OCS Study
BOEM 2022-075

Movements and Habitat Use of the Florida Manatee (*Trichechus manatus latirostris*) in the Northern Gulf of Mexico

US Department of the Interior
Bureau of Ocean Energy Management
New Orleans Office

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ABOUT THE COVER

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List of Abbreviations and Acronyms

Short form	Long form
AL	Alabama
AOI	areas of interest
BOEM	Bureau of Ocean Energy Management
CIRES	Cooperative Institute for Research in Environmental Sciences
CUDEM	continuously updated digital elevation model
DISL	Dauphin Island Sea Lab
DOI	Department of the Interior
ESP	Environmental Studies Program
ESPIS	Environmental Studies Program Information System
FL	Florida
FLDEP	Florida Department of Environmental Protection
FPL	Florida Power and Light
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Florida Wildlife Research Institute
GIS	geographic information system
GPS	global positioning system
GWMI	Gulf World Marine Institute
IA	Interagency Agreement
IACUC	Institutional Animal Care and Use Committee
IMMS	Institute for Marine Mammal Studies
LDWF	Louisiana Department of Wildlife and Fisheries
MIPS	Manatee Individual Photo-Identification System
MML	Mote Marine Lab
MSL	Mean Sea Level
NAVD	North American Vertical Datum
NGO	non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
ppt	parts per thousand
PVC	polyvinyl chloride
SAV	submerged aquatic vegetation
TMMSN	Texas Marine Mammal Stranding Network
USGS	US Geological Survey
USFWS	US Fish and Wildlife Service
UTM	Universal Transverse Mercator

1 Introduction

The West Indian manatee (*Trichechus manatus*) is a tropical marine mammal that inhabits Caribbean and Atlantic coastal waters, estuaries, and rivers from northern South America to the southeastern United States. The federally-threatened Florida subspecies (*T. manatus latirostris*; hereafter manatee) inhabits coastal waters of the Gulf of Mexico (Gulf) (Powell and Rathbun 1984; Rathbun et al. 1990; Fertl et al. 2005) and southeast Atlantic states (Deutsch et al. 2003) as part of its extensive range. Sightings have been reported from far western Texas through Cape Cod, Massachusetts and as far up the Mississippi as Memphis, Tennessee, but the core of the species range is confined to coastal estuaries and near-shore waters of the southeastern states of Alabama, Florida, and Georgia.

This research initiative was part of an extended US Geological Survey (USGS) study on manatee distribution, use patterns, and characterization of local resources in the northern Gulf . There has been increasing interest within the Department of the Interior (DOI) for understanding the relationship of manatee distribution and habitat use to northern Gulf energy industry activities, including oil and gas exploration, operation of energy infrastructure including oil and gas wells and wind turbines, and movement of supply or other vessels. The goal of this study was to determine the seasonal and annual movements of Florida manatees in the northern Gulf and to identify and characterize available manatee habitats in the region. Study methods included photo-identification and radio tracking for monitoring individual manatees, as well as environmental sampling and analysis of available coastal data to map suitable manatee habitats along the northern Gulf . The following methods were used to achieve study goals:

– To capture wild manatees, apply radio tags, and follow their movements.

This was accomplished through land- and vessel-based observation, followed by selection of appropriate capture locations for vessel- and land-based net captures. Manatees were captured with nets using established methodology (Bonde et al. 2012). They were temporarily restrained, fitted with radio tags, and released near the capture site by experienced manatee researchers and trained volunteers.

Captured manatees were monitored using state-of-the-art satellite-linked global positioning system (GPS) tags that yielded accurate telemetry data for describing manatee movements. Manatee habitat use patterns were identified by remote monitoring and field tracking.

– To conduct health assessments on captured manatees.

Each manatee captured and restrained received a complete biomedical evaluation (Bonde et al. 2012). Samples were collected and analyzed to characterize the health of each individual manatee captured, including samples for virology, microbiology, pathology, parasitology, physiology, endocrinology, contaminants, biotoxins, clinical medicine, and nutrition. Results from these tests have been included in the animals' detailed medical records.

– To determine areas where manatees most often obtain their needed resources.

We used remote GPS data from the tagged manatees to identify and delineate important resource locations and habitat areas along the northern Gulf coast, including foraging areas. This was accomplished through characterizing the distribution and abundance of seagrass communities within base waters and assessing their potential use by manatees. Habitat-related field efforts were performed during five semi-annual trips lasting 7 to 10 sampling days each. Benthic communities were characterized by a modified rapid visual assessment technique similar to Braun-Blanquet (1932) that quantified seagrass locations and species abundance and documented benthic substrates.

Data collected for this study is available in Slone et al. (2021). Data from the Manatee Individual Photo-Identification System have limited availability owing to their size and complexity. Contact A. Teague, USGS or the authors for more information.

1.1 Study area

The study area was defined as a band approximately 80 km wide centered on the coastline of the northern Gulf (Figure 1). This area was chosen to represent potential manatee habitat and travel corridors in the northern Gulf, from offshore seagrass beds to inland rivers and lakes.

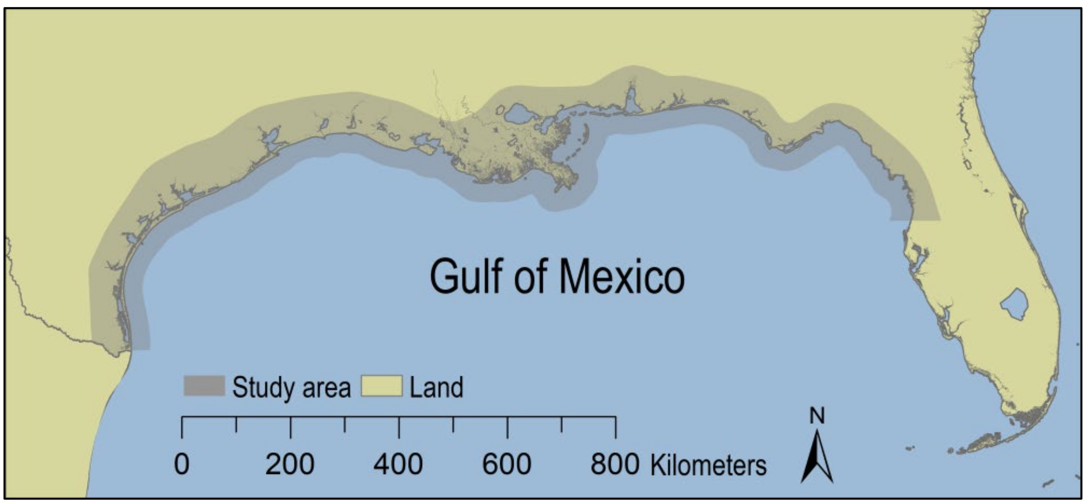

Figure 1. The study area for this project encompassed all coastal areas in the northern Gulf of Mexico from the Rio Grande River on the Texas-Mexico border to the Weekie Watchee River basin in Florida.

1.1.1 Regions

The study area was subdivided into smaller regions for analysis and discussion (Figures 2 and 3). Each region was delineated based on one or more significant habitat features, such as large river deltas or embayments, and named for a prominent feature such as a city found within each region. Throughout this document, the names of bays, rivers, and other aquatic features were chosen to agree with those listed in National Oceanic and Atmospheric Administration (NOAA) nautical charts, specifically Nos. 1117, 11340, 11360, and 11400 (NOAA Office of Coast Survey 2020). The eastern part of the study area, from Lake Pontchartrain in Louisiana through the Withlacoochee River in Florida, were further subdivided into "Areas of Interest" (AOI) for further analysis of manatee movements and vegetation surveys (Figure 4 – Figure 9). These polygons were delineated around discrete habitat features relevant to manatees, such as an embayment, river system, or island chain. The AOIs encompass habitat areas from upper riverine habitat to estuarine deltas to the offshore shallow shelf, where applicable.

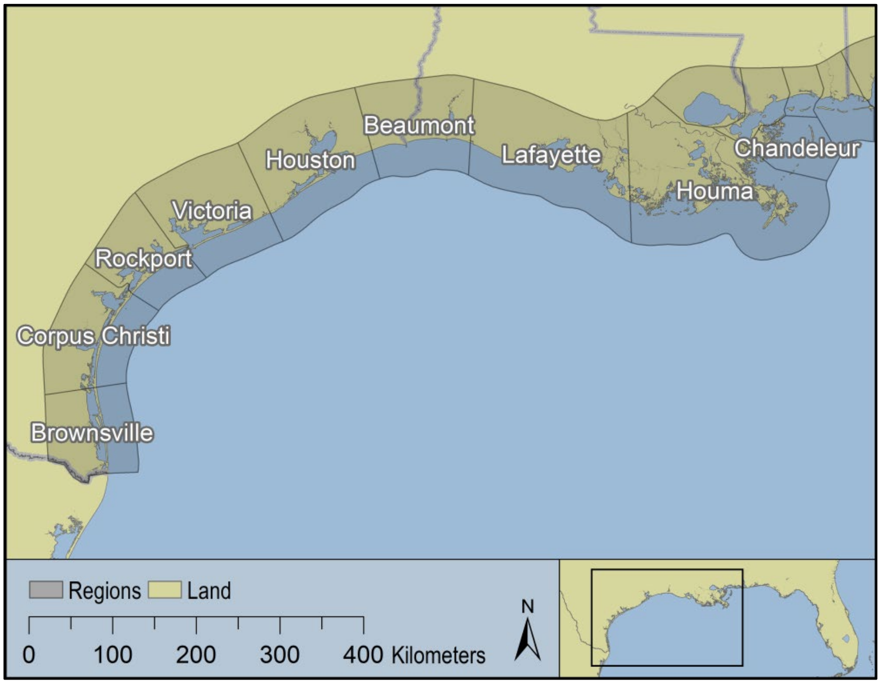

Figure 2. The western part of the study area divided into nine regions.

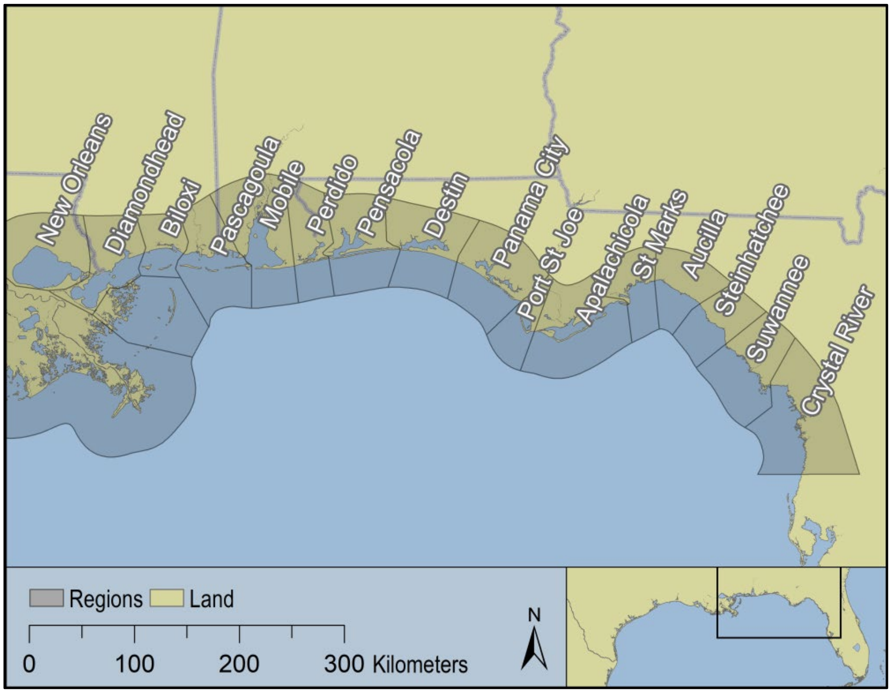

Figure 3. The eastern part of the study area divided into 16 regions.

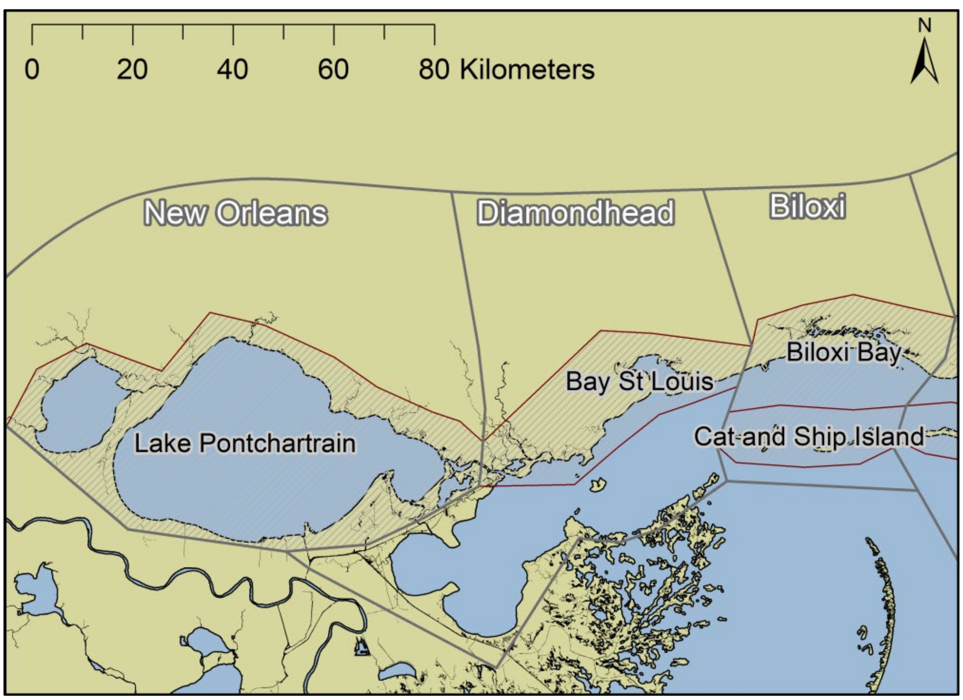

Figure 4. The coastline north of the Mississippi River delta divided into three regions.

Each region was further subdivided into Areas of Interest (red outlines) based on major water features or island chains.

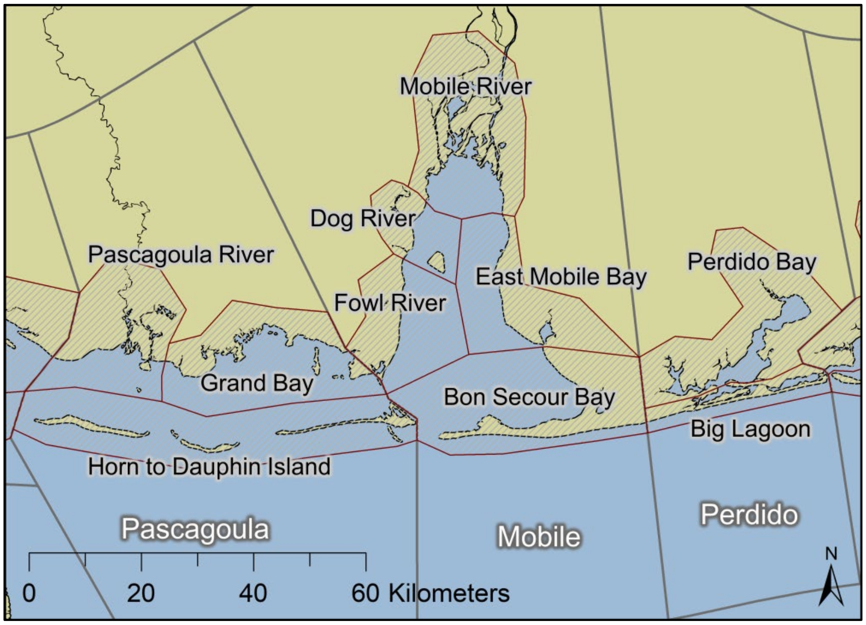

Figure 5. Mobile Bay and surrounding areas, divided into three regions.

Each region was further subdivided into Areas of Interest (red outline and hatching) based on major water features or island chains.

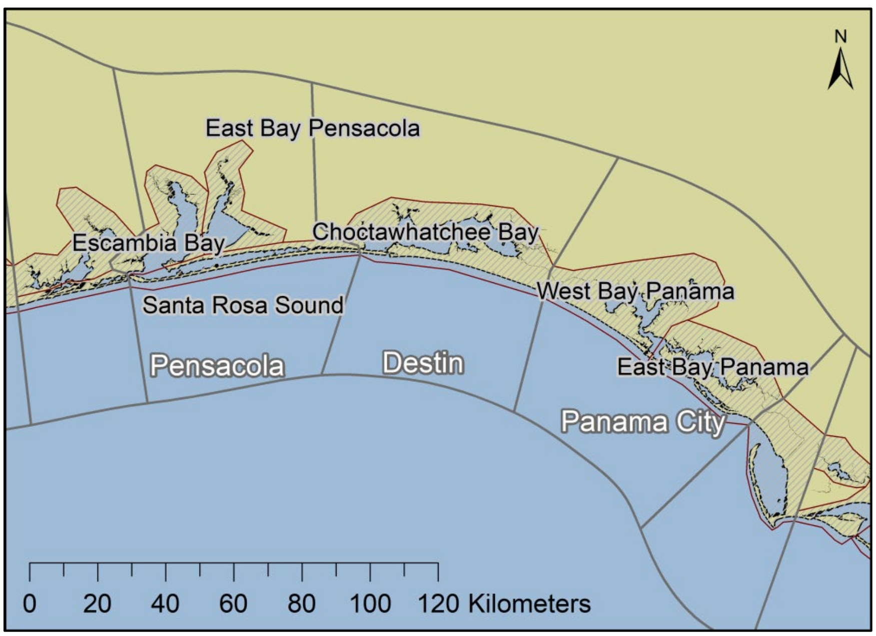

Figure 6. Most of the western panhandle of Florida divided into three regions.

Each region was further subdivided into Areas of Interest (red outline and hatched) based on major water features.

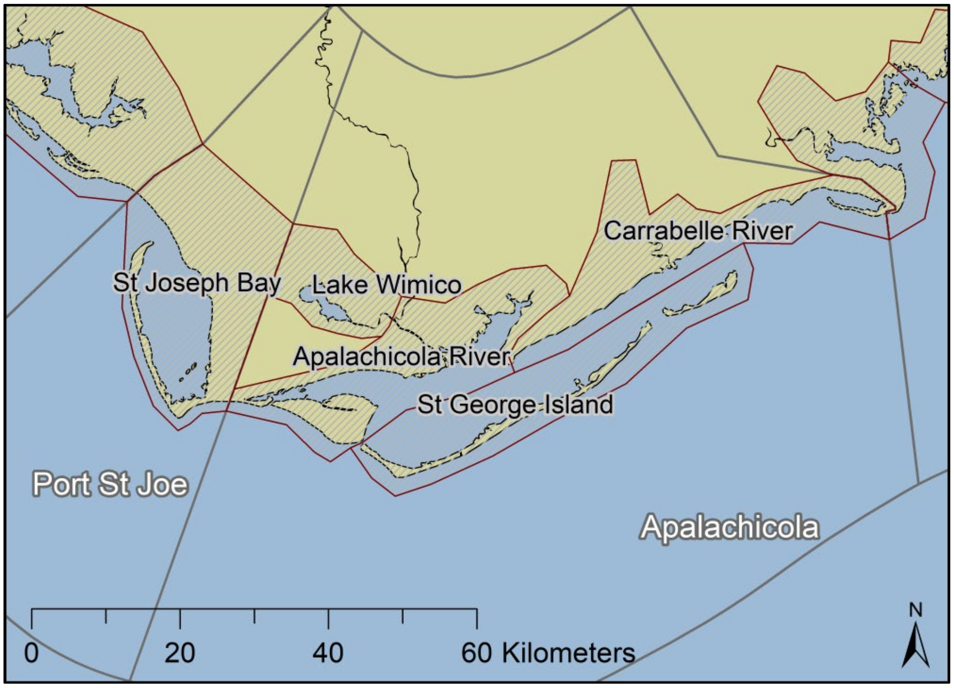

Figure 7. The Apalachicola River area divided into two regions, named for a nearby town or city.

Each region was further subdivided into Areas of Interest (red outline and hatched) based on major water features.

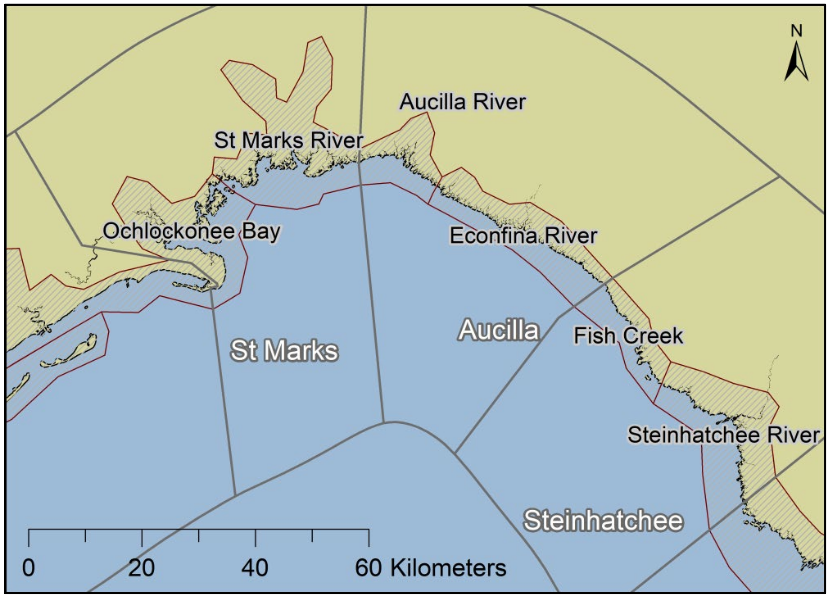

Figure 8. The central Big Bend part of the study area, divided into three regions.

Regions were loosely associated with large coastal features or embayments, named for a nearby town or city, then subdivided into two Areas of Interest (red outline and hatched) based on major water features.

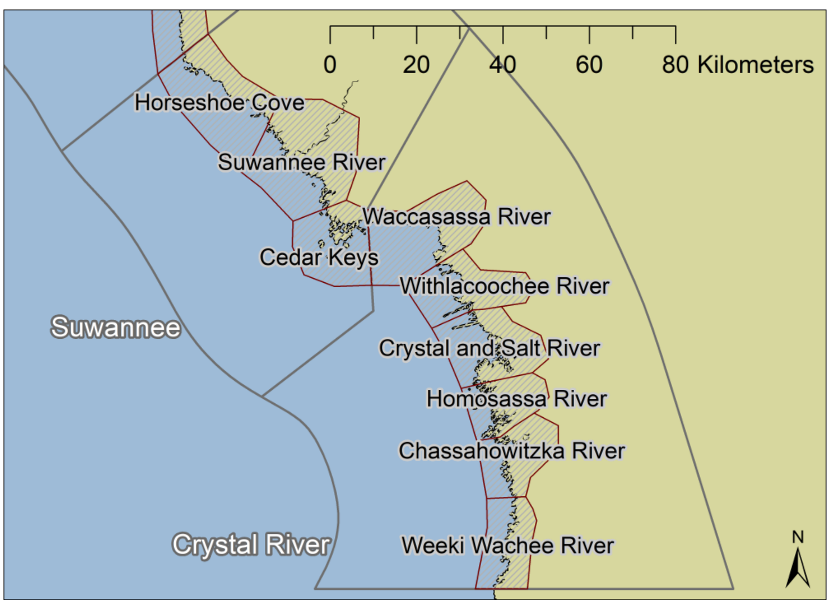

Figure 9. The easternmost part of the study area, divided into two regions.

Each region is named for a nearby by town or city, then further subdivided into Areas of Interest (red outline and hatched) based on major water features.

2 Methods

2.1 Manatee observations

Manatee sighting reports ranging from northern Florida through Texas of both tagged and untagged manatees were collected throughout the study period by the US Geological Survey (USGS) with many cooperators (Appendix A:). USGS Sirenia Project personnel built a network of cooperators via meetings, seminars, sighting fliers, visits to marinas, boat ramps etc. to encourage reporting. The network consisted of federal personnel, state personnel, facilities, non-governmental organizations (NGOs) and private citizens. Public sighting reports were primarily relayed to USGS from one of the cooperators which included (geographically from east to west):

- US Fish and Wildlife Service (USFWS) in Florida, Alabama, Mississippi, Louisiana, and Texas,
- Florida Fish and Wildlife Conservation Commission (FWC),
- Florida Wildlife Research Institute, (FWRI),
- Crystal River National Wildlife Refuge,
- Edward Ball Wakulla Springs State Park,
- St. Marks National Wildlife Refuge,
- Apalachicola National Estuarine Research Reserve,
- Emerald Coast Wildlife Refuge,
- Gulf World Marine Institute (GWMI),
- Dauphin Island Sea Lab (DISL),
- Institute for Marine Mammal Studies (IMMS),
- Grand Bay National Estuarine Research Reserve,
- Audubon Nature Institute,
- Louisiana Department of Wildlife and Fisheries (LDWF),
- Bureau of Ocean Energy Management (BOEM) in Louisiana
- Texas Marine Mammal Stranding Network (TMMSN).

Manatee sightings were also logged directly from members of the public via phone call or email. Once sightings were logged and verified, supplied coordinates were confirmed in a GIS application. If coordinates were not supplied, they were estimated based on the description, and noted in the database as an estimate.

2.2 Manatee documentation

The Manatee Individual Photo-Identification System (MIPS) is a database containing photographs and life history information for over 4900 individual manatees, some photographed regularly over their lifetime since the 1980s (Beck and Reid 1995). In addition to photographs and sketches of markings, MIPS includes information about the location of each sighting and notes on age, size, injuries, health and behavior. From its origin in the late 1970s, MIPS has evolved into a cooperative effort by the USGS Sirenia Project, FWC's FWRI, and Mote Marine Laboratory (MML). Today, over 116,000 sighting records exist for over 4900 individually recognized manatees in MIPS (unpublished MIPS data, FWC/MML/USGS). This provides sighting histories for individuals that are used to estimate survival and reproductive rates and to model manatee population dynamics for state and federal population assessments (Langtimm et al. 2004).

For this study, most photo-documentation was collected by USGS biologists while in the field at winter aggregation sites, at known summer sites, during manatee captures, or while tracking tagged individuals. Some photographs were collected by cooperating agencies and the public along with location information. On few occasions, a manatee was identified from photographs taken when the manatee's carcass was recovered and still intact.

2.3 Manatee captures and health assessments

Activities were conducted in accordance with USFWS Federal Fish and Wildlife Permit (MA791721) issued to the USGS-Sirenia Project and comply with USGS Institutional Animal Care and Use Committee (IACUC) standards.

The extent of field efforts was developed on a regional basis, targeting areas with appropriate habitat or consistent manatee use, coupled with interest and participation among cooperating agencies. Specific areas for manatee radio tagging were based on availability of capture sites, field logistics support and federal, state and non-governmental organization (NGO) partners.

2.4 Manatee tagging and tracking

Radio tracking studies were conducted to determine local and regional movement and habitat use patterns. Manatees were tagged with a floating satellite-monitored location and data collection telemetry tag that is effective for tracking and monitoring manatees in both freshwater and marine environments (Reid et al. 1995; Deutsch et al. 1998). The floating transmitter was connected to an adjustable belt attached around the base of the tail by a flexible nylon tether. Each tether had an engineered weak link with a breaking point that is varied based on animal size class and designed to break free if the transmitter becomes entangled. These telemetry tags (TMT-462 and the smaller TMT-464; Telonics, Inc.)—with GPS receivers coupled with satellite monitored Argos platform terminal transmitters (PTTs)—have been the primary tracking device employed by researchers for application on manatees since the mid-2000s (CITE). The tags were programmed to periodically acquire GPS locations by using standard or quick fix pseudoranging (QFP) technology (Tomkiewicz et al. 2010) that are relayed to users through the Argos System satellite uplink. For tags used in this database, the rate of acquisition was generally programmed to 15-minute intervals. A saltwater switch synchronized GPS fixes and Argos transmissions during surfacings and enabled the tag to log dive data along with temperature and tag activity data. A greater than 96 percent success in obtaining an accurate GPS location fix each hour enabled us to document detailed movements and assign precise habitat-use patterns within the fine scale of inland waterways and coastal environments occupied by telemetered manatees (Marmontel et al. 2012).

2.5 Habitat assessment

Manatees are dependent on seagrasses and other aquatic or shoreline vegetation for forage. In the Gulf of Mexico (Gulf), manatees consume seagrass species, such as *Thalassia testudinum, Syringodium filiforme*, *Halodule wrightii* and *Ruppia maritima* (Lefebvre et al. 2000; Deutsch and Carlson 2007; Alves-Stanley et al. 2010; Slone et al. 2013; Lefebvre et al. 2017), and freshwater vegetation, including *Vallisneria americana, Najas spp., Myriophyllum spp.* and the introduced *Hydrilla verticillata* (Campbell and Irvine 1977; Etheridge et al. 1985).

A sampling location was defined as the area approximately within 10 meters of each sampling waypoint that was defined by the slow-speed manatee habitat use analysis.

To view the bottom in these low-visibility conditions and to characterize seagrass species composition and abundance, we adapted a video-based sampling device called the "Quad-Cam" (Slone et al. 2012; Slone et al. 2013). It consists of a low-light, high resolution video camera (Sartek Industries SDC-CAL with a resolution of 720 x 480 pixels) mounted on a polyvinyl chloride (PVC) pipe frame, with the camera viewing straight down (Figure 10). The view of the seafloor is 22.5 centimeter (cm) x 16 cm, so the pixel size on the substrate is approximately 0.3 millimeter (mm) x 0.3 mm. The PVC frame is weighted to descend straight, has skids to allow it to land and remain stable on the benthic substrate, and is outfitted with a rear fin to keep it from rotating. The frame was lowered through the water on a line that contained the camera video cable. The camera output was viewed and recorded on a laptop (Figure 11).

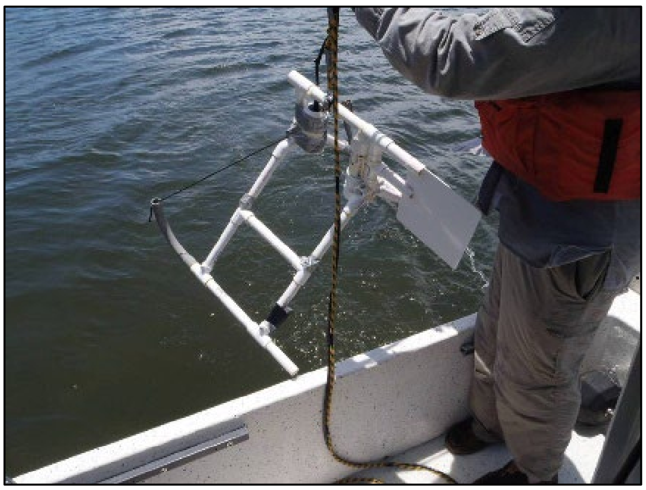

Figure 10. Sled with camera and depth logger, compensated for height above substrate.

Photo credit: authors.

Waters in the Gulf are generally turbid with poor water clarity, thus a lens with a 170-degree wide field of view in air and short 2.9 mm focal length was used to view the benthic substrate and submerged vegetation. This fish-eye type lens was set 15 cm above the substrate. It showed some distortion of the image, but the low height allowed for a much clearer image as compared to a lens with a longer focal length. The view of the substrate was approximately 26 x 18 cm.

The video feed from the camera at each sampling point was recorded as a video file on a laptop, and also scored live. All submerged vegetation found was recorded to species, and macroalgae was scored as a group. Other benthic features, including turf algae, or invertebrates were also recorded on the data sheet. Water depth was recorded with an Onset water level logger (model U20-001-02, Onset Computer Corp.) that was attached to the camera frame. The height of the logger above the substrate was recorded for later adjustment of measurements. This logger was set to record every 2 seconds to ensure multiple readings at each sampling location.

Figure 11. Laptop computer with video recording software and display for live habitat scoring.

Photo credit: authors.

During each of the seagrass sampling trips, an Onset water conductivity logger (Onset Computer Corp.) set to record every 30 seconds was affixed to the rear of the research vessel, below the water level. This logger continuously recorded conductivity during the sampling and the data was converted to salinity (ppt) using Hoboware Pro (V. 3.7.13; Onset Computer Corp.). To record water transparency, a parameter critical to health of seagrasses, Secchi depth readings were performed near the deepest part of each sampling location (Figure 12).

Figure 12. Measuring water clarity with Secchi disk.

The reading is taken at the water surface where the disk just disappears from view. Photo credit: authors.

The location of the sampling vessel was recorded with a marine GPS (Lowrance HDS-12 Gen3 with TotalScan Transducer; Lowrance USA) set to record at 10 m resolution or better for all trips. The depth of water at the vessel was recorded by using the single beam sonar transducer integrated into the TotalScan. The height of the transducer was measured to correct the depth reading in the sonar unit, and this reading was checked in-water with a depth staff for accuracy. Water depths at the deepest point of each sampling location and the location where the deepest submerged vegetation was found were also measured with a manual depth staff.

Data from the habitat characterization trips was entered in a spreadsheet that included the date, starting time, and ending time for each sampling location. The maximum depth within the sample location, and the maximum depth where vegetation was found was also recorded. The percentage cover for each species of submerged aquatic vegetation in water shallower than the maximum vegetation was entered and summed for total cover. This data table was geolocated by including the original sampling waypoint, and by matching the location from the Lowrance marine GPS at the midpoint of the sampling times. If a discrepancy of > 10 m was found between locations, the GPS location was used for analysis.

2.5.1 Aquatic plant identification

Aquatic plants that were seen in the Quad-cam were identified to species where possible, and to genus in all other cases. To ensure correct identification, samples of plants were gathered using a modified post-hole digger with the Quad-cam as a guide (Figure 13). Plant material was washed and separated on a tray by species (Figure 14) and photographed. A representative sample from each species was placed in a labeled plastic bag and stored in a cooler. After being brought to the laboratory, the samples were examined using a dissecting scope at 10–40x magnification to view morphology. Identification was made using reference literature (Hotchkiss 1967; Tarver et al. 1979; Hurst and Beck 1988; Littler et al. 1989; Ramey 1995; Littler et al. 2008; Wunderlin et al. 2020) and assistance from aquatic plant expert, Dr. C. C. Jacono (University of Florida, UF Herbarium and Florida Museum). For the smaller and finer plants, a polarized microscope at 100-400x magnification was used to view cellular details. Identification from cells was made using reference literature (Hurst and Beck 1988; Littler et al. 2008).

Figure 13. Directed sampling of benthic vegetation with post-hole diggers.

Photo credit: authors.

Figure 14. Vegetation samples were separated, identified, and when necessary, collected for further processing.

Photo credit: authors.

Figure 15. Plant samples were examined under low-power dissecting scopes (shown) and higher-powered polarized light microscopes to confirm identification.

Photo credit: authors.

2.6 Data processing and analysis

Unless noted, all data manipulation and analysis were performed with R 3.6.0 (R Core Team, 2019). Spatial layers were transformed where necessary to match EPSG: 26916 (North American Datum 1983 [NAD83] / Universal Transverse Mercator zone 16 [UTM16]).

2.6.1 Imported data layers

Base data sources for this study were publicly available spatial geographic information system (GIS) layers. These are listed and described below.

2.6.1.1 Water bodies

Water bodies in the study area were divided into offshore and inshore types with the US and Canada Water Polygons data set (Tele Atlas North America, Inc. 2010). The water body types were simplified into two inshore types and two offshore types: 1) H10 – H22 = inland stream, 2) H30 – H42 = inland lake, 3) H50 – H51 = offshore bay, and 4) H53 = offshore gulf.

2.6.1.2 Rivers

The United States of America (USA) Detailed Streams layer (ESRI™ et al. 2004) was added to the Water bodies layer to increase detail of the riverine habitat type. Only the largest perennial river classes (1, 2, and 3) were selected. All smaller streams, and all intermittent streams were discarded to limit waterways in the study to those navigable by manatees.

2.6.1.3 Shoreline

The NOAA Medium Resolution 1:70,000 scale Digital Vector Shoreline (National Oceanic and Atmospheric Administration [NOAA] et al. 1994) was used for display maps and to delineate the shoreline for distance measurements. The shoreline of Mexico for display purposes was sourced from the ESRI™ World Countries layer (Esri 2015).

2.6.1.4 Wetlands

Polygon wetland data for Texas, Louisiana, Mississippi, and Florida were downloaded from the USFWS National Wetlands Inventory (NWI) (US Fish and Wildlife Service 2016). Deep water habitats were already recorded in the water bodies layer, thus only the shoreline and riverine habitat types were used for this study: 1) Freshwater Emergent Wetland, 2) Freshwater Forested/Shrub Wetland, 3) Riverine, and 4) Estuarine and Marine Wetland.

2.6.1.5 Salinity

Salinity polygon layers of estuarine habitat were downloaded[1] (National Centers for Environmental Information 2012). These maps delineate salinity zones (0-0.5, 0.5-5, 5-15, 15-25, >25 parts per thousand) during high, low, and transitional salinity periods.

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[1] See https://gulfatlas.noaa.gov

2.6.1.6 Tide levels

Hourly water level data from available NOAA and USGS coastal tide stations were obtained using *fromJSON* (package *jsonlite*; Ooms 2014) in an R script that downloaded historical data from NOAA (CO-OPS 2018) and USGS (US Geological Survey 2019). The NOAA stations were queried to return mean sea level (MSL) tide height. The USGS stations returned local station tide height. These were corrected to MSL by subtracting the average height of the water level over the entire data series and then adding the average MSL from the NOAA stations over the same time period (0.08 m) to standardize all stations to the same level. Each manatee telemetry and habitat sampling point was assigned a tide level station for correction by selecting the closest using *st_nearest_feature* (package *sf*; Pebesma 2019). The standardized data were then used to correct depth measurements (depth staff and depth logger) that were taken during habitat sampling. The tide stage of each region over the study time period was then standardized for mean and amplitude to give each region a standardized tide range of standard deviation = 1 to interpret manatee GPS telemetry locations.

2.6.1.7 Elevation

Digital elevation model layers were downloaded[2] . Where available, 1/9 arc-second resolution Continuously Updated Digital Elevation Model (CUDEM) Tiles were used (Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado, Boulder 2014). These were available from Matagorda Bay to Sabine Lake in Texas, the Alabama coast, and the Florida coast. In other areas, 1/3 arc-second resolution elevation was available. Locations included South Padre Island, Texas (NOAA National Geophysical Data Center 2012), Corpus Christi, Texas (NOAA National Geophysical Data Center 2007a), Northern Gulf Coast (Louisiana, Massachusetts, Alabama; Love et al. 2012), Southern Louisiana (Love et al. 2010), New Orleans, Louisiana (NOAA National Geophysical Data Center 2009), and Biloxi, Mississippi (NOAA National Geophysical Data Center 2007b). Deepwater locations for visual display were filled in using 3 arc-second Gulf of Mexico Coastal Relief Models (NOAA National Geophysical Data Center 2001a; NOAA National Geophysical Data Center 2001b; NOAA National Geophysical Data Center 2001c).

2.6.2 Created data layers

Based on the imported data layers described above, and data collected through manatee telemetry and other activities, several GIS layers for mapping and analysis were created.

2.6.2.1 Regions

The study area footprint (Figure 1) was created in ArcMap (10.7.1; Esri™ 2019) by buffering the shoreline layer 40 km offshore, and approximately 40 km inshore from any significant embayment or water body along the Gulf Coast. Each region was then delineated with a straight line in between estuaries, in locations where manatee habitat use was expected to be low (Figure 2– Figure 9).

2.6.2.2 Areas of Interest

The coastline and estuaries from Crystal River, Florida to Lake Pontchartrain in Louisiana were expected to have the greatest use by telemetered manatees based on the authors' observations and examination of manatee sightings in the northern Gulf (Fertl et al. 2005). To allow for more refined analysis of

[2]See https://www.ncei.noaa.gov

movements, AOI along that part of the coast were manually delineated in ArcGIS™ (Figure 4–Figure 9). River systems included from the accessible headwaters to the Gulf waters, barrier islands included offshore and protected waters, and large bays were cut into constituent parts.

2.6.2.3 Manatee telemetry data

All manatee location data were collected from November 2006 through May 2018. Locations were projected from the GPS native World Geodetic System 1984 (WGS84 or EPSG4326) to NAD16 to match the common projection for the study. Locations of specific manatee resources were identified through analysis of tracking data with field observations. Tracking and field data were analyzed to characterize specific resource use patterns, including identification and characterization of overwintering, foraging, and freshwater access sites. Statistics were applied to address trends in manatee abundance and distribution within discrete habitat and/or study units.

To delineate specific habitat and movement corridor use by manatees, GPS points from all manatees were combined into one GIS point layer in R (v. 3.5.1; R Core Team 2019) First, the GPS point data were retrieved from each tag. Speed and positional filters were then applied to eliminate spurious locations: any points where the travel speed was > 10 kph were removed.

Telemetry locations were converted to Universal Transverse Mercator (UTM) zone 16N (EPSG: 26916) using *spTransform* in the R package *sp* (Bivand et al. 2018; Pebesma 2019). The point locations were then converted to movement lines by joining successive points with line segments using the *Lines* and *SpatialLines* functions in *sp*. The length of each line segment was calculated in meters by using the difference in UTM positions of the endpoints, the time to travel that distance was calculated as the difference between the GPS times of the endpoints, and travel speed was calculated by dividing a simple distance by time. The polyline file was then merged with the original point file so that the attributes of each travel line were based on the second of the two points used to draw the line. This second-point assignment associated the manatee's destination with the travel paths. After merging, two more attributes were derived for each line segment: travel time (GPS fix time of the second point minus the GPS fix time of the first point) and travel speed (line length divided by travel time).

2.6.3 Telemetry analysis

Based on previous work (Slone et al. 2012; Slone et al. 2013) and observations of manatee behavior, the travel paths were subdivided into groups by the measured speed between successive GPS locations. Slow speeds (<0.4 kilometers per hour [km/h]) were designated as "habitat use" movements, typically foraging, drinking, or resting. Fast speeds (≥1.6 km/h) were designated as "travel," which typically occurs when the animal is undertaking directed, long-distance movements.

Manatee travel lines were aggregated into manatee use levels for traveling movements and habitat use locations using kernel density analyses. These were based on the quadratic kernel function described in Silverman (1986; equation 4.5) and calculated using *density.psp* (package *spatstat*; Baddeley and Turner 2005; Baddeley et al. 2015) with a cell size of 100 x 100 m and a standard deviation radius of 200 m. This kernel density analysis was also repeated for three tide levels: High tide was defined as local stage > 0.7 m, Mid tide as local stage ≤ 0.7 m and > -0.7 m, and Low tide as local stage ≤ -0.7 m (all MSL).

For display purposes, areas with densities of less than two travel paths were deleted because they do not represent heavily used pathways. The remaining raster cells were symbolized on a quantile scale to highlight areas with higher travel densities. Where slower movements were displayed together with the faster travel paths, the slow movements were layered on top of the larger travel paths to better show the extent of habitat use.

2.6.3.1 Point grid layer

A GIS point layer was created on a 200 m grid for analysis and modeling of manatee locations. The points extended along the shoreline of the study area, from 2 km offshore, to 16 km inshore within 200 m of any river or embayment. The points were generated in R by first generating an empty raster with 200 m cells using *raster* (package *fasterize*; Ross 2018) and a polygon layer by buffering the shoreline polygon to + 2 km and – 16 km with *st_buffer* (package *sf*; Pebesma 2019), and buffering the Rivers layer by +/- 200 m. The intersection of these layers (*st_intersection*; package *sf*) resulted in 817,843 points.

For assignment of existing spatial layers to these points, *st_intersection* was employed. These layers included Regions, AOI, Water bodies, Wetlands, and Elevation.

2.6.3.2 Nearby wetland

Each of the four wetland types that were mapped in the NWI (US Fish and Wildlife Service 2016) were used to create a "nearby wetland" layer. A separate spatial convolution of each wetland layer was performed by rasterizing the 200 m point grid layer using *s_rasterize* (package *sf*) and applying a convolution kernel (Allen et al. 2001) with a Gaussian shape and 1000 m standard deviation using *focal* (package *raster*; Hijmans 2018). The effect of this convolution was to have higher cell values closer to wetland locations, and where wetlands were abundant, and lower cell values farther away from wetland habitats, and where wetlands were less abundant. Cell values were zero in the absence of wetland habitat.

2.6.3.3 Habitat use model

Manatee resource use density was modeled on the point grid layer (described in 2.6.3.1) with st_as_stars (package stars; Pebesma 2018) and pixellate (package spatstat) to count movement lines in 100x100 m cell. Local movement lines (speed < 0.4 km/h) were used as indicators of manatee resource use, weighted by the number of locations recorded in each region, transformed by $x^{0.25}$ and standardized to a 0–1 range. After preliminary consideration of available variables, water depth, distance to shore, and availability of wetland habitat were focused on as potential drivers for resource use. Seagrass was not used as a spatial driver because maps were not available for all regions, and in areas where they were available, the quality, methodology and coverage were inconsistent.

Final spatial variables with their units and transformations were: Distance from shoreline (2.6.1.3) (m); Elevation (2.6.1.7) (m North American Vertical Datum [NAVD] 88); Nearby Freshwater Emergent Wetland, Freshwater Forested/Shrub Wetland, Riverine, and Estuarine and Marine Wetland (2.6.3.2) (logit transform of each scaled 0–1); and Water body type (2.6.1.1) (as factor; Ocean, Bay, and Inland [included Reservoir, Lake, Canal, or Stream]).

Each transformed parameter was binned into ~40 bins. The 90th percentile of manatee density within each bin was selected to represent the manatee use pattern while excluding rare, extreme values. A normal density function was then fit to this response surface using *nls2* (package nls2; Grothendieck 2013) for initial parameter estimation, and *nls* (package stats) for final fitting. These functional responses became the covariates in a series of linear prediction models (each region was modeled separately), with density of manatee use as the response.

3 Results

3.1 Manatee captures and health assessments

During the study period, winter manatee captures and health assessments were conducted at Paradise Point, Kings Bay, Crystal River, Florida on an annual basis from the winter season of 2013–2014 through the winter season of 2017–2018 (Table 1). These events included cooperators from federal and state agencies, municipalities, universities, colleges, facilities, NGOs and visiting international biologists and veterinarians. Through the four winter seasons, there were 19 capture and health assessment days with a total of 123 wild manatees net captured and given full health assessments (Table 2). All size classes were represented and size class categories of the captured manatees, as measured by straight-line length, were calf/juvenile (<245 cm; n=42) and adult (≥245 cm; n=81). Each manatee was given a unique capture identification number, for example, CCR1308 translates to Captured at Crystal River in 2013 and was the 8th manatee captured that year.

Of the 123 manatees assessed, 49 were females and 74 were males. Sixteen of the manatees assessed were recaptures from previous years (with 1 manatee having been captured in 2 previous capture years) indicated by a CCR number in the Tag ID and name column (Table 2). Seven cow with calf pairs were captured and assessed. Six manatees were known individuals within the MIPS, indicated by a CR number in the Tag ID and Name column. Two manatees (TCR-23 “Big Ben” and TCR-27 “CR610”) were opportunistically radio-tagged due to prior identification through MIPS as having sighting histories in the northern Gulf, and TCR-25 “Bert” was recaptured with a belt-only (his radio-tag had previously broken free) and he was re-tagged (Table 3). The largest manatee of the study weighed 1584 lbs. She was captured and examined along with her male calf November 6–7, 2014. On January 21, 2015, a male adult manatee, previously rescued as a calf and released in 2004 as a high-risk candidate, was captured, assessed, and determined to be healthy and in good body condition.

Table 1. Manatee capture efforts associated with this study, with the number of animals captured during each event

Details of each manatee can be seen in Tables 2 and 3.

Dates	Location	Format	Number captured
Dec 03Dec 04, 2013	Kings Bay, FL	Land-based	13
Jan 31, 2014	Kings Bay, FL	Land-based	8
Nov 06—Nov 07, 2014	Kings Bay, FL	Land-based	11
Jan 21—Jan 22, 2015	Kings Bay, FL	Land-based	19
May 18—May 19, 2015	Wakulla River, FL	Vessel-based	3
May 20, 2015	Lake Wimico, FL	Vessel-based	1
May 21, 2015	Wakulla River, FL	Vessel-based	2
Jun 15—Jun 16, 2015	Lake Wimico, FL	Vessel-based	3
Jun 18—Jun 19, 2015	Choctawhatchee Bay, FL	Vessel-based	1
Sep 16—Sep 17, 2015	Choctawhatchee Bay, FL	Vessel-based	2
Dec 09—Dec 10, 2015	Kings Bay, FL	Land-based	10
Feb 10—Feb 11, 2016	Kings Bay, FL	Land-based	11
Jun 19—Jun 22, 2016	Choctawhatchee Bay, FL	Vessel-based	5
Dec 13—Dec 14, 2016	Kings Bay, FL	Land-based	11

Dates	Location	Format	Number captured
Feb 08—Feb 09, 2017	Kings Bay, FL	Land-based	8
Dec 05—Dec 06, 2017	Kings Bay, FL	Land-based	13
Jan 31—Feb 01, 2018	Kings Bay, FL	Land-based	18
Total			139

All captured manatees were examined and monitored by the experienced clinical team during the health assessments. All manatees were within normal healthy ranges for all parameters, and were similar to earlier health assessments of this population (Bonde et al. 2012).

In addition to the regularly scheduled health assessments in Crystal River, several locations in the panhandle of Florida were selected for roaming capture events (Table 1). During May 18 through 21, 2015 we conducted four days of manatee captures in the Wakulla-St. Marks rivers and at Lake Wimico near Apalachicola. In total, 7 manatees were caught and 5 were instrumented with satellite-monitored GPS tags (Table 3). A male manatee captured and tagged in Lake Wimico was matched to a known individual in the MIPS database that was first documented in 1988 in Crystal River and has had regular winter sightings since then in both Crystal and Homosassa rivers.

June 15 through 19, 2015 we conducted manatee aerial surveys in the Apalachicola to Pensacola region of Florida with federal and state partners, and captures in Choctawhatchee Bay, Florida. This was also used to train marine mammal stranding partners on manatee rescue and handling techniques. Four manatees were caught and instrumented with satellite-monitored GPS tags (Table 3). A very large adult female caught in Lake Wimico was matched in the MIPS database as CR-186, first documented in Crystal River in 1982. A similar capture event was also held during September 16 through 17, 2015, with 2 manatees caught and instrumented with tags (Table 3).

June 19 through 22, 2016, we again teamed with federal and state partners at USFWS and FWC who were surveying coastal habitats for manatees from Port St. Joe, Florida, to Lake Pontchartrain, Louisiana. We coordinated aerial surveys in the Apalachicola to Pensacola region of Florida, and with their aerial support were able to capture and assess five manatees and instrument them with satellite-monitored GPS tags.

As with the health assessments in Crystal River, Florida, all captured manatees were examined and monitored by the experienced clinical team during the panhandle captures. All manatees were within normal healthy ranges for all parameters.

Table 2. Basic morphometric and health values for manatees captured and assessed during Crystal River captures and health assessments for this study (NA = measurement not recorded)

Capture ID	Tag ID and name	Capture date	Sex	Straight length (cm)	Curvilinear length (cm)	Girth at axilla (cm)	Max girth (cm)	Girth at anus (cm)	Girth at peduncle (cm)	Fat thickness at umbilicus (mm)	Fat thickness at anus (mm)	Fat thickness at peduncle (mm)
CCR1308		12/3/2013	F	290	308	165	231	163	115	10	19	19.3
CCR1309		12/3/2013	M	250	275	162	196	146	100	8	13.3	18
CCR1310		12/3/2013	M	304	325	176	236	151	123	8	19	15.3
CCR1311	CR420	12/3/2013	M	306	322	166	209	161	116	3.3	8.7	11
CCR1312		12/3/2013	F	311	338	200	246	168	115	8	12.3	5.7
CCR1313		12/3/2013	M	229	241	129	172	121	89	6	9	8.7
CCR1314	TCR-23 Big Ben/CR643	12/4/2013	M	264	299	174	199	148	116	5.3	10	17
CCR1315		12/4/2013	F	259	264	139	183	137	92	7	8	11.3
CCR1316		12/4/2013	F	230	246	127	172	122	91	8	11.7	16
CCR1317		12/4/2013	F	288	300	170	221	149	103	8.3	12.3	13.7
CCR1318		12/4/2013	M	208	228	133	168	112	83	11	7.3	9
CCR1319		12/4/2013	M	285	300	162	201	146	106	6	12	13
CCR1320		12/4/2013	F	232	257	144	181	130	96	12.7	9.3	10.3
CCR1321		12/4/2013	M	265	271	145	190	123	97	5	9.3	11
CCR1401		1/31/2014	F	241	256	154	190	127	93	7	11	10.3
CCR1402		1/31/2014	F	289	305	152	207	151	107	4.7	13	11
CCR1403		1/31/2014	F	253	258	140	177	119	96	6.3	13	16
CCR1404		1/31/2014	M	254	265	140	181	123	95	2	12.7	12
CCR1405	CCR0921	1/31/2014	M	265	282	143	197	132	101	6.3	9	11
CCR1406		1/31/2014	M	324	329	159	211	147	113	5.3	11.7	10.3
CCR1407	CCR0701	1/31/2014	F	278	298	160	210	151	108	8.7	17.3	12.7
CCR1408		1/31/2014	M	299	307	167	200	130	107	4	8	11.3
CCR1409		11/6/2014	F	318	342	190	245	182	127	7	9.3	17.3
CCR1410		11/6/2014	M	219	235	129	167	108	85	10	13.3	12
CCR1411		11/6/2014	F	231	249	135	181	125	92	10.7	14.3	11.3
CCR1412		11/6/2014	F	197	NA	131	153	98	72	NA	NA	NA
CCR1413	CCR1220	11/6/2014	M	225	239	118	178	116	82	6	10	6.7
CCR1414		11/7/2014	M	221	241	128	174	111	81	6	11.7	8
CCR1415		11/7/2014	M	323	NA	183	228	153	125	3	8.7	10.3
CCR1416		11/7/2014	F	246	258	145	189	189	94	9.7	18	17

Capture ID	Tag ID and name	Capture date	Sex	Straight length (cm)	Curvilinear length (cm)	Girth at axilla (cm)	Max girth (cm)	Girth at anus (cm)	Girth at peduncle (cm)	Fat thickness at umbilicus (mm)	Fat thickness at anus (mm)	Fat thickness at peduncle (mm)
CCR1417		11/7/2014	M	263	274	150	181	127	101	5	7	12
CCR1418		11/7/2014	F	239	248	128	179	132	89	9	14.3	10.7
CCR1419		11/7/2014	M	268	290	135	200	145	104	7.3	7.7	8.3
CCR1501		1/21/2015	F	285	312	160	235	155	112	11.7	16.3	13.7
CCR1502		1/21/2015	F	222	235	136	161	126	78	4.7	6	6
CCR1503		1/21/2015	M	235	250	138	172	126	96	7	10.7	12.7
CCR1504		1/21/2015	M	232	248	139	178	118	92	8	12.3	12
CCR1505		1/21/2015	M	249	262	143	182	120	95	12.3	6.3	10.3
CCR1506		1/21/2015	M	234	245	131	178	119	94	12.3	10	8
CCR1507		1/21/2015	M	271	282	146	195	137	101	4.7	10.3	12.7
CCR1508		1/21/2015	F	320	343	177	232	153	119	4.3	13.3	12
CCR1509		1/21/2015	M	233	248	133	170	124	97	4	5	12.7
CCR1510		1/21/2015	M	273	296	156	201	135	127	4	9.3	11
CCR1511		1/22/2015	M	263	274	145	190	129	101	4.3	7.3	10
CCR1512		1/22/2015	F	300	330	175	235	175	124	10	14	20
CCR1513		1/22/2015	F	230	246	130	172	135	94	5.3	6	2
CCR1514		1/22/2015	F	210	225	142	165	115	86	8.3	12	10.3
CCR1515		1/22/2015	M	280	295	167	204	144	107	6	7.7	9.7
CCR1516		1/22/2015	F	297	329	171	220	171	124	4	8	3.7
CCR1517		1/22/2015	F	229	246	145	175	114	93	11	4	8.7
CCR1518		1/22/2015	F	259	287	144	204	141	103	6.3	12	11.7
CCR1519		1/22/2015	M	223	245	129	179	110	87	9.3	4	7
CCR1520		12/9/2015	M	263	279	150	204	131	102	6.7	9.7	9
CCR1521		12/9/2015	M	310	323	184	216	151	115	2	15	10
CCR1522		12/9/2015	M	289	312	172	197	142	112	4.3	10	10.3
CCR1523	CCR1231	12/9/2015	M	287	309	167	220	153	106	4	10.3	9.3
CCR1524		12/10/2015	F	303	330	175	236	142	122	7	11.3	13
CCR1525	Calf of CCR1524	12/10/2015	M	187	196	112	145	95	82	11.3	16	10
CCR1526		12/10/2015	M	331	355	209	259	169	127	4.7	17	18
CCR1527		12/10/2015	M	283	303	152	207	140	103	5	13	12
CCR1528	CCR0720	12/10/2015	F	302	324	183	256	178	122	8	24.3	18
CCR1529	TCR-25 Bert-belt only-retagged/CR159	12/10/2015	M	309	338	181	228	170	119	7.7	13	11.3

Capture ID	Tag ID and name	Capture date	Sex	Straight length (cm)	Curvilinear length (cm)	Girth at axilla (cm)	Max girth (cm)	Girth at anus (cm)	Girth at peduncle (cm)	Fat thickness at umbilicus (mm)	Fat thickness at anus (mm)	Fat thickness at peduncle (mm)
CCR1601		2/10/2016	F	230	250	136	170	130	90	8.7	11.7	10
CCR1602		2/10/2016	F	238	246	140	167	121	89	8.7	12	13
CCR1603		2/10/2016	M	260	280	149	192	134	104	10.3	8.3	9
CCR1604	CCR11-07	2/11/2016	F	323	345	184	246	196	138	7	21.7	23.3
CCR1605		2/11/2016	F	245	260	160	191	146	100	10	12	12
CCR1606		2/11/2016	M	250	266	147	180	135	100	9.3	9.3	8
CCR1607		2/11/2016	F	228	241	130	166	124	85	6.3	10.7	9
CCR1608		2/11/2016	M	260	280	162	193	132	99	4	9	11.3
CCR1609		2/11/2016	M	338	355	182	222	158	128	7	6.3	4.7
CCR1610		2/11/2016	F	261	264	143	180	137	91	8	4.3	11
CCR1611		2/11/2016	F	266	280	136	180	148	97	4.7	7.3	7.3
CCR1622		12/13/2016	M	259	275	150	194	133	100	6	10.7	10.3
CCR1623	CCR0907	12/13/2016	M	294	315	166	221	140	114	4.7	10.7	13.3
CCR1624		12/13/2016	M	306	331	180	242	151	110	3.3	11	12
CCR1625	TCR-27 CR610/ CCR0824	12/13/2016	M	300	317	167	230	146	118	4.3	12	14
CCR1626	CCR1209	12/13/2016	M	324	347	188	255	175	123	5	12	18.7
CCR1627		12/13/2016	M	275	293	161	200	143	106	5	12	11.3
CCR1628		12/14/2016	M	296	310	161	211	149	104	5	9.7	13.7
CCR1629		12/14/2016	M	260	294	145	194	128	100	5.7	11.7	12.7
CCR1630		12/14/2016	F	294	306	153	208	135	110	3.7	11	8.7
CCR1631	Calf of CCR1630	12/14/2016	M	215	230	121	166	117	89	8.7	13.7	10.7
CCR1632		12/14/2016	F	269	286	152	198	152	113	7	17.7	15.7
CCR1701		2/8/2017	F	302	325	160	206	149	110	8	7.7	10
CCR1702	Calf of CCR1701	2/8/2017	F	194	216	112	245	110	79	14.3	18	10
CCR1703		2/8/2017	M	267	278	141	186	137	100	5.7	12.7	14.7
CCR1704		2/8/2017	M	232	251	135	171	110	86	5.3	12	8.7
CCR1705		2/9/2017	F	272	291	164	210	163	96	12.7	19.7	17
CCR1706		2/9/2017	M	299	322	180	216	137	111	4	14	13
CCR1707		2/9/2017	F	249	270	159	207	149	111	13	13	16.7
CCR1708		2/9/2017	M	255	271	137	191	122	95	7.3	10	11
CCR1709		12/5/2017	M	296	323	170	213	151	98	5	10.7	12
CCR1710		12/5/2017	M	289	310	176	228	142	110	5	5.7	3.7

Capture ID	Tag ID and name	Capture date	Sex	Straight length (cm)	Curvilinear length (cm)	Girth at axilla (cm)	Max girth (cm)	Girth at anus (cm)	Girth at peduncle (cm)	Fat thickness at umbilicus (mm)	Fat thickness at anus (mm)	Fat thickness at peduncle (mm)
CCR1711		12/5/2017	M	306	331	183	235	148	111	5.3	4	4
CCR1712		12/5/2017	F	310	330	187	242	159	121	11	5	4.7
CCR1713	Calf of CCR1712	12/5/2017	M	154	179	103	128	92	68	15.7	3	11.7
CCR1714	Uhura/CCR0906 /CR809	12/5/2017	F	309	335	188	234	166	125	14	14	12
CCR1715	Calf of CCR1714	12/5/2017	M	188	211	120	150	108	80	6	6.7	6.7
CCR1716	CCR0708	12/5/2017	M	318	343	178	232	156	110	4.7	5.7	3
CCR1717		12/6/2017	F	232	244	150	194	116	88	5.3	10	11
CCR1718		12/6/2017	F	270	284	138	190	126	98	11	9.7	12
CCR1719	Calf of CCR1718	12/6/2017	M	180	194	110	133	94	73	12	15	13
CCR1720	CCR1124/CCR1221	12/6/2017	M	272	296	156	203	148	110	5	10	10
CCR1721		12/6/2017	M	252	276	154	199	128	100	5.7	3	10.7
CCR1801	CR855 Maija	1/31/2018	F	222	243	132	165	103	86	3.3	3	10
CCR1802		1/31/2018	M	291	309	163	210	145	107	3.7	9	10
CCR1803		1/31/2018	M	213	234	130	170	115	90	9.3	11.3	10.7
CCR1804	CCR1631	1/31/2018	M	226	252	147	170	119	91	6	12.7	8.7
CCR1805		1/31/2018	M	279	305	184	206	146	108	4	8	13.3
CCR1806		1/31/2018	M	223	244	130	179	108	94	6.3	11	15
CCR1807		1/31/2018	M	242	259	146	173	126	92	6.7	8.3	11.7
CCR1808		1/31/2018	F	236	261	138	176	134	96	5	10	8
CCR1809		1/31/2018	M	234	254	129	168	105	85	5	6	5.7
CCR1810		1/31/2018	F	343	371	195	255	195	134	13	28	15.3
CCR1811		2/1/2018	M	228	247	127	164	112	90	6.3	8.3	9.3
CCR1812		2/1/2018	M	241	264	142	181	134	95	7	7.3	7
CCR1813	CCR0910	2/1/2018	F	290	321	164	207	159	110	5.3	15	12.3
CCR1814	Calf of CCR1813	2/1/2018	F	192	213	132	155	118	82	6.3	5	4
CCR1815		2/1/2018	F	250	275	177	196	146	105	9.3	6.3	7.7
CCR1816	CCR0803	2/1/2018	M	267	293	154	198	124	105	3	8.3	9.7
CCR1817		2/1/2018	M	264	288	157	197	138	103	7	13	12
CCR1818		2/1/2018	M	241	263	146	174	122	88	5.3	6	9.3

Table 3. Manatees that were net-captured and fitted with GPS transmitter for this study

Capture ID	Tag ID	Name	Sex	Length (cm)	Weight (kg)	Capture date	Capture site
CCR1314	TCR-28	Big Ben	M	264	433	12/4/2013	Kings Bay, Crystal River, FL
CCR1624	TCR-27	CR610	M	300	574	12/13/2016	Kings Bay, Crystal River, FL
LPZ103373[a]	TCR-28	Hoth	M	293	481	6/13/2017	Kings Bay, Crystal River, FL
CPH1501	TPH-10	Smark	M	315	NA	5/19/2015	Wakulla River, FL
CPH1502	TPH-11	Soppy	M	296	NA	5/19/2015	Wakulla River, FL
CPH1503	TPH-12	Mystee	F	236	NA	5/19/2015	Wakulla River, FL
CPH1504	TPH-13	Hitch	M	324	NA	5/20/2015	Lake Wimico, Apalachicola, FL
CPH1505	TPH-14	Bugs	F	313	NA	5/21/2015	Wakulla River, FL
CPH1506	not tagged	Calf of CPH1505	M	201	NA	5/21/2015	Wakulla River, FL
CPH1507	TPH-15	Delta Girl	F	226	NA	6/16/2015	Lake Wimico, Apalachicola, FL
CPH1508	TPH-16	CR186	F	356	NA	6/16/2015	Lake Wimico, Apalachicola, FL
CPH1509	TPH-17	TPH-17	F	288	NA	6/16/2015	Lake Wimico, Apalachicola, FL
CPH1510	TPH-18	Tallyho	M	271	NA	6/18/2015	Choctawhatchee Bay, FL
CPH1511	TPH-19	Billy Joe	M	305	NA	9/16/2015	Choctawhatchee Bay, FL
CPH1512[b]	TPH-18	Tallyho	M	276	NA	9/17/2015	Choctawhatchee Bay, FL
CPH1601	TPH-20	Escambia	M	323	NA	6/20/2016	Choctawhatchee Bay, FL
CPH1602	TPH-21	Rumpus	M	296	NA	6/20/2016	Choctawhatchee Bay, FL
CPH1603	TPH-22	Choctaw	M	318	NA	6/21/2016	Choctawhatchee Bay, FL
CPH1604[c]	TCR-19	Dash	M	331	NA	6/21/2016	Choctawhatchee Bay, FL
CPH1605	TPH-23	Nojoy	M	306	NA	6/22/2016	Choctawhatchee Bay, FL
SWFTm1476B[d]	TTB-140	Trinidad	M	320	483	3/4/2015	TECO Electric power plant, Tampa, FL

[a]Rescued 2/3/17 in Southport, North Bay, Panama City, FL with cold stress; previous MIPS history in Crystal River, FL

[b]Belt only attached; tag recovered in July15; retagged at capture

[c]Sept2014 recovered all gear; retagged at capture

[d]Rescued 11/25/14 in Trinity Bay, Houston, TX with cold stress; previous MIPS history in TECO Electric power plant, Tampa, FL

NA = measurement not taken.

3.2 Photo-identification to target western-traveling manatees

The MIPS database (unpublished MIPS data, FWC-MML-USGS) was used as a tool for targeting specific manatees for radio tagging. Searches were performed within the database to identify manatees that had been documented in areas of the northern Gulf including the Florida Panhandle, Alabama, Mississippi, Louisiana, and Texas. A field guide was created with photographs of these scarred manatees along with their sighting histories. This became a way of uniquely identifying individual manatees while working on in-water photo-identification at Crystal, Wakulla, and St. Marks rivers. Using this guide, nineteen manatees were identified and free-tagged over the course of the study by biologists in the water (Table 4). Free-tagging is the process of attaching the radio tagging assembly to the manatee while in the water and does not include a net capture or health assessment. Seventeen of these manatees were targeted based on MIPS histories and 2 were opportunistically tagged due to their location, but were not documented MIPS manatees. This field guide also aided tagging of 2 animals during annual manatee captures at Crystal River, as it enabled the identification of target manatees pulled on shore for health assessments.

Photo documentation of scarred manatees was collected throughout the study period and study area. Photographs were checked for matches to previously documented manatees in the MIPS database. This provided another means to track manatee movement via sighting information (see Appendices B, D).

MIPS was queried for manatee sightings in the Florida panhandle from Destin west, Alabama, Mississippi, Louisiana, and Texas (unpublished data, USGS-FWC-MML). Fifty-nine manatees had MIPS sighting documentation for these areas. Fifty-four of these manatees had initial sightings in winter at traditional warm water sites in Florida, many of them with long term histories at these sites prior to being seen in the northern Gulf . Four manatees had initial sightings at summer sites, and one was first documented upon rescue in Texas (See Appendix D, Table D-1). USGS was responsible for adding new northern Gulf f sighting documentation for 17 manatees during the study period. For this group, the longest sighting history of an individual manatee in MIPS with northern Gulf documentation belongs to CR054. Over the span of 39 years, this female has 124 verified photo-documented sightings in MIPS. She was first photo-documented by USGS in January 1978 in Crystal River, Florida. Between 1978 and January 2000, she was documented every winter (with the exception of 3 non-consecutive seasons) using either or both the Crystal River and Homosassa River, Florida sites. Over the course of this time period there are 64 photo-documented sightings in MIPS, and she produced 9 calves. In July 2000 she was documented in Bayou LaBatre, Alabama for the first time. Over the next 17 years, she was documented in warm seasons using Edward Ball Wakulla Springs State Park, Florida, the Wakulla River, Florida, the Florida panhandle, Alabama, and Mississippi. In winter seasons she was documented at Crystal River, Homosassa River, Edward Ball Wakulla Springs State Park and more recently in Tampa Bay, Florida at the Bartow Power Plant. In total, she has been documented with 11 calves, and multiple agencies (USGS, Edward Ball Wakulla Springs State Park, Dauphin Island Sea Lab [DISL] and FWC) have contributed to her sighting history. (See Appendix D, Table D-1).

Of the 59 manatees with sighting histories in MIPS in the northern Gulf , 17 (14 males, 3 females) have been recovered as carcasses (Appendix C). Seven of these individuals had winter sighting histories at known warm water sites in Florida and the carcass recovery was the first documentation out-of-state (TB136, TB228, CR613, CR709, TB561, CH279, TB432). This is not to say that these manatees had not traveled to the northern Gulf before they were recovered, but this was the first documentation for these locations. Two of these had histories in Tampa Bay and were recovered in Louisiana (TB136 and TB288). Two had histories in Crystal River and were recovered in Mississippi (CR613 and CR709). One had a history in Tampa Bay and Edward Ball Wakulla Springs State Park and was recovered in Mississippi

(TB561). One had a history in Tampa Bay and was recovered in Alabama (CH279), and one had a history in Tampa Bay, Edward Ball Wakulla Springs State Park, and the Wakulla River and was recovered in Alabama (TB432). Of the remaining 10, 3 individuals had long term winter sighting histories in Crystal River and the Homosassa River, with summer sightings in Alabama in between winters and were recovered in Alabama (CR123, CR267, CR813). One individual had winter sighting histories in Tampa Bay at the TECO Electric power plant with summer sightings in Edward Ball Wakulla Springs State Park (1 sighting) and Alabama (1 sighting) in between winters and was recovered in Santa Rosa Sound, Florida (TB186). Another individual had long term winter sightings in Crystal River with 1 summer sighting in Alabama then was recovered in Panama City, Florida (CR140). One individual had a lengthy winter sighting history in Crystal River and Homosassa River, with 2 years of summer sightings in Alabama in between winters and was recovered in Lake Wimico, Florida (CR224) and 1 individual was first documented in Crystal River, captured and tagged by DISL in summer, lost the gear by winter that year when sighted in Crystal River, revisited Alabama and Panama City Beach, Florida, then was recovered in Crystal River (CR848). One individual had a sighting history in the Wakulla River then was recovered in Pensacola, Florida (CR585). One individual had summer sightings in Sarasota Bay, Florida and was recovered in Santa Rosa Island, Florida (SB070) and one individual had winter sighting histories in Fort Myers and Tampa Bay and was recovered in Choctawhatchee Bay, Florida (SB145). Of note, two of these individuals (CR267, CR813) were recovered near the Mobile Bay, Alabama, shipping channel with acute watercraft listed as cause of death.

3.3 Manatee tagging and tracking

A total of 36 wild-caught manatees were GPS tracked for this study. We prioritized multi-year tracks of the same animals over tagging new animals each year, so several of the manatees were re-tagged multiple times, resulting in 141 GPS bouts, defined as the time period from when a GPS transmitter was attached to a manatee to the time when it was replaced with another tag, the tag detached due to entanglement, or the tag stopped functioning (Appendix E:). Only records from healthy, wild caught or free-tagged manatees were used for this project. The tracks included 852,838 locations generated from the 36 manatees from locations in the Gulf north of Tampa, Florida (Table 5). Of those manatees, 13 were initially tagged during winter in Kings Bay and 23 were initially tagged outside of winter in the Florida panhandle. The most days tracked for a single animal was 1563, and the shortest was 13. The average track covered 388 days. The total tracking effort was approximately 40.5 manatee-years. Many of the manatees that were tagged were known through photo-identification from the panhandle or other Gulf states (Table D-1), and so this data set represents manatees that were biased toward movements in the northern Gulf .

Table 4. Manatees that were free-tagged (GPS transmitter attached while in-water) for this study

MIPS[a] ID	Tag ID	Name	Sex	Size Class[b]	Tag date	Tagging site
CR723	TCR-05	Pilo	M	SA	6/9/2011	Wakulla River, FL
CR419[c]	TCR-10	Ebb	F	MA	5/22/2008	Kings Bay, Crystal River, FL
CR505[c]	TCR-11	CR505	F	LA	5/14/2008	Kings Bay, Crystal River, FL
CR123	TCR-12	Ellie	F	LA	1/12/2009	Kings Bay, Crystal River, FL
CR018	TCR-13	CR018	M	LA	1/12/2009	Kings Bay, Crystal River, FL
CR289	TCR-19	Dash	M	LA	3/23/2010	Kings Bay, Crystal River, FL
CR643	TCR-23	Big Ben	M	MA	2/9/2016	Kings Bay, Crystal River, FL
CR054	TCR-24	CR054	F	VLA	1/30/2014	Kings Bay, Crystal River, FL
CR159	TCR-25	Bert	M	LA	1/20/2015	Kings Bay, Crystal River, FL

MIPS[a] ID	Tag ID	Name	Sex	Size Class[b]	Tag date	Tagging site
CR566	TPH-01	Izzy	F	LA	6/19/2008	Wakulla River, FL
CR639	TPH-02	Zip	M	SA	12/8/2009	Edward Ball Wakulla Springs State Park, FL
N/A	TPH-03	Two Notch	M	SA	12/9/2009	Edward Ball Wakulla Springs State Park, FL
N/A	TPH-04	Coontie	F	SUB	6/2/2010	Wakulla River, FL
CR500	TPH-05	Getty	F	SA	6/3/2010	Wakulla River, FL
CR661	TPH-06	Muse	F	SA	5/3/2011	Wakulla River, FL
CR511	TPH-07	Taz	M	SUB	6/8/2011	Wakulla River, FL
CR627	TPH-08	Gordo	M	MA	12/9/2011	Edward Ball Wakulla Springs State Park, FL
CR023	TPH-09	Herman	M	LA	1/27/2012	Edward Ball Wakulla Springs State Park, FL
CR267	TMA003	Zewie	M	MA	1/17/2014	Kings Bay, Crystal River, FL

[a]MIPS = Manatee Individual Photo-Identification system

[b]SA = Small adult, MA = Medium adult, LA = Large adult, VLA = Very large adult, Sub = Subadult

[c]Females with calves originally tagged with radio transmitters only (TCR-10 and TCR-11) for University of Florida reproductive hormone study; tags were then switched to GPS tags in May2008 in the Wakulla River, Florida.

Table 5. Summary manatee GPS tracking table

Tracking between First on date and Final off date may not be continuous. Number of days tracked accounts for any gaps in tracking period.

Tracking ID	Manatee name	Sex	First on date	Final off date	Number of days tracked	Number of locations
TCR-05	PILO	M	11/7/2006	12/30/2011	225	8383
TCR-11	CR505	F	5/14/2008	6/2/2008	20	685
TCR-10	EBB	F	5/22/2008	4/4/2009	315	6480
TPH-01	IZZY	F	6/19/2008	10/12/2010	828	20551
TCR-12	ELLIE	F	1/12/2009	7/15/2009	185	4753
TCR-13	CR018	M	1/13/2009	4/19/2012	1070	24610
TPH-02	ZIP	M	12/8/2009	6/18/2012	536	12817
TPH-03	TWO NOTCH	M	12/9/2009	1/23/2012	298	7450
TCR-19	DASH	M	3/23/2010	2/14/2018	1563	73557
TPH-04	COONTIE	F	6/2/2010	6/20/2010	19	637
TPH-05	GETTY	F	6/3/2010	12/30/2011	425	15985
TPH-06	MUSE	F	5/3/2011	6/13/2012	363	14463
TPH-07	TAZ	M	6/8/2011	6/12/2012	371	11880
TPH-08	GORDO	M	12/9/2011	9/2/2013	378	10008
TPH-09	HERMAN	M	1/27/2012	1/19/2013	311	8123
TCR-23	BIG BEN	M	12/4/2013	2/14/2018	439	26806
TMA-003	ZEWIE (CR267)	M	1/17/2014	8/20/2015	419	17099
TCR-24	CR054	F	1/30/2014	8/24/2017	554	27597
TCR-25	BERT (CR159)	M	1/20/2015	1/7/2018	340	23815
TTB-140	TRINIDAD	M	3/6/2015	5/31/2016	252	21524
TPH-10	SMARK	M	5/19/2015	12/22/2016	378	33694
TPH-11	SOPPY	M	5/19/2015	1/9/2017	597	50517
TPH-12	MYSTEE	F	5/19/2015	12/12/2016	290	26415
TPH-13	HITCH	M	5/20/2015	2/14/2018	993	79822
TPH-14	BUGS	F	5/21/2015	6/3/2016	380	24506
TPH-15	DELTA GIRL	F	6/16/2015	7/29/2016	219	19764
TPH-16	CR186	F	6/16/2015	8/19/2017	541	42656
TPH-17	TPH-17	F	6/16/2015	6/28/2015	13	1017
TPH-18	TALLYHO	M	6/18/2015	11/23/2016	466	37875
TPH-19	BILLY JOE	M	9/16/2015	1/31/2017	307	21802
TPH-20	ESCAMBIA	M	6/20/2016	2/14/2018	328	27182
TPH-21	RUMPUS	M	6/20/2016	2/15/2018	466	37374
TPH-22	CHOCTAW	M	6/21/2016	10/7/2016	109	5847
TPH-23	NOJOY	M	6/22/2016	5/21/2017	334	25460
TCR-27	CR610	M	12/13/2016	2/14/2018	415	37199

Tracking ID	Manatee name	Sex	First on date	Final off date	Number of days tracked	Number of locations
TCR-28	HOTH	M	6/13/2017	1/5/2018	78	6581

Manatees carrying GPS telemetry tags were tracked traveling as far west as Lake Pontchartrain, Louisiana, and as far south to Tampa Bay, Florida (Figure 16). To focus on the northern Gulf study area, locations south of the Weeki Wachee River in the Crystal River region were removed for all analyses.

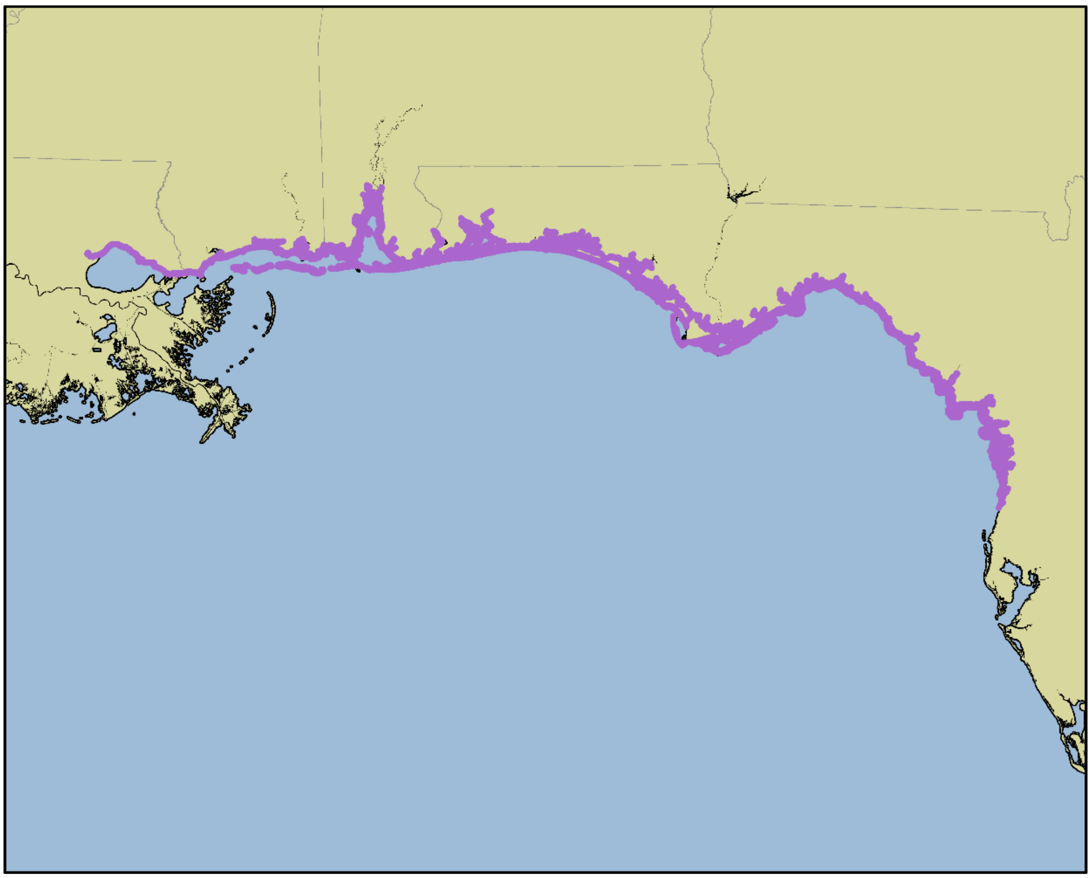

Figure 16. Extent of manatee tracking.

Locations south of the Weeki Wachee River in the Crystal River region were removed.

The monthly distribution of telemetry locations was fairly even, with a minimum of 50,749 locations (6.1 percent) in November and a maximum of 85,323 locations (10.3 percent) in January (Table 6). While the majority of manatee captures were performed in winter at Crystal River, Florida, manatees were also tagged during summer in the panhandle of Florida, and manatee tags were replaced throughout the year before the 8–10 month battery life was reached.

Table 6. Number and percentage of GPS telemetry records by month

Month	Number of locations	Percentage of locations
January	85323	10.3%
February	76001	9.2%
March	78479	9.5%
April	67570	8.2%
May	64143	7.7%
June	71124	8.6%
July	77135	9.3%
August	65399	7.9%
September	57350	6.9%
October	57654	7.0%
November	50749	6.1%
December	78132	9.4%

In contrast to the temporal pattern of telemetry locations, the spatial pattern was very uneven. The Crystal River region had the highest number of locations at 299,138 (42.6 percent). There was a general pattern of fewer locations in the more western regions, but with clear hotspots in St. Marks, Apalachicola, Destin, and Mobile regions (Table 7), indicating superior resources for manatees (forage, freshwater, safety, etc.) in those locations.

Table 7. Number and percentage of GPS location per region

The percentage values are relative to other regions in the same season.

Region	Number of GPS locations					Percentage of GPS locations				
	All	Winter	Spring	Summer	Fall	All	Winter	Spring	Summer	Fall
Crystal River	299138	203787	68799	6883	19669	42.6%	94.9%	40.3%	3.9%	14.2%
Suwannee	43512	3437	21293	10769	8013	6.2%	1.6%	12.5%	6.0%	5.8%
Steinhatchee	7057	485	2972	729	2871	1.0%	0.2%	1.7%	0.4%	2.1%
Aucilla	12064	1438	9073	481	1072	1.7%	0.7%	5.3%	0.3%	0.8%
St. Marks	98469	4337	25500	29573	39059	14.0%	2.0%	14.9%	16.6%	28.2%
Apalachicola	133135	272	33405	63330	36128	19.0%	0.1%	19.5%	35.5%	26.1%
Port St. Joe	2985	35	1013	1671	266	0.4%	0.0%	0.6%	0.9%	0.2%
Panama City	8787	637	1820	4491	1839	1.3%	0.3%	1.1%	2.5%	1.3%
Destin	44331	42	600	22873	20816	6.3%	0.0%	0.4%	12.8%	15.0%
Pensacola	8088	0	947	5991	1150	1.2%	0.0%	0.6%	3.4%	0.8%
Perdido	3193	0	416	2450	327	0.5%	0.0%	0.2%	1.4%	0.2%
Mobile	28041	258	1785	24588	1410	4.0%	0.1%	1.0%	13.8%	1.0%
Pascagoula	12311	0	3009	4273	5029	1.8%	0.0%	1.8%	2.4%	3.6%
Biloxi	889	0	31	50	808	0.1%	0.0%	0.0%	0.0%	0.6%
Diamondhead	166	0	71	95	0	0.0%	0.0%	0.0%	0.1%	0.0%
New Orleans	157	0	157	0	0	0.0%	0.0%	0.1%	0.0%	0.0%

Combining monthly and regional telemetry locations shows that the tagged manatees followed a strong seasonal spatial pattern in the northern Gulf (Figure 17). Almost all winter locations were in the Crystal River region, home to the Crystal River National Wildlife Refuge and its many protected springs. However, a significant minority were also found in the St. Marks region, home to Edward Ball Wakulla Springs State Park. Spring found the manatees near the regions with reliable warm-water (Crystal River and St. Marks, and to a lesser extent Suwannee), but very few early migrators were tracked as far as Lake Pontchartrain (Figure 18). By summer, the majority of tracked manatees had left the Crystal River region, with the majority of them in the St. Marks and Apalachicola regions, with noticeable populations in Destin (Choctawhatchee Bay) and Mobile (Mobile Bay and Dog River). After summer, manatees started moving closer to warm-water springs; by fall, the population of tracked manatees in Mobile was mostly absent, and by early winter the Destin population had all but disappeared.

Manatees with GPS telemetry tags did not travel west of the New Orleans region, but manatees are known from the entire US Gulf coast through agency and public sightings of both live animals and carcasses (e.g., Fertl et al. 2005). Compiling these sightings and plotting them on the same spatial and temporal scales as Figure 17, we can see that the pattern of use in summer and early fall continued all the way to the regions in the western Gulf (Figure 19). For the regions farthest west (Brownsville, Corpus Christi), the majority of sightings did not occur until mid-summer. Occasional sightings outside of the expected warm-weather pattern were also seen. These may represent animals that were later rescued or died from cold stress, but also may have been individuals with greater tolerance to hypothermia.

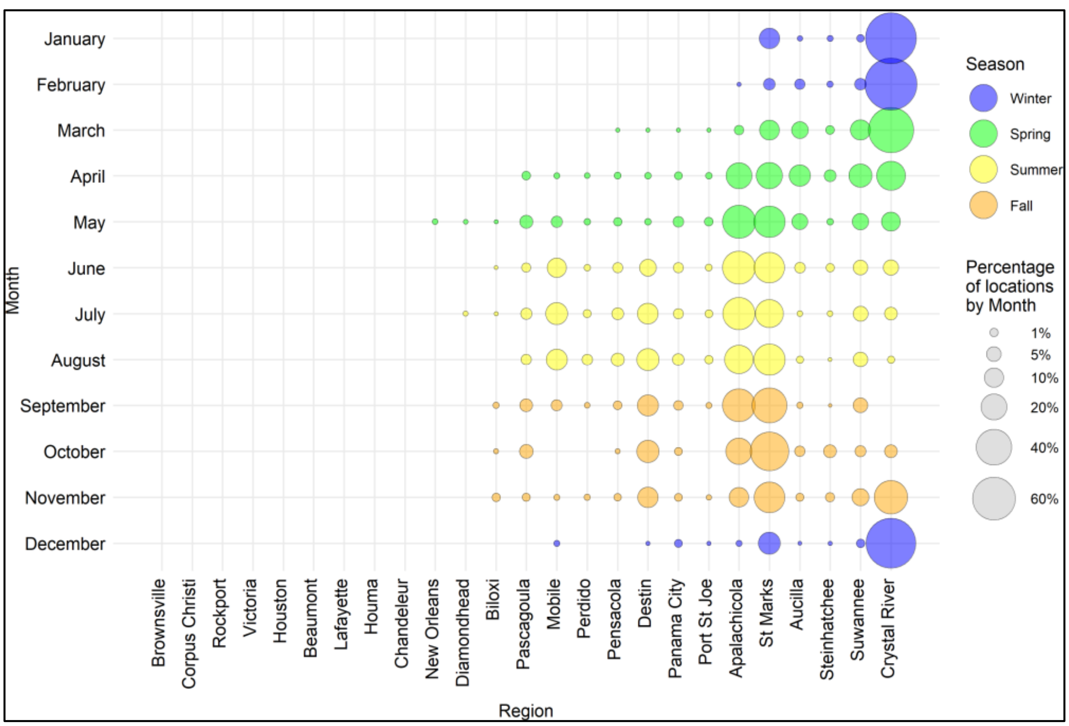

Figure 17. Seasonal manatee GPS locations by region and month.

Regions are arranged from west (left) to east (right).

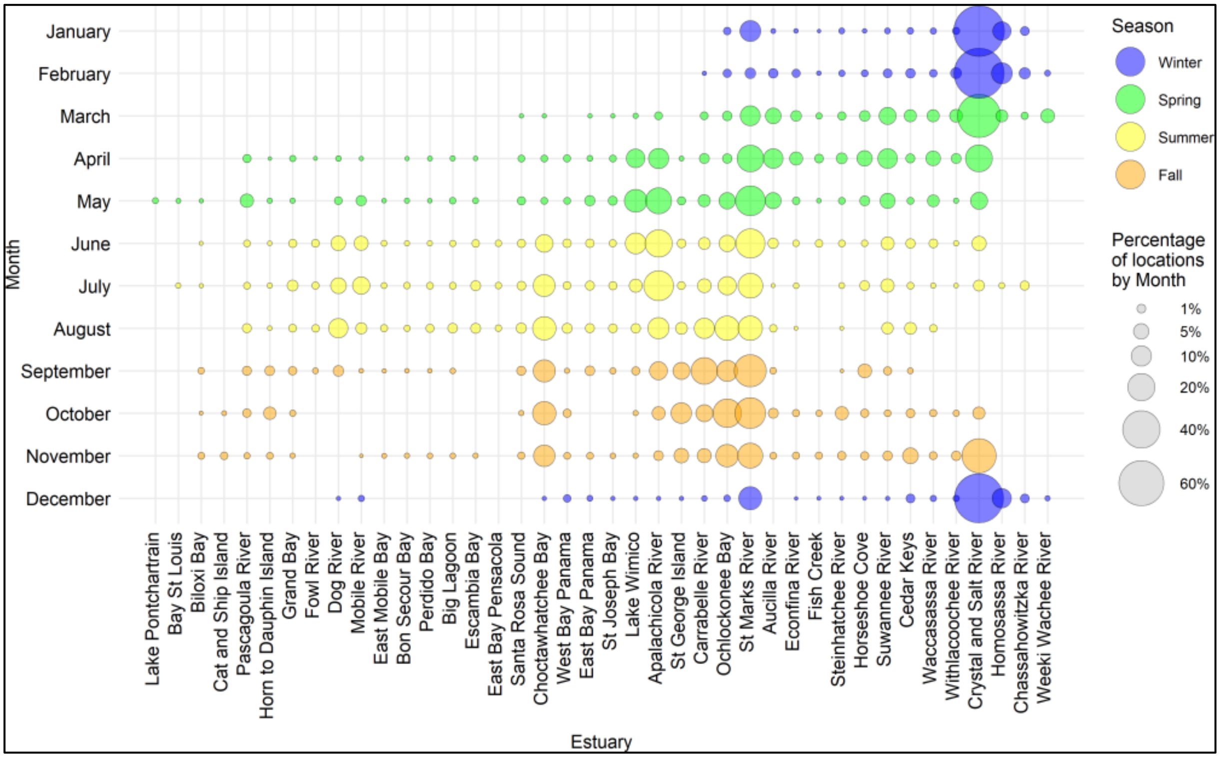

Figure 18. Seasonal manatee GPS locations by Area of Interest and month.

