser	28	62	12.24	25	80	57.6	67.1
Sailing	74	59	10.79	29	80	56.5	61.5
Offshore Fisherman	65	55	10.01	26	77	52.2	57.1
Open Fisherman	281	54	10.69	16	88	52.5	55.0
Other	20	57	9.68	32	75	52.9	62.0
More than one type	30	53	9.59	29	77	49.4	56.6

Survey respondents had, on average, approximately 20 years of recreational offshore boating experience, with a median of 20 years of boating experience (Table 9; Fig. 9). It was estimated that the mean number of years of boating experience among survey respondents was somewhere between 18.9 and 21.5 years overall, based on the estimated 95% confidence interval for the mean. The maximum reported number of years of boating experience was 63 years, and the minimum number was 0.25 year (roughly 3 months) (Table 19; Fig. 9).

Table 19. Descriptive statistics of years of offshore boating experience in study area (all survey respondents) based on N=496 responses to question 11.

Statistic	Boating experience (years)
Average (overall)	**20.2 years**
Standard Deviation	14.3 years
Minimum	0.25 years (or approx. 3 months)
Maximum	63 years
Median (overall)	20 years
95% Confidence Interval	18.9–21.5

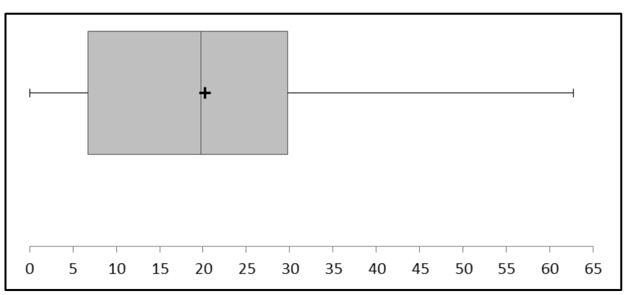


Figure 9. Box plot of years of offshore boating experience of survey participants. Mean (+).

The breakdown of boating experience of survey responses by frequency of offshore boating trips are shown in Table 20. Of the N=475 survey responses to both question 7 (number of trips by season) and question 11 (offshore boating experience), approximately 50% reported offshore boating trips for all seasons (year-round). In general, as offshore boating experience decreases, so does the frequency of offshore boating trips (Table 20; Fig. 10).

Table 20. Offshore boating experience of survey participants (years) by frequency of offshore boating trips based on N=475 responses to questions 7 and 11.

Offshore boating trip reported for:	**Frequency Count**	**Mean of Boating Experience**	**Standard Deviation**	**Min**	**Max**	**95% Confidence Interval**	
						Lower Bound	**Upper Bound**
Overall	475	20.26	14.25	0.25	63	18.97	21.54
One Season	53	15.8	14.03	0.25	55	11.98	19.72
Two Seasons	100	17.2	13.01	1	50	14.63	19.79
Three Seasons	84	20.1	14.29	2	60	17.05	23.26
Year-Round	238	22.6	14.38	1	63	20.71	24.39

Results suggest that offshore boating experience varies significantly across boating frequency groups (Fig. 10). Respondents who boated year-round were significantly more experienced than were respondents who only boated during one season ($p=0.010$) or two seasons ($p=0.008$). However, there were no significant differences between respondents who use their boat during three quarter of the year (3 seasons) and those who used it year-round ($p=0.536$).

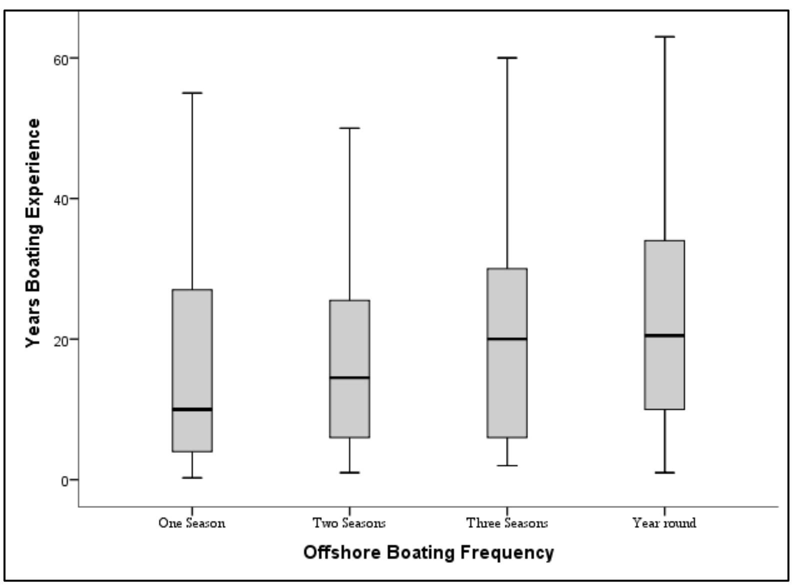


Figure 10. Box plot of years of offshore boating experience by frequency of boating trips.

Based on n=495 responses to survey question 11 and question 5 (Vessel Type Category), there is a significant difference with respect to boating experience and the vessel type used to access offshore waters ($F=6.97$, $p>0.05$). Sailors tend to have fewer years of boating experience (mean = 12 years) than do recreational boaters using Open and Offshore Fishing Boats (mean = 22 and 24 years respectively) (Table 21, Fig. 11).

Table 21. Boating experience of survey participants (years) by vessel type.

Vessel Type	Frequency Count	Mean of Boating Experience (years)	Standard Deviation	Min	Max	95% Confidence Interval	
						Lower Bound	Upper Bound
Power Cruiser	28	19	13.6	1	55	13.5	24.0
Sailing	73	12	10.7	0.25	40	9.4	14.4
Offshore Fisherman	66	24	12.8	2	50	21.0	27.4
Open Fisherman	276	22	14.5	1	63	20.0	23.4
Other	21	21	15.1	2	50	13.6	27.4
More than one type	31	20	16.3	2	60	14.2	26.1
Overall	495	20	14.3	0.25	63	19.0	24.5

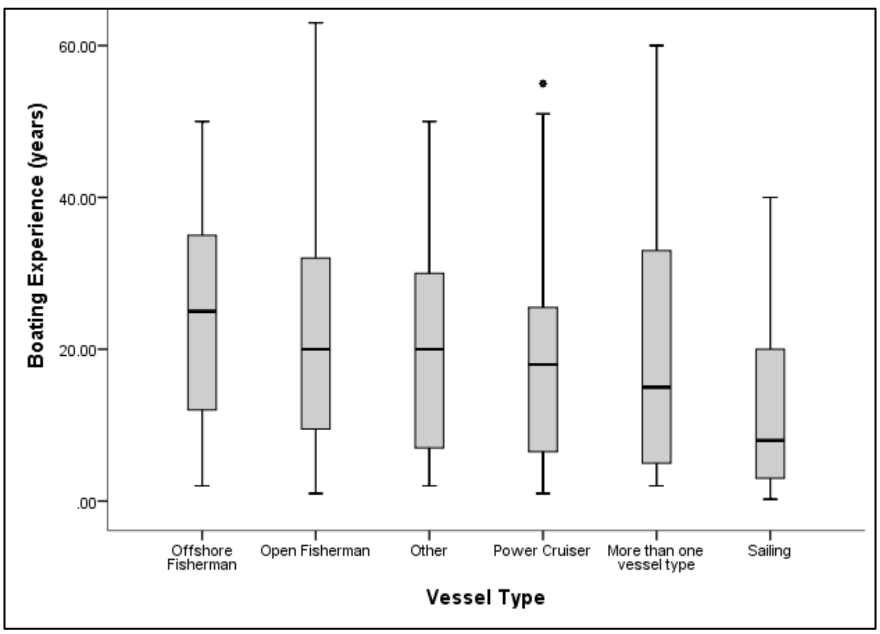


Figure 11. Box plot of years of offshore boating experience by vessel type.

There was no statistically significant difference between the departure sites with respect to boating experience ($F=0.435$; $p>0.01$). The differences between the means of boating experience are likely due to chance and not due to the departure site used by participants (Table 22, Fig. 12).

Table 22. Offshore boating experience of survey respondents (years) by departure site based on N=489 responses to questions 7 and 11.

Departure Site	Frequency Count	Mean of Boating Experience	Standard Deviation	Min	Max	95% Confidence Interval	
						Lower Bound	Upper Bound
Boat Ramp	276	19.77	14.09	0.25	63	18.10	21.44
Marina Wet	100	19.71	13.92	1	60	16.95	22.47
Marina Dry	29	22.45	13.74	2	50	17.22	27.68
Home or Condo Dock	47	22.38	16.29	2	60	17.60	27.17
Shoreline or Causeway	5*	20.00	21.41	4	51	--	--
More than 1 departure site year-round	32	20.56	14.71	2	60	15.26	25.87

*Small sample

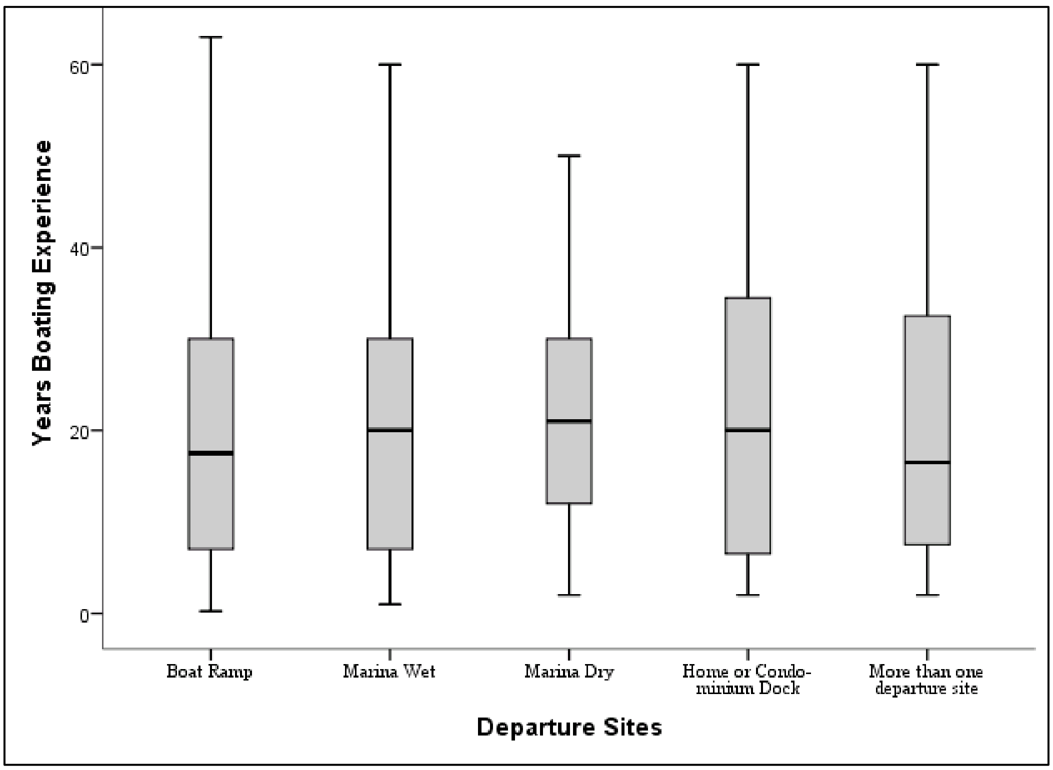


Figure 12. Box plot of years of offshore boating experience by departure sites. Shoreline and causeway departure sites were omitted because of small sample size (N=5).

Survey results for question 12 suggest that approximately 69% of survey respondents completed a boating safety or seamanship course (Table 23). Even though there is a 11% difference between boaters who took a safety or seamanship course and use their boat year-round and those that only used their boat during one season, there is no statistical significance between these two variables (Chi-Square = 0.225, $p > 0.05$).

Table 23. Respondents having completed a boating safety or seamanship course, by offshore boating frequency.

Safety or Seamanship Course		Offshore Boating Frequency				
		One Season	Two Seasons	Three Seasons	Year-Round	Total
Yes	Count	34	67	55	177	333
	Percentage	61.8%	67.7%	64.7%	73.4%	69%
No	Count	21	32	30	64	147
	Percentage	38.2%	32.3%	35.3%	26.6%	30.6%
Total	Count	55	99	85	241	480

Survey respondents who reported using a Sailing boat and/or Power Cruiser vessel tended to be more likely to have had a boating safety or seamanship course than those in the other vessel categories (Chi-Square =34.4, $p < 0.05$). Open Fisherman users were the less likely to have had a boating safety or seamanship course (Table 24).

Table 24. Respondents having completed a boating safety or seamanship course, by vessel type.

Safety or Seamanship Course		Vessel Type						
		Sailing	Power Cruiser	Other	Offshore Fisherman	More than one vessel type	Open Fisherman	Total
Yes	Count	67	25	18	49	19	169	347
	Percentage	89.3%	89.3%	85.7%	74.2%	63.3%	60.1%	69.3%
No	Count	8	3	3	17	11	112	154
	Percentage	10.7%	10.7%	14.3%	25.8%	36.7%	39.9%	30.7%
Total	Count	75	28	21	66	30	281	501

A summary of the reported primary residence ZIP codes of survey respondents is given in Table 25 and Fig. 13. Most of the survey respondents are Florida residents (86%), although respondents identified any of 24 U.S. states.

Table 25. Frequency counts of respondents' primary residence ZIP code (N=500).

State	**Frequency Counts**	**Percentage of Total**
Florida	430	86
Georgia	33	6.6
Virginia	5	1.0
Massachusetts	3	0.6
Maryland	3	0.6
Texas	3	0.6
California	2	0.4
Colorado	2	0.4
North Carolina	2	0.4
Pennsylvania	2	0.4
South Carolina	2	0.4
Connecticut	1	0.2
Columbia	1	0.2
Delaware	1	0.2
Illinois	1	0.2
Kansas	1	0.2
Kentucky	1	0.2
Michigan	1	0.2
Minnesota	1	0.2
New Hampshire	1	0.2
New Jersey	1	0.2
New York	1	0.2
Ohio	1	0.2
Vermont	1	0.2

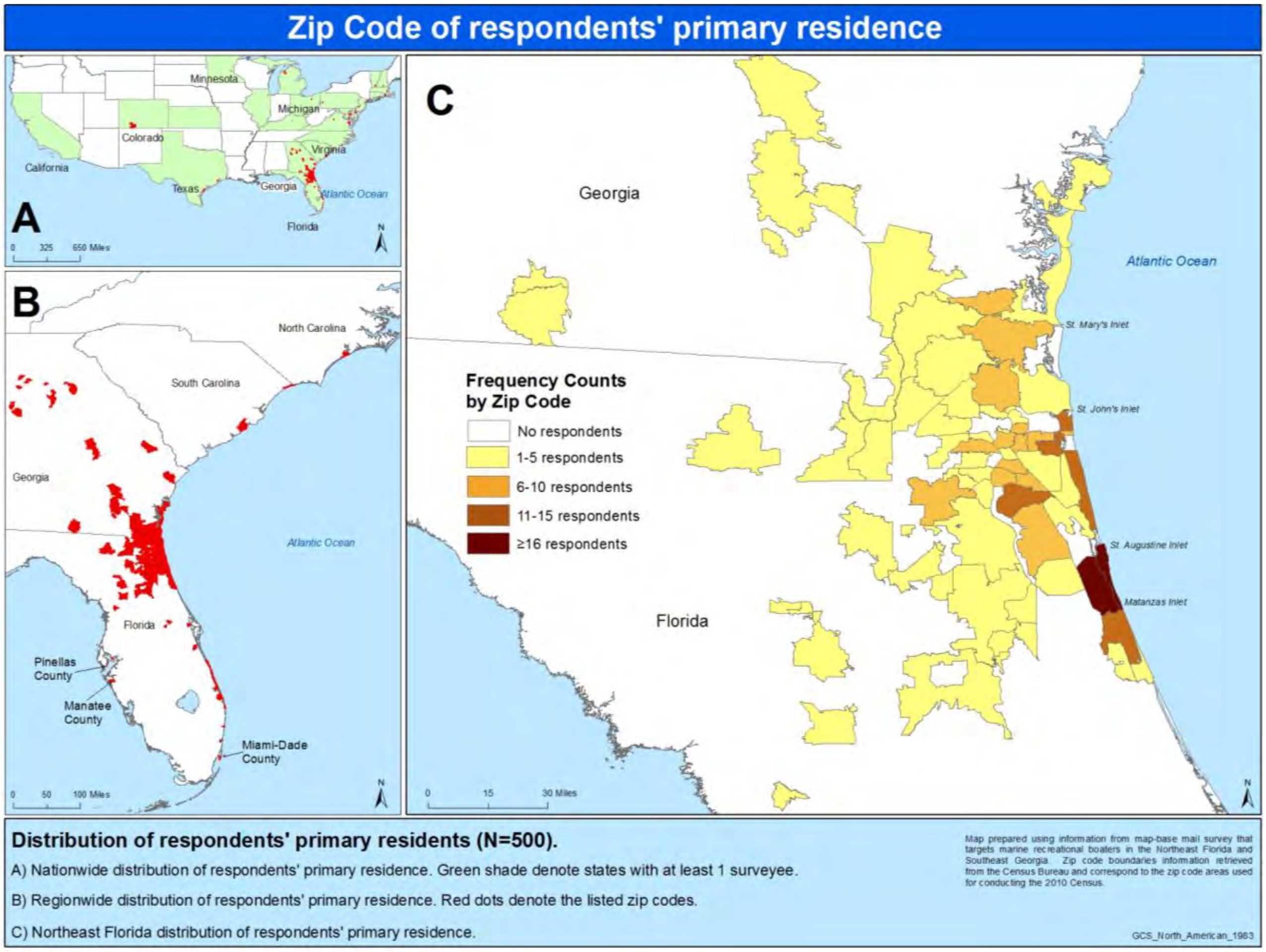


Figure 13. ZIP codes of respondents' primary residence (N=500).

Addressing Needs and Barriers of Survey Respondents

A typology of main comments was developed through a content analysis of the responses to question 16. Respondents with shared general themes were grouped into categories. Every effort was made to capture the intended meaning of a given response and to maintain consistency in its assignment to a particular category. Many survey respondents provided multiple comments or suggestions, so that the total response number does not equal the returned survey count.

More than half of the respondents (59%, N=302) provided comments about their boating trips, boating facilities, waterway improvements, or information/actions that would increase their boating enjoyment. Certain responses were excluded from this analysis because they were not amenable to intervention, such as descriptions of boating trips. In 180 cases (35%), respondents provided comments related to waterway improvements, and information/actions that would increase boating enjoyment (Table 26).

Table 26. Frequency and percentage of survey respondents who provided comments and/or suggestions that would improve their boating enjoyment.

Group	N	Percentage
Did not provide any comment	213	41%
Description of boating trips	122	24%
Comments on waterway improvements, and information / actions that would increase your boating enjoyment	180	35%

Recreational boaters' suggestions and comments were grouped in 10 categories (Table 27). The leading category, accounting for one-third (31.6%) of all analyzed responses (N=234), addressed the excess of regulations, particularly as to fishing. Some of the comments related with the excess of fishing regulations are:

"Please relax fishing regulation, number of trips significantly reduce due to strict regulations in place"

"Fishing regulations and catch limits are making it very difficult to fish offshore"

"Less rules and regulations for fish species"

"Fisherman are being crushed by federal regulations"

"The offshore fishing regulations are horrible"

"Federal regulations on recreational fishing should be modified/relaxed based on sound scientific data"

Responses citing the need for maintenance and improvement of current departure facilities made up the second highest category, with 26.1% of total responses. In this category we included comments about the need for maintenance of departure sites (e.g., clean restrooms, more trash cans, signage), as well as the need for improvements. Some of the suggestions for improvements were the expansion of parking spots, the addition of fishing cleaning stations and boat washing capacity (Table 27).

The third largest category overall was **Waterway Infrastructure Maintenance and Improvements** (20.5%). Within this category, respondents argued that keeping the inlets and channels dredged is very important to improve their boating enjoyment. The second largest sub-category was inadequate channel and inlet marks, and confusing, poorly maintained, or hazardous waterway signs, particularly unlighted ones. Some comments related with marks and sign improvements are: "*Put lights on all inlet channel markers," "improve markers at St Augustine Inlet," "buoys should have lights or large reflectors," "some inlet signs are difficult to see at night."*

More Water Access concerns were the focus of 7.7% of all responses. This category includes comments on the need for more boat ramps (e.g., Marys River, Amelia River), anchorages and mooring fields, marinas and dry stack facilities near inlets (Table 27).

Table 27. Frequency and percentage of survey respondents who provided comments and/or suggestions that would improve their boating enjoyment.

Category/Sub-Category	**N**	**Percentage**
Excessive Regulations	**74**	**31.6**
Fishing Regulations	64	27.4
Speed, No Wake, and Manatee Zones	10	4.3
Departure Facilities Maintenance and Improvement	**61**	**26.1**
Ramp maintenance in General	22	9.4
More Parking	13	5.6
Add Cleaning Stations and Washing Capacity	12	5.1
Improved boat ramps in general	6	2.6
Storm Protection	1	0.4
More Docks	3	1.3
More Amenities (i.e., soda, snacks, ice machine)	3	1.3
Pumpout Stations with ethanol	1	0.4
Waterway Infrastructure Maintenance and Improvements	**48**	**20.5**
Dredging	27	11.5
Waterway Marks, Signs, and Buoys	19	8.1
Improve Jetties	1	0.4
Add a Cellphone Towers	1	0.4
More water access	**18**	**7.7**
Boat Ramps	10	4.3
Anchorages and Mooring Fields	4	1.7
Kayak access	2	0.9
Ramps and Marinas with Sailboat Capacity	1	0.4
Marinas	1	0.4
Boater Education	**10**	**4.3**
Altered Environment	**5**	**2.1**
More Destinations/Activity Provisions	**5**	**2.1**
More destinations	1	0.4
More artificial reefs	3	1.3
Designated Watersport Areas	1	0.4
Better Enforcement	**3**	**1.3**
More information (fishing closing schedule, weather, location of anchorages and mooring fields)	**4**	**1.7**
General Category	**6**	**2.6**
Development of Matanzas	2	0.9
Gas Prices	2	0.9
Inshore Study	1	0.4
Visitors Tax	1	0.4

The need for **Boater Education** comprises a category with 4.3% of total responses. Some of the comments in this category were: "The problem today most boaters do not know the rules of the waterway. More education for new boaters," "…boating safety classes should be a requirement to operate a vessel," "I think a mandatory boating course would be a good thing."

Part 3-Spatial Analysis of Boating Patterns

3.1. Mapping Boating Patterns

General Density Patterns

This chapter presents the results of a GIS analysis that mapped the distribution or spread of the digitized trip information as "density of occurrence." Continuous density surfaces generated by the GIS illustrate the degree of concentration or clustering of digitized trip information. General clustering patterns for travel routes and destinations were mapped and described using 100-meter grid cells and a search radius of 1,000 meters (Figs. 14 and 15). Furthermore, the Getis-Ord G statistic (Getis & Ord, 1996) was calculated and the Z-scores of the statistic (Gi*) were rendered using ArcMap to reveal statistically significant hot-spots of boating routes (Figs. 16 and 17) and destinations (Fig. 18). The Getis-Ord G-statistic gives a measure of clustering relative to a neighborhood of values. So, if features that have high values are clustered in one area, the G-statistic will be larger than would be expected if the values were the result of random chance, and that feature is part of a "hotspot." For this analysis, the G statistic was calculated using a 1 km sampling grid cell and the neighborhood was restricted using a queen's matrix. This means that only the cells immediately adjacent (not diagonal) to the sides of any given cell were considered in the neighborhood calculation. From these values, Z scores by season were calculated and those with statistically significant scores were mapped. For the analysis, any Z scores greater than 1.96 ($\alpha = 0.5$), were shown. To render the results, we used the significant level values based on the standard normal critical values (i.e., 1.645, 1.960, 2.576) to summarize the results into 5 classes, which range nominally from non-significant levels of clustering to highly significant levels.

The greatest mapped density (Fig. 14) is restricted to the areas near and west of the main river entrances (St. Marys, St. Johns, and St. Augustine inlets). From each river entrance, recreational boating routes spread out moving mainly west (towards offshore waters), but also there are some routes traveling north and south, and between inlets. Recreational vessel traffic using the St. Marys river entrance showed the least spread pattern when compared with the other two main navigable inlets in the study area. Recreational vessels using the St. Augustine inlet traveled the furthest to reach the fishing ground at the ledge zone. The Getis-Ord G-statistic reveals that areas near the three main inlets, and up to 5nm at St. Marys inlet, 20 nm at St. Johns inlet, and 15nm at St. Augustine inlet, have consistent heavy clustering of recreational boating routes throughout the 4 seasons (Fig. 17 and 18).

Popular destinations seem to be located between 8-10 nautical miles from the nearest inlet and extend to an area that is about 15 nm for boaters using the St. Marys inlet, 25-30 nm for boaters using the St. Johns and St. Augustine inlets (Fig. 15). The Getis-Ord G-statistic supported the presence of heavy clustering of boating destinations at the locations described previously (Fig. 18). Three main features may be influencing the spatial distribution of recreational boating destinations: presence of artificial reefs and fish havens and deep-water areas at the ledge of the Florida continental shelf.

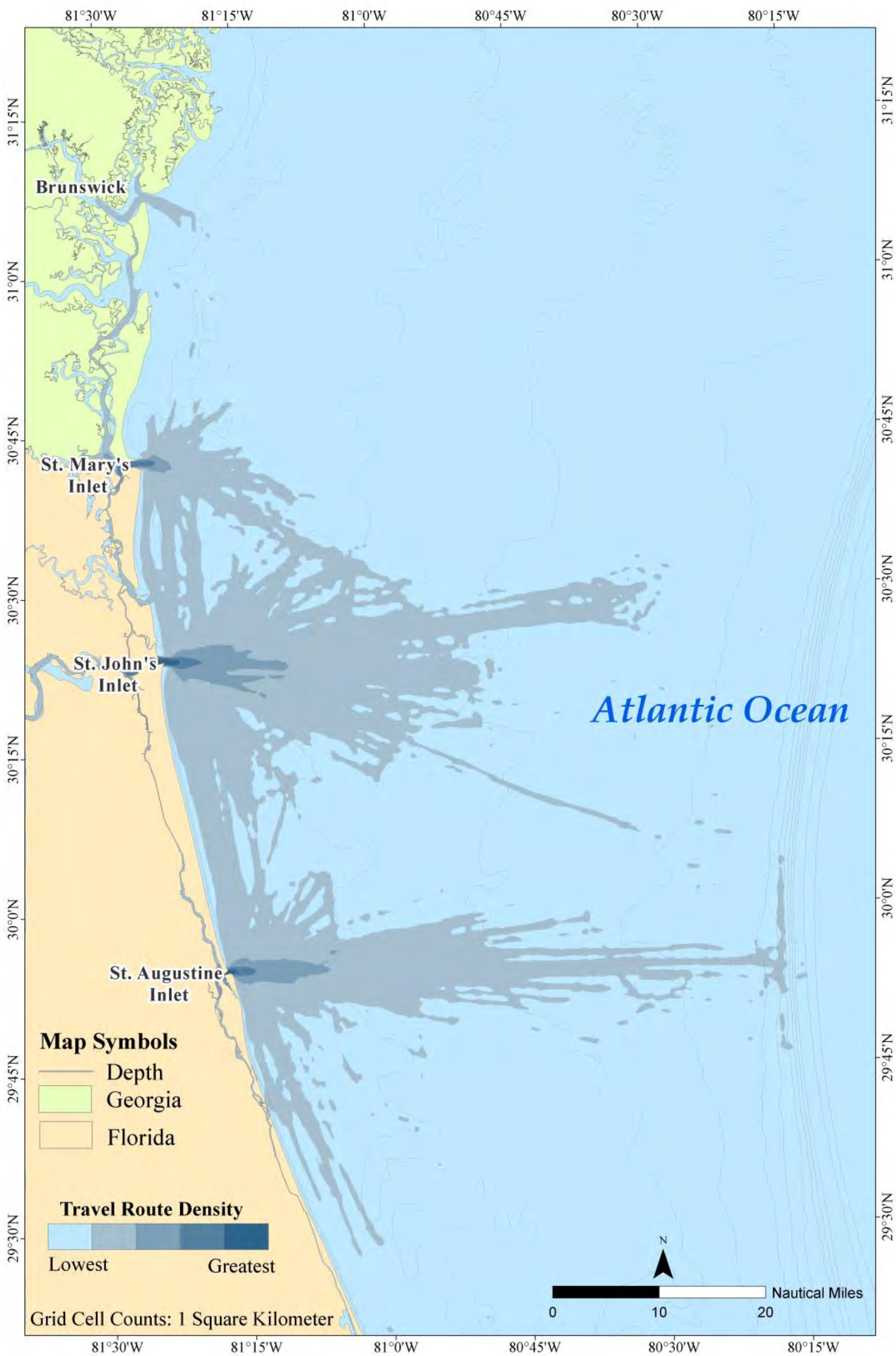


Figure 14. GIS summary of trip routes (all seasons) identified by survey respondents (N=2,522 trips).