Areas are arranged from west (left) to east (right).

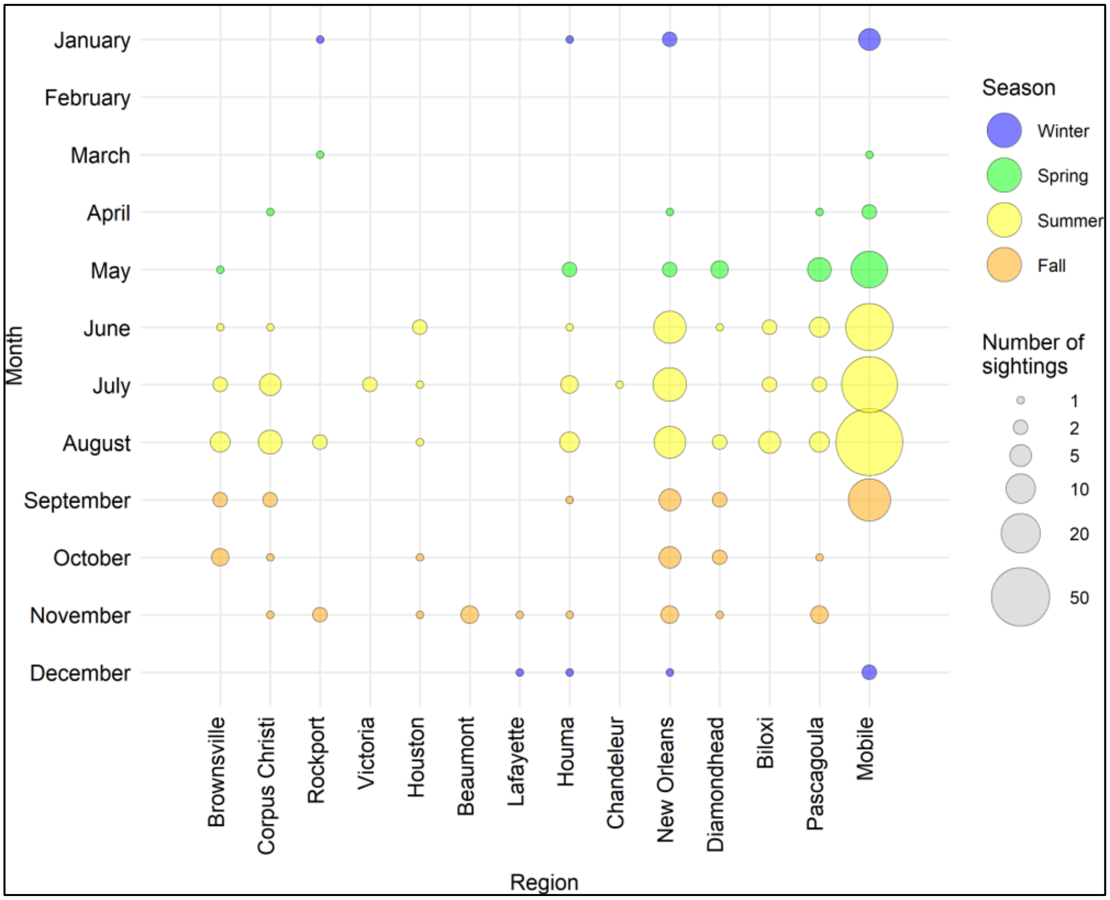

Figure 19. Manatee sightings by region (west of Florida only) and month.

Regions are arranged from west (left) to east (right).

3.3.1 Local movement patterns

The fine-scale temporal and spatial resolution of the GPS telemetry allowed us to make several measurements and inferences regarding manatee movement rates and spatial patterns. The tagged manatees showed a strong bimodal movement speed pattern corresponding to habitat use including feeding, drinking and resting (~40 m/h), and traveling between habitat patches (~2.5 km/h; Figure 20). Furthermore, while the majority of habitat use corresponded with shallow water or inland estuarine locations, traveling movements were preferentially through deeper water, even where shallow water habitat was available. Very little time was spent traveling at intermediate speeds between these two extremes.

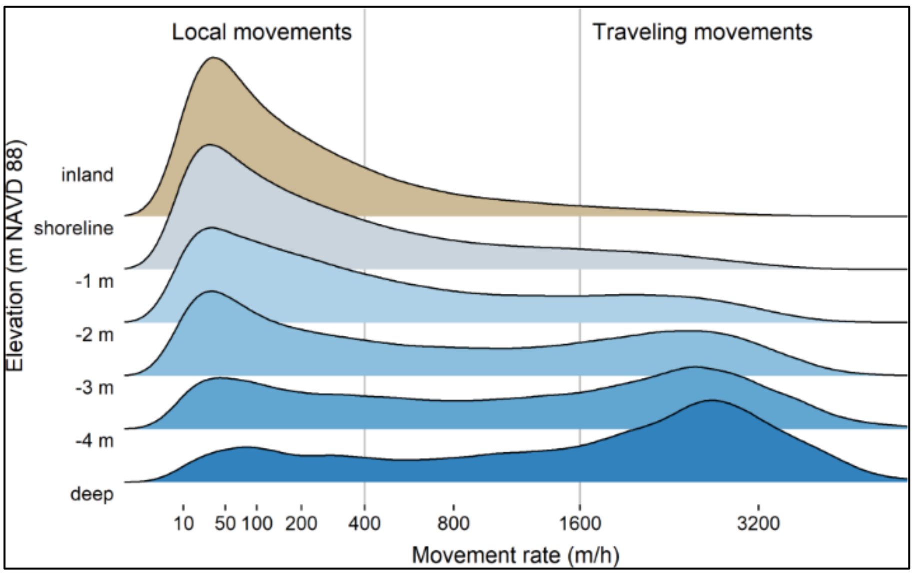

Figure 20. Manatee movement rates and depths of travel showed a bimodal pattern.

The bimodal movement pattern can also be seen in the distance from shore manatees chose for habitat use versus traveling. Strongly correlating with depth of habitat, traveling locations in all regions except St. Marks were farther from shore than habitat use locations (Table 8). In regions where deep Gulf waters were found close to shore (ex., Pensacola and Perdido), manatees traveled close to shore and used habitats that were very close to shore. By contrast, in regions where the shallow West Florida Shelf extends far offshore (ex., Steinhatchee and Suwannee), the median travel distance was over one km offshore, and habitat use areas were found hundreds of meters offshore.

Table 8. Mean distance from shore of offshore manatee habitat use locations and traveling movements

Region	Mean distance from shore (m)	
	Habitat use	Traveling movements
Biloxi	196 (142—259)	210 (160—266)
Pascagoula	314 (298—332)	341 (317—365)
Mobile	155 (143—167)	455 (435—475)
Perdido	21 (14—31)	81 (66—98)
Pensacola	60 (51—70)	117 (107—129)

Region	Mean distance from shore (m)	
Destin	64 (61—67)	201 (190—213)
Panama City	67 (58—78)	158 (143—173)
Port St. Joe	53 (34—77)	80 (55—111)
Apalachicola	252 (248—255)	344 (336—353)
St. Marks	409 (404—415)	386 (375—398)
Aucilla	254 (241—266)	691 (657—726)
Steinhatchee	528 (503—553)	1,114 (1,071—1,158)
Suwannee	788 (777—799)	1,025 (1,004—1,046)
Crystal River	220 (217—224)	451 (440—462)

3.3.2 Effect of tides on manatee movements

Nine tide stations, maintained by NOAA and USGS, were found in the eastern part of the study area where manatees with telemetry tags traveled (Table 9). These had sufficient temporal and spatial coverage to identify the tide stage of manatees in each of the regions. The tidal range in the northern Gulf of Mexico was not very large, averaging from 0.38 to 1.16 m, but its effect on manatee movements was substantial.

Table 9. Tide stations used to correct depth readings collected during this study

Agency	Station Number	Station Name	Latitude	Longitude	Mean daily range (m)
NOAA[a]	8747437	Bay Waveland Yacht Club	30.3250	-89.3250	0.54
NOAA	8741533	Pascagoula NOAA Lab	30.3678	-88.5631	0.47
NOAA	8736897	Coast Guard Sector Mobile	30.6483	-88.0583	0.52
NOAA	8729840	Pensacola	30.4044	-87.2112	0.38
NOAA	8729108	Panama City	30.1523	-85.6669	0.41
NOAA	8728690	Apalachicola	29.7267	-84.9817	0.49
USGS[b]	2326550	Aucilla River Near mouth	30.1123	-83.9798	1.12
USGS	2323592	Suwannee River near Suwannee Fl	29.3394	-83.0865	0.71
NOAA	8727520	Cedar Key	29.1350	-83.0317	1.16

[a] (CO-OPS 2018)

[b] (US Geological Survey 2019)

As noted in 3.3.1, the distance from shore that was preferred by manatees was correlated with bathymetry (shallow wide shelf associated with movements farther offshore). When tide level was considered, the correlation held strongly for low and mid tides, but was weak at high tide (Figure 21). For habitat use, the median distance from shore of the tracked manatees at high tide was between 7 and 171 m, for mid tide the median distance was from 45 to 797 m and during low tide it was 38 to 1052 m (Figure 21a), indicating that the majority of the manatee movements were father offshore during lower tide levels in most regions. The exception was in regions with almost no shallow shelf, where deeper water was available close to shore.

Traveling movements followed the same pattern as habitat use, but proportionally farther offshore for each tide range. High tide median distance ranged from 55 to 543 m, mid tide from 46 to 1189 m, and low tide from 87 to 1847 m (Figure 21b). Larger median distance from shore was again associated with regions with long shallow offshore shelves, and the interquartile ranges were also much greater in these same regions, indicating a greater variability in both habitat use and travel path locations where bathymetry was more uniform.

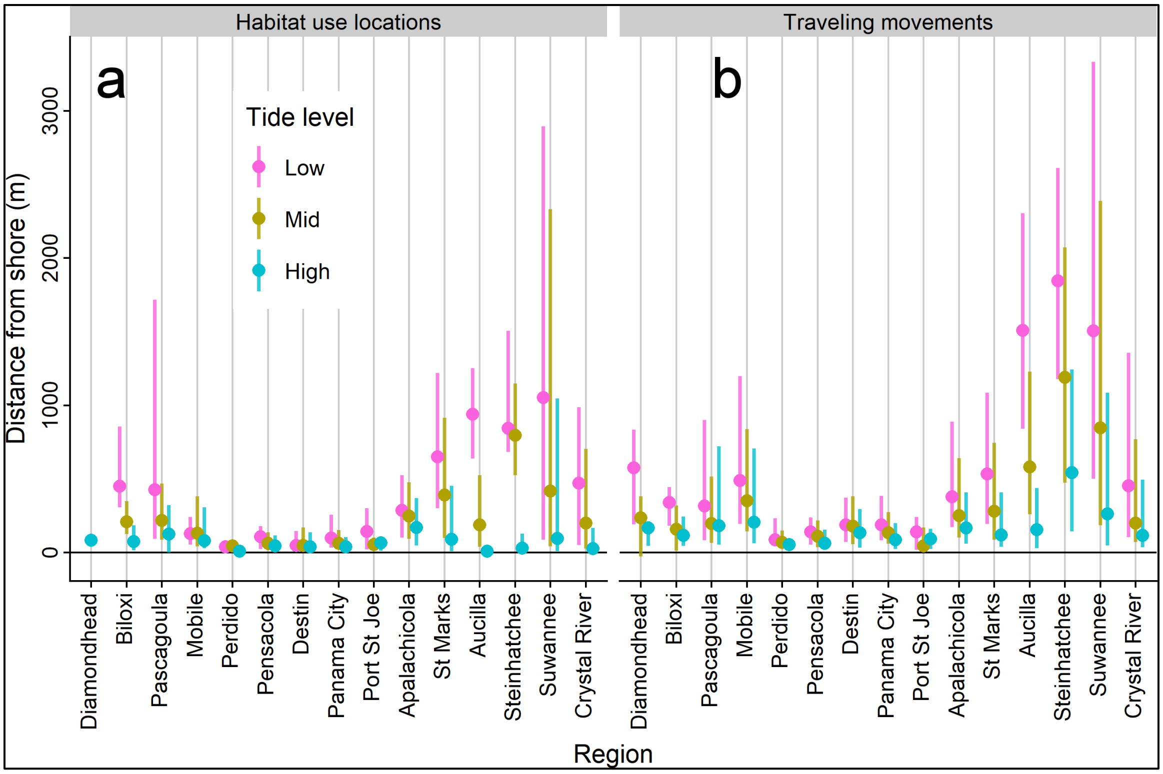

Figure 21. Distance from shore of manatee telemetry locations during low, mid and high tide for habitat use locations and traveling movements.

Colored circles are the median distance from shore, and colored bars are the interquartile range.

3.4 Habitat use forecasting

The manatee habitat use prediction results were standardized to the level of manatee use per region to make visual interpretations and comparisons more clear within a region and to see the relative locations of habitat hotspots. Between-region comparisons are not valid using the following maps. For that purpose, the regional tracking results (Figure 17) and, to a lesser extent, the sighting results (Figure 19) will give the best available information about relative manatee use by region.

The habitat use model characterized manatee use areas by wetland type, distance to wetland habitat, distance from shore, and land elevation. Areas that had high manatee-use were identified, and all similar areas within the region were then highlighted as potential manatee habitat, whether or not manatees were tracked in the area. In regions with very high actual manatee use, the overlap of use and expected habitat areas should be mostly complete, that is, most of the expected manatee use areas should have actual manatee use. In regions with lower manatee use, the expected habitat area may be much larger than the actual use area. Finally, in regions with no manatee telemetry, the model parameters from the region that best predicted the sighting and carcass data was applied to the region.

Model predictions do not consider access limitations nor previously mapped offshore seagrass bed locations. Maps of these beds, generally generated by aerial photography, often with some in-water validation, are not complete for the Gulf Coast, and where they are available, often do not contain species listings nor differentiate among true seagrass, other vascular plans, or macroalgae.

3.5 Regional manatee locations

3.5.1.1 Brownsville

The Brownsville region in Texas is dominated by the southern part of the Laguna Madre Lagoon, a shallow, hypersaline estuary that is contained by Padre Island to seaward (Figure 22 through 24). The lagoon has supported a diverse collection of seagrass meadows, dominated in turns by *Halodule wrightii*, *Syringodium filiforme* and *Thalassia testudinum*, with the latter species increasing during times with overall higher salinity (Quammen and Onuf 1993). It is fed by several creeks and rivers, with the most freshwater flow coming from the Arroyo Colorado (Texas Water Development Board 2020).

The earliest manatee record from the Brownsville region was a carcass retrieved in 1853 (Gunter 1941). Live animals and carcasses have continued to be recorded every few years, mostly near Padre Island, at the southern end of Laguna Madre, or near Arroyo Colorado (Figure 26). It is possible some of the manatees sighted in this region are from the Mexican population of Antillean manatees in the Yucatan (Puc-Carrasco et al. 2017).

The predicted manatee habitat for the Brownsville region was concentrated in the shallow wetland areas of Laguna Madre near Arroyo Colorado, Padre Island across from Arroyo Colorado and the southern end of the lagoon (Figure 27). These locations matched the historical manatee sightings (Figure 26) fairly well.

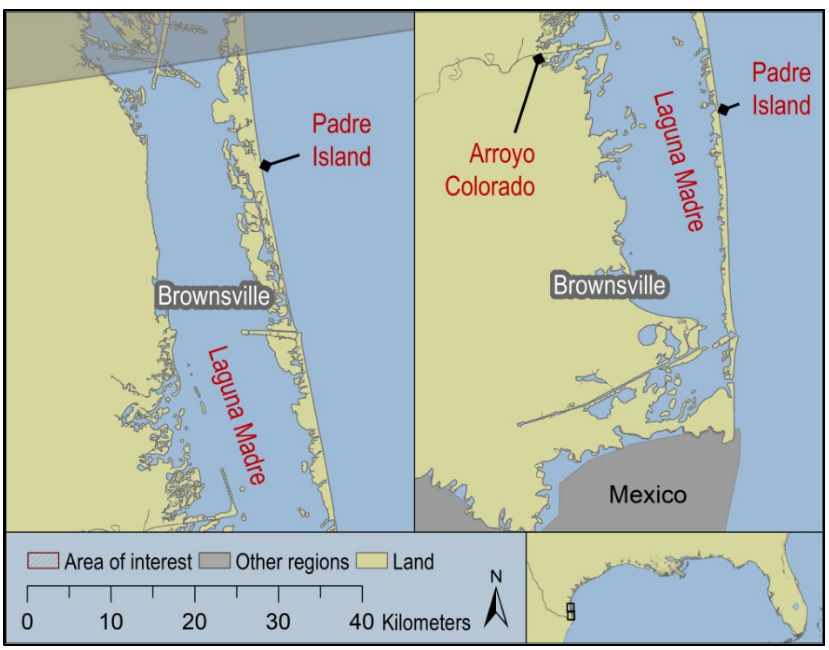

Figure 22. The Brownsville region in Texas encompassed the southern Laguna Madre Lagoon and its tributaries.

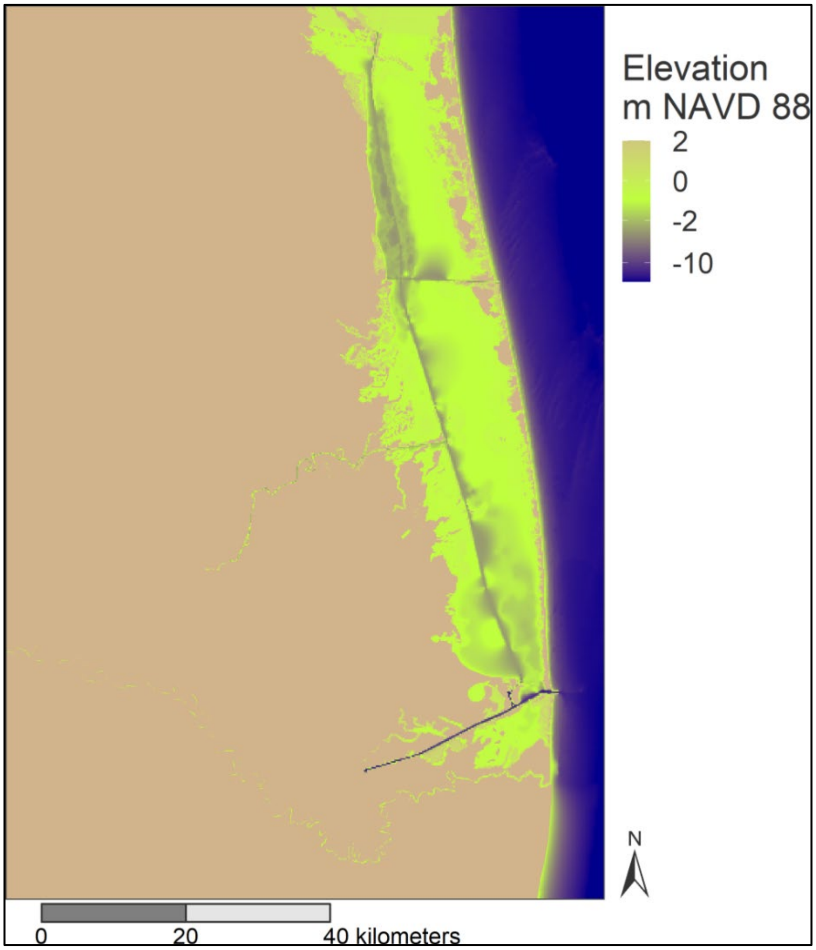

Figure 23. Digital elevation model of the Brownsville region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

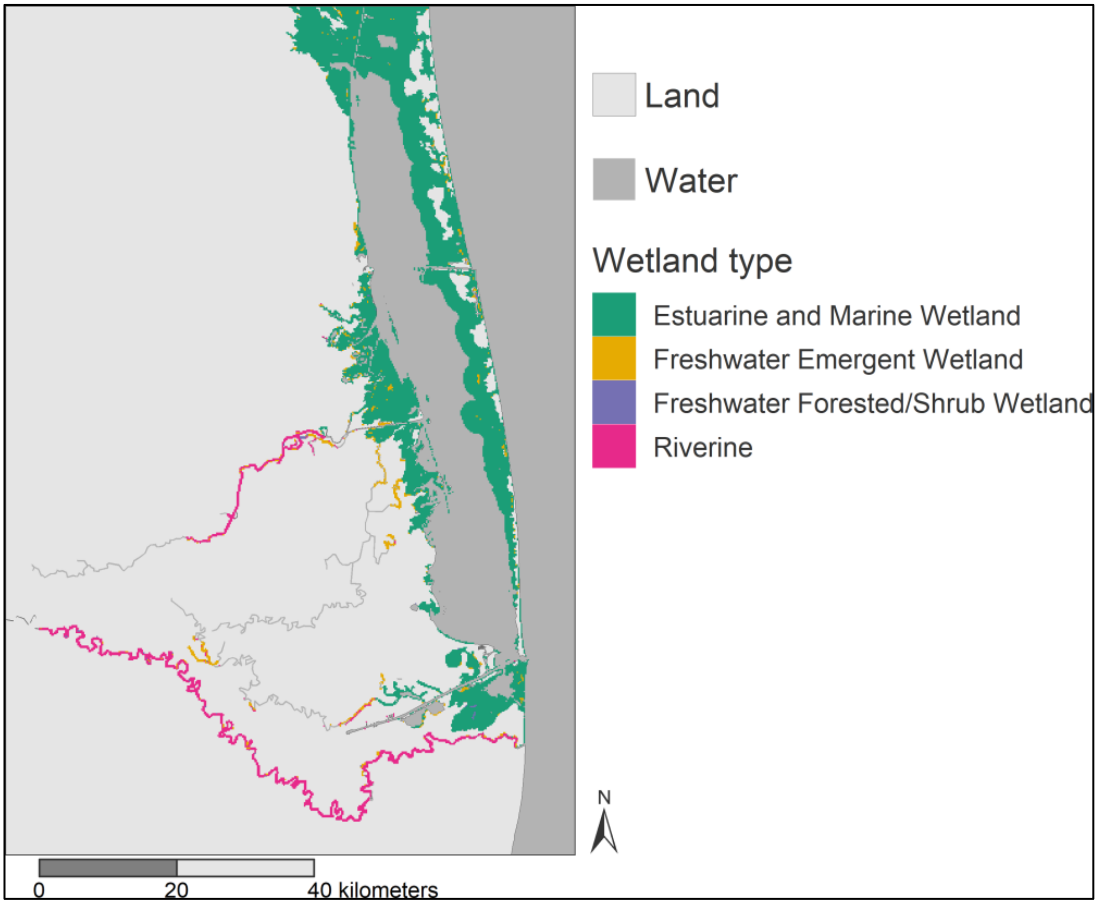

Figure 24. Wetland types and locations within the Brownsville region.

Modified from US Fish and Wildlife Service (2016).

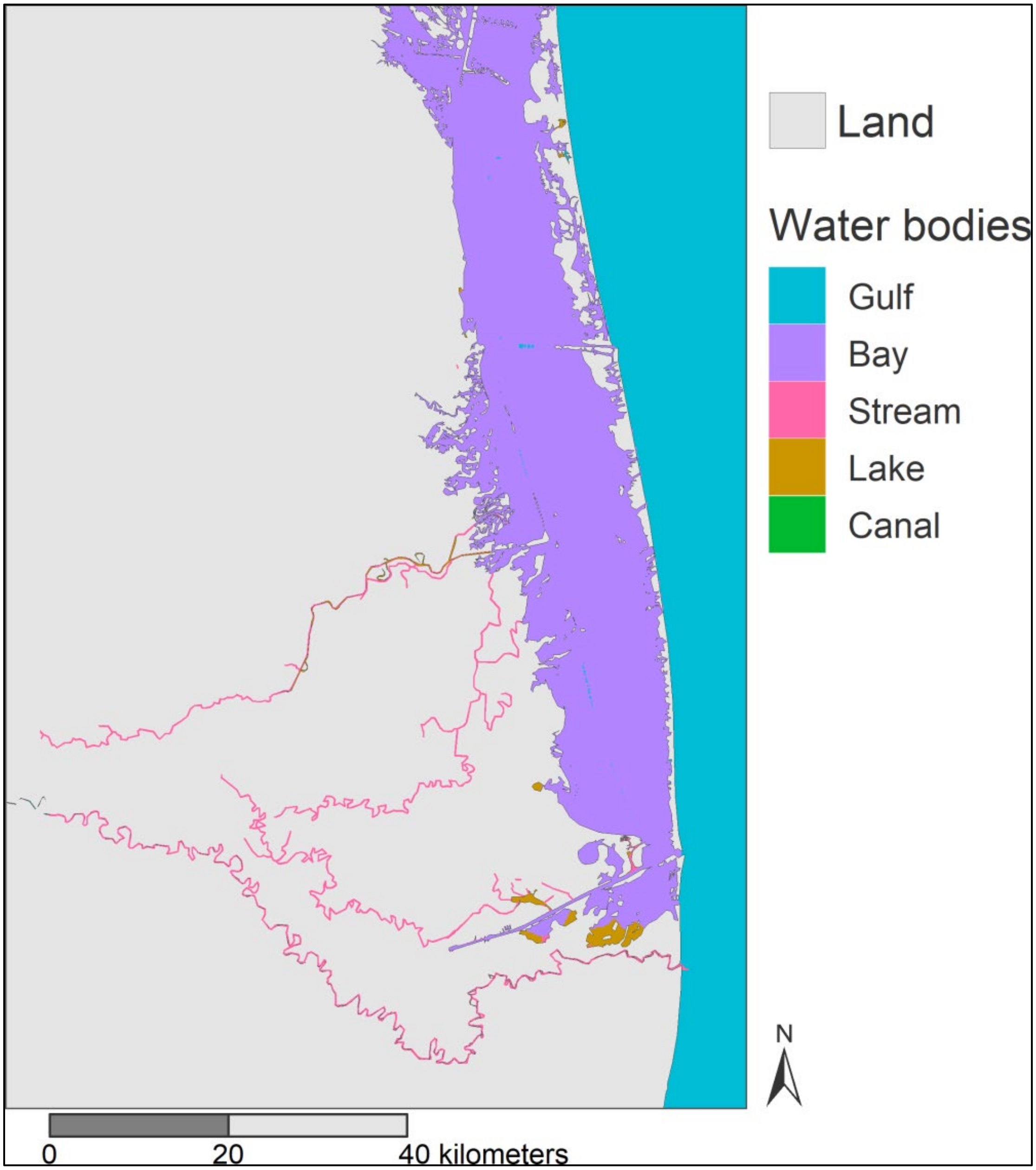

Figure 25. Water bodies of the Brownsville region.

Modified from Tele Atlas North America, Inc. (2010).

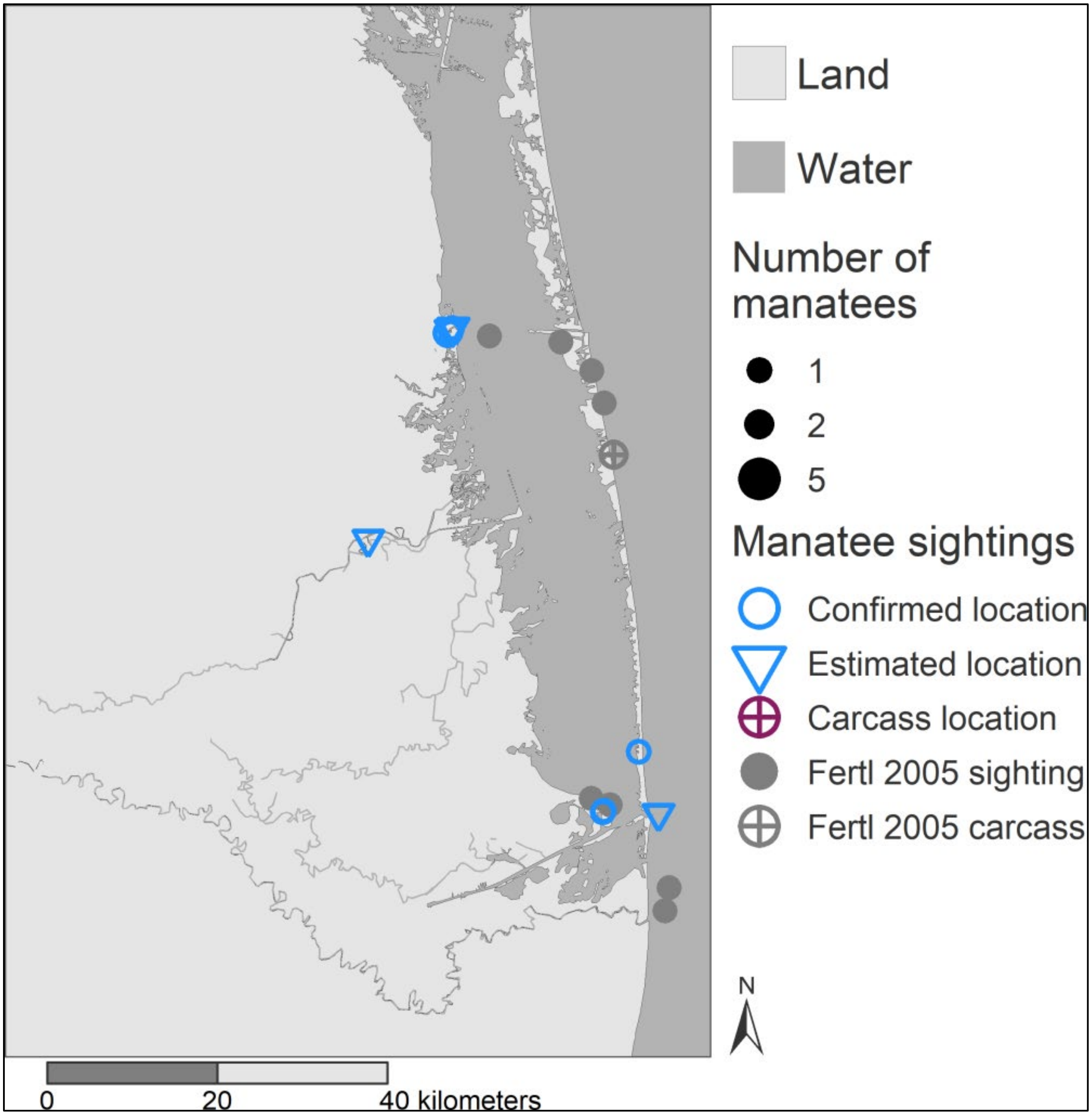

Figure 26. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; darker gray points were previously published in Fertl et al (2005).

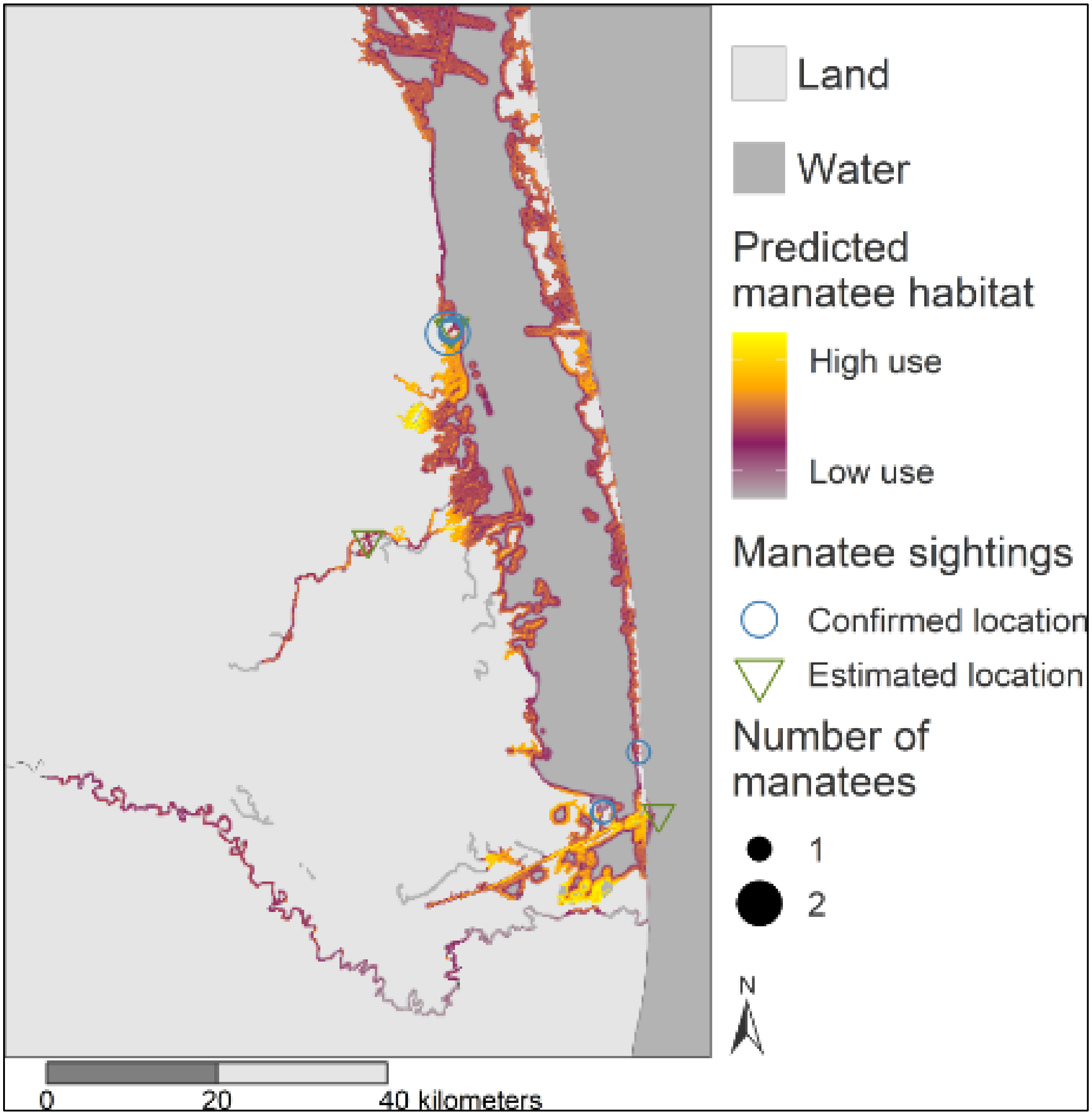

Figure 27. Habitat use prediction for the Brownsville region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are darker gray.

3.5.1.2 Corpus Christi

The Corpus Christi region in Texas includes the northern part of the Laguna Madre Lagoon, including Baffin Bay, and Corpus Christi Bay (Figure 28 through Figure 29). These bays maintains marine salinity despite freshwater input from the Nueces River that feeds into Corpus Christi Bay (National Centers for Environmental Information 2012). Benthic vegetation are limited to saltmarsh, including *Spartina sp.* (Stachelek and Dunton 2013) marine or brackish seagrass species, including *Halodule wrightii* and *Thalassia testudinum*, with a low abundance of *Syringodium filiforme*, *Ruppia maritima*, and *Halophila engelmannii* (Wilson and Dunton 2012).

Manatee sightings in this region are limited to Corpus Christi Bay and nearby parts of Laguna Madre (Figure 28 through Figure 32). They are sighted almost every year, but still remain a noteworthy event (Rice 2012 Oct 5; Ren 2019 Aug 23). Recent sightings collected for this study match the spatial distribution of earlier sightings collected by Fertl et al. (2005), namely along the shoreline of Corpus Christi Bay, the nearby Laguna Madre, and Aransas Inlet. The Bay is deep, while the nearby lagoon is shallow (Figure 29), so feeding on fringing *Spartina sp.* in the bay is one possible attraction to the area, compared to the Laguna Madre south of Baffin Bay which has a large area of marine wetlands (Figure 30), but the uniformly shallow bathymetry offers no deep water escape.

Predicted manatee habitat in the Corpus Christi region was found in the shallow fringes of Corpus Christi Bay and the waters of Laguna Madre that are nearby (Figure 33). This matches well with historic sightings (Figure 32). The model also predicted habitat along the shore of Baffin Bay and the shores of Laguna Madre to the south. These are areas that contain wetland habitat and forage species, but no manatees have been recorded there.

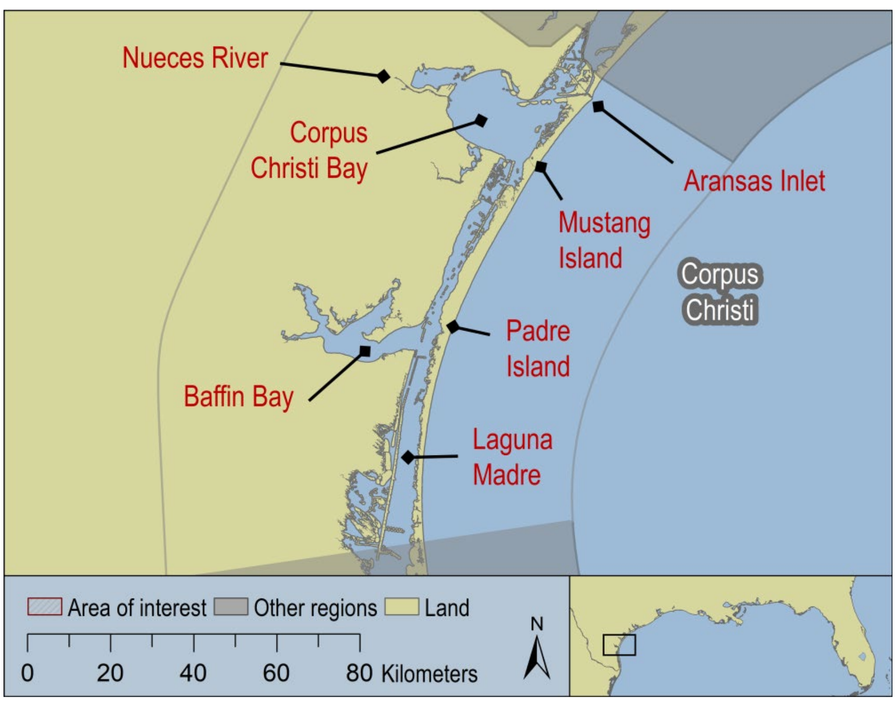

Figure 28. The Corpus Christi region in Texas covers the northern Laguna Madre Lagoon to the Aransas Inlet, and includes two bay systems with their tributaries.

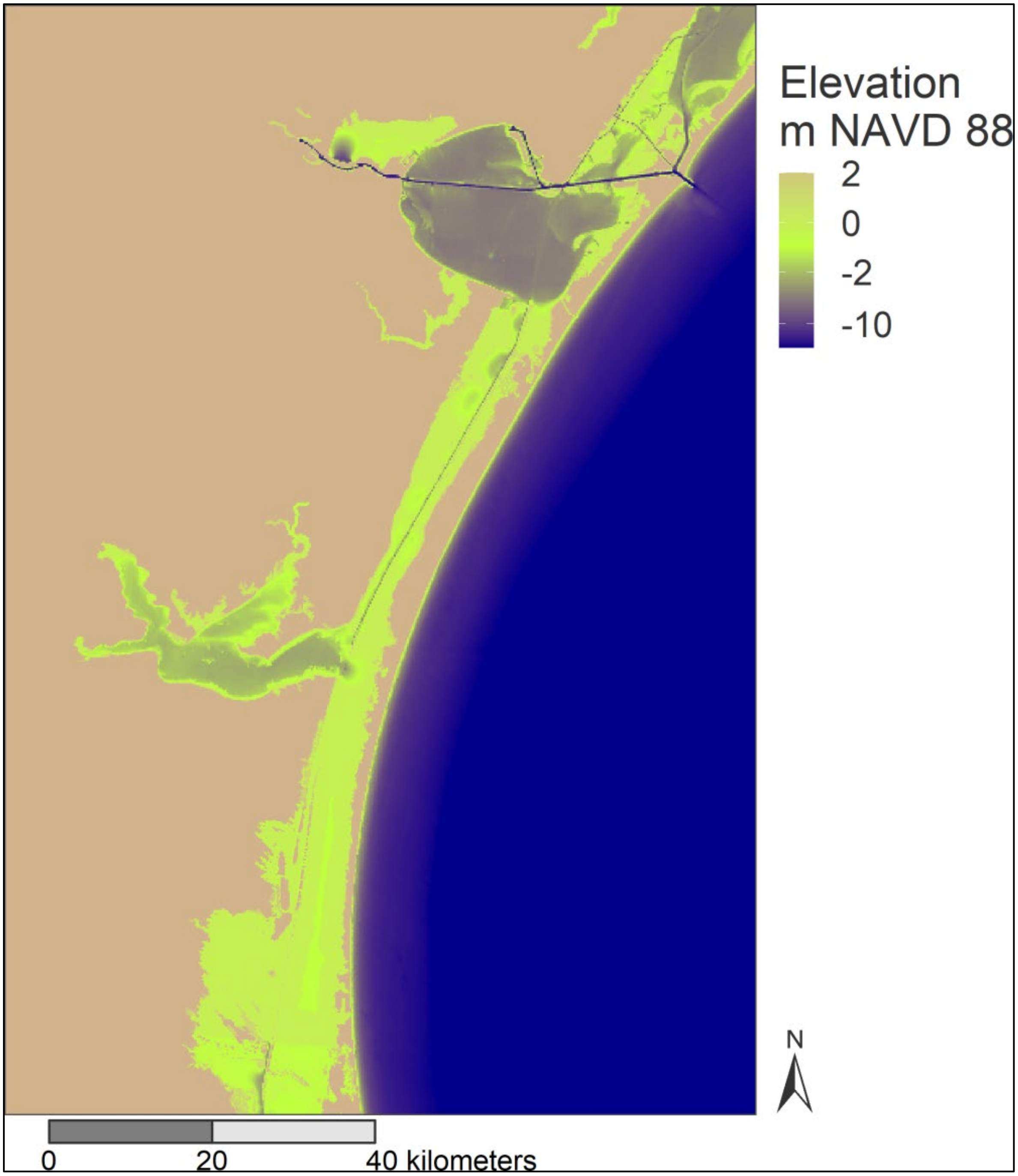

Figure 29. Digital elevation model of the Corpus Christi region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (violet-dark blue).

Data compiled from NOAA sources; see text for details.

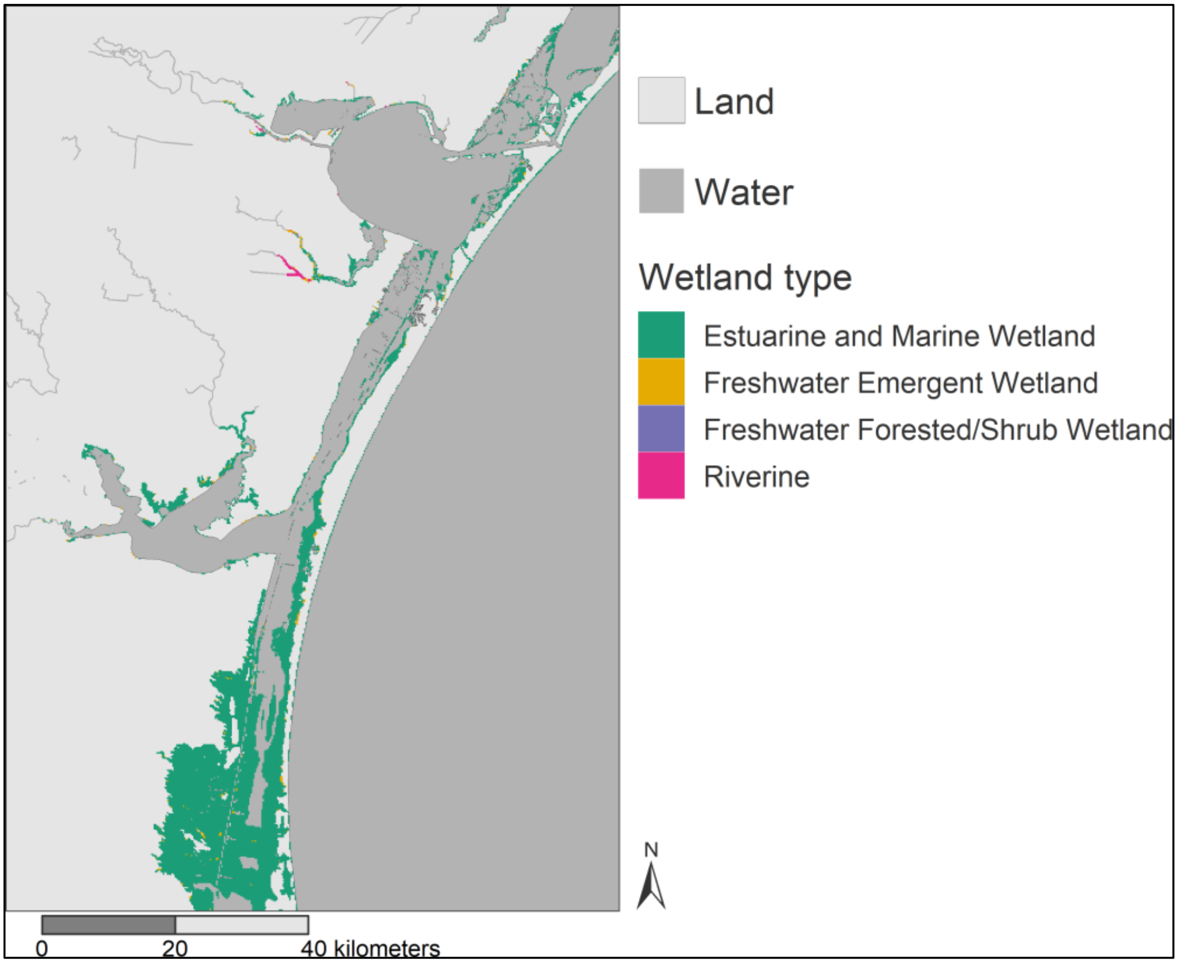

Figure 30. Wetland types and locations within the Corpus Christi region.

Modified from US Fish and Wildlife Service (2016).

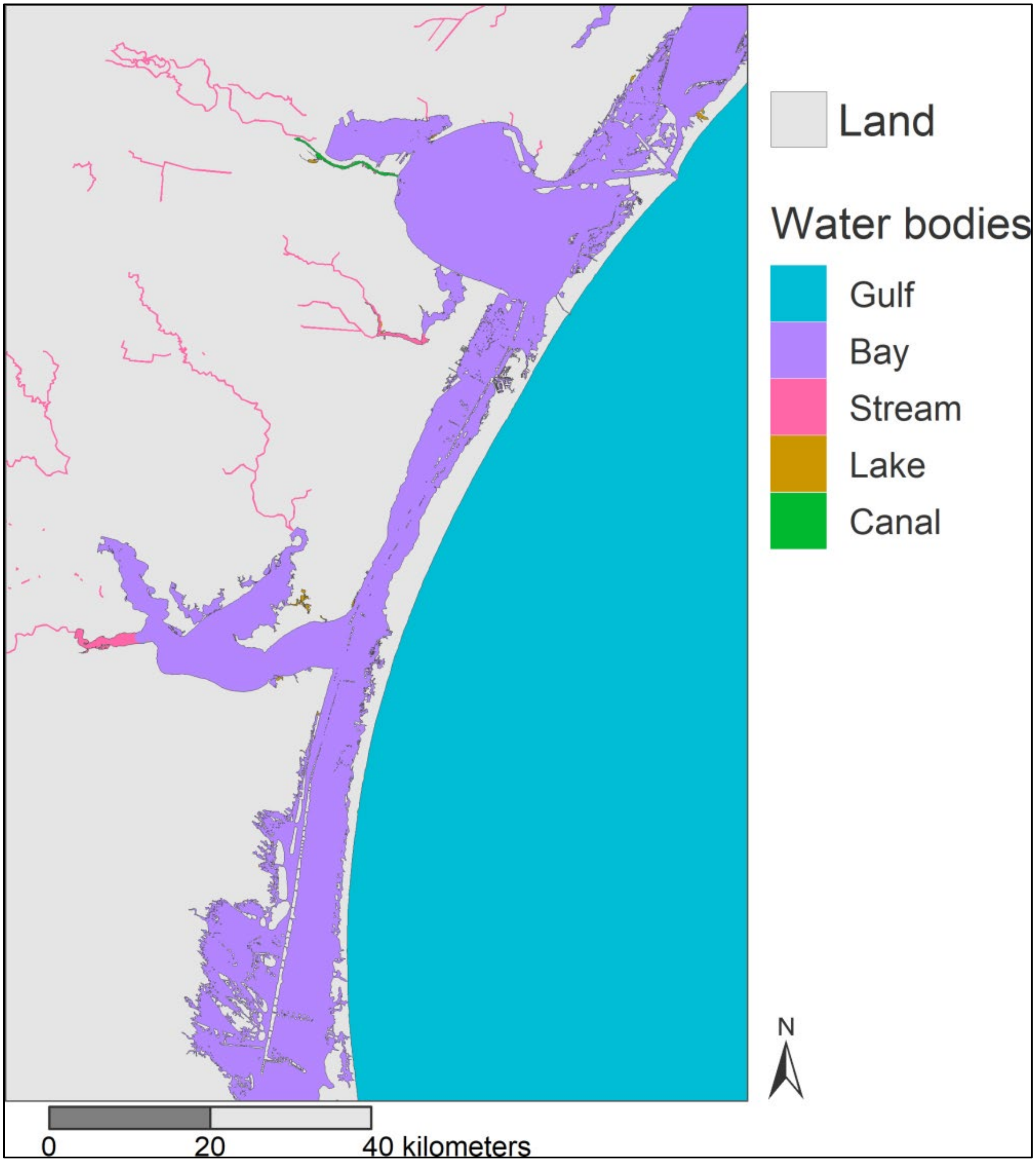

Figure 31. Water bodies of the Corpus Christi region.

Modified from Tele Atlas North America, Inc. (2010).

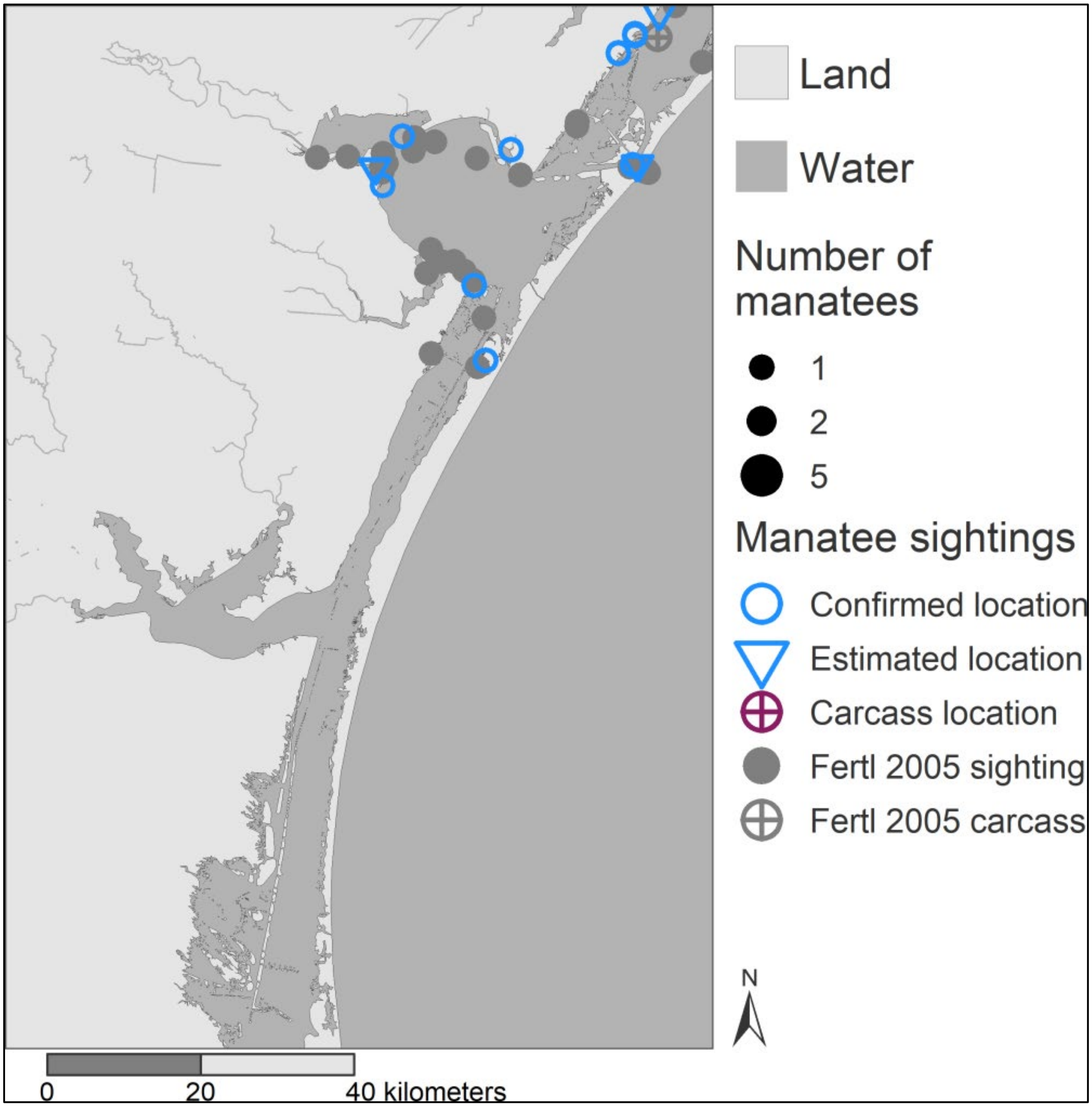

Figure 32. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the Corpus Christie region.

Colored points were collected for this study; gray points were previously published in Fertl et al. (2005).

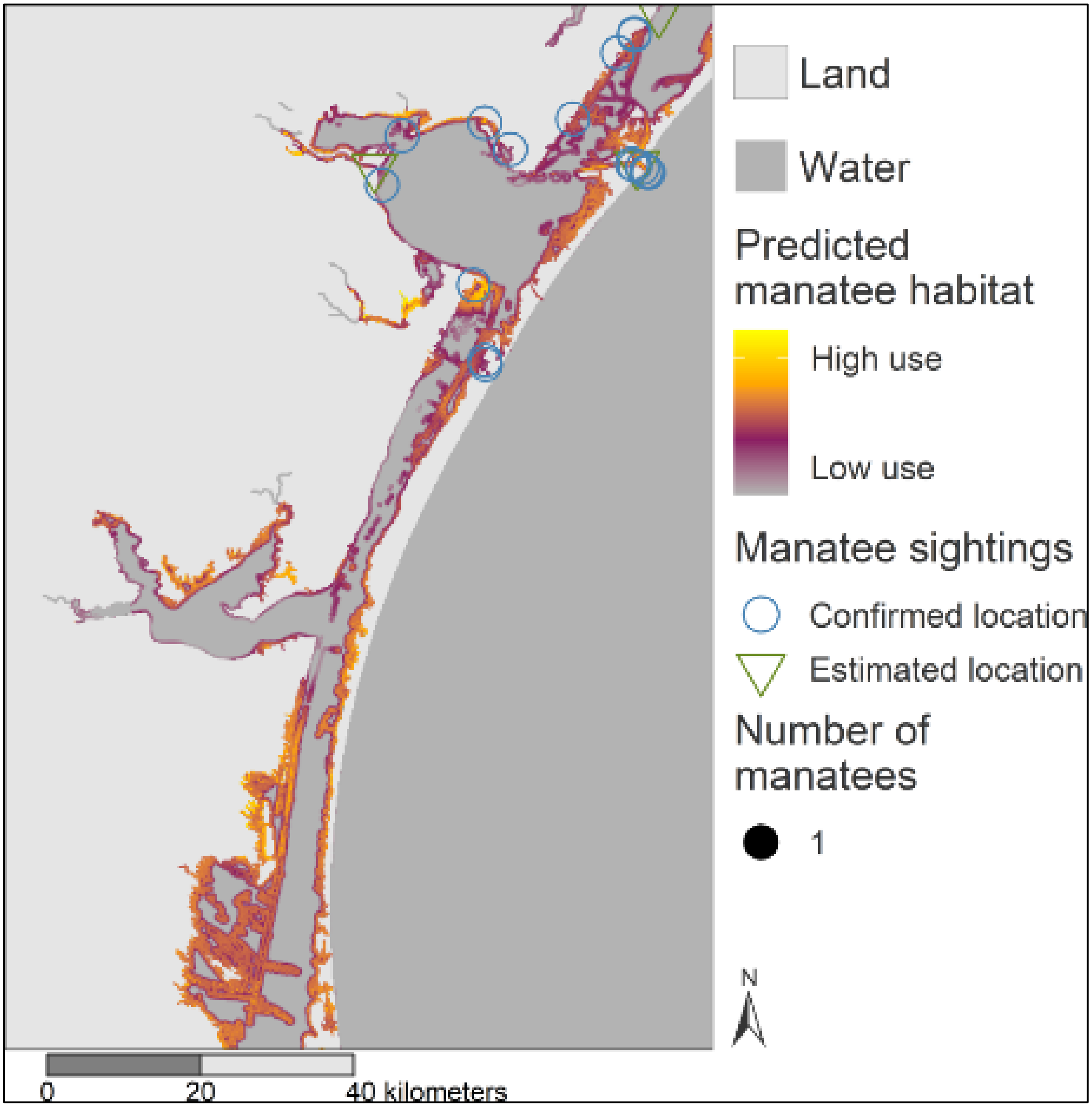

Figure 33. Habitat use prediction for the Corpus Christi region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are darker gray.

3.5.1.3 Rockport

The Rockport region (Figure 34 through 35) features estuaries with the lowest salinity along the Texas coast, with the exception of Galveston Bay. While Aransas Bay salinity remains above 15 ppt all year, the upper reaches of Copano Bay, which is fed by the Aransas River, can become brackish in the 5–15 ppt range (National Centers for Environmental Information 2012). The upper reaches of San Antonio Bay, where it is fed by the Guadalupe River, remain fresh or brackish all year. While San Antonio Bay and Espiritu Santo Bay are dominated by *Halodule wrightii* with *Ruppia maritima* and *Halophila engelmannii* (Hobson and Whisenant 2018), the oligohaline upper reaches that are influenced by the Guadalupe River are dominated by herbaceous freshwater vegetation, and the tidal mixing zone dominated by rushes, grasses, and herbaceous species that tolerate a wide range of salinity (Sullivan et al. 2020).

A manatee carcass was retrieved from Copano Bay in 1928 (Gunter 1941), and modern manatee sightings from this region are limited to the same bay and the nearby Aransas Bay (Figure 38). These water bodies are closely connected to the observed manatee use areas from the Corpus Christi region, and it is likely that visiting manatees freely traverse from Corpus Christi Bay to Aransas Bay. Similar to sightings in other regions in Texas, manatee sightings are often reported in the news, whether in summer as a curiosity (Port Aransas South Jetty Staff 2013 Jul 11), or in deep winter when it is in mortal danger from cold stress (Mays 2011 Jan 18). These news reports were an additional reliable source for manatee sightings when direct public reports to management or research agencies were scarce.

Predicted manatee habitat in the Rockport region was strongly concentrated in the braided rivers north of San Antonio Bay, the north shore of Espiritu Santo Bay, and the north shore of Laguna Madre between Aransas Bay and Espiritu Santo Bay (Figure 39). These are all areas with wetland vegetation, including freshwater wetland north of San Antonio Bay (Figure 36), but no manatees have been sighted using those locations.

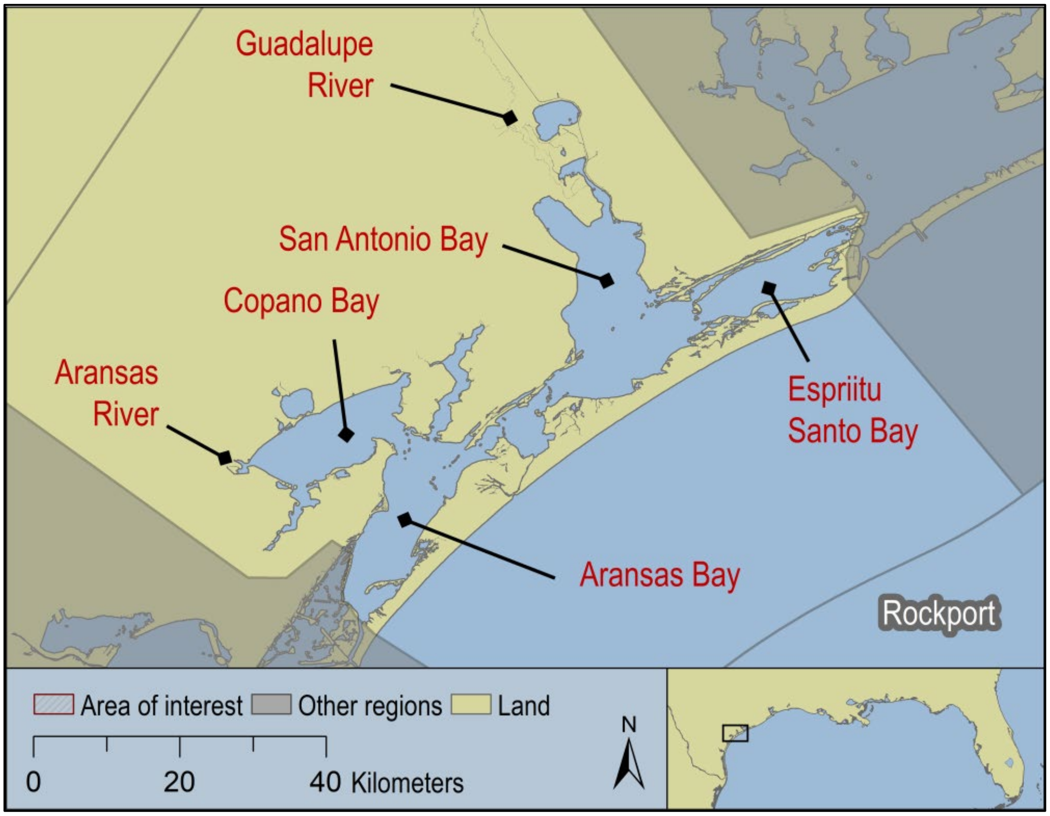

Figure 34. The Rockport region in Texas contains two coastal bays and two inland bays with their tributaries.

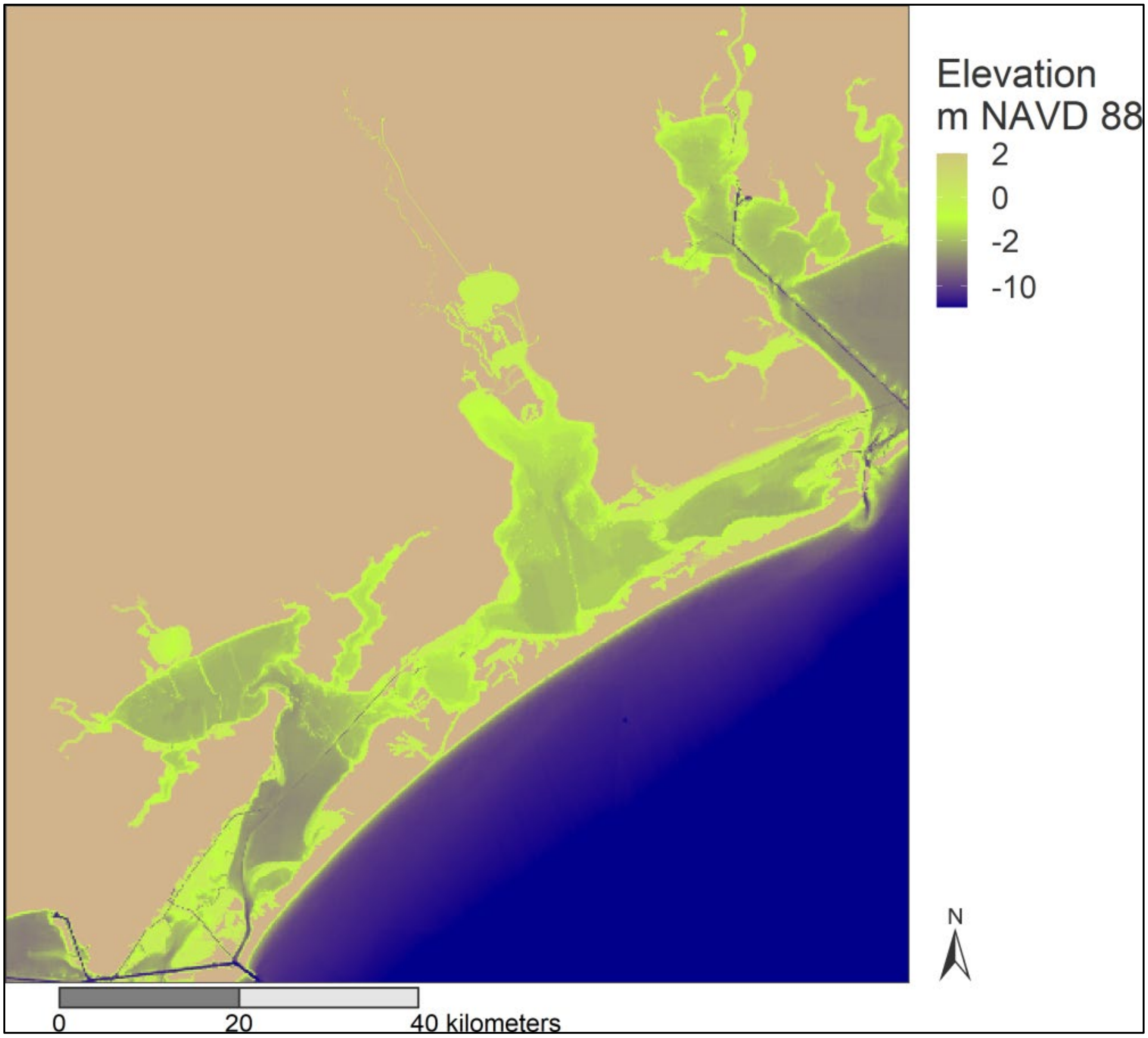

Figure 35. Digital elevation model of the Rockport region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

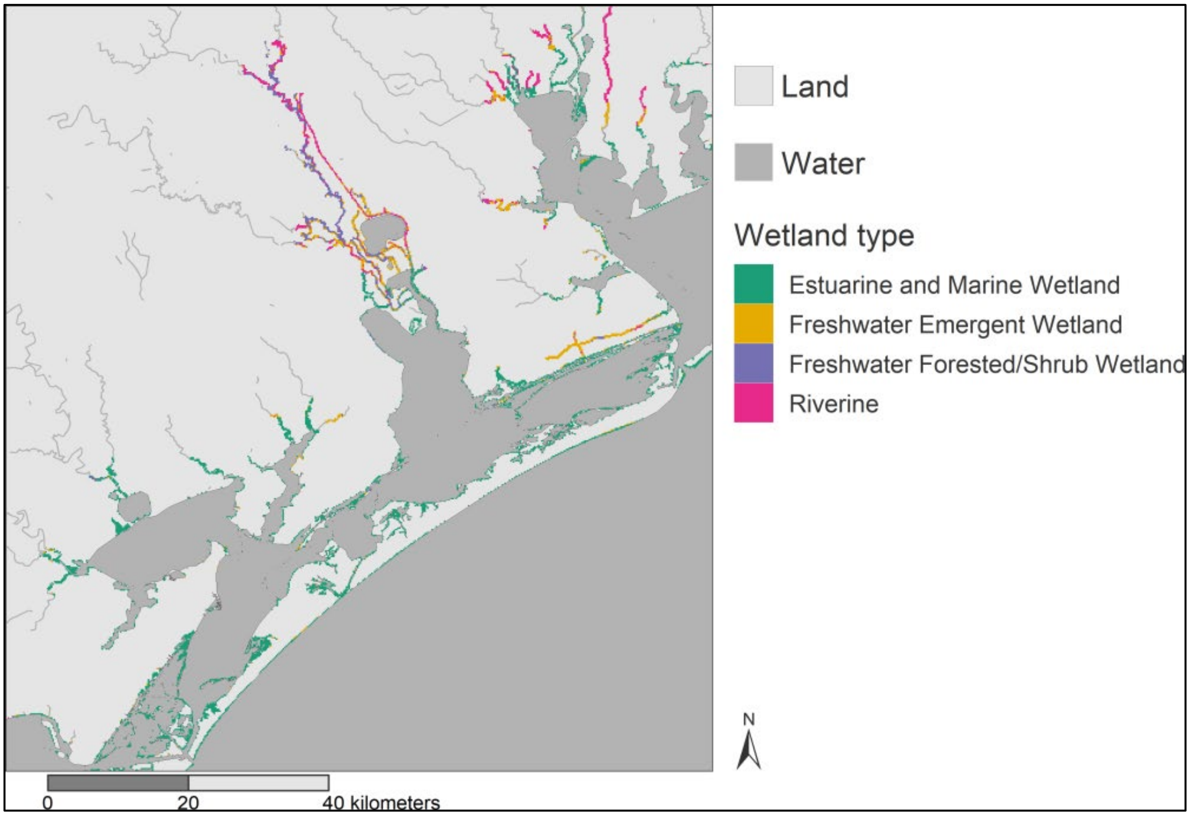

Figure 36. Wetland types and locations within the Rockport region.

Modified from US Fish and Wildlife Service (2016).

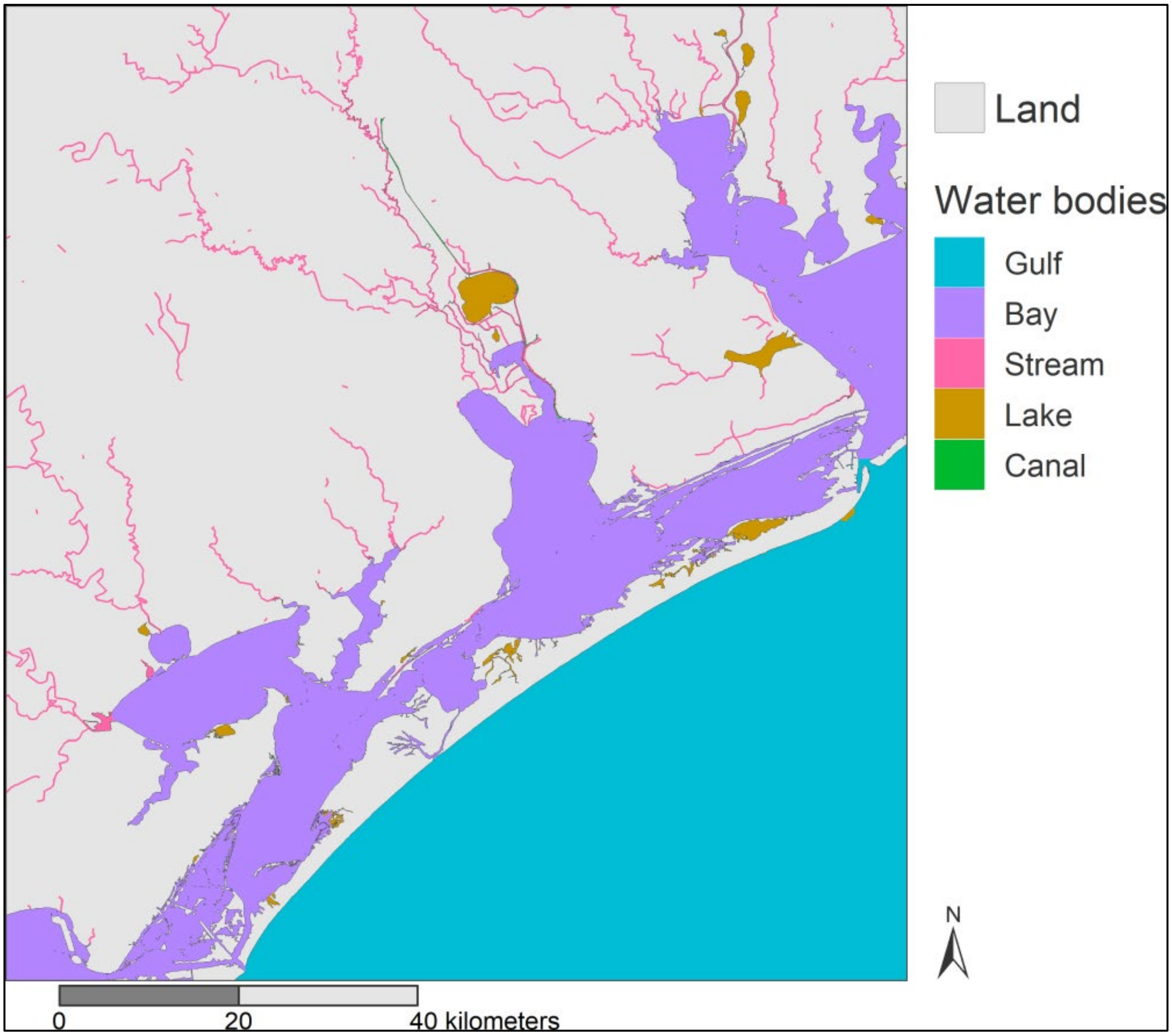

Figure 37. Water bodies of the Rockport region.

Modified from Tele Atlas North America, Inc. (2010).

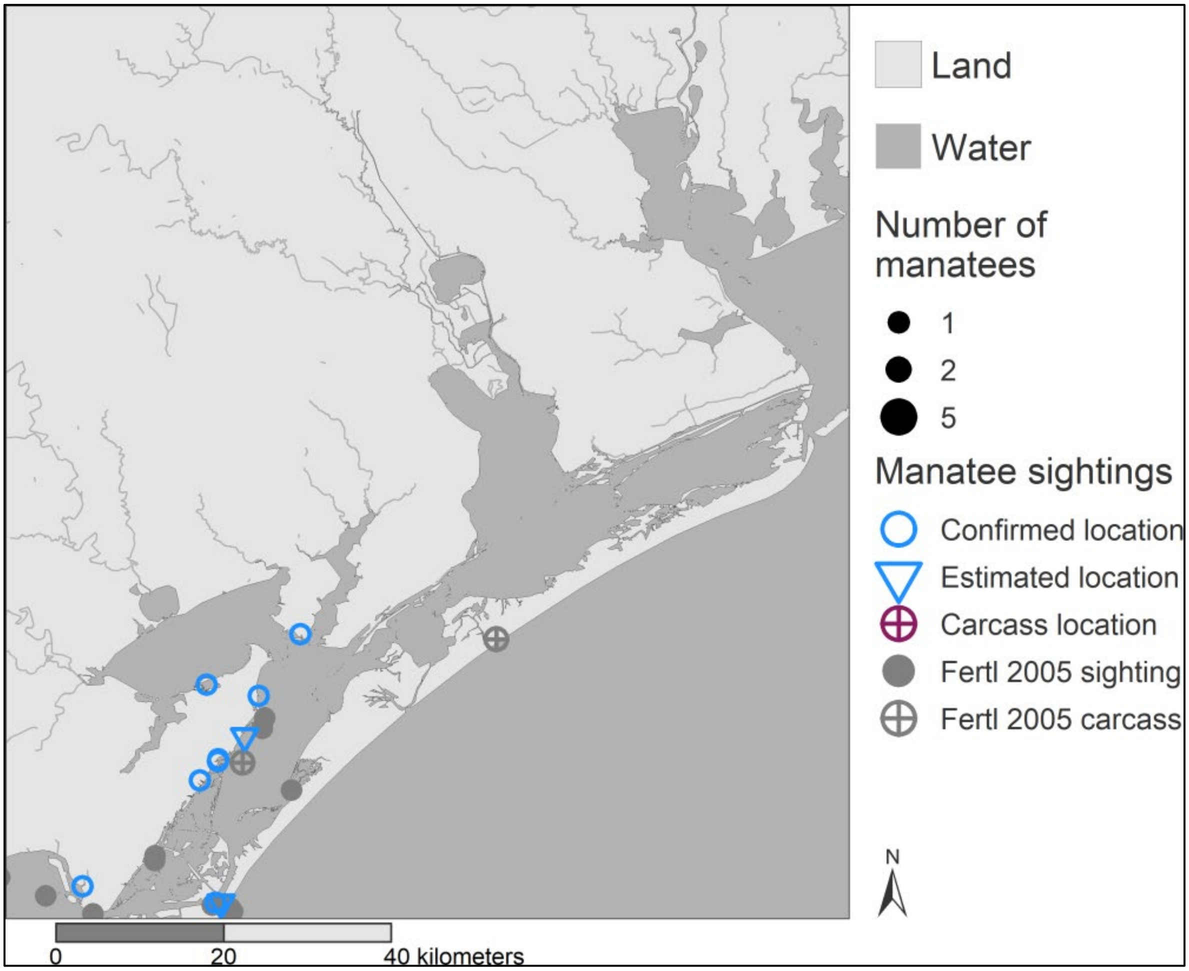

Figure 38. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; gray points were previously published in Fertl et al. (2005).

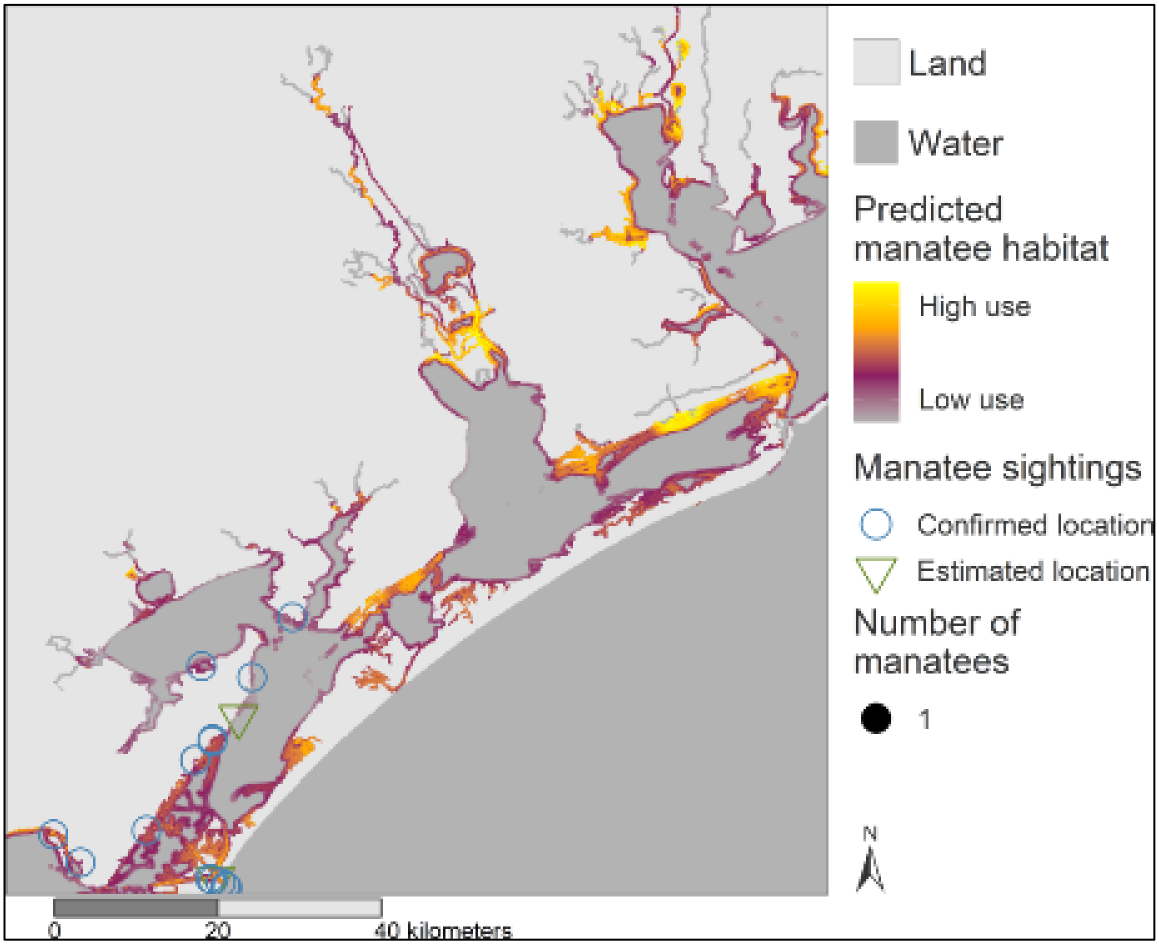

Figure 39. Habitat use prediction for the Rockport region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are darker gray.

3.5.1.4 Victoria

The Victoria region contains Matagorda Bay, which is fed on the west side by the Lavaca River, and subdivided on the east side by the Colorado River (Figure 40 through Figure 43). Matagorda Bay, similar to other bays along the Texas coast, remains polyhaline at greater than 15 ppt salinity all year. The upper reaches of the bay, which is fed by several streams and rivers, can drop below 15 ppt during the wet season. The area with the largest inflow of freshwater is Lavaca Bay, where the Lavaca River flows (National Centers for Environmental Information 2012). Submerged aquatic vegetation is dominated by *Halodule wrightii*, and *Ruppia maritima* with a low occurrence of *Halophila engelmannii* (Adair et al. 2009).

There have been very few manatee sightings in the Victoria region. Carcass recoveries have been more common, especially in or near East Matagorda Bay (Figure 44). This is a more rural area of the coast compared to Corpus Christi to the southwest or Houston the east, thus the lack of sightings and relative abundance of carcasses may be due to less opportunity for people to see an elusive live manatee swimming in the area.

Predicted manatee habitat was located in the upper reaches of Lavaca Bay, the east shore of Matagorda Bay, and to a lesser extent the estuaries feeding into each of the embayments in the region (Figure 45).

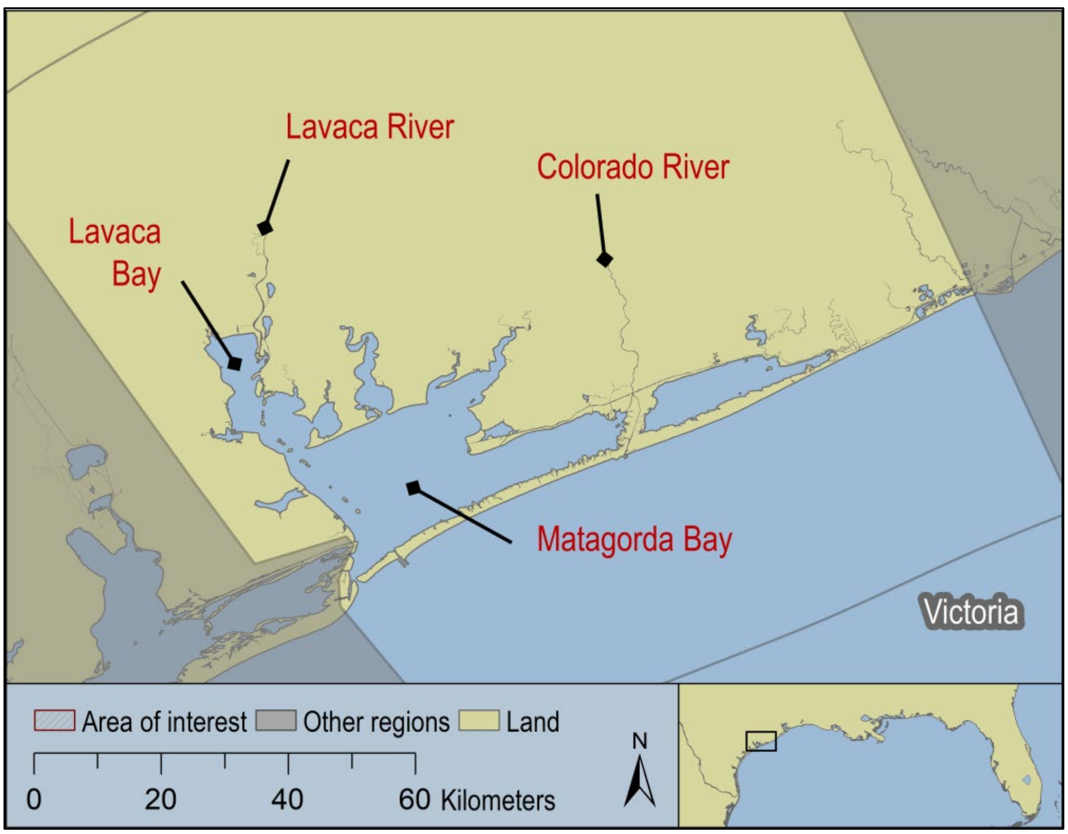

Figure 40. The Victoria region in Texas consists of Matagorda Bay and its tributaries.

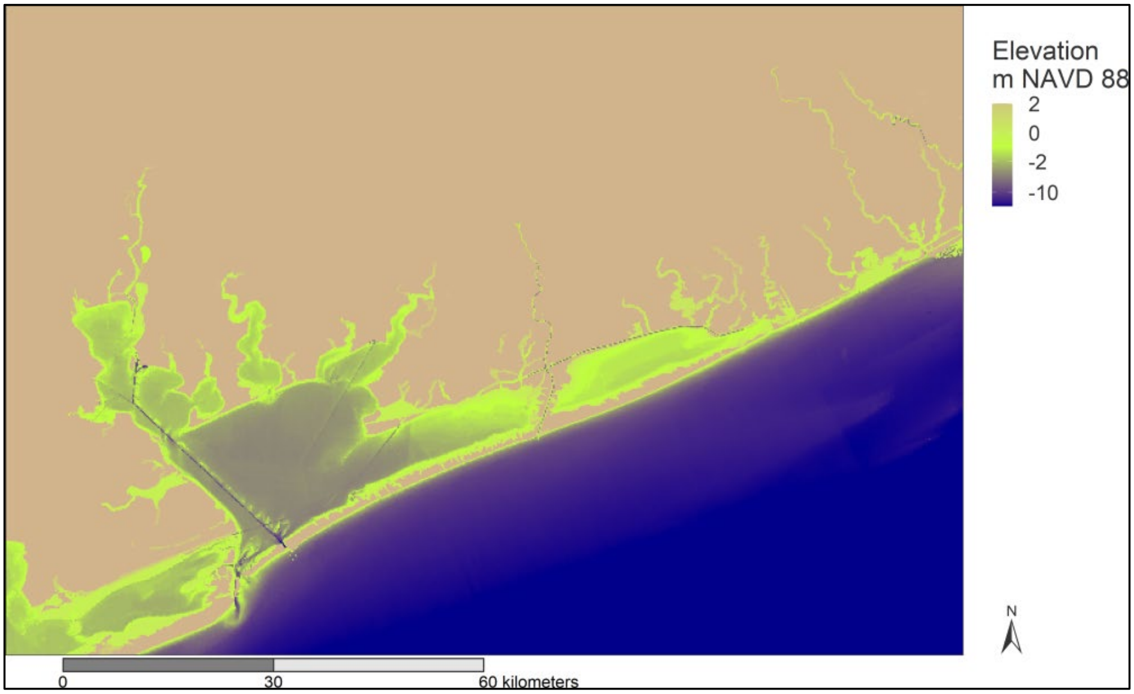

Figure 41. Digital elevation model of the Victoria region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

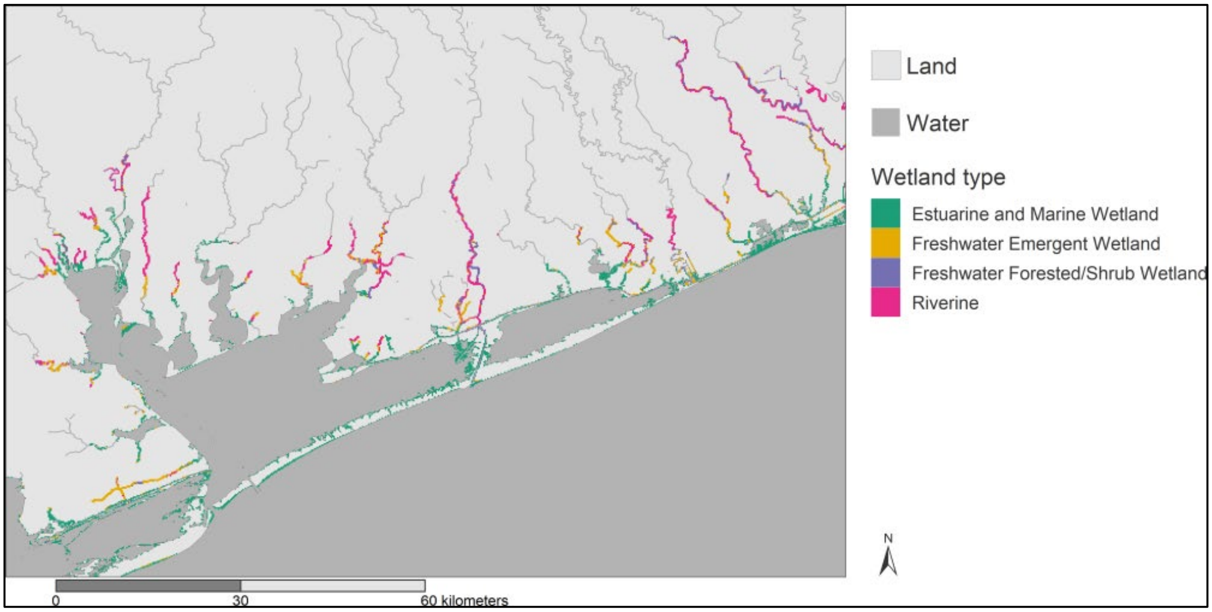

Figure 42. Wetland types and locations within the Victoria region.

Modified from US Fish and Wildlife Service (2016).

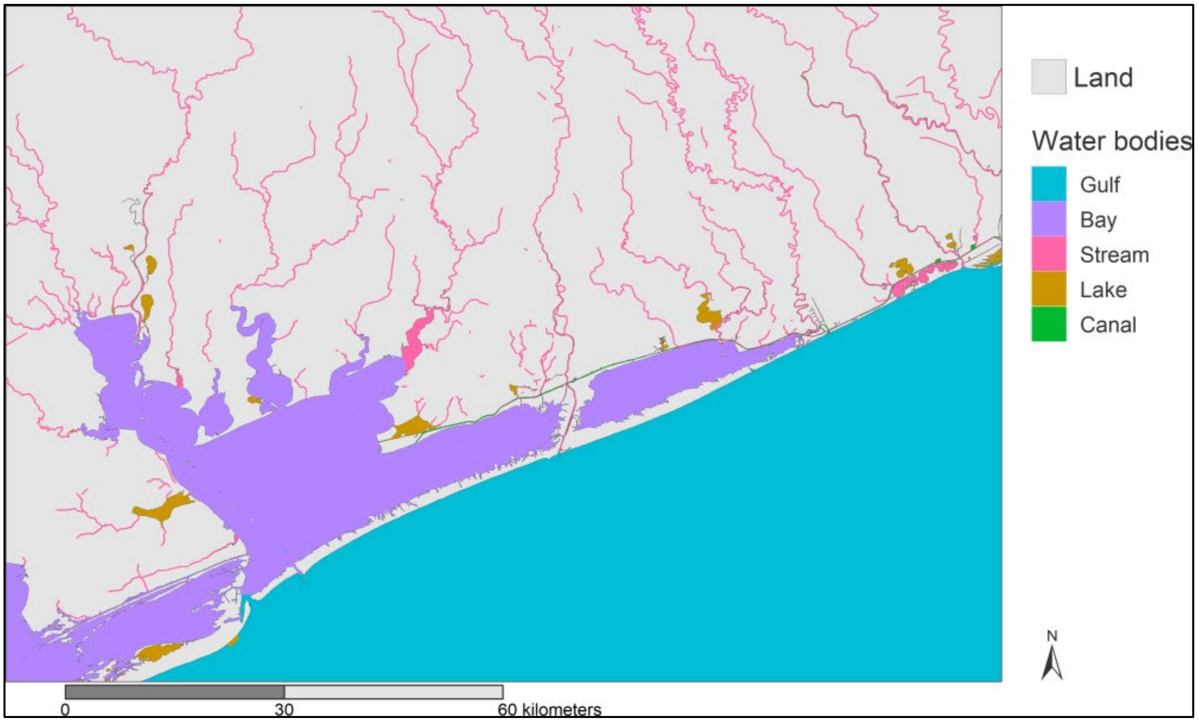

Figure 43. Water bodies of the Victoria region.