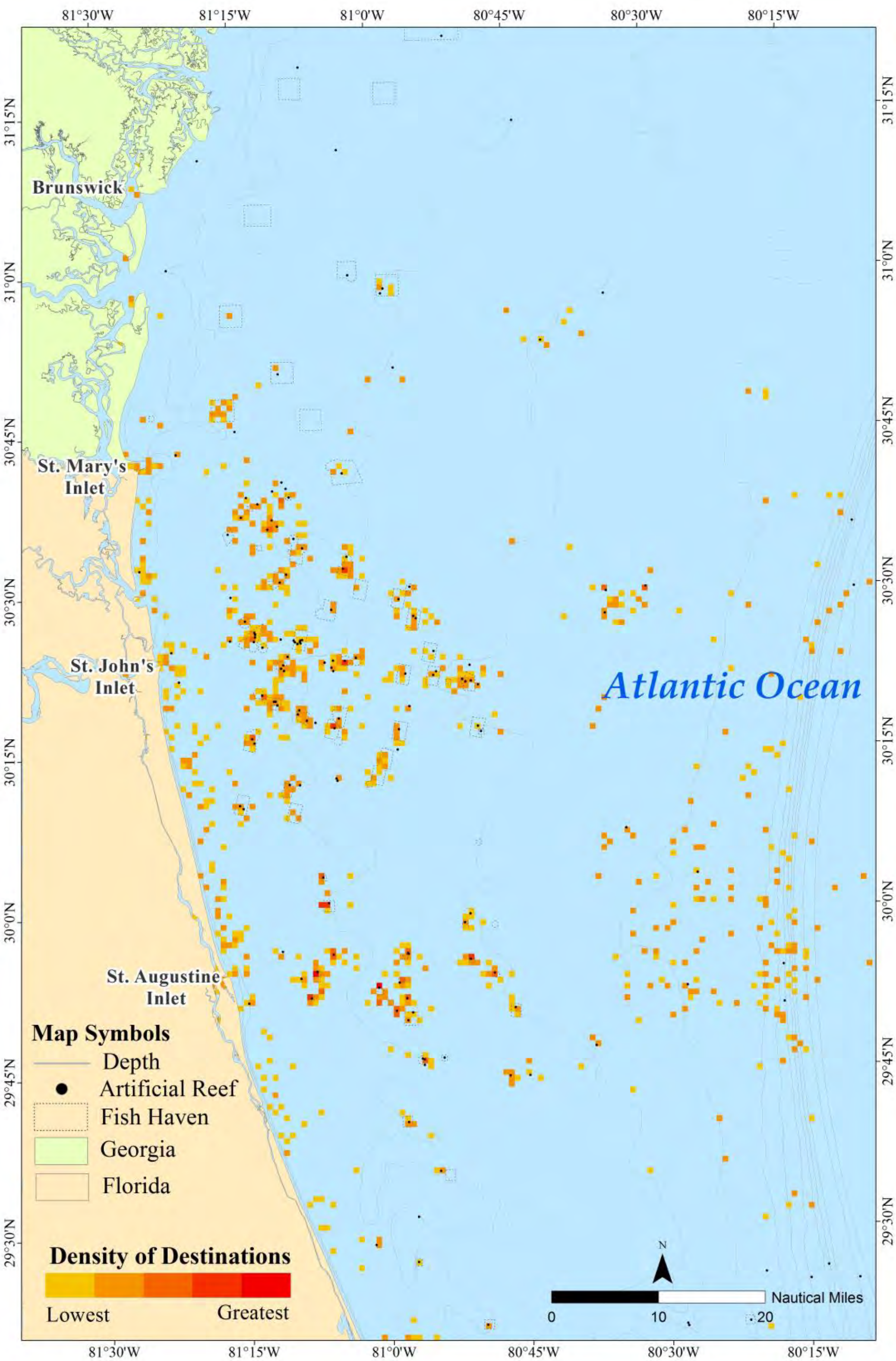


Figure 15. Recreational boating destinations identified by survey respondents (N=1,881).

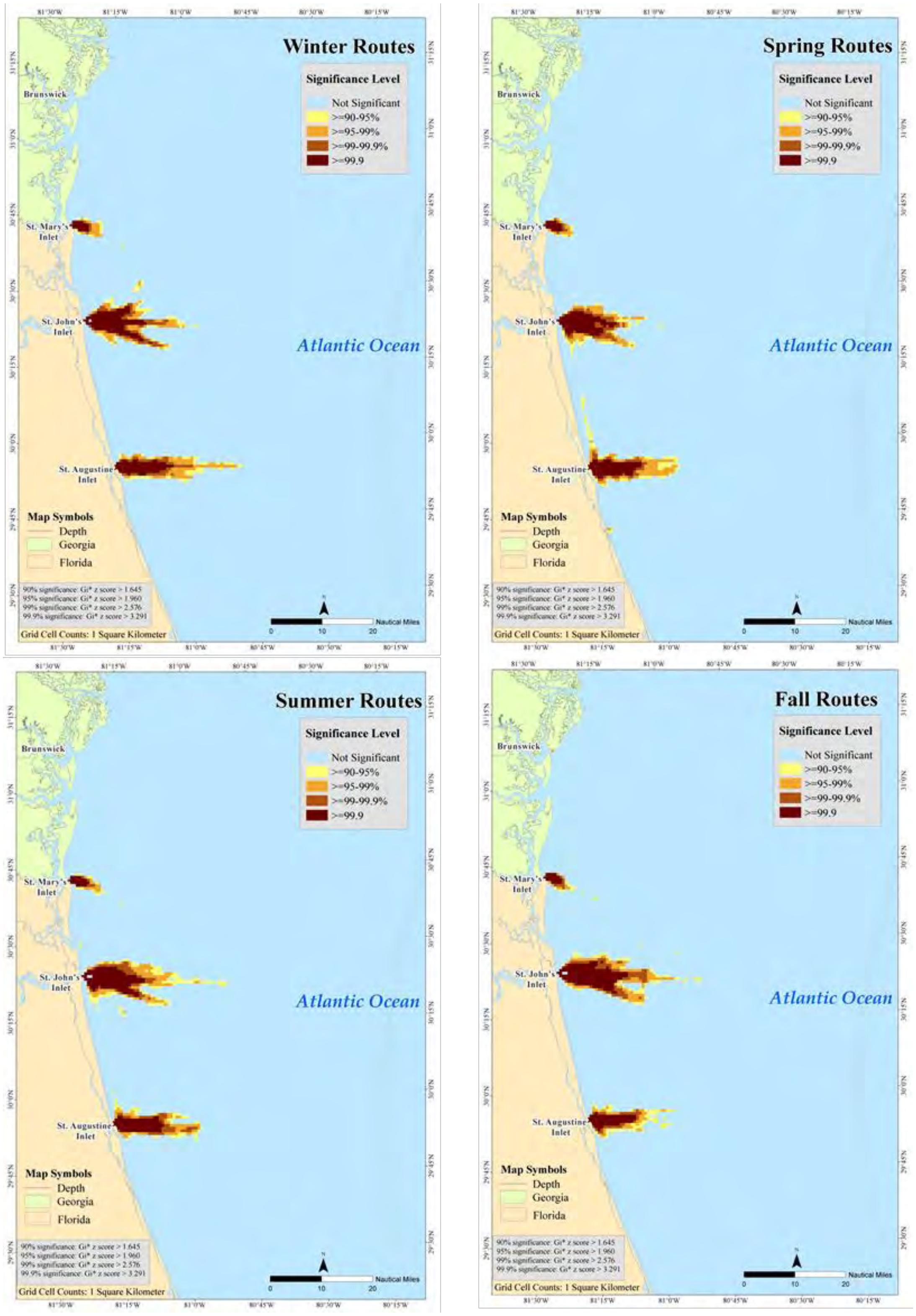


Figure 16. Getis-Ord (Gi*) statistic showing grid cells with statistically significant Z-scores for boating trip routes by season.

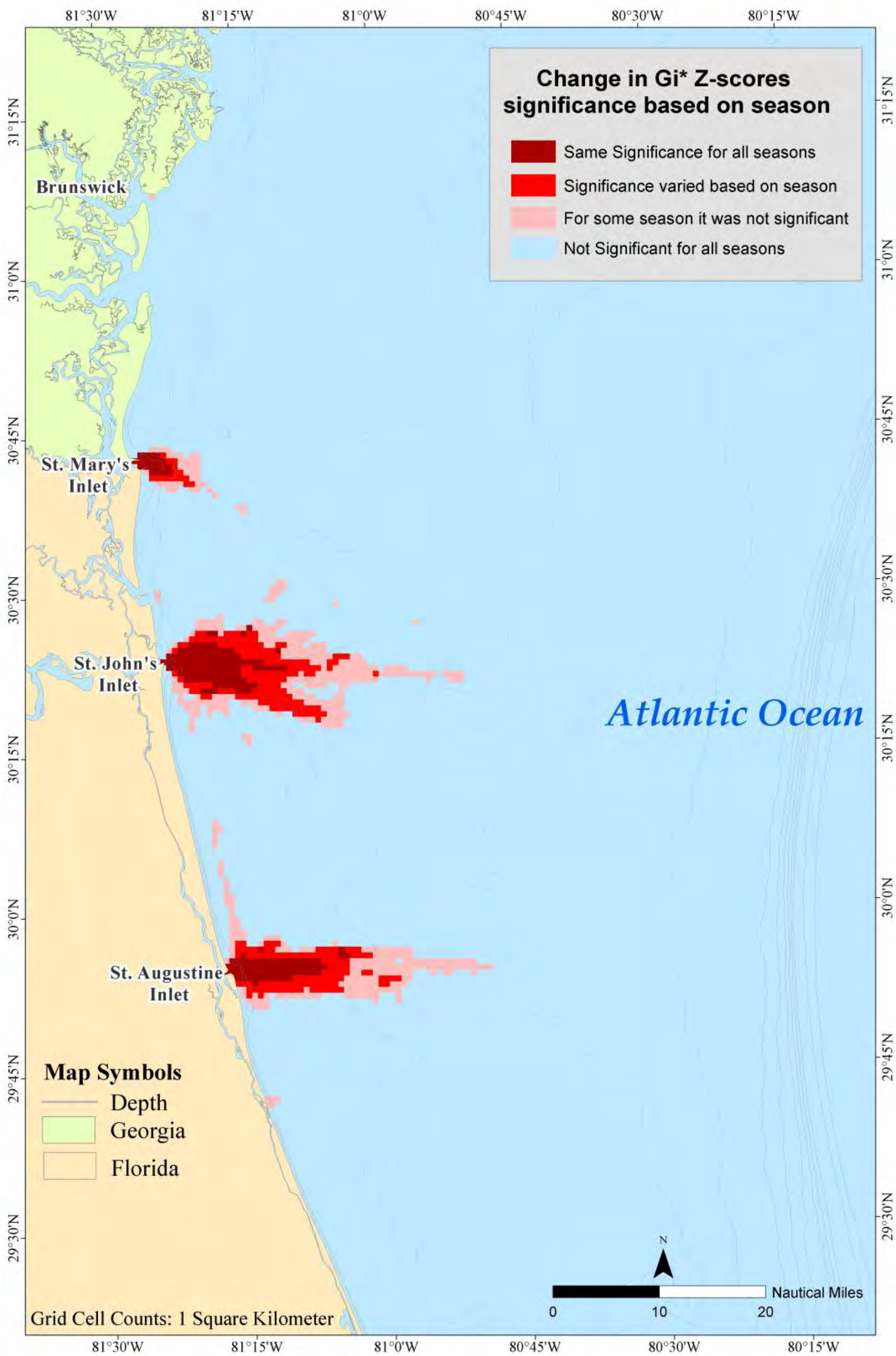


Figure 17. Getis-Ord (Gi*) statistic showing grid cells with statistically significant Z-scores based on season.

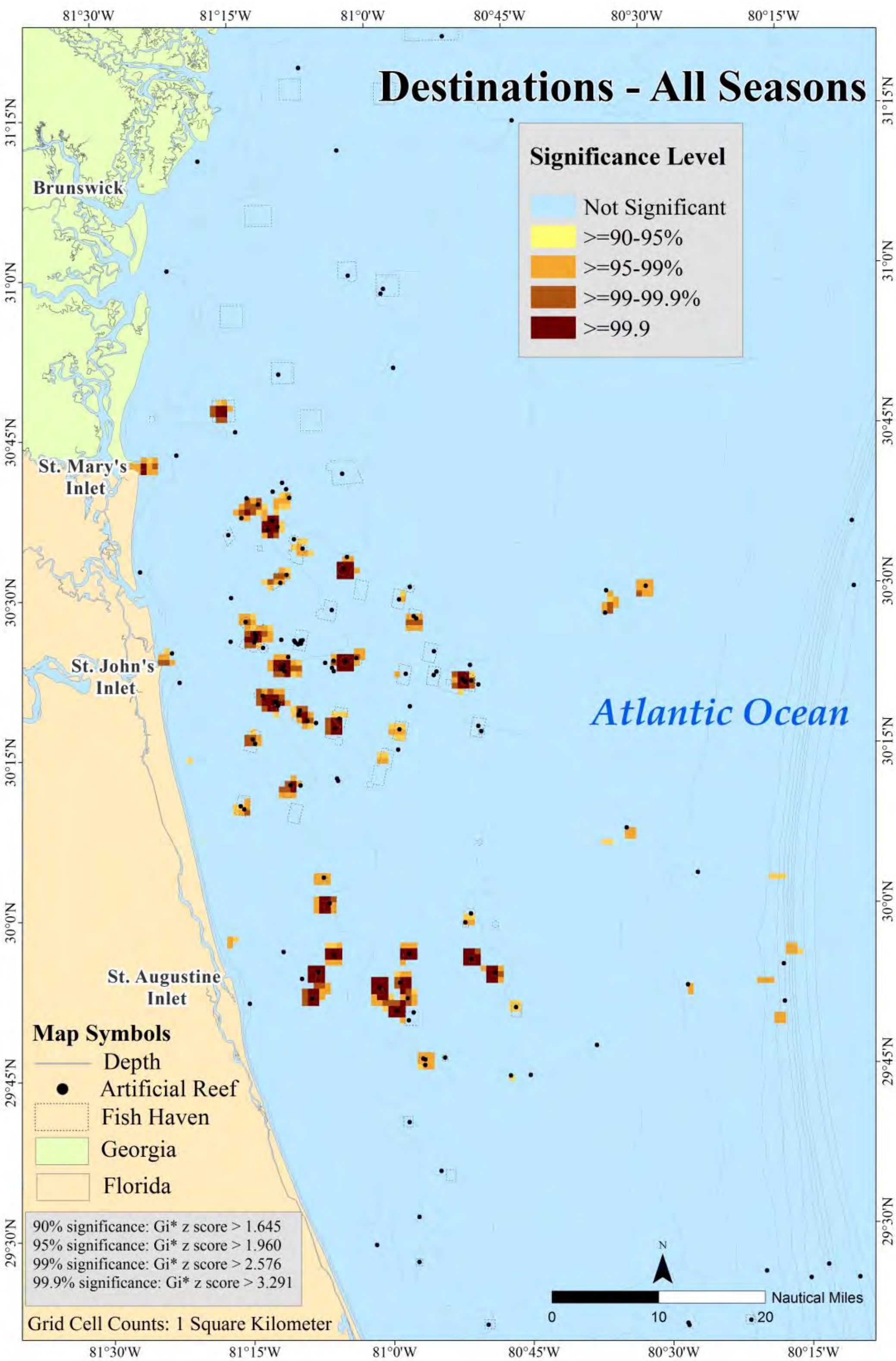


Figure 18. Getis-Ord (Gi*) statistic showing grid cells with statistically significant Z-scores for destination points for all seasons.