Modified from Tele Atlas North America, Inc. (2010).

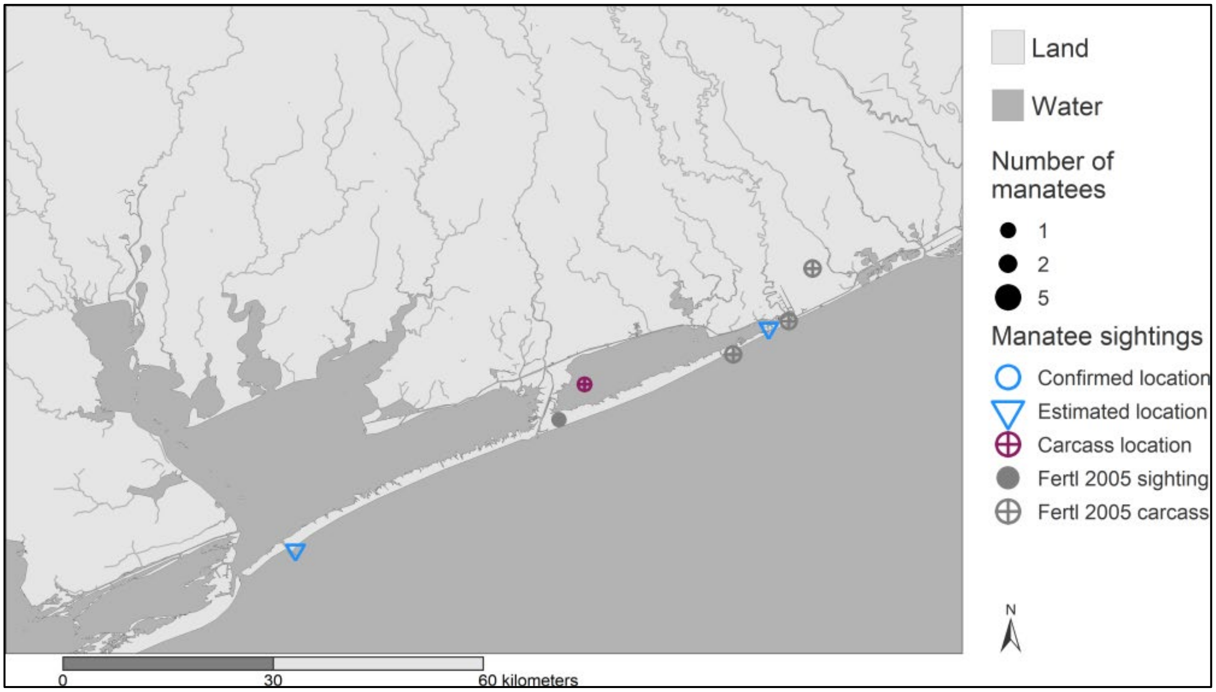

Figure 44. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; darker gray points were previously published in Fertl et al. (2005).

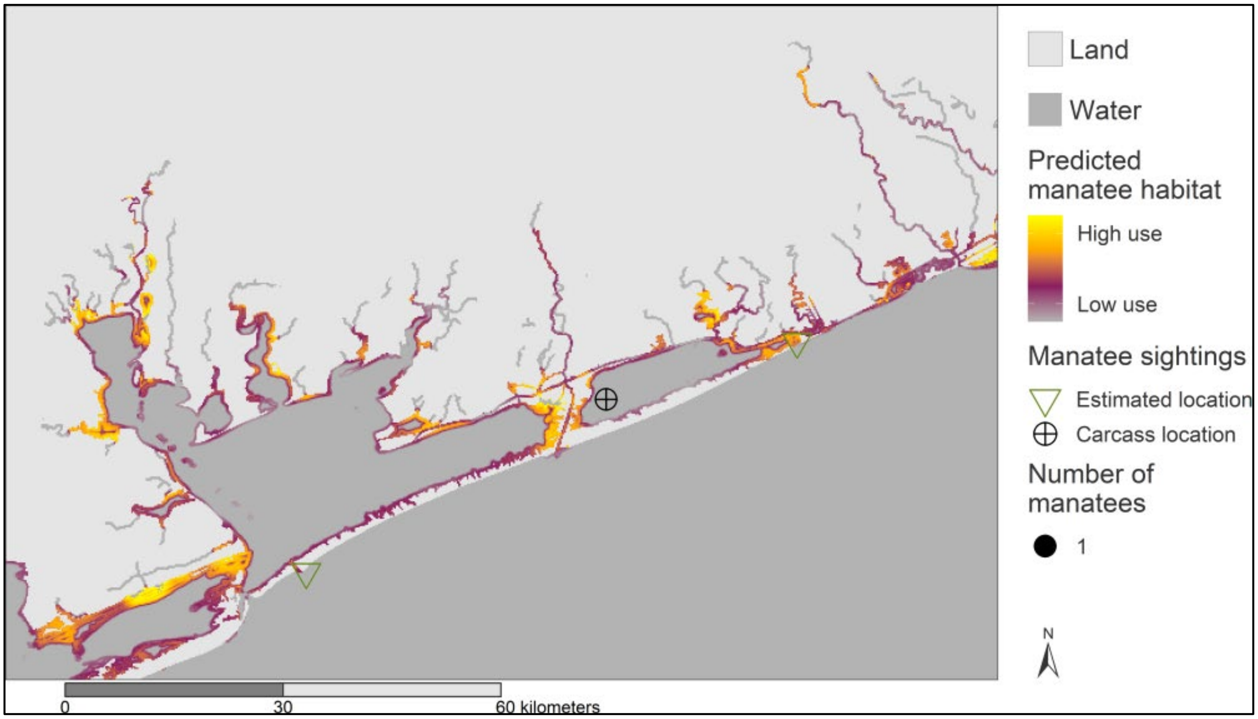

Figure 45. Habitat use prediction for the Victoria region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray.

3.5.1.5 Houston

The Houston region (Figure 46 through 47) has one of the most diverse bay systems in Texas, in terms of salinity regime and aquatic vegetation. The marine outer bays contain beds of *Halodule wrightii* and *Ruppia maritima* with a low occurrence of *Halophila engelmannii*. The upper, freshwater reaches of Trinity Bay support euryhaline and freshwater submerged vegetation, including *Ruppia maritima, Vallisneria americana*, and *Najas guadalupensis* (Adair et al. 2009).

Manatees have been sighted throughout the waterways of the Houston region in the last few decades, with only one carcass being found in the same time period (Figure 50). Most of the sightings were located in West Bay, which is part of the Intracoastal Waterway, and would likely be used by manatees traversing the area, but the shallow bay also contains a rich variety of habitats that are associated with manatee habitat (Figure 48). Sightings far inland of the Intracoastal Waterway were all associated with shallow coastal habitats, and likely represented local habitat use.

Predicted habitat in the Houston region was located in the estuaries of tributaries feeding West Bay and Galveston Bay, as well as the southern shoreline of East Bay (Figure 51). An especially strong prediction was made for the upper Trinity Bay, which is generally freshwater and supports a diverse assemblage of Submerged Aquatic Vegetation (SAV). Structurally, this area is similar to the east shore of Choctawhatchee Bay, Florida, which supports a significant regional population of manatees during spring, summer, and fall.

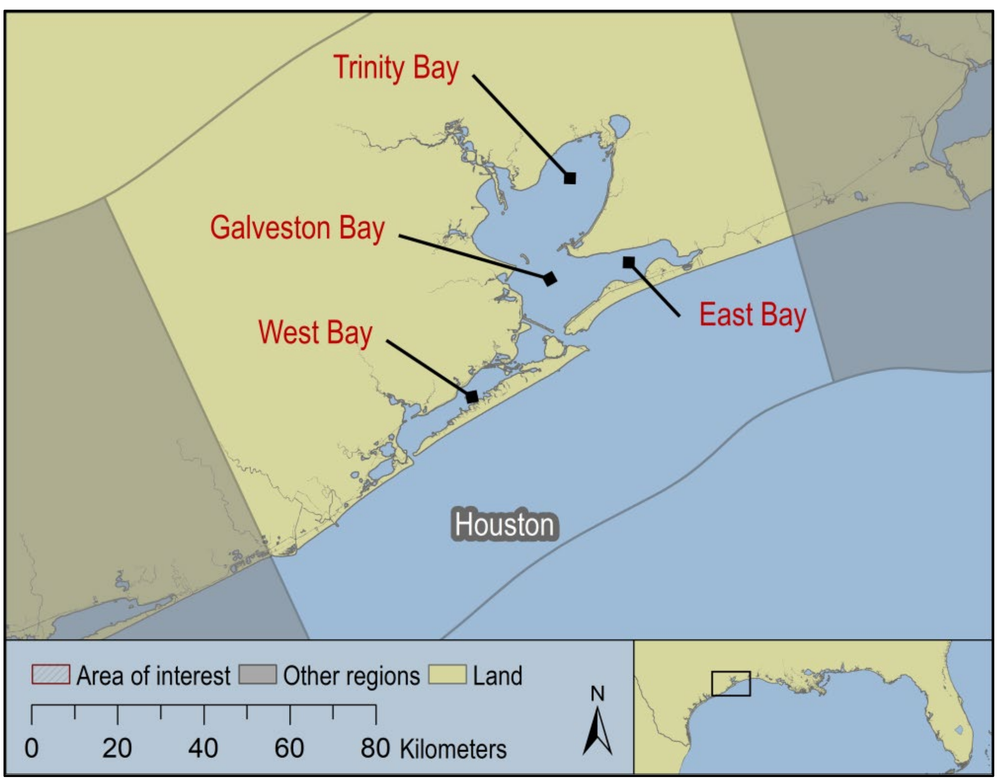

Figure 46. The Houston region in Texas covers Galveston Bay and the unique freshwater Trinity Bay.

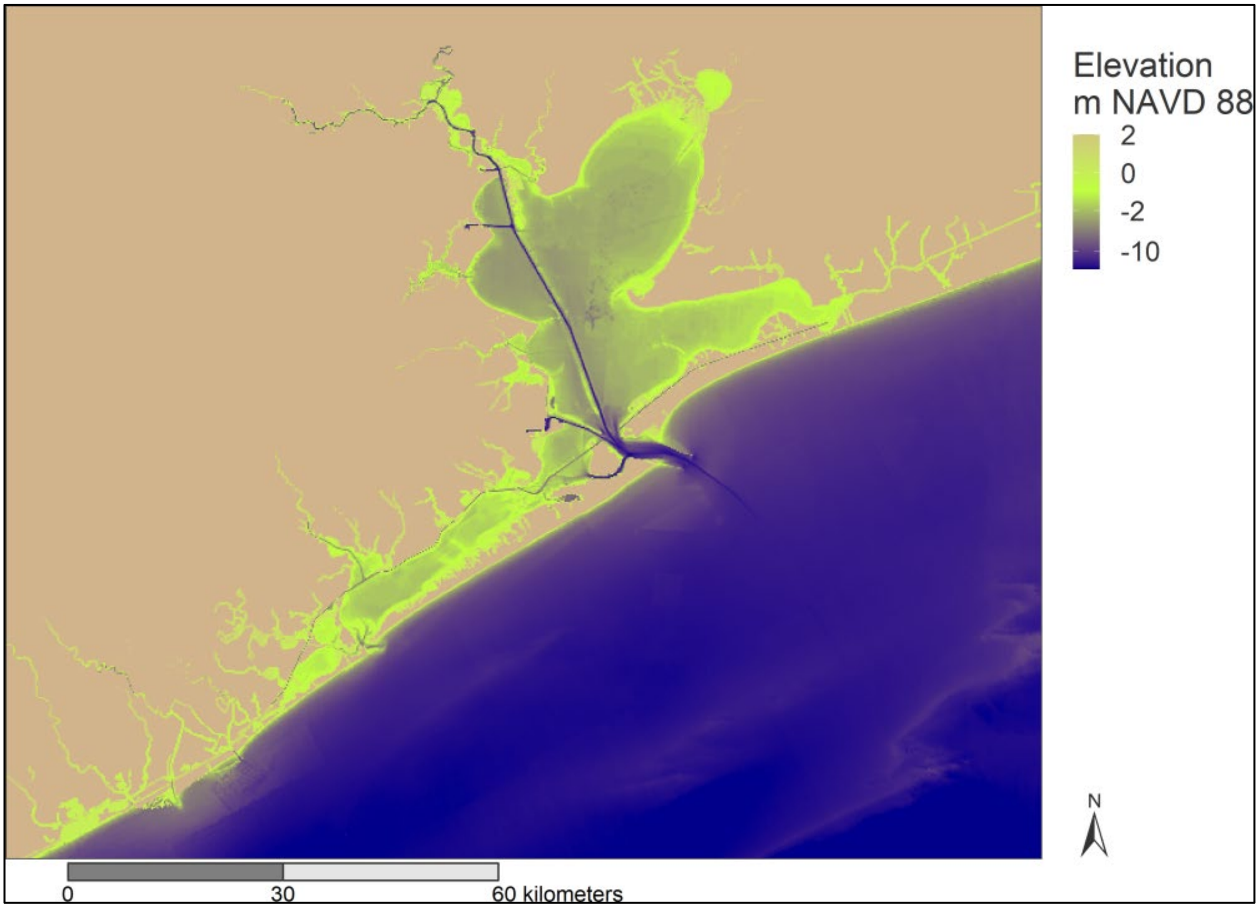

Figure 47. Digital elevation model of the Houston region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

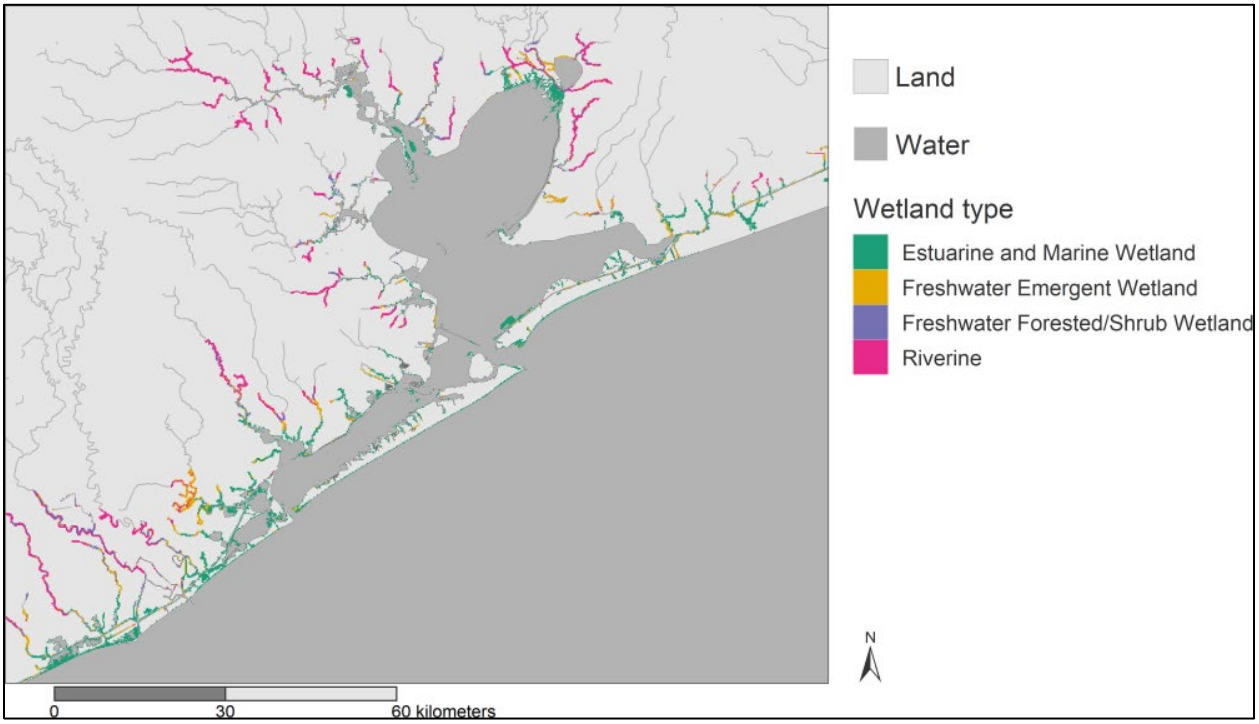

Figure 48. Wetland types and locations within the Houston region.

Modified from US Fish and Wildlife Service (2016).

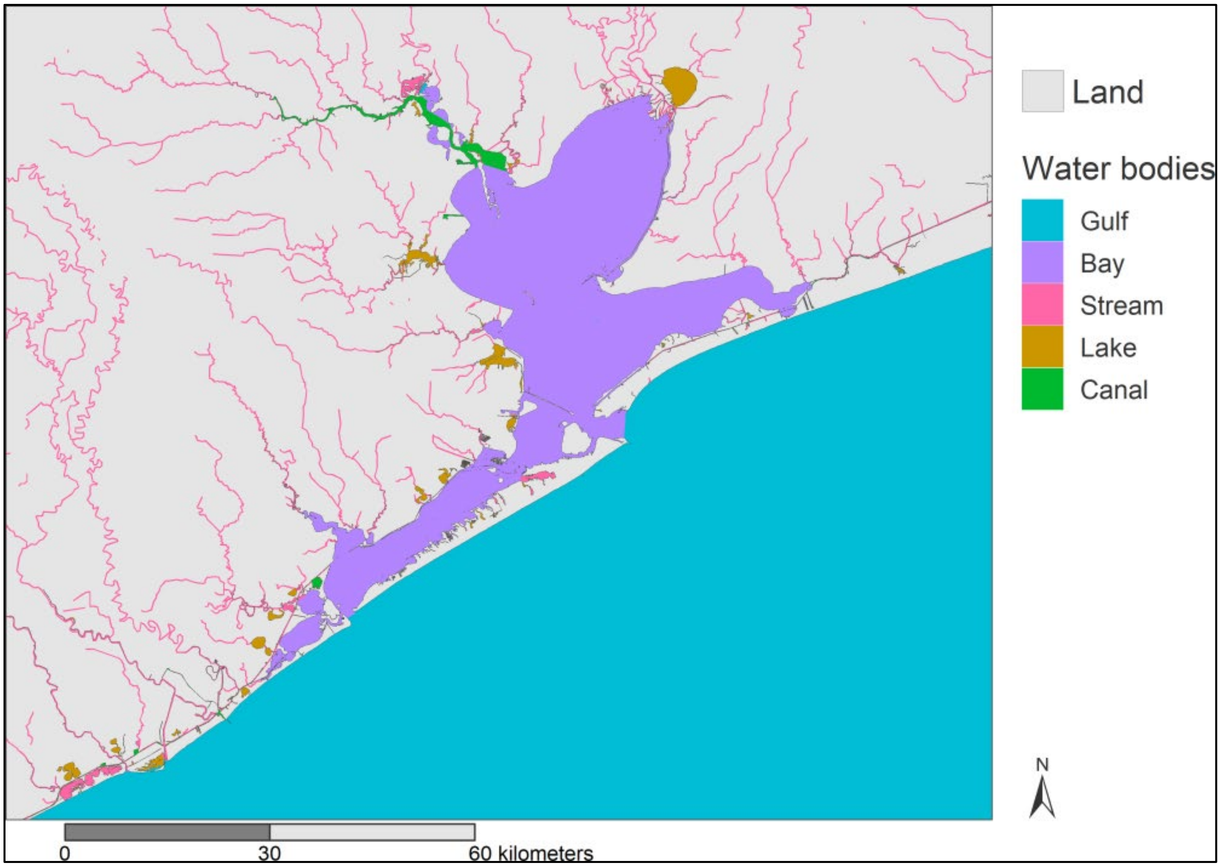

Figure 49. Water bodies of the Houston region.

Modified from Tele Atlas North America, Inc. (2010).

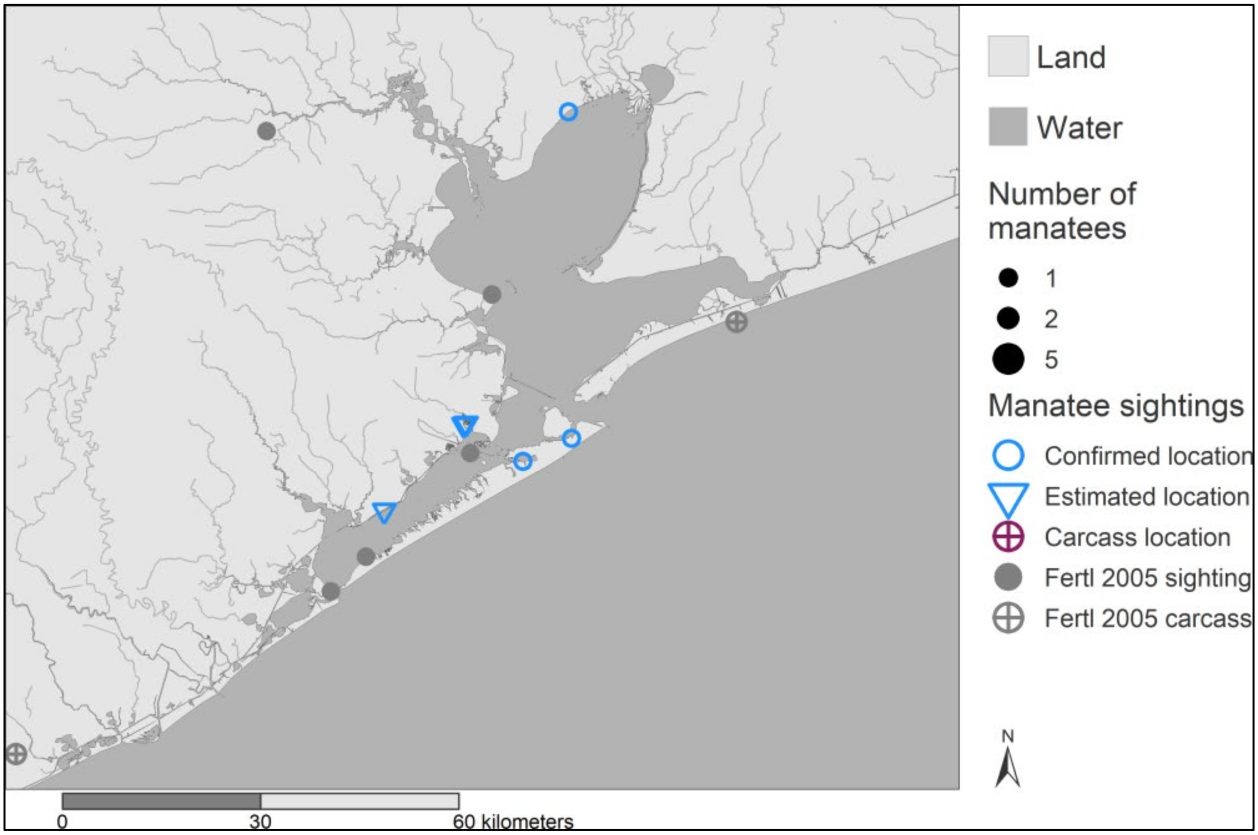

Figure 50. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; gray points were previously published in Fertl et al. (2005).

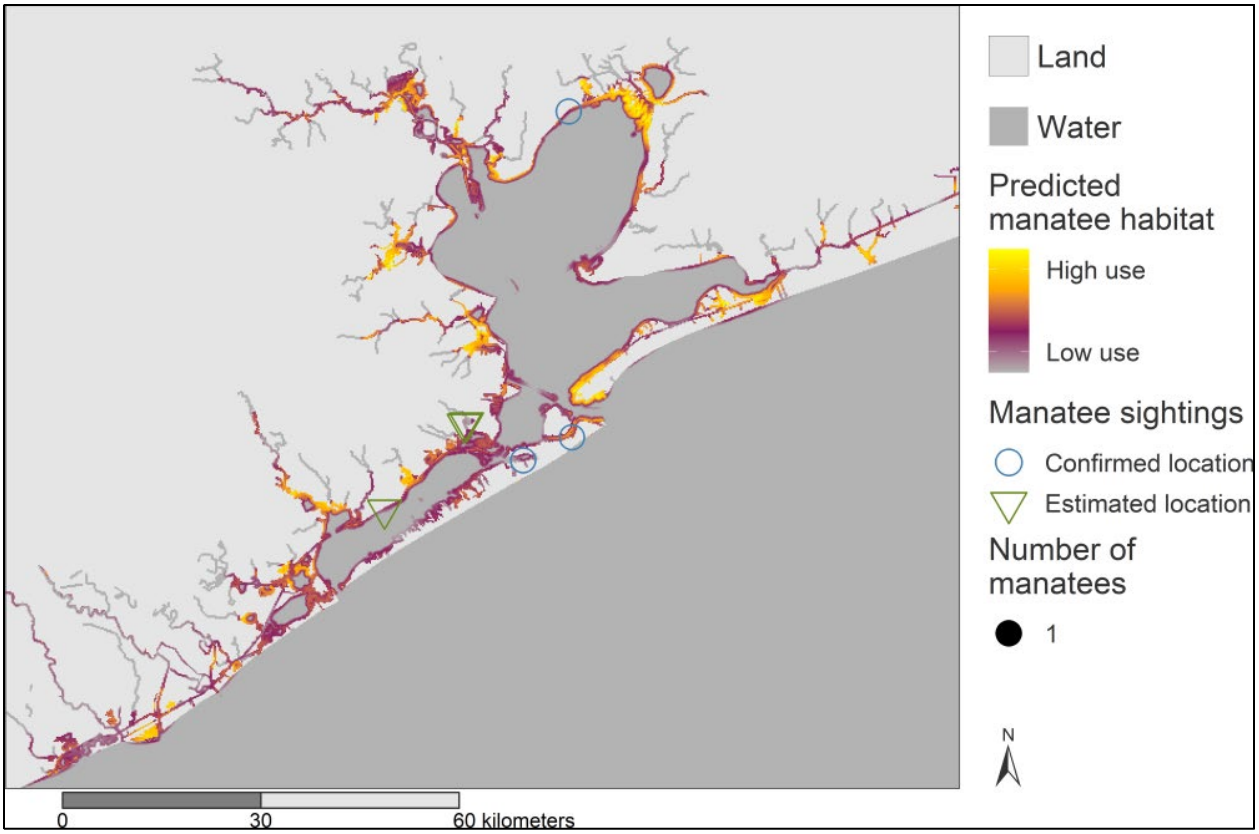

Figure 51. Habitat use prediction for the Houston region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray.

3.5.1.6 Beaumont

The Beaumont region is in the center of Chenier Plain (Figure 52 through Figure 55). It contains two large euryhaline lakes: Sabine Lake which straddles the Texas-Louisiana border and Calcasieu Lake in Louisiana. The salinity of these lakes varies seasonally, with the fresher Sabine Lake ranging from approximately 0.5–15 ppt, and Calcasieu Lake from 5–25 ppt. Dominant marsh vegetation in the region are dependent on salinity regimes, and include *Spartina*, *Sagittaria*, *Panicum*, and *Phragmites* species (Visser et al. 2000).

Manatee carcasses were recovered from Calcasieu Lake in 1929 and Sabine Lake in 1937 (Gunter 1941), indicating a long history of at least occasional use of the Beaumont region. More recently, live animals have been sighted and carcasses recovered from both lakes and their tributaries, but Calcasieu Lake has seen more of both (Figure 56).

Predicted manatee habitat in the Beaumont region agrees with the pattern of sightings, with a slightly higher signal in the northern estuary of Calcasieu Lake compared to Sabine Lake (Figure 57). Both lake systems show predicted habitat areas, especially in the northern, fresher areas and tributaries.

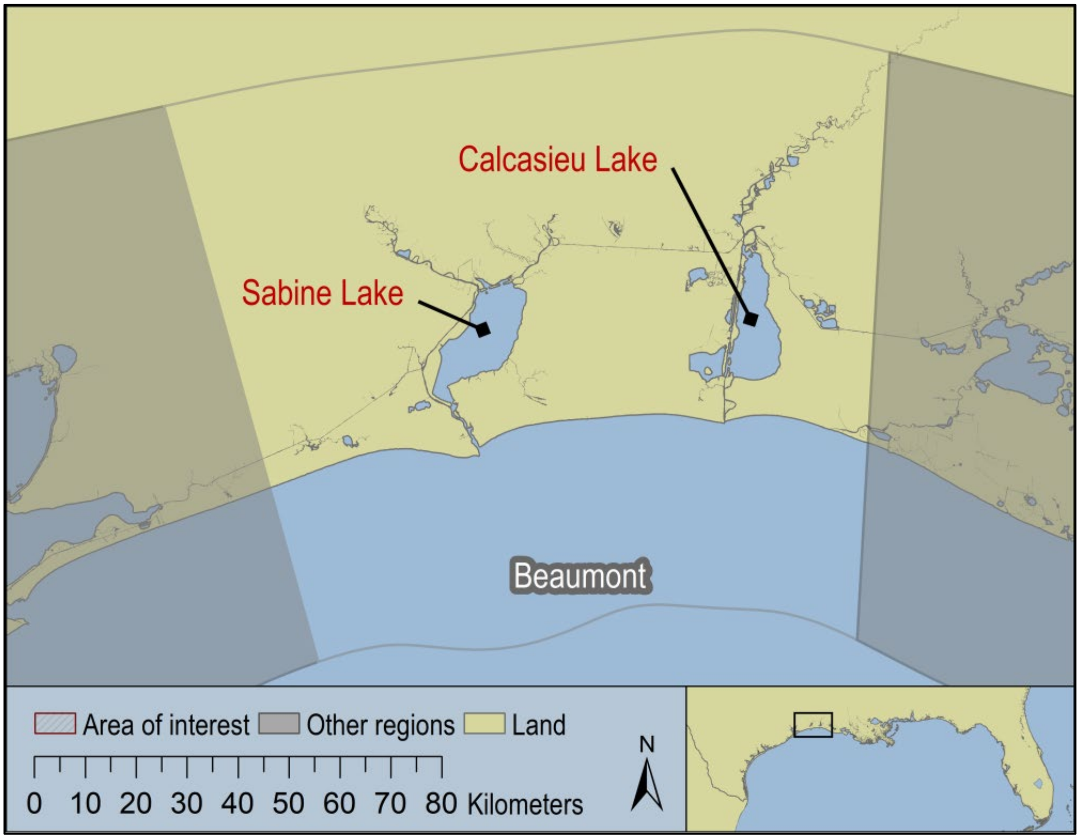

Figure 52. The Beaumont region straddles Texas and Louisiana.

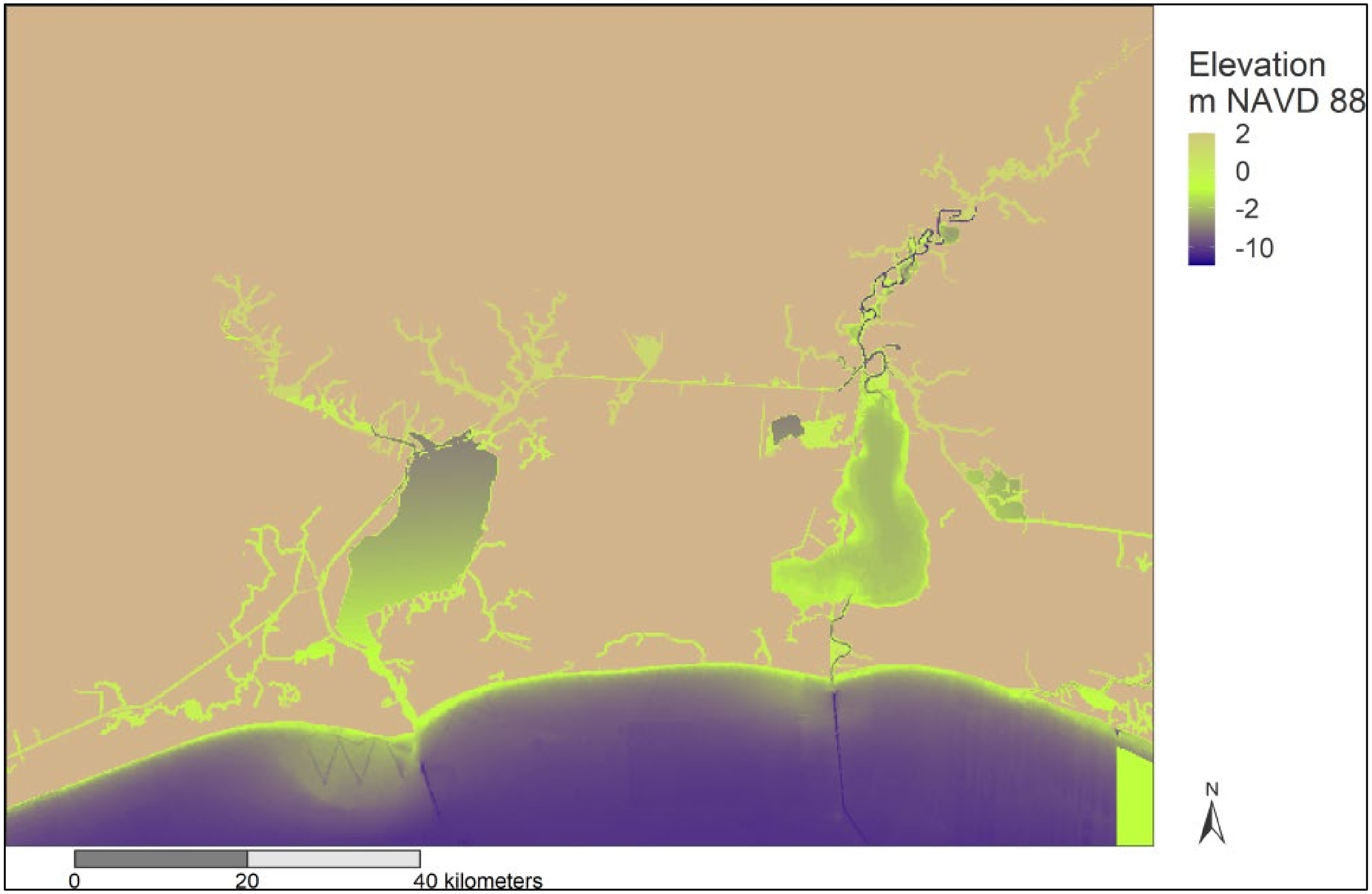

Figure 53. Digital elevation model of the Beaumont region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

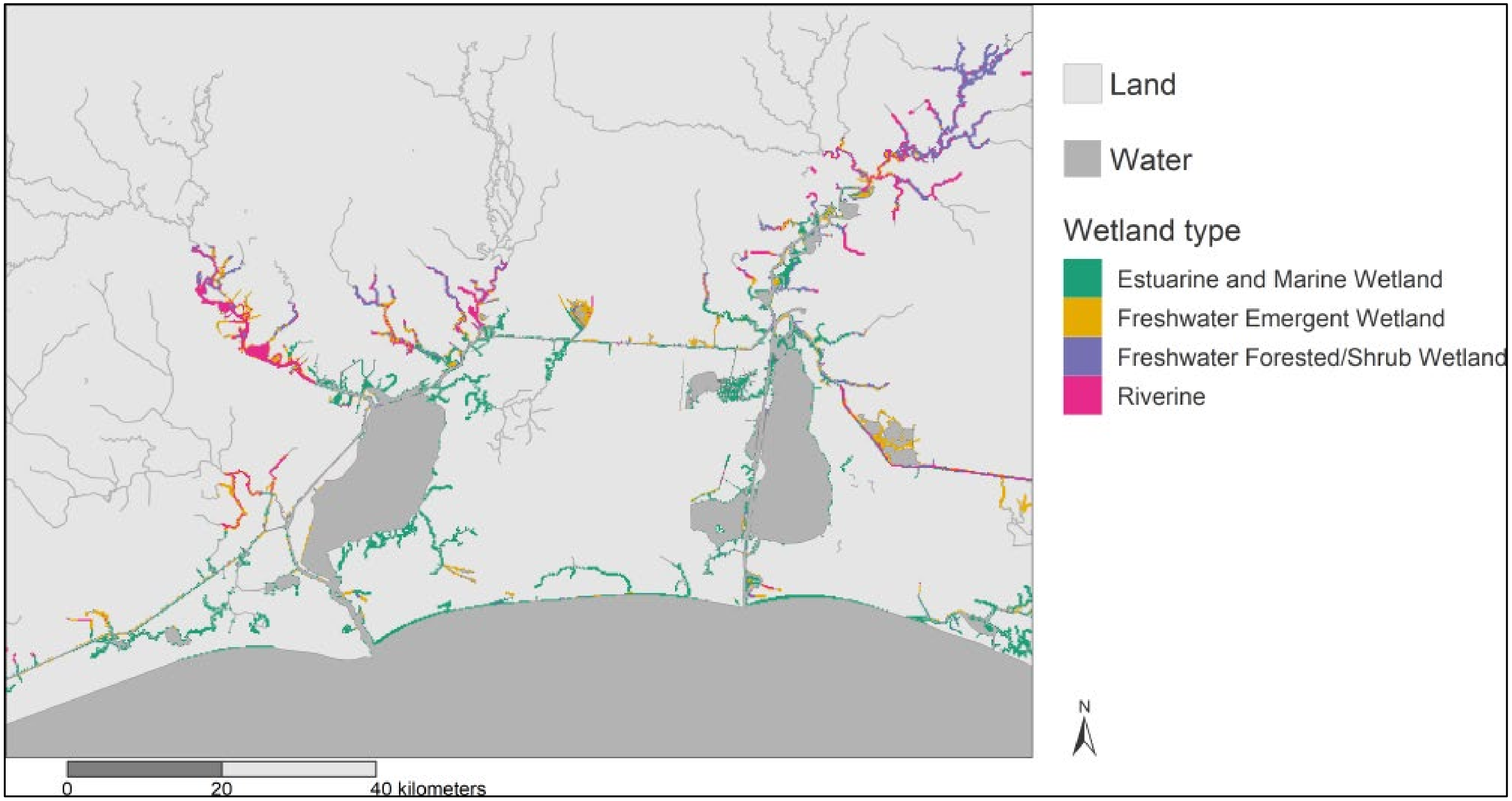

Figure 54. Wetland types and locations within the Beaumont region.

Modified from US Fish and Wildlife Service (2016).

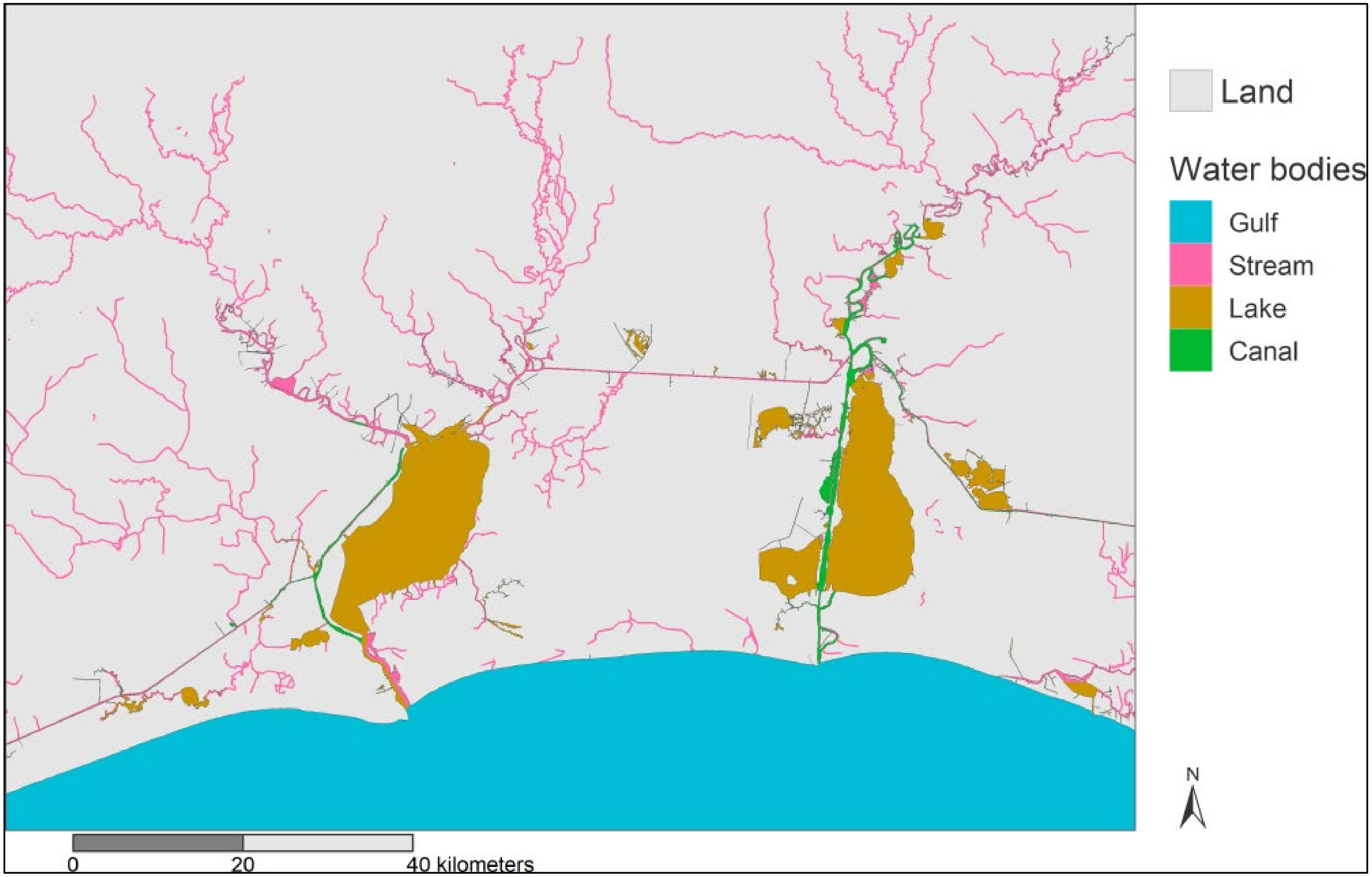

Figure 55. Water bodies of the Beaumont region.

Modified from Tele Atlas North America, Inc. (2010).

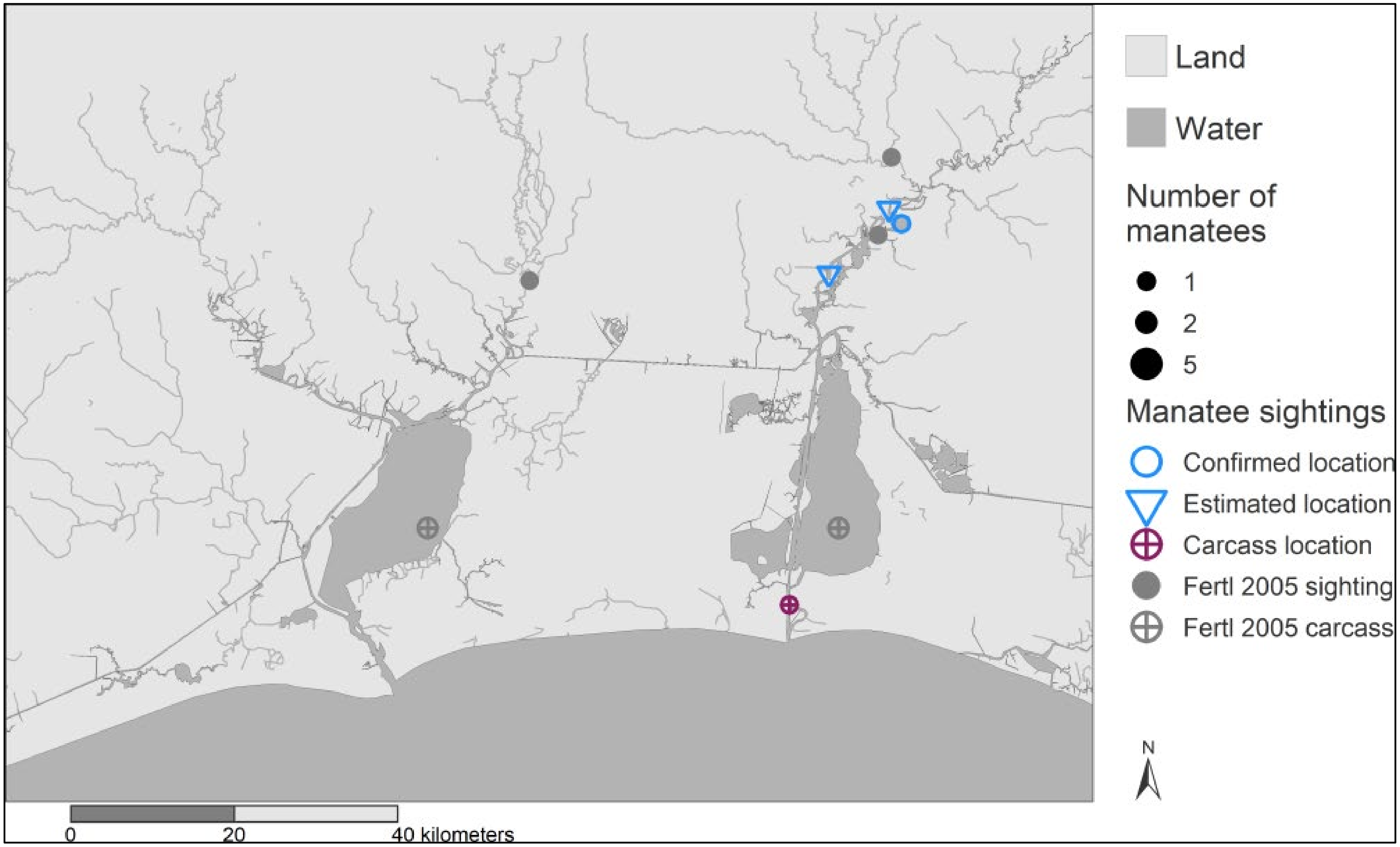

Figure 56. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; darker gray points were previously published in Fertl et al. (2005).

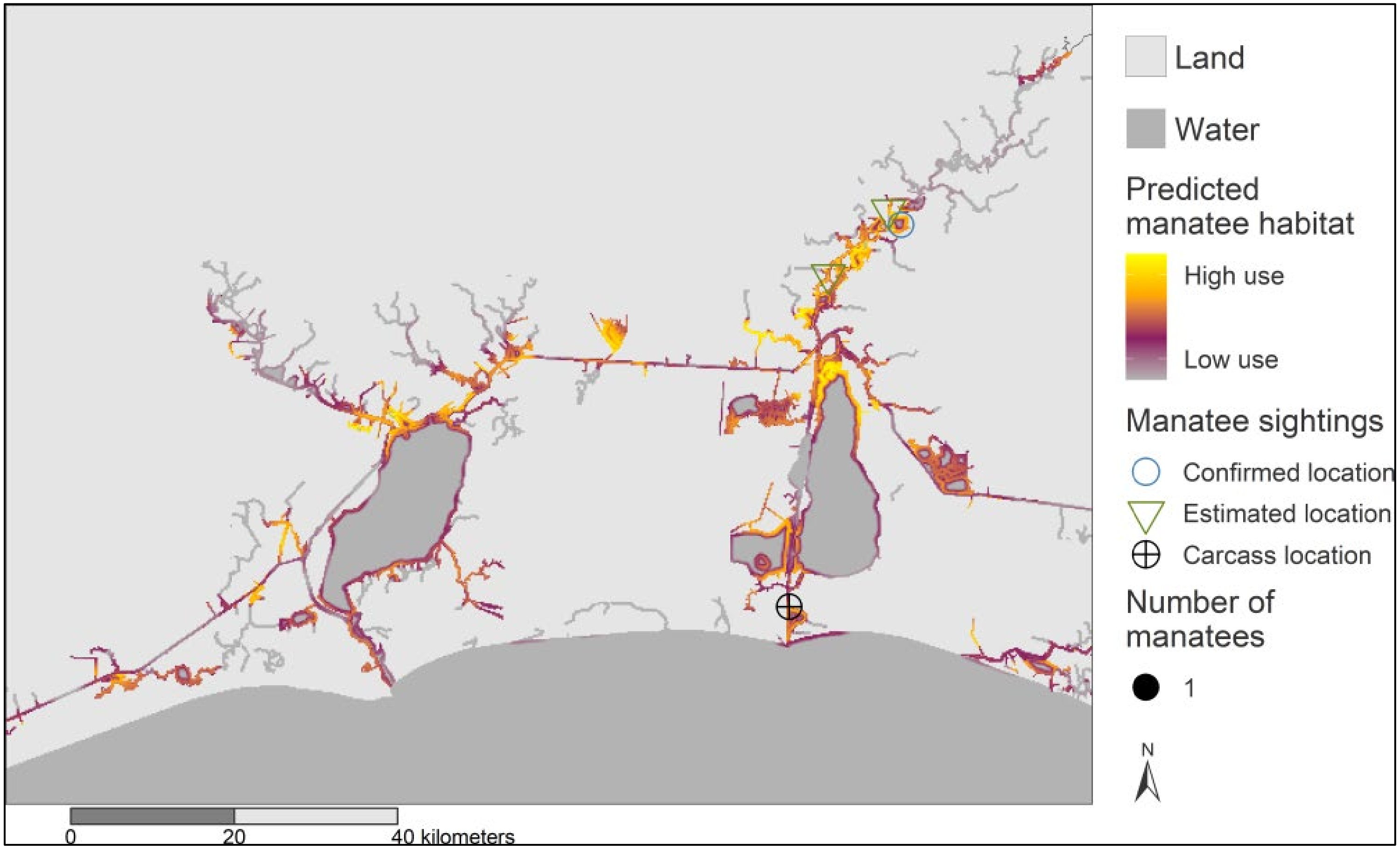

Figure 57. Habitat use prediction for the Beaumont region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray.

3.5.1.7 Lafayette

The dominant feature of the Lafayette region in Louisiana is the Atchafalaya River and associated Atchafalaya and Vermilion bays (Figure 58 through Figure 61). The Atchafalaya Bay stays fresh all year, but Vermilion Bay, farther from the freshwater outflow, ranges from fresh to brackish seasonally. Upstream of the Atchafalaya Bay are numerous braided riverbeds and freshwater lakes. The Atchafalaya delta hosts a rich diversity of emergent and submerged freshwater vegetation including *Potamogeton nodosus, Najas guadalupensis*, *Scirpus, Sagittaria, Leersia,* and *Salix* species (Shaffer et al. 1992; Castellanos and Rozas 2001), while Vermilion Bay hosts both freshwater and euryhaline vegetation including *Ruppia maritima, Myriophyllum spicatum, Ceratophyllum demersum*, and *Potamogeton pusillis* (Merino et al. 2005).

The earliest manatee sighting from the Lafayette region was in the Atchafalaya River in 1976 (Fertl et al. 2005). The Atchafalaya delta has continued to show the most manatee sightings and carcass recoveries in the region, but several sightings and carcasses have also been reported from the northwest shore of Vermillion Bay (Figure 62).

Predicted manatee habitat in the Lafayette region is concentrated along the northwest shore of Vermilion Bay, in agreement with where the sightings were reported, but the Atchafalaya delta is predicted to be low-quality habitat (Figure 63). The latter river is classified as riverine rather than wetland habitat, which is the driving factor in the low rating.

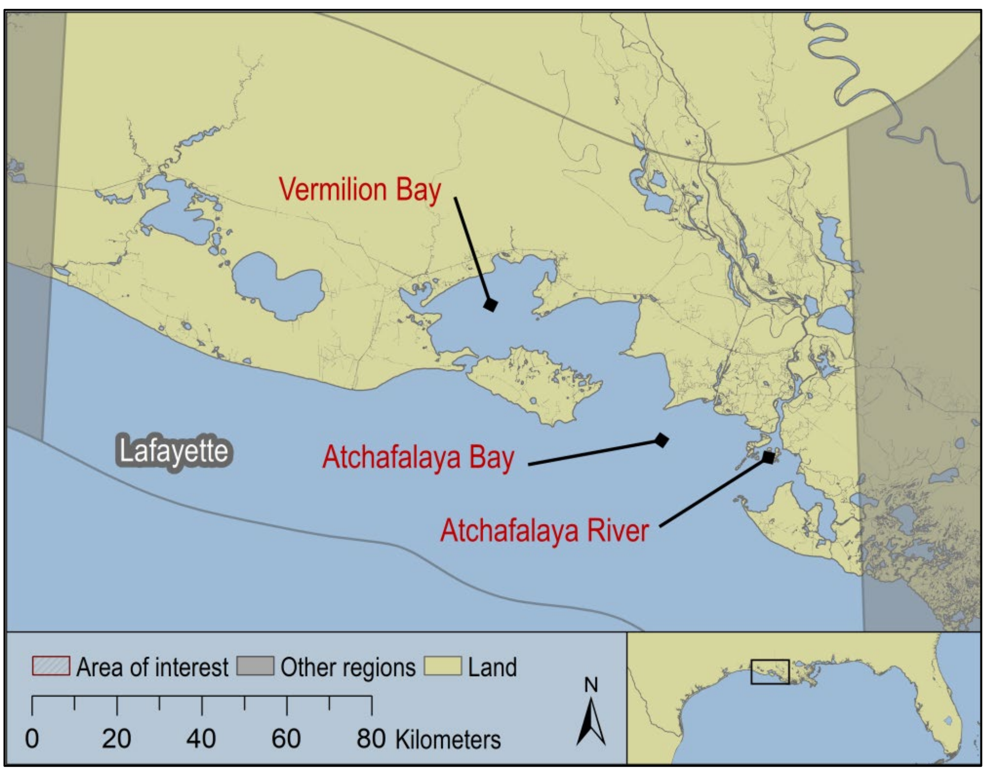

Figure 58. The Lafayette region in Louisiana, outflow of the Atchafalaya River.

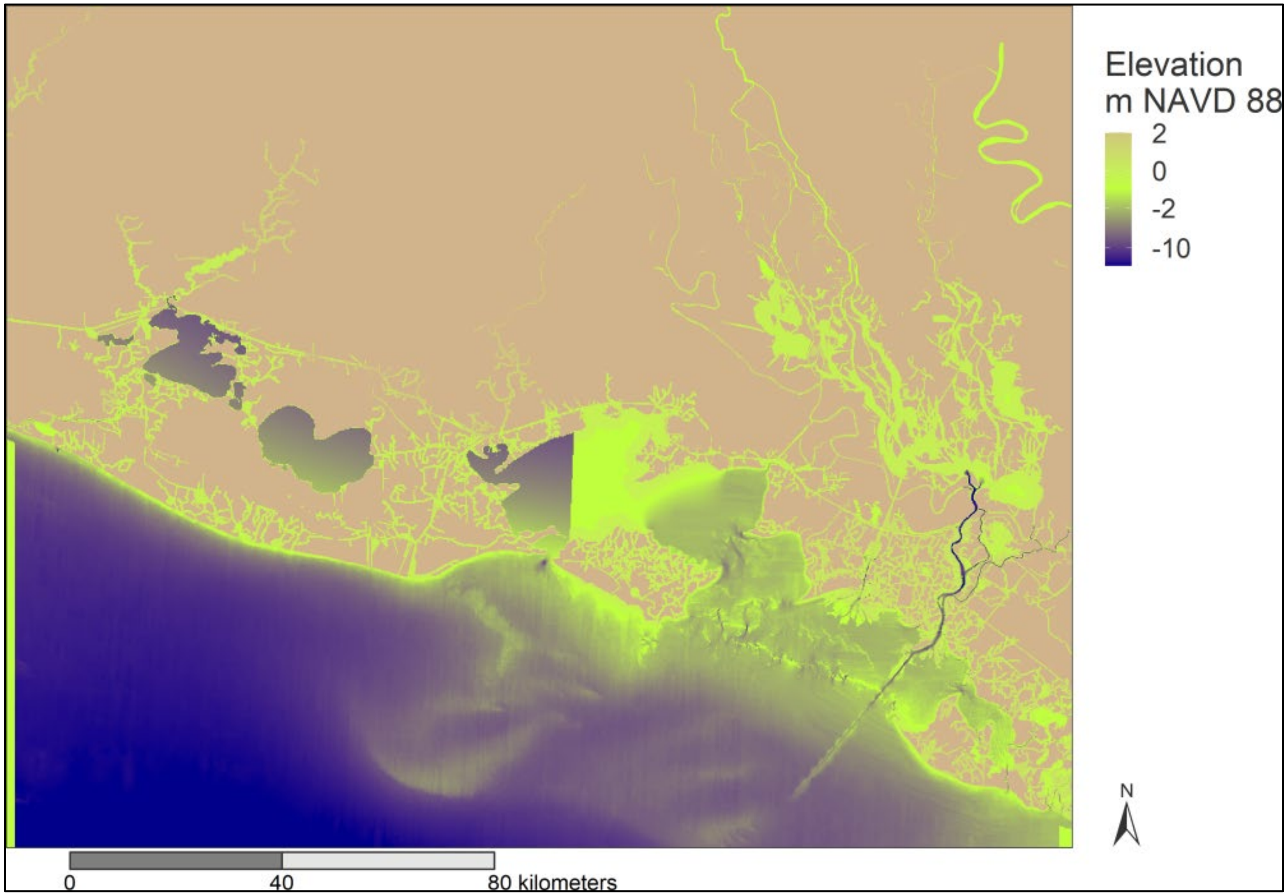

Figure 59. Digital elevation model of the Lafayette region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (violet-dark blue).

Data compiled from NOAA sources; see text for details.

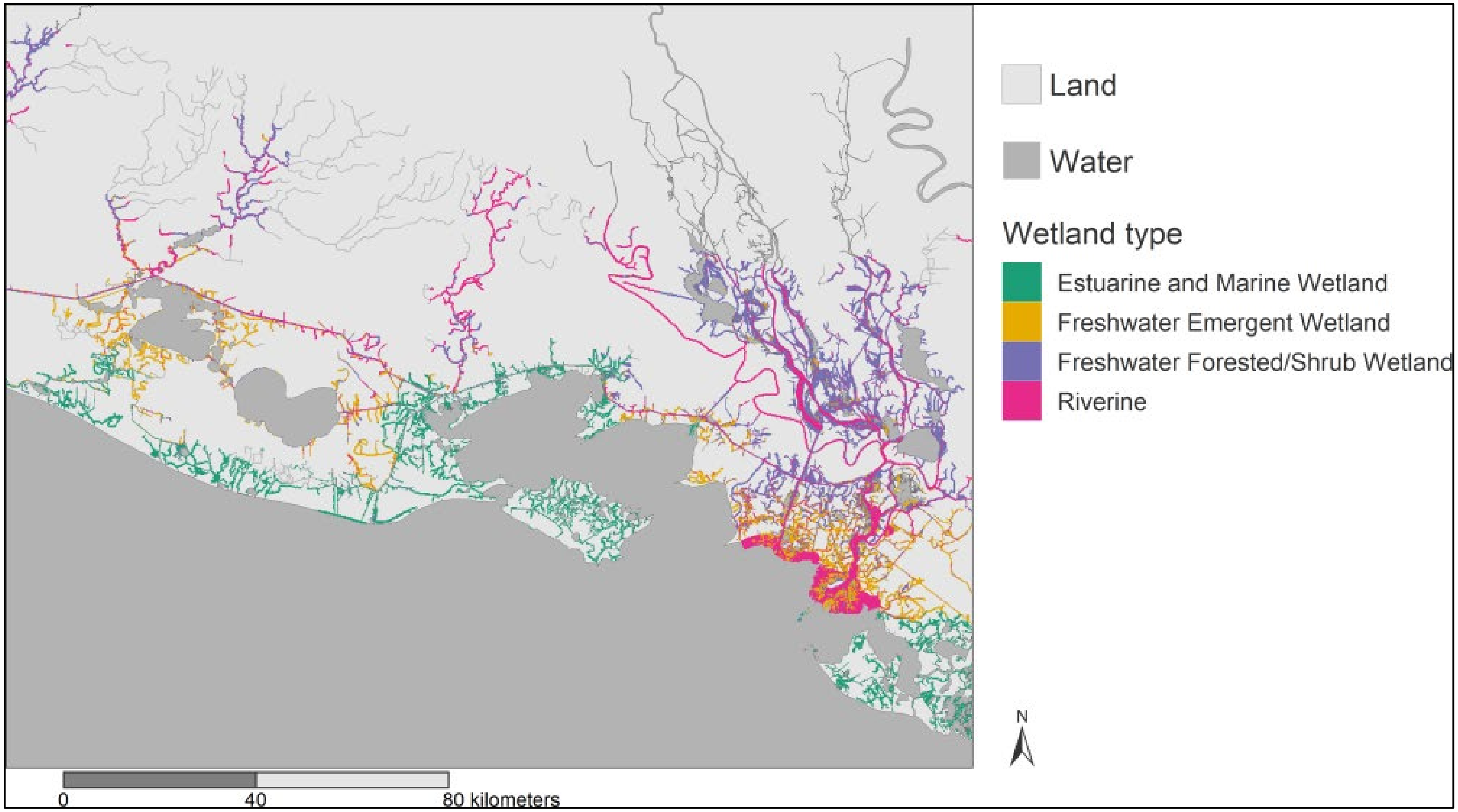

Figure 60. Wetland types and locations within the Lafayette region.

Modified from US Fish and Wildlife Service (2016).

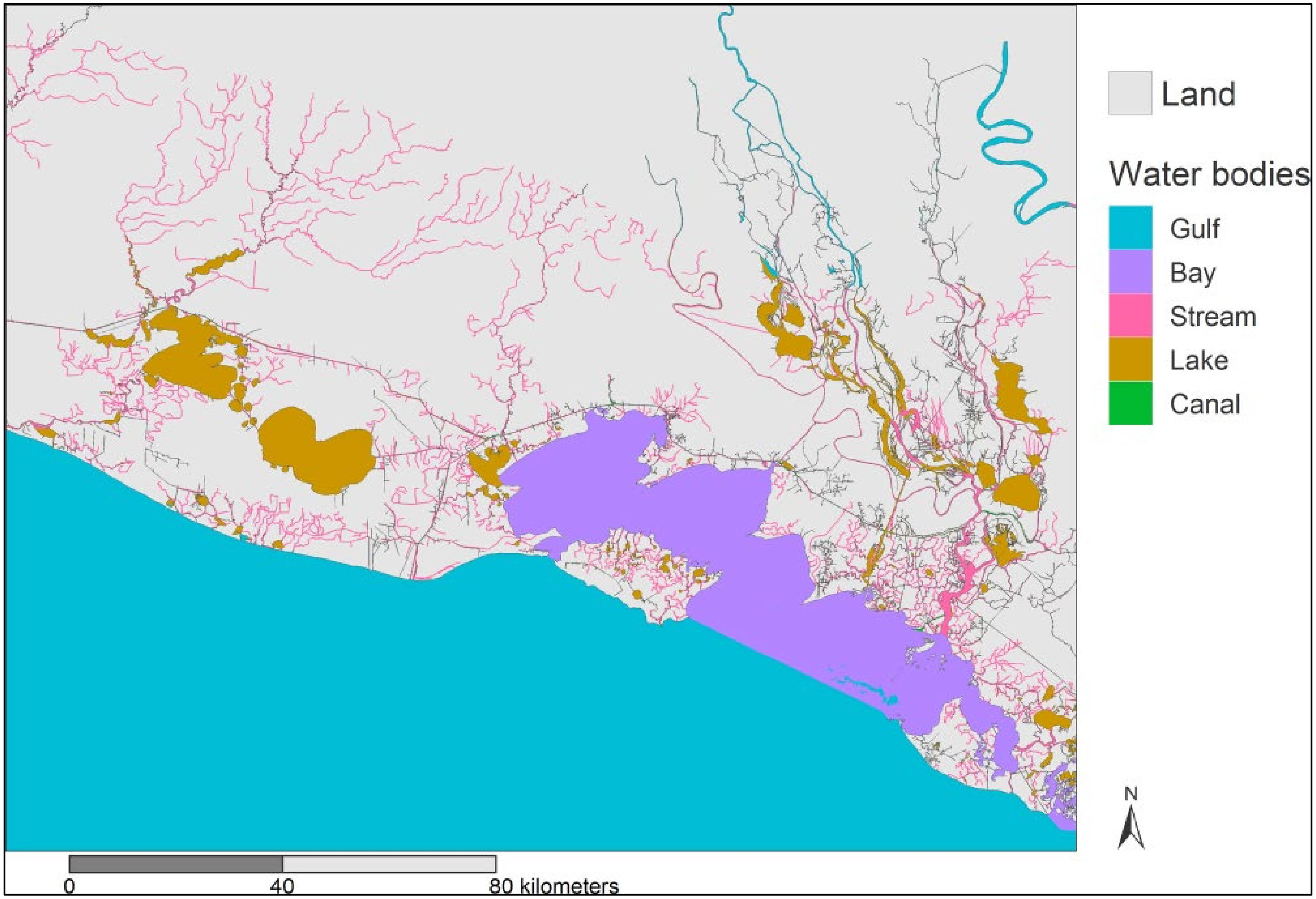

Figure 61. Water bodies of the Lafayette region.

Modified from Tele Atlas North America, Inc. (2010).

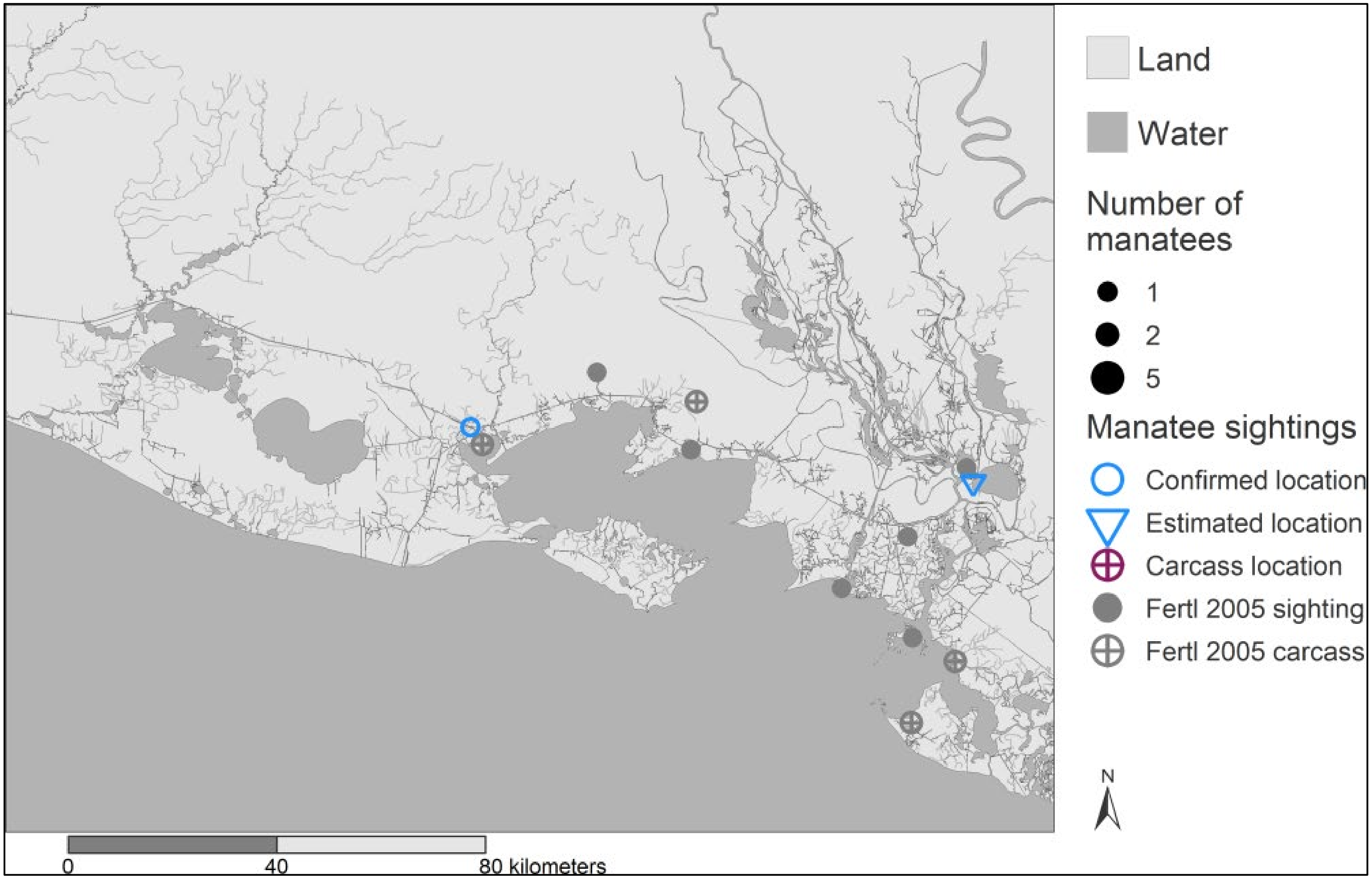

Figure 62. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; gray points were previously published in Fertl et al. (2005).

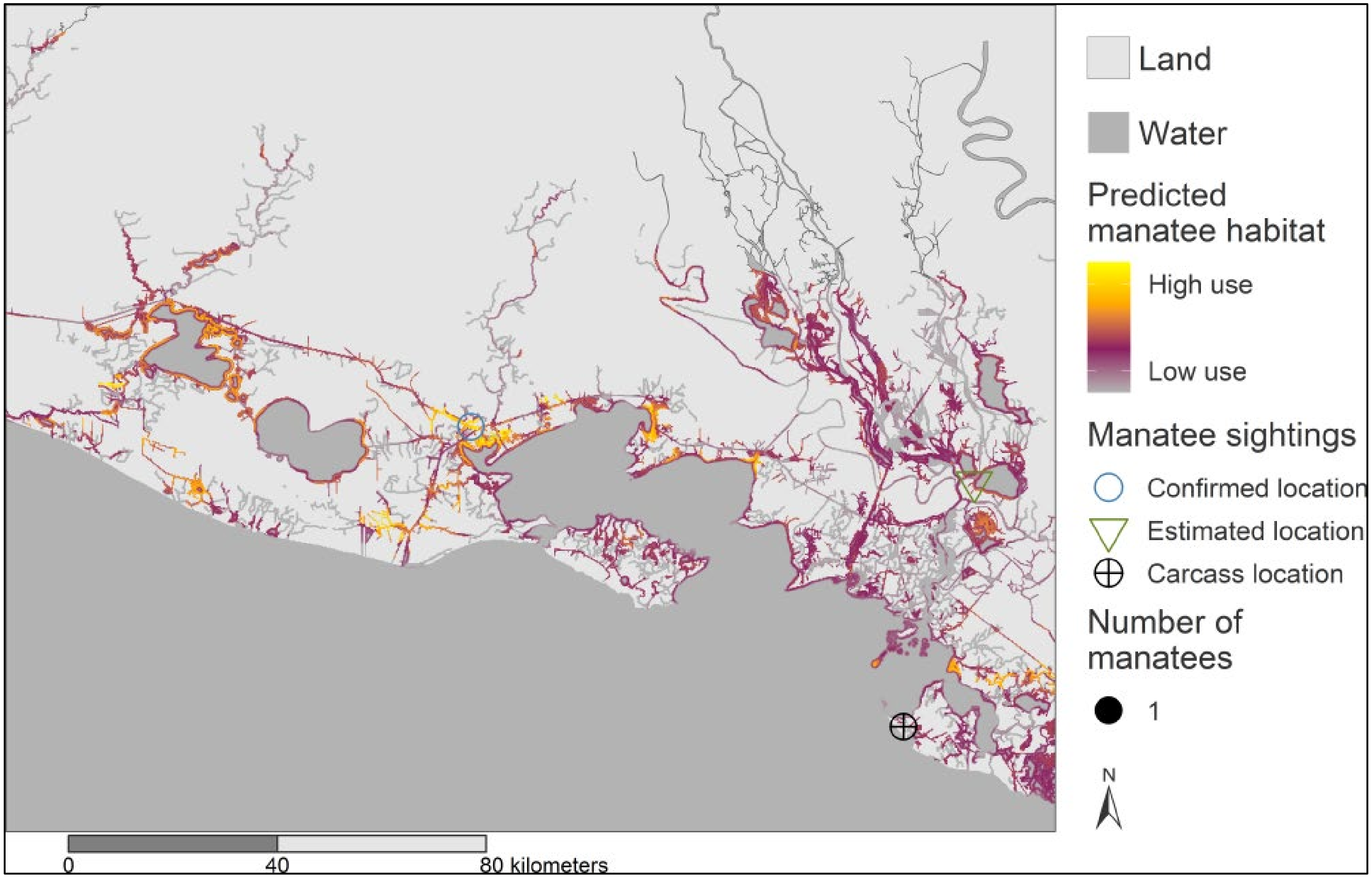

Figure 63. Habitat use prediction for the Lafayette region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray.

3.5.1.8 Houma

The Houma region is essentially the Mississippi Delta, with the freshwater Mississippi outflow surrounded by brackish to saline bays that are connected with extensive freshwater marshlands (Figure 64 through Figure 67). Vegetation in these bay systems include *Spartina*, *Distichlis*, or *Avicennia* species in the outer saline bays, *Spartina* or *Schoenoplectus* species in the brackish marshes, *Panicum* and *Phragmites* in the intermediate marshes, and *Sagittaria* and *Panicum* species in the freshwater marsh, among others (Sasser et al. 2008).

Manatees have been sighted throughout the Houma region, from the Mississippi River to the outlying barrier islands (Figure 68). Several carcasses have also been retrieved, mostly in smaller inland waterways. Notably absent in the sighting reports are the larger embayments, including Terrebonne Bay and Black Bay. It is not known whether this represents a lack of manatee use or less human use of those areas compared to the interior waterways.

Predicted habitat for the Houma region was concentrated in the fringing marshes of the entire delta, including the bays where manatees have not been sighted (Figure 69). Interior waterways were also represented, where they were represented in the input layers. With a system as complicated as the Mississippi River delta, many waterways were not included in map layers. The prediction model may have shown different results had the complete water system been available.

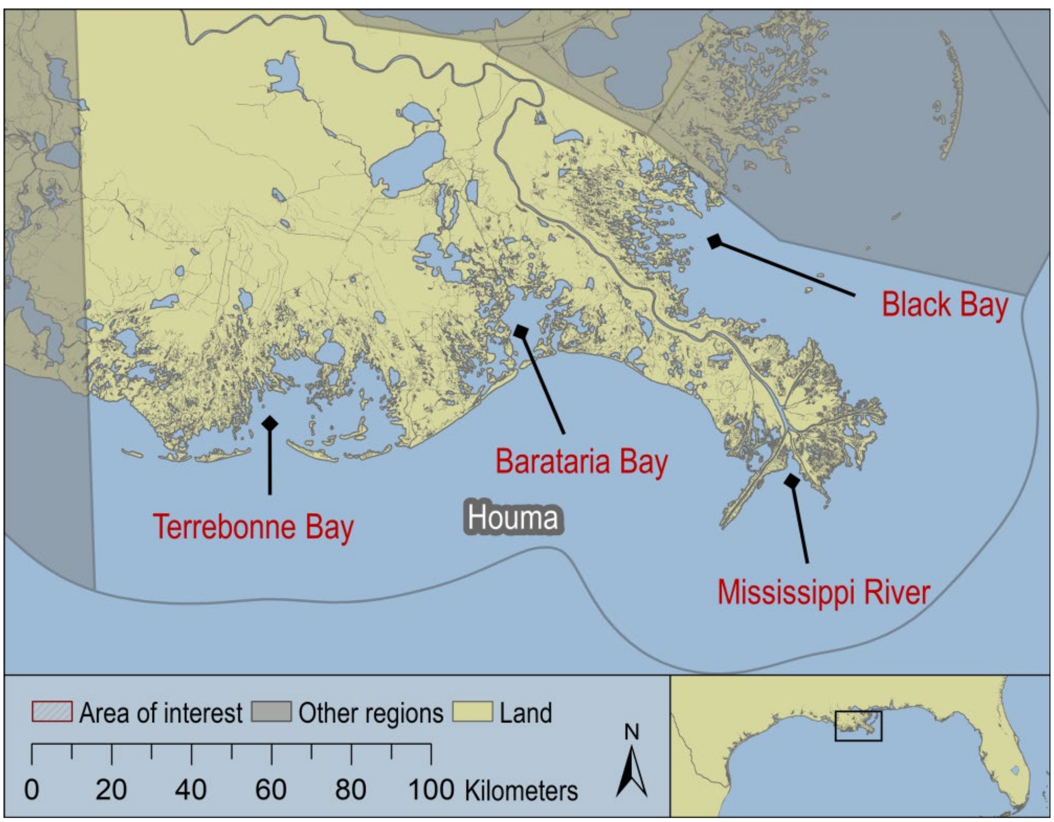

Figure 64. The Houma region, the central Mississippi delta.

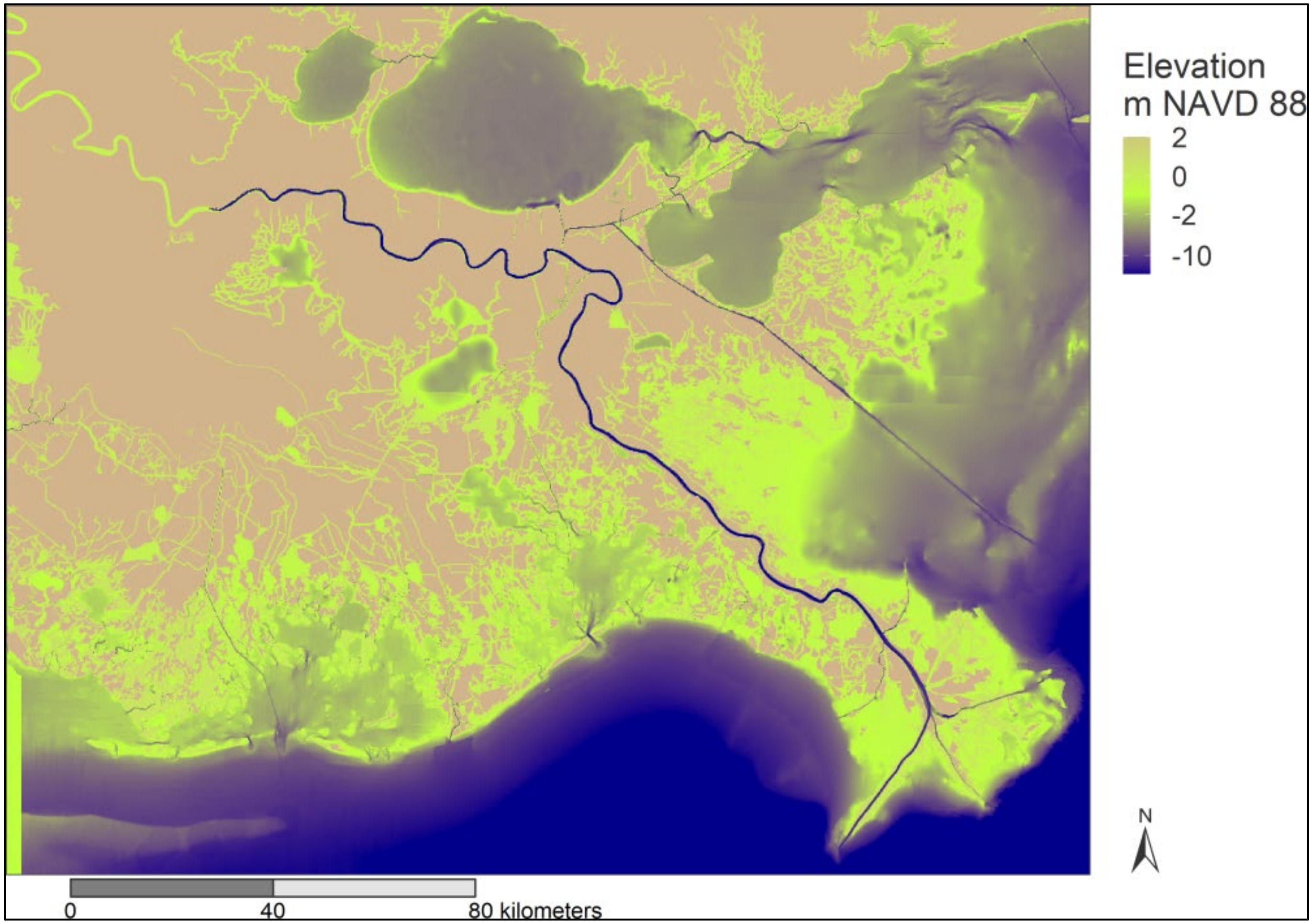

Figure 65. Digital elevation model of the Houma region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (violet-dark blue).

Data compiled from NOAA sources; see text for details.

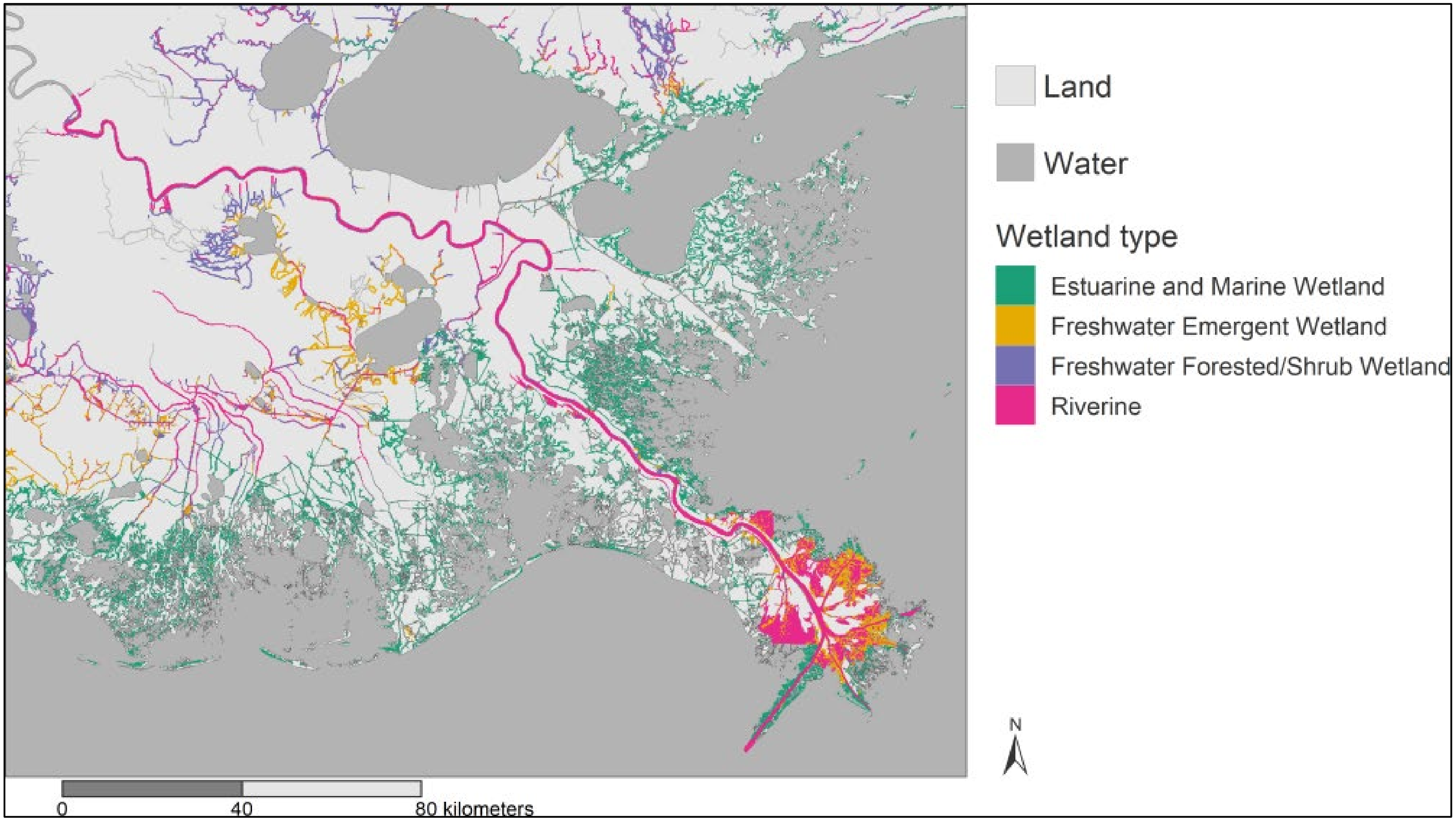

Figure 66. Wetland types and locations within the Houma region.

Modified from US Fish and Wildlife Service (2016).

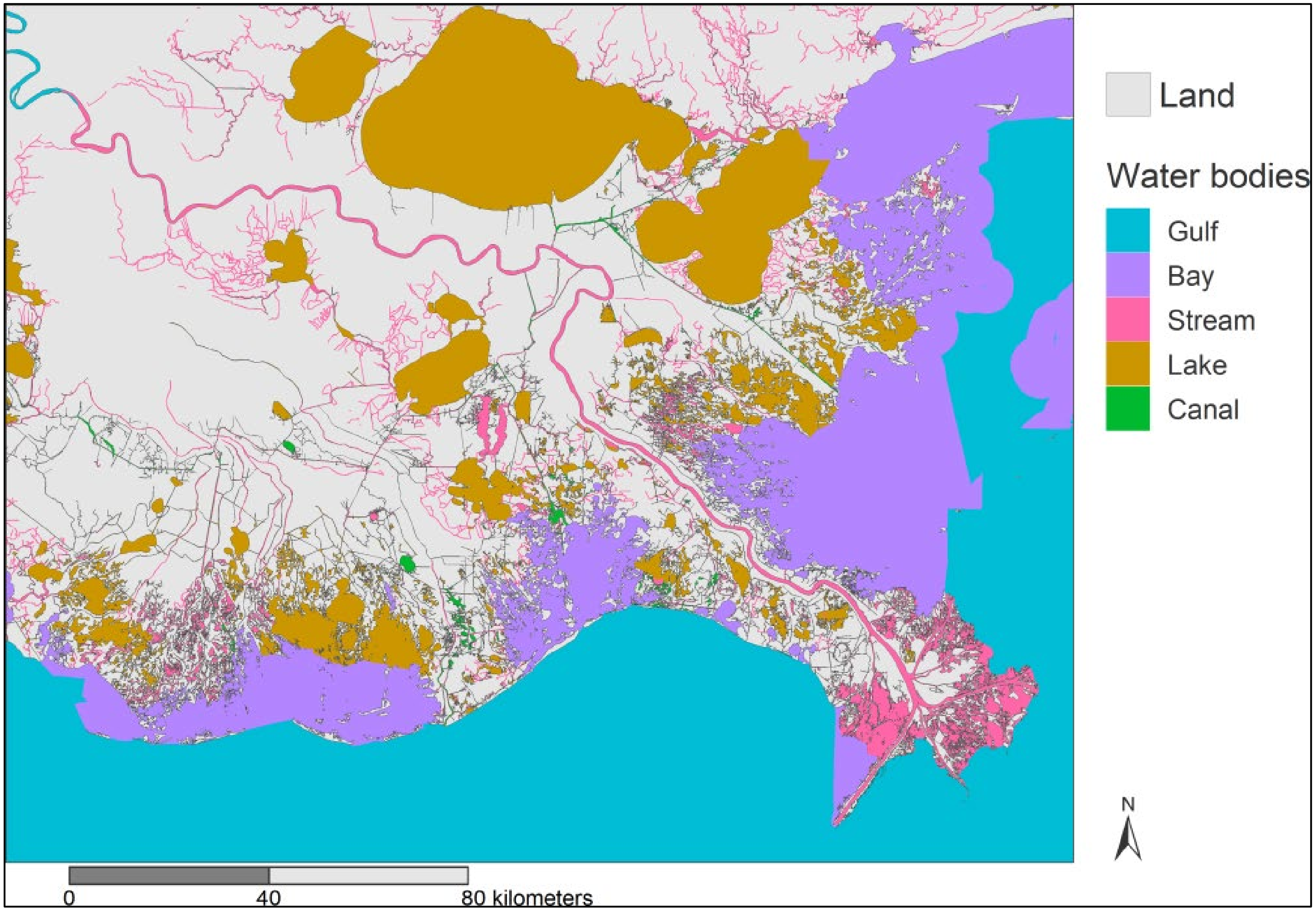

Figure 67. Water bodies of the Houma region.

Modified from Tele Atlas North America, Inc. (2010).

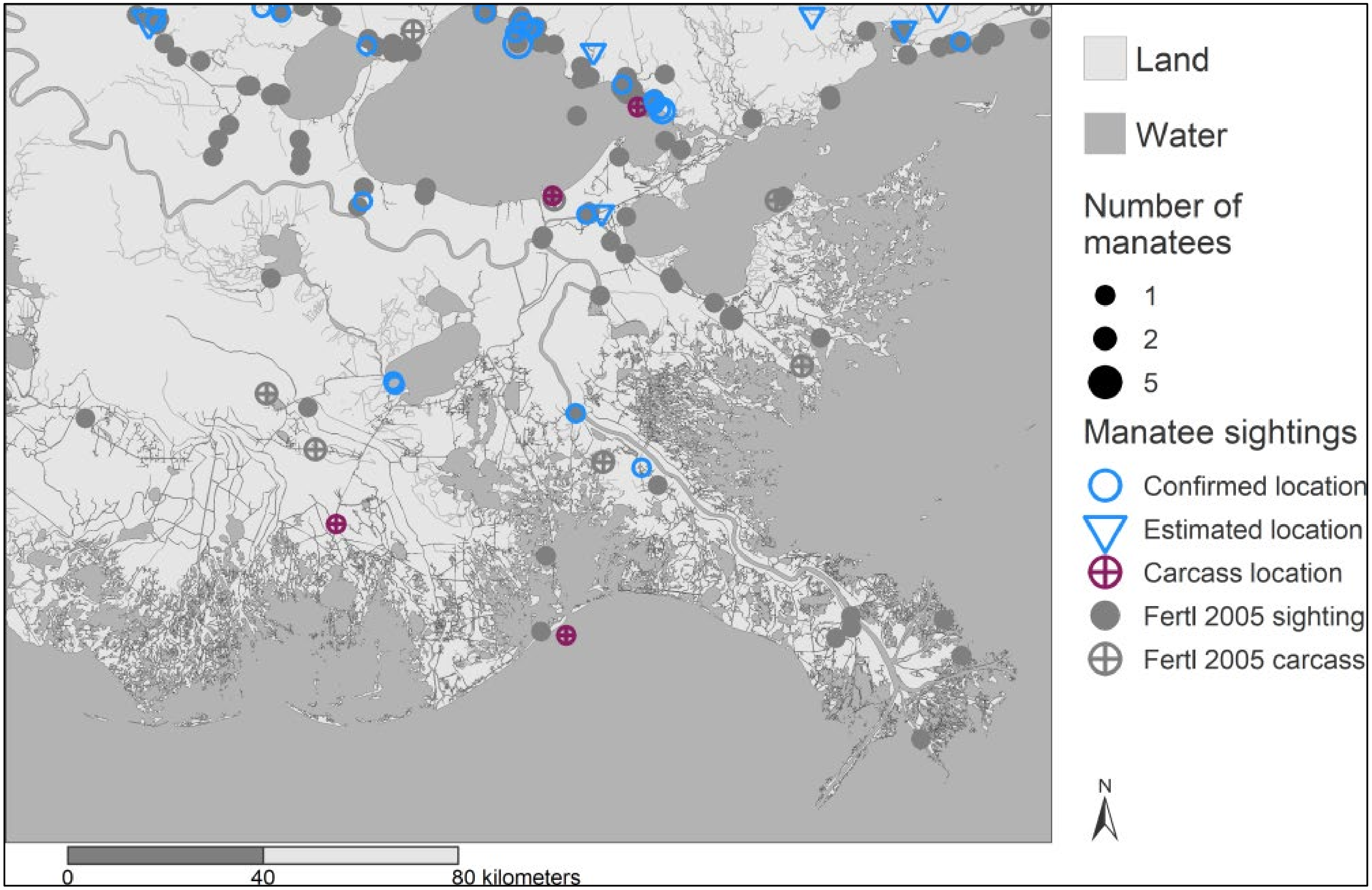

Figure 68. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the Houma region.

Colored points were collected for this study; gray points were previously published in Fertl et al. (2005).

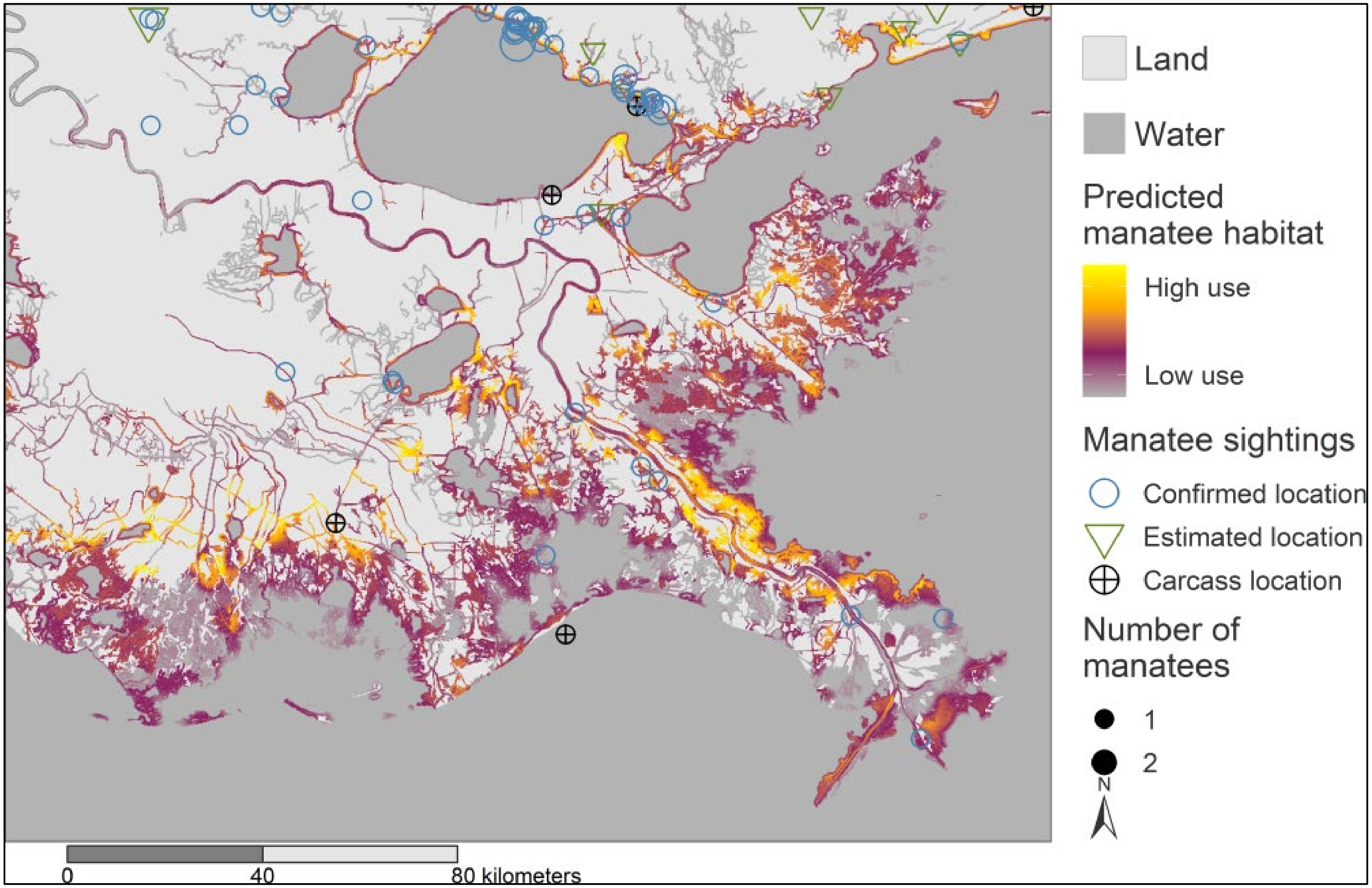

Figure 69. Habitat use prediction for the Houma region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray.

3.5.1.9 Chandeleur

The Chandeleur region, named for the well-known barrier island, is where the upper Mississippi Delta meets the Mississippi Sound (Figure 70 through Figure 73). The delta portion of this region is similar to the bays of the Houma region, and the protected waters west of Chandeleur Island are home to marine seagrasses including *Thalassia testudinum* , *Syringodium filiforme*, *Halophila engelmannii*, and *Halodule wrightii.* The euryhaline species *Ruppia maritima* is also found in shallow nearshore waters (Pham et al. 2014).

Very few manatee sightings have been reported from the Chandeleur region (Figure 74). Except for an early sighting from 1979 near Breton Island (Fertl et al. 2005), all of the sightings and carcass recoveries have been from the Mississippi delta area. No new sightings were recorded from the region since the publication of Fertl (2005). One of the tracked manatees made a brief visit to the region, logging just a small area of use near the Mississippi Sound (Figure 75).

Predicted manatee habitat in the Chandeleur region was concentrated in the interior of the Mississippi Delta area of the region (Figure 76). This pattern generally tracks well with the sighting locations. Though the Chandeleur Islands support a generally thriving seagrass community, they were not rated as a manatee use hotspot.

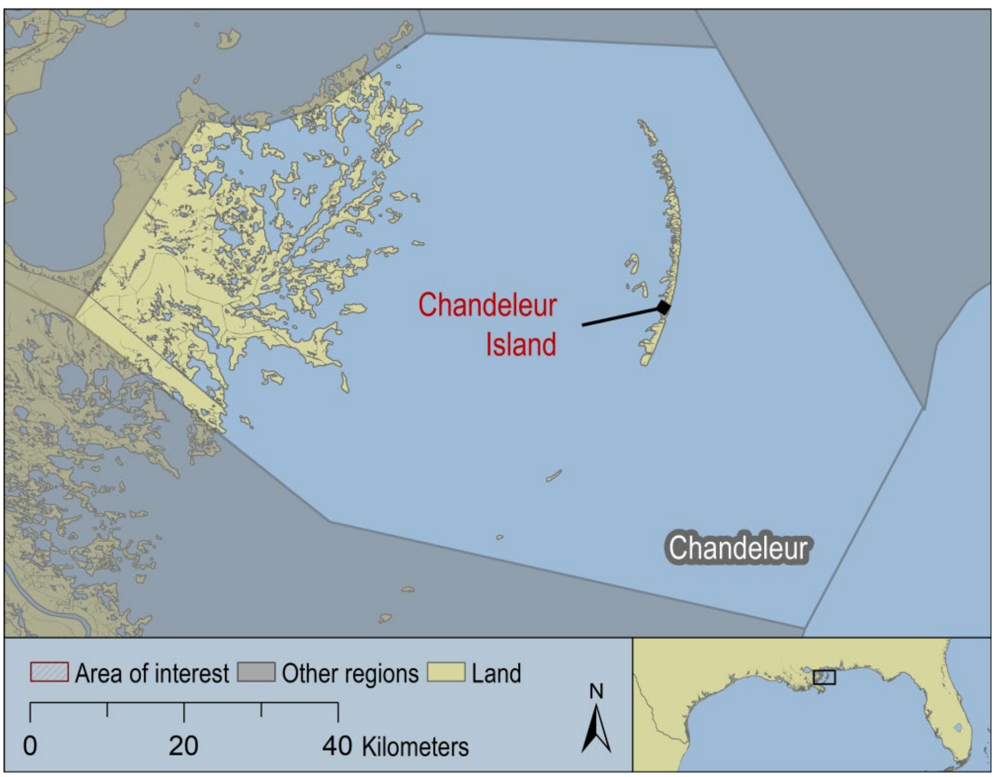

Figure 70. The Chandeleur region, featuring the Chandeleur Islands.

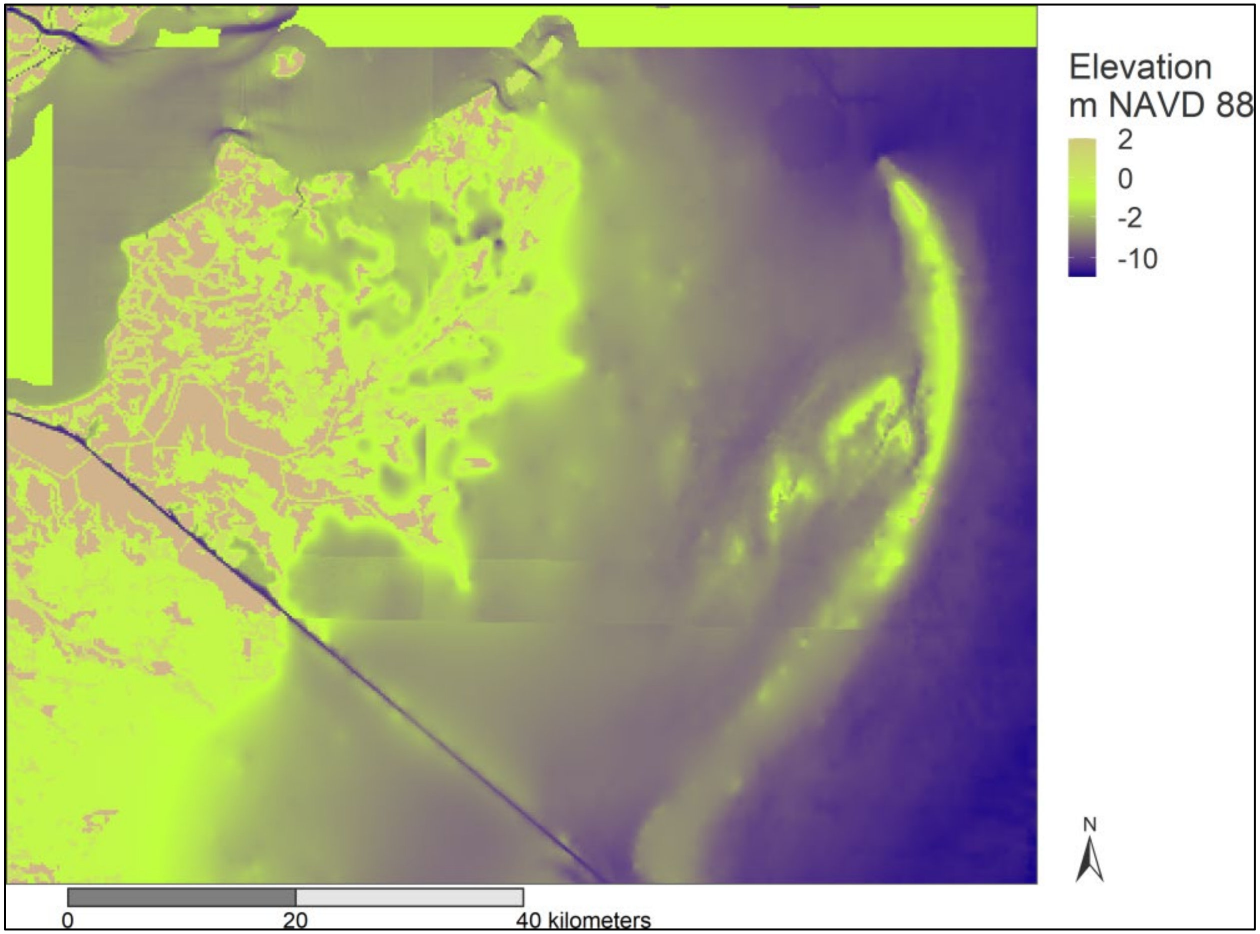

Figure 71. Digital elevation model of the Chandeleur region showing shallow areas where submerged vegetation growth is likely (yellow- green), and deeper areas (violet).

Data compiled from NOAA sources; see text for details.

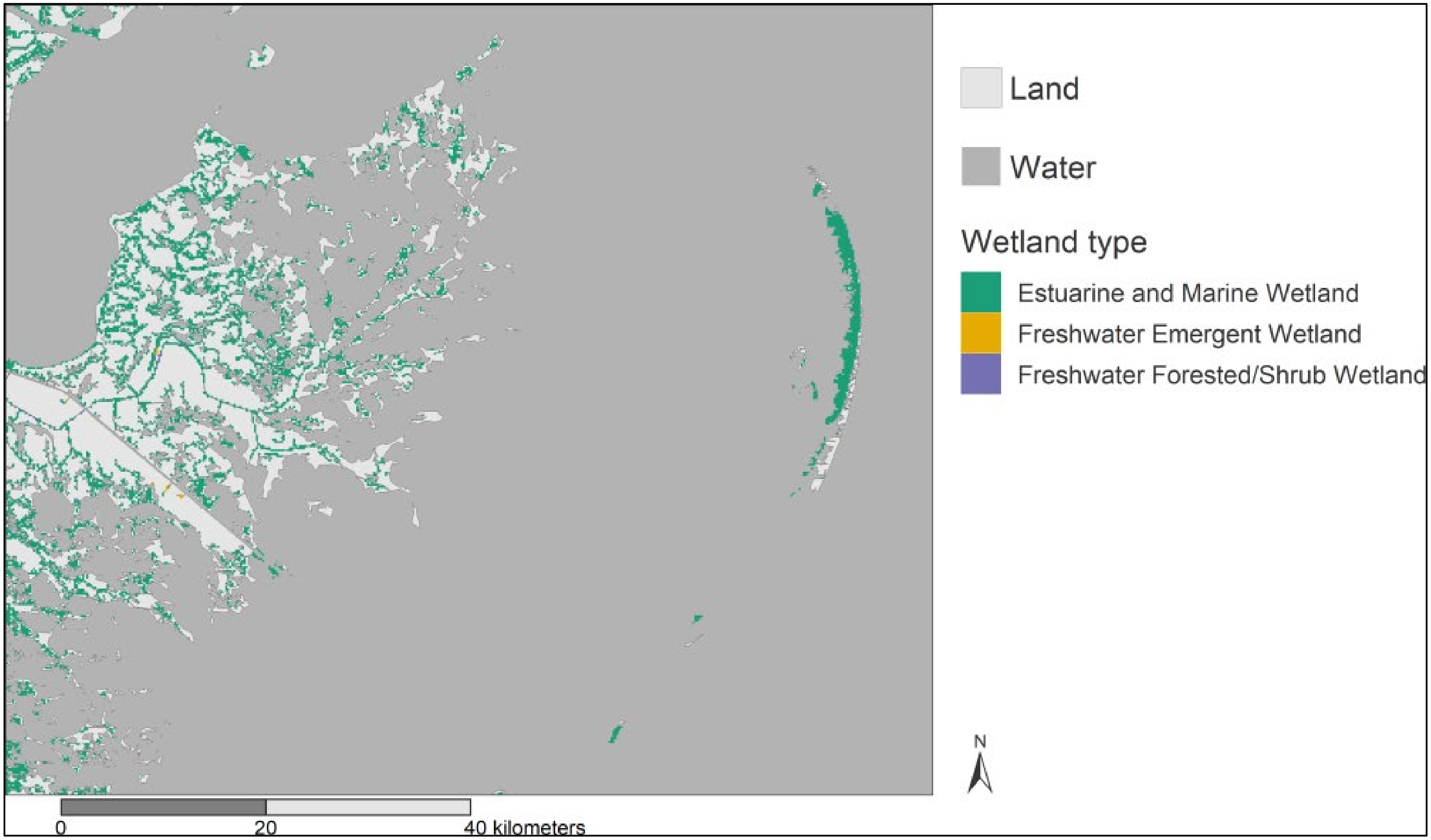

Figure 72. Wetland types and locations within the Chandeleur region.

Modified from US Fish and Wildlife Service (2016).

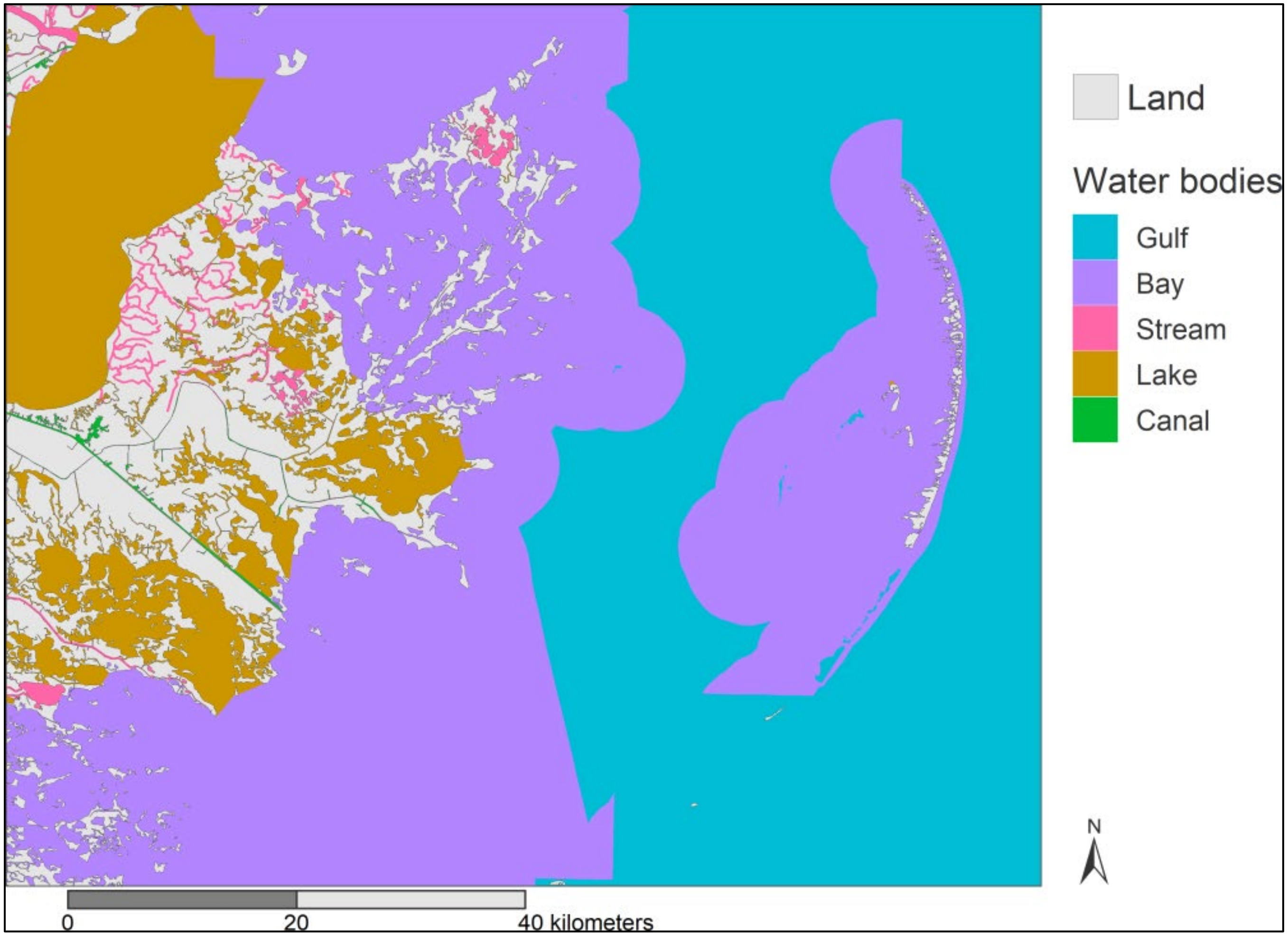

Figure 73. Water bodies of the Chandeleur region.

Modified from Tele Atlas North America, Inc. (2010).

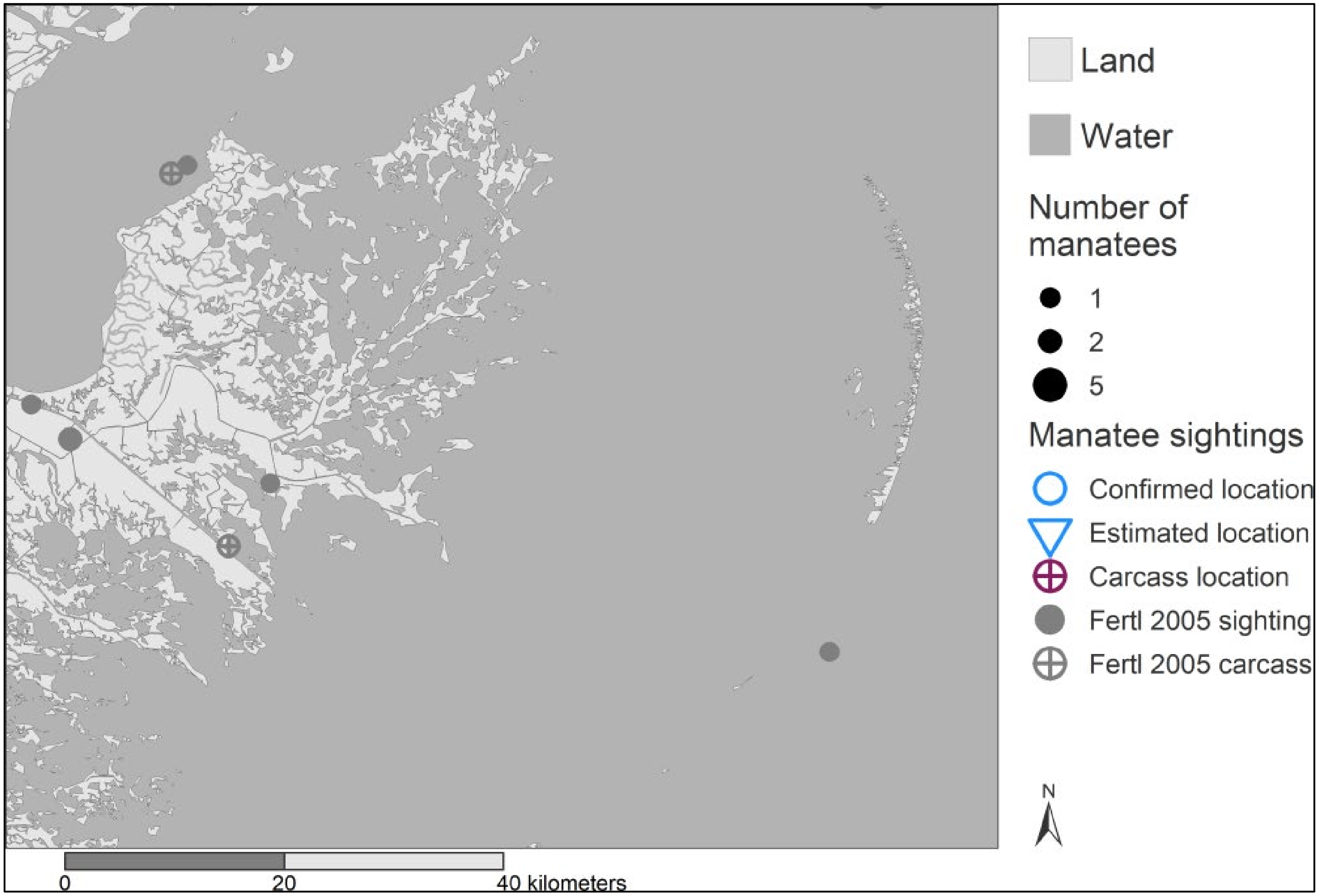

Figure 74. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points (none present here) were collected for this study; darker gray points were previously published in Fertl et al. (2005).

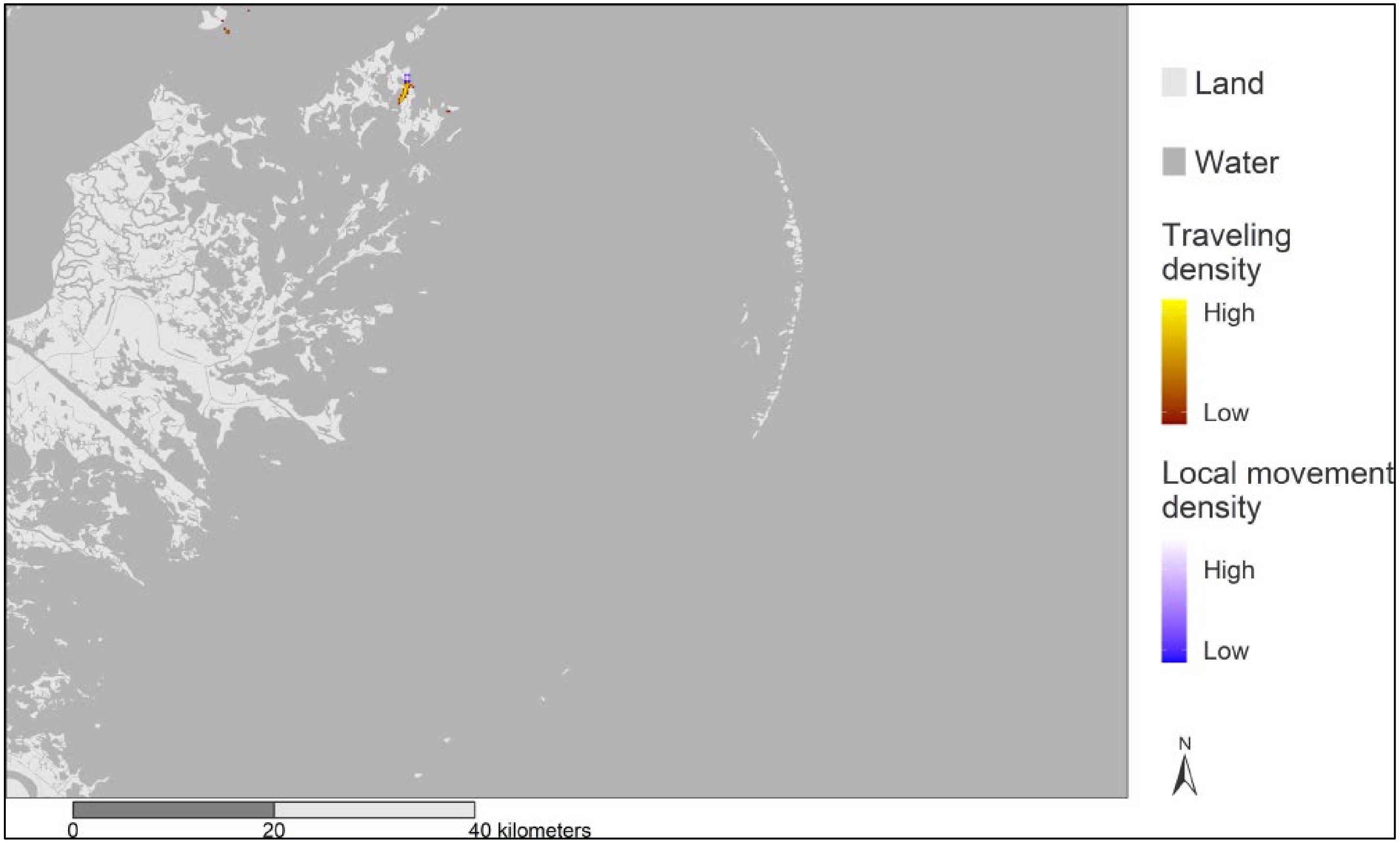

Figure 75. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region. Data for this region was limited; shown in upper left.

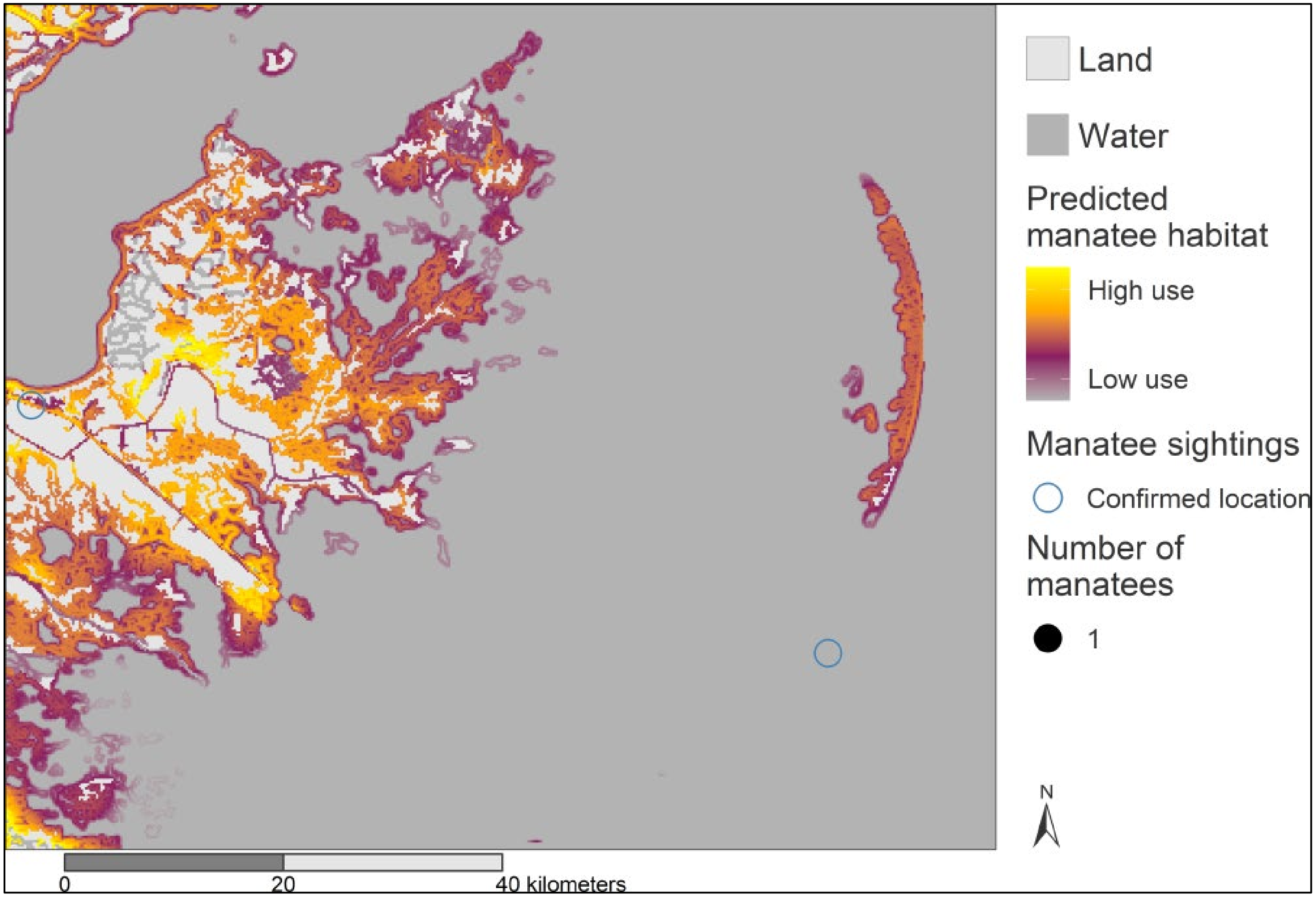

Figure 76. Habitat use prediction for the Chandeleur region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray.

3.5.1.10 New Orleans

The New Orleans region consists entirely of Lake Pontchartrain and Lake Maurepas to the west (Figure 77 through Figure 80). These freshwater lakes historically contained widespread submerged vegetation such as *Vallisneria americana, Potamogeton,* and *Najas* species, and also the cosmopolitan *Ruppia maritima* (Montz 1978). Throughout the 20th century, decreasing water clarity reduced the coverage of aquatic species to shallow fringes along the north and east shores (Cho and Poirrier 2005).

Manatee sightings have been consistently reported by the public along the north shore of Lake Pontchartrain, with a total of 53 animals from 43 reports (25 previously reported in [Fertl et al. 2005]), mostly of single animals (Figure 81). There were also carcasses reported in the lake in 2013 and 2014. Approximately half of the sightings were reported in the months of June and July, but all other months are represented, except for February and March. Sighting location included the canals, wetlands and bayous near Bayou Bonfouca, the lake shore, canals and bayous near Mandeville, and the Tchefuncta River. One of the tracked manatees (TCR-23) traveled the length of the north shoreline in late May 2015, reaching as far as Lake Maurepas (Figure 82). He visited each of the aforementioned locations, and also spent several hours in Bayou Laurier during both the trip out and the return leg. This was the farthest west that any of the tracked manatees traveled during the study, although another did travel as far west as the entrance to Lake Pontchartrain in July 2014. Additional sighting locations around Lake Pontchartrain include Lake Maurepas (1 sighting), Natalbany River (2), Henry River (2), Blind River (3), and also canals between Lake Pontchartrain and the Mississippi River (4).

Predicted manatee use in the New Orleans region was consistent with the sightings history and telemetry records (Figure 83), showing highest habitat compatibility along the northern shore of Lake Pontchartrain, the tributaries between Lake Pontchartrain and Lake Maurepas, and the tributaries between Lake Pontchartrain and the Mississippi Sound.

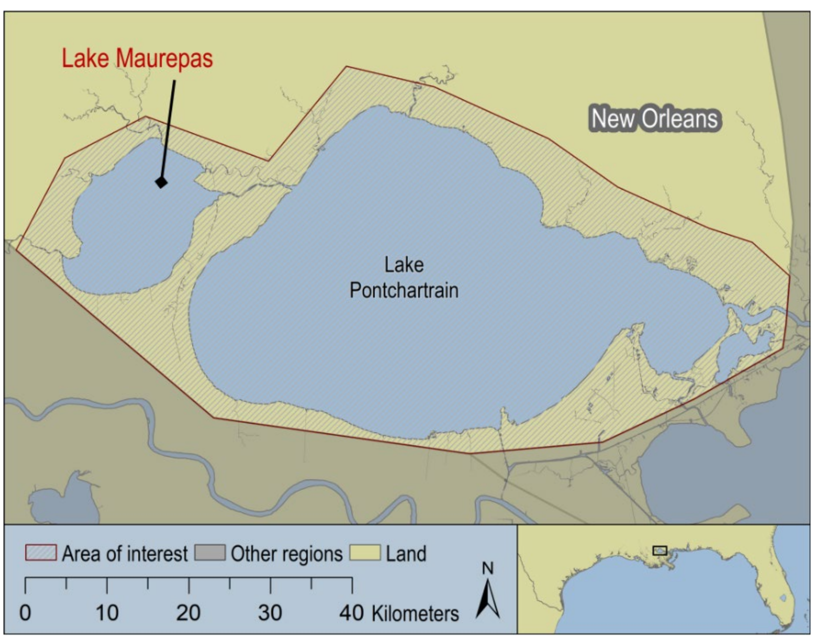

Figure 77. The New Orleans region, comprising Lake Pontchartrain and Lake Maurepas.

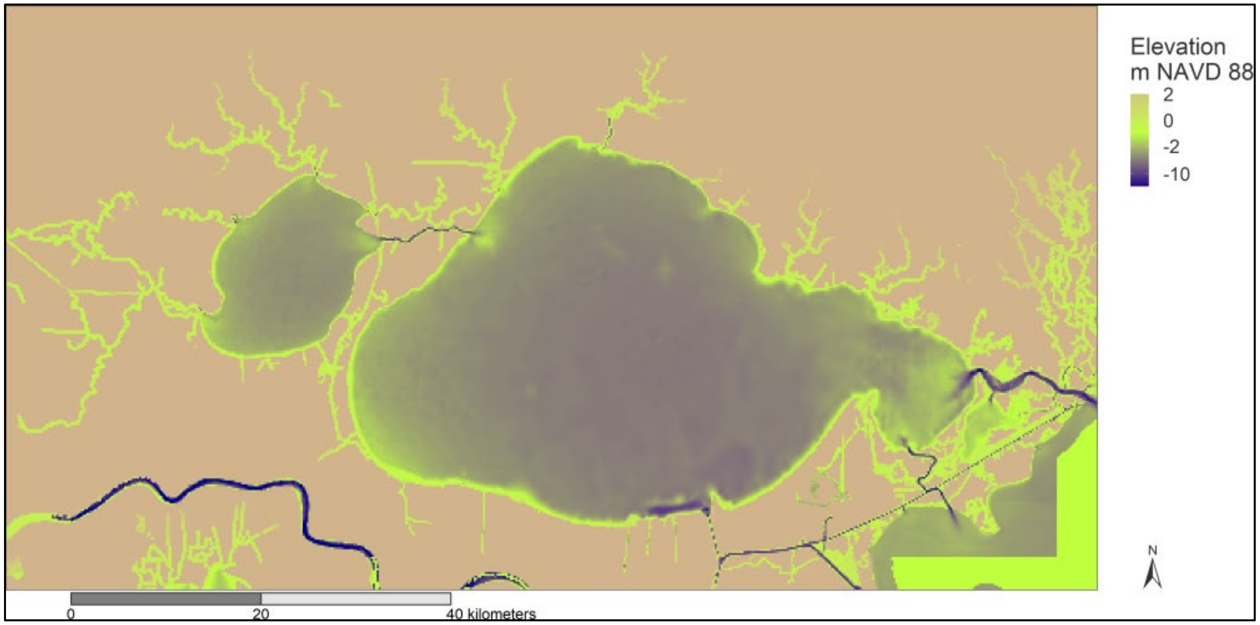

Figure 78. Digital elevation model of the New Orleans region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (violet-dark blue).

Data compiled from NOAA sources; see text for details.

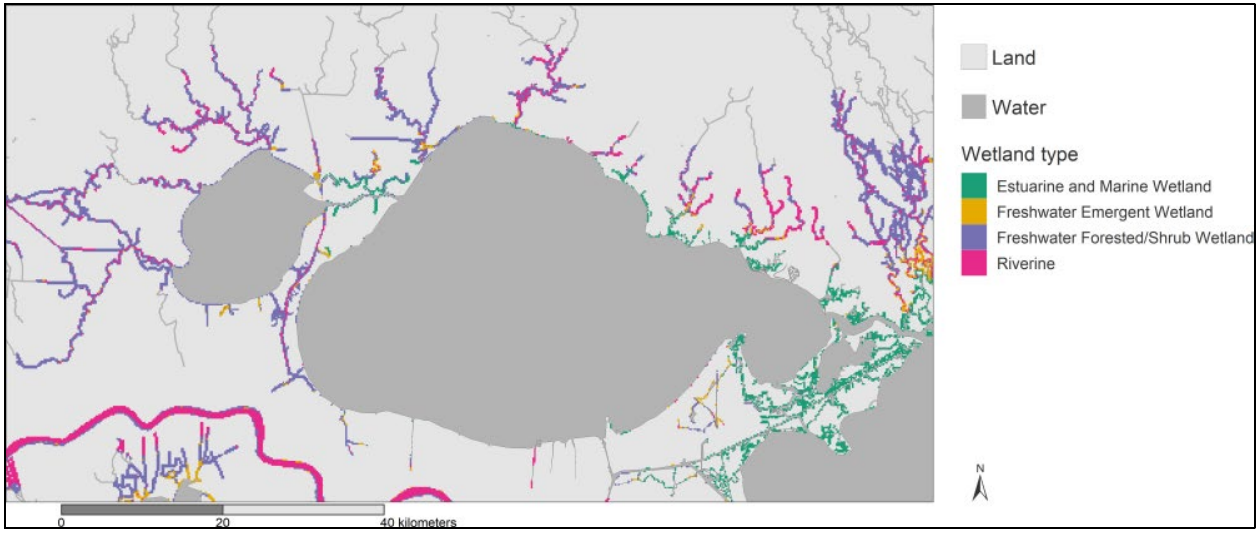

Figure 79. Wetland types and locations within the New Orleans region.

Modified from US Fish and Wildlife Service (2016).

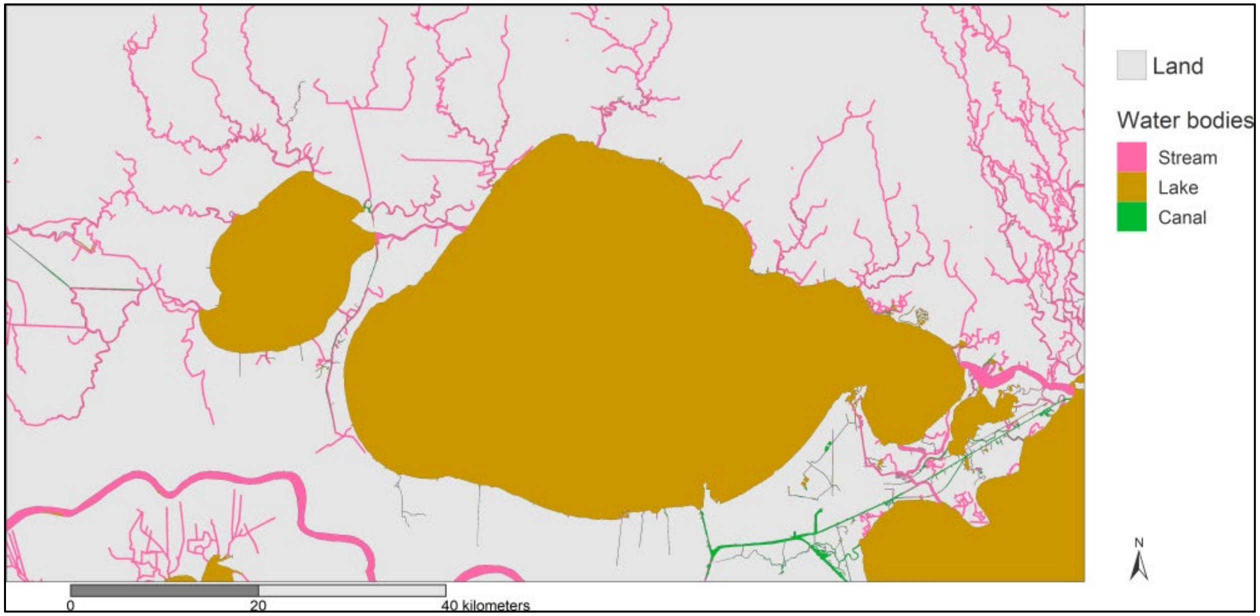

Figure 80. Water bodies of the New Orleans region.

Modified from Tele Atlas North America, Inc. (2010).

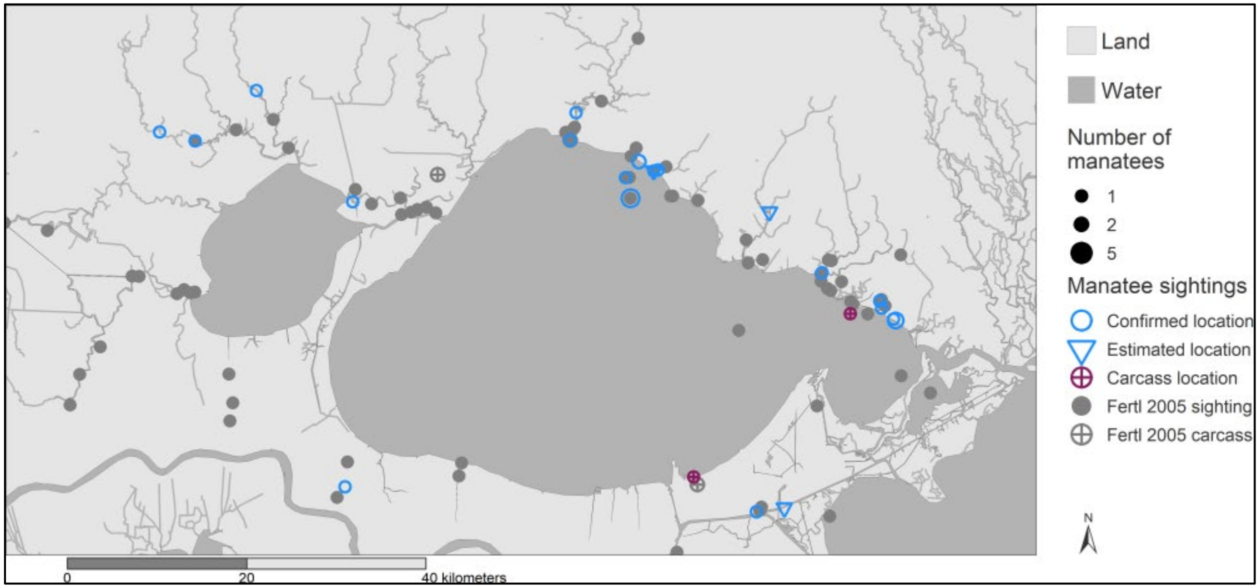

Figure 81. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; gray points were previously published in Fertl et al. (2005).

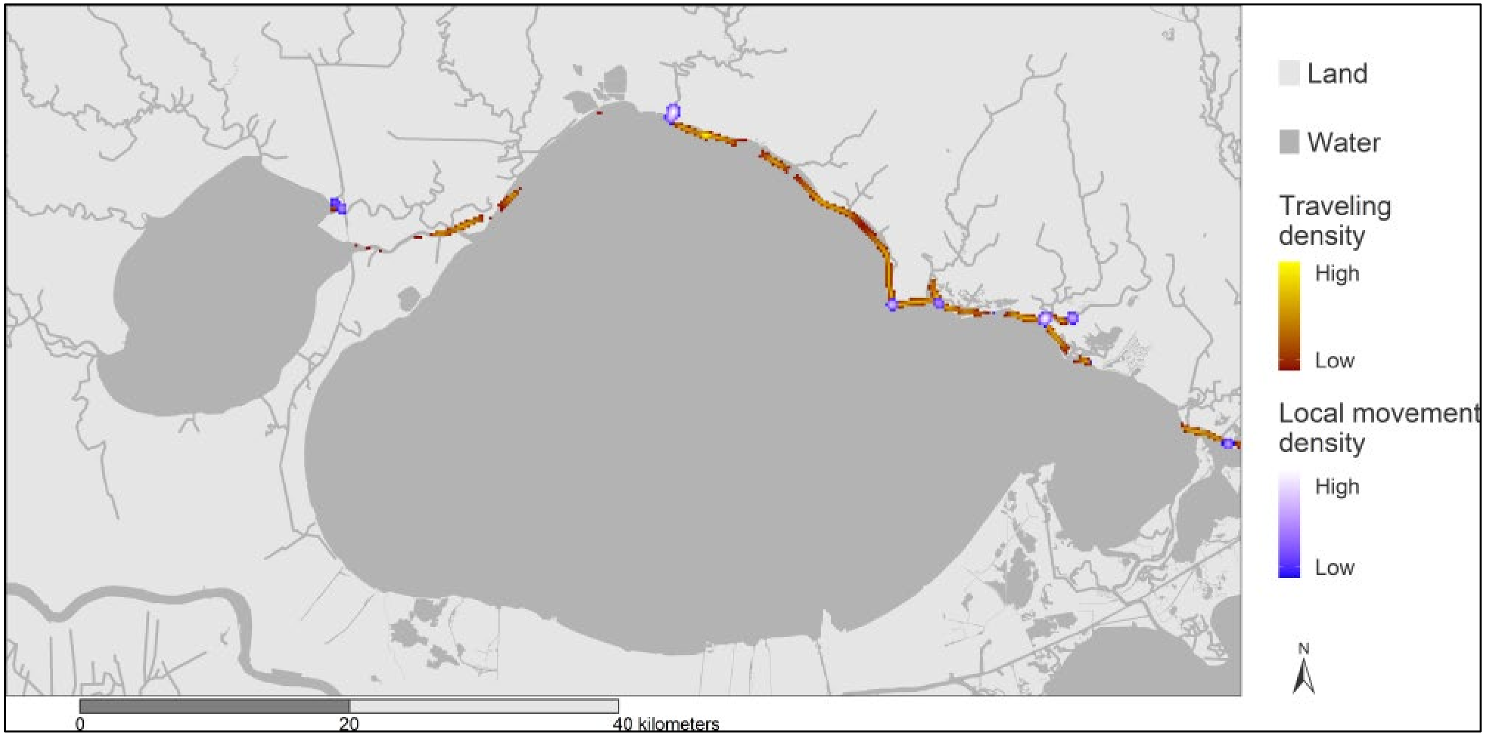

Figure 82. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

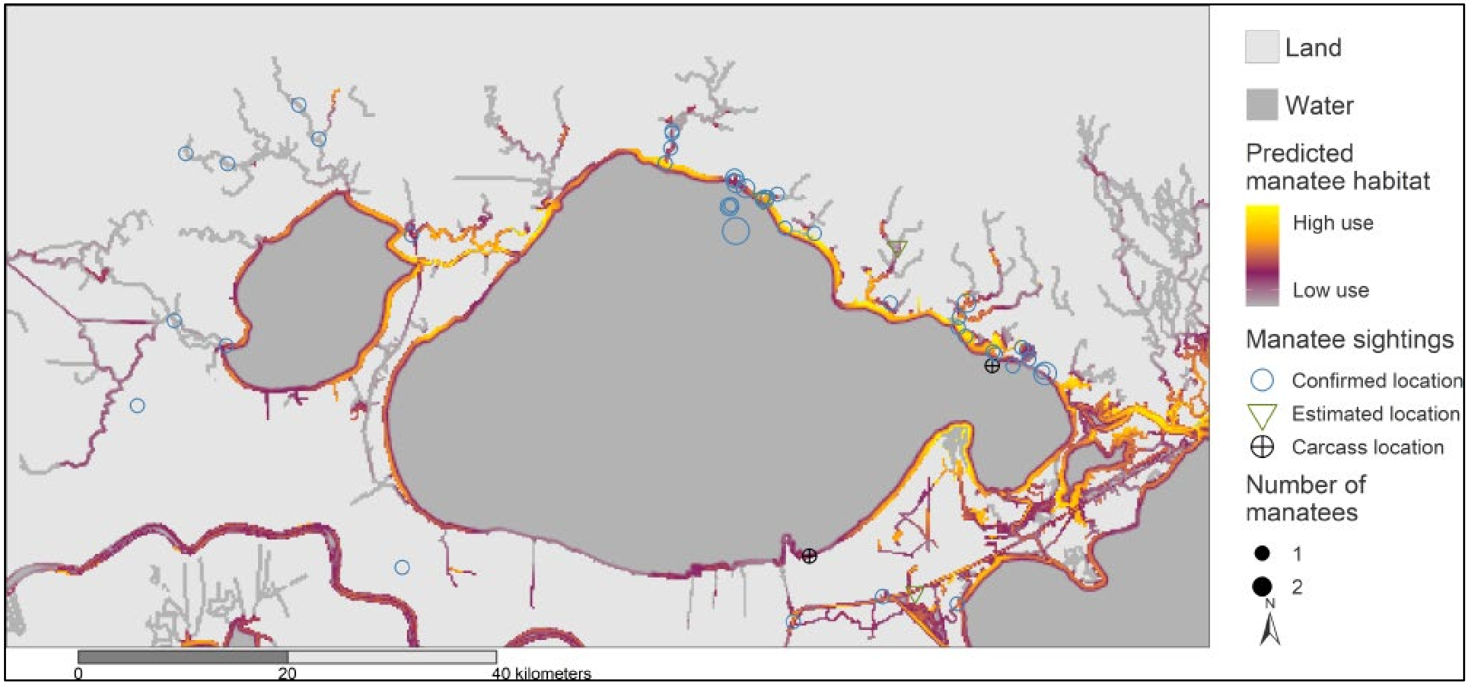

Figure 83. Habitat use prediction for the New Orleans region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray.

3.5.1.11 Diamondhead

The Diamondhead region lies immediately east of Lake Pontchartrain (Figure 84 through Figure 85). The waters of this region are fresh in Lake Borgne and begin to grade to brackish in the Mississippi Sound. Bay St. Louis in Mississippi is to the north. *Eleocharis*, *Sagitaria*, *Spartina*, and *Phragmites* species are found along the Mississippi coastline, including Bay St. Louis (Peterson and Partyka 2006; Merino et al. 2009).

Manatee sightings in the Diamondhead region are concentrated along the shoreline, within Bay St. Louis, and in the tributaries of the bay (Figure 88). Telemetry records also show a strong traveling pathway along the northern shore, with habitat use spots in the tributary to Lake Pontchartrain and near the entrance of Bay St. Louis (Figure 89). A travel path along the eastern shore of the bay shows that the tracked manatees did access the bay and tributaries on multiple occasions.

Predicted manatee habitat for the Diamondhead region corresponds well to the patterns seen in the sighting and telemetry data. The strongest signal was found along the eastern shore of Bay St. Louis, where several sightings and a travel path were found (Figure 90). Another strong signal was seen in the tributary to Lake Pontchartrain, where sightings and telemetry habitat use signals were recorded. The lack of predicted habitat along the north shore of Mississippi Sound is consistent with the strong travel path recorded from the telemetry data, indicating that manatees were not stopping there, and only passing through.

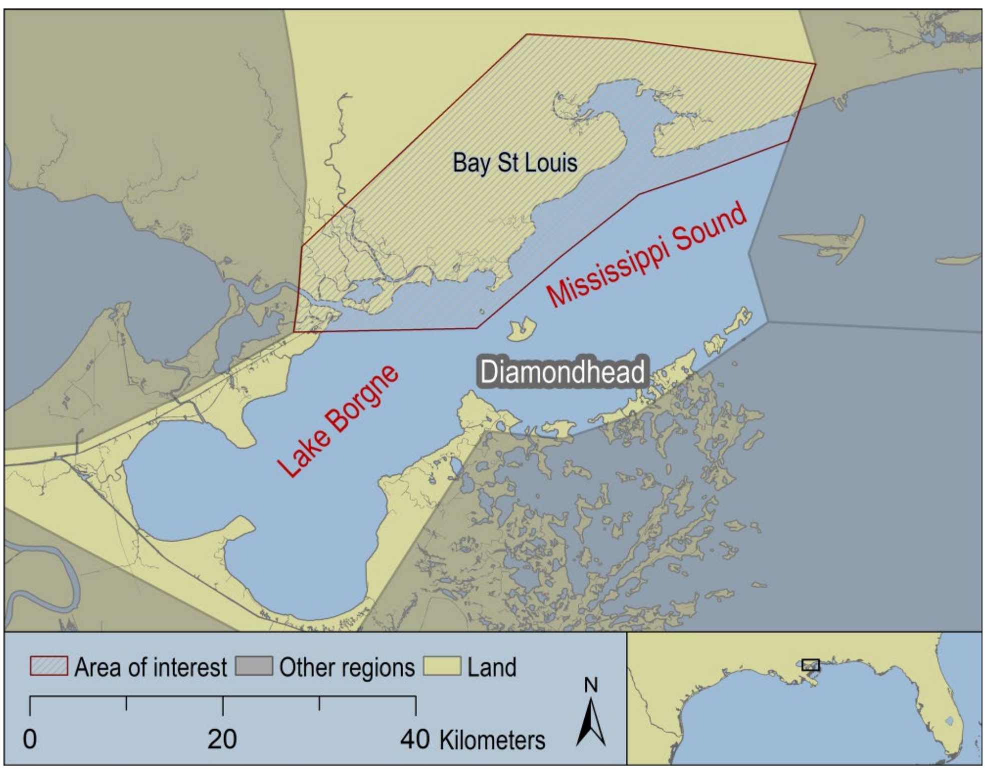

Figure 84. The Diamondhead region, from Lake Borgne to the start of the Mississippi Sound.

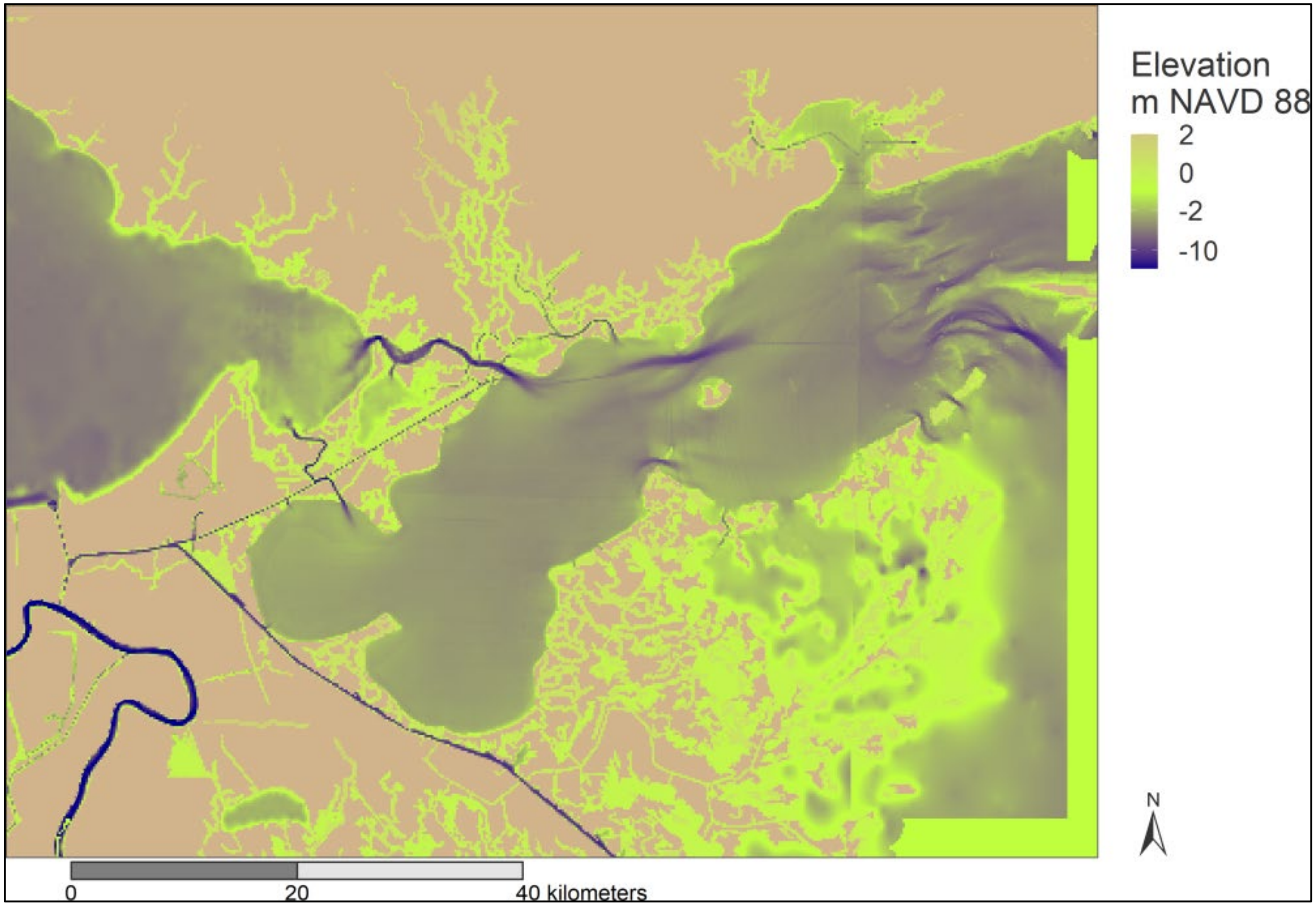

Figure 85. Digital elevation model of the Diamondhead region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (violet).

Data compiled from NOAA sources; see text for details.

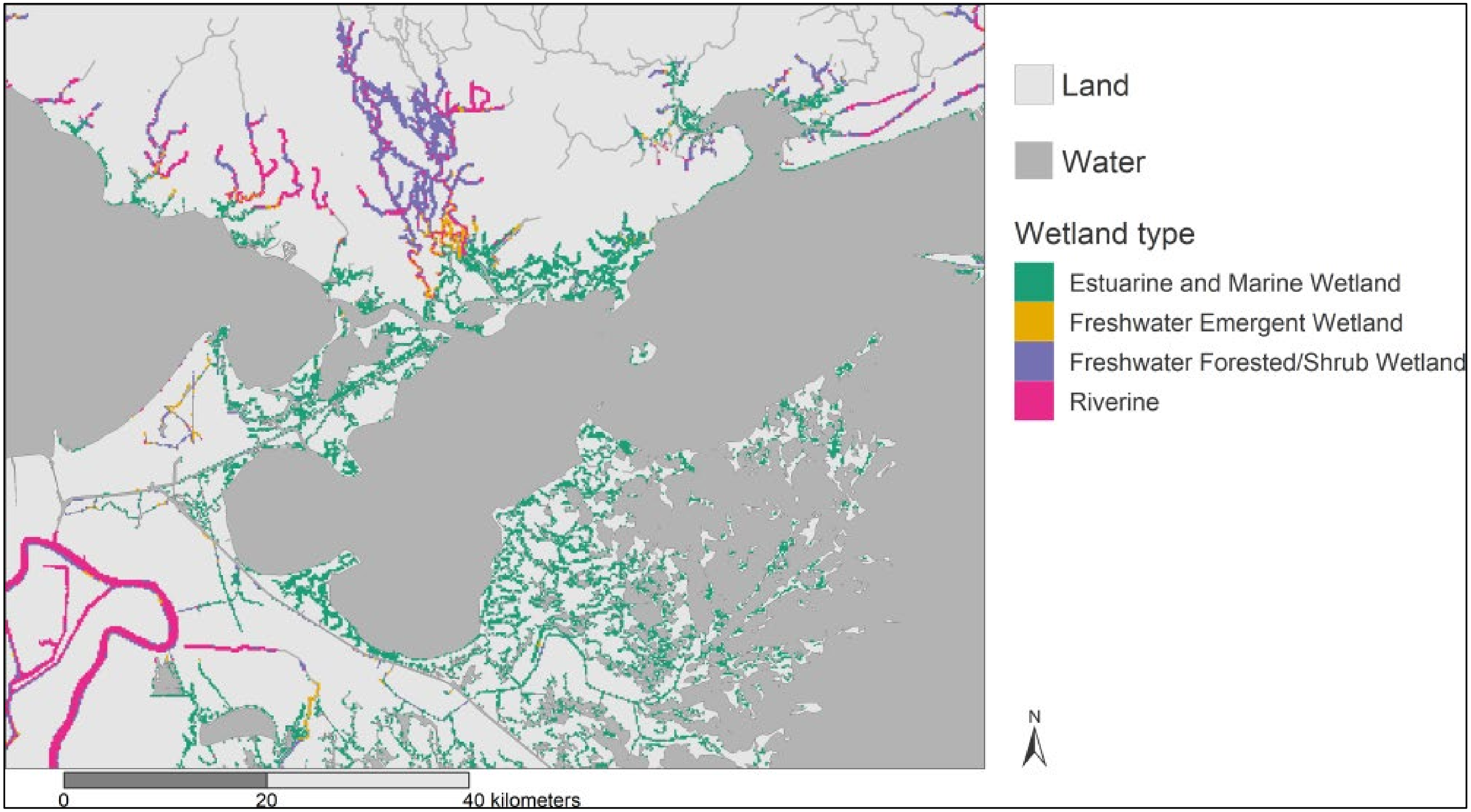

Figure 86. Wetland types and locations within the Diamondhead region.

Modified from US Fish and Wildlife Service (2016).

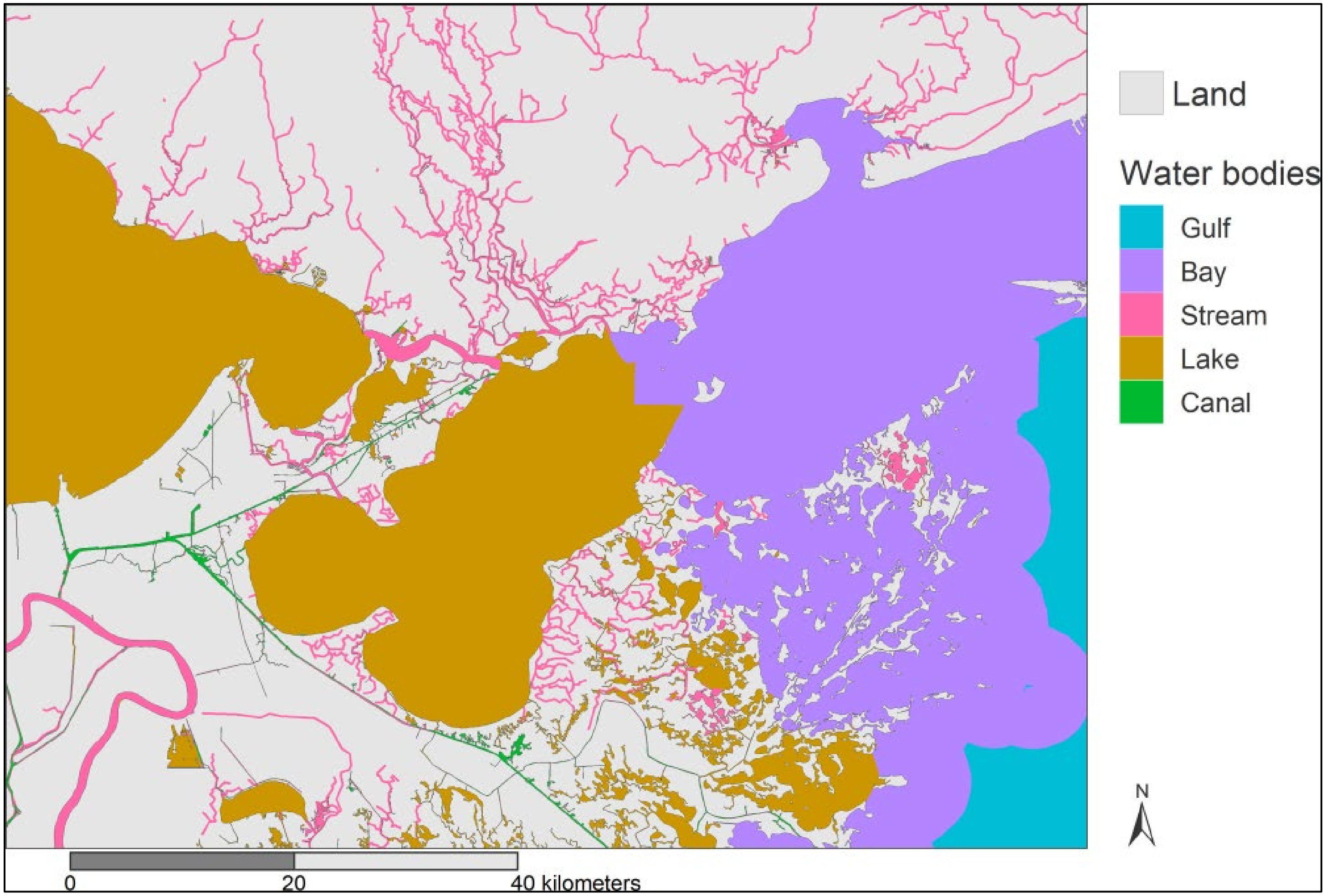

Figure 87. Water bodies of the Diamondhead region.

Modified from Tele Atlas North America, Inc. (2010).

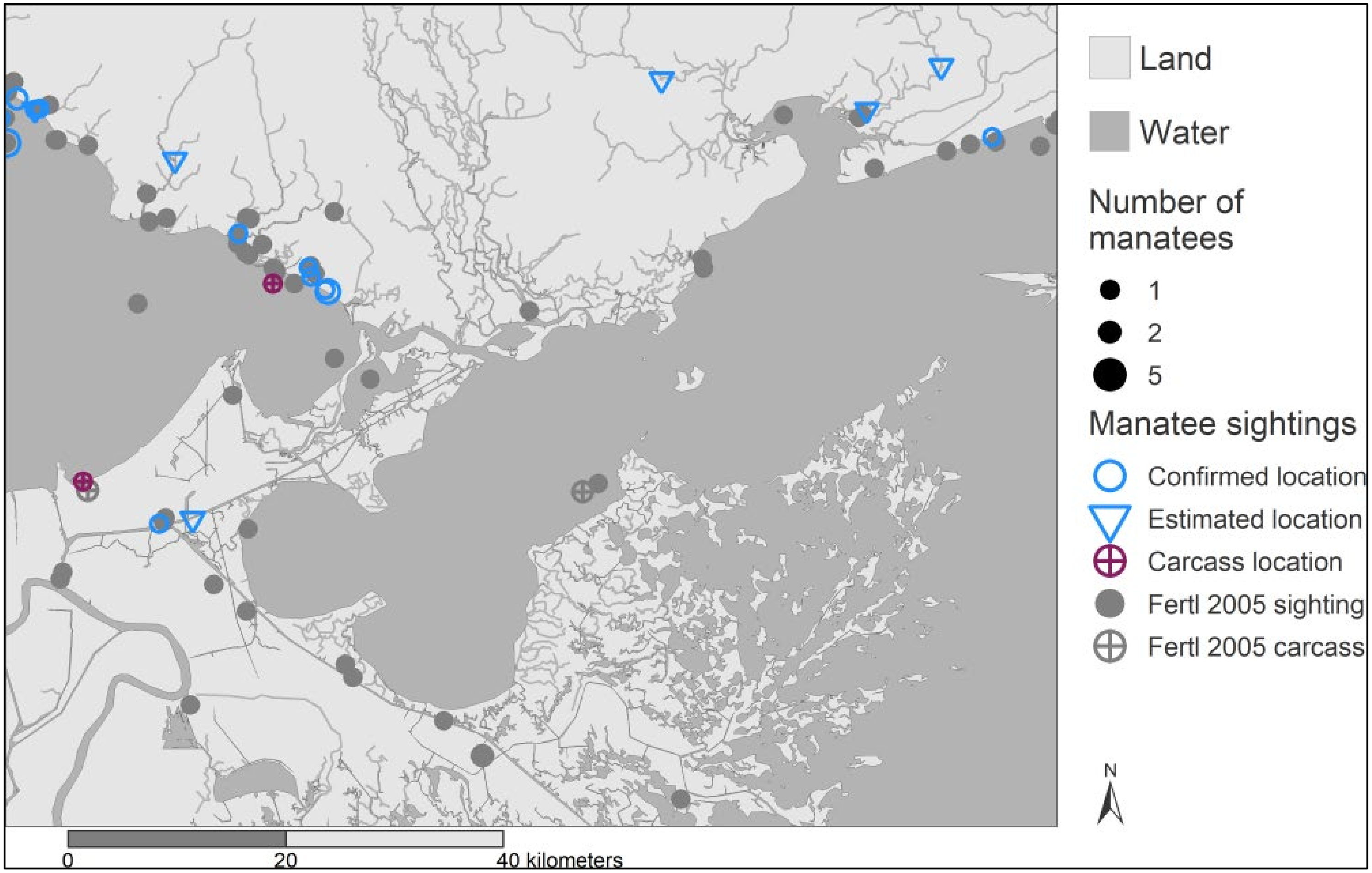

Figure 88. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; darker gray points were previously published in Fertl et al. (2005).

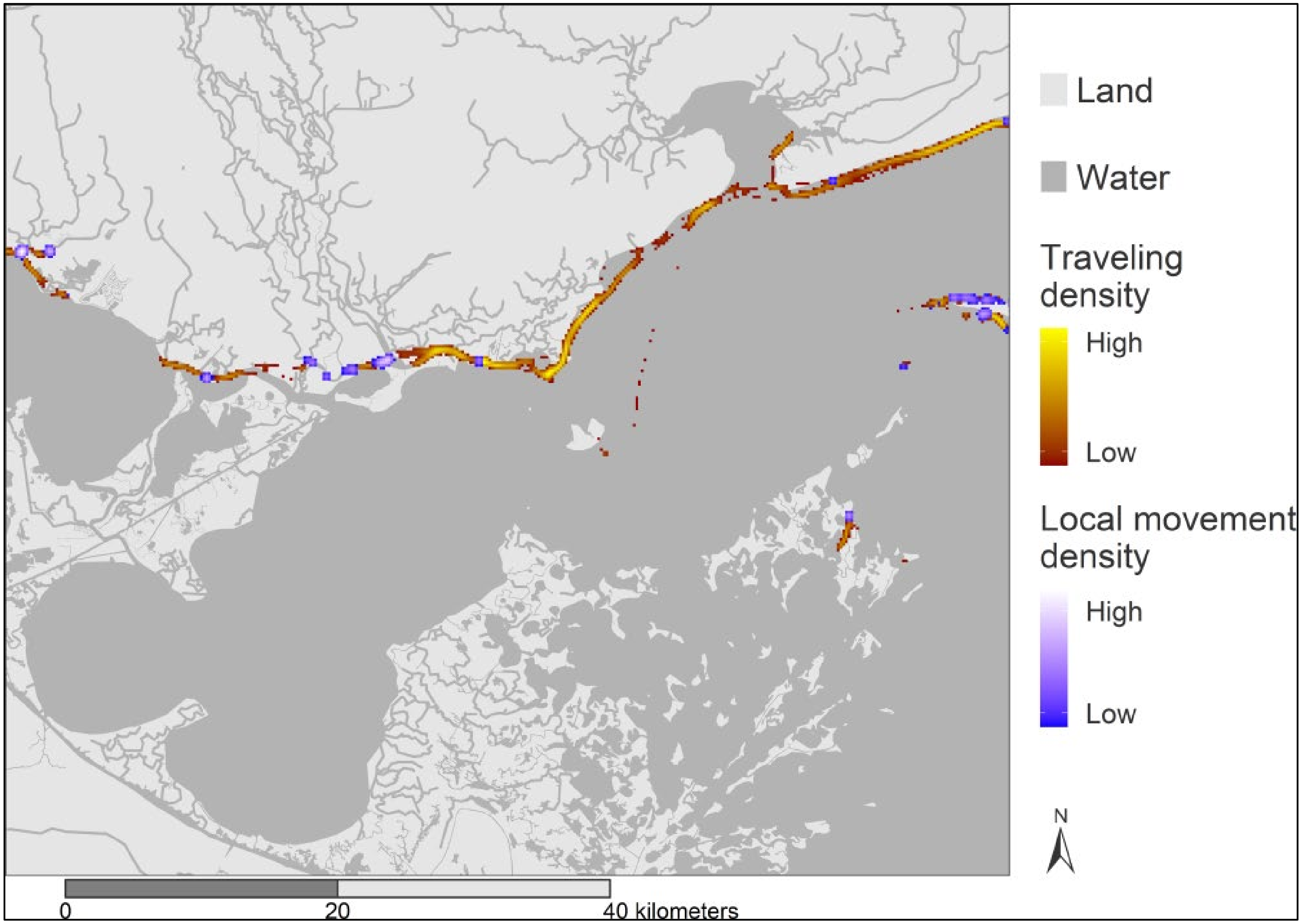

Figure 89. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

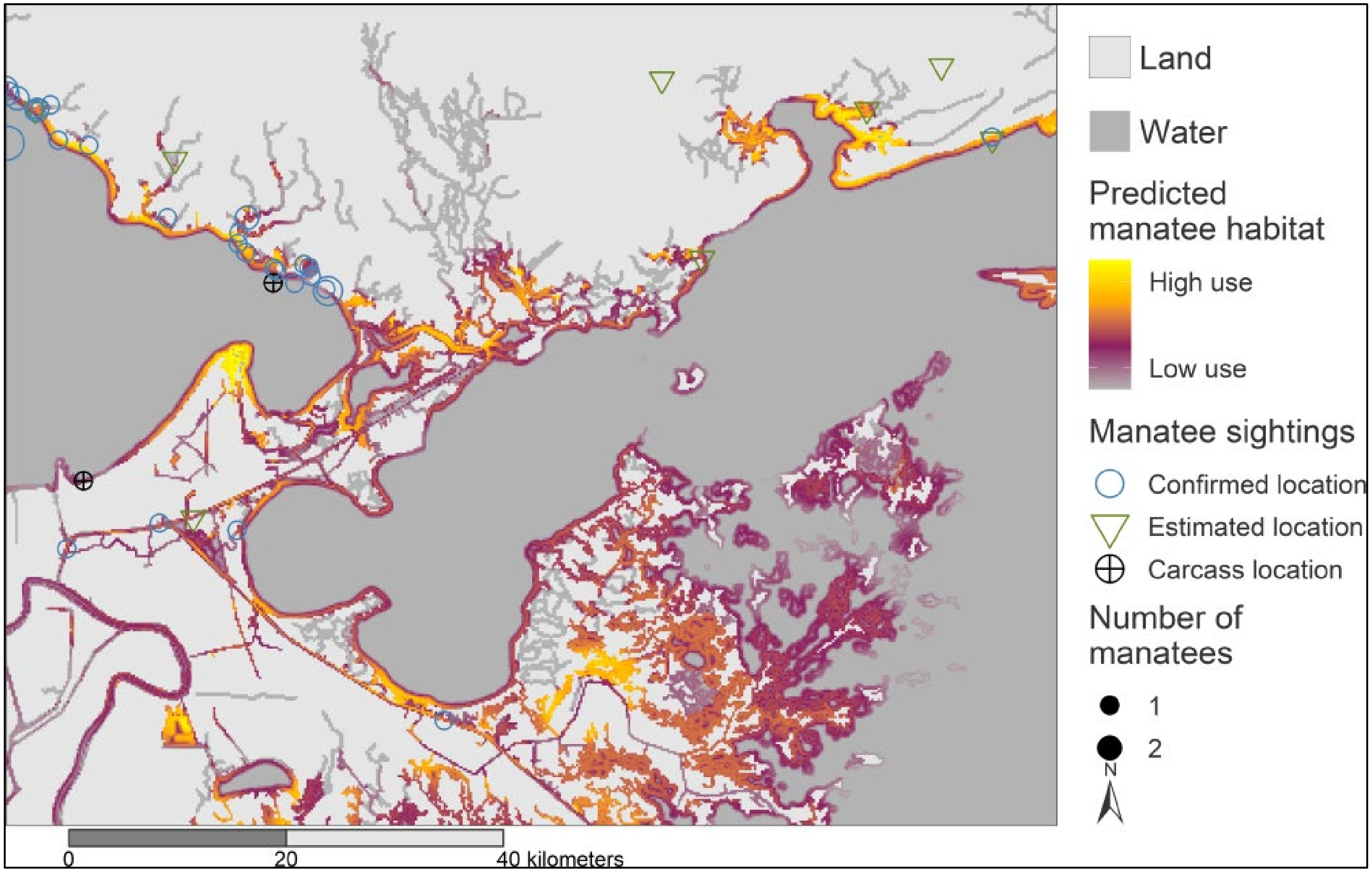

Figure 90. Habitat use prediction for the Diamondhead region with manatee sightings.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray.

3.5.1.12 Biloxi

The Biloxi region contains Biloxi Bay to the north and Mississippi barrier islands Cat Island and Ship Island to the south (Figure 91 through 92). The Mississippi Sound is the protected water between the coast and the islands. *Eleocharis* and *Sagitaria* marshes and *Ruppia maritima* can be found along the coastline (Merino et al. 2009; Pham et al. 2014), while *Halodule wrightii* can be found on the protected side of the islands (Pham et al. 2014).

Compared to the Diamondhead region, manatee sightings for the Biloxi region show more locations offshore, as well as along the north shore of the Mississippi Sound, within Biloxi Bay, and in tributaries to the bay (Figure 95). Kernel density analysis of the telemetry travel path shows only traveling movements along the north shore and near Cat and Ship barrier islands (Figure 96), except for a small area on the north shore of Cat Island. Within Biloxi Bay, habitat use areas were seen in the tributaries leading into the bay, and in the center of the bay itself. These areas are associated with identified wetland habitat.

Starting with the Biloxi region, the predictive habitat model output is plotted with quantiles of the telemetry kernel density analysis (see section 2.6.3; Figure 97). The predicted habitat here matches the quantiles well, with hotspots located in the estuaries of Biloxi Bay, and medium use predicted for Cat Island (Figure 97). Ship Island was also used by manatees, but was not included in the predictive model as a use area. The shallow shelf and wetland habitat around Ship Island is smaller than those of Cat Island, which likely contributed to the discrepancy.

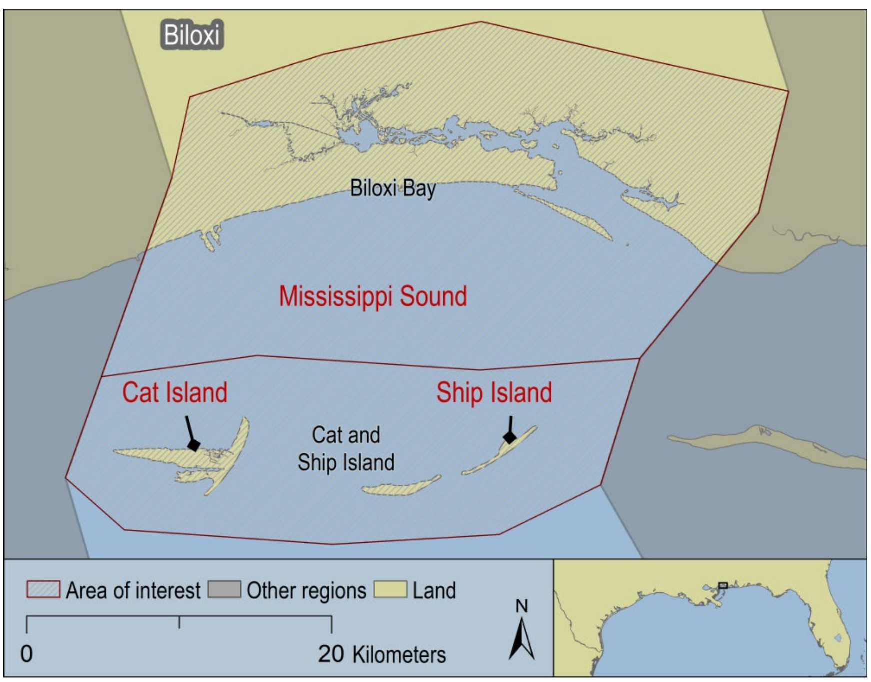

Figure 91. The Biloxi region, with Biloxi Bay to the north, the Mississippi Sound in the center, and barrier islands to the south.

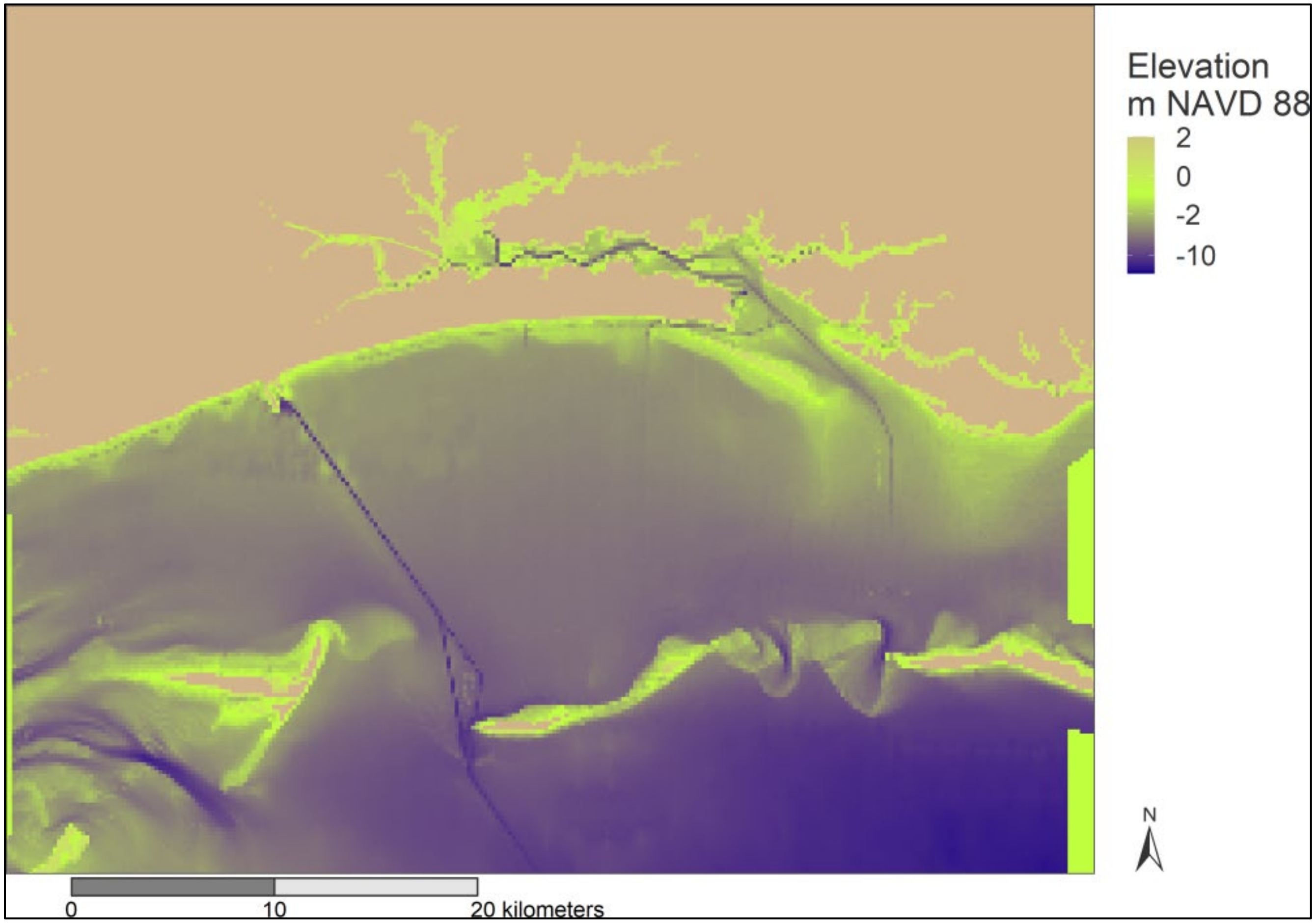

Figure 92. Digital elevation model of the Biloxi region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

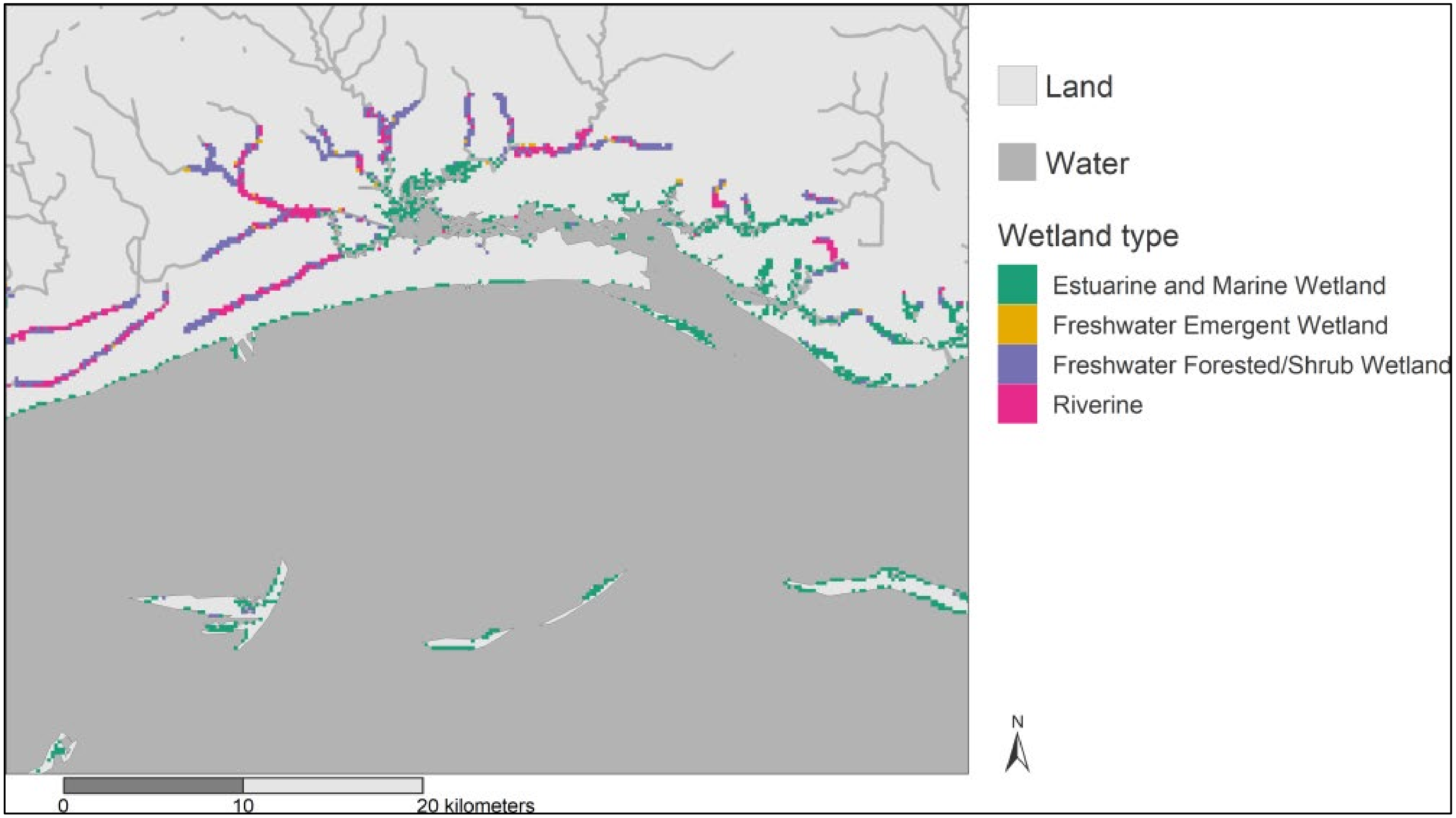

Figure 93. Wetland types and locations within the Biloxi region.

Modified from US Fish and Wildlife Service (2016).