3.1 Offshore Recreational Vessel Abundance

Background

Estimates of abundance are important to understand the population dynamics of the species of interest, as well as to develop management strategies. We used open-population capture-recapture models to estimate the abundance of offshore recreational vessels in the northeast Florida and southeast Georgia Region. Capture-recapture models have been used traditionally to estimate population of animals (Williams et. al., 2011; Madon et. al., 2013; Goswani et.al, 2007). However, to our knowledge, this is the first attempt to use this approach to estimate abundance of recreational vessels. We counted already marked vessels (i.e., vessel ID, name, characteristics) over a number of occasions in order to obtain an estimate of population size. The population estimate was obtained using the superpopulation approach which can be thought of as either the total number of offshore vessels available for sighting at any time during the study, or, alternatively, as the total number of offshore vessels ever in the sampled area between the first and last sampling occasion (Williams et.al., 2011). The superpopulation approach embodies the Cormack-Jolly-Seber (CJS) model assumptions (Williams et. al., 2001):

a) Every marked animal (recreational vessel) present in the population at sampling period i has the same probability of being recaptured or resighted.

b) Every marked animal (recreational vessel) present in the population immediately following the sampling in period i has the same probability of survival until sampling period i+1.

c) Marks are neither lost nor overlooked, and are recorded correctly.

d) Sampling periods are instantaneous and recaptured animals are released immediately.

e) All emigration from the samples area is permanent.

f) The fate of each animal (recreational vessel) with respect to capture and survival probability is independent of the fate of any other animal (recreational vessel).

Based on these assumptions of the CJS model, we think that capture-recapture histories of offshore recreational vessels can be used to estimate offshore recreational abundance in the study area.

Methods

Capture histories were conducted for each offshore recreational vessel photographed. The methodology to obtain the recreational vessel capture histories is described in the sampling design section of this report.

Sampling days within each season were analyzed in program CloseTest (Stanley and Richards, 2005) to test whether or not offshore recreational vessels population is “closed” to additions and deletions (no emigration, immigration, births, or deaths) (Armstrup, et.al., 2005).

We ran a number of Cormack-Jolly-Seber (CJS) models. We followed the model notation used by Cooch and White (2015), where (t) denote models that allow for the parameters to vary over time and (.) denote models that assume that any of the parameters are constant. The parameters used for estimating superpopulation (N-hat) were apparent survival (ϕ_i), probability of recapture (p_i), probability of entry (b_i). For each treatment within each season the following models were tested:

- All variables time dependent: ϕ(t) p(t) b(t)
- Apparent survival probability constant and the other variables time dependent: ϕ(.) p(t) b(t)
- Probability of capture constant and the other variables time dependent: ϕ(t) p(.) b(t)
- Only probability of entry is time dependent: ϕ(.) p(.) b(t)

Not all parameters in the model are identifiable (Schwarz and Arnason, 1996). To mitigate this issue, when models in which survival probability (ϕ) and/or probability of recapture (p) are allowed to vary in time, we followed the approach suggested by Williams and others (2011), where the probability of recapture was set $p_1=p_2$ and $p_k=p_{k-1}$ (where k is the final sample occasion). The time intervals were adjusted for time elapsed between surveys. We estimated the apparent survival and encounter probability parameters using a logit link function, a mlogit(1) function was used to estimate the probability of entry parameters, and the superpopulation size was estimated using a log link function (Cooch and White, 2015). The gross superpopulation size (N-hat) is a derived parameter of the POPAN model. It includes all the vessels that are available to be detected during at least one survey because they enter the population (net superpopulation size N) and recreational vessels that are never available to be detected because they enter and leave the population between consecutive surveys (Williams, et.al. 2011).

Goodness-of-fit (GOF) test for the CJS model was performed in program RELEASE (implemented in program MARK). When overdispersion was detected the variance inflation factor ($\hat{c}$ or c-hat) was estimated using the bootstrapping GOF, resulting in a quasi-Akaike Information Criterion (QAIC). Models were ranked and compared using AIC or QAIC. Models with the lowest AIC (or QAIC) values were most supported by the data. When appropriate the abundance estimate was calculated using model average (Williams et al., 2011).

Results

Over the course of the 17 months of data collection, 39,317 events were recorded which involved different vessel categories (e.g., commercial, recreational, and military). The majority of vessels sightings correspond to recreational vessels (Table 28). The greatest number of events (45%) were recorded at St. Johns inlet, followed by St. Augustine inlet (31%), and St. Marys inlet (23%).

Table 28. Number of events recorded at each inlet, by vessel category

Code	Vessel Type	St. Augustine Inlet	St. Johns Inlet	St. Marys Inlet	Total
CA	Cargo ships	0	231	34	265
T	Tug boats	11	187	80	278
SH	Shrimp boats	119	306	204	629
CF	Commercial fishing	109	6	7	122
CR	Crab boats	117	95	13	225
H	Head boat (big)	177	289	223	689
H(S)	Head boat (small)	786	2	191	979
O	Other (law enforcement, gov, mil)	622	1322	463	2,407
F	Open fisherman	6320	11290	4907	22,517
CC	Cabin cruisers	661	581	426	1,668
R	Runabouts	822	1701	953	3,476
W	Walk-around boats	519	990	493	2,002
S	Sailing	1178	306	707	2,191
OF	Offshore boats	728	405	304	1,437
P	Pontoon boats	63	65	78	206
J	Jet Skies	48	83	7	138
K	Kayaks	20	11	26	57
WR	Wind riders	14	5	0	19
UN	Unknown	10	0	2	12
Total		12,324 (31%)	17,875 (45%)	9,118 (23%)	39,317

Recreational vessels (86%) comprised most of the maritime traffic in the study area and further analysis was conducted only on this category, which, for the purpose of this study, includes: open fisherman, offshore, cabin cruisers, runabouts, walkarounds, pontoon, and sailing vessels. Figure 19 shows the number of recreational vessel sightings by inlet (using bar chart) and the average air temperature (degrees celcius) observed for each of the 64 sampling days (line chart). As expected, as temperature increased so did the number of sightings. We accounted for this variation by analysing the data by seasons: Winter (December, January, February), Spring (March, April, May), Summer (June, July, August), and Fall (September, October, and November).

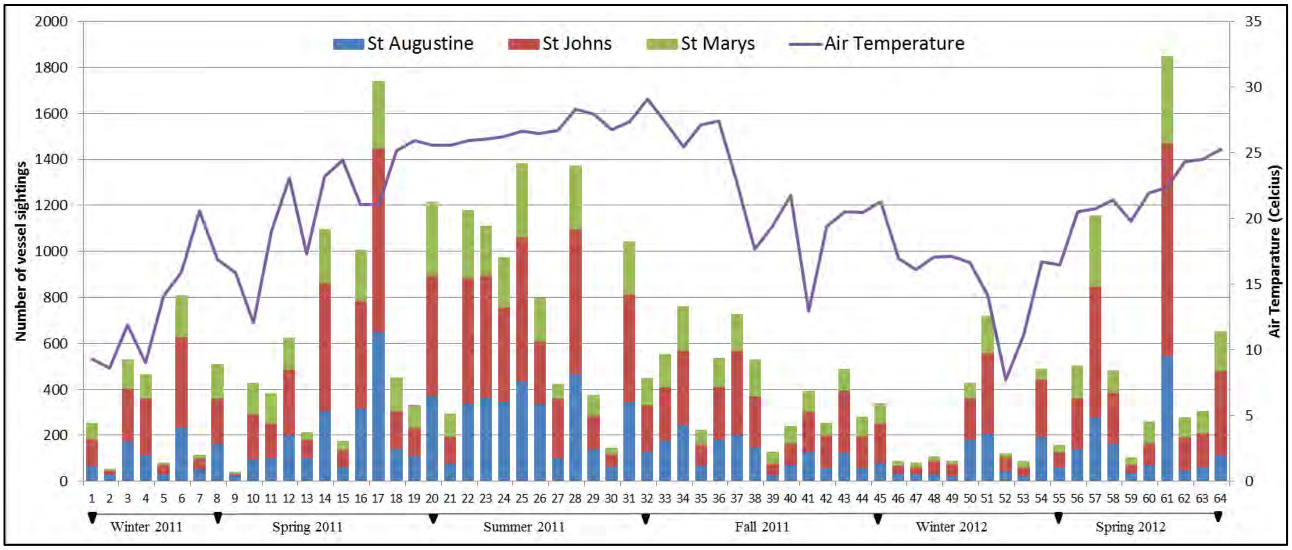


Figure 19. Number of recreational vessel sightings by inlet (bar chart) and the average air temperature observed during sampling days.

In total, 33,497 sightings of recreational vessels were recorded. After accounting for multiple sightings of the same vessel, either by sampling day or on different seasons, we calculated the capture-recapture history for 10,464 unique vessels IDs (Table 29). Based on the number of sightings per vessel throughout the different seasons, there were more sightings of offshore recreational vessels during the spring and summer seasons.

Table 29. Summary of the number of sightings per sampling day and season.

Season	Identified Vessels	With multiple sightings by sampling day and season				With multiple sightings within season				# Sampling days by season
		#	Mean (std. dev)	Min	Max	#	Mean (std. dev)	Min	Max	
Winter 2011	1,425	2,555	1.79 (1.12)	1	12	1,633	1.15 (0.43)	1	5	8
Spring 2011	3,293	6,944	2.11 (1.64)	1	24	4,103	1.25 (0.66)	1	10	12
Summer 2011	3,690	8,493	2.30 (1.93)	1	25	5,048	1.37 (0.85)	1	10	12
Fall 2011	2,444	4,899	2.00 (1.55)	1	25	2,996	1.23 (0.65)	1	9	13
Winter 2012	1,112	2,168	1.95 (1.14)	1	11	1,262	1.13 (0.41)	1	4	10
Spring 2012	2,528	4,962	1.96 (1.31)	1	16	3,029	1.20 (0.55)	1	6	9
Total	14,492	30,021				18,071				64

There were two sampling dates with large numbers of recreational vessel sightings (May 7, 2011 and April 28, 2012). Both dates coincide with a number of activities in the area (e.g., the reenactment of Ribault's arrival to Mayport in 1562). We decided to excluded the information from these two days because they correspond to special occasions and depart from the regular recreational boating traffic in the study area (Fig. 20).

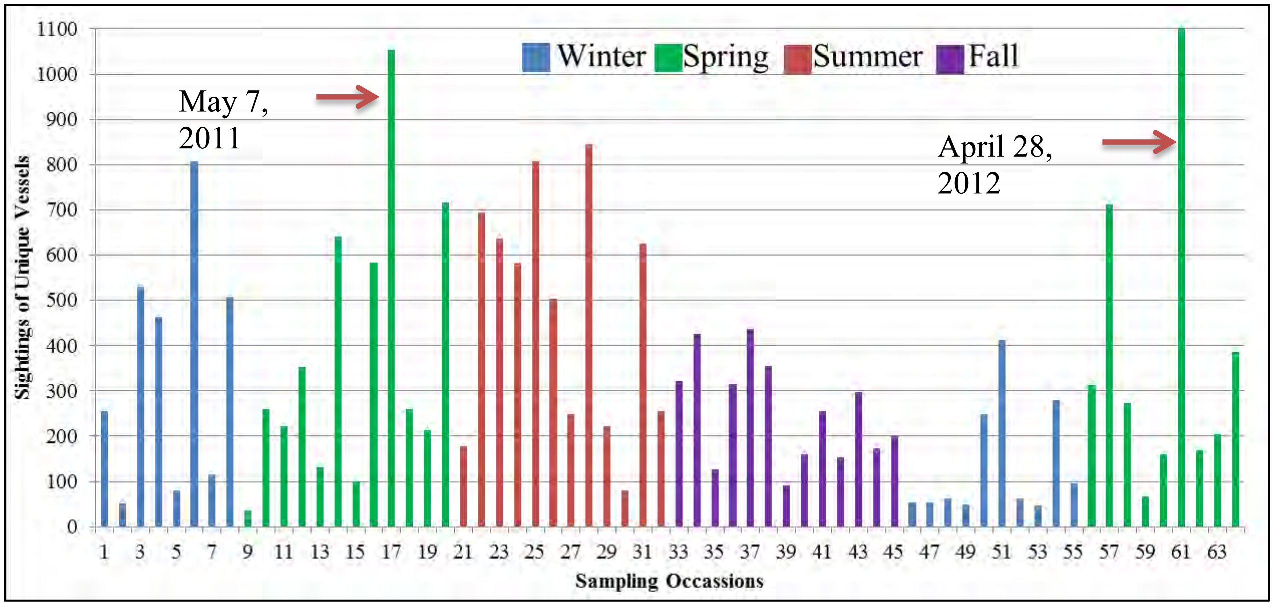


Figure 20. Unique vessels sightings by sampling day. A large number of vessels were sighted on sampling day 17 (May 7, 2011) and day 61 (April 28, 2012) as compared with other sampling days.

Table 30 provides a description of the number of unique vessel sightings by season. About 80% of offshore recreational vessels were observed over one season, 15% were observed over two seasons, and 4% were observed over 3 seasons, and only 1% of vessels were observed year around. In most cases (except for summer 2011) the number of recaptured vessels was relatively low when compared with the number of vessels caught (Fig. 21).

Table 30. Summary of observed seasonal capture and recapture histories of observed recreational vessels (2011) in the study area.