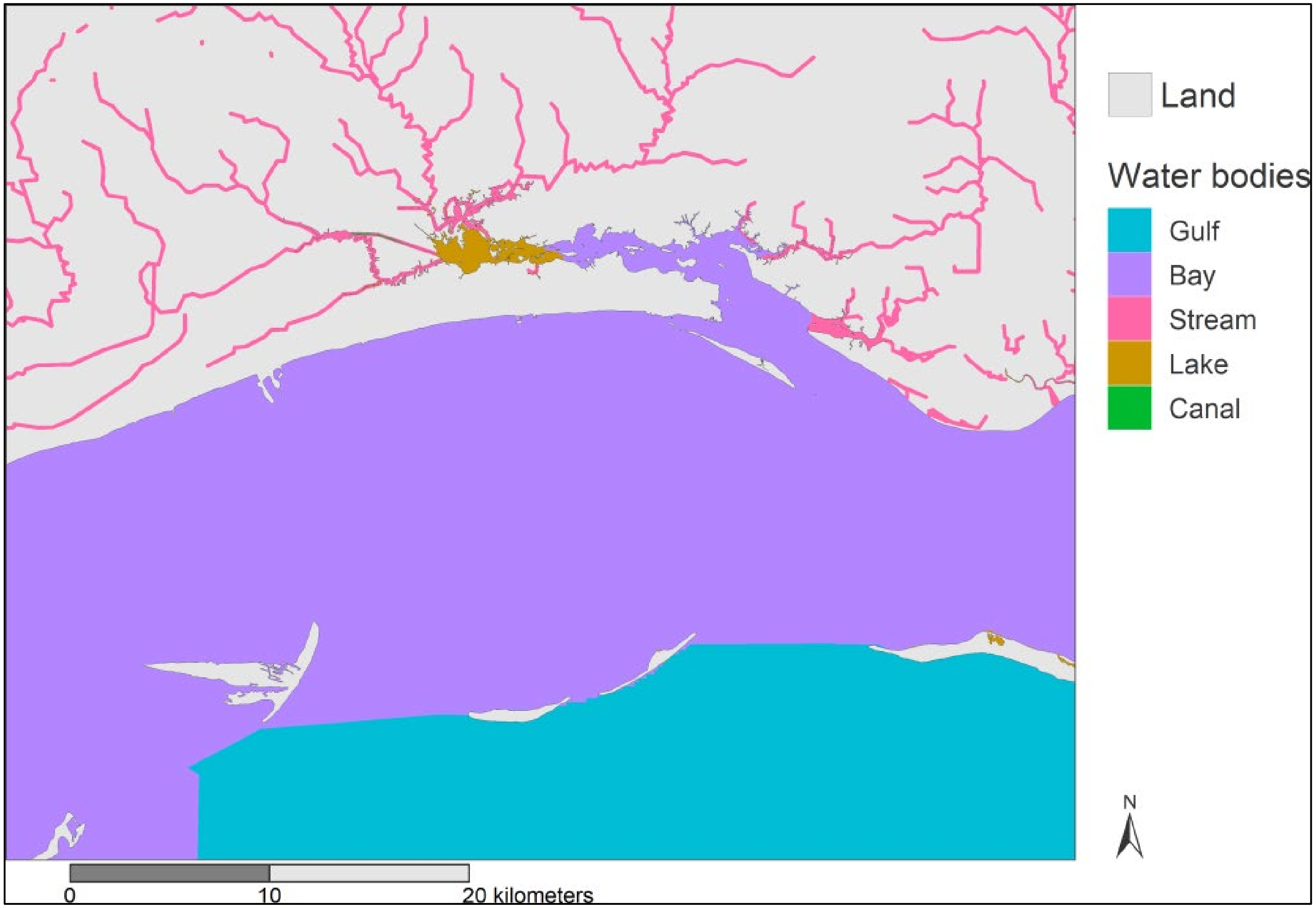

Figure 94. Water bodies of the Biloxi region.

Modified from Tele Atlas North America, Inc. (2010).

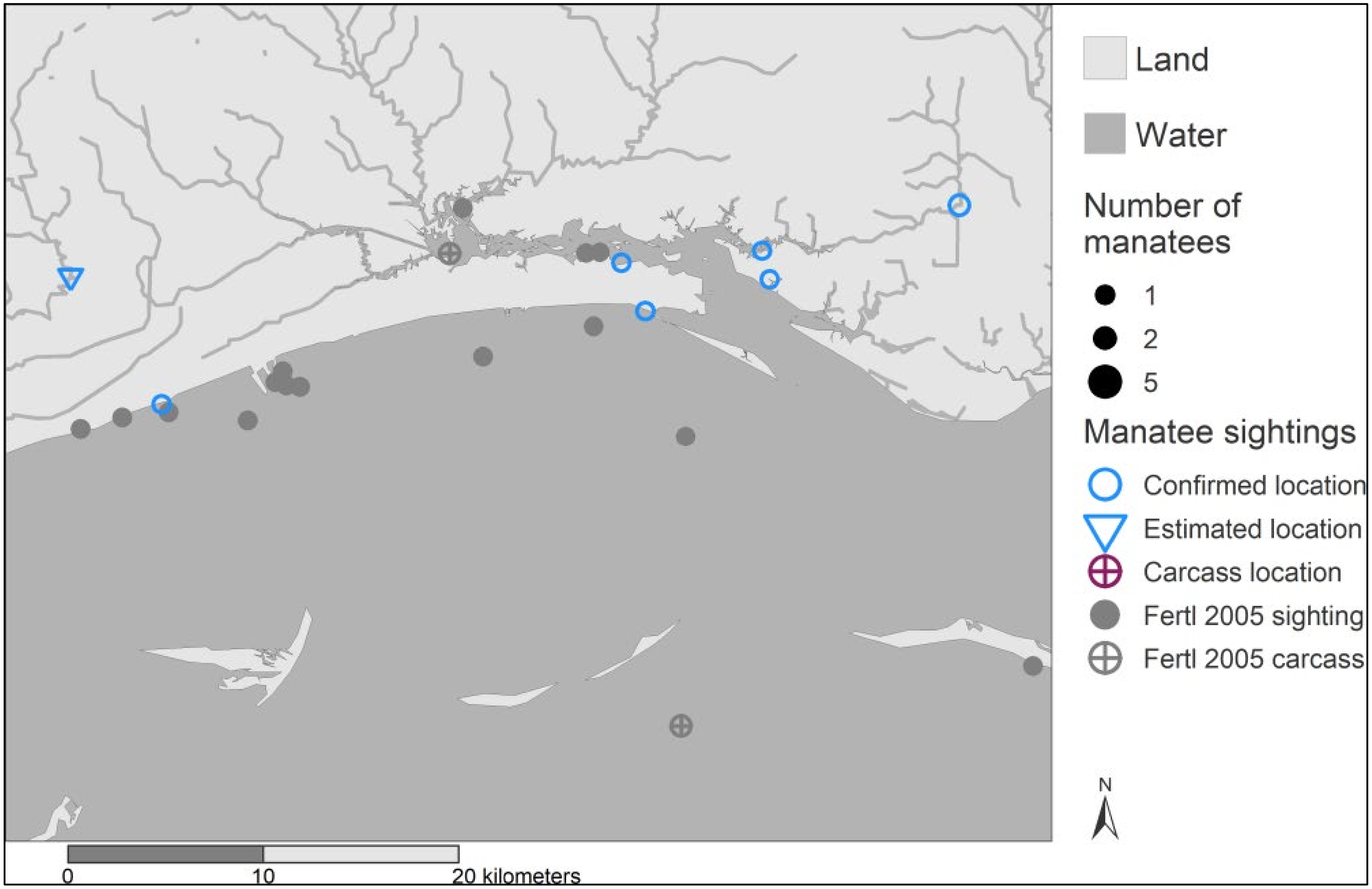

Figure 95. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; darker gray points were previously published in Fertl et al. (2005).

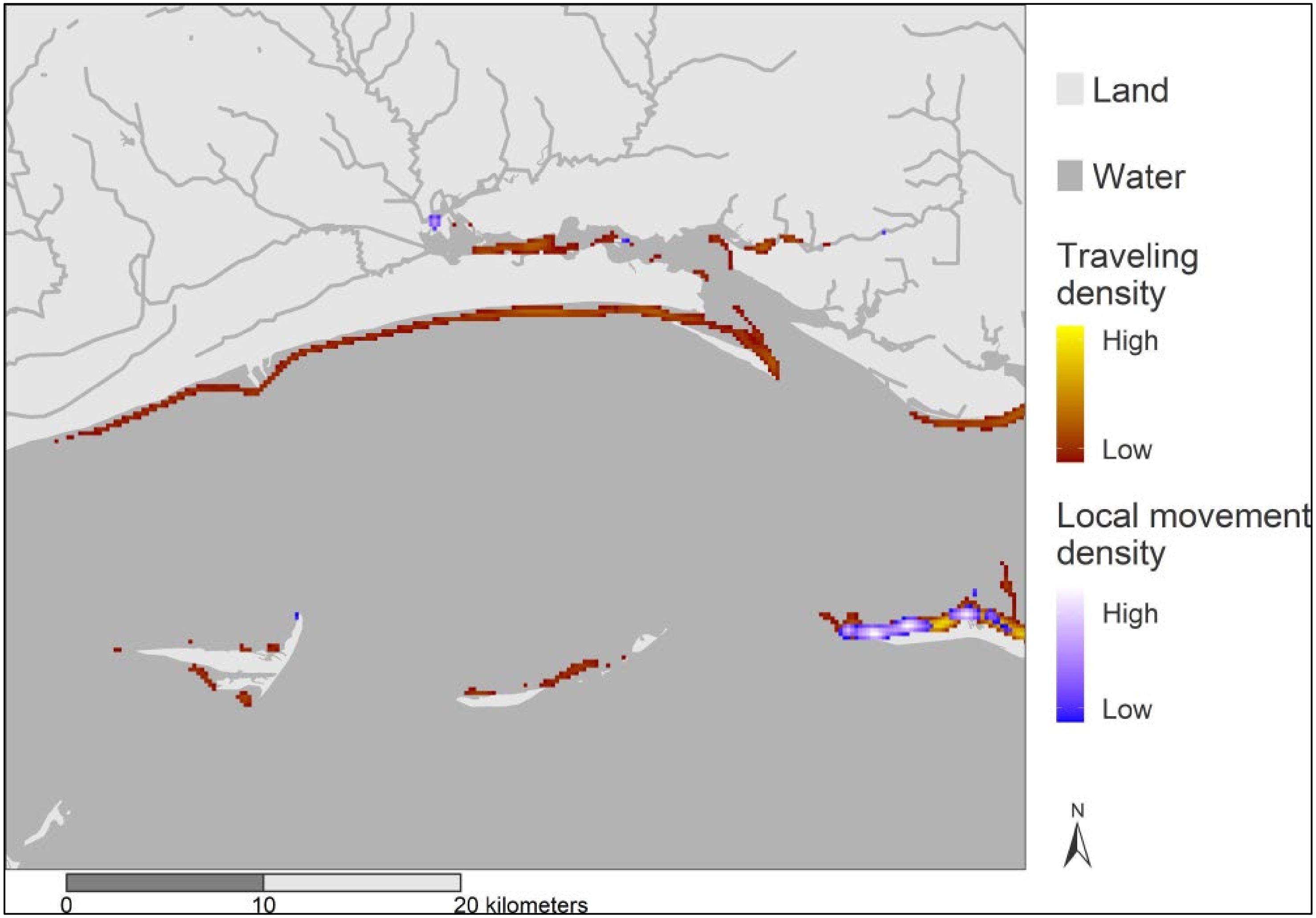

Figure 96. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

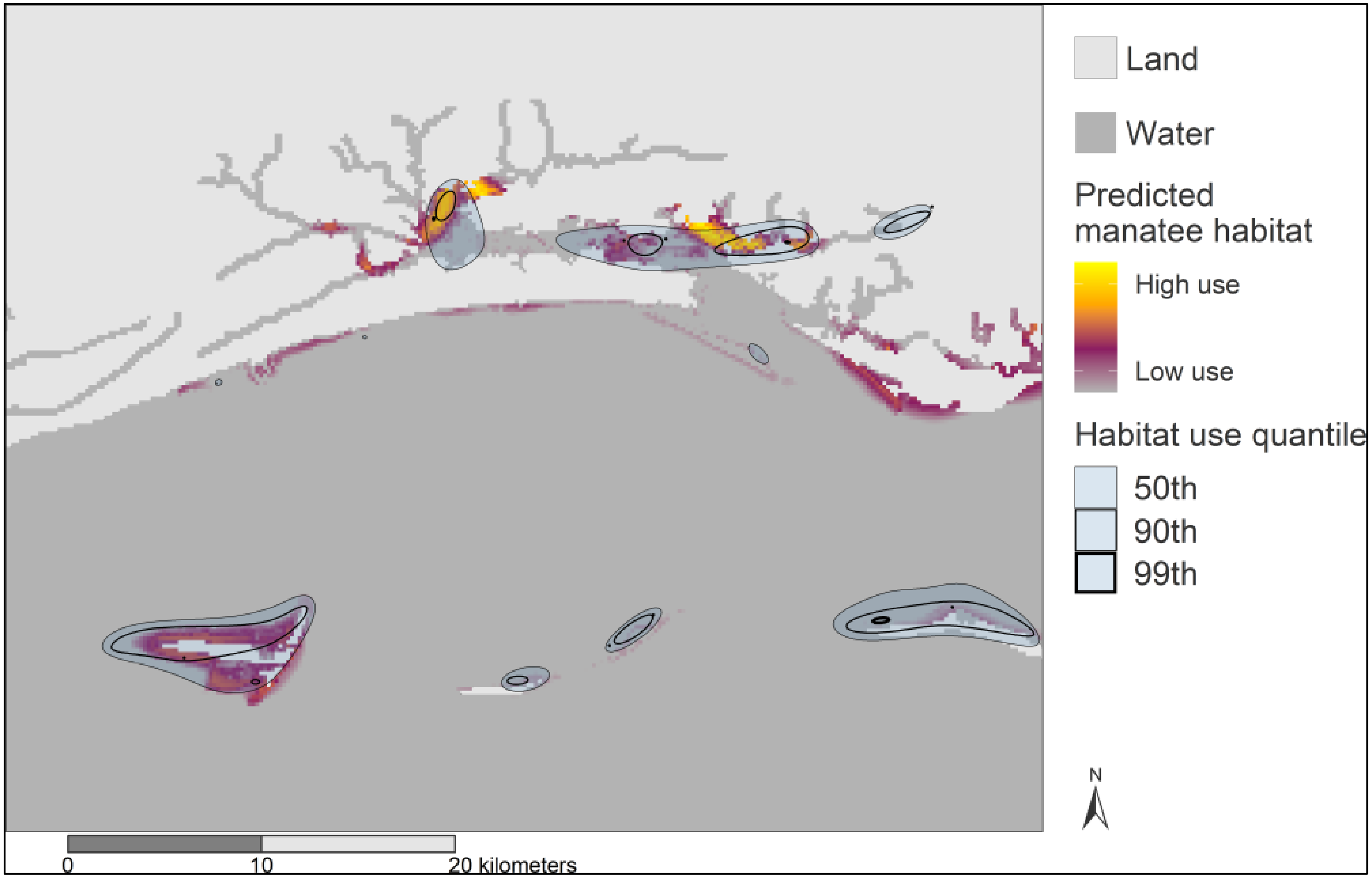

Figure 97. Habitat use prediction for the Biloxi region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.13 Pascagoula

The Pascagoula region (Figure 98 through Figure 99) is similar to the Biloxi region to the west in that it contains part of the Mississippi Sound. The Pascagoula River and Grand Bay lie to the north along the Mississippi and Alabama coastline, and a line of barrier islands protect the waters of the Sound. The Pascagoula River is a complex, braided estuary that maintains freshwater out into the sound; Grand Bay has little freshwater flow and remains brackish to marine. Abundant and diverse freshwater vegetation communities are found in the Pascagoula system, including *Najas*, *Vallisneria*, *Potamogeton* and *Myriophyllum* species (Cho et al. 2010), and Grand Bay shares aquatic communities with the Barrier islands, including *Halodule wrightii* and *Ruppia maritima* (Cho and May 2008; Pham et al. 2014).

Manatee sightings in the Pascagoula region were few in the earlier Fertl et al. (2005) report, but we encountered many times that number in the time that we collected for the current study (Figure 102). This may represent an increase in relative use of this region, especially the Pascagoula river system, assuming that the relative chance of human-manatee encounters did not dramatically increase here relative to other regions. Telemetry records also showed that the western branch of the Pascagoula River was an intense habitat use hotspot (Figure 103), with travel paths offshore to Horn Island, and a heavy travel path along the north shore of Mississippi Sound to Grand Bay, and into the Fowl River.

The highest probability of predicted habitat was in the western branch of the Pascagoula River, matching the telemetry records (Figure 104). The eastern branch of the river is deeper that the western, and more heavily traveled by watercraft. Similar to the Biloxi region, the predicted use of the barrier islands was less than the actual habitat use where the shallow shelf and associated wetland habitat was narrow (Figure 100). The wetlands of Grand Bay were also correctly indicated as manatee use habitat.

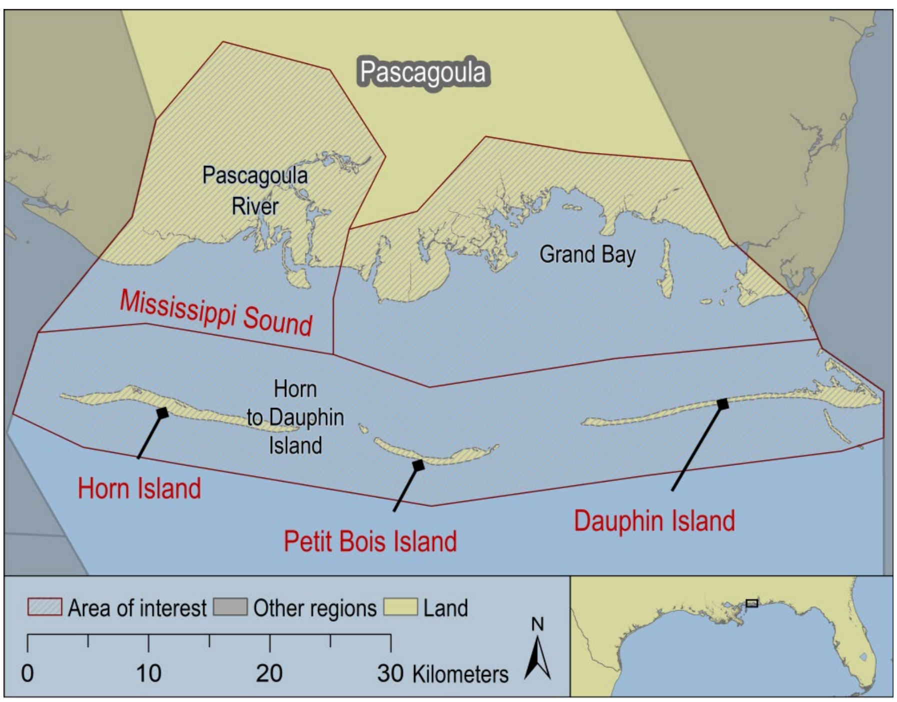

Figure 98. The Pascagoula region, with the Pascagoula River and Grand Bay to the north, and barrier islands to the south.

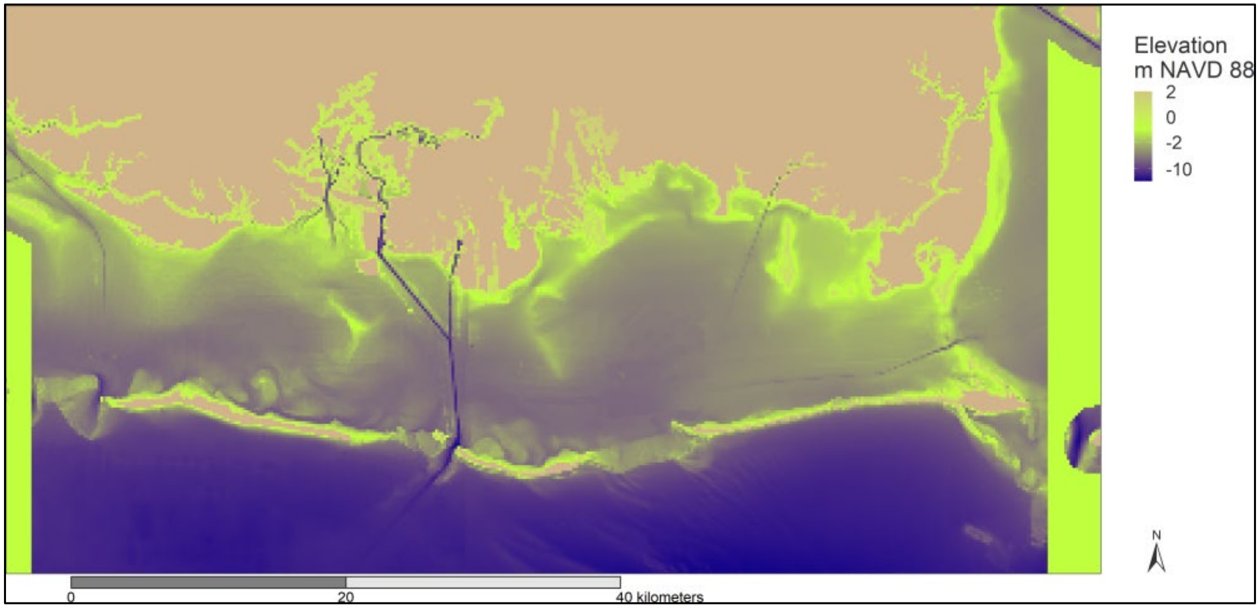

Figure 99. Digital elevation model of the Pascagoula region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

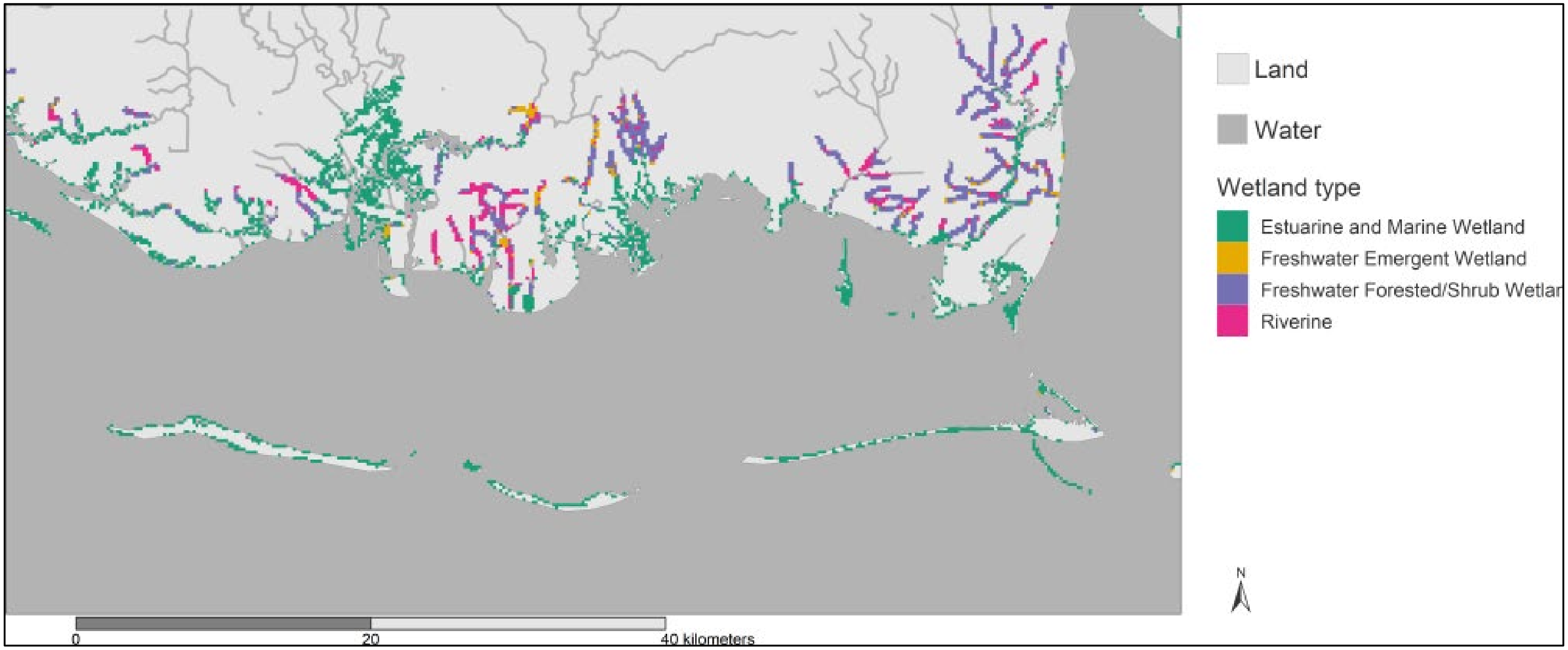

Figure 100. Wetland types and locations within the Pascagoula region.

Modified from US Fish and Wildlife Service (2016).

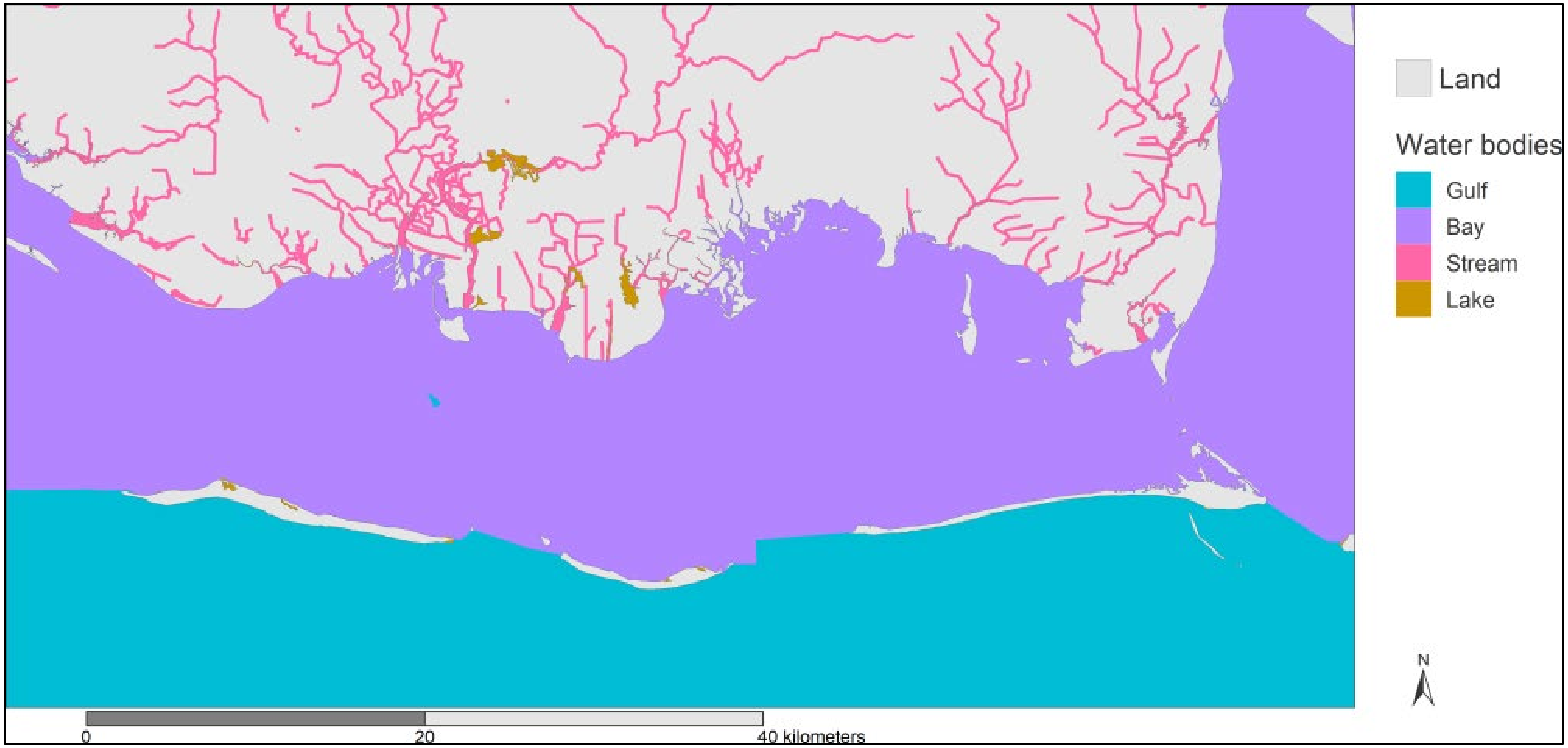

Figure 101. Water bodies of the Pascagoula region.

Modified from Tele Atlas North America, Inc. (2010).

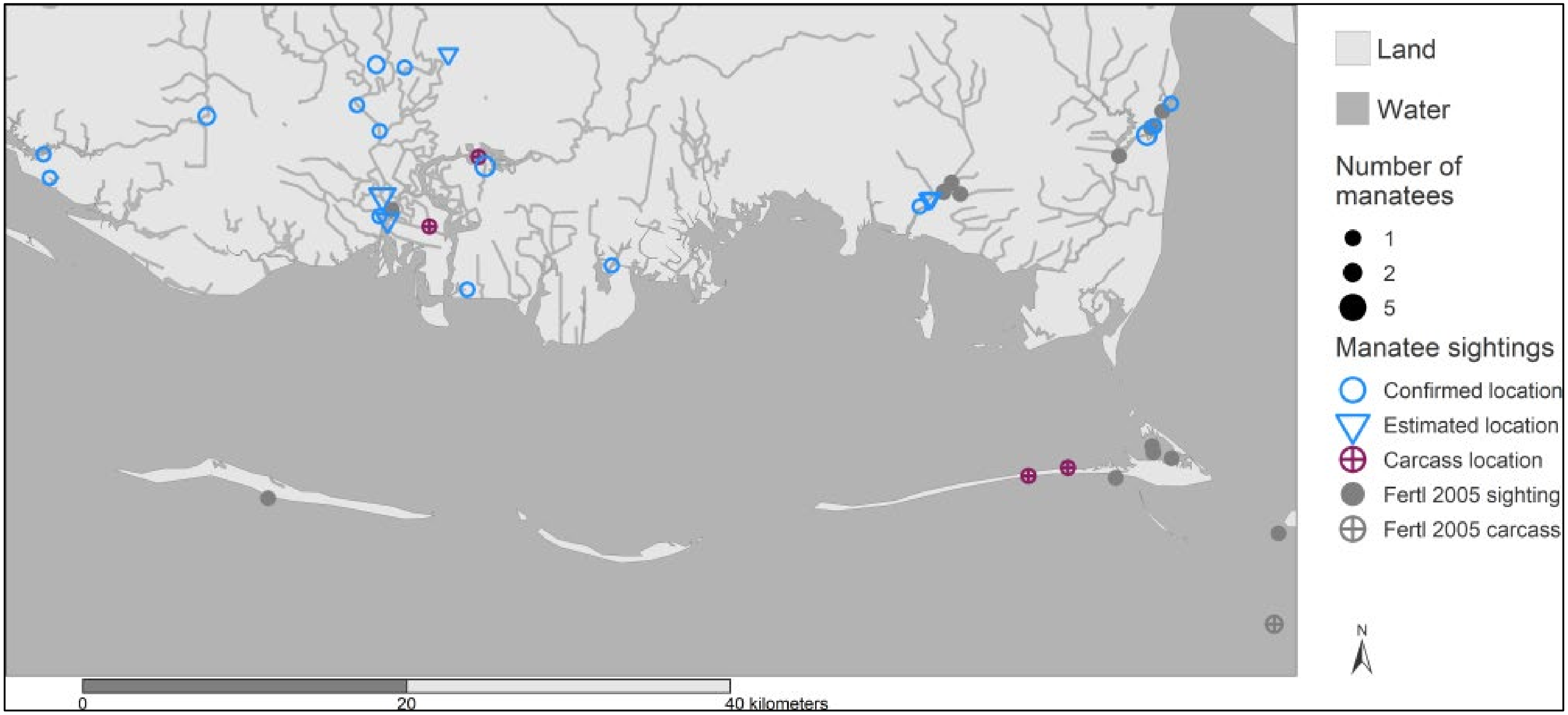

Figure 102. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; darker gray points were previously published in Fertl et al. (2005).

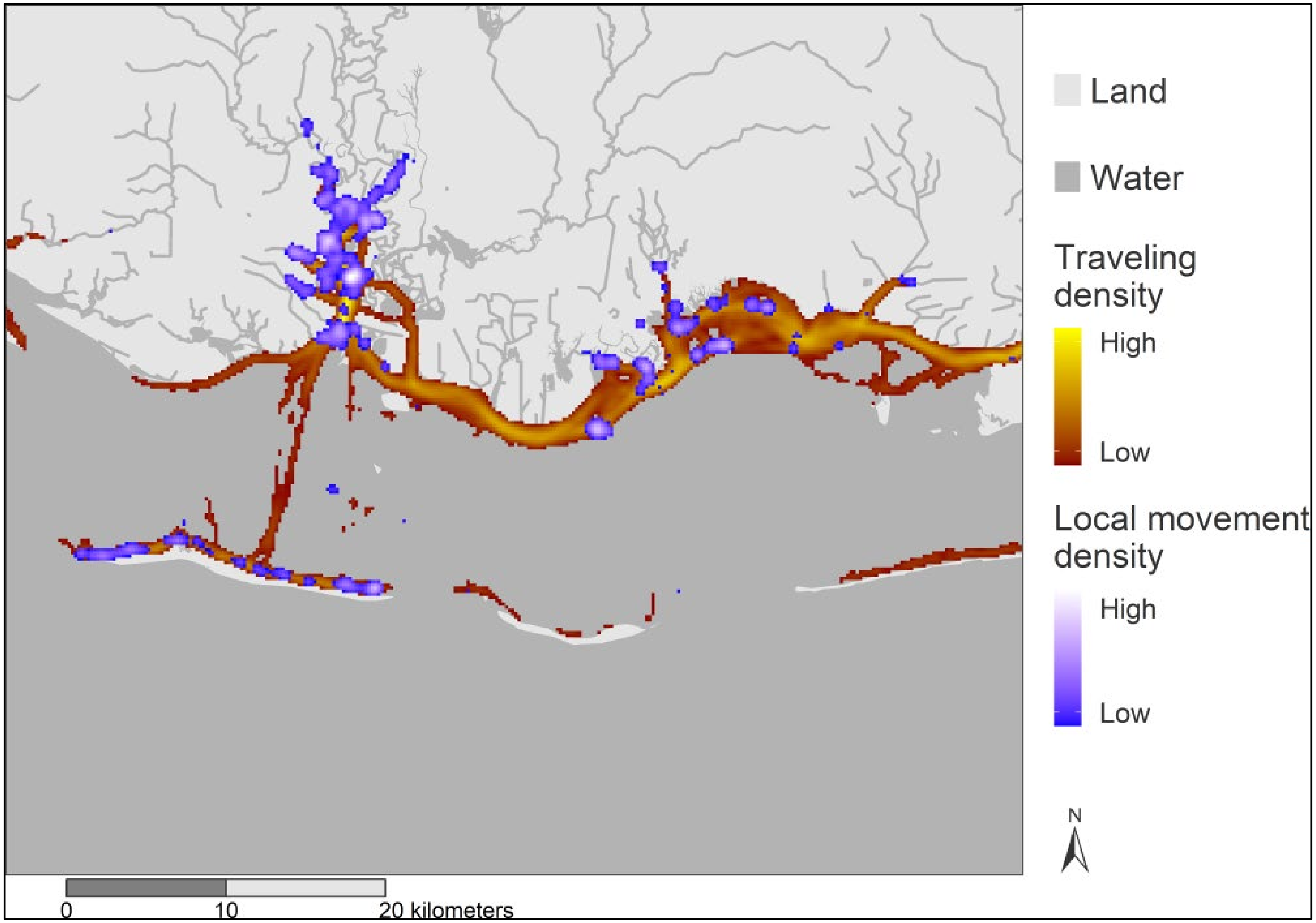

Figure 103. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

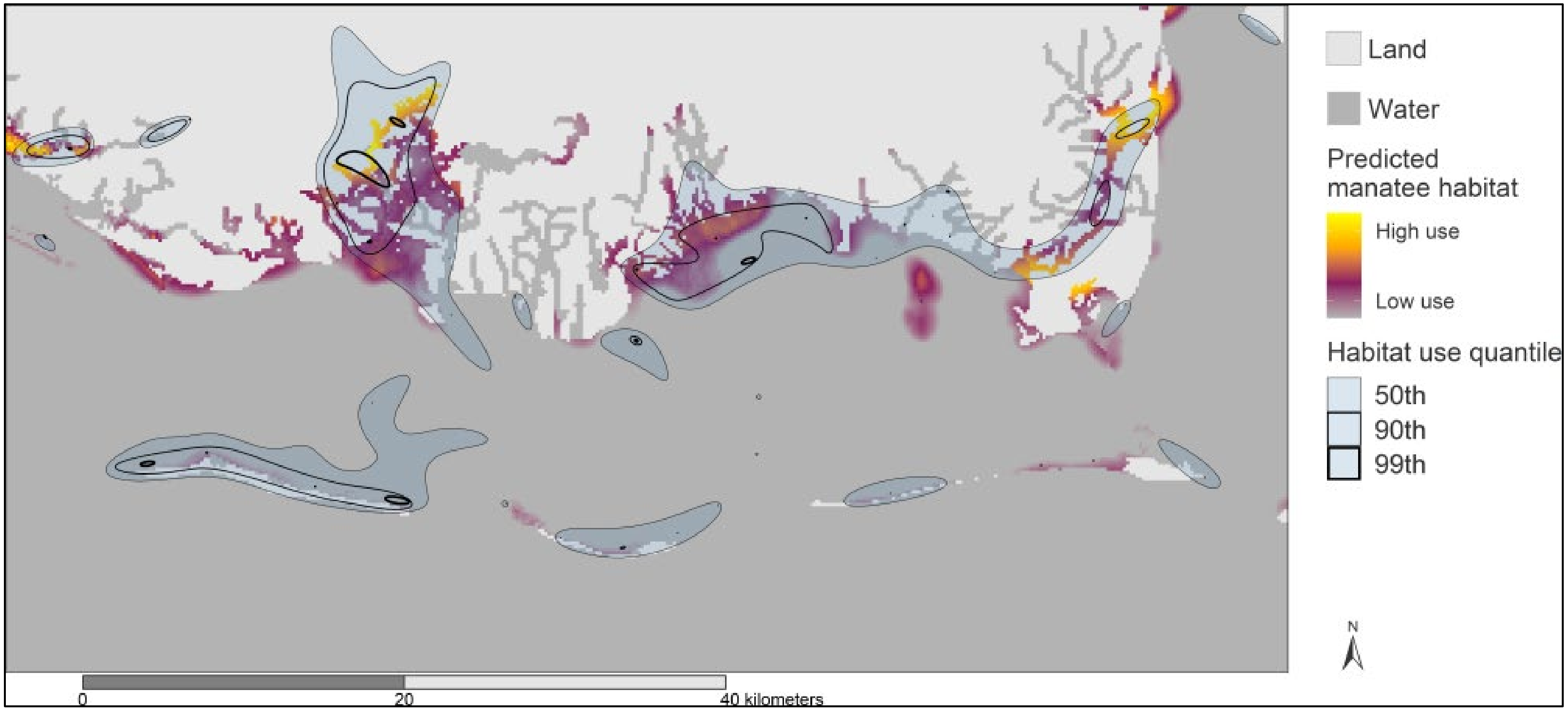

Figure 104. Habitat use prediction for the Pascagoula region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.14 Mobile

The Mobile region contains Mobile Bay, a large freshwater embayment fed primarily by the Mobile River to the north (Figure 105 through Figure 108). Other important estuaries are the Dog River and Fowl River to the west, and Bon Secour Bay to the southeast. The Intracoastal Waterway that begins in Bon Secour Bay forms a protected path all the way to Apalachicola Bay to the east. Mobile Point and Dauphin Island to the south form a protective barrier for the bay. The estuaries that drain into Mobile Bay contain diverse, abundant freshwater vegetation, with the most common being *Vallisneria*, *Myriophyllum*, *Najas*, *Ruppia*, *Heteranthera*, *Halodule* and *Ceratophyllum* species (Vittor 2016).

The Mobile region has a long history of regular manatee sightings, being the closest region to Florida. We again encountered more sighting records during the time we collected for this study than were found for the earlier Fertl et al. (2005) report, increasing the evidence that use of the northern Gulf , especially close to Florida has been experiencing a recent increase in use corresponding with the increase in manatee population size (Hostetler et al. 2021). This region also has an active sighting network that actively solicits sighting reports (Pabody et al. 2009; Hieb et al. 2017) which is also likely contributing to an increased sighting rate.

Sightings in the Mobile region were concentrated in the upper Mobile Bay-Mobile River delta and the Dog River, with additional sightings in the Mobile River estuary, the Fowl River, and along the eastern shore of Mobile Bay (Figure 109). This pattern was closely mirrored by the habitat use of telemetered manatees, which also showed heavy travel paths around the shoreline of Mobile Bay, with only light traveling paths crossing at mid-bay and along the protected side of Dauphin Island (Figure 110).

Predicted habitat use in the Mobile region closely matched the measured habitat use patterns of the telemetered manatees and the sighting locations, with the Dog River, Fowl River and the Mobile River delta and estuaries picked out as predicted high-use areas (Figure 111). One noticeable area was the south shoreline of Bon Secour Bay, which was predicted as a hotspot of manatee activity while no use was recorded. A large expanse of “estuarine and marine wetland” from the wetland habitat map (Figure 107) and a wide shallow shelf along that shoreline (Figure 106) was driving this prediction, so it is likely this area contains useable forage species, but was not chosen by the tracked animals for use. Habitat areas that are not currently used indicate a potential surplus in carrying capacity.

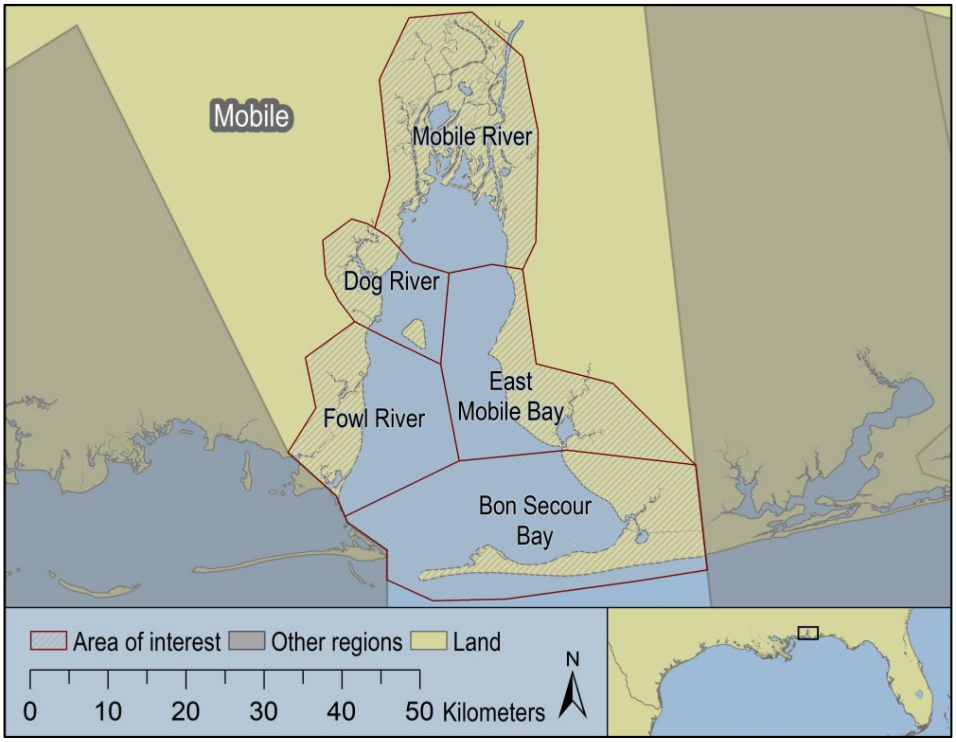

Figure 105. The Mobile region, dominated by Mobile Bay and associated estuaries.

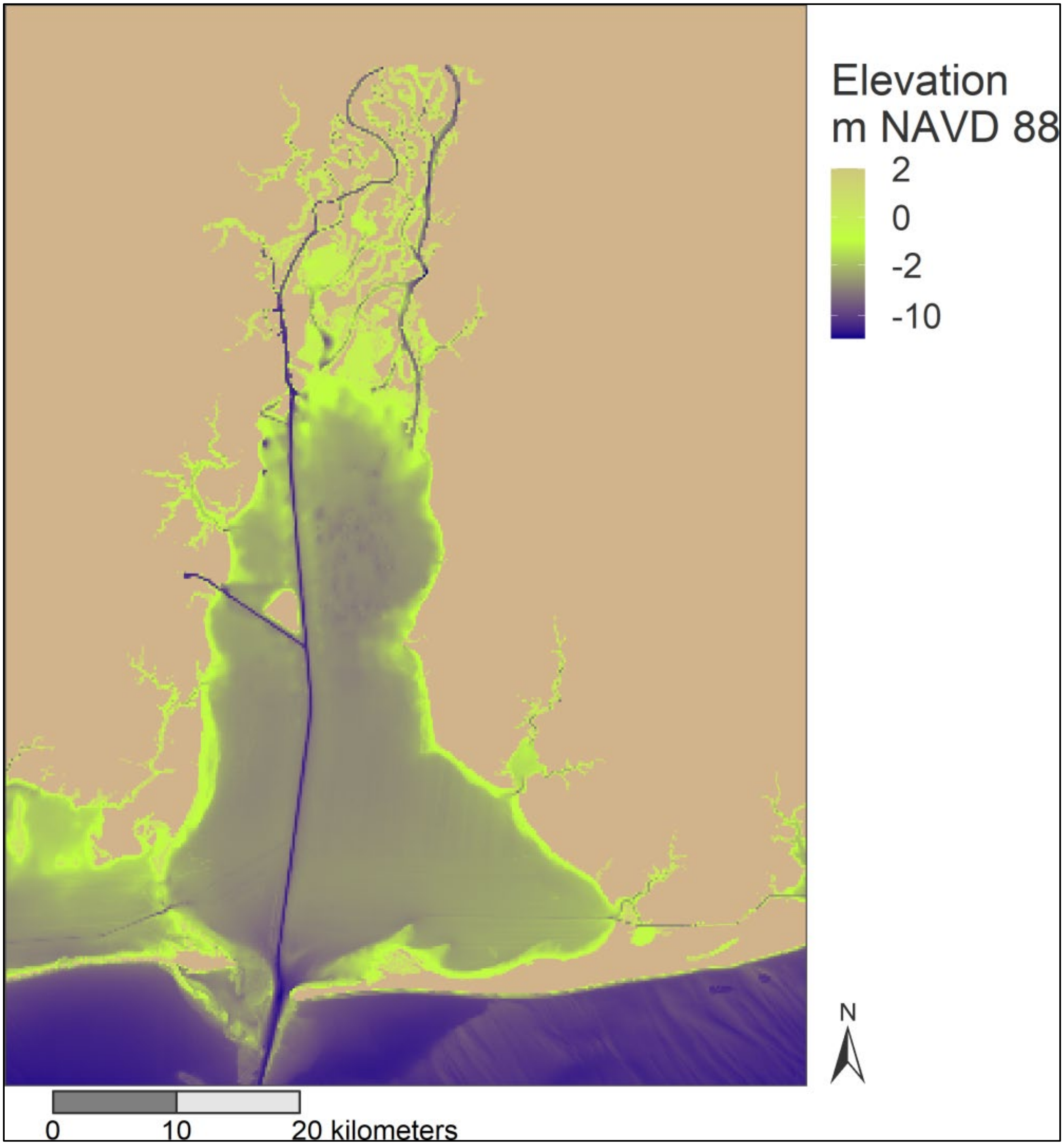

Figure 106. Digital elevation model of the Mobile region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

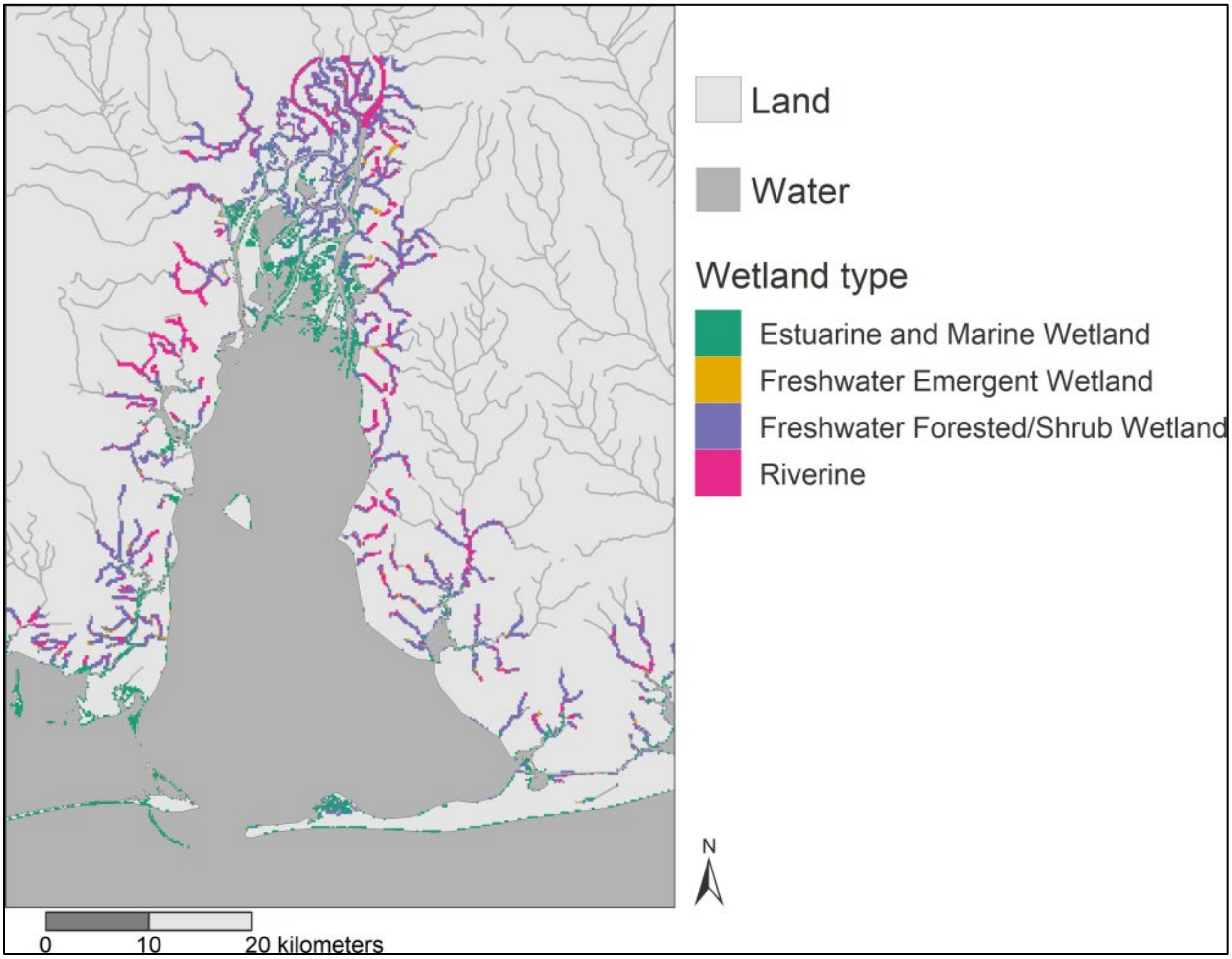

Figure 107. Wetland types and locations within the Mobile region.

Modified from US Fish and Wildlife Service (2016).

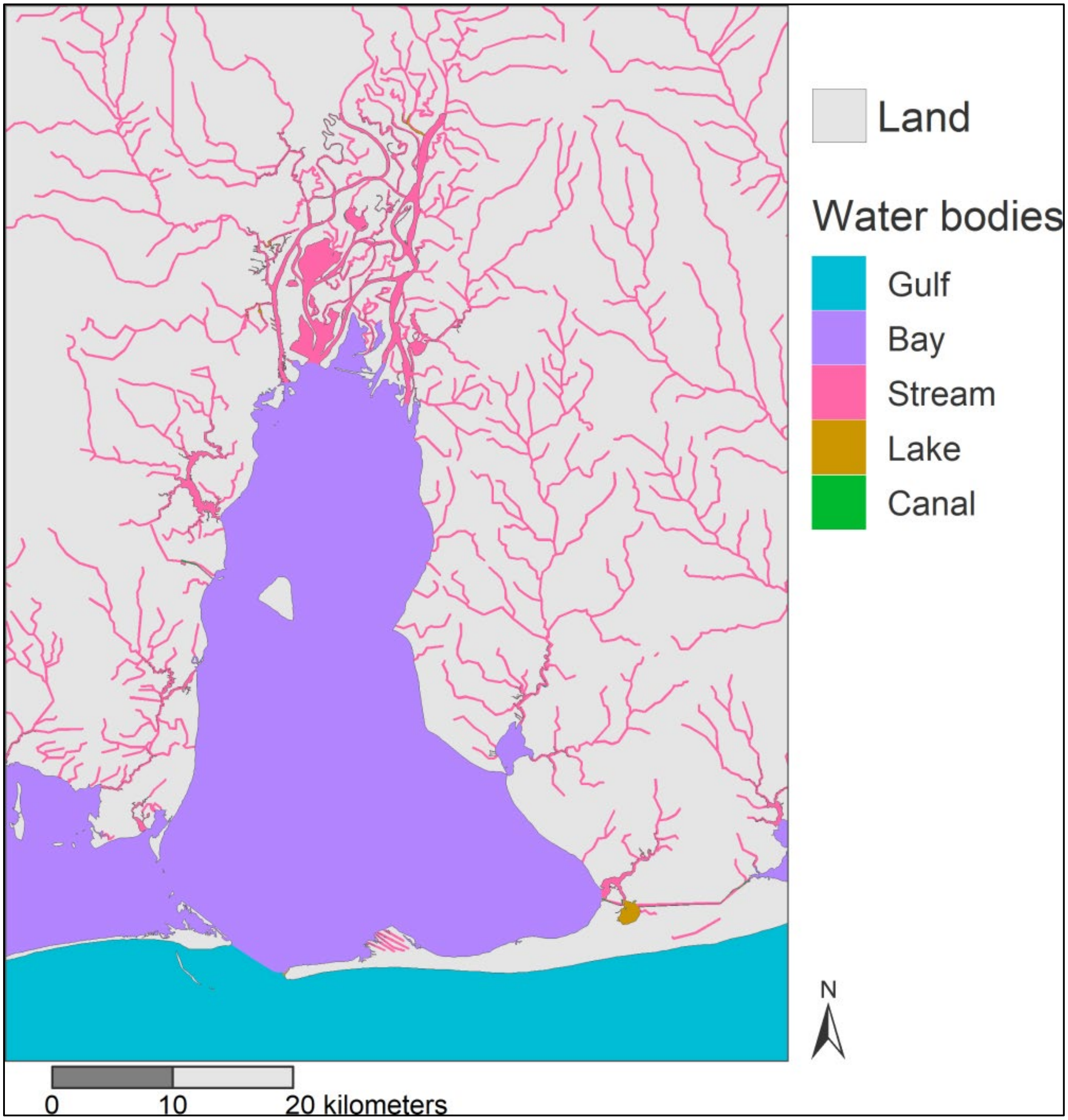

Figure 108. Water bodies of the Mobile region.

Modified from Tele Atlas North America, Inc. (2010).

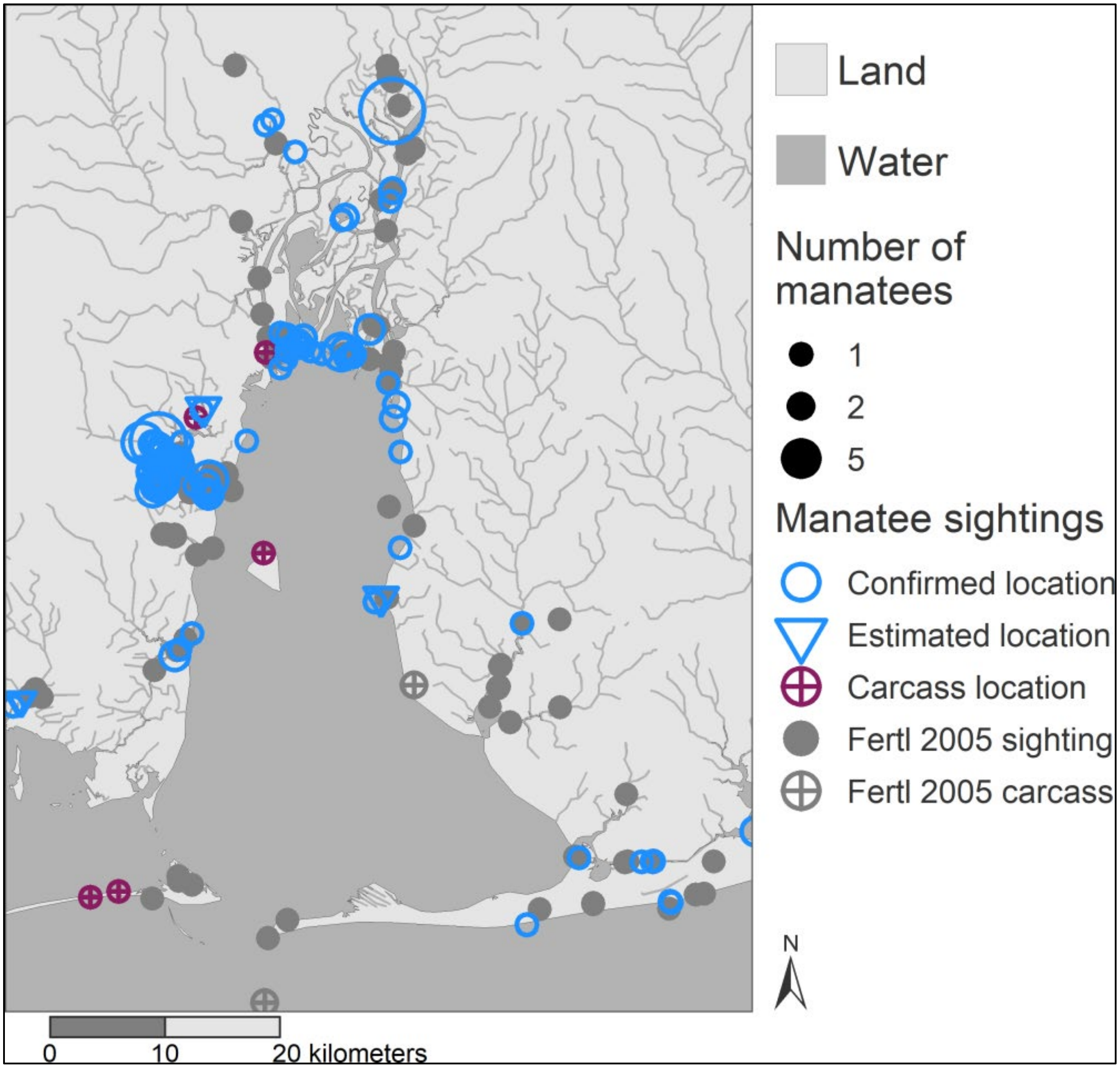

Figure 109. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; darker gray points were previously published in Fertl et al. (2005).

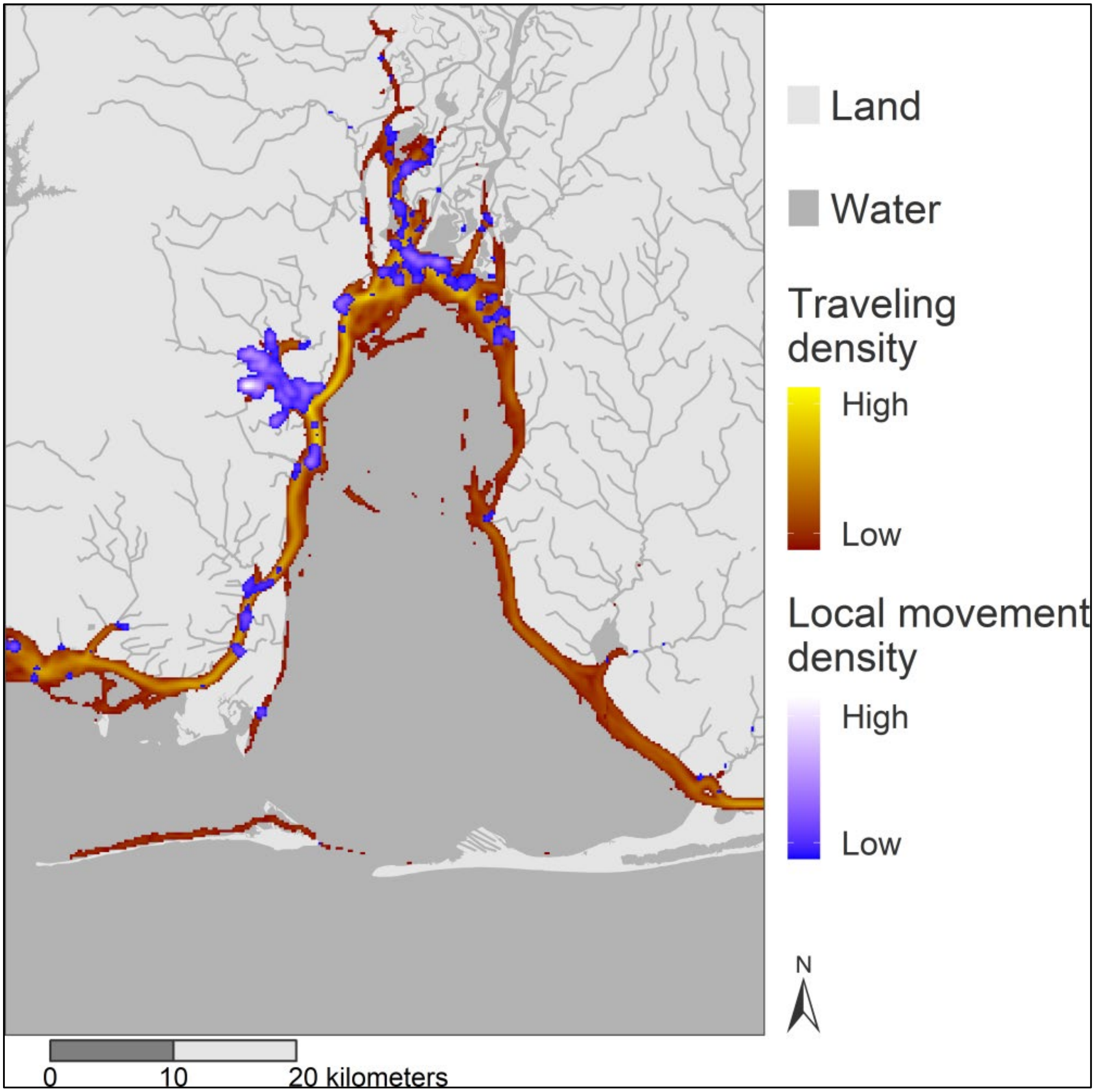

Figure 110. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

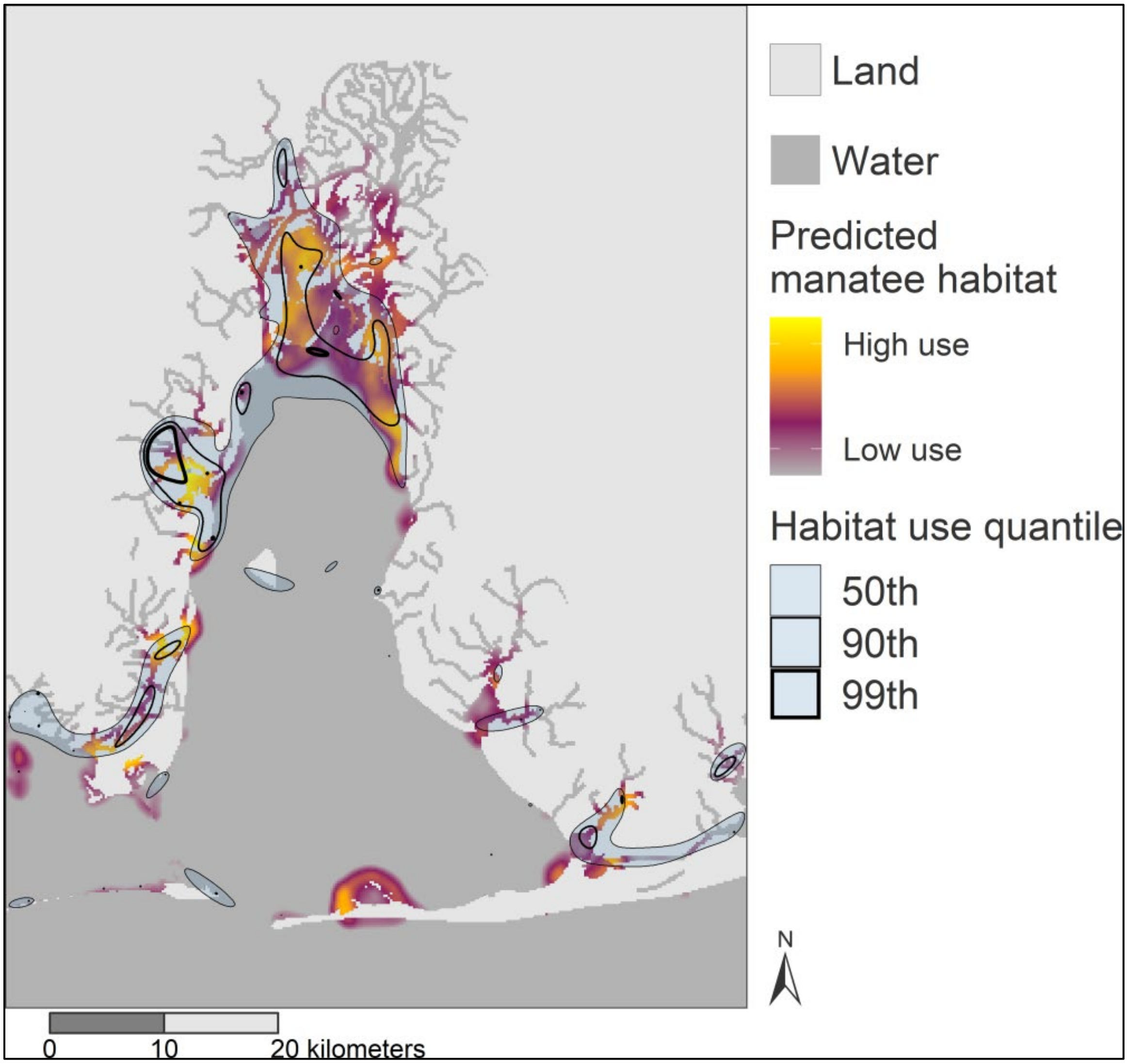

Figure 111. Habitat use prediction for the Mobile region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.15 Perdido

The Perdido Bay region consists of Perdido Bay and Wolf Bay to the north, and Big Lagoon to the south, which is part of the Intracoastal Waterway (Figure 112 through Figure 113). Wolf Bay and the upper reaches of Perdido Bay are fresh; the inlet from the Gulf and Big Lagoon are marine. Euryhaline species such as *Halodule wrightii* and *Ruppia maritima* are reported throughout the region, and freshwater species, including *Vallisneria americana* are reported from the upper, freshwater reaches. *Thalassia testudinum* is found in the outer marine areas (Byron and Heck 2006; Kirschenfeld et al. 2007).

Manatee sightings in the Perdido region have been increasing in the last decade, concentrated in the Big Lagoon and Intracoastal Waterway (Figure 116). This pattern does not precisely match that of the telemetered manatees, which showed a heavy travel path through the intracoastal waterways, with lighter use paths along the shores of Perdido Bay and into big Lagoon, but also a concentrated habitat use pattern slightly to the east of the majority of the sightings (Figure 117). Along this part of the coastline, where the Intracoastal Waterway is present, essentially no manatee travel offshore was recorded.

The habitat use model for Perdido region matched the habitat use pattern for the Intracoastal Waterway, but predicted a high suitability for the southern part of Big Lagoon, while the telemetry data for that area was light (Figure 118). The model does not account for "convenience", or difficulty of travel for different habitat locations. It is likely that the intracoastal part of Big Lagoon was used much more than the southern part because of its dual utility as a migratory path and forage habitat. The model also predicted habitat use areas in the estuaries north of Perdido Bay, which were matched by manatee use in two out of three estuaries.

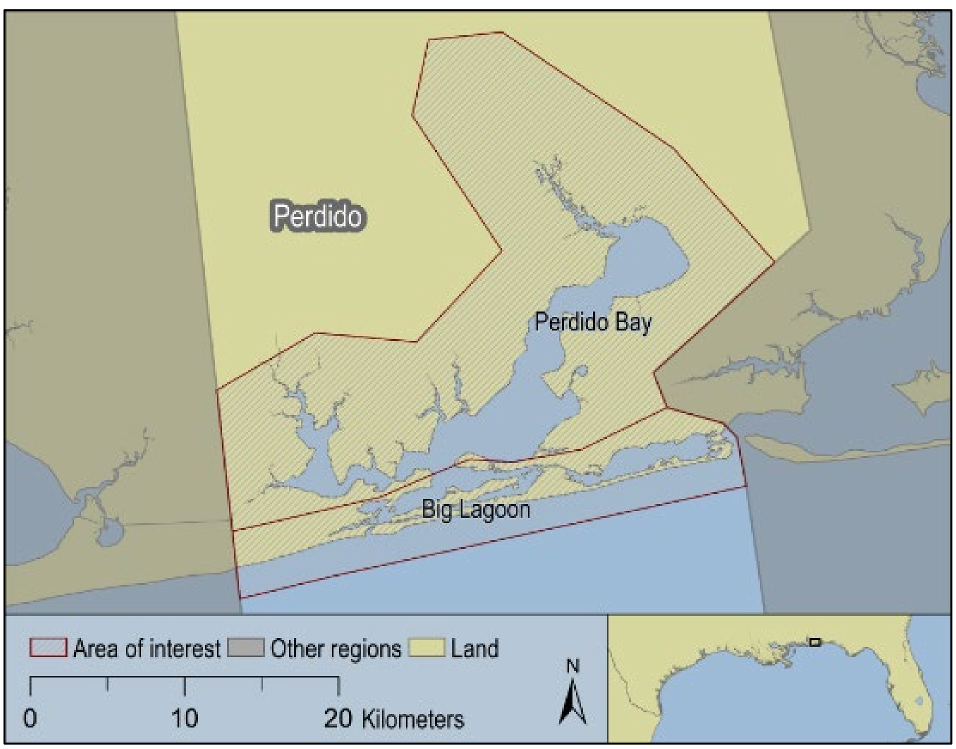

Figure 112. The Perdido region containing Perdido Bay.

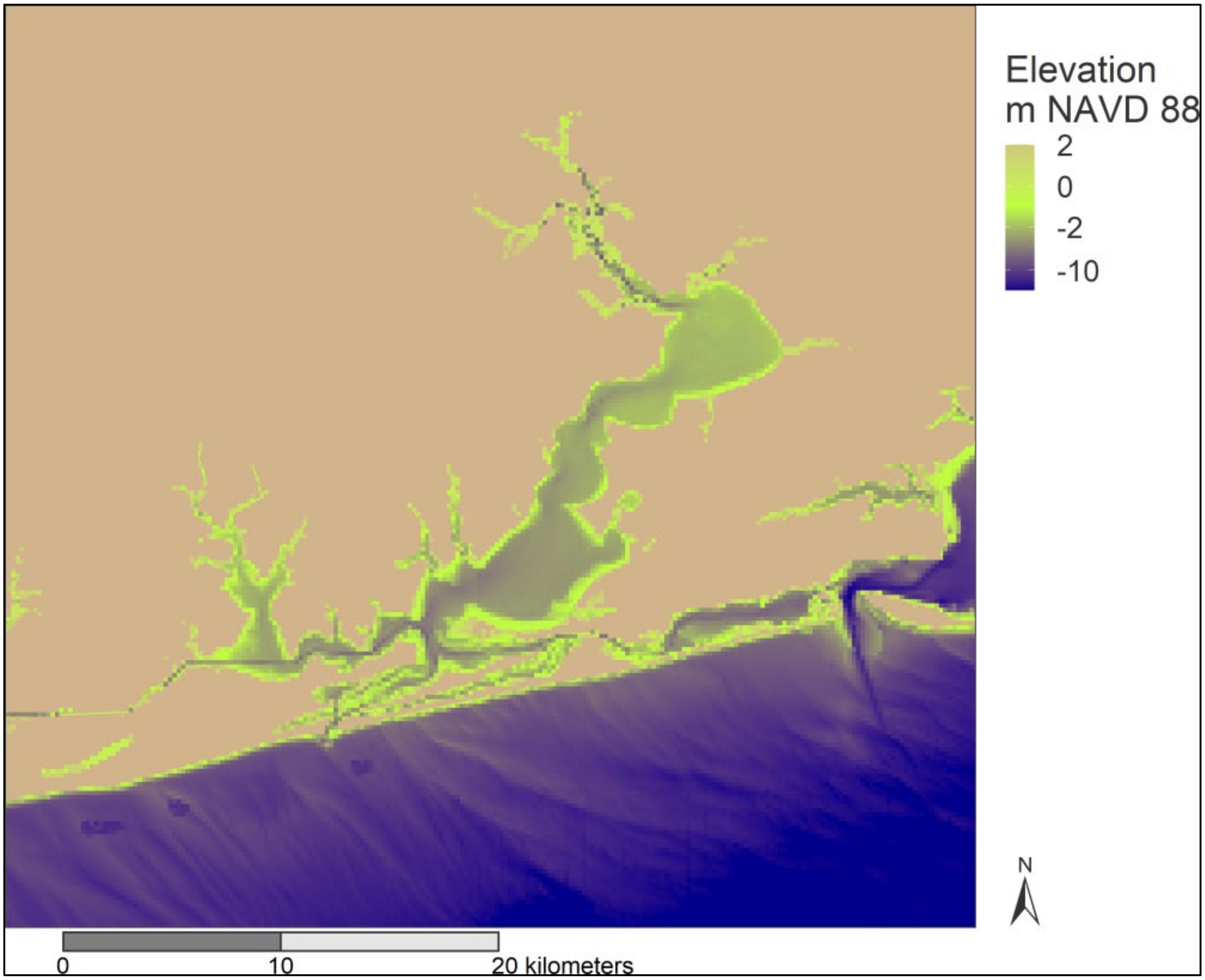

Figure 113. Digital elevation model of the Perdido region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

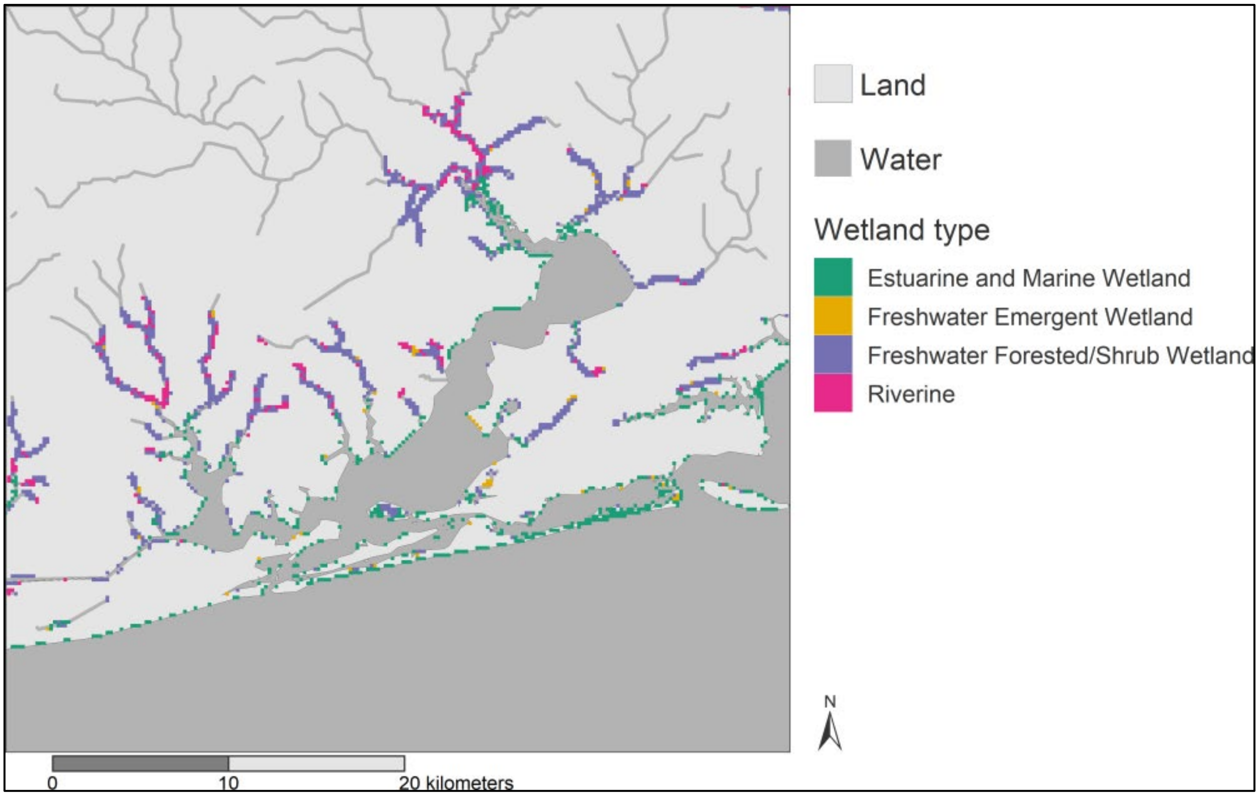

Figure 114. Wetland types and locations within the Perdido region.

Modified from US Fish and Wildlife Service (2016).

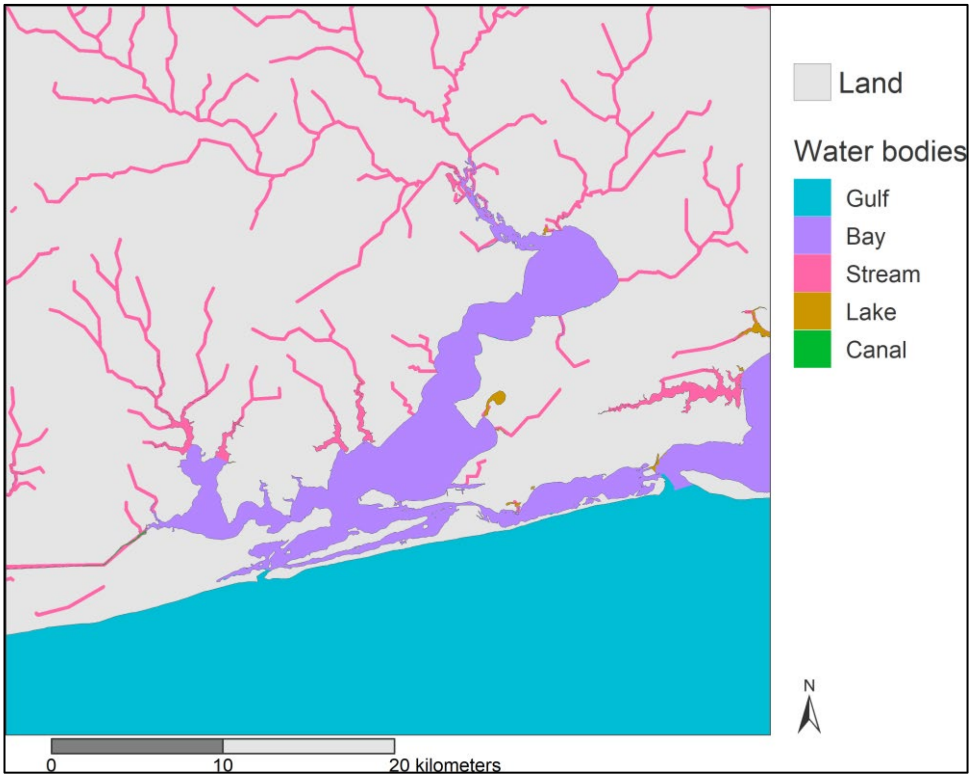

Figure 115. Water bodies of the Perdido region.

Modified from Tele Atlas North America, Inc. (2010).

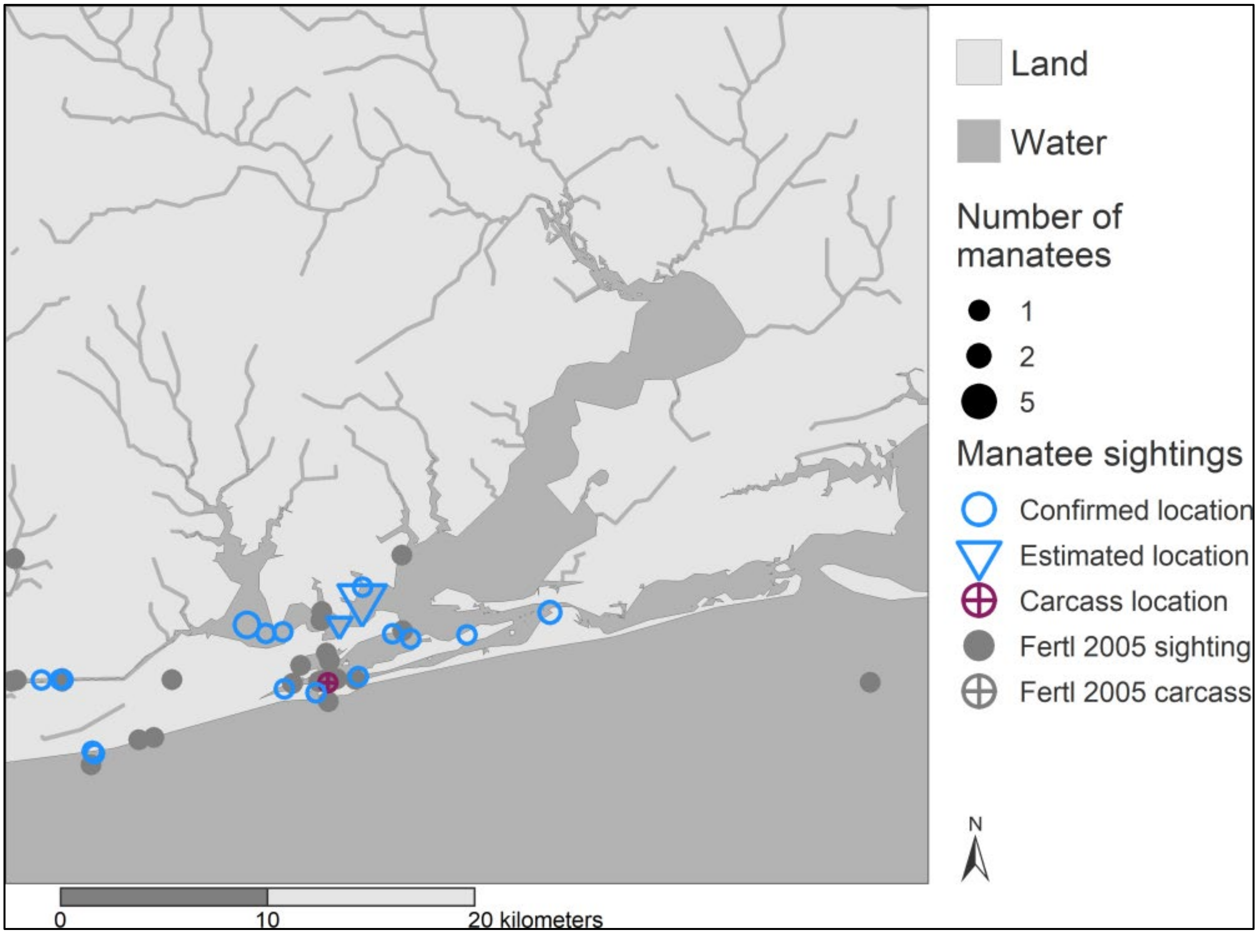

Figure 116. Manatee sightings (confirmed and estimated locations) and carcass locations reported for the region.

Colored points were collected for this study; darker gray points were previously published in Fertl et al. (2005).

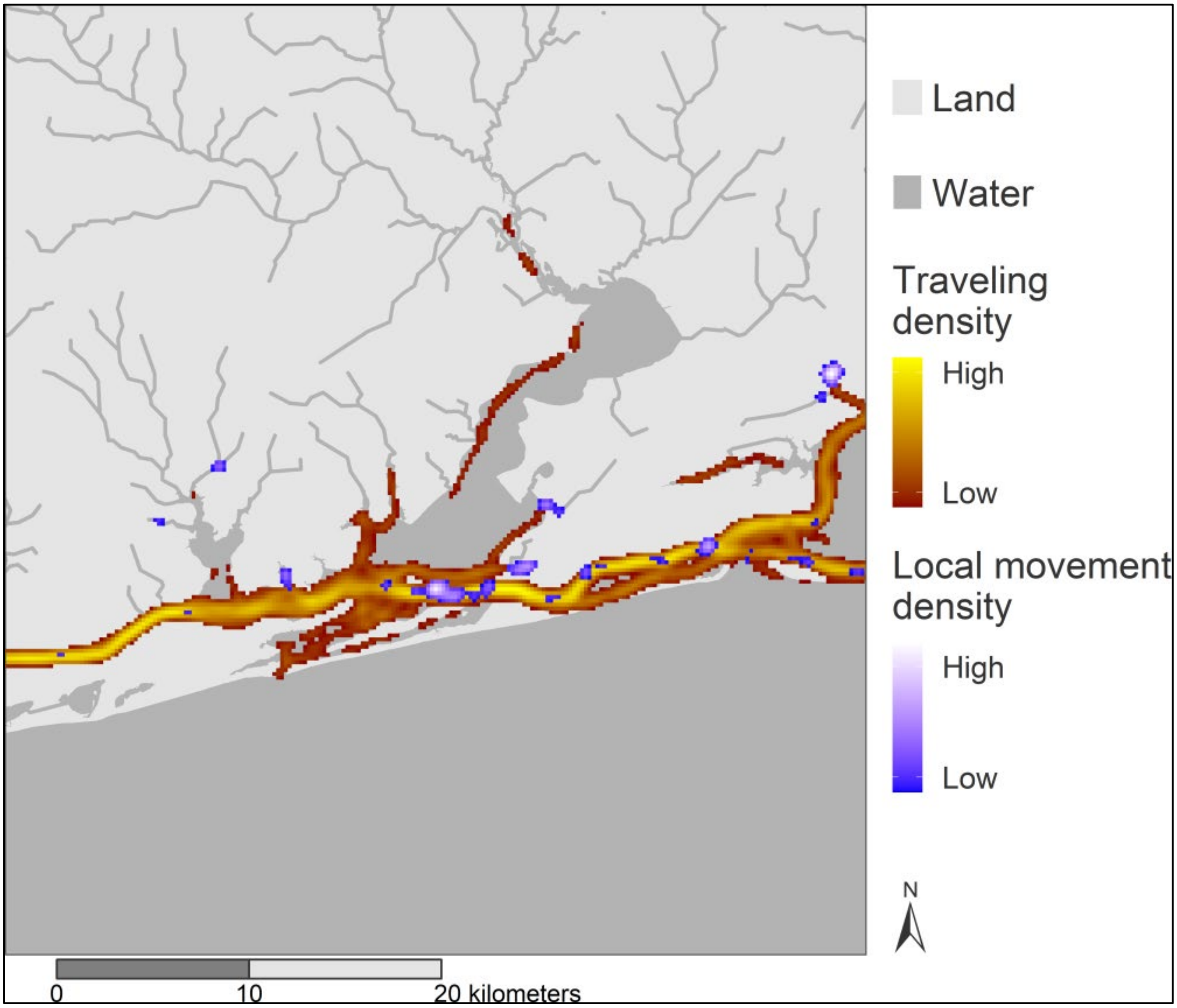

Figure 117. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

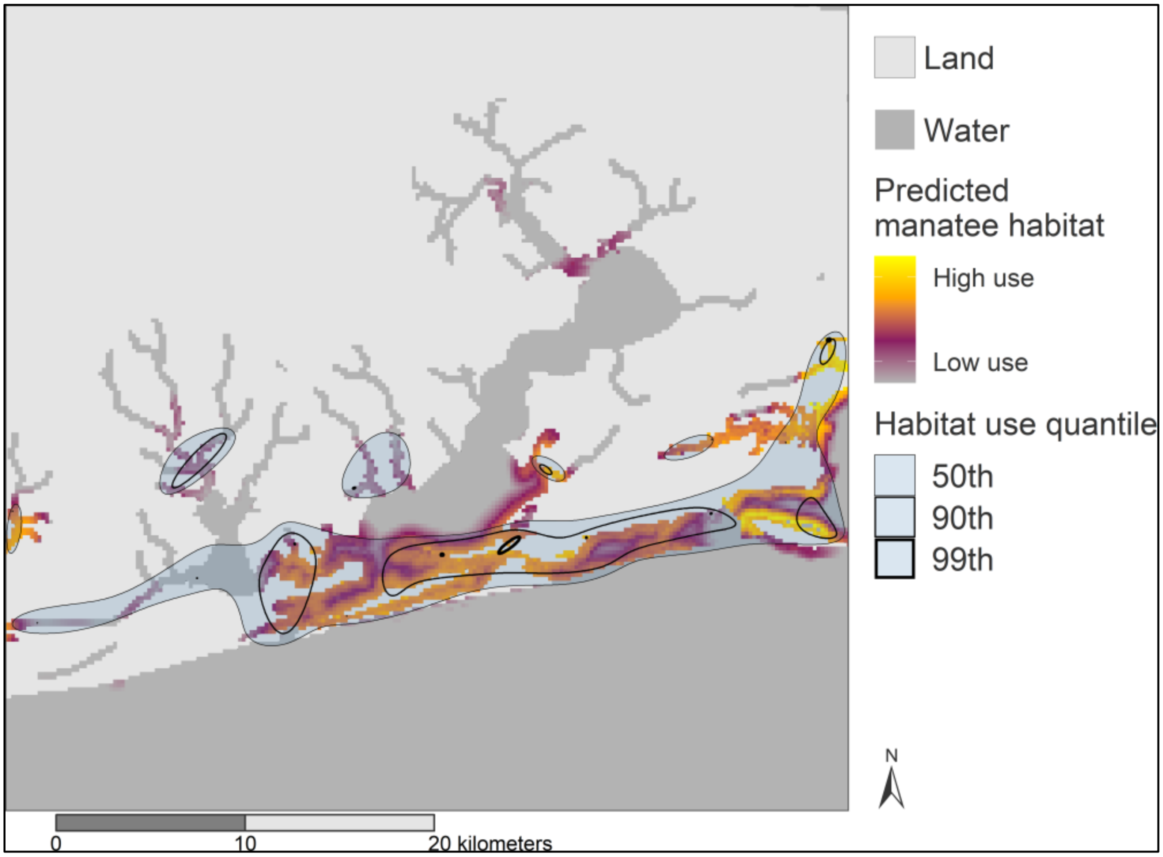

Figure 118. Habitat use prediction for the Perdido region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.16 Pensacola

The Pensacola region (Figure 119 through Figure 122) continues the Intracoastal Waterway in the Santa Rosa Sound, which connects to Pensacola Bay and Escambia Bay to the north (here combined into Escambia Bay polygon). East Bay (here called East Bay Pensacola) forms the eastern lobe. Submerged vegetation reported from the region include *Thalassia testudinum*, *Halodule wrightii* and *Syringodium filiforme* in Santa Rosa Sound, and freshwater communities including *Vallisneria americana* and *Ruppia maritima* in the upper reaches of Escambia and East Bays (Lores et al. 2000). Both fresh and saltwater SAV communities have experienced significant declines in recent decades (Lores and Sprecht 2001; Lewis et al. 2008).

Manatees are a common sight in Pensacola and the regions to the east; they are not routinely reported by members of the public or by resource agencies. Because of the reduced sighting effort, and abundant locations from telemetry tags, we will not present sightings or carcass locations from these regions.

The telemetered manatees showed strong travel paths along the north shore of Santa Rosa Sound and the western shore of Escambia Bay (Figure 123). Lighter travel paths were seen along south shore of Santa Rosa Sound and the northern and southern shores of Escambia and East Bays. mMost manatees that entered Escambia Bay did so along the extreme western shore, but some did cross open water directly from Santa Rosa Sound. Local habitat use locations were seen in the upper estuary of Escambia Bay, and smaller discrete locations along the shorelines of each water body and in the northern tributary of East Bay, the Blackwater River. The habitat use model predicted high-use areas in the deltas of both Escambia and East Bay, as well as the eastern side of Santa Rosa Sound (Figure 124).

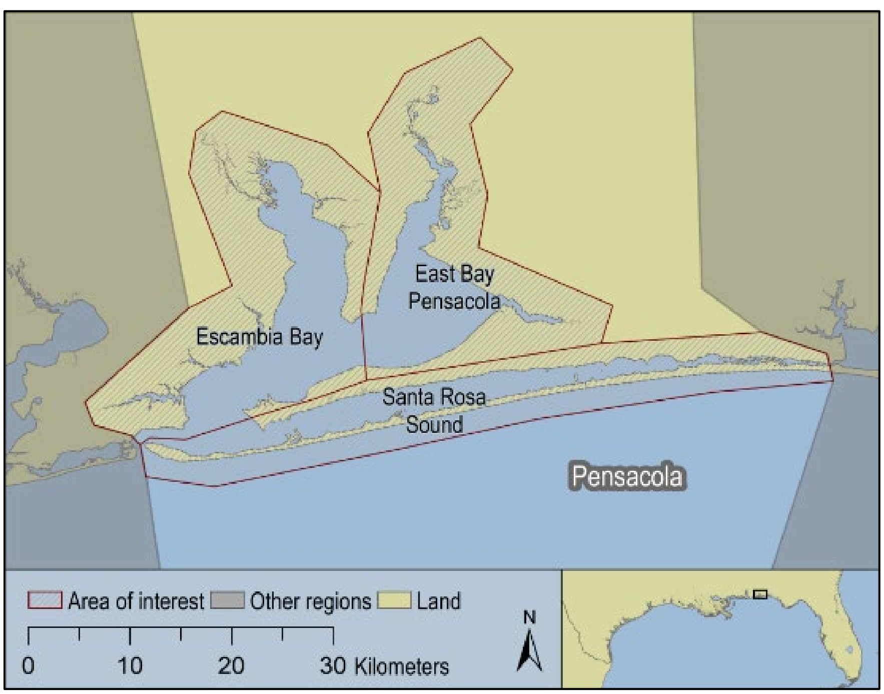

Figure 119. The Pensacola region, with Escambia bay, East Bay, and Santa Rosa Sound.

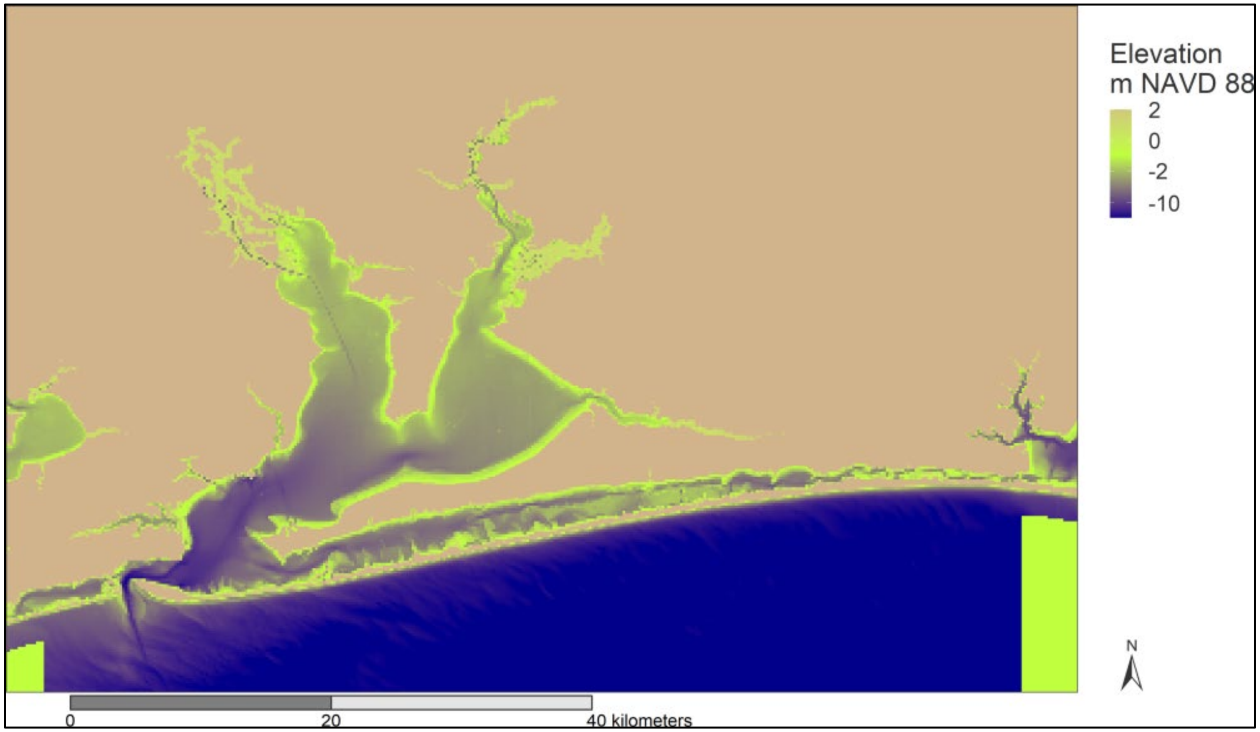

Figure 120. Digital elevation model of the Pensacola region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas(violet-dark blue).

Data compiled from NOAA sources; see text for details.

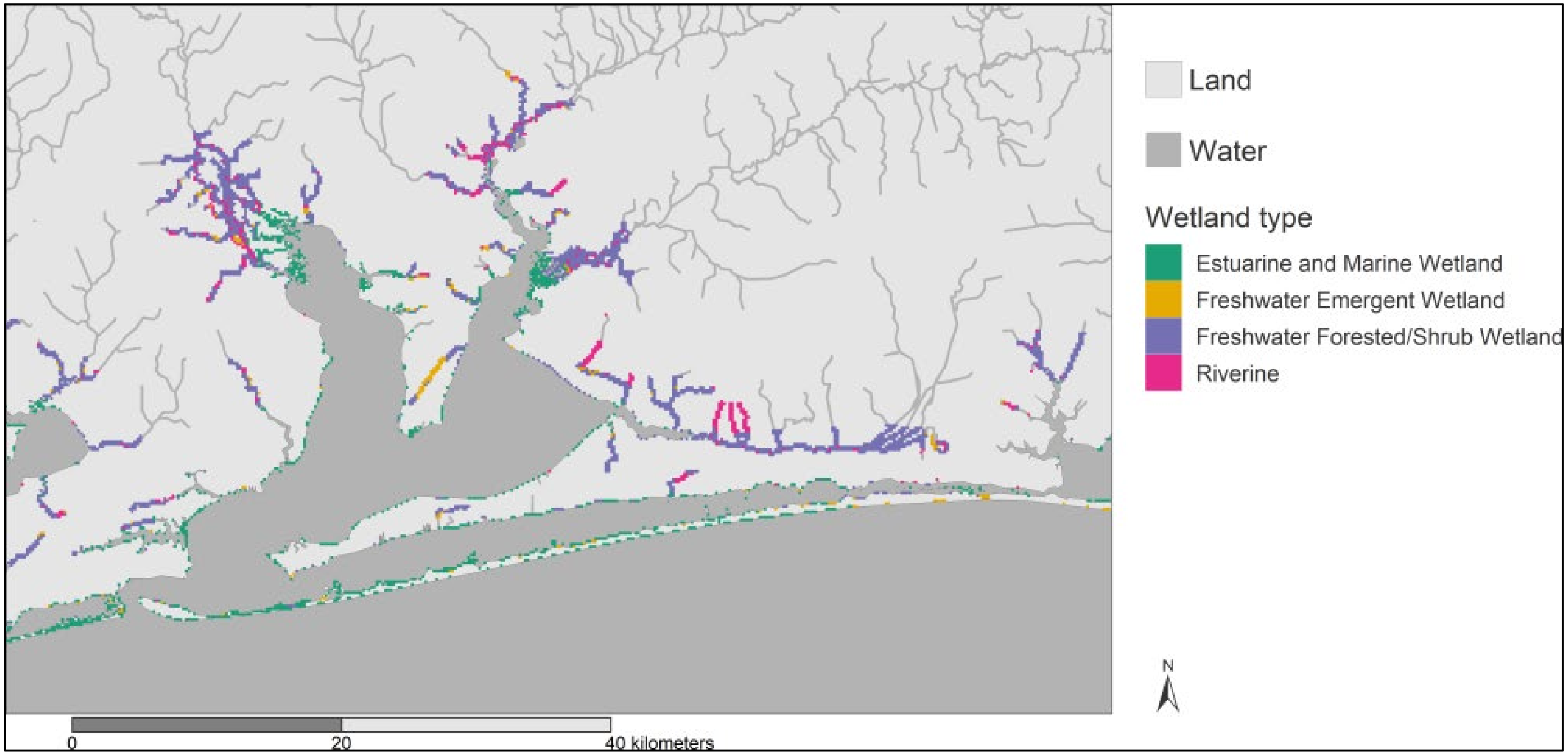

Figure 121. Wetland types and locations within the Pensacola region.

Modified from US Fish and Wildlife Service (2016).

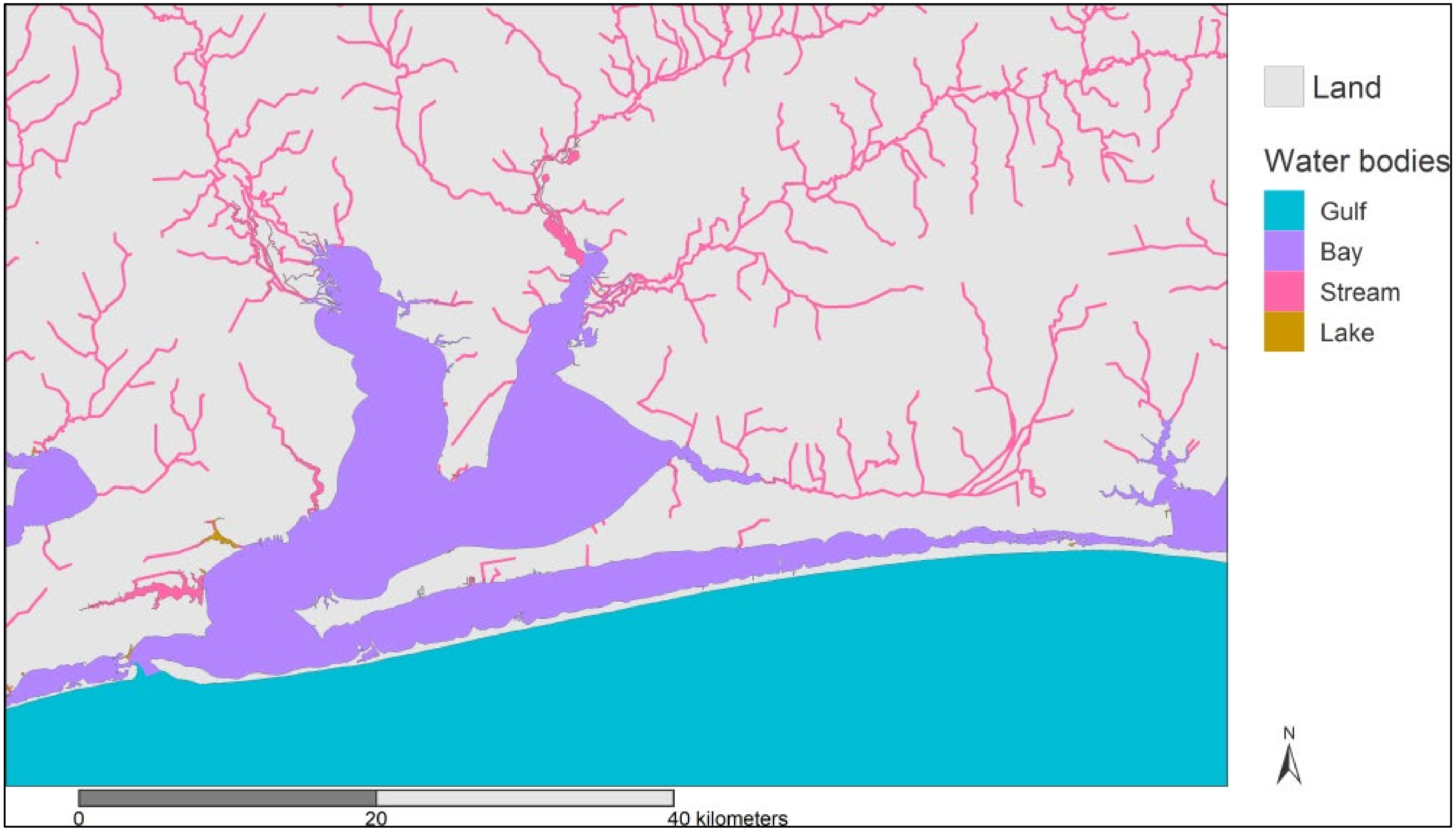

Figure 122. Water bodies of the Pensacola region.

Modified from Tele Atlas North America, Inc. (2010).

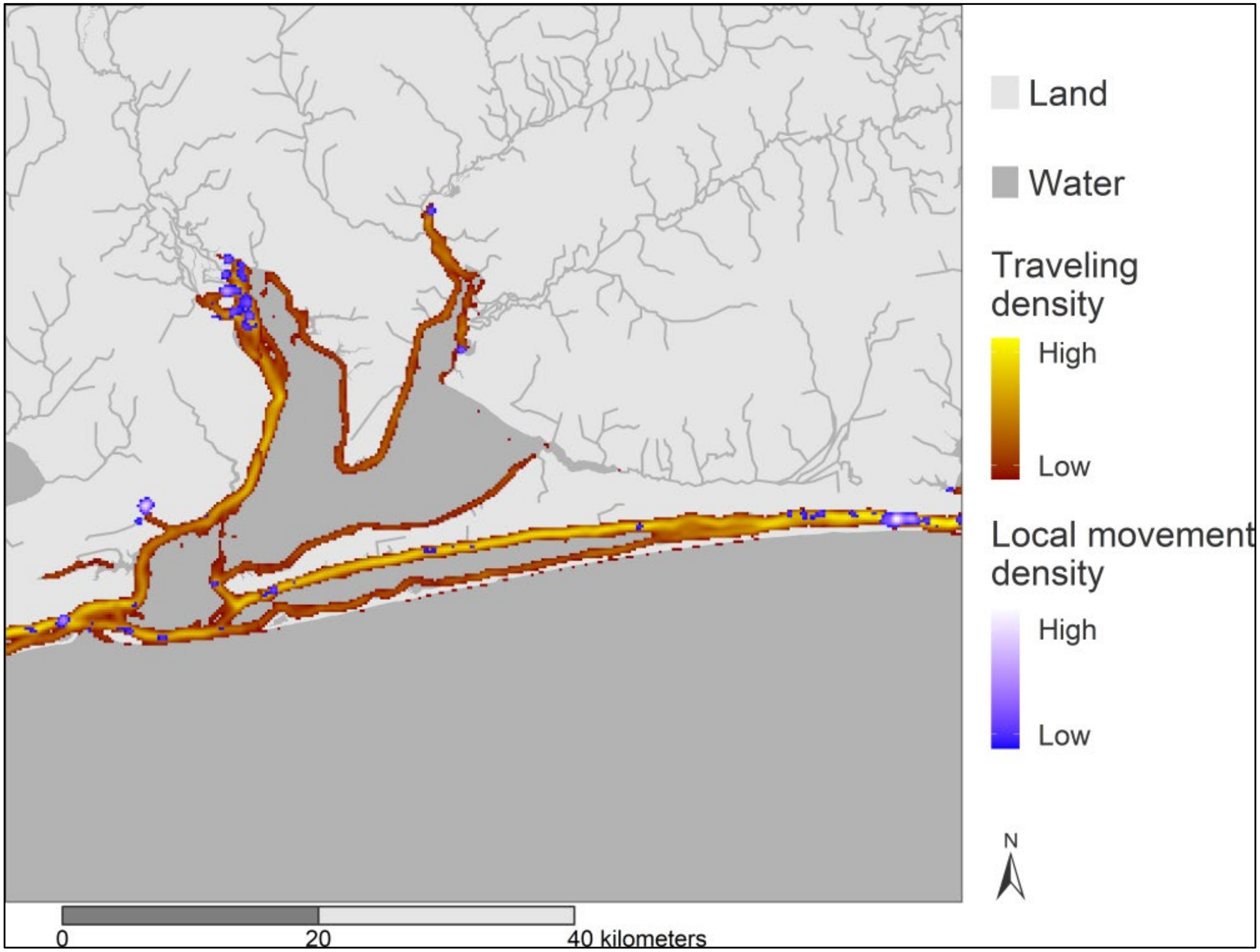

Figure 123. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

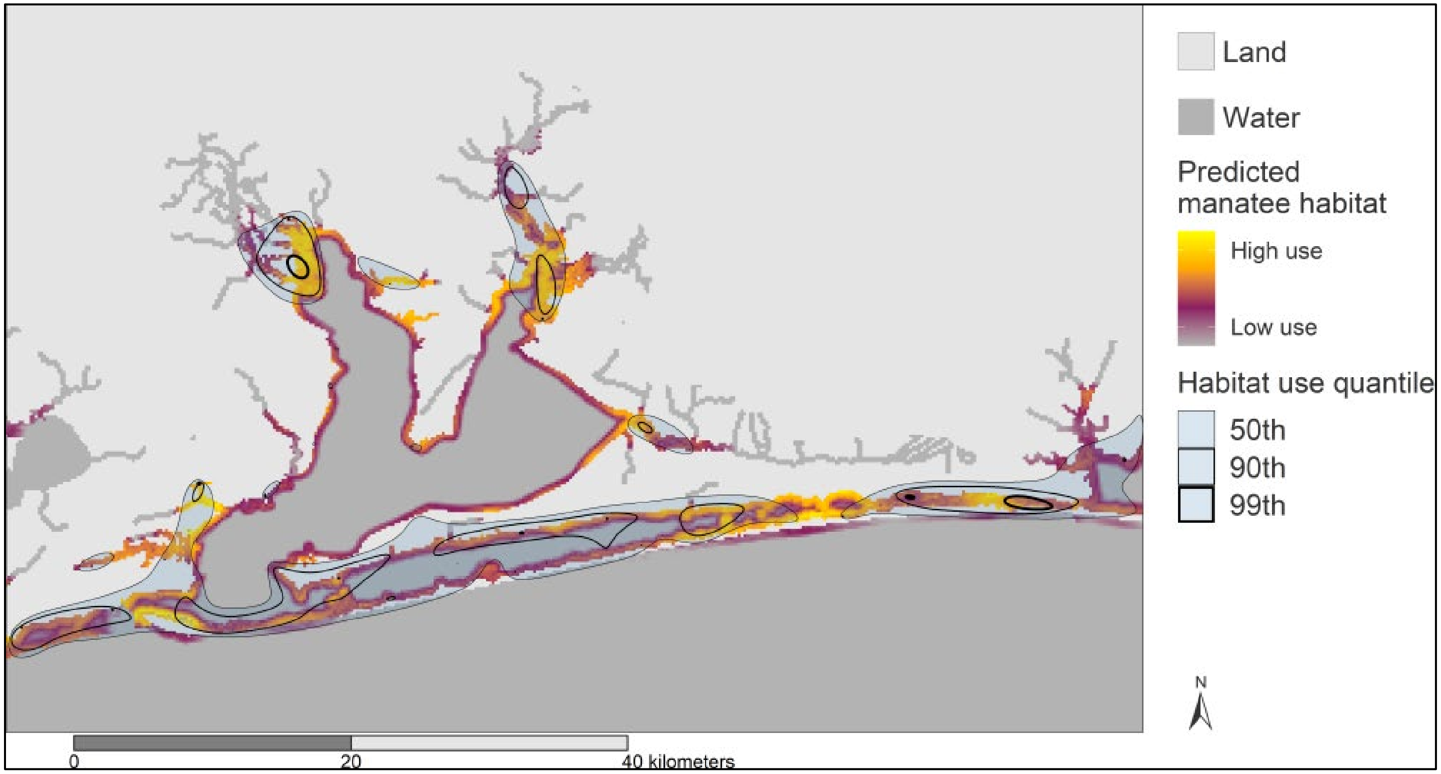

Figure 124. Habitat use prediction for the Pensacola region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with thickening black outlines show high density manatee GPS locations.

3.5.1.17 Destin

The Destin region encompasses Choctawhatchee Bay (Figure 125 through Figure 128). It connects to Santa Rosa Sound to the west and the Gulf Intracoastal Waterway to the east. The sole connection to the Gulf is the narrow East (Destin) Pass. The west side of the bay is marine; the east side is often fresh from high volumes of river runoff. Submerged vegetation along the shores of the western half is limited to *Halodule wrightii* and *Ruppia maritima* (Ruth and Handley 2007); freshwater communities, including *Vallisneria americana* are found in the far eastern section. Vegetation coverage and density have been in decline in recent years (Yarbro and Carlson Jr 2016).

Choctawhatchee Bay forms part of the Gulf Intracoastal Waterway, but the Destin region is one of the few where manatees traveled in substantial numbers along the Gulf shoreline as well as through the intracoastal waterways (Figure 129). There were no habitat use locations in the Gulf aside from a few small areas near the mouth of the bay. Within Choctawhatchee Bay, travel lines were seen around the entire perimeter, with a few crossing lines between habitat use patches. The habitat use areas within the bay were distributed on all shorelines, with a very heavy use area along the freshwater eastern shoreline. This is also the shallowest part of the bay, with a greater area to support SAV.

Habitat use in the Destin region was predicted for almost all of the shoreline of Choctawhatchee Bay, with the heaviest use predicted for the eastern and southeastern shorelines (Figure 130). These predictions match closely with actual manatee use. The small habitat use patch near the bay entrance was accurately predicted, but a predicted patch southeast of the bay was not used by the manatees that passed by.

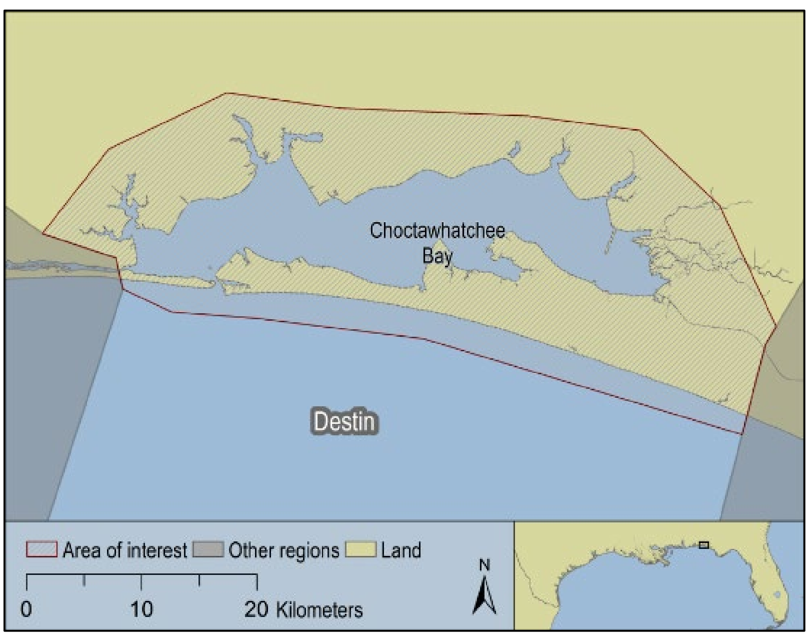

Figure 125. The Destin region, with Choctawhatchee Bay.

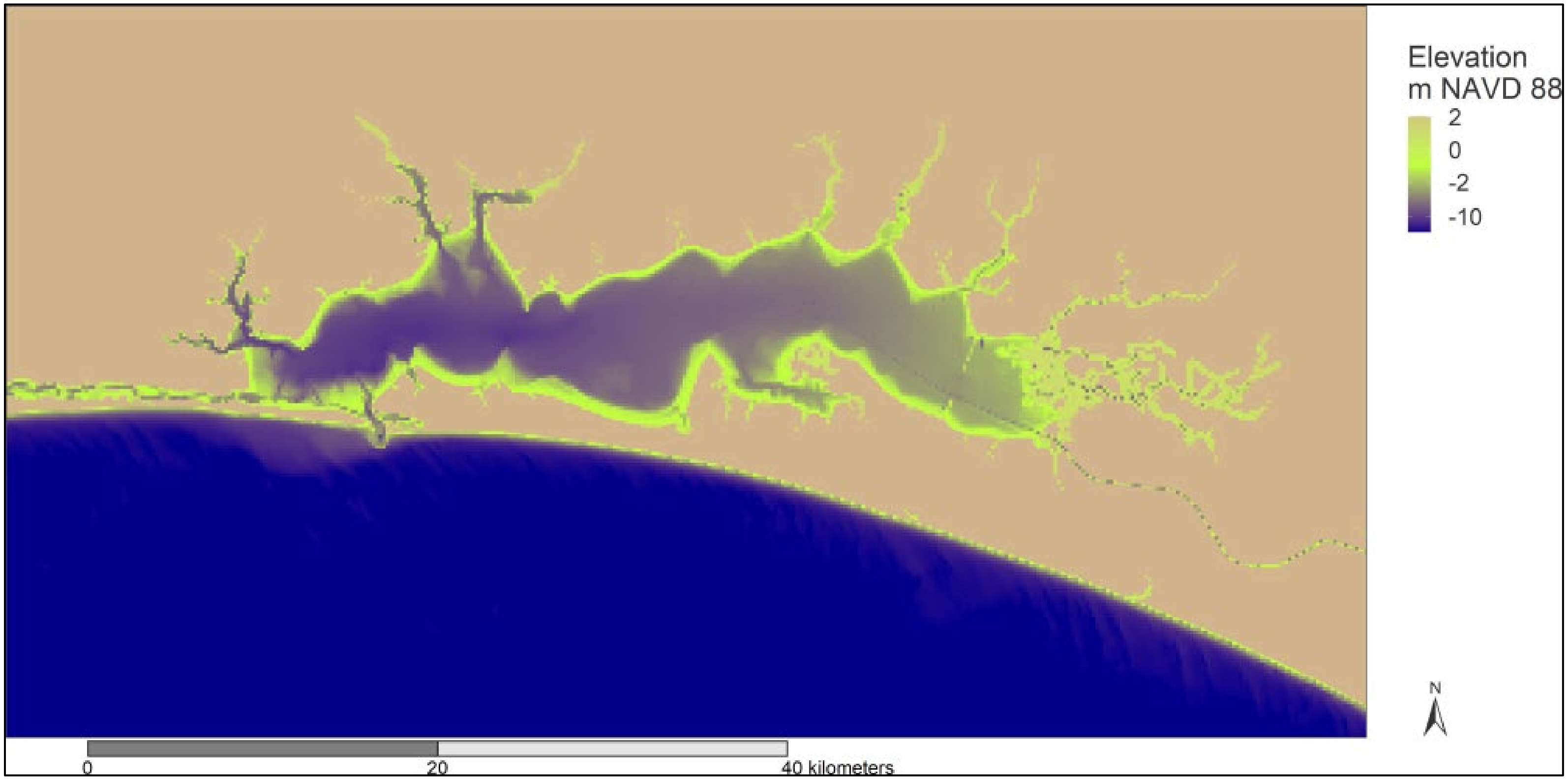

Figure 126. Digital elevation model of the Destin region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (violet-dark blue).

Data compiled from NOAA sources; see text for details.

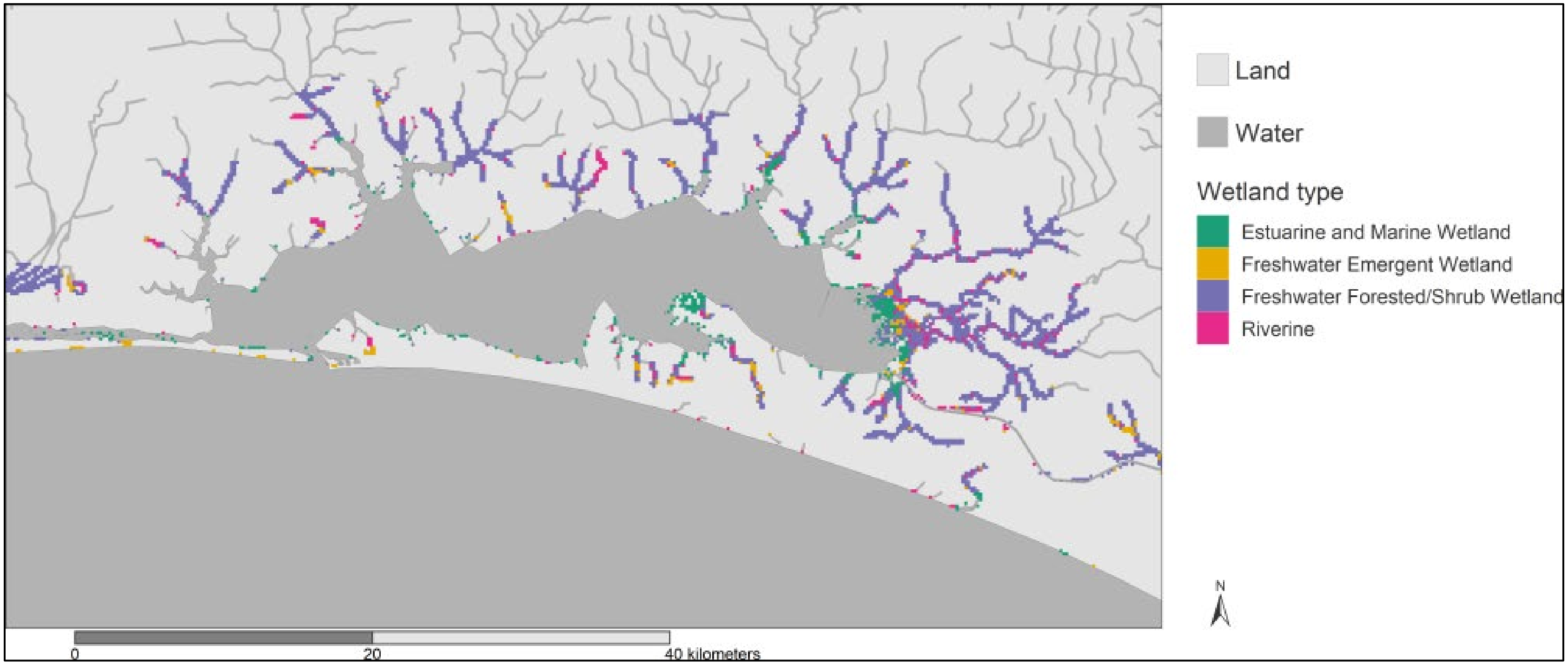

Figure 127. Wetland types and locations within the Destin region.

Modified from US Fish and Wildlife Service (2016).

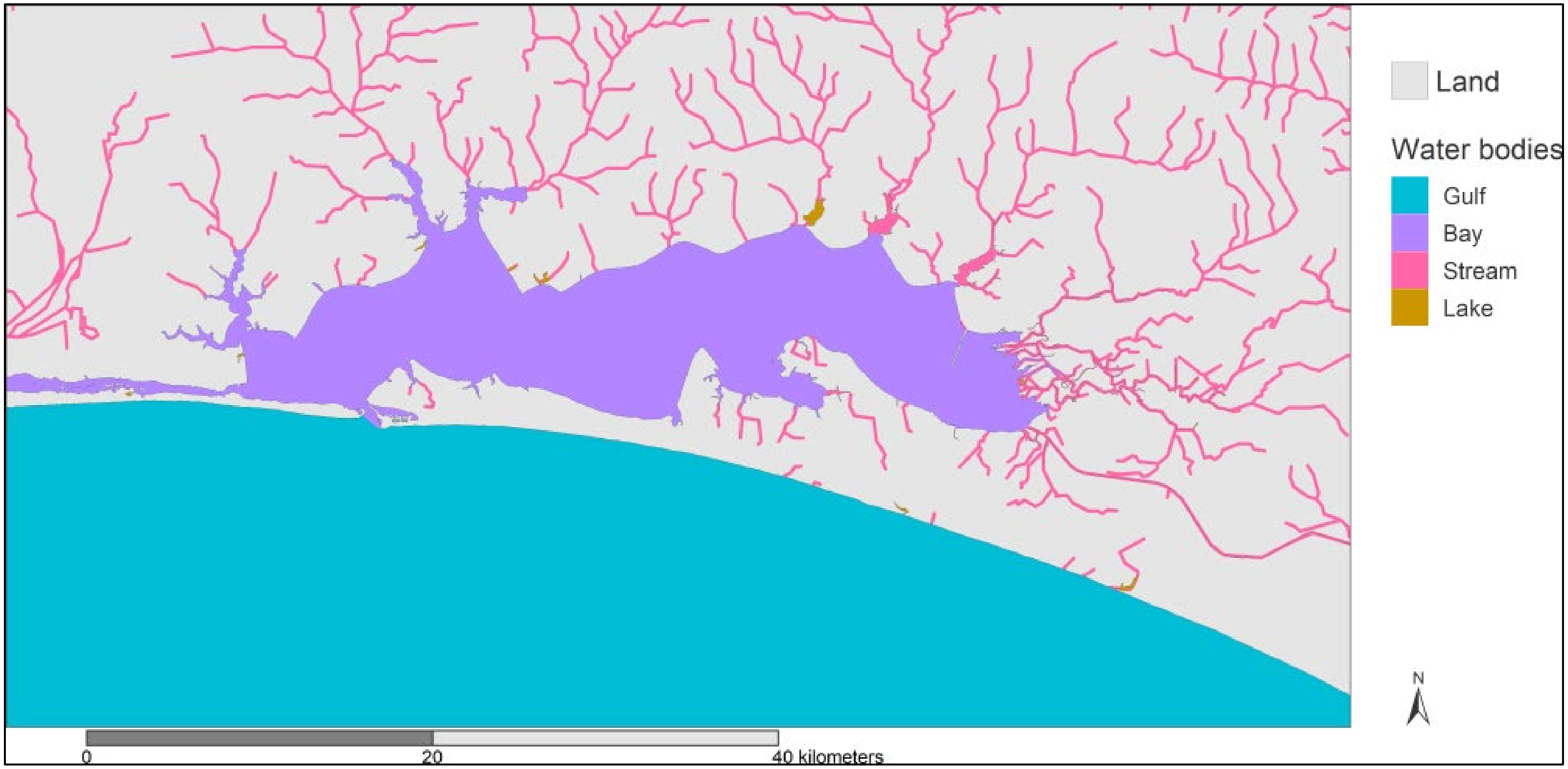

Figure 128. Water bodies of the Destin region.

Modified from Tele Atlas North America, Inc. (2010).

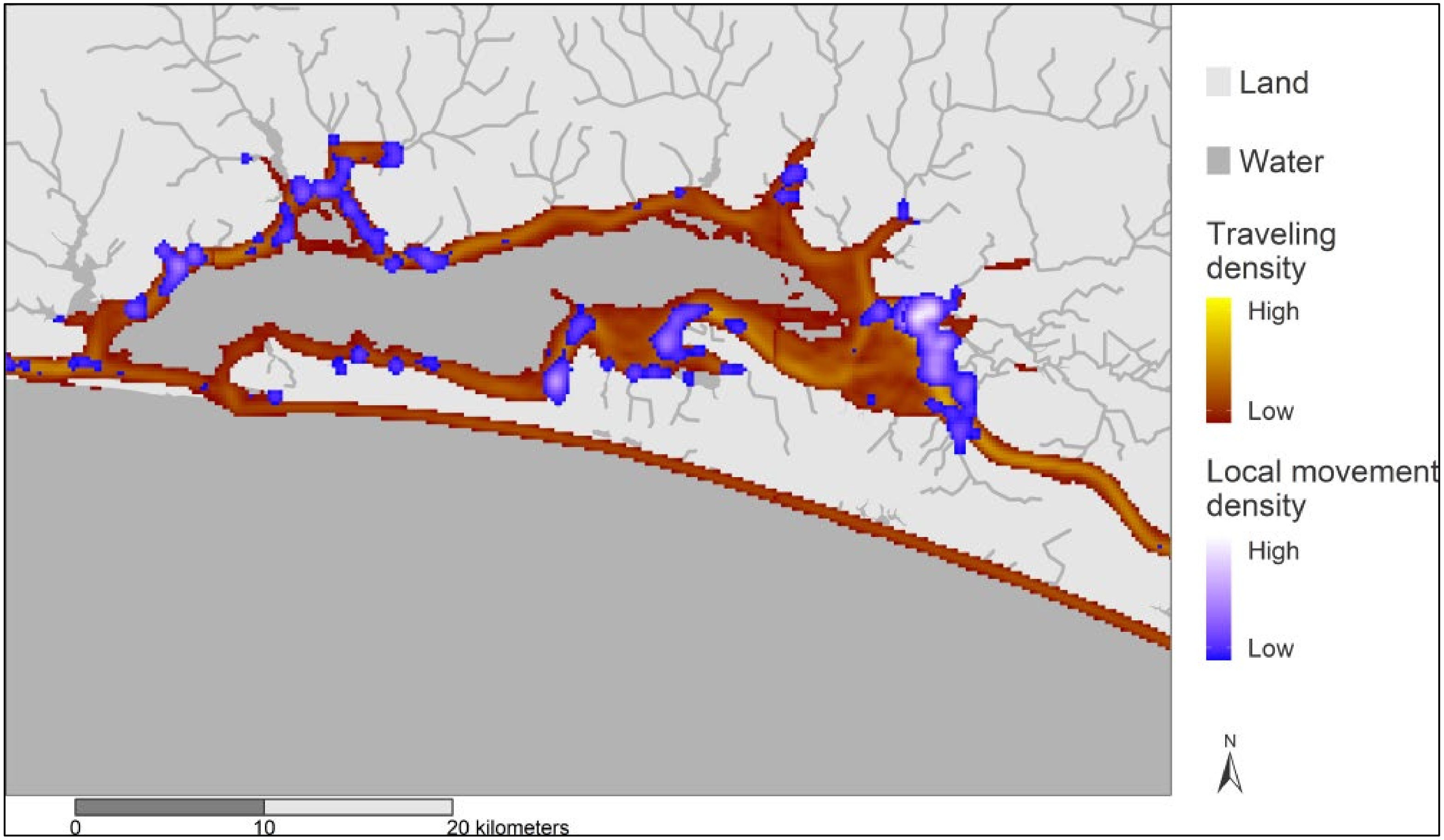

Figure 129. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

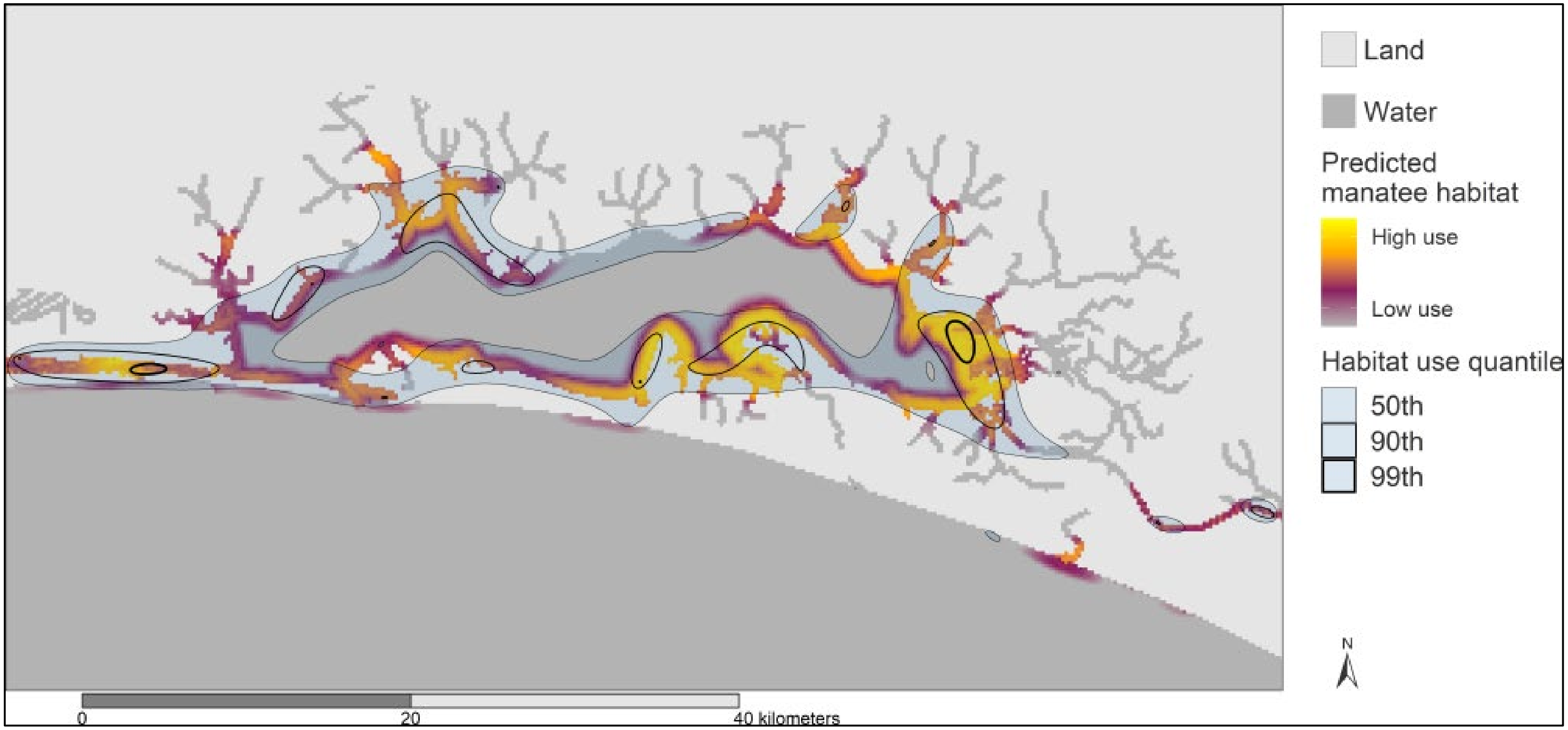

Figure 130. Habitat use prediction for the Destin region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.18 Panama City

The Panama City region is comprised of an interconnected embayment, where each lobe is individually named (Figure 131 through Figure 134). From west to east, these are West Bay, North Bay, St. Andrew Bay, and East Bay. Areas of interest combine the lobes into two parts, split in the central St. Andrew Bay. The Gulf Intracoastal Waterway extends from both East Bay and West Bay to adjoining regions. *Halodule wrightii* and *Thalassia testudinum* have been reported in the lower parts of the bay (Grady 1981), and consistent with nearby regions, seagrass resources have been in decline for the last several decades (Brim and Handley 2007). The upper reaches of North Bay maintain low salinity, with vegetation communities of rushes, sedges, *Spartina spp.,* and other freshwater submerged vegetation (Heard et al. 2002), but there is a dam preventing manatees from entering this upper section.

Manatees passed through the Panama City region through the north and south shorelines of East Bay and West Bay, and the north shore of St. Andrew Bay (Figure 135). They also traveled along both shorelines of North Bay, and a significant minority passed by the entire embayment traveling along the Gulf shoreline. Manatees traveling between the Gulf and St. Andrew Bay did so along the east shore. Small areas of habitat use were spotted along the shorelines and into several estuaries, and there were habitat use locations along the gulf shore south of St. Andrew Bay and St. Andrew Sound. None of the habitat use areas were used extensively.

The habitat use model for the Panama City region showed most of the shoreline of the bays and the Gulf shoreline south of St. Andrew Bay to be equally suitable for manatee use (Figure 136). Because each region was scaled to the relative amount of manatee use, these hotspots covering most of the bay indicate that all of the shoreline was equally mediocre. Most tagged manatees passed quickly through this region (only 1.3 percent of all manatee locations were recorded in the region; Table 7), indicating that habitat quality in neighboring regions with higher overall use (Apalachicola to the east, Destin to the west) was superior.

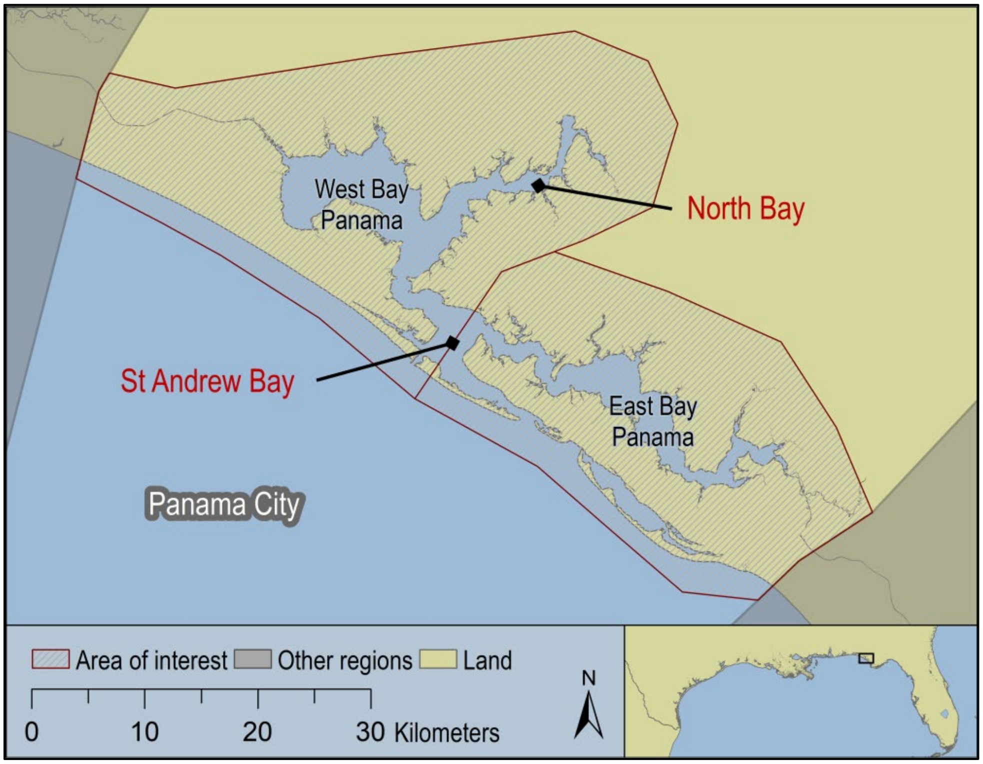

Figure 131. The Panama City region.

West Bay, North Bay, St. Andrew Bay, and East Bay. West Bay, North Bay and the western half of St. Andrew Bay are combined into the West Bay Panama AOI. The eastern half of St. Andrew Bay and East Bay are combined into the East Bay Panama AOI.

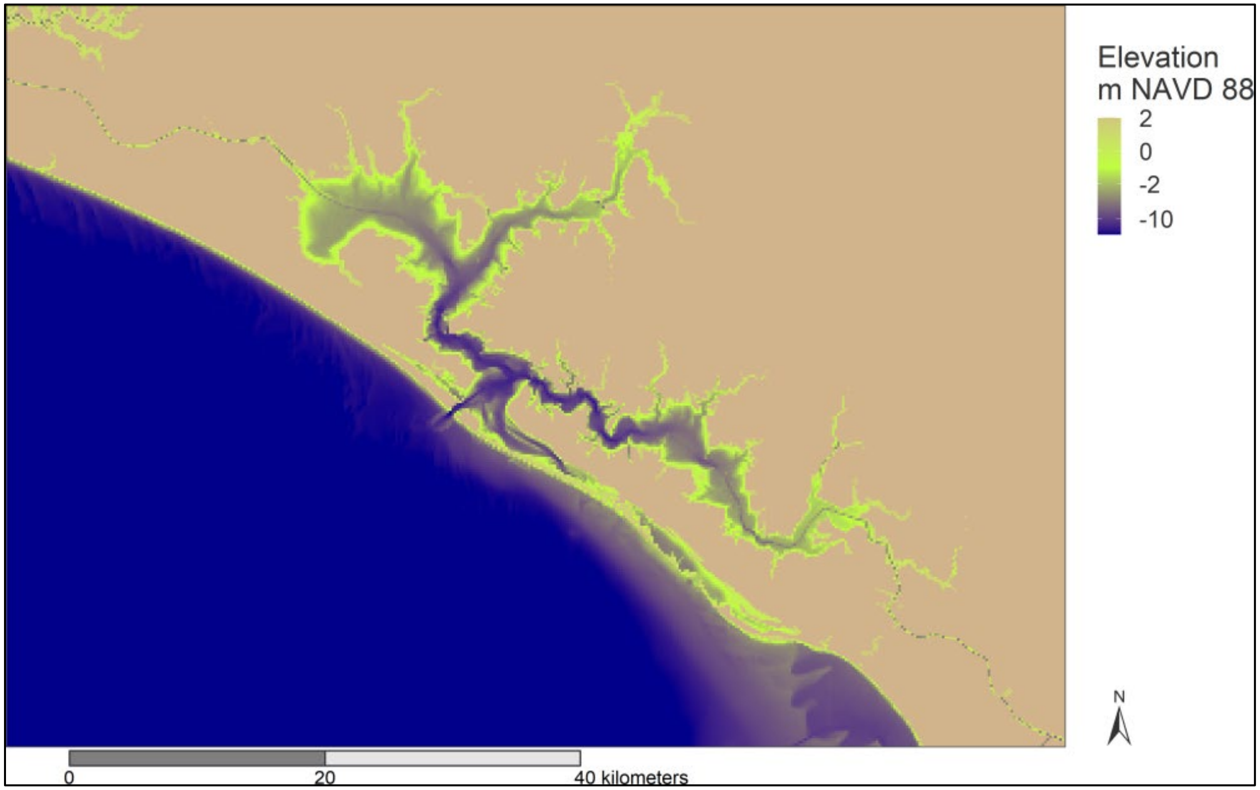

Figure 132. Digital elevation model of the Panama City region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (violet-dark blue).

Data compiled from NOAA sources; see text for details.

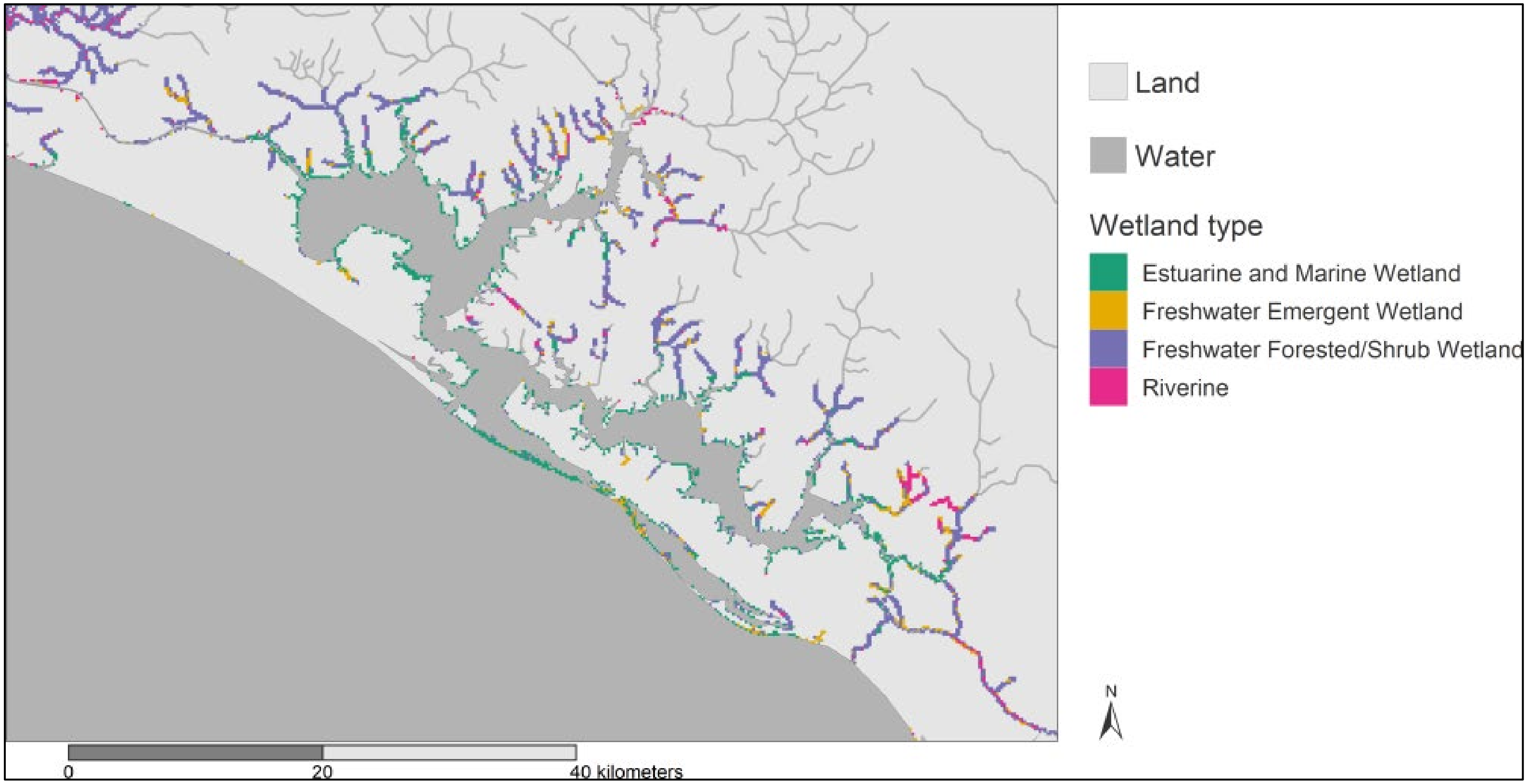

Figure 133. Wetland types and locations within the Panama City region.

Modified from US Fish and Wildlife Service (2016).

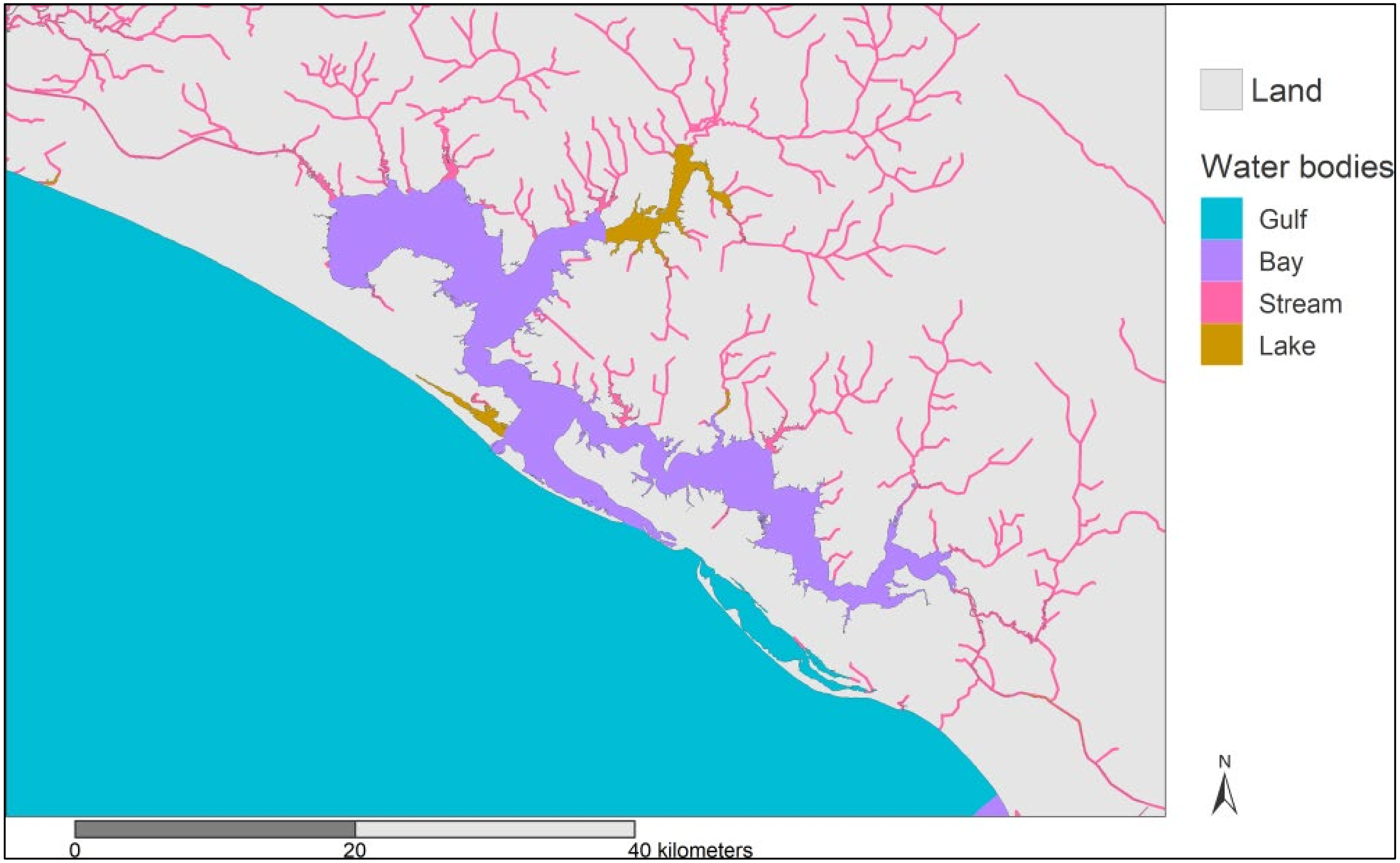

Figure 134. Water bodies of the Panama City region.

Modified from Tele Atlas North America, Inc. (2010).

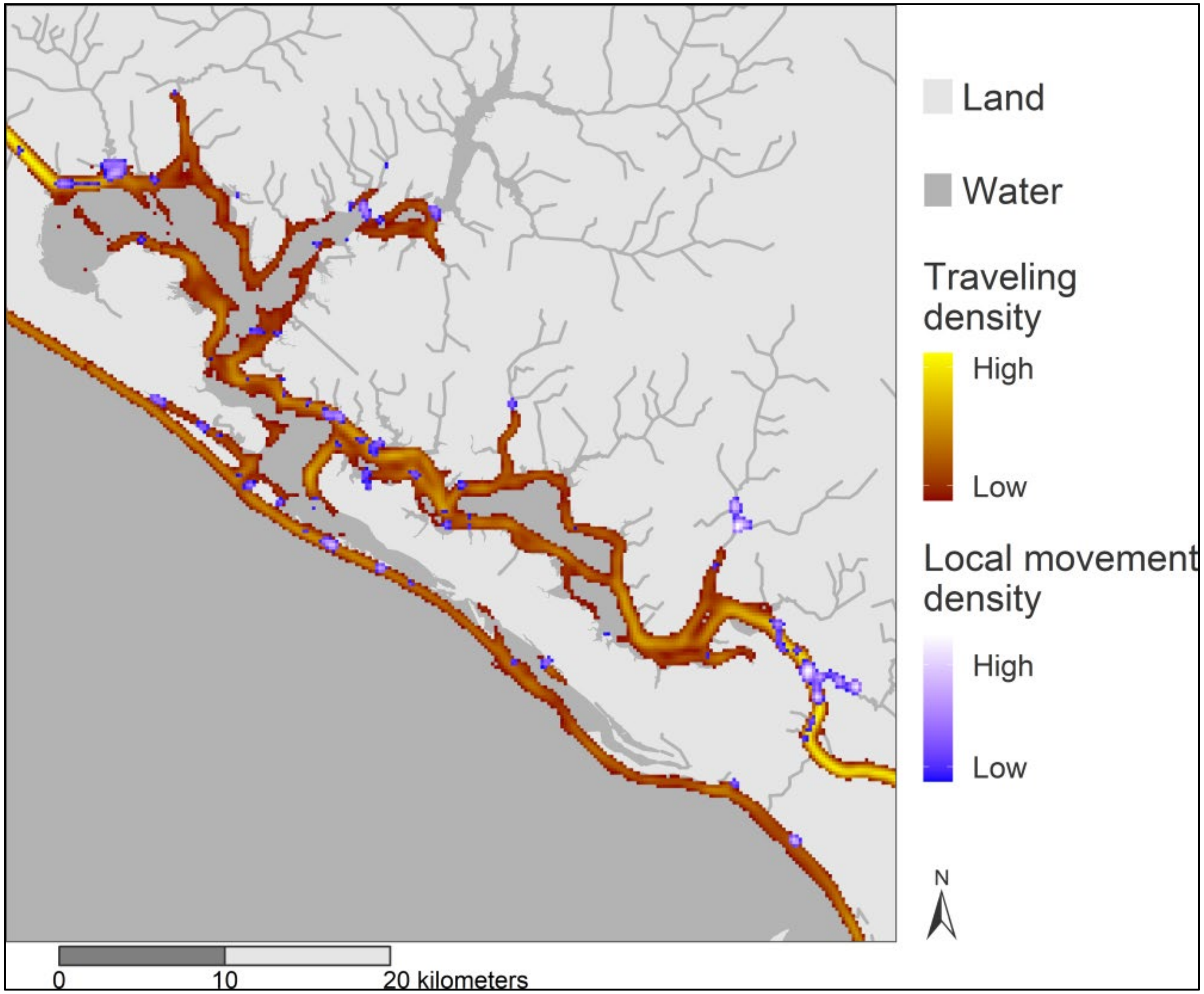

Figure 135. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the Panama City region.

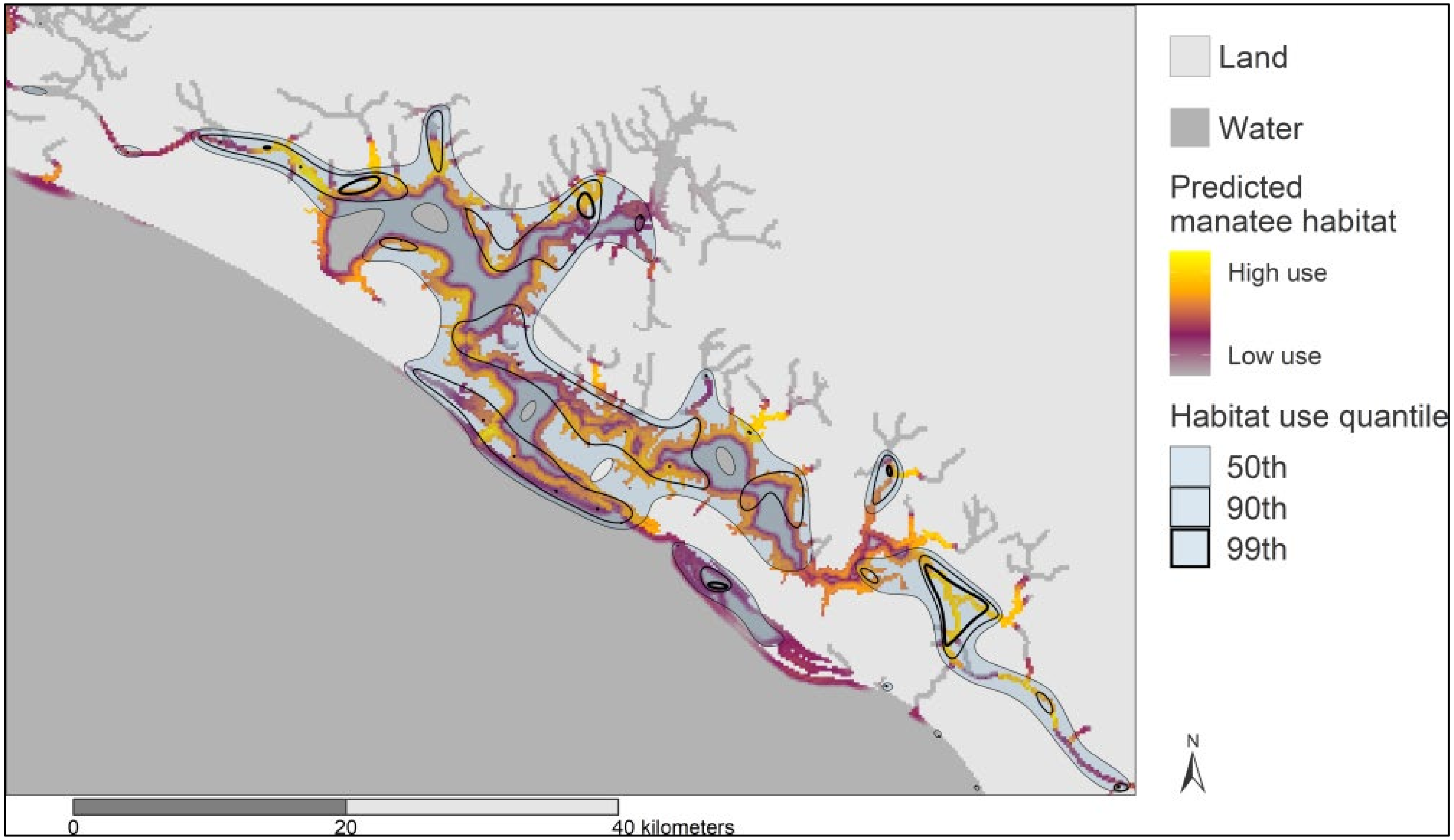

Figure 136. Habitat use prediction for the Panama City region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.19 Port St. Joe

The Port St. Joe region consists of St Joseph Bay, which is connected to the Gulf Intracoastal Waterway by a canal (Figure 137 through Figure 140). The bay is shallow, and contains a stable seagrass assemblage dominated by *Thalassia testudinum*, along with *Syringodium filiforme* and a small amount of *Halodule wrightii* (Iverson and Bittaker 1986). This embayment is not fed by a large river system, and contains no freshwater estuary.

Despite a large and stable area of seagrass habitat in St Joseph Bay, the Port St. Joe region was also a "pass-through" region. Only 0.4 percent of all manatee locations were recorded from the region. Despite the seagrass, the region is very saline, with no easily accessible freshwater. By contrast, forage and freshwater were available in the next region to the east. Very few manatees traveling between Port St. Joe and the Apalachicola region to the east passed around St Joseph bay along the Gulf shoreline. Instead, the vast majority traveled via the Intracoastal Waterway (Figure 141). Manatees traveling between Port St. Joe and Panama City to the west split equally between the intracoastal and the Gulf shoreline. A small area of local habitat use near the canal entrance indicated a patch of SAV forage that may have been a draw to those animals that traveled that way.

The habitat use prediction model showed hotspots along the intracoastal waterways, but only a weak signal near the forage patch in St Joseph Bay (Figure 142). Because the rest of the bay, despite having plentiful seagrass resources, was not used by manatees, the model discounted all habitat areas in the bay.

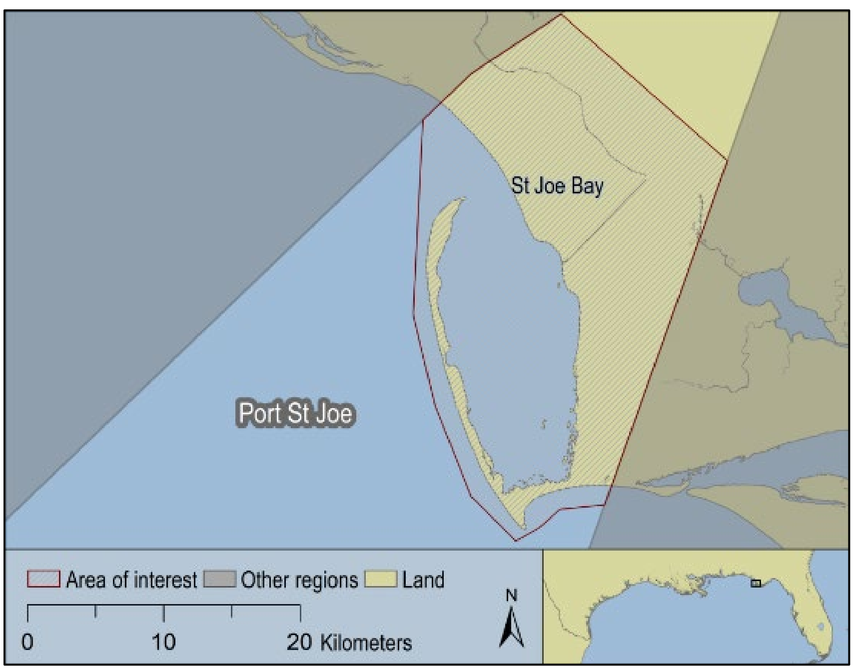

Figure 137. The Port St. Joe region, with St Joseph Bay (contained within the St Joe Bay AOI).

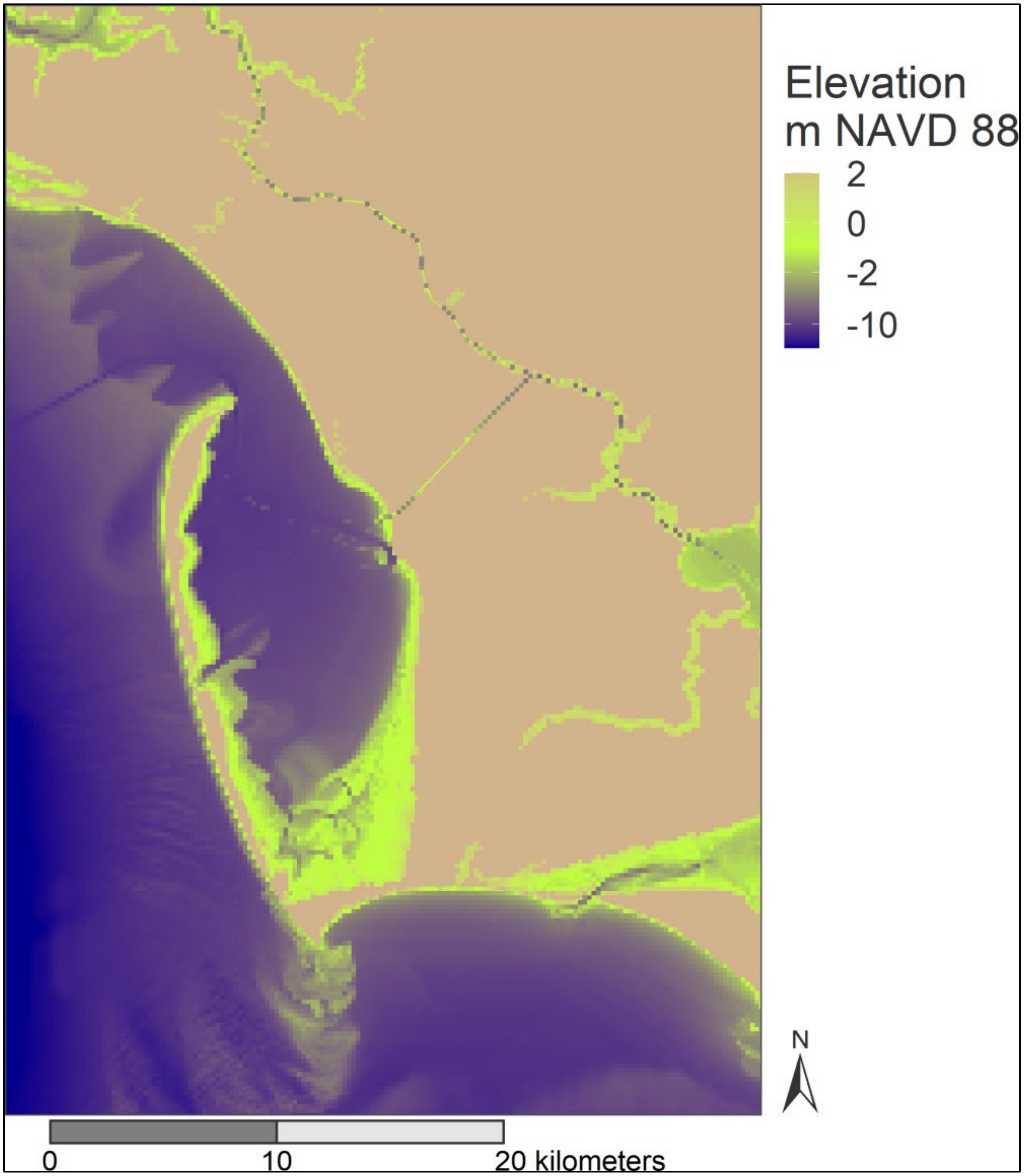

Figure 138. Digital elevation model of the Port St. Joe region showing shallow areas where submerged vegetation growth is likely (yellow- green), and deeper areas (violet-dark blue).

Data compiled from NOAA sources; see text for details.

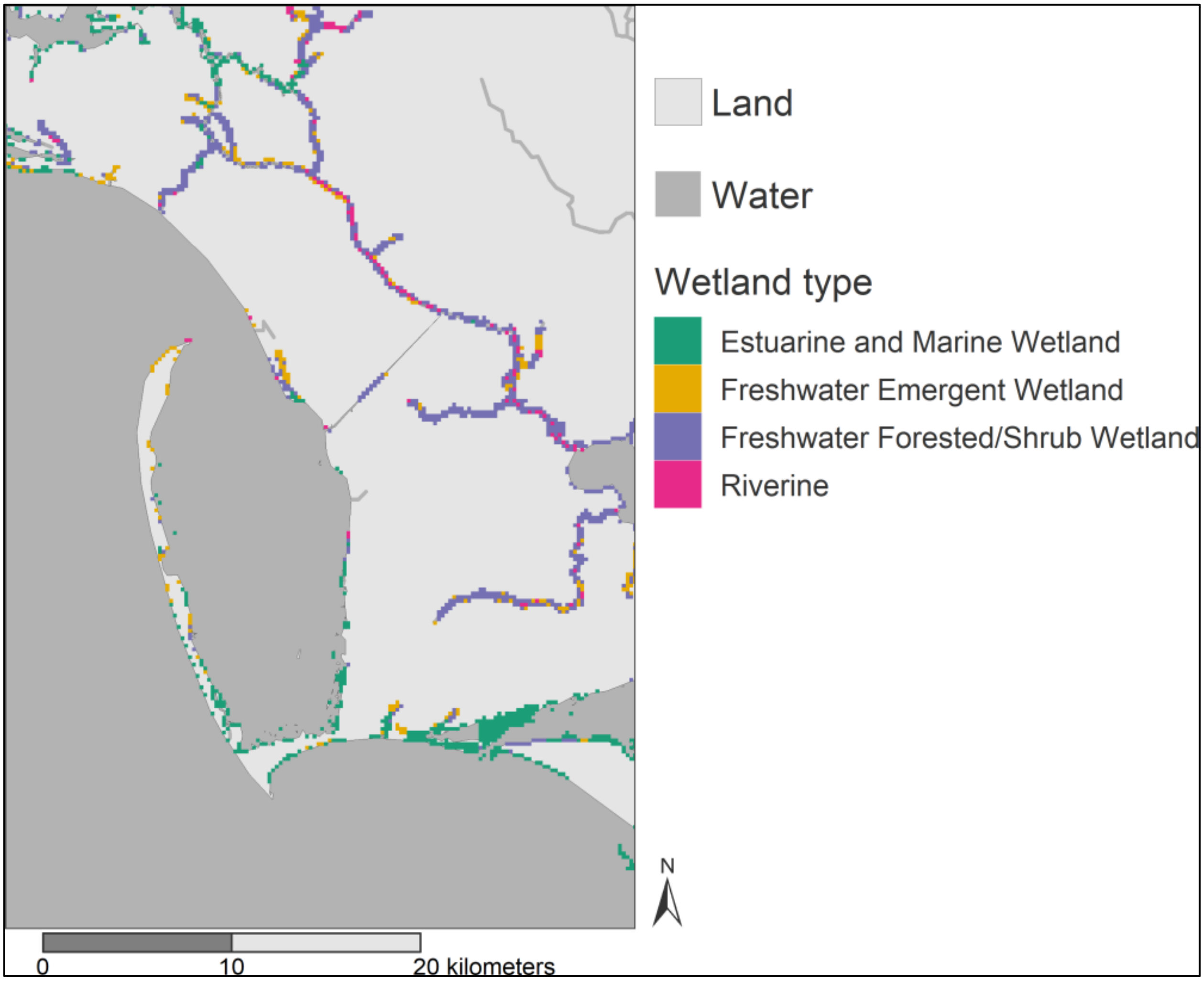

Figure 139. Wetland types and locations within the Port St. Joe region.

Modified from US Fish and Wildlife Service (2016).

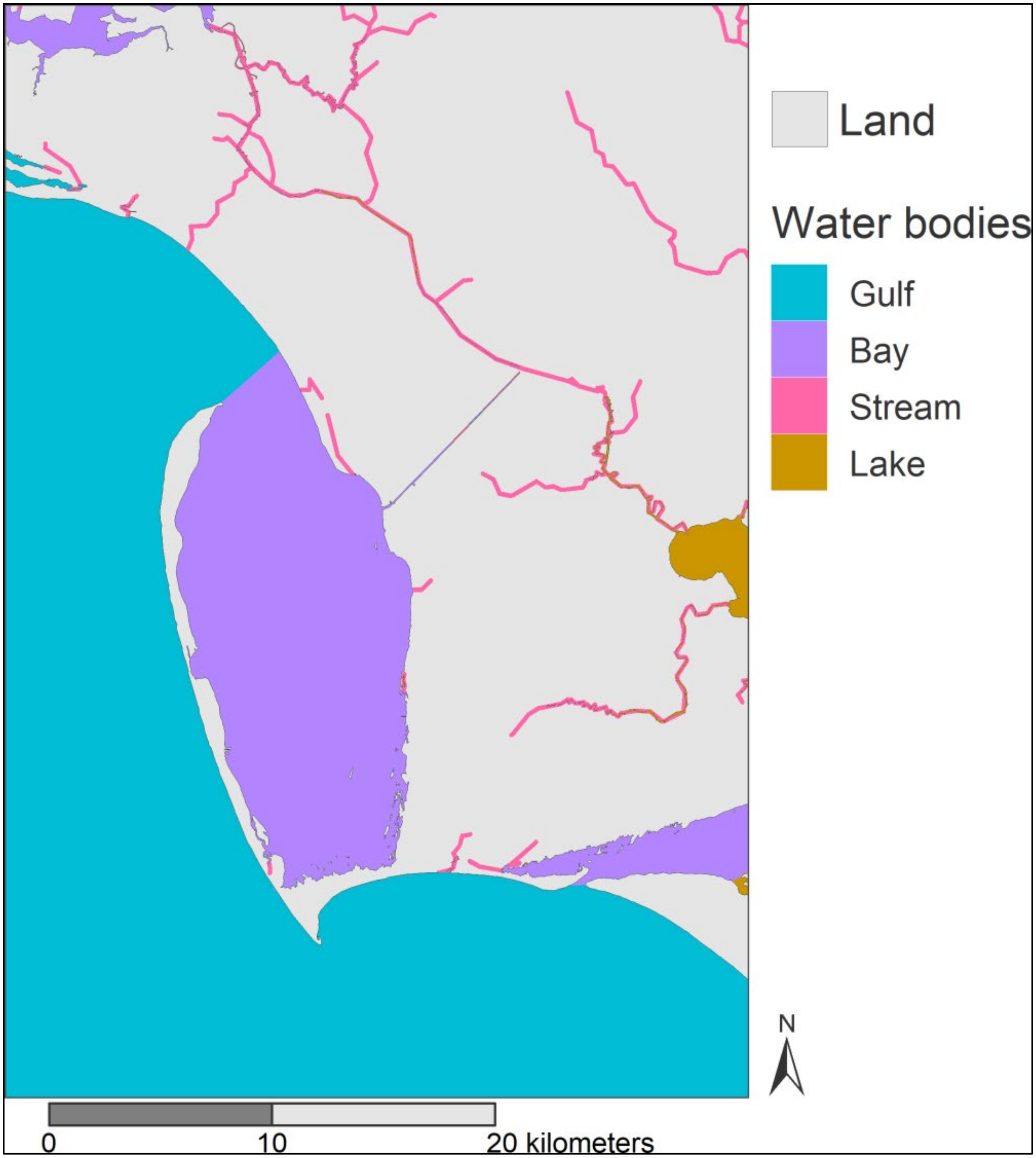

Figure 140. Water bodies of the Port St. Joe region.

Modified from Tele Atlas North America, Inc. (2010).

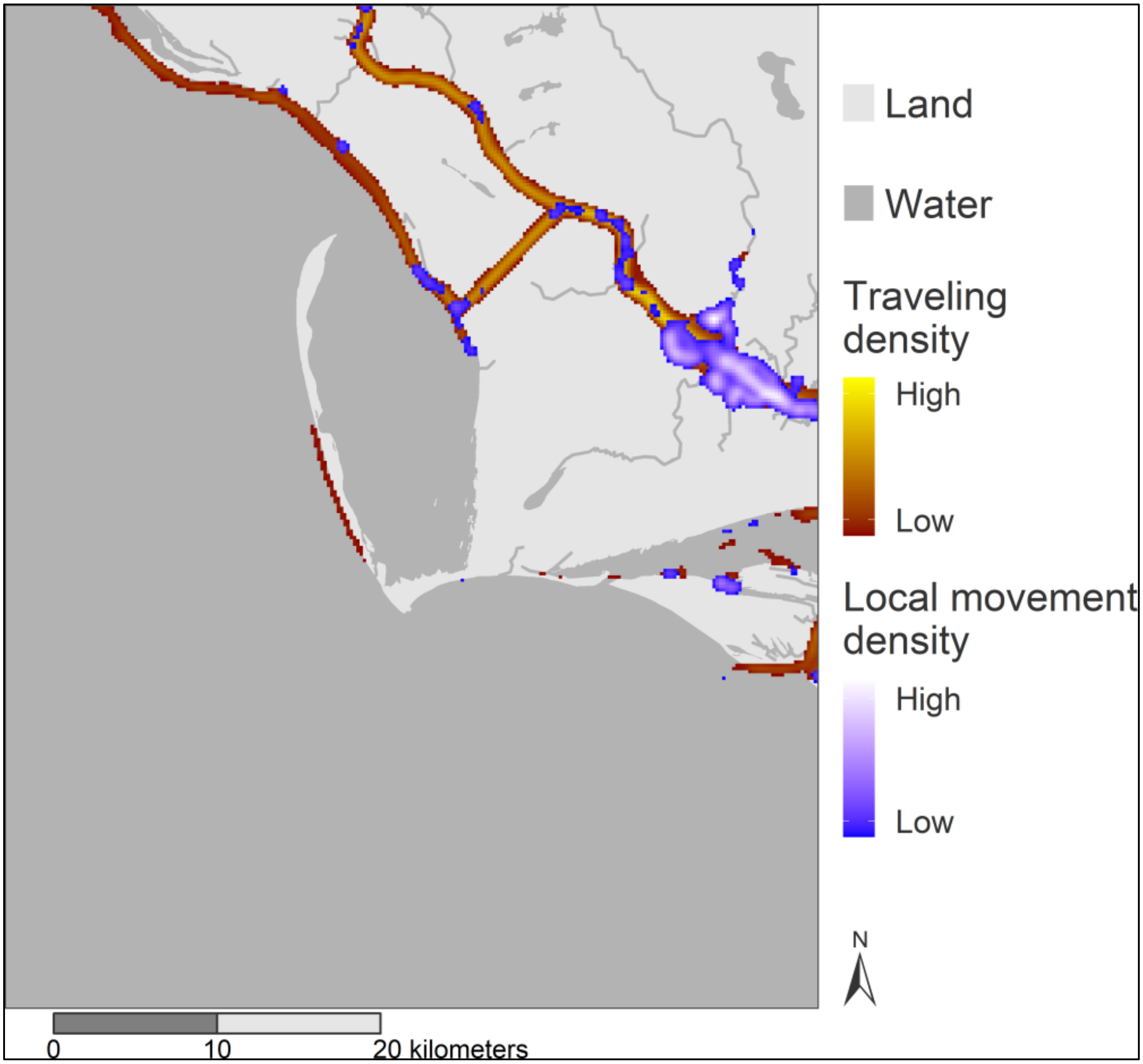

Figure 141. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

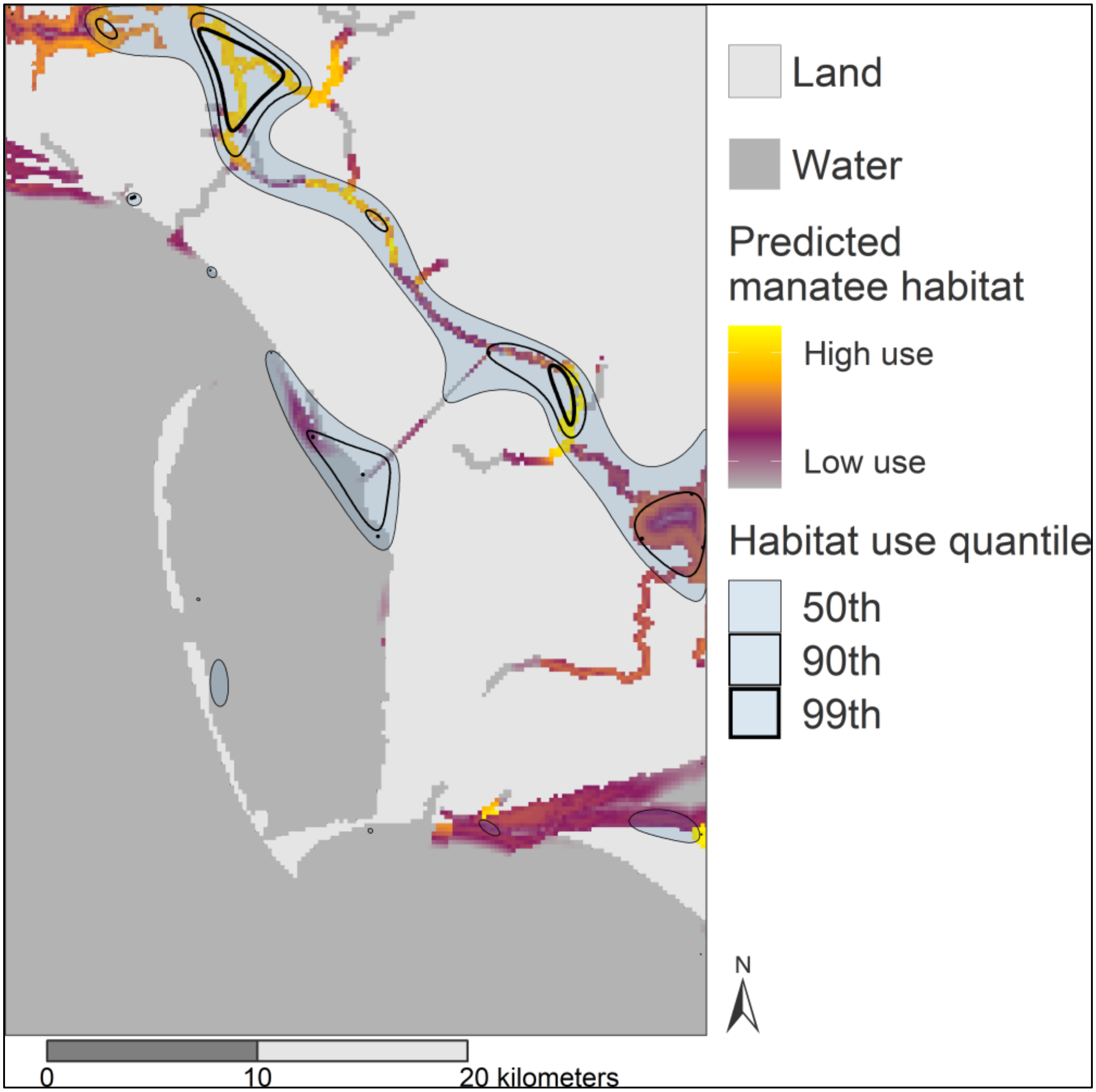

Figure 142. Habitat use prediction for the Port St. Joe region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.20 Apalachicola

The Apalachicola region (Figure 143 through Figure 144) is one of the more diverse areas in the northern Gulf of Mexico. It includes four distinct AOI, including the freshwater Lake Wimico, which is connected to the Gulf Intracoastal Waterway on the west and the Apalachicola River to the east. The barrier islands that protect Apalachicola Bay and St George Sound make up the St. George Island AOI. The final AOI includes the Carrabelle River and the northern shoreline of S.t George Sound. St. George Sound is marine, with *T. testudinum*, *S. filiforme* and *H. wrightii* found along the shallow fringes. The Apalachicola River Delta and Lake Wimico are brackish to freshwater, and contain submerged vegetation species such as *Ruppia maritima, Vallisneria americana, Potamogeton sp.* and *Myriophyllum spicatum* (Livingston 1984).

The quality of the habitat in the Apalachicola region was evident by the variety of locations used by manatees and the amount of time they spent in the region. The Apalachicola region had the second highest number of locations overall after Crystal River (19.0 percent of all locations) and the highest by far during summer (35.5 percent of summer locations; Table 7. Number and percentage of GPS location per region. The percentage values are relative to other regions). Travel paths between the Apalachicola region and the Port St. Joe region to the west was overwhelmingly through the Intracoastal Waterway via Lake Wimico. Between this region and St. Marks to the east, travel was mostly along the Gulf shoreline, but a significant minority traveled inland from the Carrabelle River to Ochlockonee Bay (Figure 147). Additional travel paths were seen along the southern shoreline of Apalachicola Bay along St George Island, and between the Apalachicola River delta directly south to St. George Island. Habitat use areas were seen in Lake Wimico, the Apalachicola River Delta, and along both the north and south shorelines of Apalachicola Bay.

The predicted habitat locations for the Apalachicola region matched the use of the tagged manatees very well, but the highest density areas did not exactly match the most intense predictions (Figure 148). Lake Wimico, one of the most heavily used areas in the region, was predicted to be moderately used. The Apalachicola river delta as correctly predicted to be a heavy manatee use area, but the highest use area was farther downstream than the predicted peak location. The Carrabelle River was accurately predicted, as were the shorelines of Apalachicola Bay, but a predicted high-use area on St. Vincent Island to the west of Apalachicola Bay is not accessible, and not used by manatees.