Seasonal History	Count	Description
0010	2,746	Observed only in SUMMER
0100	2,301	Observed only in SPRING
0001	1,729	Observed only in FALL
1000	933	Observed only in WINTER
0110	565	Observed in SPRING and SUMMER
0011	337	Observed in SUMMER and FALL
0101	184	Observed in SPRING and FALL
1100	164	Observed in WINTER and SPRING
1010	103	Observed in WINTER and SUMMER
1001	55	Observed in WINTER and FALL
0111	213	SPRING-SUMMER-FALL
1110	109	WINTER-SPRING-SUMMER
1011	54	WINTER-SUMMER-FALL
1101	46	WINTER-SPRING-FALL
1111	104	Year around
Total	9,643	

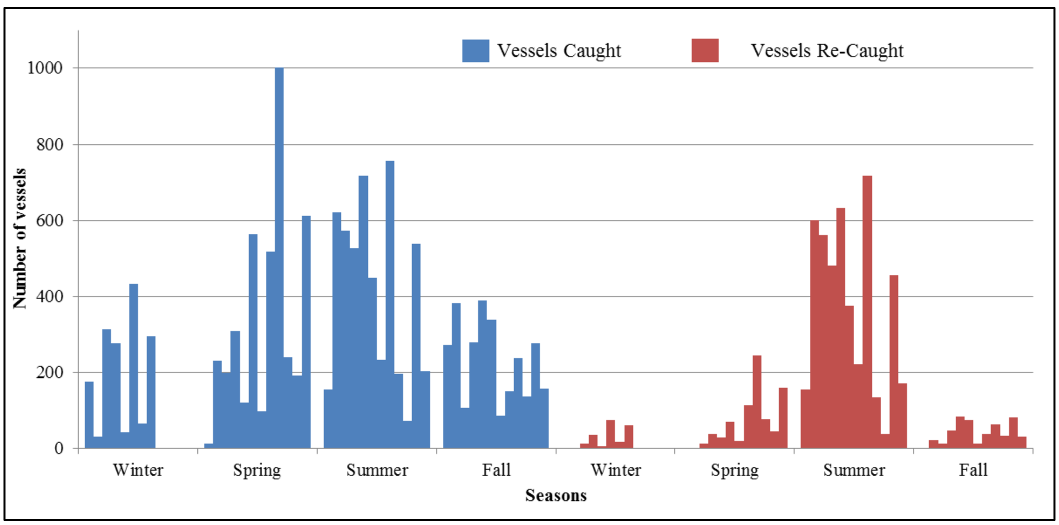


Figure 21. Summary of recreational vessel captures (on left) and recaptures (on right) by season.

In the case of offshore recreational vessels, since we did not mark the vessels but used already established marks (e.g., the vessel name, vessel number, or vessel characteristics), we reasoned that the probability of capture does not depend on previous capture history (no behavioral response). However, it is possible that individual capture probability may be heterogeneous across boaters, especially between the days of the week that the recreational vessel was observed. We accounted for this variation by stratifying our sampling day based on temporal boating reports for other areas in Florida (Sidman et al., 2005).

The majority of recreational boaters were recorded only within a specific day of the week treatment (80.8%). Over 12% of vessels were observed over the Weekend and Holiday treatments. Less than 1% of vessels were sighted between all our days of the week treatments (Table 31).

Table 31. Summary of recreational vessel captures and recaptures histories based on the days of the week: Weekend (Friday to Sunday), Mon-Thu (Monday to Thursday), and Holiday (varies).

History	**Day of the week**	**# of sightings**	**Percentage**
100	Observed on WEEKEND only	4,862	50.3%
001	Observed on HOLIDAY only	1,937	20.0%
010	Observed on MON-THU only	1,011	10.5%
101	Observed on WEEKEND and HOLIDAY	1,162	12.0%
110	Observed on WEEKEND and MON-THU	345	3.6%
011	Observed on MON-THU and HOLIDAY	86	2.7%
111	Observed on all	258	0.9%

Overall there were more sightings of recreational vessels over the weekend treatment (N=2,091; min=185; max=471). The highest number of sightings for the weekend treatment was recorded over the summer (2011). Over the holiday treatment we also observed a great number of vessel sightings (N=2,069; min=111; max=646), especially for spring and summer 2011. The lowest number of vessel sightings was observed for the Mon-Thu treatment (Table 32, Fig. 22). Analysis of variance (ANOVA) revealed a significant difference between the number of observed vessels for the three day of week treatments ($F=12.3$, $p<0.05$). The Tukey post-hoc test showed no significant difference in the number of observed vessels between the weekend and holiday groups ($p = 0.925$). However, there were significant differences between the weekend days and Mon-Thu groups ($p <0.05$), as well as between holidays and Mon-Thu groups ($p<0.05$). Since there were no statistical significant differences between the weekend and holiday treatment, further analysis was performed by combining these two previous categories into one named Weekend-Holiday.

Table 32. Descriptive statistics of the number of offshore recreational vessels observed by day of the week treatments. Weekend (Friday to Sunday), Mon-Thu (Monday to Thursday), and Holiday (varies).

Treatment	Occasions	Mean	Std. Deviation	Min	Max	95% CI
Weekend	30	320.40	174.07	48	756	255-385
Mon-Thu	19	107.11	64.66	14	233	76-138
Holiday	13	340.46	219.28	44	718	208-473
Total	62	259.24	188.55	14	756	211-307

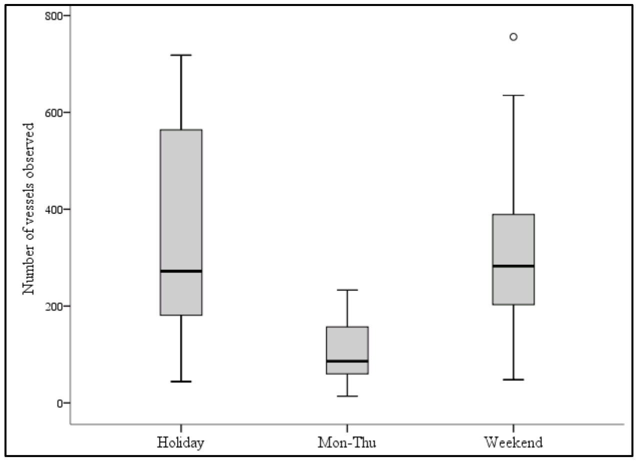


Figure 22. Box plot of the number of offshore recreational vessels observed by day of the week treatment. Weekend (Friday to Sunday), Mon-Thu (Monday to Thursday), and Holiday (varies).

Abundance estimates

We used a capture-recapture approach to estimate seasonal abundance of offshore recreational vessels in the study area. The population of offshore recreational vessels cannot be considered as closed because the total number of individuals is changing through additions (immigration and new vessels) or deletions (emigration and vessels out of circulation) over time (Armstrup, et. al. 2005). This assumption was confirmed using the program CloseTest (Stanley and Richards, 2005). We found that for all the study seasons the offshore recreational vessel population is open to gains by immigration and new recreational vessels and also to losses by emigration and retiring vessels (Table 33).

Table 33. CloseTest results for the capture-recapture dataset of offshore recreational vessels by season. Low p-values suggest population not closed.

Season	Vessel captures	Occasions	Chi-square	Degrees of freedom	p-value
Winter 2011	1,425	8	23.34	11	0.016
Spring 2011	2,582	11	132.12	17	0.001
Summer 2011	3,690	12	286.14	20	0.001
Fall 2011	2,444	13	204.42	22	0.001
Winter 2012	1,112	10	42.06	13	0.001
Spring 2012	1,772	8	82.89	12	0.001

As expected, the estimated population size varied seasonally (Table 34). The lowest abundance estimate was for winter followed by fall. The population estimate for spring and summer seasons were the highest. The seasonal abundance estimates fluctuated, with higher abundance estimated for the spring 2011 and summer 2011 seasons. The coefficient of variation (CV), which is a measure of precision, varied by treatment and season. Weekends and holidays CV ranged from 3.8% – 32.2%. The CV for the Monday-Thursdays treatment was smaller than the one observed for the previous treatment, ranging from 2.6 % – 10.2%. In general, there were more sampling occasions over the weekend and holiday treatment than over the Mon-Thu treatment (Table 34 and Fig. 29).

Table 34. Model selection results from capture-recapture for the seasonal open-population of offshore recreational vessels using POPAN parametrization in Program MARK. Apparent survival (ϕ_i), probability of recapture (p_i), probability of entrance (b_i), variance inflation factor (c-hat), QAIC, super-population size estimate (N-hat), standard error (SE), 95% confidence intervals (CI), and coefficient of variation (CV).

Season	Treat-ment	Occasions (Caught)	Supported model	c-hat	QAICc	QAICc Weight	N-hat	SE	95% CI		CV
									Lower	Upper	
Winter 2011	Weekends & Holidays	5 (1318)	$\phi(.)\ p(t)\ b(t)$ $\phi(t)\ p(t)\ b(t)$ $\phi(.)\ p(.)\ b(t)$	1.781	1010.7 1010.9 1018.5	0.5223 0.4671 0.0106	5,727	615.86	4,236	7,218	9.3%
	Mon-Thu	3 (131)	$\phi(.)\ p(.)\ b(t)$ $\phi(t)\ p(t)\ b(t)$ $\phi(t)\ p(.)\ b(t)$	1.243	75.0 82.3 82.5	0.95355 0.02417 0.02229	735	257.49	230	1,240	3.2%
Winter 2012	Weekends & Holidays	7(950)	$\phi(.)\ p(t)\ b(t)$ $\phi(t)\ p(t)\ b(t)$	2.002	504.6 525.0	0.9999 0.00004	4,914	1,287.40	2390	7,437	3.8%
	Mon-Thu	3 (186)	$\phi(.)\ p(.)\ b(t)$ $\phi(t)\ p(.)\ b(t)$	1.213		0.73895 0.26105	455	54.90	347	563	8.3%
Spring 2011	Weekends & Holidays	7(2205)	$\phi(t)\ p(t)\ b(t)$ $\phi(.)\ p(t)\ b(t)$	1.686	1721.4 1721.4	0.50257 0.49739	10,576	789.09	8985	12,167	13.4%
	Mon-Thu	4 (478)	$\phi(.)\ p(.)\ b(t)$ $\phi(t)\ p(.)\ b(t)$ $\phi(.)\ p(t)\ b(t)$ $\phi(t)\ p(t)\ b(t)$	1.904	131.6 133.0 133.5 134.8	0.47511 0.24280 0.18400 0.09809	3,887	14,68.30	802	6,973	2.6%
Spring 2012	Weekends & Holidays	6(1506)	$\phi(t)\ p(t)\ b(t)$ $\phi(.)\ p(t)\ b(t)$	1.674	928.4 931.2	0.80181 0.19819	7,651	755.76	5,943	9,358	10.1%
	Mon-Thu	2(324)	$\phi(t)\ p(.)\ b(t)$ $\phi(t)\ p(t)\ b(t)$	1.000	57.4 59.5	0.73714 0.26286	777	76.97	626	928	10.1%
Summer 2011	Weekends & Holidays	9(3430)	$\phi(t)\ p(t)\ b(t)$	1.738	4650.4	1.0000	8,823	274.20	8,302	9,377	32.2%
	Mon-Thu	3 (436)	$\phi(t)\ p(.)\ b(t)$ $\phi(.)\ p(t)\ b(t)$ $\phi(.)\ p(.)\ b(t)$	1.181 1.171 1.155	197.2 199.3 206.7	0.72834 0.26531 0.00635	2,424	586.69	1,248	3,600	4.1%
Fall 2012	Weekends & Holidays	10(2170)	$\phi(.)\ p(t)\ b(t)$ $\phi(t)\ p(t)\ b(t)$ $\phi(t)\ p(.)\ b(t)$	2.155 2.185 2.158	1803.9 1806.2 1812.8	0.75099 0.24031 0.00869	8,249	617.41	7,006	9,492	13.4%
	Mon-Thu	3(349)	$\phi(t)\ p(t)\ b(t)$	1.192	92.09	1.0000	962	94.66	795	1,167	10.2%

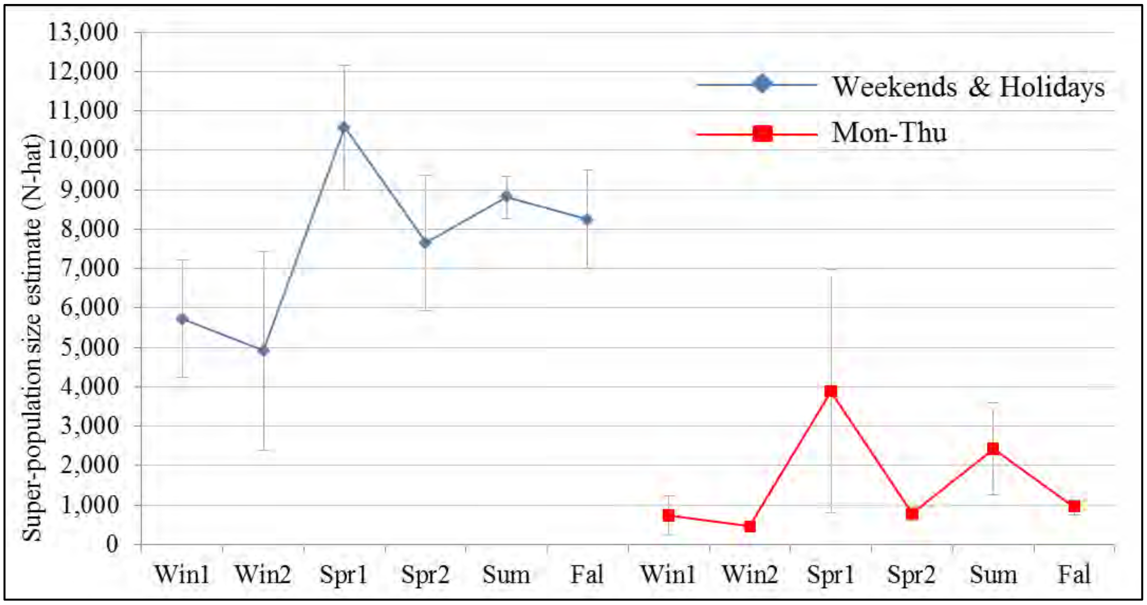


Figure 23. Super-population size estimates with error bars (gray lines) by day of the week treatment for each of the studied seasons. Winter 2011 (Wi1), Winter 2012 (Wi2), Spring 2011 (Sp1), Spring 2012 (Sp2), Summer 2011 (Sum), and Fall 2011 (Fal).

Even though we observed the highest number of vessels in the study area during summer 2011, population estimates for spring 2011 are higher than the ones calculated for the summer 2011. This may be explained by the fact that over the summer 2011 we recorded the highest percentage of recaptures (34%). Capture-recapture analysis takes this information into account while performing the estimation of population size (Fig. 24)

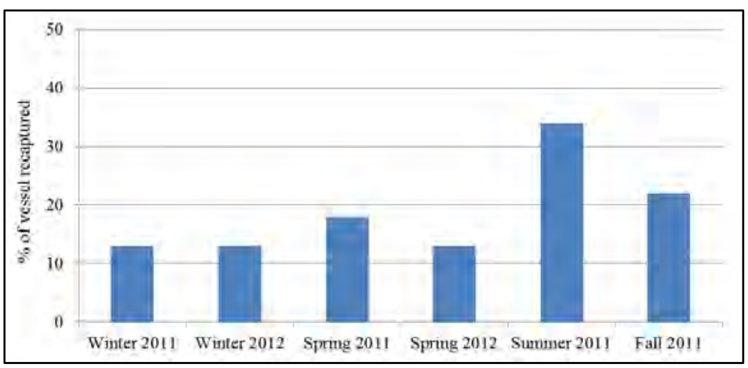


Figure 24. Percentage of recreational vessels recapture during the weekend and holiday treatment.

Offshore recreational population size estimates varied by year. Based on the analysis there was a greater abundance of offshore recreational vessels during the winter and spring seasons in 2011 than during winter and spring 2012.