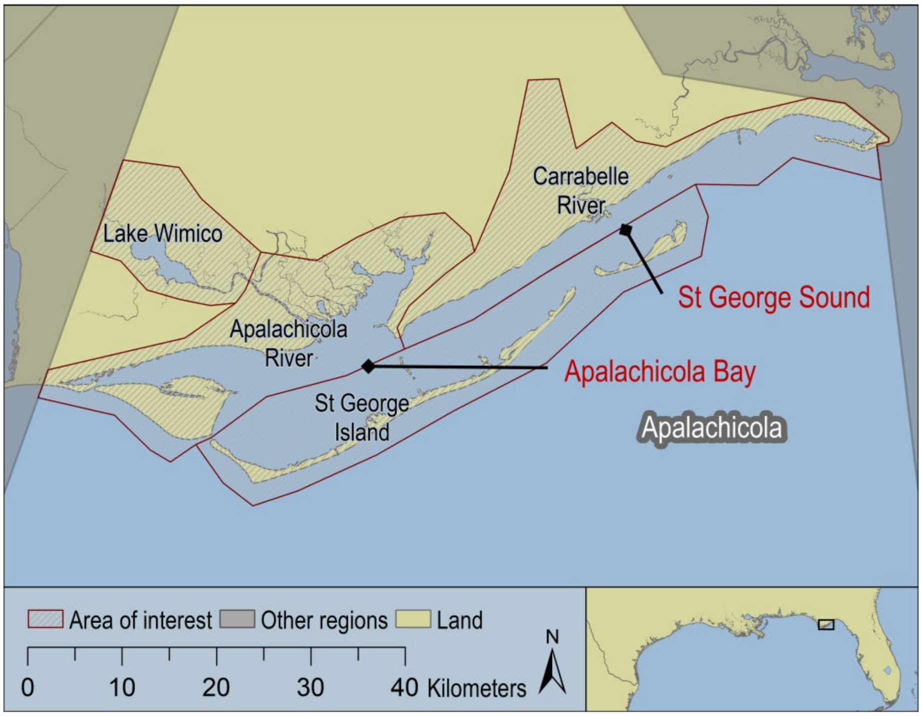

Figure 143. The Apalachicola region, with Lake Wimico, Apalachicola River and Bay, and the St George Sound.

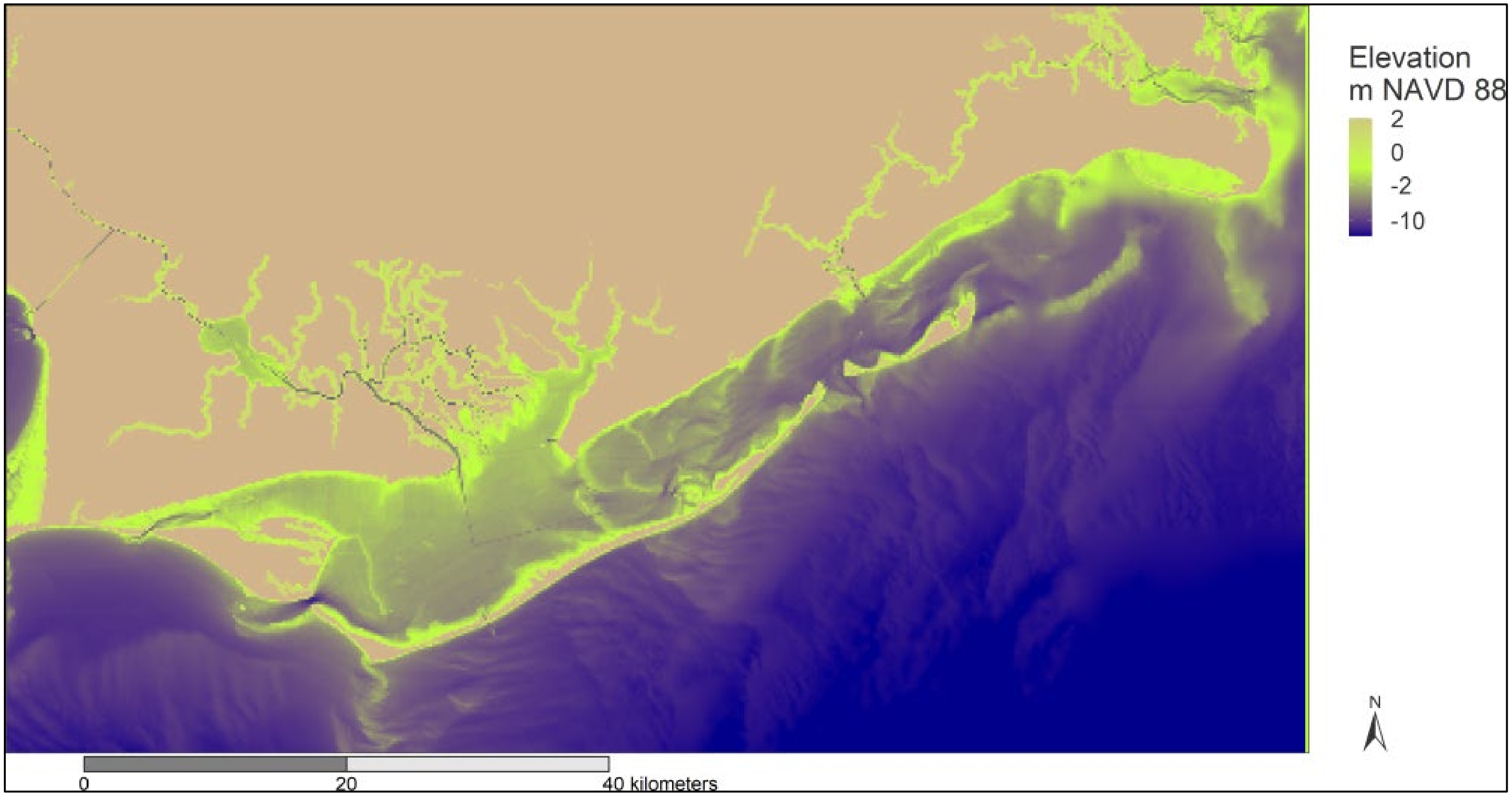

Figure 144. Digital elevation model of the Apalachicola region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (violet-dark blue).

Data compiled from NOAA sources; see text for details.

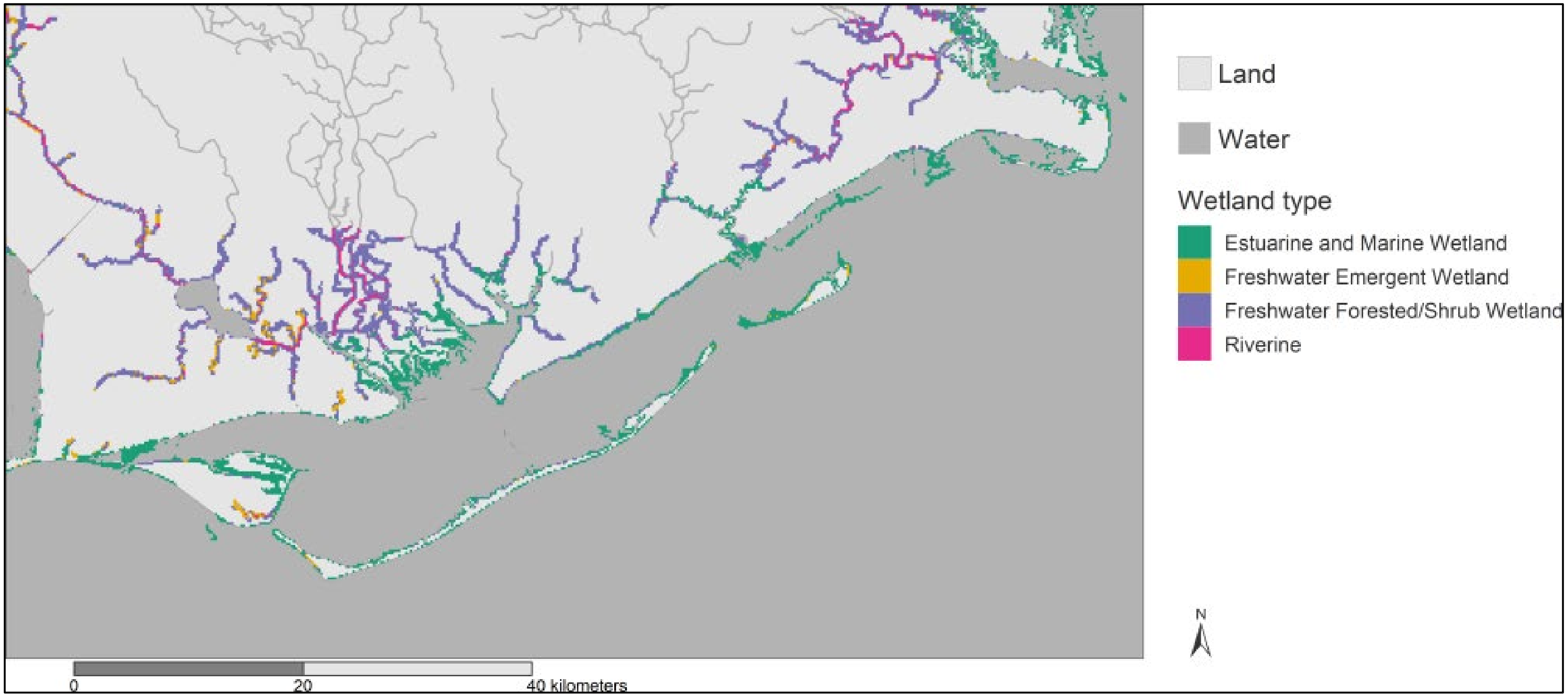

Figure 145. Wetland types and locations within the Apalachicola region.

Modified from US Fish and Wildlife Service (2016).

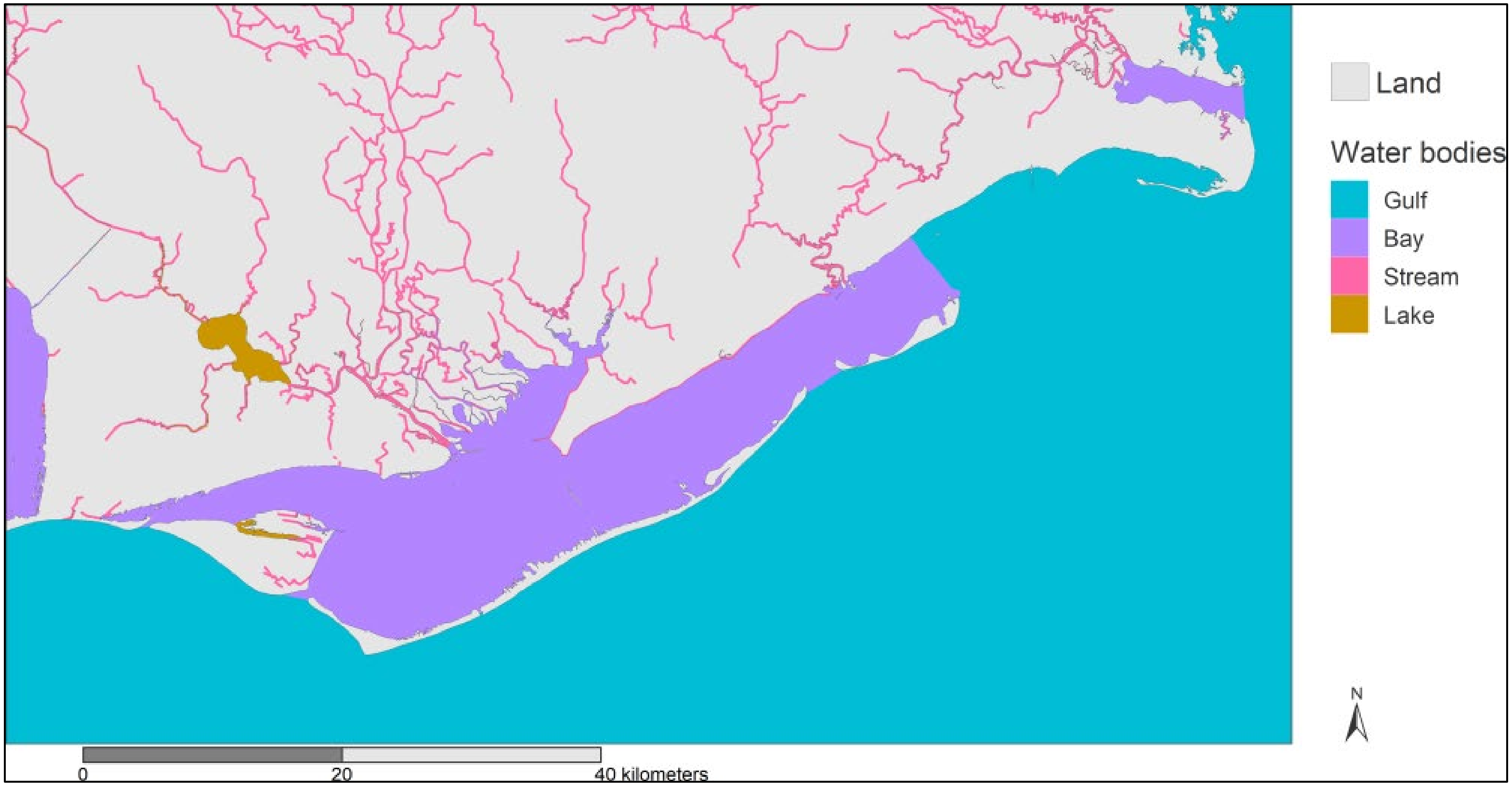

Figure 146. Water bodies of the Apalachicola region.

Modified from Tele Atlas North America, Inc. (2010).

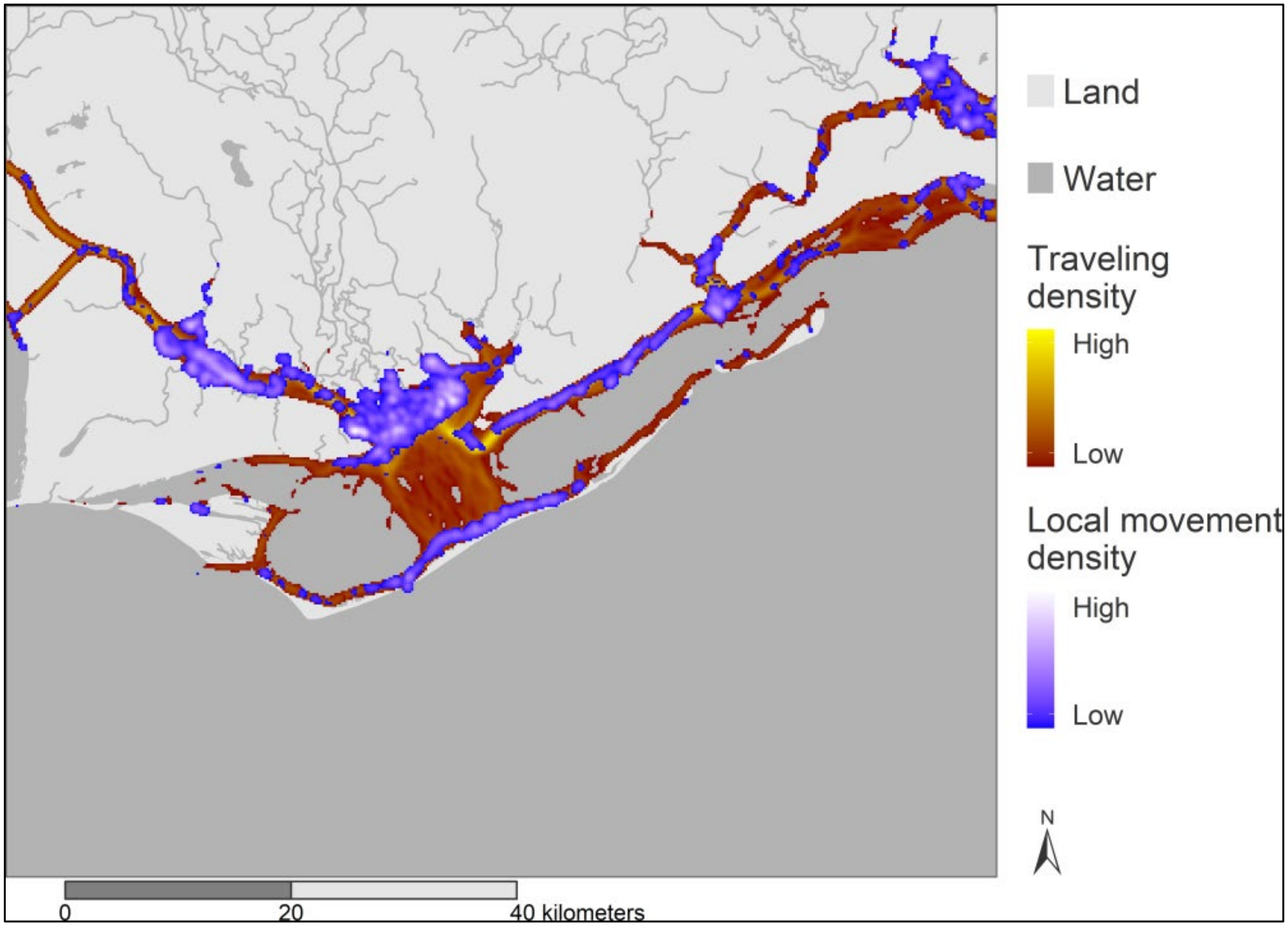

Figure 147. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

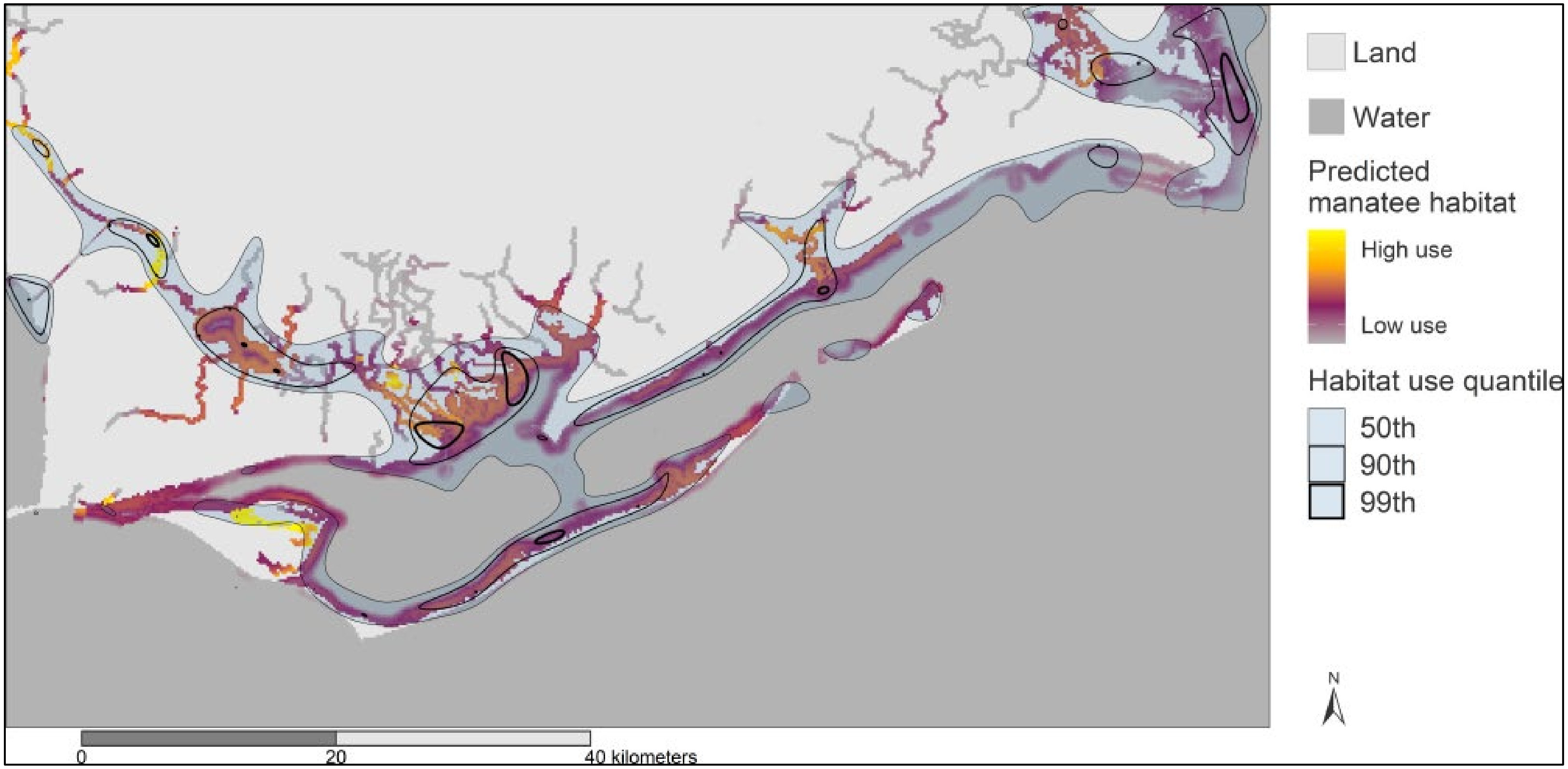

Figure 148. Habitat use prediction for the Apalachicola region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.21 St. Marks

The St. Marks region (Figure 149–Figure 152) was split into two AOI: Ochlockonee Bay and nearby environments forms the bulk of the eastern AOI, and the Wakulla-St. Marks river complex, including Goose Creek Bay forms the western AOI. Ochlockonee Bay is "poorly drained" and so maintains a high salinity most of the time (Wolfe et al. 1988), but the Ochlockonee River does remain fresh. *Spartina alterniflora* can be found along salt marsh coastal margins, and small amounts of *Thalassia testudinum, Halodule wrightii* and *Syringodium filiforme* have been reported near the mouth of the bay (Northwest Florida Water Management District 2017). By contrast, The St. Marks River AOI contains large swaths of continuous mixed-species seagrass bed on the shallow marine shelf that is found in the Big Bend of Florida. *Halodule wrightii, Thalassia testudinum, Halophila sp.* and *Syringodium filiforme* have been reported in the marine environment, while *Ruppia maritima* can be found in the St. Marks River estuary (Mattson 2000; Mattson et al. 2007) along with *Spartina alterniflora* saltmarsh (Lewis et al. 2009). Upstream, the Wakulla/St. Marks River complex is host to a diverse assemblage of freshwater SAV, including *Vallisneria americana, Sagittaria sp. Najas guadalupensis, Ceratophyllum demersum* and *Potamogeton sp. Hydrilla verticillata* was introduced in 1997 and has been present in varying amounts since that time, primarily in the upper reaches of the Wakulla River (Lewis et al. 2009). Wakulla Springs is the western-most natural warm water outflow along the Gulf coast, and so represents the limit of the Florida manatee's winter range.

The St. Marks region is the northernmost limit of the wide Florida shelf that supports vast seagrass beds offshore. The manatee use pattern reflected this topography, showing traveling and habitat use movements out to at least five kilometers offshore (Figure 153). The heaviest habitat use was the western end and shoals just outside the entrance of Ochlockonee Bay, Oyster Bay, Goose Creek Bay, and across all of the St. Marks estuary, and the St. Marks and Wakulla rivers. Eastward of the St. Marks estuary, only a few lesser used habitat use patches were seen, though the traveling movements to the Aucilla region were heavy and broad. Both the St. Marks and Wakulla rivers showed traveling and habitat use movements, especially in the Wakulla River, all the way up to Wakulla Springs.

The habitat use prediction model excluded much of the Wakulla and St. Marks rivers, including Wakulla Springs, because the upper rivers were not represented on all of the base layers. Nevertheless, the river system up to the confluence of the two rivers was correctly identified as heavily used habitat (Figure 154). Other predicted high-use areas were the eastern end of Ochlockonee Bay, the center of Oyster Bay, and the St. Marks River estuary. The shallow shelf within approximately four kilometers was identified as a medium-use area.

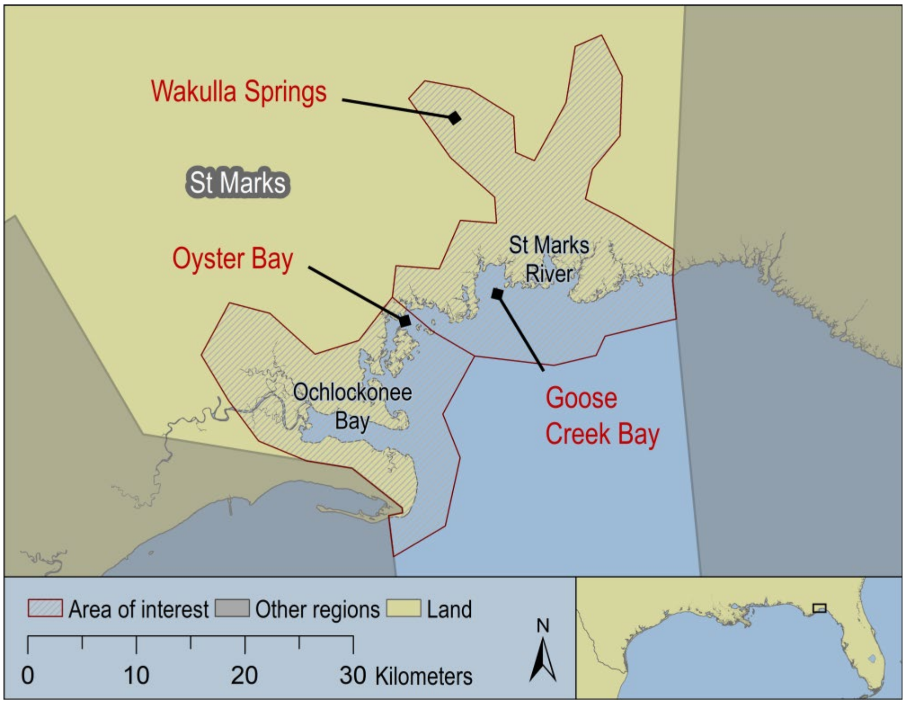

Figure 149. The St. Marks region, with the Wakulla-St. Marks Rivers and Ochlockonee Bay.

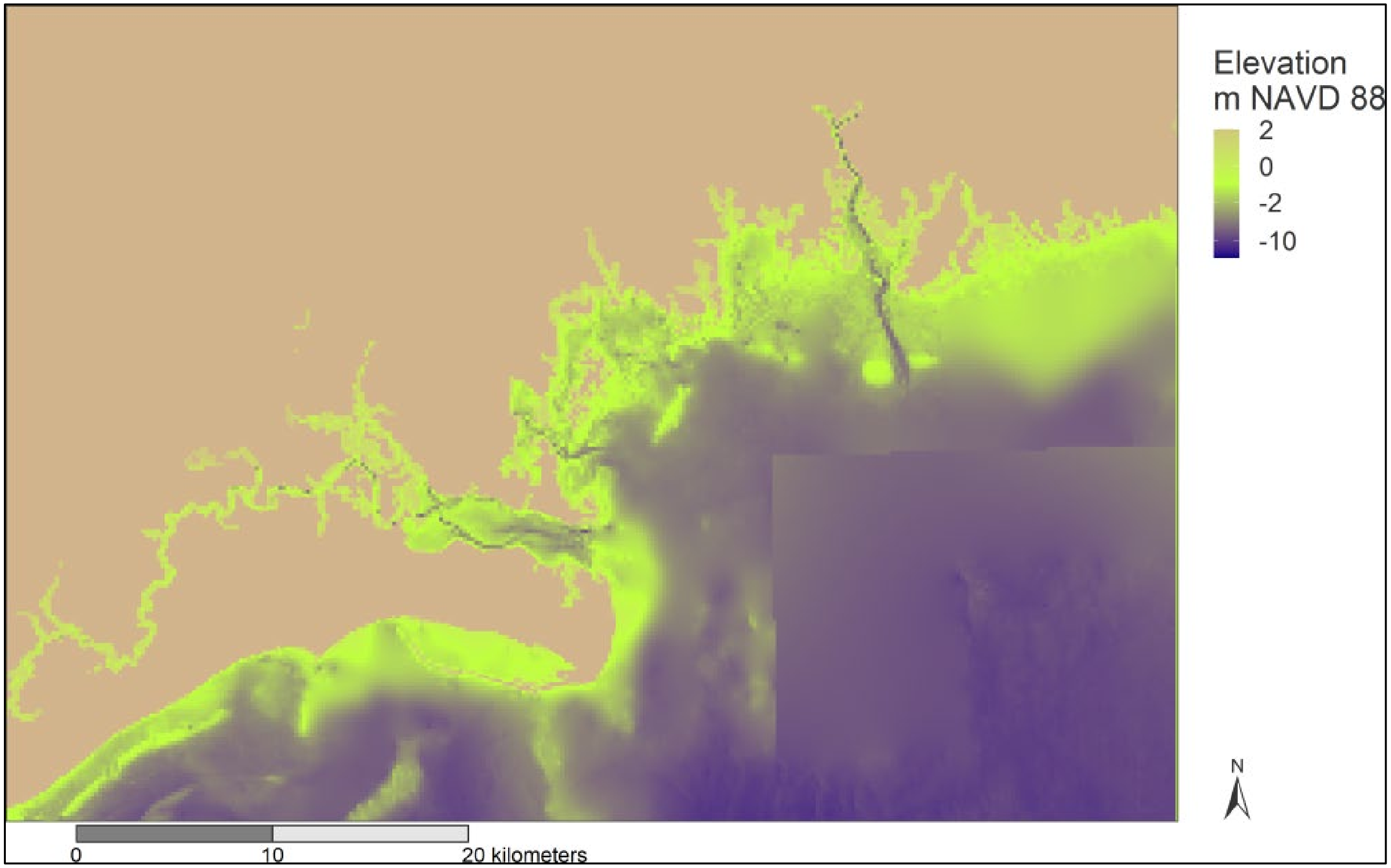

Figure 150. Digital elevation model of the St. Marks region showing shallow areas where submerged vegetation growth is likely (yellow- green), and deeper areas in (dark blue-violet).

Data compiled from NOAA sources; see text for details.

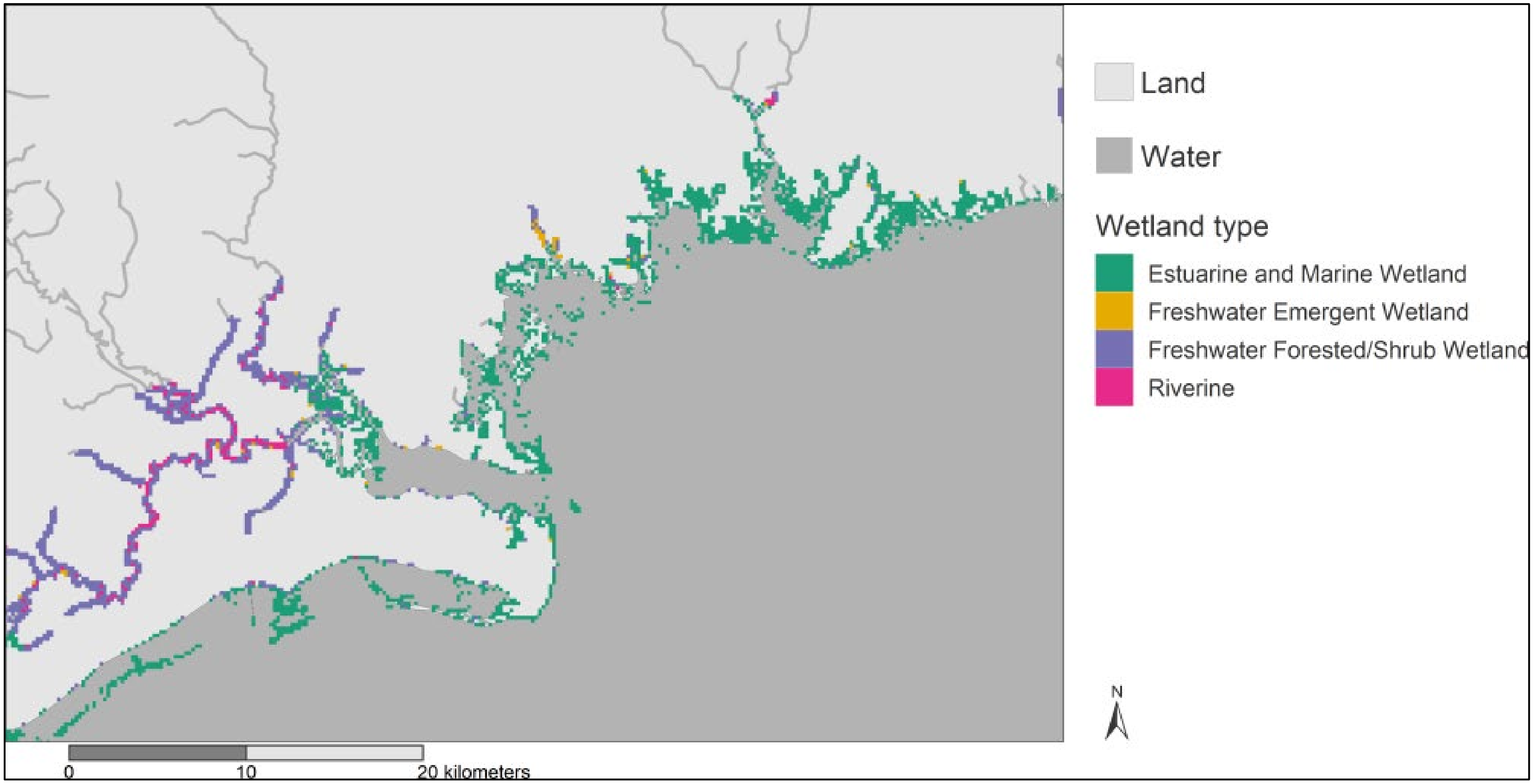

Figure 151. Wetland types and locations within the St. Marks region.

Modified from US Fish and Wildlife Service (2016).

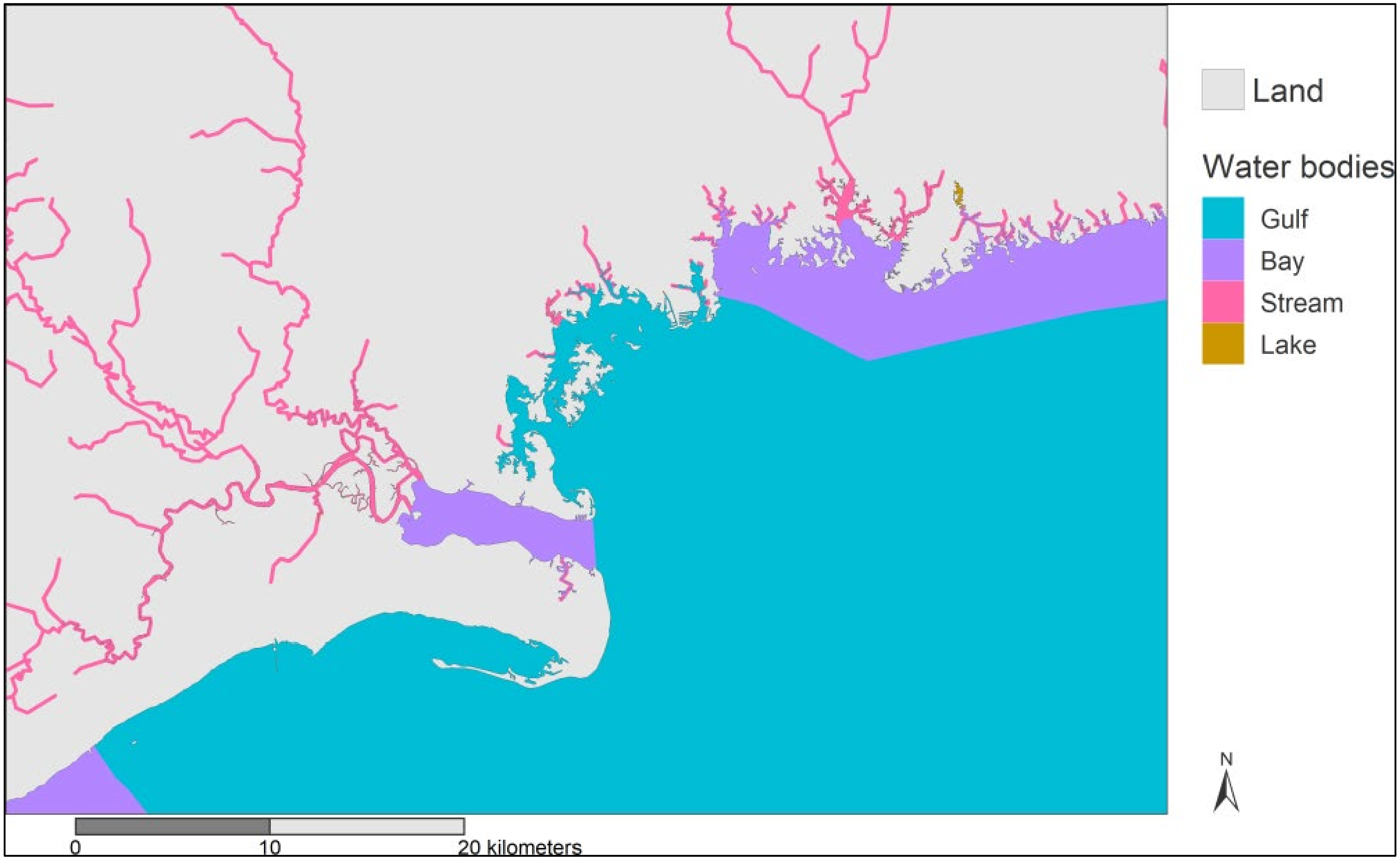

Figure 152. Water bodies of the St. Marks region.

Modified from Tele Atlas North America, Inc. (2010).

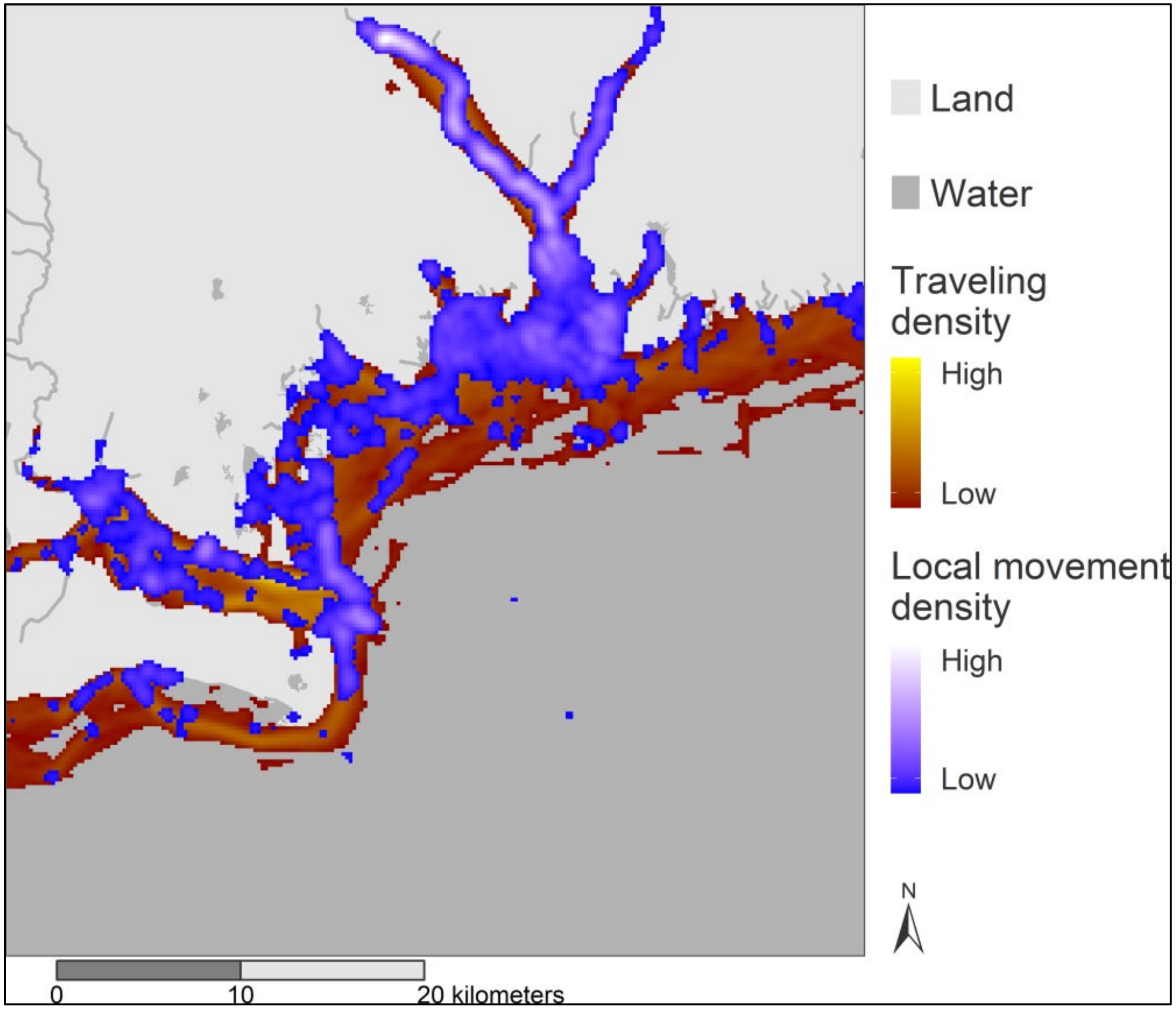

Figure 153. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

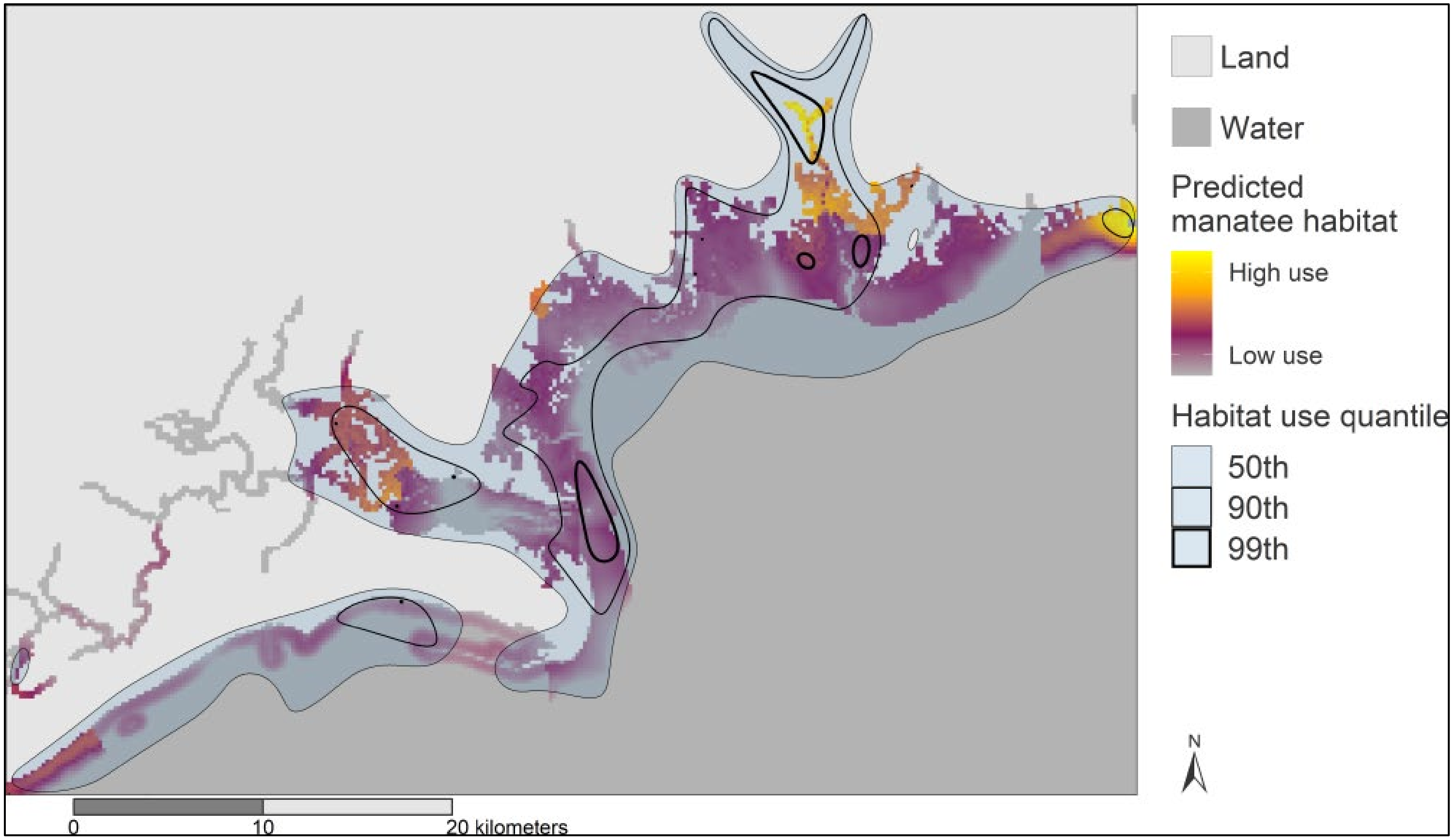

Figure 154. Habitat use prediction for the St. Marks region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.22 Aucilla

The Aucilla region (Figure 155 through Figure 158) is divided into two AOI, each centered on a river system. With the broad shallow shelf extending far offshore, this region is known for large swaths of diverse offshore seagrass beds. Species found include *Thalassia testudinum, Halodule wrightii, Halophila sp.* and *Syringodium filiforme* (Mattson 2000; Mattson et al. 2007).

Manatee movements in the Aucilla region were characterized by a broad swath of traveling movements out to several kilometers offshore, and a very heavy habitat use area centered on the Aucilla River estuary (Figure 159). The Econfina River also showed some habitat use, and a concentrated use area was seen in an embayment approximately six kilometers to the southeast called Big Spring Creek that was protected from heavy waves by several prominent oyster bars.

The manatee habitat prediction model for the Aucilla region predicted evenly distributed medium habitat use along the shoreline out to a few kilometers, except for the Aucilla River estuary, which was predicted to be a very high use area (Figure 160). This pattern was accurate in general, though the actual location of the highest-use habitat in the Aucilla River estuary was offset by several kilometers. This suggests that more favorable manatee habitat extends along much of this coastline than is currently utilized, supporting the idea that this relatively undeveloped section of the Big Bend coast comprises some of the highest-quality manatee habitat in the state (Powell and Rathbun 1984).

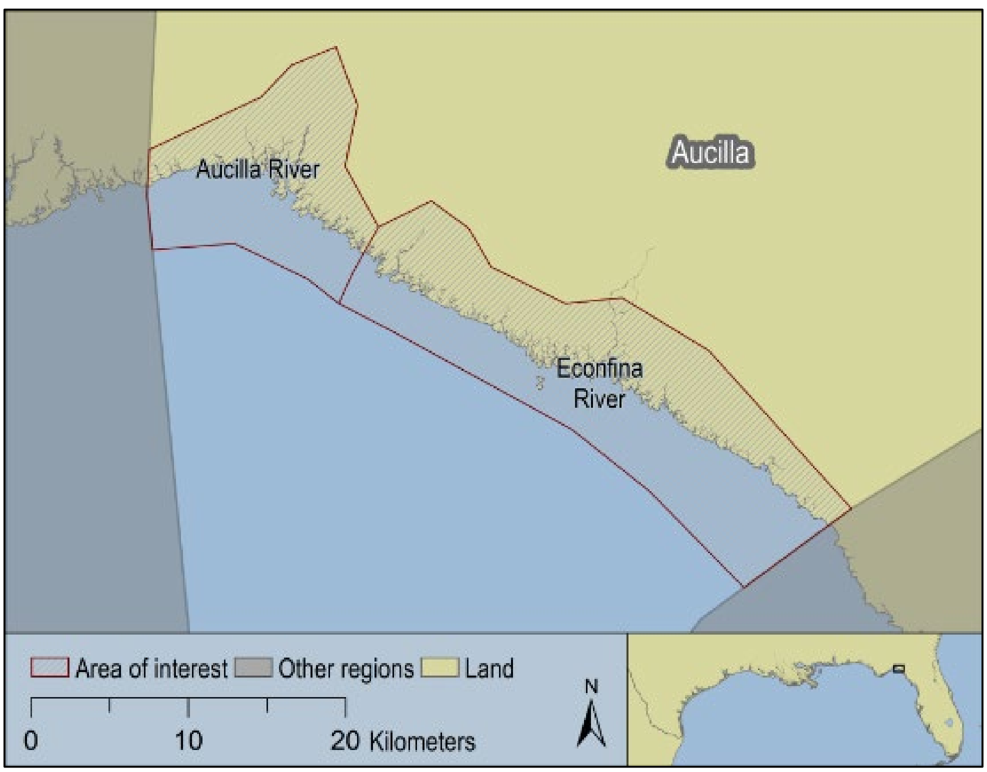

Figure 155. The Aucilla region of the Big Bend of Florida, the Aucilla and Econfina Rivers.

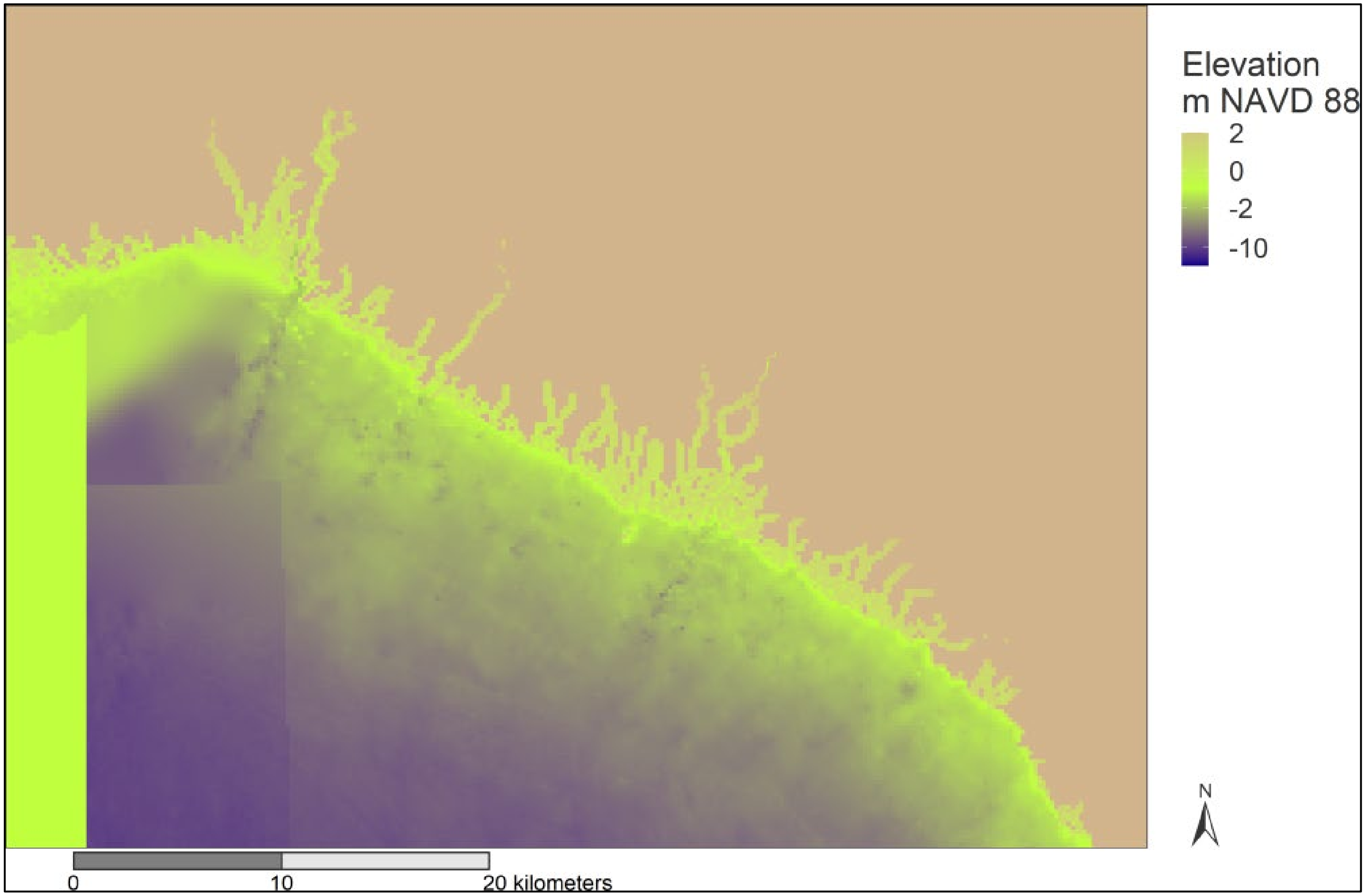

Figure 156. Digital elevation model of the Aucilla region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources, see text for details.

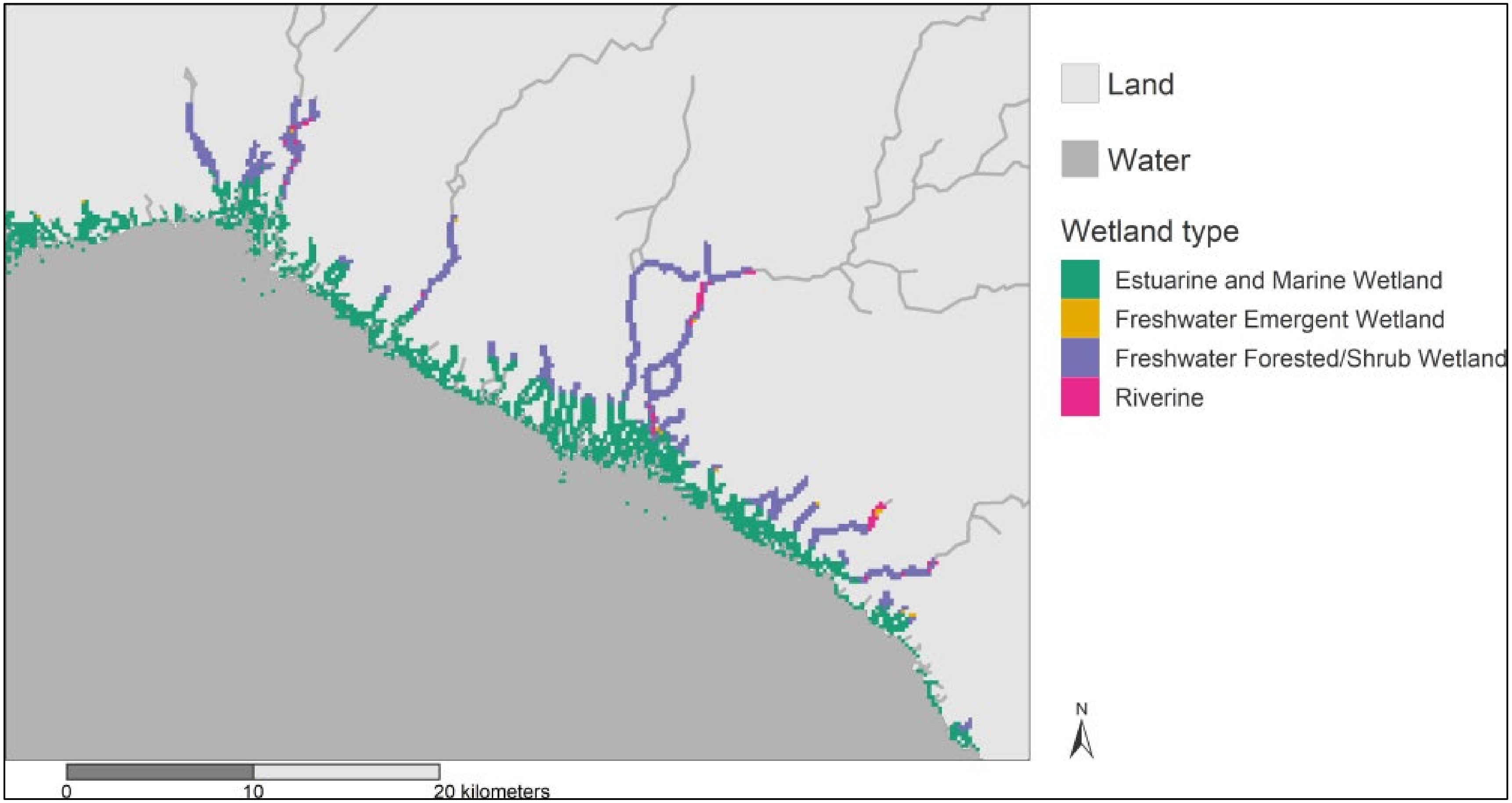

Figure 157. Wetland types and locations within the Aucilla region.

Modified from US Fish and Wildlife Service (2016).

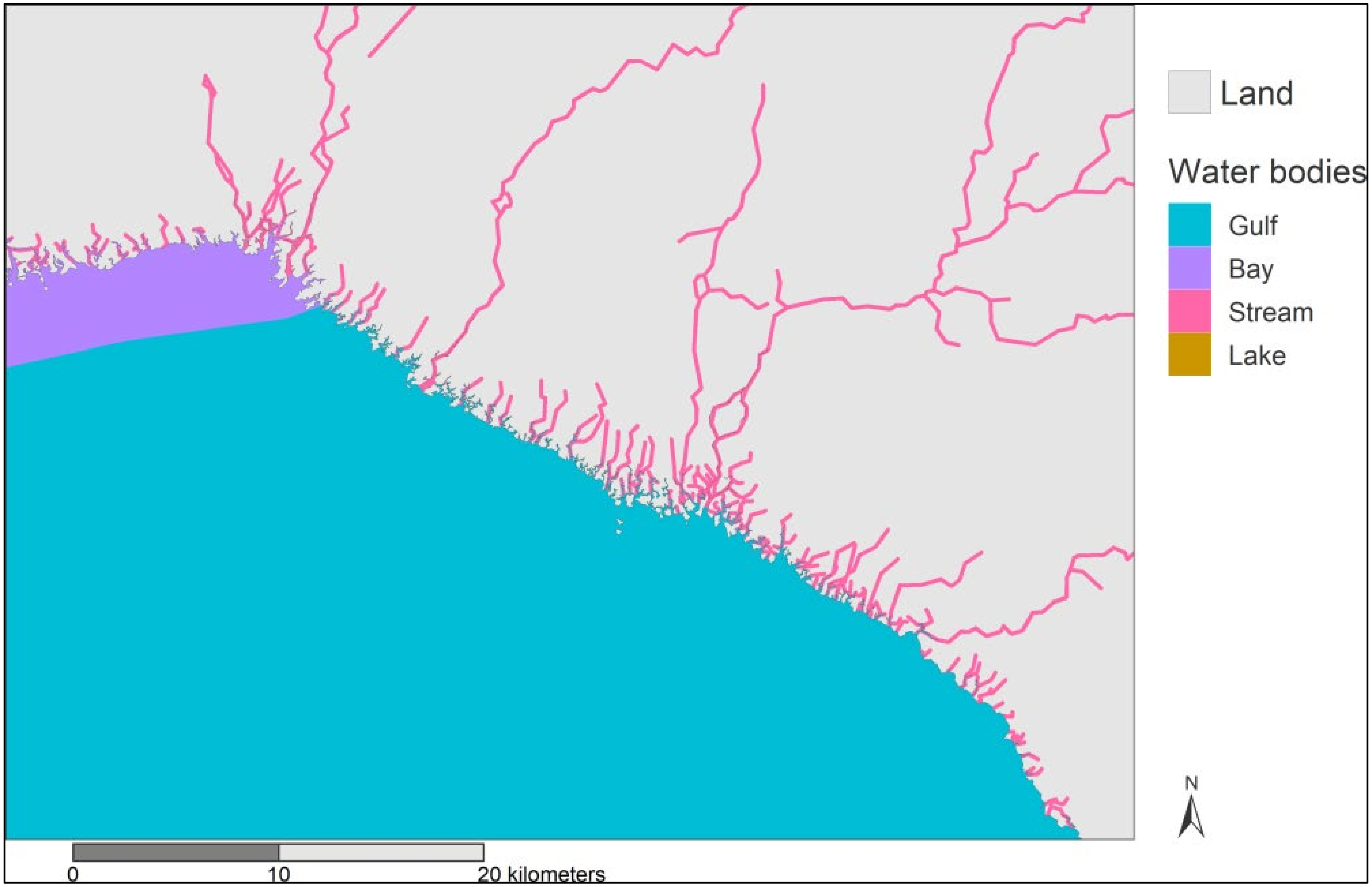

Figure 158. Water bodies of the Aucilla region.

Modified from Tele Atlas North America, Inc. (2010).

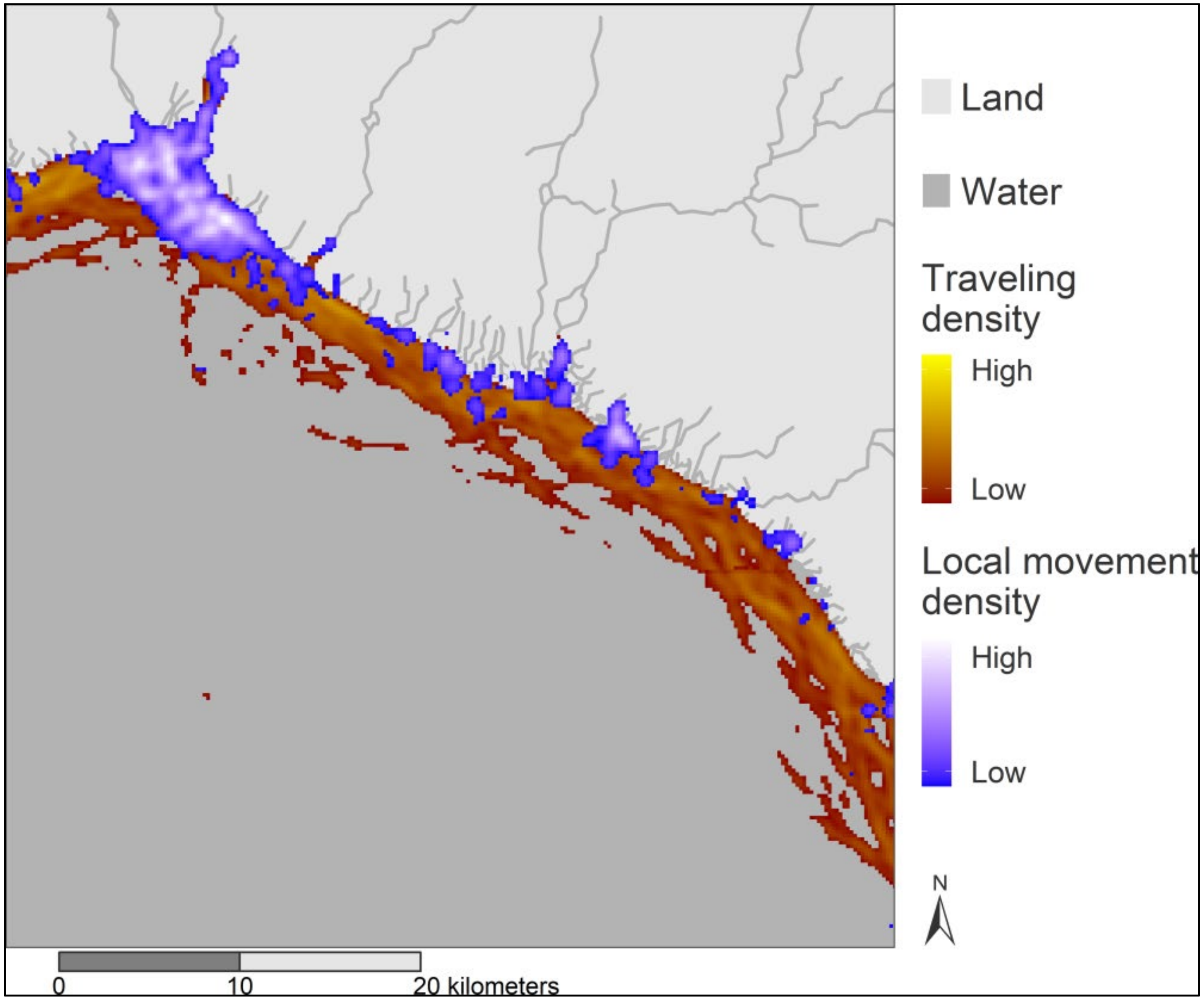

Figure 159. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

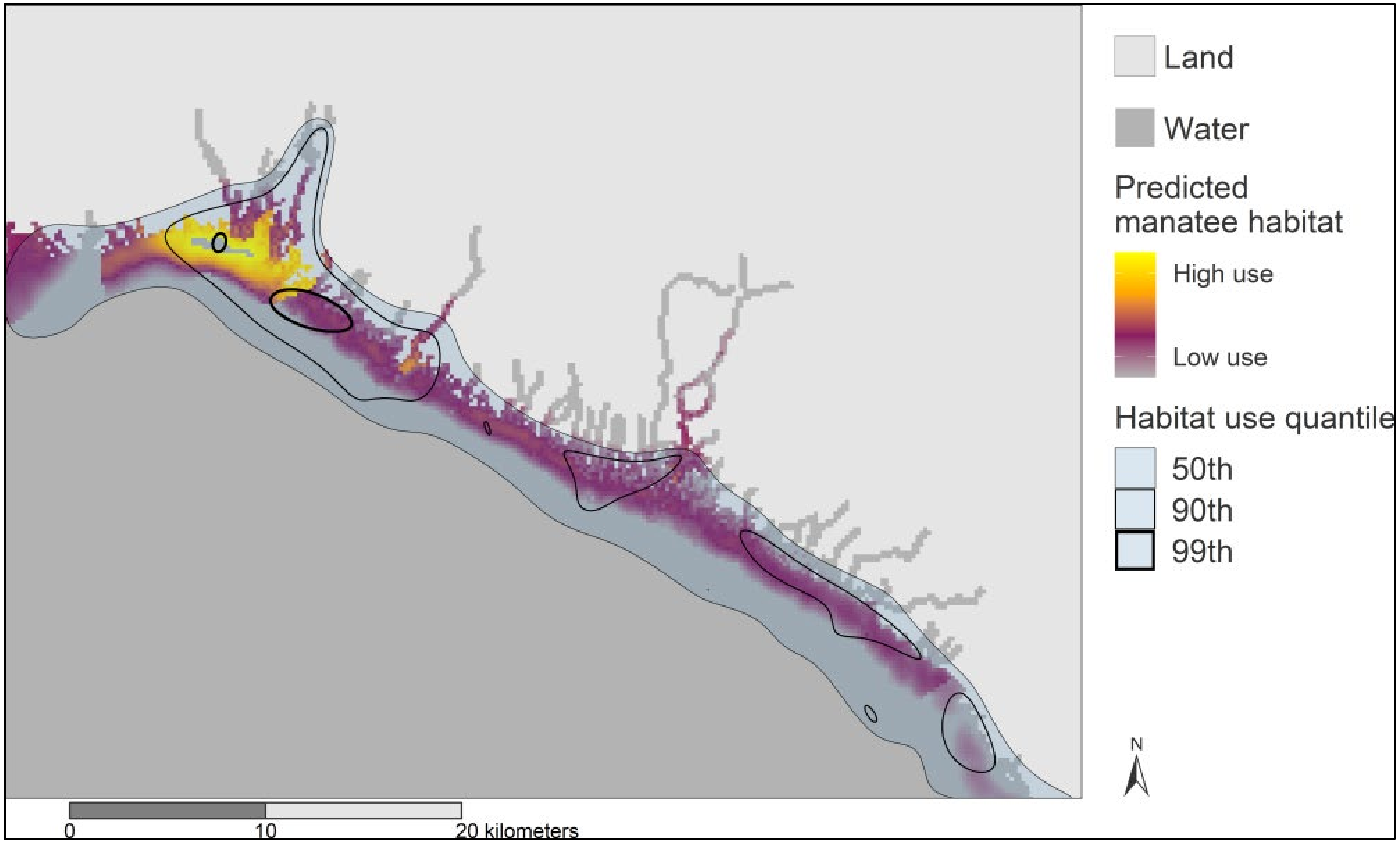

Figure 160. Habitat use prediction for the Aucilla region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.23 Steinhatchee

Similar to the Aucilla region, the Steinhatchee region (Figure 161 through 164) is also split into two AOI, and features a broad shelf with a mix of seagrass species, including *Thalassia testudinum, Halodule wrightii, Halophila sp.* and *Syringodium filiforme* (Mattson 2000; Mattson et al. 2007).

Habitat use in the Steinhatchee region was similar to that of the Aucilla region. A broad swath of travel pathways along the coastline was seen out to at least 10 kilometers offshore (Figure 165). Habitat use in this region was concentrated in the Steinhatchee River estuary with a lesser-used patch at the entrance to Fish Creek. The Steinhatchee region appears to be another "pass through" region, with less local habitat use overall compared to the surrounding regions. Only 1.0 percent of all manatee location were seen in this region, generally in spring and fall when manatees would be traveling to or from the Crystal River region. (Table 7).

The manatee habitat prediction model for the Steinhatchee region correctly identified the Steinhatchee River as an important habitat area, but struggled with the rest of the region, showing predicted hotspots that were offset from the use areas of the tagged manatees (Figure 166).

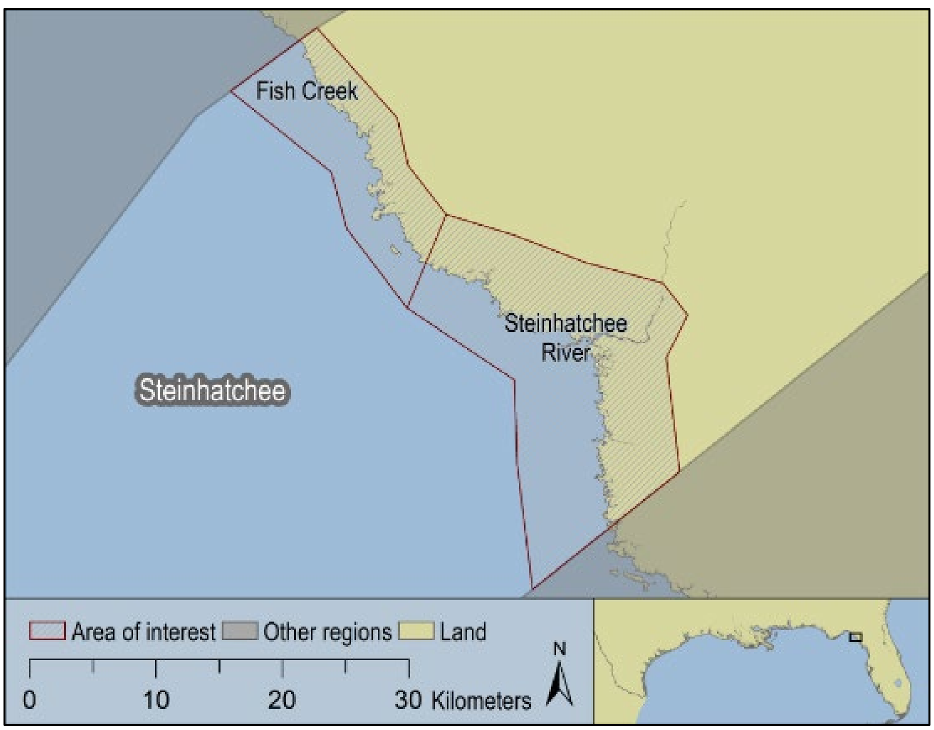

Figure 161. The Steinhatchee region, with Fish Creek and the Steinhatchee River.

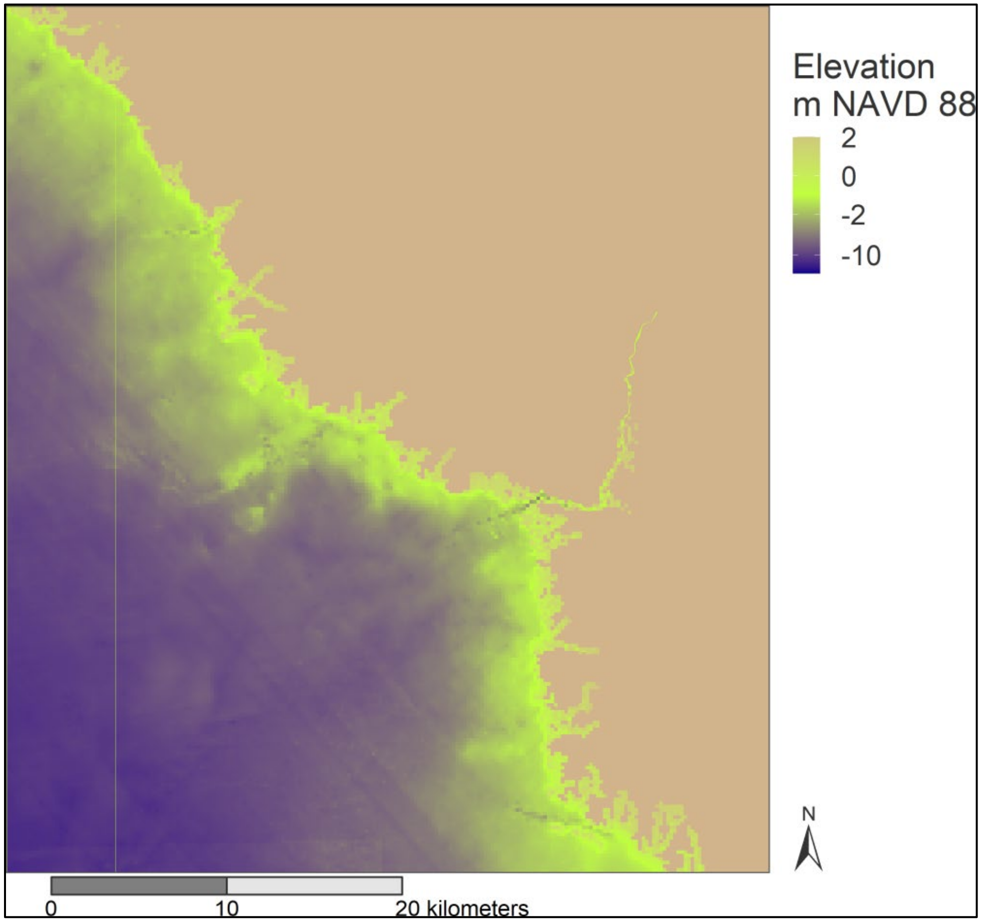

Figure 162. Digital elevation model of the Steinhatchee region showing shallow areas where submerged vegetation growth is likely (yellow- green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources, see text for details.

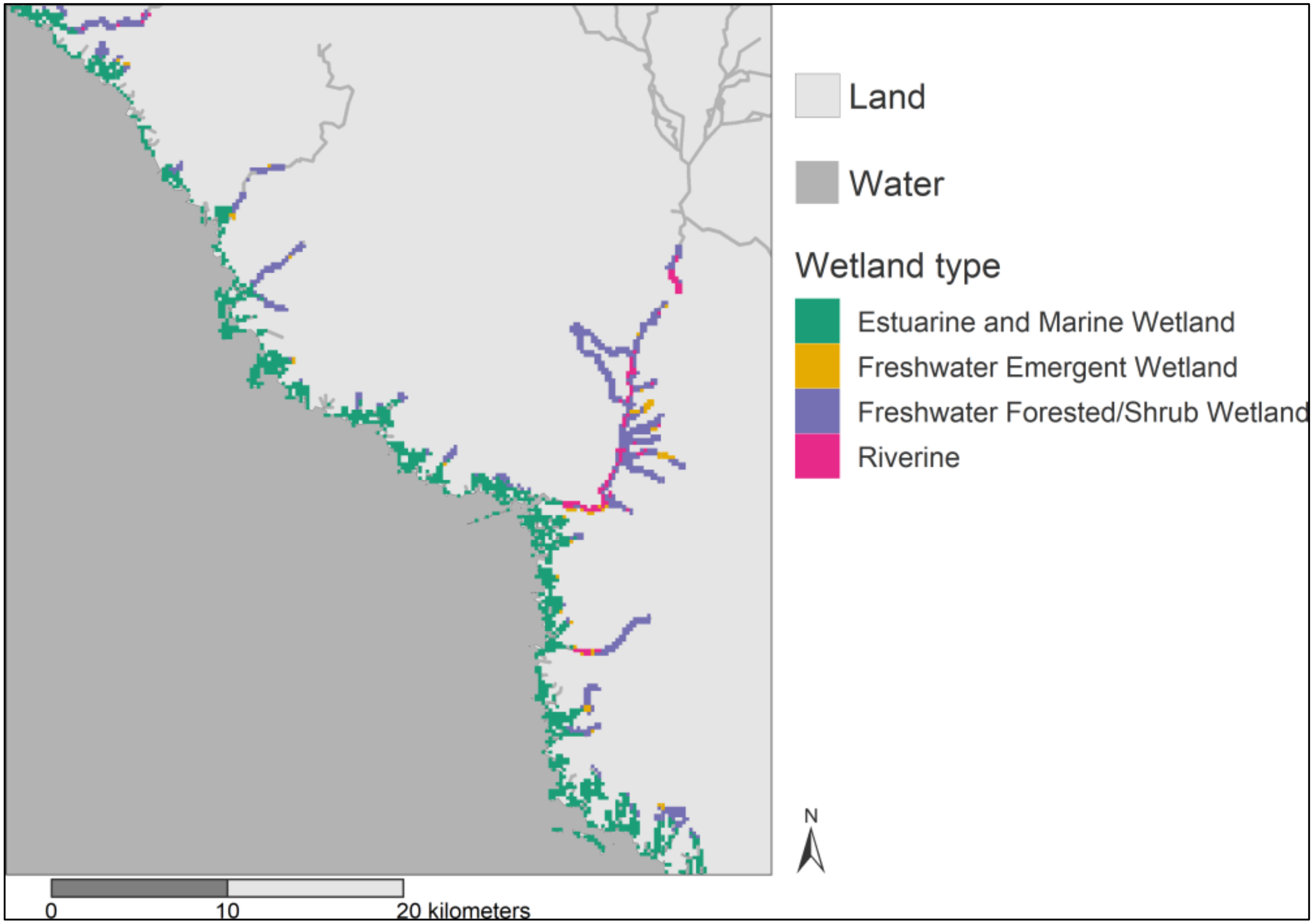

Figure 163. Wetland types and locations within the Steinhatchee region.

Modified from US Fish and Wildlife Service (2016).

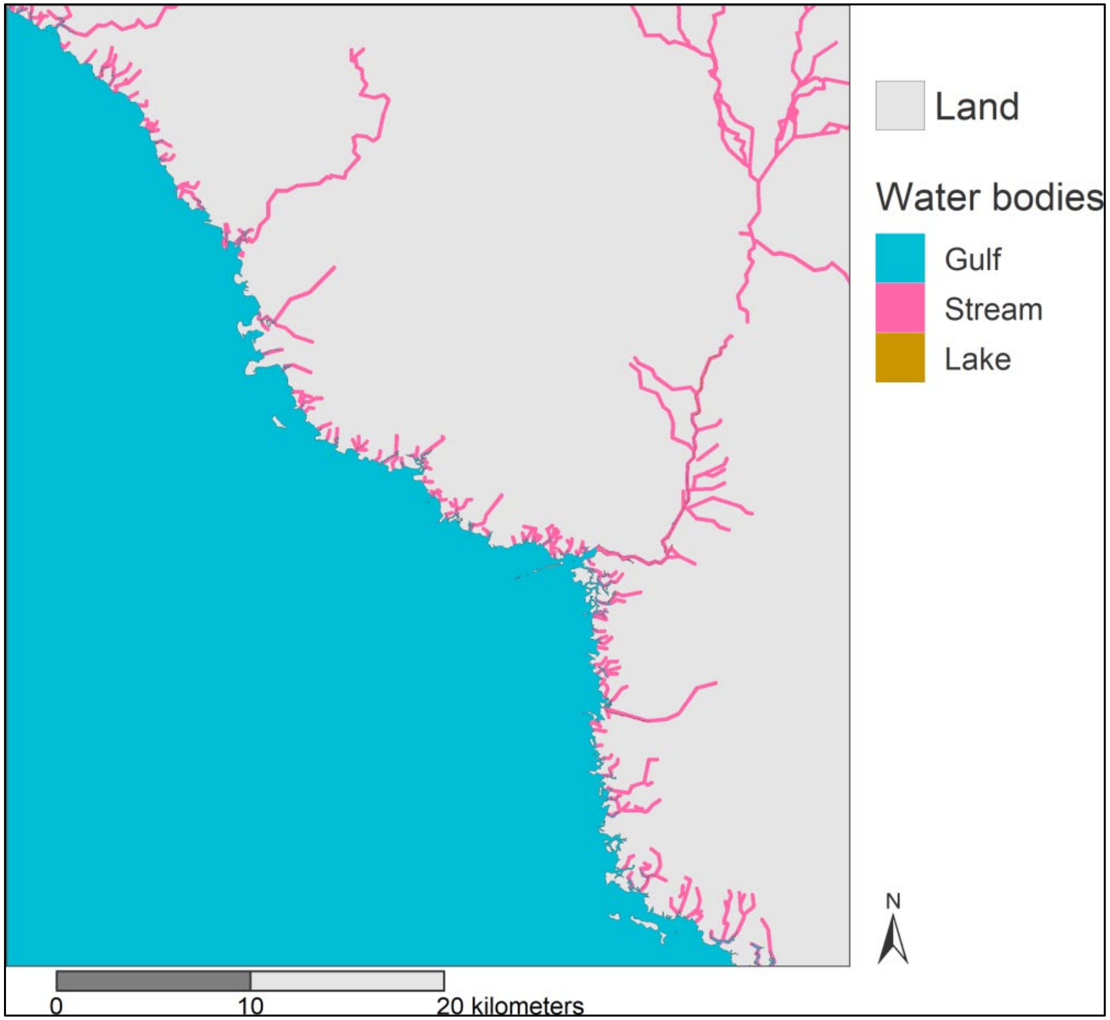

Figure 164. Water bodies of the Steinhatchee region.

Modified from Tele Atlas North America, Inc. (2010).

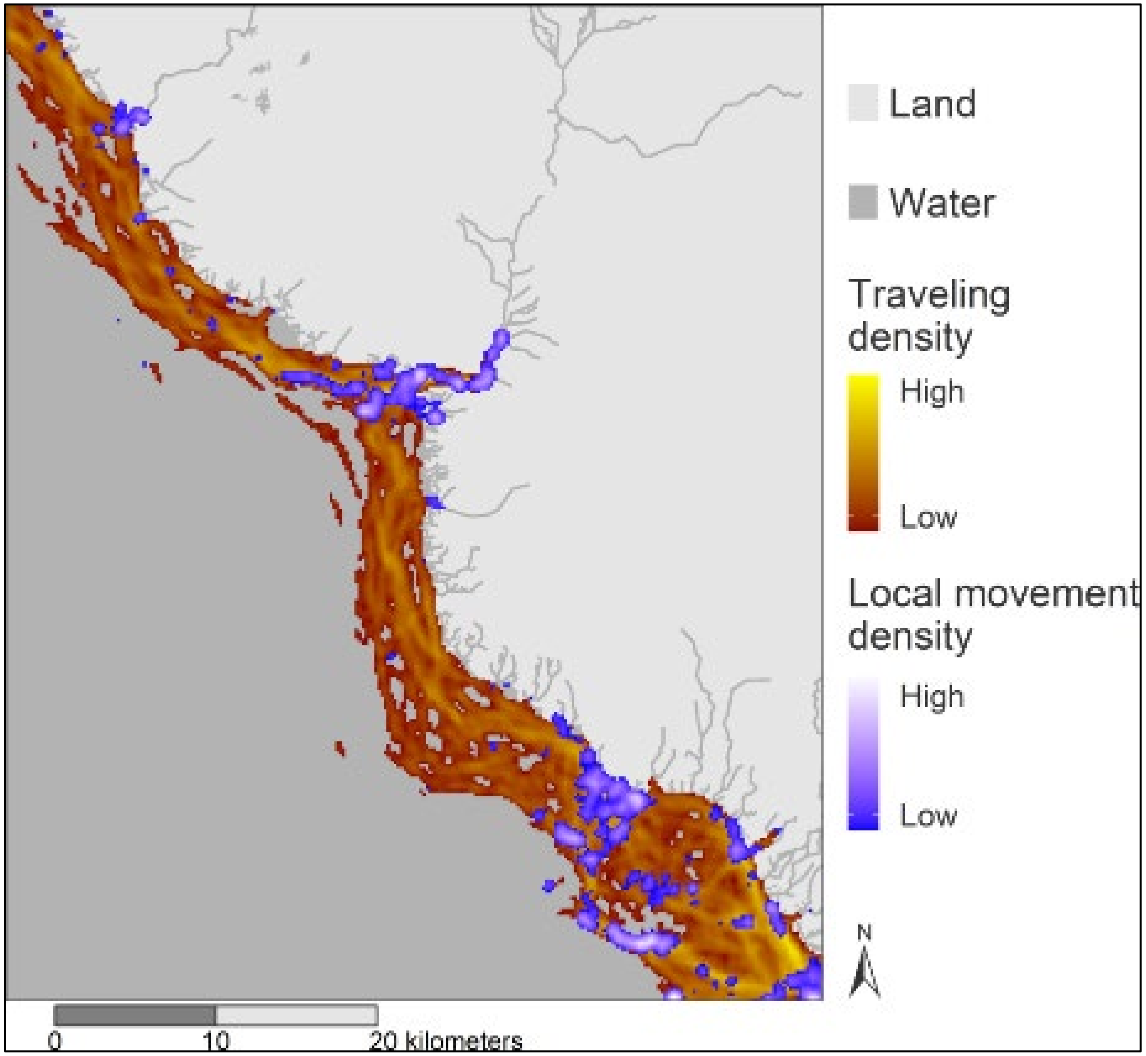

Figure 165. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

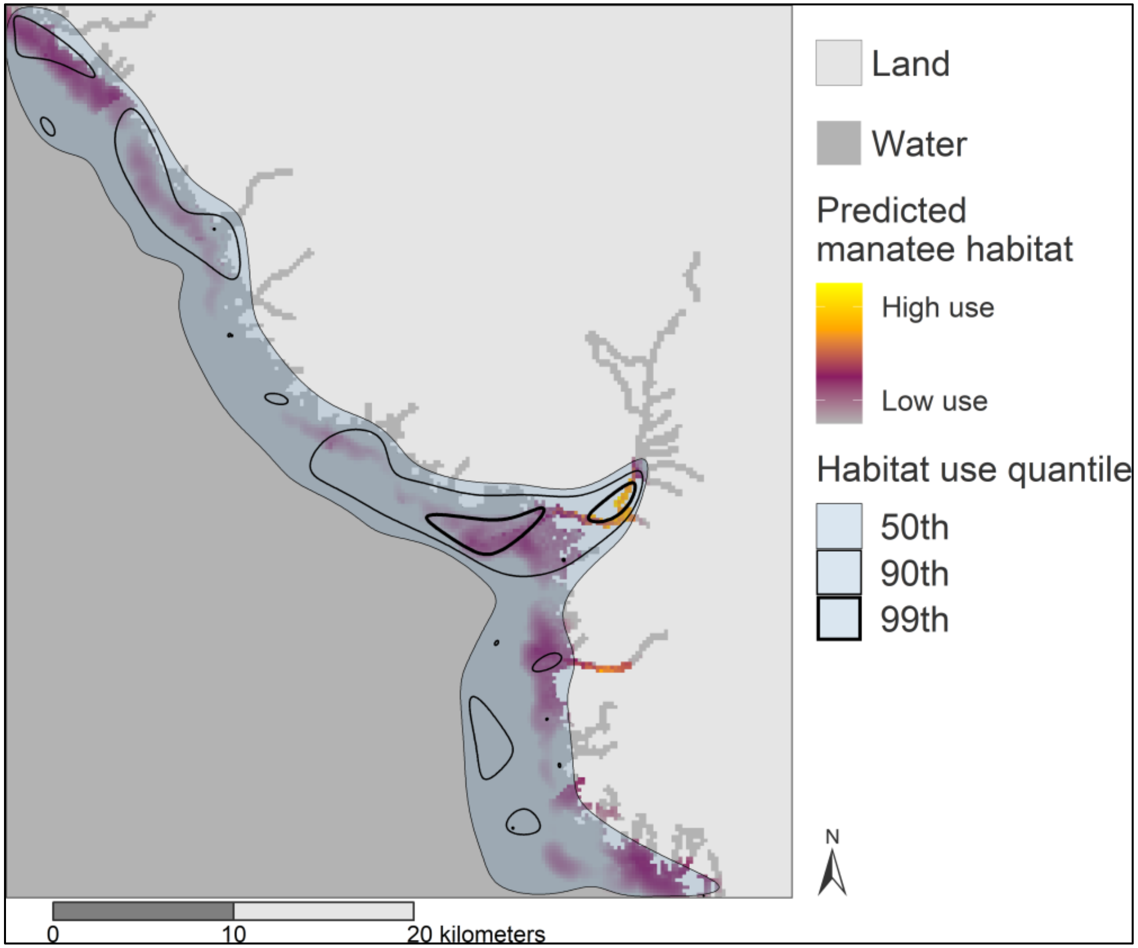

Figure 166. Habitat use prediction for the Steinhatchee region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.24 Suwannee

The Suwannee region (Figure 167 through Figure 170) is centered on the Suwannee River, with additional AOI representing physical features to the north and south (Horseshoe Cove and Cedar Keys). Offshore seagrass beds, similar to the other regions in the Big Bend of Florida contain a mix of species including *Thalassia testudinum, Halodule wrightii, Halophila sp.* and *Syringodium filiforme* (Mattson 2000; Mattson et al. 2007). The Suwannee River estuary has lost much of its submerged vegetation in recent decades (Mattson et al. 2007), but *Ruppia maritima, Vallisneria americana, Sagittaria kurziana,* and *Myriophyllum spicatum* have been documented in the upper freshwater reaches (Estevez et al. 2000).

Manatee habitat use of the Suwannee region reflected the very wide and shallow shelf present in the area. Local foraging locations were seen from near shore out to at least 10 kilometers offshore, and travel paths along the shoreline were also seen across the shelf out to a similar distance (Figure 171). Manatee foraging hotspots were seen at Horseshoe Cove, offshore from the Suwannee River, and offshore of Cedar Key. Additional smaller habitat use hotspots were seen far upstream in the Suwannee River, consistent with freshwater or warm water access.

The habitat use model correctly identified the Suwannee River delta and Cedar Key locations as important foraging hotspots, and also the riverine habitat in the Suwannee River (Figure 172). Offshore foraging hotspots were not very well identified, likely because there were no identifying features in any of the base maps that could differentiate one location from another, but the model did correctly identify that some locations far offshore on the broad shallow shelf were generally used as foraging locations.

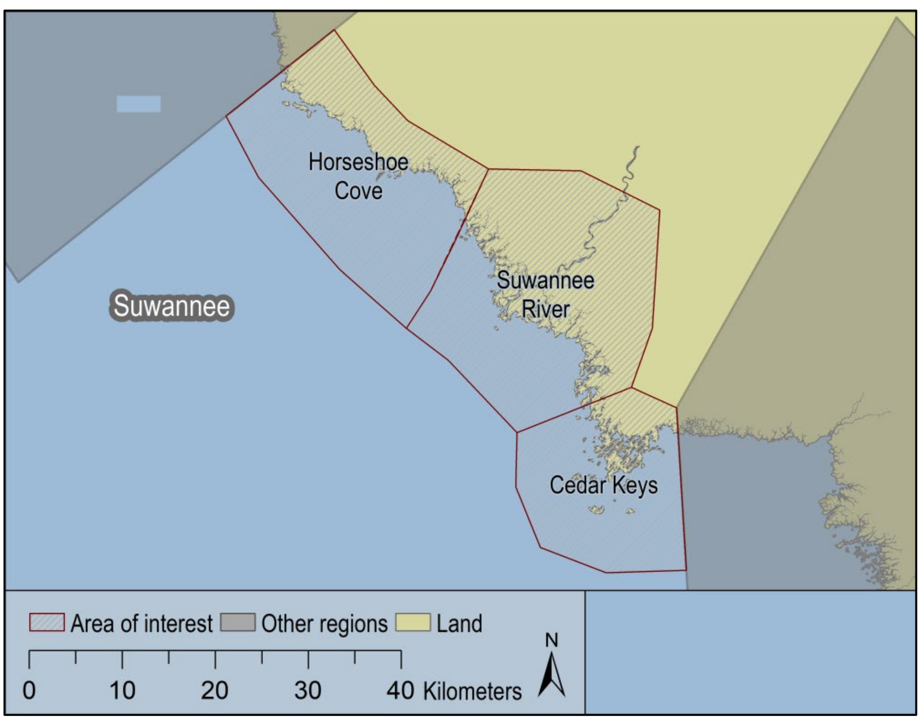

Figure 167. The Suwannee region, from Horseshoe Cove to the Cedar Keys.