Part 4 - Mapping Offshore Recreational Vessels and Right Whales Co-Occurrences

Background

The Southeast United States (SEUS) is a very important area for human activities. It involves a great amount of vessel traffic involving military, commercial, and recreational vessels. The area also corresponds with the wintering habitat of the North Atlantic right whales (*Eubalaena glacialis*), which use it as nursing and calving ground from December to March. Waring and others (2013) estimated that the current population or *E. glacialis* comprises about 450 individuals. Due to the precarious situation of *E. glacialis*, which was almost brought to extinction due to whaling, several management actions to protect the species have been developed. However, Kraus and other (2005) suggested that the recovery of this species has been prevented by low reproductive rates and declining survival probabilities, and by right whale mortalities due to collisions with ships and entanglements in fishing gear.

Some studies have documented the probability of co-occurrence between right whales and commercial ships (65 ft. or greater) in the main habitats of *E. glacialis* (Ward-Geiger et al., 2005; Fonnesbeck et al., 2008; Vanderlaan et al., 2008; Lagueux et al., 2011). However, information about the spatial distribution and overlap of recreational vessels (less than 65 ft. in length) with right whales is limited (Hain et al., 1994).

By law, all vessel traffic cannot approach or remain within 500 yards of *E. glacialis*. However, in the previous section of this report, we estimated that approximately 5,000 recreational vessels use the study area during the winter months and that most of the vessel traffic in the study area is composed of recreational vessels. The Early Warning System (EWS) reported 78 whale\vessel interactions[4] in this area from 2009-2013. Therefore, in this section we analyzed the spatial and monthly relative probability of right whales and recreational vessels co-occurrence based on sighting per unit effort (SPUE) reported by the EWS. This information may be used by managers and educators to improve current management, education, and communication strategies to promote compliance with right whale regulations.

Method

Aerial surveys conducted by the Early Warning System (EWS) provided spatial and temporal information about right whales and recreational vessel sightings from the 2009-2013 right whale seasons in the northeast Florida and southeast Georgia Region. The EWS is an extensive aerial survey network in right whale calving and nursing grounds to locate whales and alert mariners of their presence of whales. From December to March, the EWS flew established track lines every day (weather permitting) during the right whale calving and nursing season, from December to March. Details about the protocol followed by the EWS are described by Jackson and Pitchford (2009).

Monthly relative probabilities of co-occurrence were produced following the method used by Fonnesbeck et al. (2008), Vanderlaan et al. (2008), and Williams and O'Hara (2010). This

[4] The EWS defines a right whale\recreational vessel interaction as an event when the survey team visually determined that a vessel was on a course that could result in the vessel and whale(s) being less than one nautical mile (1.8 km) apart.

method estimates the relative probability of whale and vessel co-occurrences using density estimates of right whales (Equation 1) and vessel sightings (Equation 2). Where the relative probability (P_{rel}) that a whale or a vessel occupies a grid cell, i, is relative to other cells in a domain of n cells. Then, a multiplicative approach is used to calculate the relative probability of co-occurrence (Equation 3).

Equation 1. Relative probability that a whale occupies grid cell *i:*

$$P_{rel}(Whale)_i = \frac{Whale\ sighthings\ per\ unit\ effort_i}{\sum_{i=1}^{n} Whale\ sightings\ per\ unit\ effort_i}$$

Equation 2. Relative probability that a vessel occupies grid cell *i:*

$$P_{rel}(Vessel)_i = \frac{Vessel\ sightings_i}{\sum_{i=1}^{n} Vessel\ sightings_i}$$

Equation 3. Probability of encounter:

$$P_{rel}(Encounter)_i = \frac{P_{rel}(Whale)_i\ x\ P_{rel}(Vessel)_i}{\sum_{i=1}^{n} P_{rel}(Whale)_i\ x\ P_{rel}(Vessel)_i}$$

To accommodate for disparities in our study area (e.g., coastline) a sampling grid cell (5.56 x 5.56 km) was overlaid in the study area. Figure 25 shows the area covered by the EWS aerial surveys in relationship with the study area of the survey map used in this report for previous sections. Maps showing the relative probability for whales, recreational vessels, and co-occurrence were produced in ArcGIS 10.3 using an equidistant Universal Transverse Mercator (UTM) projection.

Results

From December 2009 to March 2013 the EWS documented 1,038 sightings of right whales, which involved 2,325 individual whales. At the same time, they reported 5,467 sightings of recreational vessels involving 10,850 individual vessels (Table 35).

Right whales and recreational vessel sightings varied seasonally. Table 35 shows that the greatest number of right whale sightings occurred during the 2009-2010 right whale season. In the case of recreational vessels, the greatest number of sightings was reported for the 200-2012 right whale season.

Over the 5 right whale seasons, the survey effort also varied. The 2009-2010 season reported the greatest number of right whale sightings per unit of effort (an average of 6 sightings per effort). The number of recreational vessel sightings for the 2009-2010 was the lowest (average of 110 sightings per aerial flight) when compared with the other seasons. The EWS started documenting vessel sighting over the 2009-2010 season, therefore the lower number of recreational vessels for this season could be an artifact of data collection. The 2010-2011 right whale season reported an estimated 4 right whales per aerial flight. During the 2011-2012 season the number of recreational vessel sightings almost tripled despite a lower number of aerial surveys. For the remaining right whale seasons (2011-2013) the EWS reported between 2-3 right whale sightings per aerial survey. The number of recreational vessel sightings has not been constant, with reports as low as 377 vessel sightings/aerial survey during the 2012-2013 season, up to 981 vessel sightings/aerial survey in the 2010-2011 right whale season.

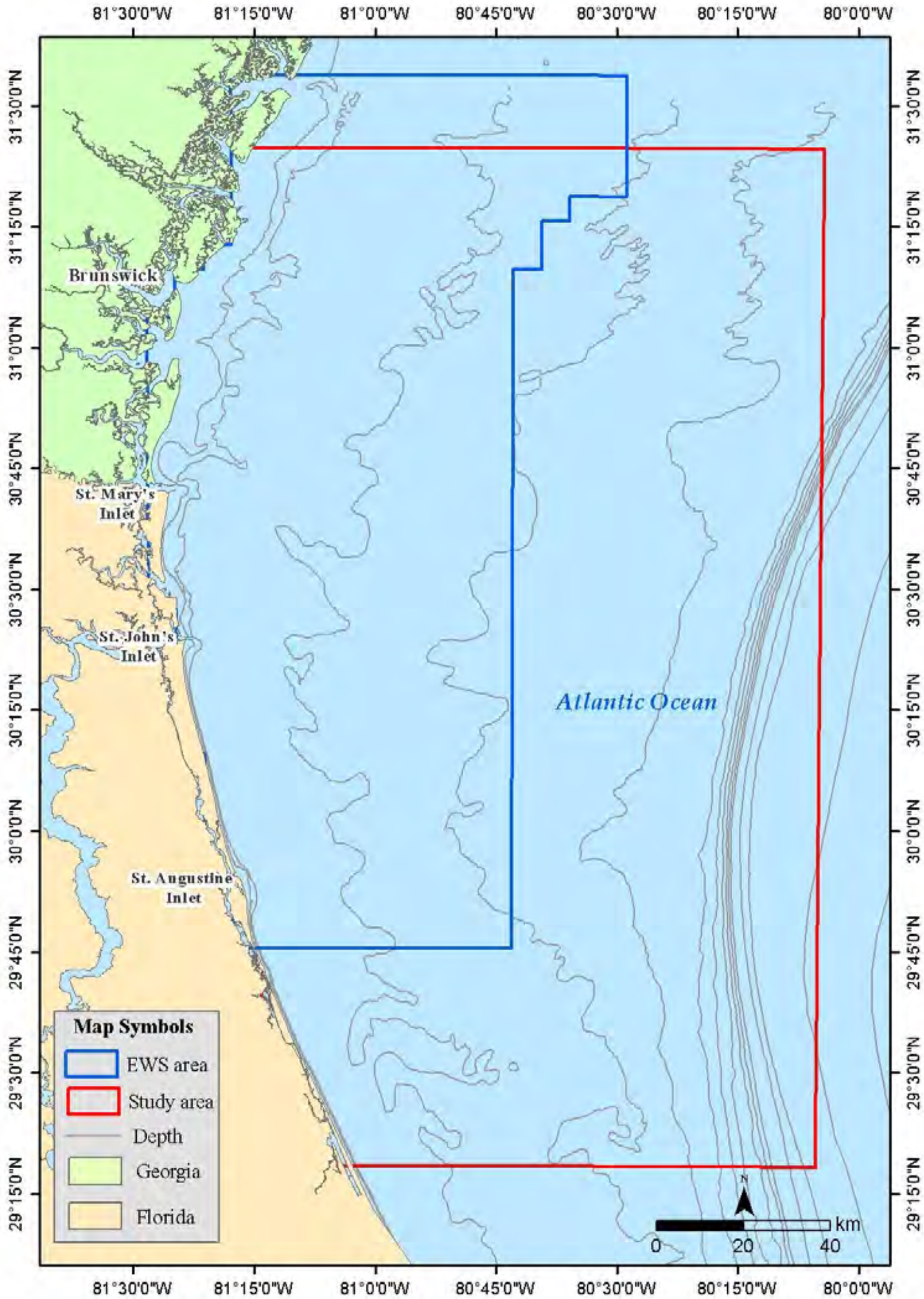


Figure 25. Area covered by aerial surveys conducted by the Early Warning System (EWS). For reference, the map also shows the area covered by the map-based survey (in red).

Table 35. Summary of right whale (RW) and recreational vessel sightings obtained by the EWS during the 2009-2013 right whale seasons.

Season	RW sightings	RW total number	Vessel sightings	Vessel total number	Effort days	Interactions
2009—2010	**451**	**1046**	**618**	**528**	**80**	**34**
Dec2009	27	78	95	124	16	2
Jan2010	166	382	139	164	20	10
Feb2010	139	309	139	243	17	10
Mar2010	117	273	221	397	23	12
Apr2010	1	2	21	78	3	0
2010—2011	**215**	**514**	**1080**	**2782**	**56**	**25**
Dec2010	67	129	252	482	14	9
Jan2011	86	206	243	409	12	14
Feb2011	60	177	217	566	15	2
Mar2011	2	3	401	1376	15	0
2011—2012	**95**	**230**	**1479**	**3134**	**63**	**3**
Dec2011	14	25	349	562	14	0
Jan2012	60	175	370	738	16	0
Feb2012	26	63	214	387	14	2
Mar2012	3	6	574	1478	19	1
2012—2013	**165**	**319**	**1054**	**2157**	**59**	**15**
Dec2012	33	64	250	463	15	9
Jan2013	78	152	216	477	13	2
Feb2013	56	108	223	396	16	4
Mar2013	2	4	384	843	13	0
2013—2014	**112**	**216**	**1236**	**2249**	**58**	**3**
Dec2013	17	24	293	655	12	0
Jan2014	30	67	167	247	12	1
Feb2014	47	91	300	502	13	1
Mar2014	23	45	517	869	15	1

The North Atlantic right whale feeds and mates in Canada and the northeast United States. The relative probability of *E. glacialis* calculated using the SPUE method shows the migratory pattern of these whales. At the beginning of each season (December), right whale sightings were mainly distributed in the study area, especially in the center (latitudes of 30°30’N, near St. Johns inlet) and in the northern portions. As the season progressed (January and February), the greater numbers of sightings were located in the southwest portion of the study area (near St. Augustine inlet). By the end of the right whale calving season whales moved back to the central and northern portions of the study area (Fig. 26). From December to February most whale sightings were from longitudes between 81°30’W and 81°0’W, which corresponds to areas closer to shore (up to 25-30 km offshore). In March, the longitude of right whale sightings shifted to areas farther away from shore, between 81°0’W and 80°45’W longitudes.

The relative probability of recreational vessel occurrence was concentrated near the three main inlets and remained similar between seasons. The longitudinal distribution of recreational vessels was wider in December and January with a high probability of recreational vessels occurring up to 35km offshore (about 81°0’W) for vessels departing from St. Johns inlet, and up to 30 km offshore for vessel using the St. Augustine inlet (Fig. 26). Over February and March, vessel tended to remain closer to shore and up to 25-30 km offshore.

The highest probability of right whales and recreational vessel co-occurrence was located in areas associated with the main inlets. Seasonally, the greatest probability of co-occurrence varied depending on the movements of right whales. In December, areas near the St. Johns river entrance up to 25 km west and St. Augustine entrance up to 20 km west showed the highest probabilities. In February, areas closest to St. Johns and St. Augustine (up to 15 km west) showed the greatest probabilities of co-occurrences. In March, as whales moved back to the northeast habitats, the highest probabilities of right whale and recreational vessel co-occurrence was observed at St. Johns and St. Marys inlets (Fig. 27). These results were validated using direct reports of right whale/vessel interactions documented by the aerial survey crew. There is a good level of agreement between our estimates of relative probability of right whale\recreational vessel co-occurrence and the direct observations.

Figure 28 shows the cumulative (2009-2014) relative probability of right whales and recreational vessel co-occurrence. Generally, the highest probabilities are located near the St. Johns river entrance up to 25 km offshore, followed by areas near St. Augustine inlet and up to 20 km offshore. Areas near the St. Marys river entrance showed a high probability of co-occurrence, but it remained nearest to shore (about 5 km west). Direct observations of right whale\recreational vessel interactions reported by the EWS seem to validate the relative probability of co-occurrence obtained using the SPUE method.

The analysis involved in the calculation of the SPUE method are relatively straightforward and easy to calculate. Additionally, the results of this analysis can be accessed by managers in a timely manner (as soon as the aerial records are available). This kind of analysis does not require external information that may influence the distribution of right whales, recreational vessels, and its co-occurrence. However, this method has its limitations; for instance it does not account for imperfect detectability and limited coverage area (Guisan et al., 2002; O'Connor, 2002). Therefore, future studies should explore the use of other approaches such as modeling techniques that allow for testing the effects of external variables and that can be used to make predictions in space or time. Furthermore, Tixerant and others (2010) suggested that because the marine environment is very complex with a large number of temporal and spatial variables interacting at different scales, a modeling approach is more suitable to study man/environment interactions.

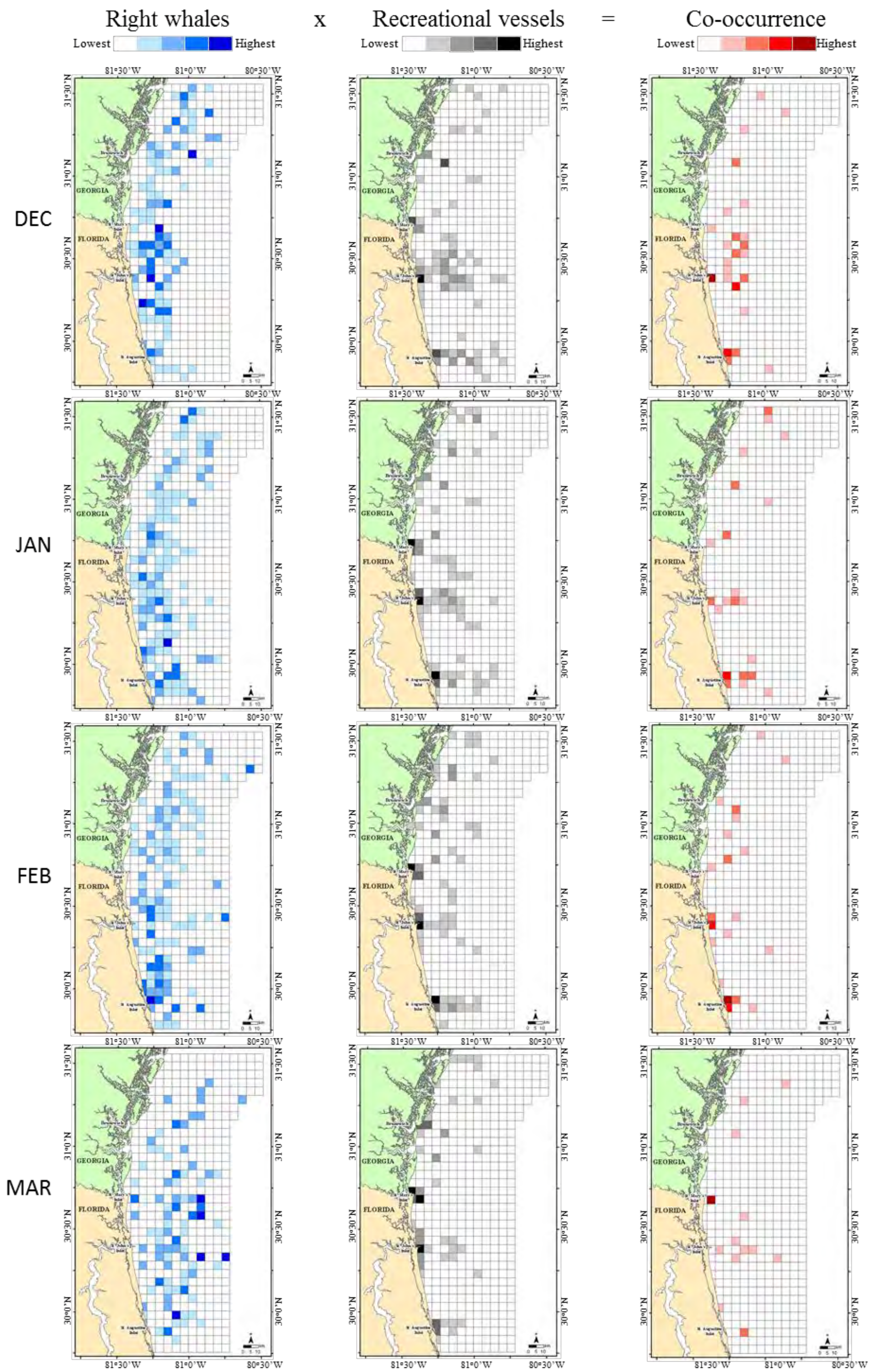


Figure 26. Monthly relative probability of right whales (on left), recreational vessels (middle), and right whale/ recreational vessel co-occurrence (on right). Analyses were performed based on data from 2009-2014 right whale seasons.

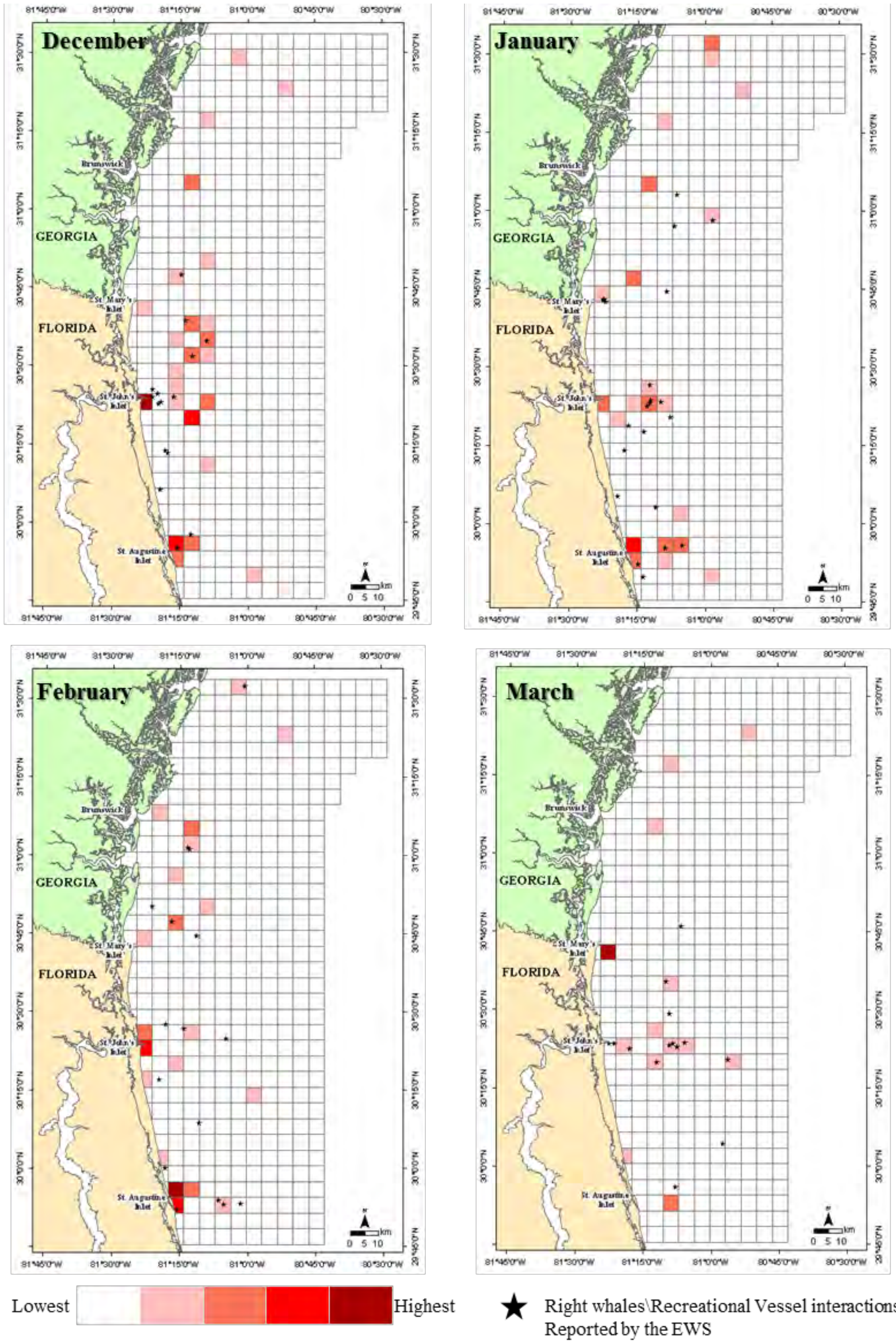


Figure 27. Monthly relative probability of right whale/recreational vessel co-occurrence. Analyses were performed based on data from 2009-2014 right whale seasons. Black stars represent direct observations of right whale/recreational vessel co-occurrences reported by the Early Warning System (EWS).

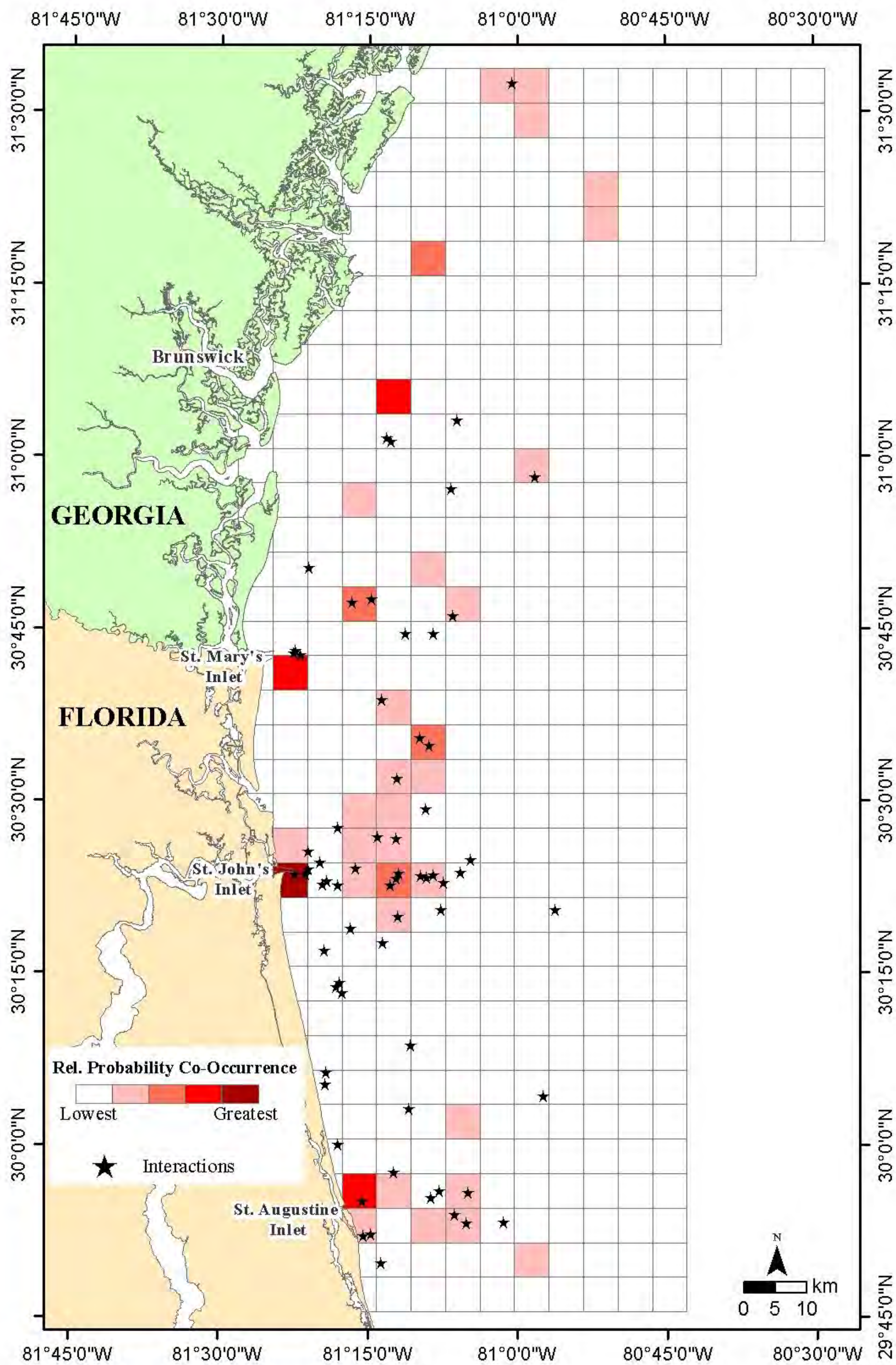


Figure 28. Cumulative relative probability of right whale/recreational vessel co-occurrence. Analyses were performed based on data from 2009-2014 right whale seasons. Black stars represent direct observations of right whale/recreational vessel co-occurrences reported by the Early Warning System (EWS).

Part 5 – Summary and Conclusions

The purpose of this study was (1) the development of spatial data sets within a geographic information system (GIS) for the offshore waters of the northeast Florida and southeast Georgia region to map boating patterns in the study area, (2) the analysis of trip information provided by boaters to describe the preferences and behaviors of boaters who use the offshore waters of the study area, (3) to estimate relative seasonal abundance of offshore recreational boaters, and (4) to map right whales and recreational vessel co-occurrence. We used a map-based survey distributed to recreational boaters observed transiting the main navigable inlets in the study area (St. Marys, St. Johns, and St. Augustine). A compilation of the responses to a subset of survey questions reveals that the characteristics and preferences of typical respondents to the survey can be described as follows:

- Is a year-round resident in the study area (86% Florida and 33% Georgia) and is approximately 55 years of age;
- Has, on average, 20 years of boating experience in the study area and 69% of respondents have taken a boating safety or seamanship course;
- Owns an open fishing vessel (59%);
- Operates a vessel with an average length of 23 feet;
- Mainly uses boat ramps (59%) to access inlet and offshore waters in the study area;
- Prefers boating facilities that are close to inlets, offshore waters, and\or close to favorite boating destinations, have adequate and safe parking, and have convenient hours of operation;
- The most popular boat ramps in the study area were Mayport, Vilano Boat Basin, and Dee Dee Bartels, Joe Calucci, Lighthouse Park, and Jim King Park;
- The most popular marinas were Camache Cove, Conch House Marina, Fernandina Harbour, and Amelia Island Yacht Basin;
- Takes an average of three to eight trips per season (primarily on weekends), with more trips taken during the spring and summer months (March through August) and fewer trips during fall and winter months (September through February);
- Begins a trip between 7-8AM (depending on the season) and spends about 8 hours on the water, and lastly;
- Perceives that there is an excess of regulations in the study area, particularly with regard to fishing regulations.

The first analytical component of this study focused on spatial patterns of offshore use and seasonal boating patterns from reported trip data. Density analysis and the Getis & Ord G*-statistic (a measure of localized spatial dependence) were used to map and evaluate boating routes identified by mail survey respondents. A visual inspection of the resulting maps shows that areas near inlets have the highest probability of occurrence throughout the year and experience some seasonal differences in use intensity.

The land-based inlet observations reveal that St. Johns inlet recorded the most vessel traffic (45%), followed by St. Augustine inlet (31%) and St. Marys inlet (23%). It also showed that most of the maritime traffic in the study area is composed of recreational vessels (86%). We used a capture-recapture approach to estimate seasonal abundance of offshore recreational vessels in the study area. Winter showed the lowest abundance estimate, followed by the fall season. The population estimate for spring and summer seasons were the highest. The seasonal abundance estimates fluctuated, with higher abundance estimated for the spring 2011 and summer 2011 seasons.

Monthly spatial analysis of recreational vessel and right whale sightings shows that the probability of co-occurrence may be driven by the migratory movement of the right whales while in the study area. Overall, the highest relative probabilities of right whale\recreational vessel co-occurrence are located near the St. Johns river entrance up to 25 km offshore, followed by areas near St. Augustine inlet and up to 20 km offshore. Areas near St. Marys river entrance showed a high probability of co-occurrence but it remained nearest to shore (about 5 km west).

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Appendices

Appendix A. Questionnaire and Correspondence

Cover letter

UF UNIVERSITY of FLORIDA

Florida Sea Grant College Program
Boating and Waterway Planning Program

Bldg. 107 Mowry Road
PO Box 110760
Gainesville, FL 32611-0760
(352) 392-6234
fas-boat@ifas.ufl.edu

Studying Recreational Boating Patterns in Northeast Florida
A Survey Conducted by the University of Florida
Sea Grant College Program with funds from NOAA

Dear Boat Owner / Operator,

We are asking you to participate in a boating study to characterize recreational boating patterns in the near- and off-shore waters of Northeast Florida. A goal of the study is to ensure that decisions about the siting of boating infrastructure and resource protection, including right whales, are based on information that includes input from the boating community. Please help in this effort by completing our questionnaire. Florida Sea Grant has worked with coastal communities throughout the state to enhance boating infrastructure, improve navigation access to local waterways, and preserve working waterfronts.

<u>You are one of a small number of recreational boaters selected to receive this survey</u>, so your response is very important. Please rest assured that your responses to this survey will remain strictly confidential. Answers will NOT be linked to individuals. Your name and address will NOT be made available to anyone. The survey number on the questionnaire is only to track returns and to enable us to send a copy of the Northeast Florida map used in this survey to those who request one.

If you have any questions about the study you may contact the project's principal investigator, Dr. Bob Swett, (352) 392-6234, or by email fas-boat@ifas.ufl.edu. If you would like more information about your rights as a survey participant, feel free to contact the University of Florida Institutional Review Board, PO Box 112250, Gainesville, FL 32611, (352) 392-0433.

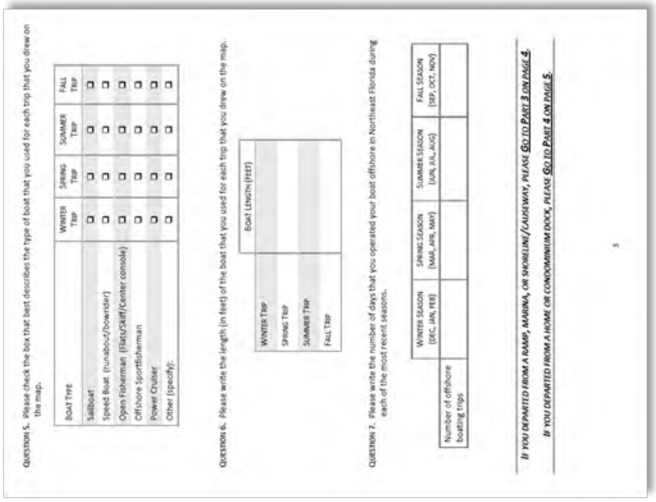
We are most grateful for your help in this project.

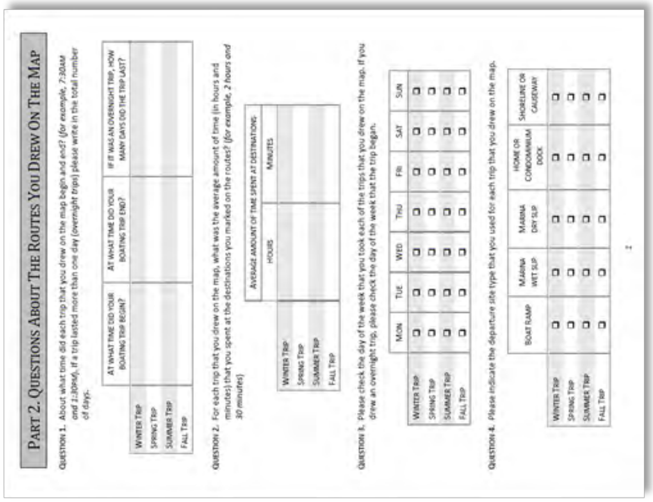
Robert A. Swett
Bob Swett, Ph.D.
Associate Professor
University of Florida

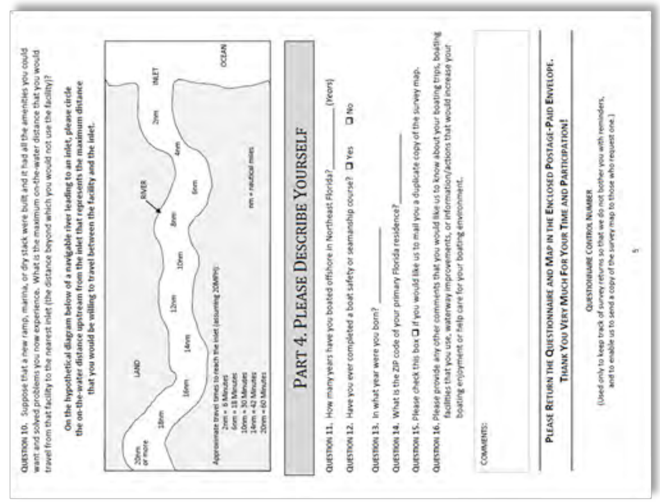
The Foundation for The Gator Nation
An Equal Opportunity Institution

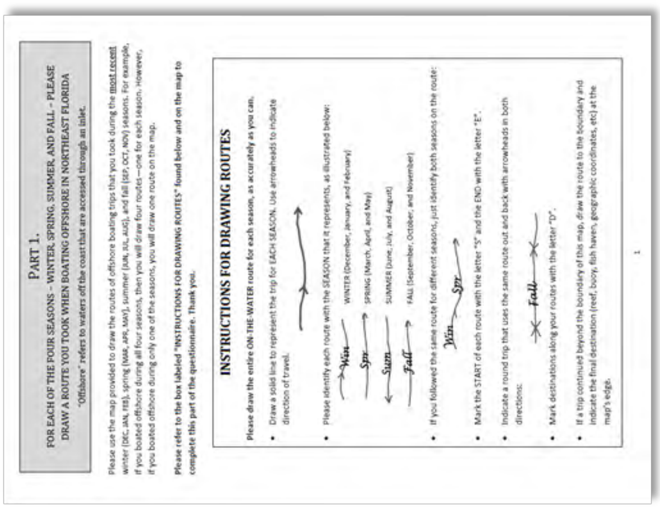
Sea Grant
Florida

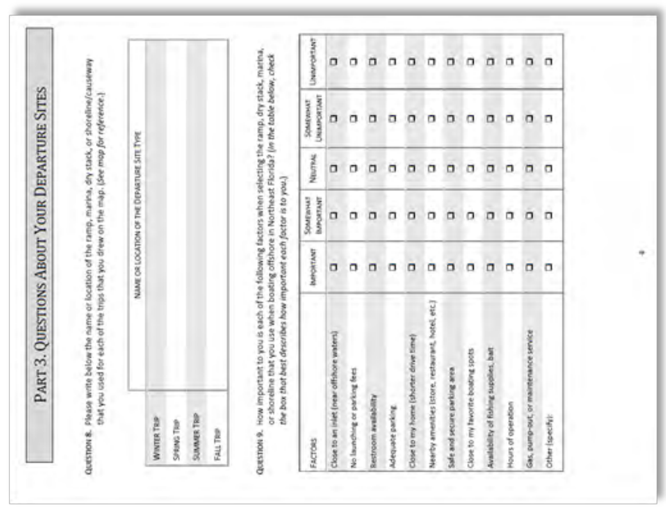
Questionnaire



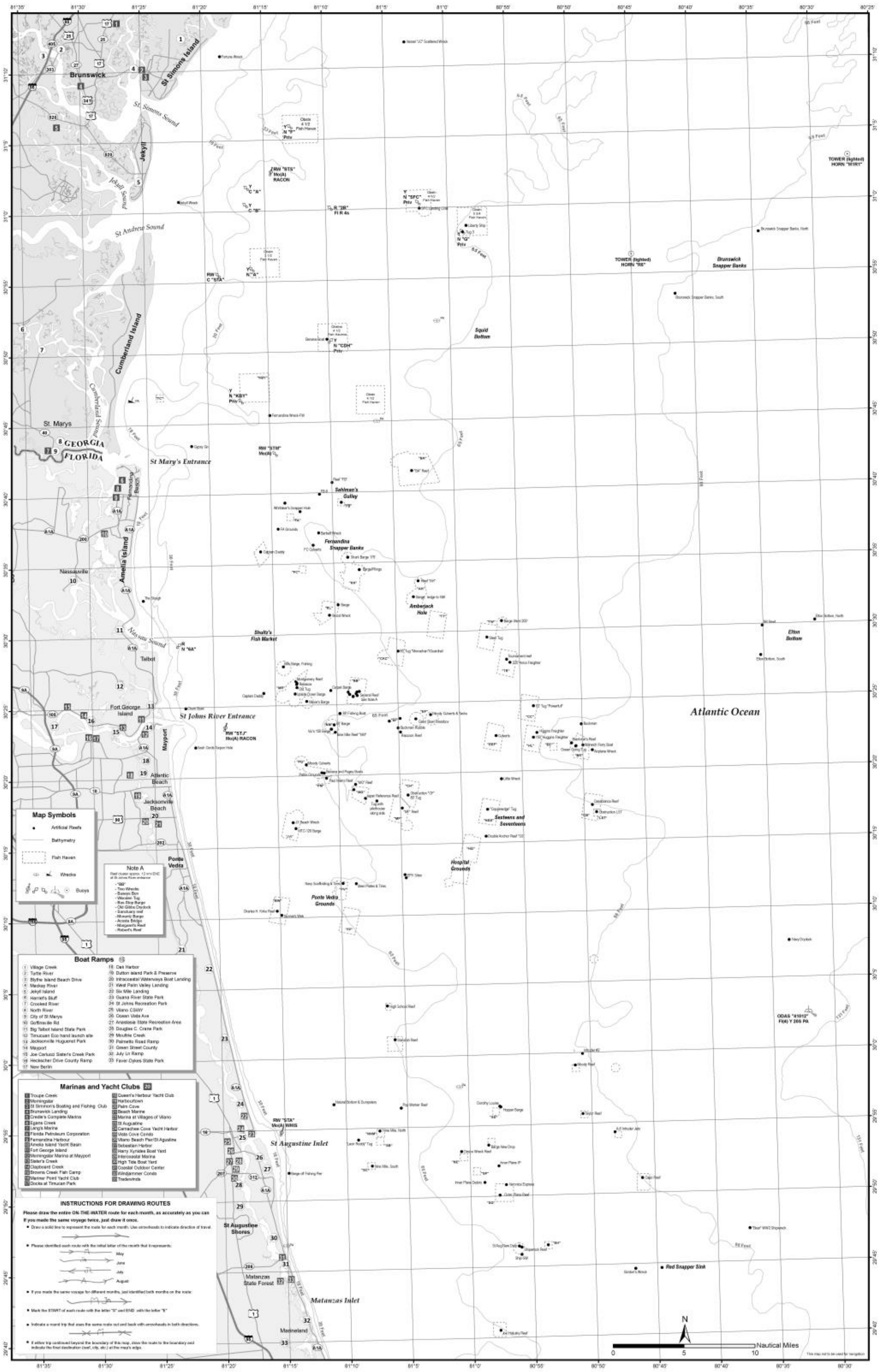








Questionnaire Map



Appendix B. Land-based Survey

Sampling Schedule

#	Season	Date	# of events recorded		
			St. Augustine	St. Johns	St. Marys
1	Winter	1/16/2011	69	131	90
2	Winter	1/27/2011	31	49	13
3	Winter	1/29/2011	187	263	152
4	Winter	2/13/2011	121	265	111
5	Winter	2/16/2011	38	86	26
6	Winter	2/19/2011	261	404	197
7	Winter	2/22/2011	74	64	42
8	Winter	2/27/2011	172	221	165
9	Spring	3/3/2011	31	25	25
10	Spring	3/12/2011	116	220	169
11	Spring	3/22/2011	136	176	157
12	Spring	3/27/2011	222	309	147
13	Spring	4/1/2011	127	93	52
14	Spring	4/23/2011	372	607	266
15	Spring	4/27/2011	72	123	50
16	Spring	4/30/2011	383	549	243
17	Spring	5/7/2011	723	854	319
18	Spring	5/13/2011	173	215	172
19	Spring	5/23/2011	154	169	118
20	Spring	5/29/2011	431	562	352
21	Summer	6/9/2011	117	155	135
22	Summer	6/11/2011	389	584	319
23	Summer	6/18/2011	430	566	271
24	Summer	6/26/2011	400	449	253
25	Summer	7/2/2011	507	675	362
26	Summer	7/10/2011	374	316	203
27	Summer	7/19/2011	168	311	89
28	Summer	7/30/2011	554	680	334
29	Summer	8/5/2011	200	210	115
30	Summer	8/9/2011	92	82	47
31	Summer	8/13/2011	396	511	252
32	Summer	8/28/2011	157	256	124
33	Fall	9/4/2011	228	285	177

#	Season	Date	# of events recorded		
			St. Augustine	St. Johns	St. Marys
34	Fall	9/10/2011	282	360	208
35	Fall	9/15/2011	80	166	80
36	Fall	9/25/2011	199	280	149
37	Fall	10/15/2011	227	409	184
38	Fall	10/22/2011	163	268	179
39	Fall	10/25/2011	41	68	68
40	Fall	10/28/2011	85	140	103
41	Fall	11/12/2011	148	218	118
42	Fall	11/19/2011	66	184	66
43	Fall	11/20/2011	148	315	104
44	Fall	11/21/2011	80	193	95
45	Fall	11/26/2011	106	214	100
46	Winter	12/3/2011	47	58	24
47	Winter	12/9/2011	35	65	34
48	Winter	12/19/2011	40	90	35
49	Winter	12/24/2011	29	85	17
50	Winter	1/1/2012	207	213	74
51	Winter	1/7/2012	224	375	177
52	Winter	1/14/2012	64	84	19
53	Winter	1/19/2012	38	75	30
54	Winter	1/22/2012	217	261	49
55	Winter	2/15/2012	112	101	54
56	Spring	3/16/2012	190	269	171
57	Spring	3/17/2012	336	607	335
58	Spring	3/24/2012	199	252	125
59	Spring	4/13/2012	71	84	59
60	Spring	4/16/2012	106	141	109
61	Spring	4/28/2012	607	987	399
62	Spring	5/12/2012	57	184	105
63	Spring	5/23/2012	86	253	111
64	Spring	5/26/2012	143	430	198
		TOTAL	**12338**	**17894**	**9126**

Data Collection Sheets

Florida Sea Grant Boating and Waterway Management Program. **Recreational boating in Northeast Florida**

Data collected by ____Date_____________________ Page #_____________out of _____________

At Station: St. Augustine inlet ____ St.John's inlet _____ St.Mary's inlet_____Time: from___________to______________ Break time: from______to______

#	**Vessel registration number** **Vessel name + Hailing Port** (when possible) **Commercial number** If boat does not have a # or name, write **No tag**. If unable to get # or name, write why: **Too fast, too far, too many**	Length (ft)			Vessel type:	Heading	Photo #	Time	Comment
		<10	10-20	>20	-Sailboat -**S** -Cabin Cruiser –**CC** -Open fisherman -**F** -Offshore fisherman-**OF** -Commercial fishing -**CF** -Other – **O** (indicate what when possible)	Outbound- **Out** Inbound -**In**			
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