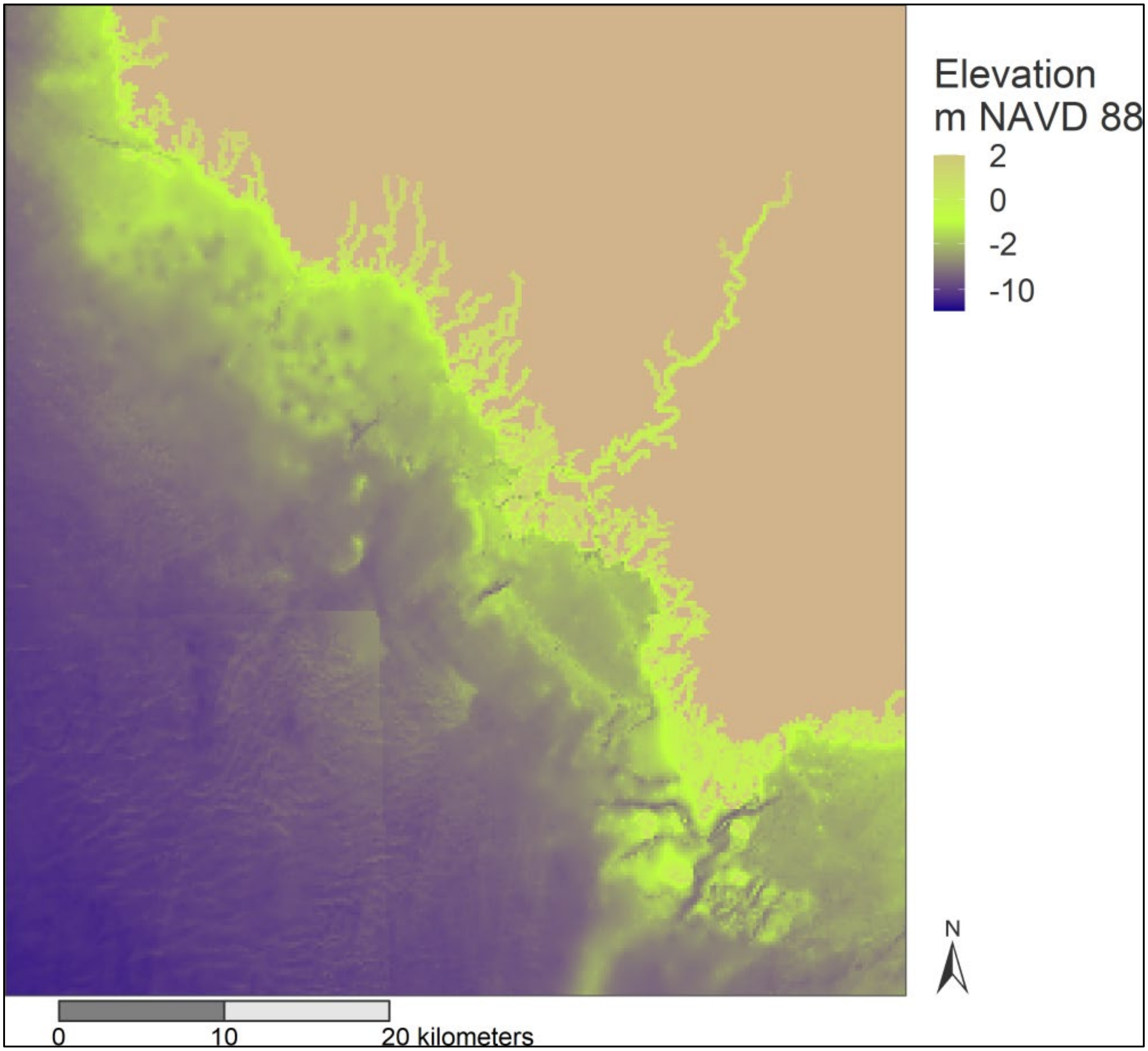

Figure 168. Digital elevation model of the Suwannee region showing shallow areas where submerged vegetation growth is likely (yellow-green), and deeper areas (dark blue-violet).

Data compiled from NOAA sources; see text for details.

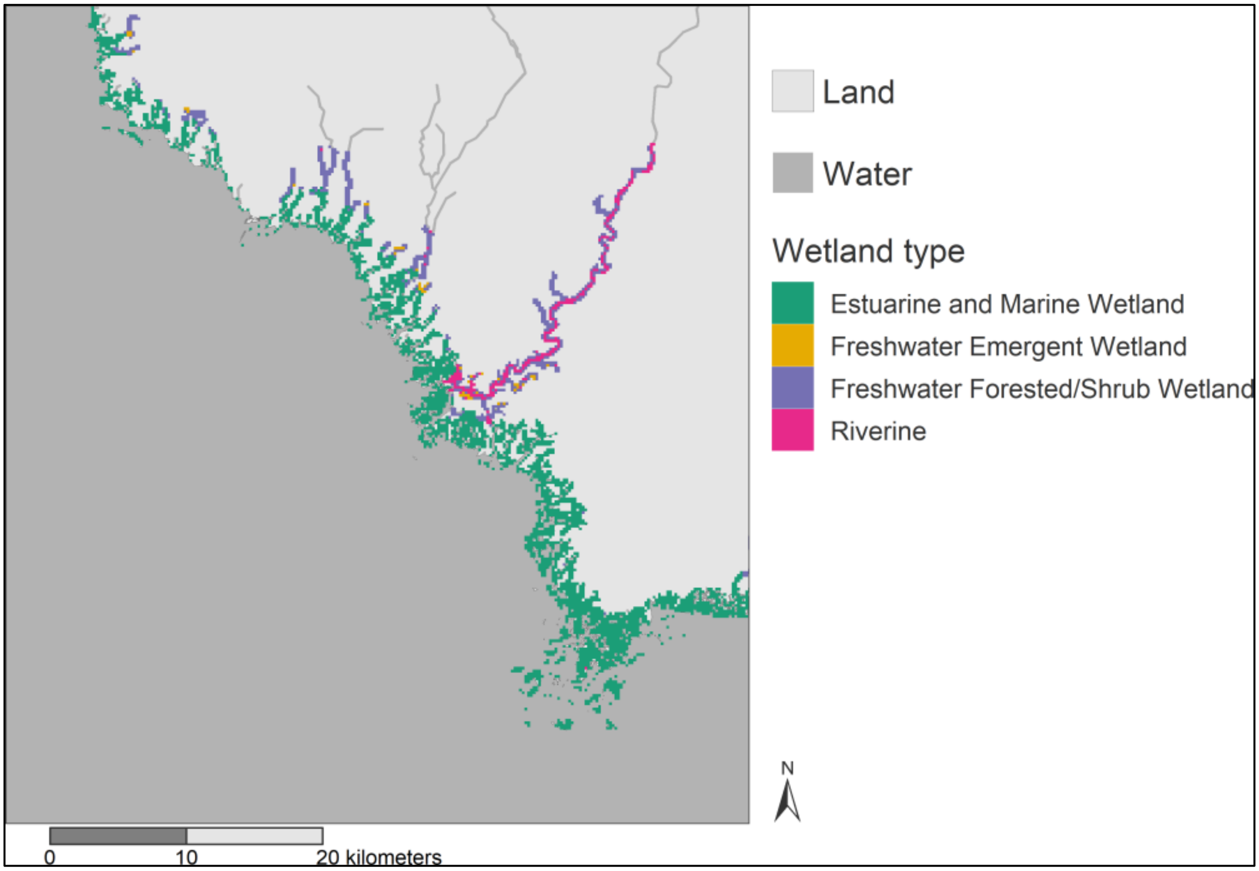

Figure 169. Wetland types and locations within the Suwannee region.

Modified from US Fish and Wildlife Service (2016).

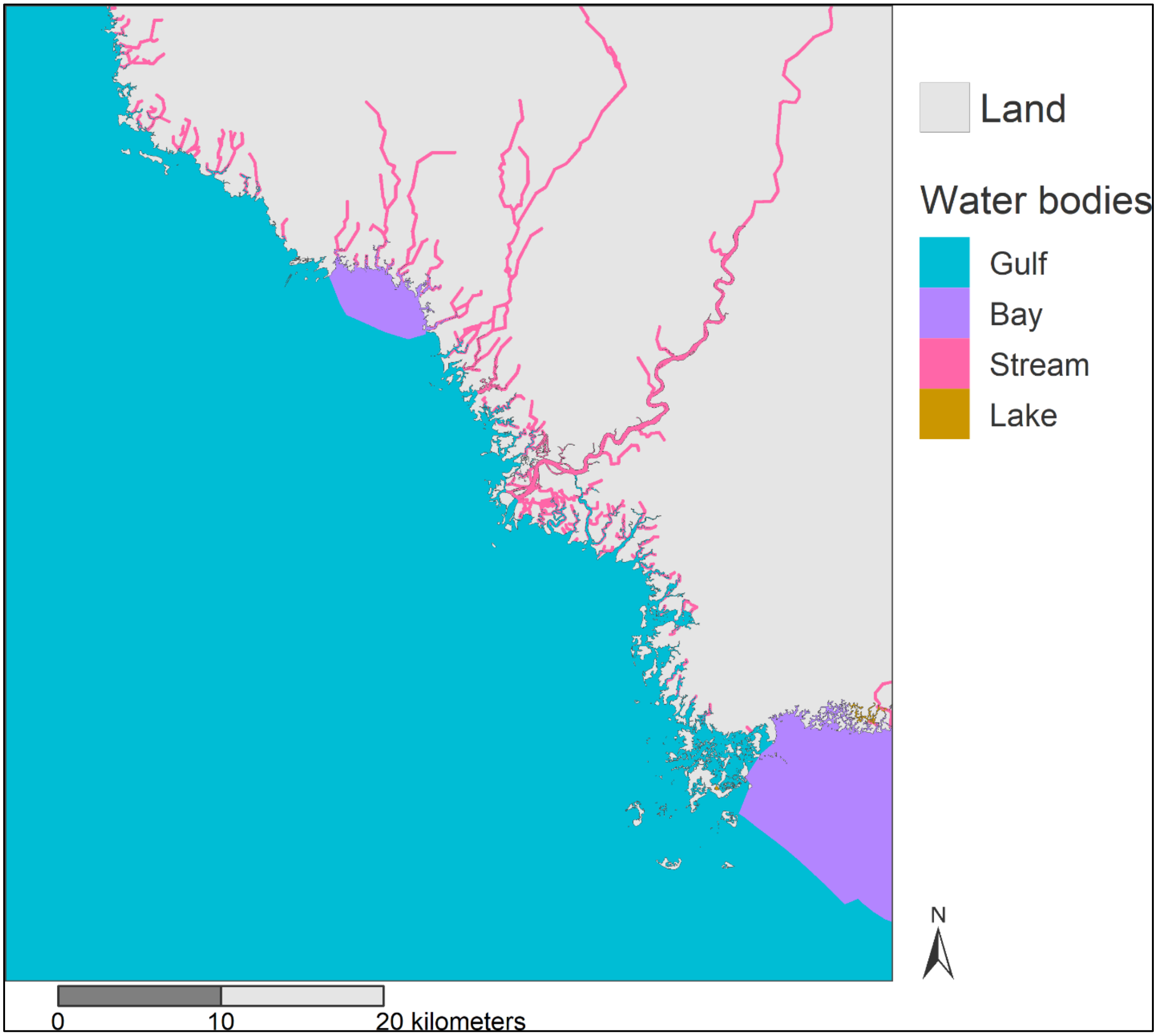

Figure 170. Water bodies of the Suwannee region.

Modified from Tele Atlas North America, Inc. (2010).

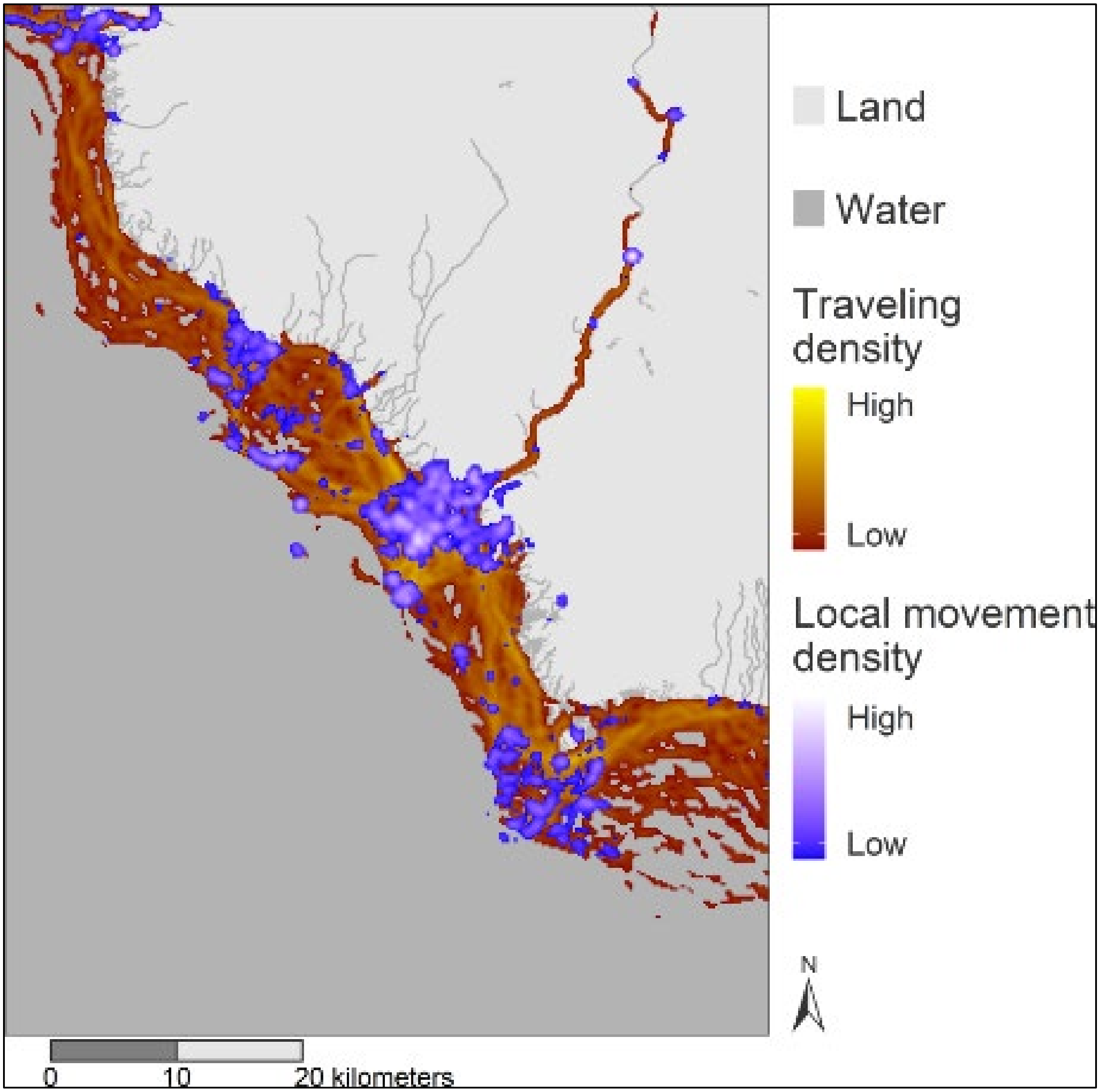

Figure 171. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

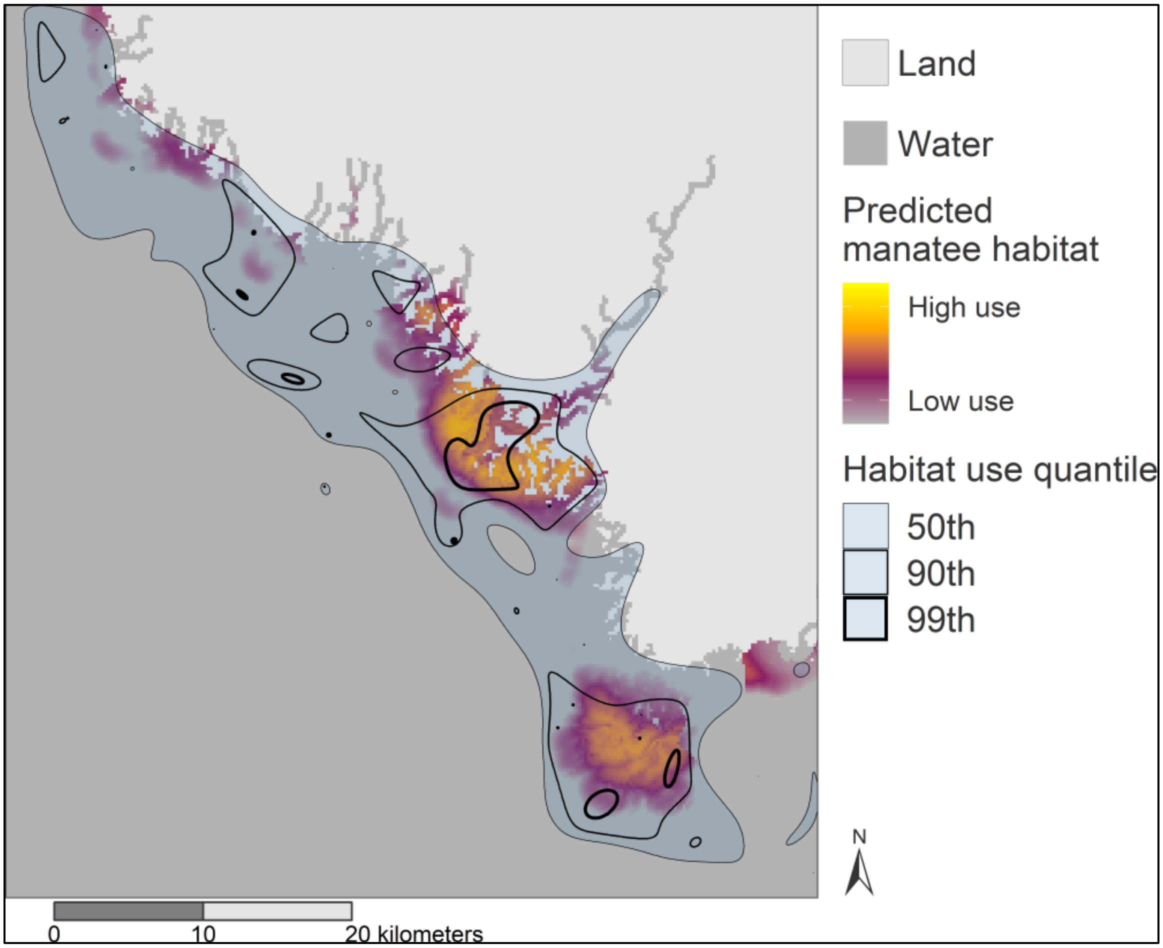

Figure 172. Habitat use prediction for the Suwannee region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with heavy black outlines show high density manatee GPS locations.

3.5.1.25 Crystal River

The Crystal River region (Figure 173 through Figure 176) is home to well-known winter manatee aggregation areas centered around large freshwater springs in the Crystal, Homosassa, Chassahowitzka and Weeki Wachee Rivers. Each of the estuaries, along with the Waccasassa and Withlacoochee Rivers, were delineated as separate AOI. The offshore shelf of this region is wide and shallow, similar to the other regions in the Big Bend, and thus contains the mix of seagrass species common to the area (*Thalassia testudinum, Halodule wrightii, Halophila sp.* and *Syringodium filiforme;* (Mattson et al. 2007)). The rivers in this region have experienced a decline in freshwater SAV in recent decades due to increasing turbidity and salinity over time, but otherwise support a mix of freshwater plant species such as *Vallisneria americana, Potamogeton sp., Najas guadalupensis* and *Myriophyllum spicatum*, along with the salt-tolerant *Ruppia maritima* (Hoyer et al. 2004).

Habitat use in the Crystal River region was especially interesting because of the region's unique distinction as the largest manatee winter population at a natural spring (Kleen and Breland 2014; Sattelberger et al. 2017). The winter habitat locations in the springs of Crystal River National Wildlife Refuge in the Crystal and Salt River AOI can clearly be seen in the convolution analysis map (Figure 177). To a lesser extent, these natural winter refuges also occur in the Homosassa and Chassahowitzka rivers, and manatees can access nearby seagrass beds in the Gulf (Slone et al. 2017). Other habitat use locations were seen in the Withlacoochee and Waccasassa rivers, and along the coastline between them. A small habitat use patch was also seen in the Weeki Wachee River estuary to the south. Travel paths were seen along the shoreline out to more than 10 kilometers from shore, almost all of which were at or north of the Crystal River, likely influenced by our targeted tagging of western-moving indidividuals.

The habitat use model identified high use areas in most of the river systems within the Crystal River region (Figure 178). The spatial pattern of these high-use areas was accurate, but the model did not differentiate use levels among the different river systems. Specifically, habitat use in the Crystal and Salt rivers was predicted to be approximately the same as the neighboring river systems, while in reality habitat use in and near the Crystal and Salt rivers is much higher. The habitat prediction model does not account for the strong draw of the large freshwater springs for warm water refuge, and so "sees" the habitat as being equivalent among the river systems. The extent of the offshore seagrass beds is captured, but there are some odd artifacts driven by the elevation base layer.

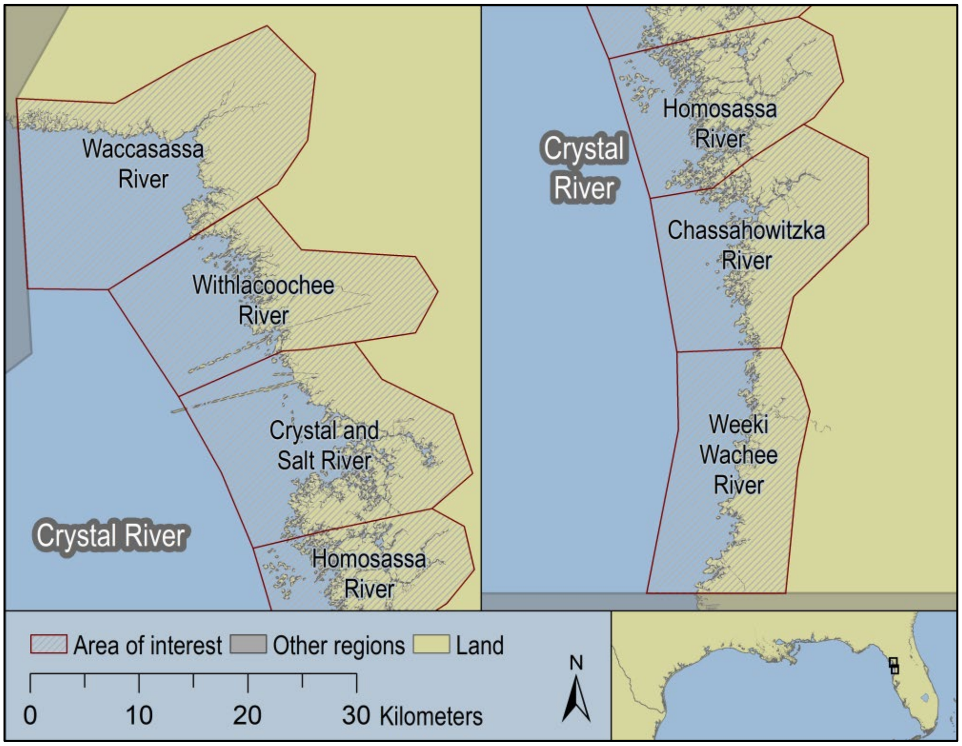

Figure 173. The Crystal River region, from the Waccasassa River to the Homosassa River.

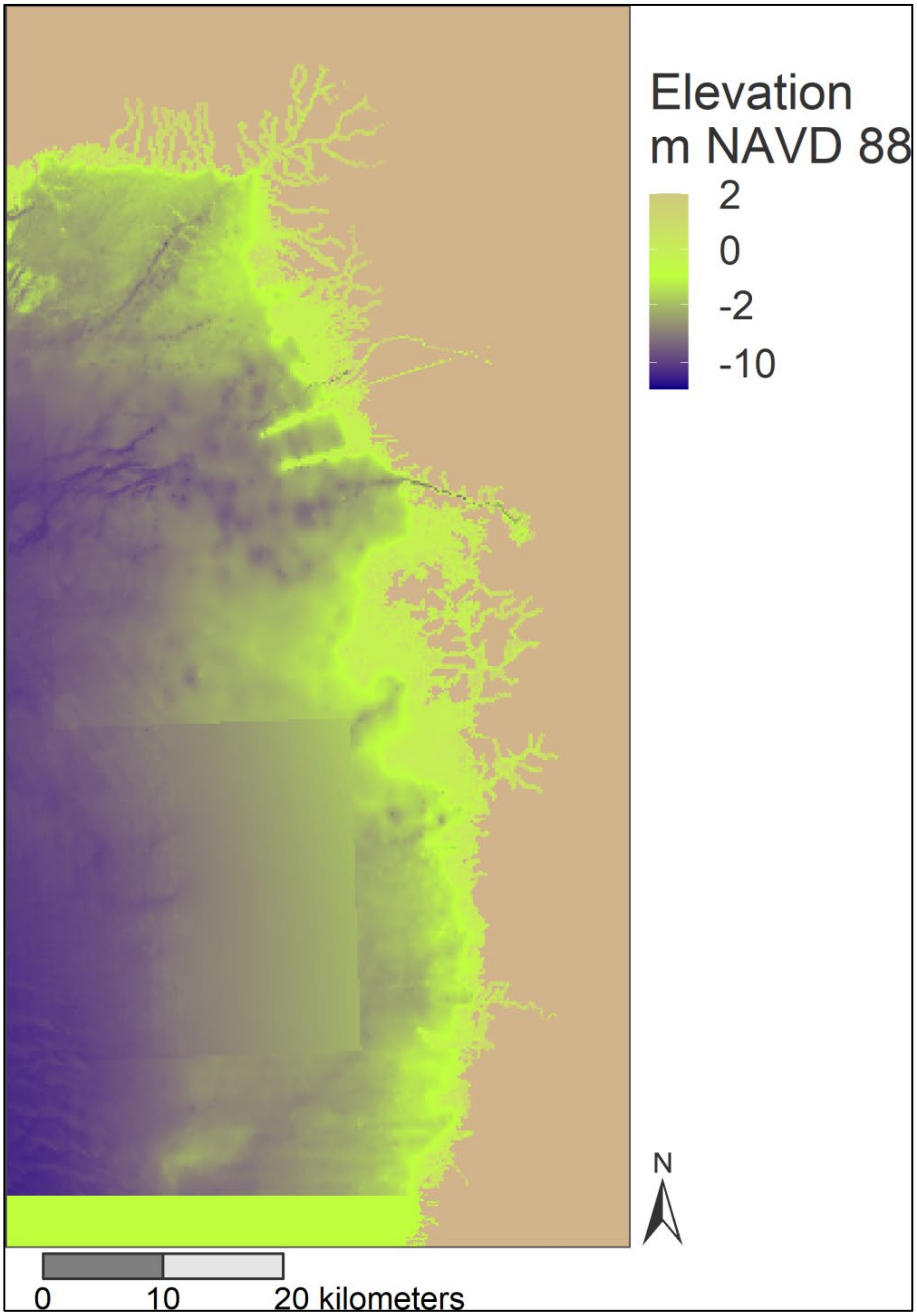

Figure 174. Digital elevation model of the Crystal River region showing shallow areas where submerged vegetation growth is likely (yellow- green), and deeper areas (violet).

Data compiled from NOAA sources; see text for details.

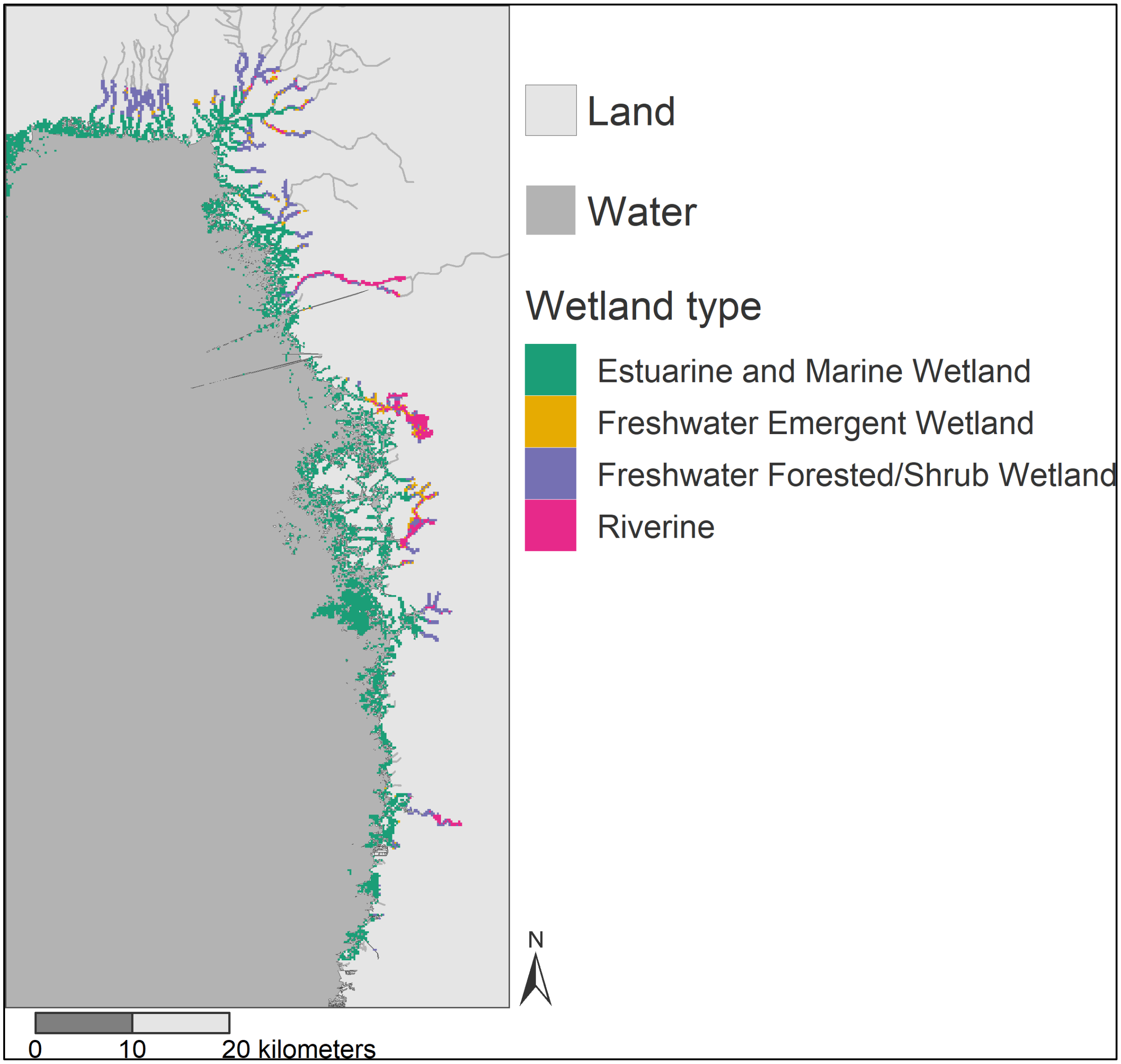

Figure 175. Wetland types and locations within the Crystal River region.

Modified from US Fish and Wildlife Service (2016).

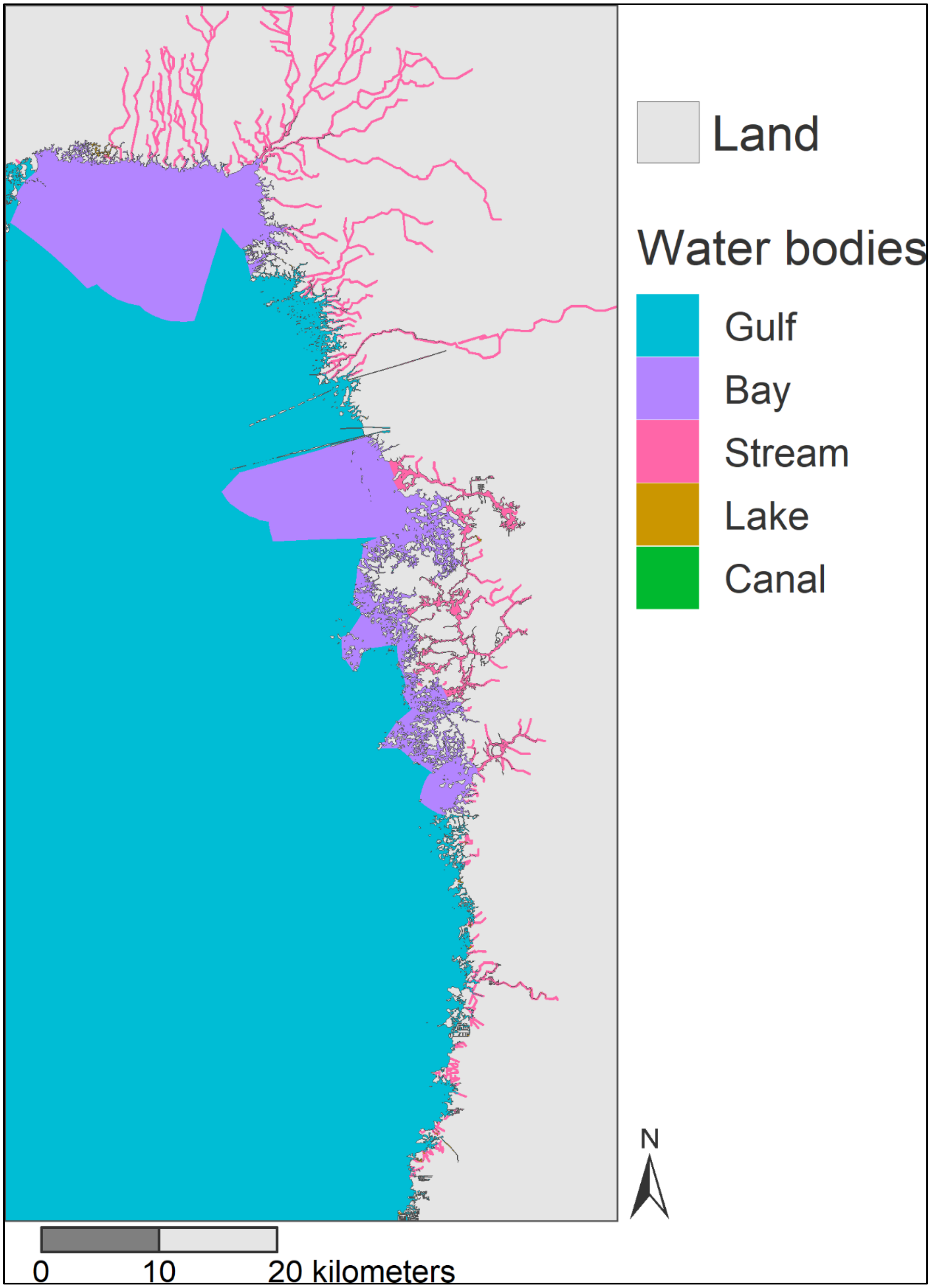

Figure 176. Water bodies of the Crystal River region.

Modified from Tele Atlas North America, Inc. (2010).

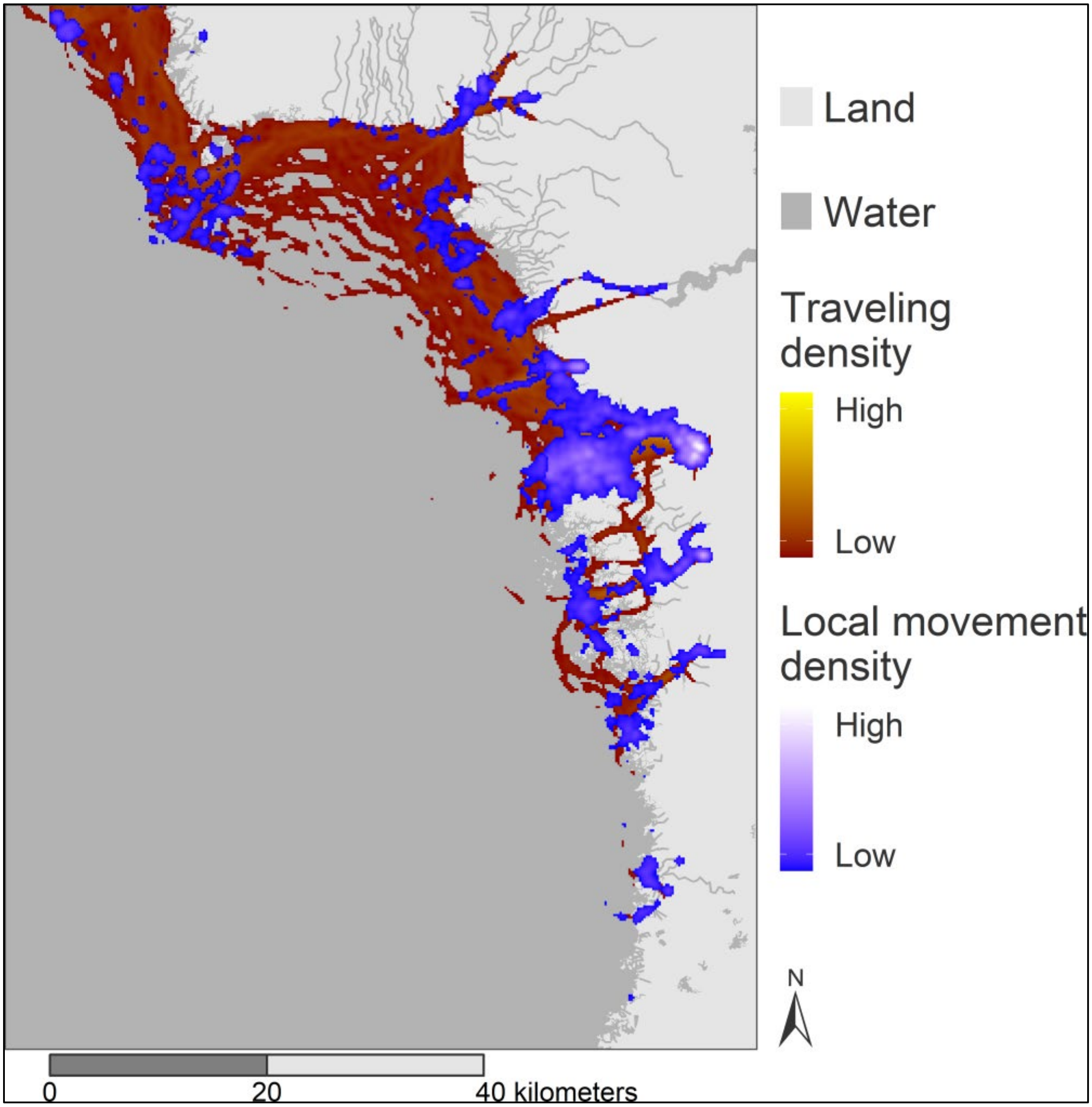

Figure 177. Convolution analysis results showing densities of fast-movement travel paths (brown-yellow) and slow-movement habitat use locations (violet-white) for the region.

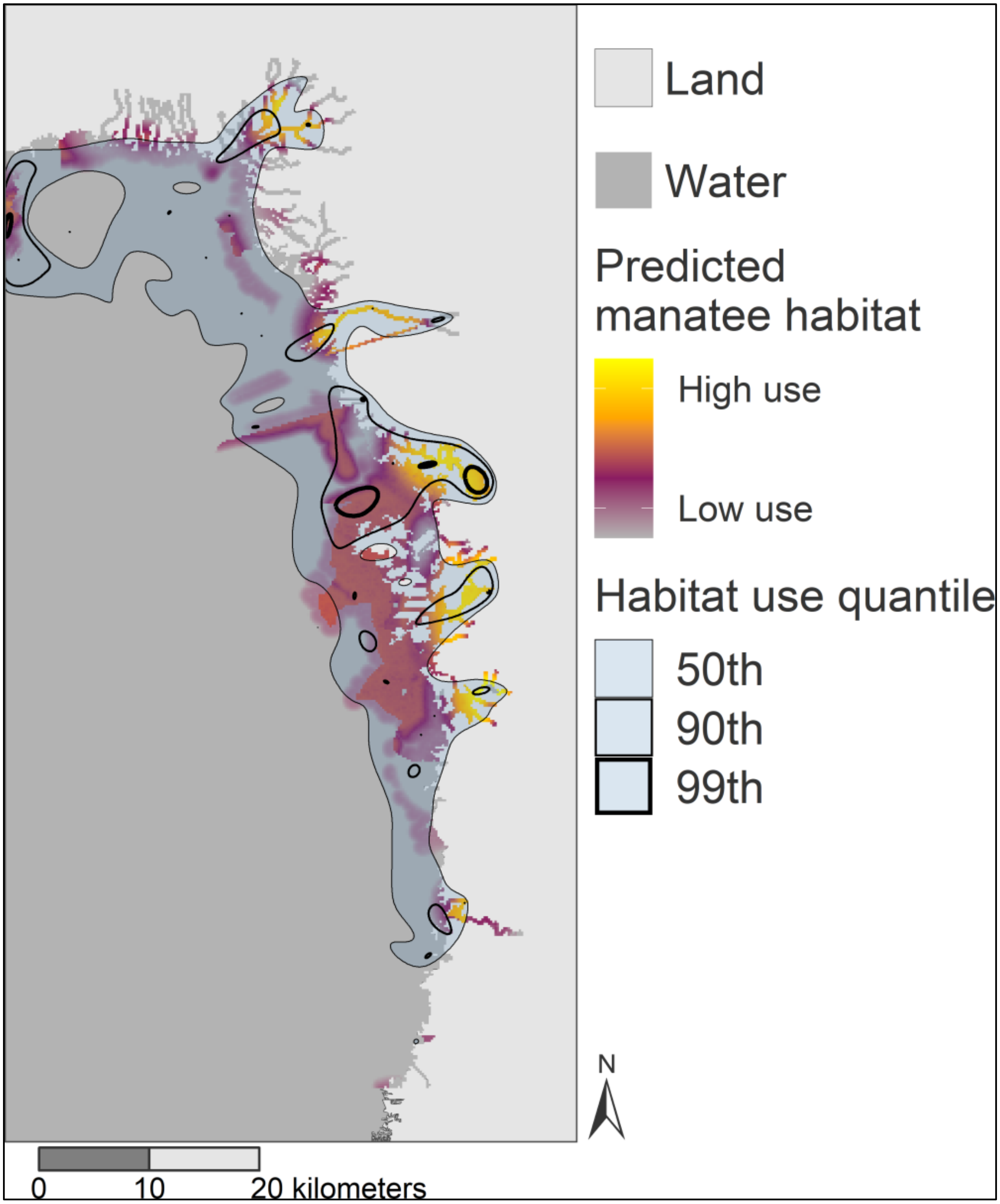

Figure 178. Habitat use prediction for the Crystal River region with manatee GPS telemetry quantiles.

Areas with higher predicted suitability are yellow, and lower predicted suitability are dark red. Unsuitable areas are gray. Light blue areas with thickening black outlines show high density manatee GPS locations.

3.6 Habitat assessment

3.6.1 Habitat availability

Based on habitat type polygons from the Water Bodies layer (2.6.1.1), the eastern regions (Aucilla – Crystal River) contained an abundance of offshore habitat, which was extensively used by manatees (Figure 179). This corresponds with the wide shallow shelf present in that area. The rest of the regions where telemetered manatees traveled contained a greater proportion of protected bays. Of these bays, manatee use ranged from almost none (Port St. Joe), to some use (Biloxi–Pensacola) to the majority of the habitat area (Destin, Panama City, Apalachicola, St. Marks). Inland habitat areas were more difficult to quantify because of the more convoluted narrow waterways, but were in general smaller than the open bay or offshore habitats. Regions with significant inland movements, including Biloxi, Pascagoula, Apalachicola, St. Marks, and Suwannee were not those with the largest measured area of lake or stream habitat types, so a correlation between amount of inland habitat and high levels of use cannot be assumed. In all regions, the proportion of habitat use relative to habitat area was higher for streams than lakes.

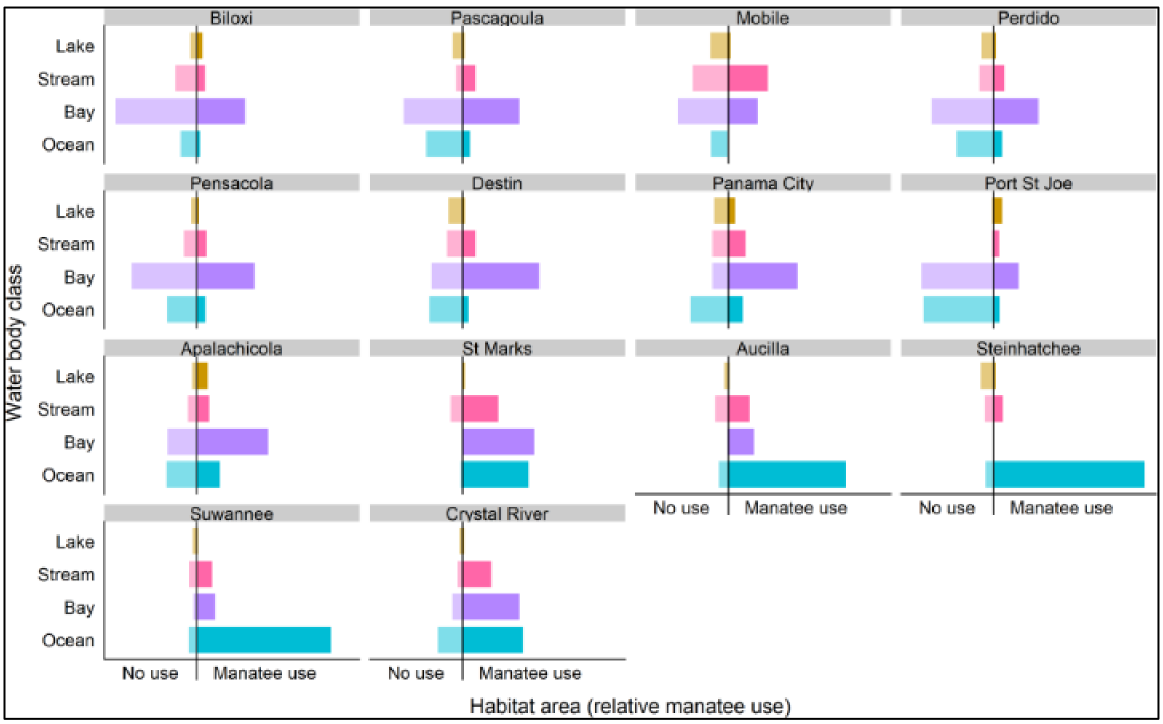

Figure 179. Relative amount of available habitat for manatee use by water body class per region (total width of colored bars).

The proportion of each habitat class that had manatee use as documented by telemetry records is indicated by the proportion of each bar that is to the right side of the centerline.

3.6.2 Habitat sampling efforts

From June 2016 through August 2018, 24 sampling days of effort were spent at 18 Areas of Interest from Pascagoula River to Crystal/Salt Rivers. A total of 327 locations were surveyed using the area sampling technique described above. Submerged aquatic vegetation was found in 83.3 percent of locations surveyed, ranging from 50.0 percent to 100.0 percent by Area of Interest (Table 10). Salinity at the sampling locations ranged from very fresh (min = 0.0 ppt) to polyhaline (max = 28.8 ppt). Depths that were sampled ranged from -0.63 m MSL NAVD88 to 5.79 m MSL, and SAV was found form -0.63 m to 1.84 m MSL.

Table 10. Areas of interest and number of locations sampled for submerged aquatic vegetation (SAV)

Region	Area of Interest	Median salinity	Number of sample locations	Number of locations with SAV	% of locations with SAV
Pascagoula	Pascagoula River	0.06	17	14	82.4
Pascagoula	Grand Bay	16.23	14	13	92.9
Mobile	Dog River	0.56	22	20	90.9
Mobile	Mobile River	0.34	11	10	90.9
Pensacola	Escambia Bay	0.13	8	8	100.0
Pensacola	East Bay Pensacola	8.36	14	7	50.0
Pensacola	Santa Rosa Sound	16.19	5	5	100.0
Destin	Choctawhatchee Bay	17.27	18	18	100.0
Apalachicola	Lake Wimico	0.09	8	7	87.5
Apalachicola	Apalachicola River	0.25	21	16	76.2
Apalachicola	Carrabelle River	26.00	8	5	62.5
St. Marks	Ochlockonee Bay	23.11	17	11	64.7
St. Marks	St. Marks River	16.05	29	28	96.6
Aucilla	Aucilla River	19.40	13	12	92.3
Steinhatchee	Steinhatchee River	19.10	20	16	80.0
Suwannee	Horseshoe Cove	20.00	15	9	60.0
Suwannee	Suwannee River	15.25	26	20	76.9
Crystal River	Crystal and Salt River	18.76	61	58	95.1

3.6.3 Submerged aquatic vegetation

The number of species encountered in manatee use areas was surprisingly small and consistent across the study area. Eight freshwater species in five genera were identified (including two only identified to genus), two euryhaline species and three marine species (Table 11). An additional three freshwater species were seen in one camera quadrat each and were not identified. This list does not include fringing marsh vegetation or emergent shoreline vegetation, such as *Spartina* or *Phragmites* species. Marine macroalgae encountered included *Caulerpa*, *Gracilaria*, and *Halimeda* species among a wide variety of unidentified red and green fleshy algae, green filamentous algae, and turf species.

Table 11. Vascular plant species found in sampling locations

Freshwater species	Euryhaline species	Marine species
Ceratophyllum demersum L	*Ruppia maritima L.*	*Halophila engelmannii Asch.*
Ceratophyllum sp.	*Halodule wrightii Asch.*	*Syringodium filiforme Kütz.*
Myriophyllum spicatum L.		*Thalassia testudinum K.D.Koenig*
Najas guadalupensis (Spreng.) Magnus		
Potamogeton crispus L.		
Potamogeton pusillis L.		
Potamogeton sp.		
Vallisneria americana Michx.		

These species were found in a striking pattern where the marine species were not found west of the Carrabelle Sound (Table 12), and with two exceptions, freshwater species were not found in large amounts east of this same AOI. The two exceptions were the St. Marks River AOI (including Wakulla Springs, the freshwater rivers, and the polyhaline Gulf), and the Crystal/Salt River AOI (also including from the headwaters to the Gulf). These two diverse river systems supported large numbers of manatees across several habitat types and salinity regimes. These spatial patterns of vegetation type in the data were driven by manatee preference in that we did not perform a complete sampling strategy to describe "non-manatee habitat" or all SAV communities. We examine potential unvisited SAV communities in section 3.5 using published accounts, below. One forage community that is lacking in our dataset is SAV immediately north of Mississippi Sound barrier islands. We were unable to sample those communities.

Table 12. Submerged aquatic vegetation species encountered in manatee use areas by estuary

Species	Common name	Salinity range	Pascagoula River	Grand Bay	Dog River	Mobile Delta	Escambia Bay	East Bay Pensacola	Santa Rosa Sound	Choctawhatchee Bay	Lake Wimico	Apalachicola Delta	Carrabelle	Ochlockonee Bay	St. Marks River	Aucilla River	Steinhatchee River	Horseshoe Beach	Suwannee River	Kings Bay
Ceratophyllum spp.	coontail, hornwort	freshwater	X		X	X														
Myriophyllum spicatum	Eurasian watermilfoil	freshwater	X		X	X	X	X				X			X					X
Najas spp.	waternymph	freshwater	X		X	X	X			X	X	X			X					X
Potamogeton spp.	pondweed	freshwater	X			X		X		X	X	X		X	X				X	X
Vallisneria americana	tapegrass	freshwater	X		X	X	X	X		X	X	X			X					X
Ruppia maritima	wigeongrass	euryhaline		X	X	X	X		X	X		X		X	X	X		X	X	
Halodule wrightii	shoalweed	euryhaline		X					X	X			X	X	X		X	X	X	X
Halophila engelmannii	star grass	marine											X	X	X	X	X			X
Syringodium filiforme	manateegrass	marine											X	X	X	X	X			X
Thalassia testudinum	turtlegrass	marine												X	X	X	X	X		X

The nine most common species (or genera) were all found in several locations across multiple regions. They are shown in identification figures (Figure 181 through Figure 183) and are further analyzed below.

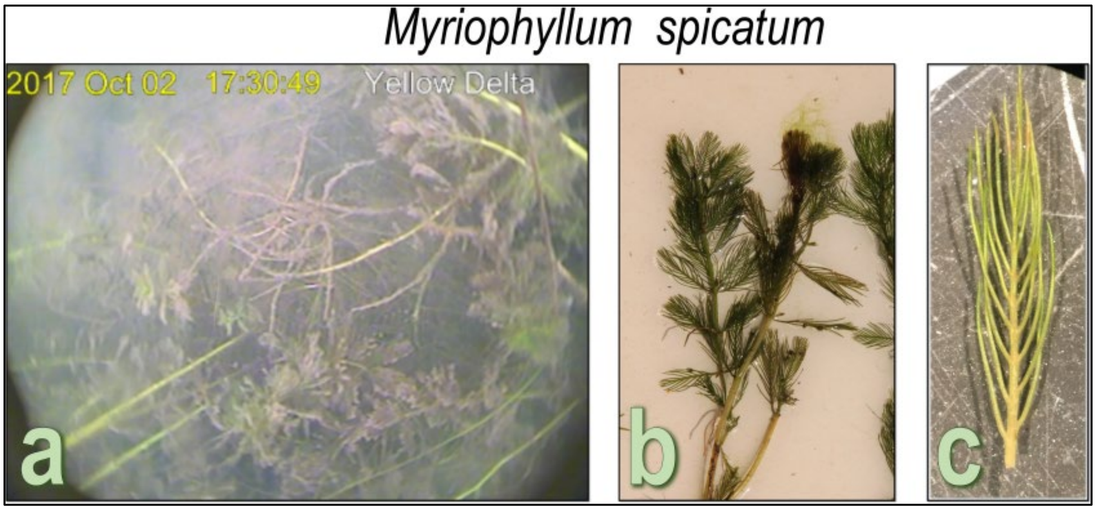

Figure 180. Identification of *Myriophyllum* spicatum encountered in manatee habitat use areas.

Panels: a) In situ as viewed by Quad–Cam. b) Sample on tray for examination of morphology, showing feathery leaves. c) Details of microscopic features to confirm identification (number of leaflets and shape of leaf).

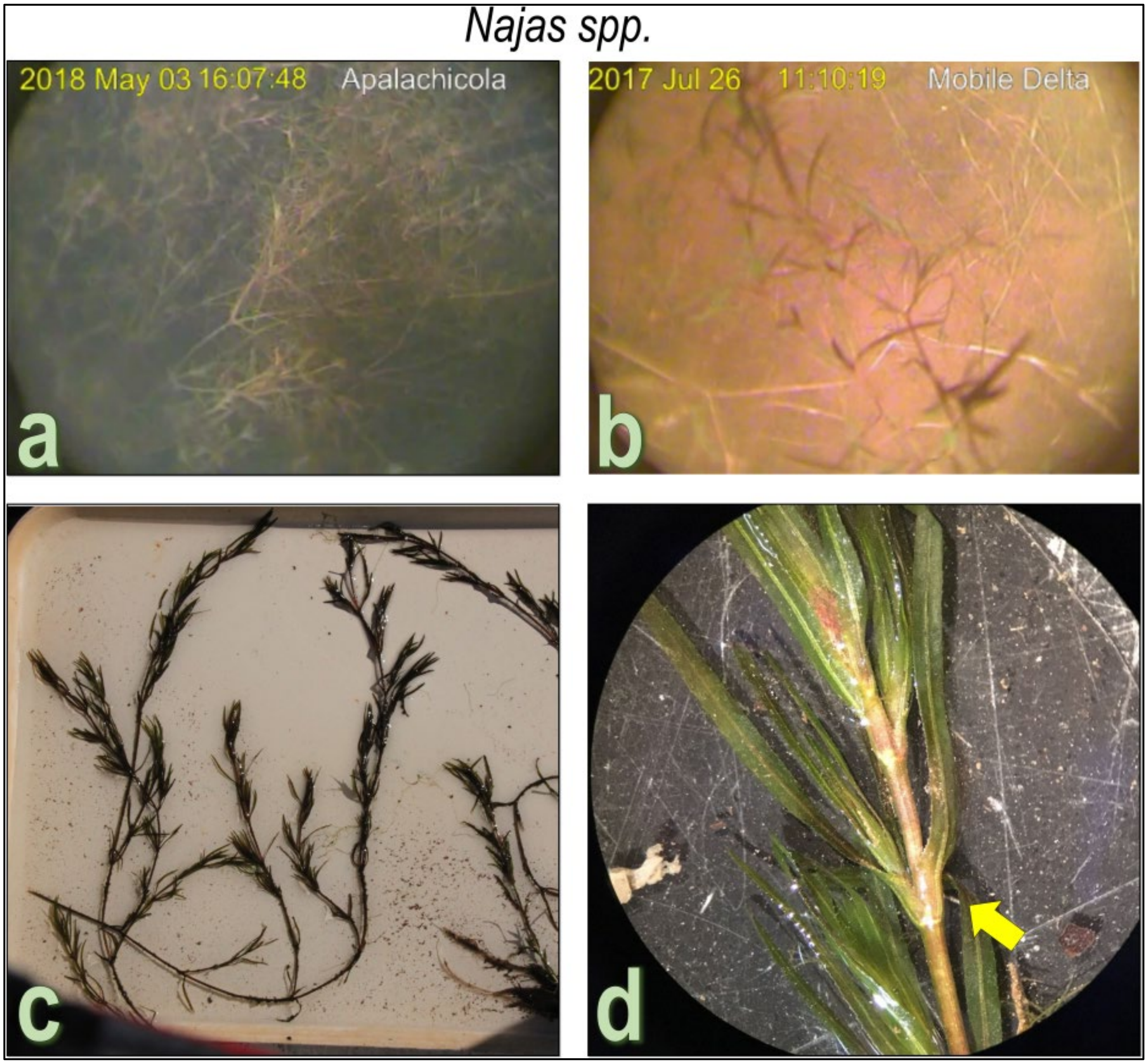

Figure 181. Identification of *Najas* species encountered in manatee habitat use areas.

Panels: a andb) in situ as viewed by Quad–Cam. c) Sample on tray for examination of morphology. d) Details of microscopic features to confirm identification (arrow indicates characteristic clasping expanded leaf base).

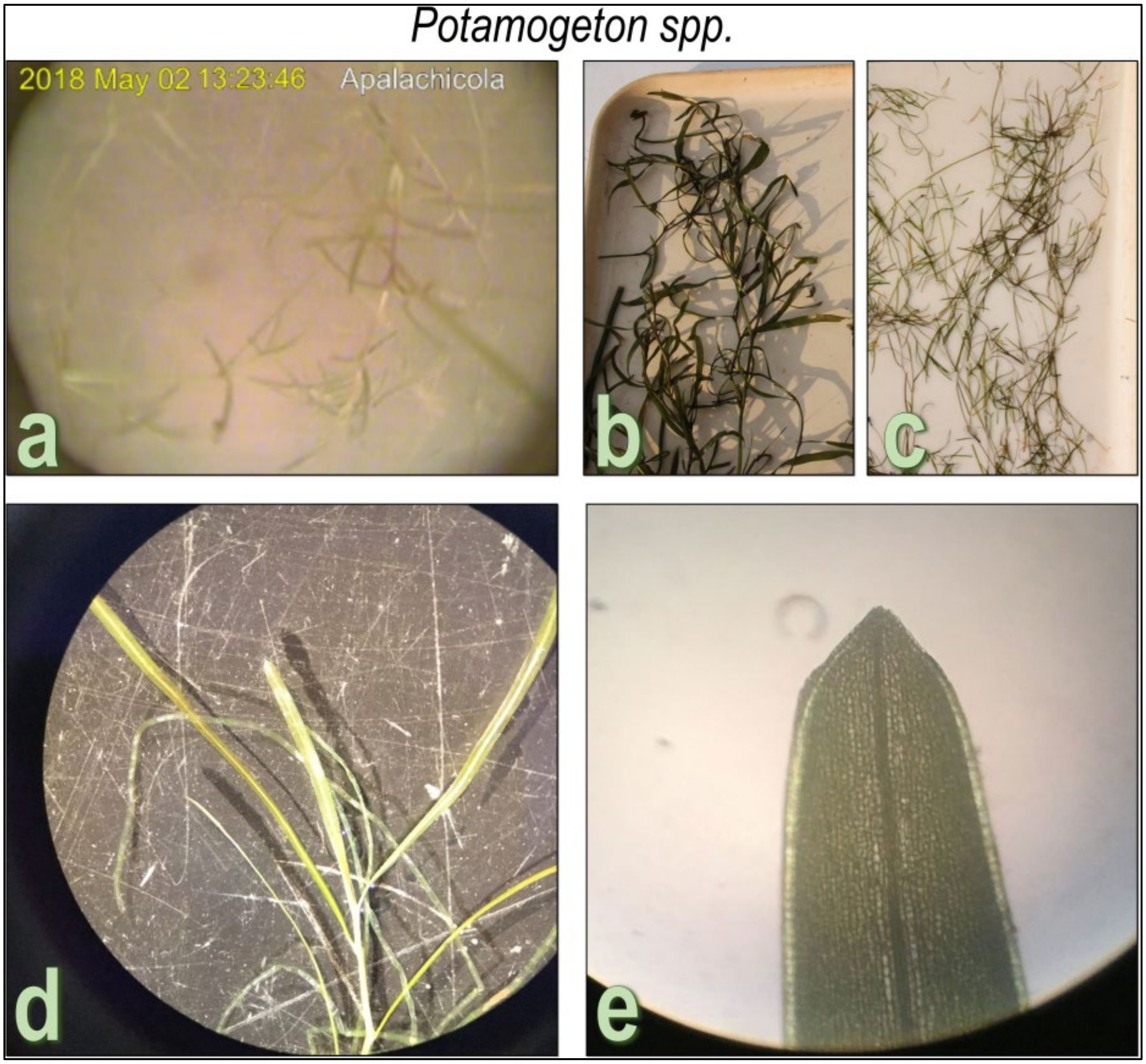

Figure 182. Identification of *Potamogeton* species encountered in manatee habitat use areas.

Panels: a) in situ as viewed by Quad–Cam. b and c) Samples of different species on tray for examination of morphology. d and e) Details of microscopic features to confirm identification.

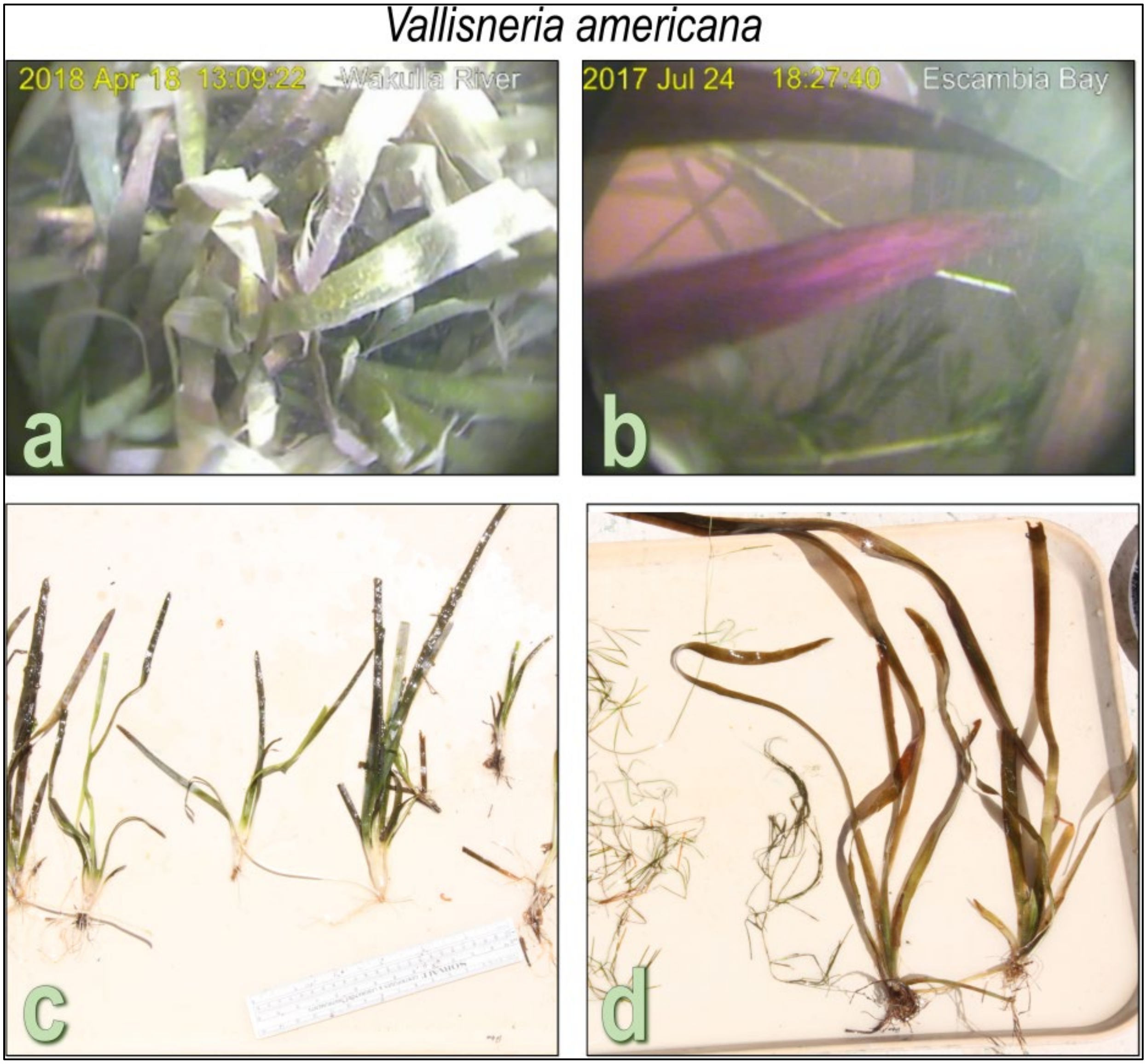

Figure 183. Identification of *Vallisneria americana* encountered in manatee habitat use areas.

Panels: a and b) in situ as viewed by Quad–Cam. c and d) Sample on tray for examination of morphology.

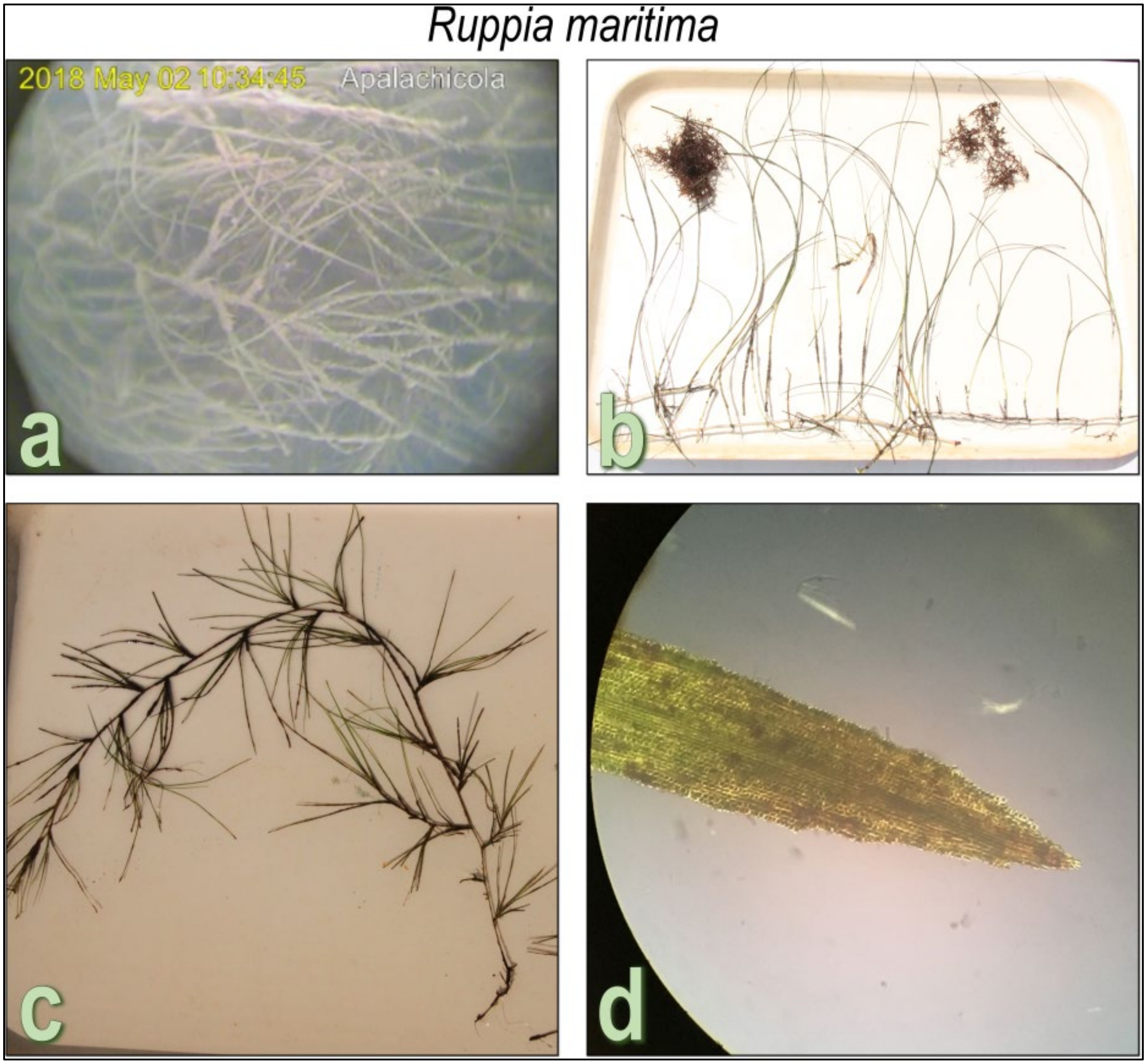

Figure 184. Identification *of Ruppia maritima* encountered in manatee habitat use areas.

Panels: a) in situ as viewed by Quad–Cam. b and c) Samples on tray for examination of morphology showing characteristic branching growth pattern. d) Details of microscopic features to confirm identification (pointed shoot tip).

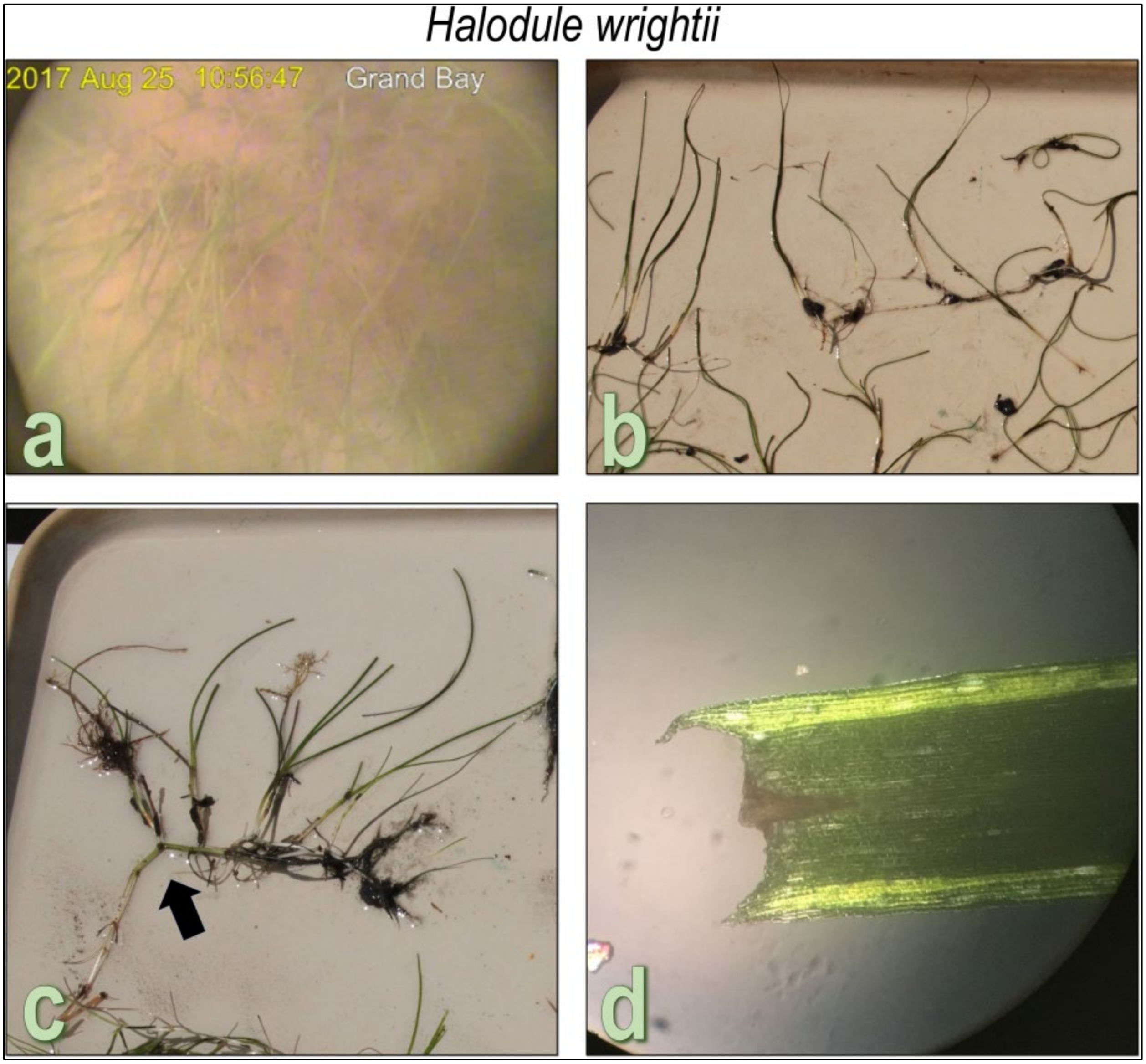

Figure 185. Identification *of Halodule wrightii* encountered in manatee habitat use areas.

Panels: a) in situ as viewed by Quad–Cam. b and c) Sample on tray for examination of morphology, showing clumped emergence from rhizome. d) Details of microscopic features to confirm identification showing scalloped shoot tip and glowing edges under polarizing microscope.

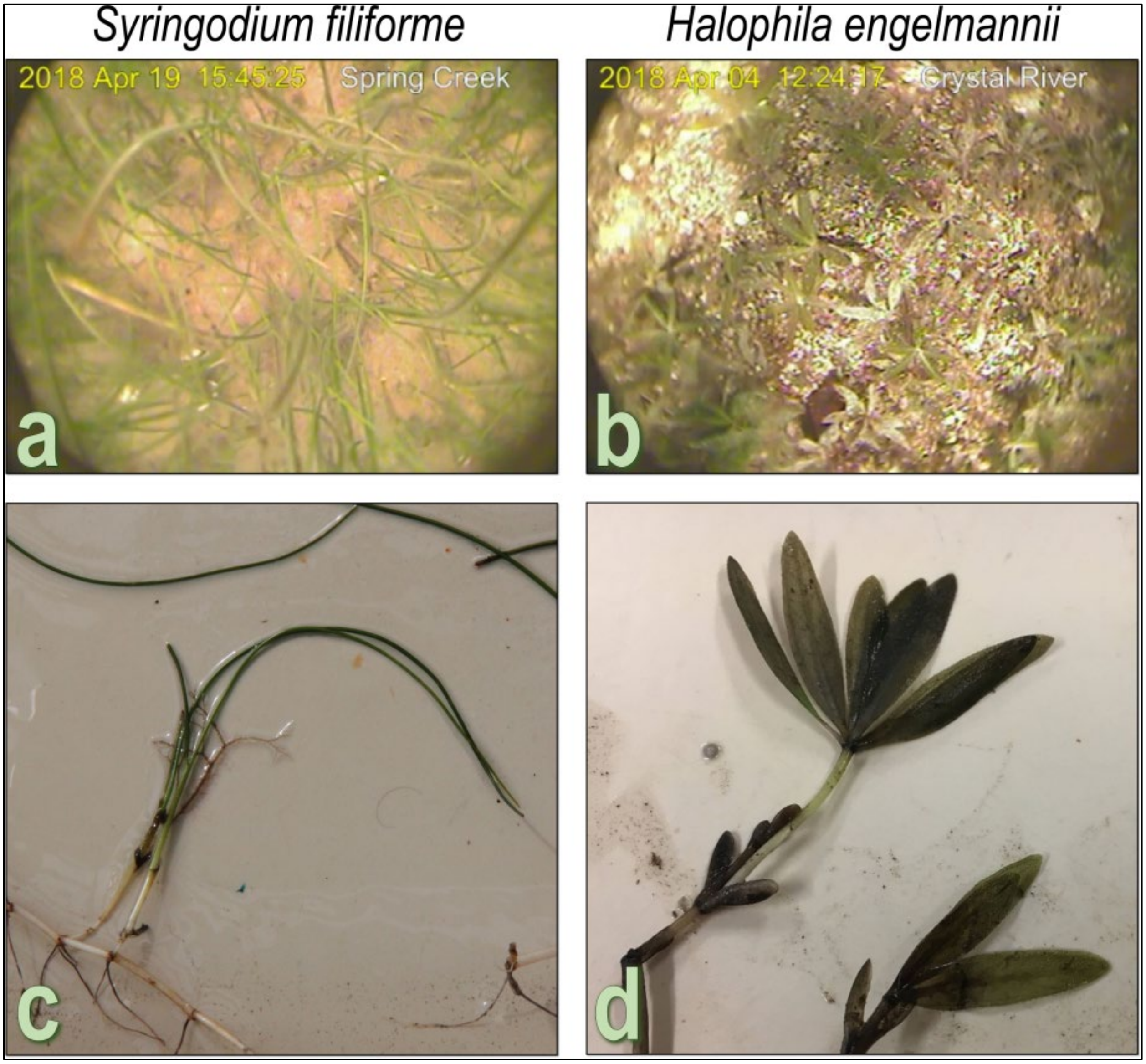

Figure 186. Identification of *Syringodium filiforme* and *Halophila engelmannii* encountered in manatee habitat use areas.

Panels: a and b) in situ as viewed by Quad–Cam. c and d) Samples on tray for examination of morphology, showing c) round *S. filiform* shoots emerging from rhizome and d) star-shaped leaves of *H. engelmannii*.

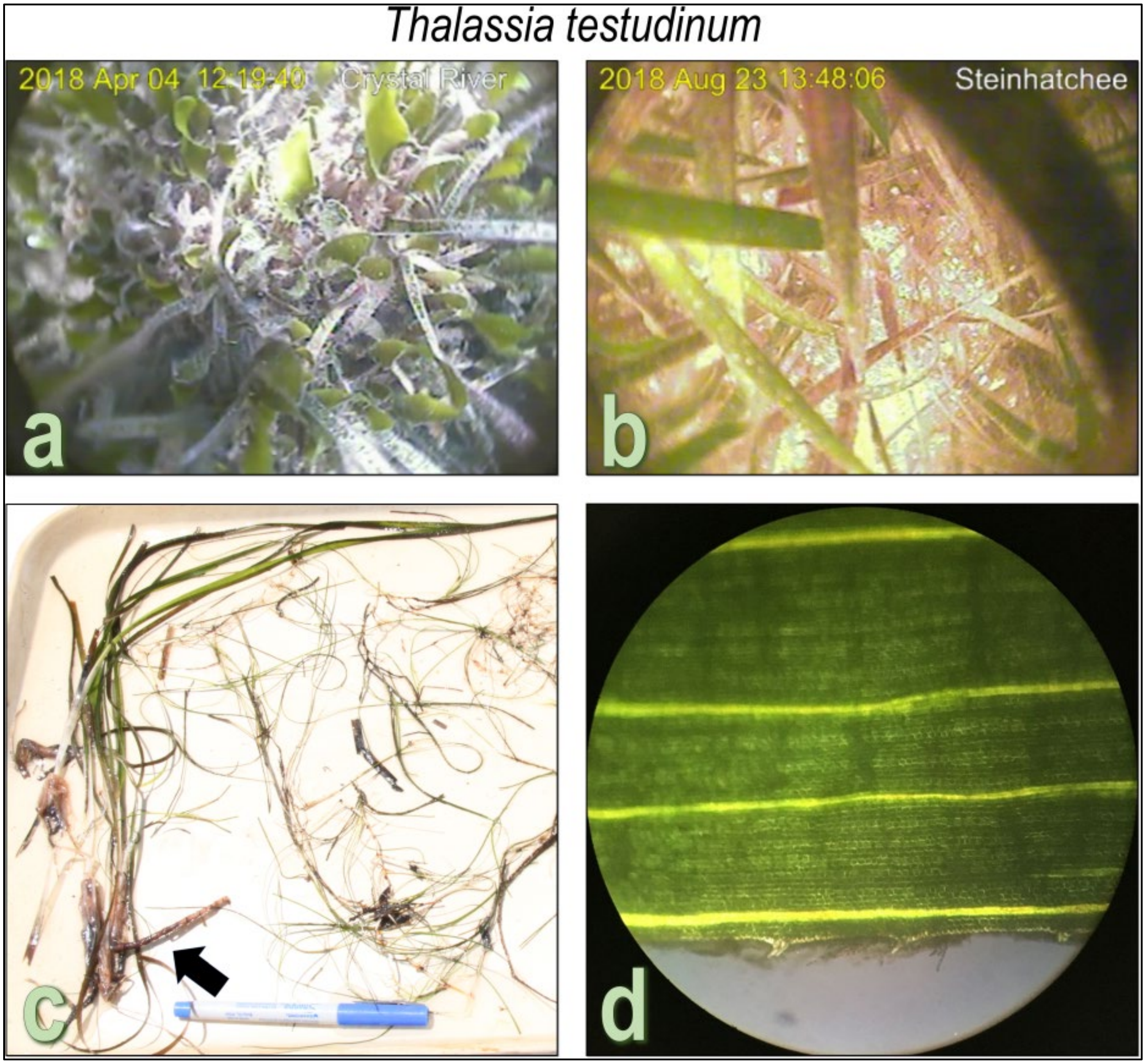

Figure 187. Identification of Thalassia testudinum encountered in manatee habitat use areas.

Panels: a and b) in situ as viewed by Quad–Cam. c) Sample on tray for examination of morphology (arrow shows thick rhizome and base of *Thalassia testudinum*). d) Details of microscopic features to confirm identification.

Marine forage species were found at a somewhat deeper depth range compared to freshwater or brackish species (Figure 188). This is likely related to water clarity as the freshwater streams were generally more turbid than the offshore foraging areas. The salinity where each of the most common plants was found was as expected: The freshwater species were found generally near zero ppt salinity with a few tide-dependent outliers up to 15 ppt (Figure 189). The marine species were found generally between 20 and 25 ppt with (again) a very few tide dependent outliers down to 8 ppt. The euryhaline species showed their cosmopolitan nature: we encountered them from fresh to almost marine-level salinity conditions.

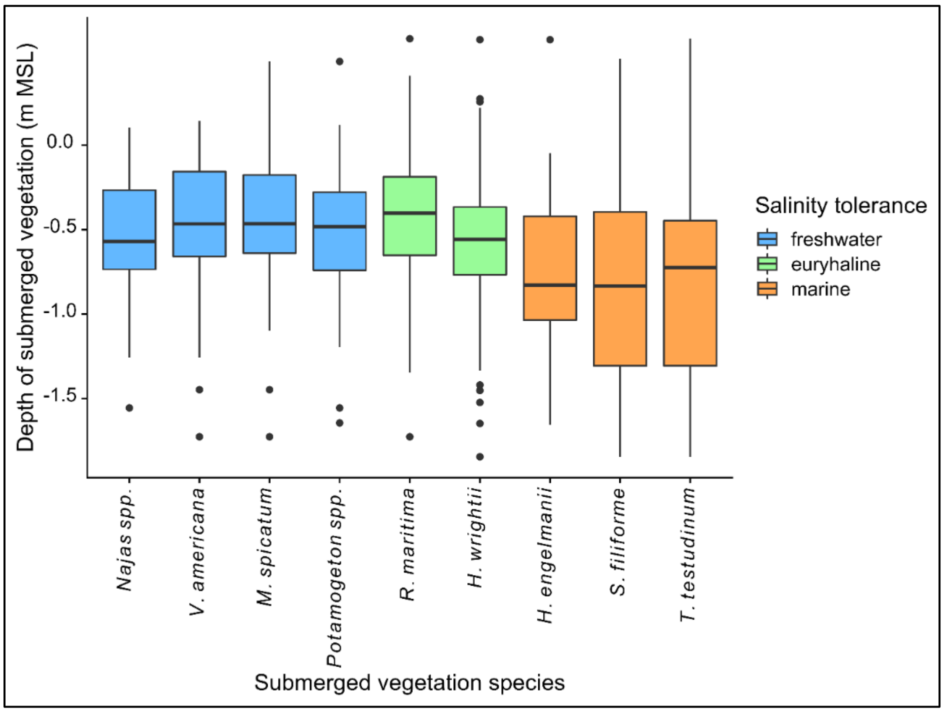

Figure 188. Boxplot of depths where submerged aquatic vegetation species were found, corrected for tide stage to Mean Sea Level (MSL).

Depth at or above zero indicate shoreline locations that are accessible to manatees only at high tide.

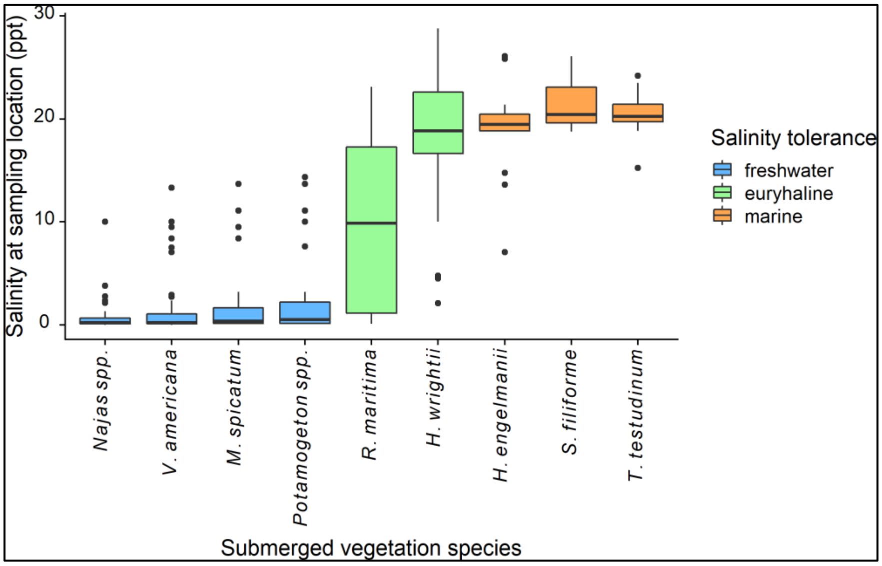

Figure 189. Boxplot of salinity (ppt) where submerged aquatic vegetation species were found.

The relative makeup of the common SAV communities that were targeted by foraging manatees shifted across the regions. On the western end of the vegetation sampling regions (Pascagoula–St. Marks), freshwater SAV communities were targeted (Figure 190). Euryhaline foraging sites were found throughout the sampling regions but were more dominant on the western side. Marine SAV communities were targeted more in the eastern regions (St. Marks–Crystal River). At a finer scale, foraging sites within a region tended to contain specific communities based on the salinity regime of the local site, as expected (Figure 191). These finer-scale results show that the regions themselves did not necessarily contain different plant community types based, but rather the manatees were targeting different, generally fresher communities as they moved farther west, even though saltwater forage was available. It is possible they were targeting these freshwater communities by preference.

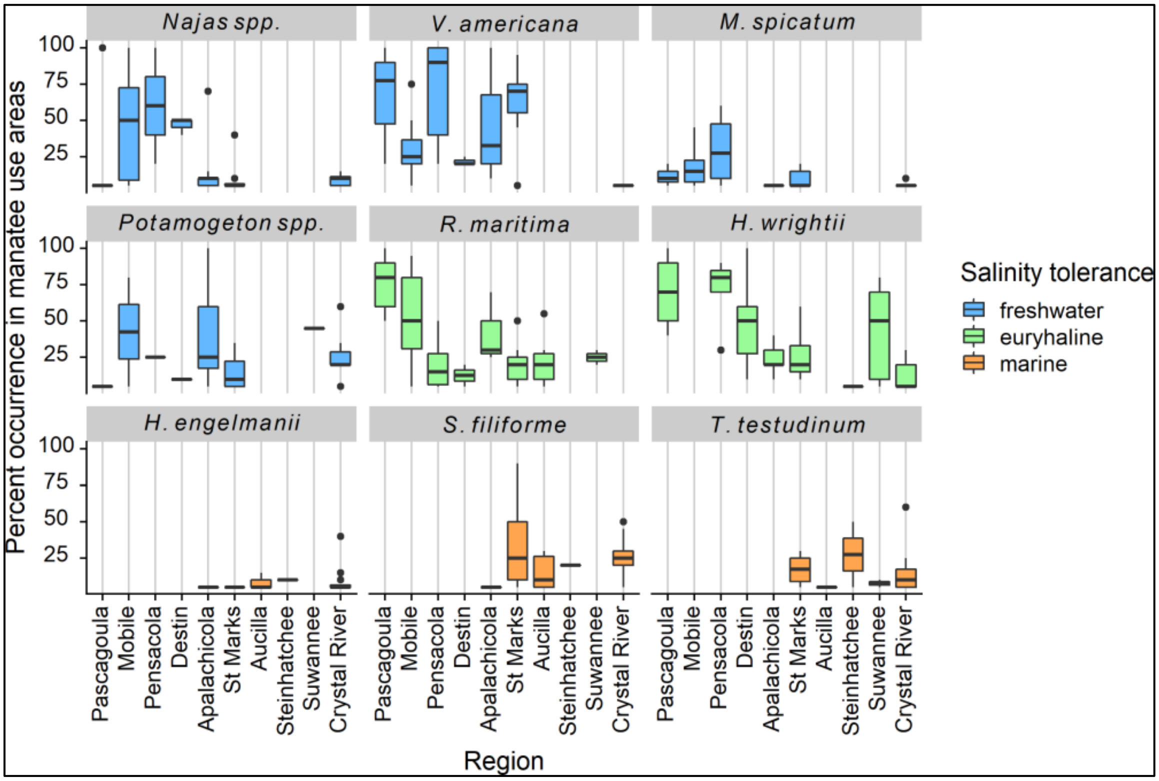

Figure 190. Relative abundance of submerged aquatic vegetation species in manatee use areas per region.

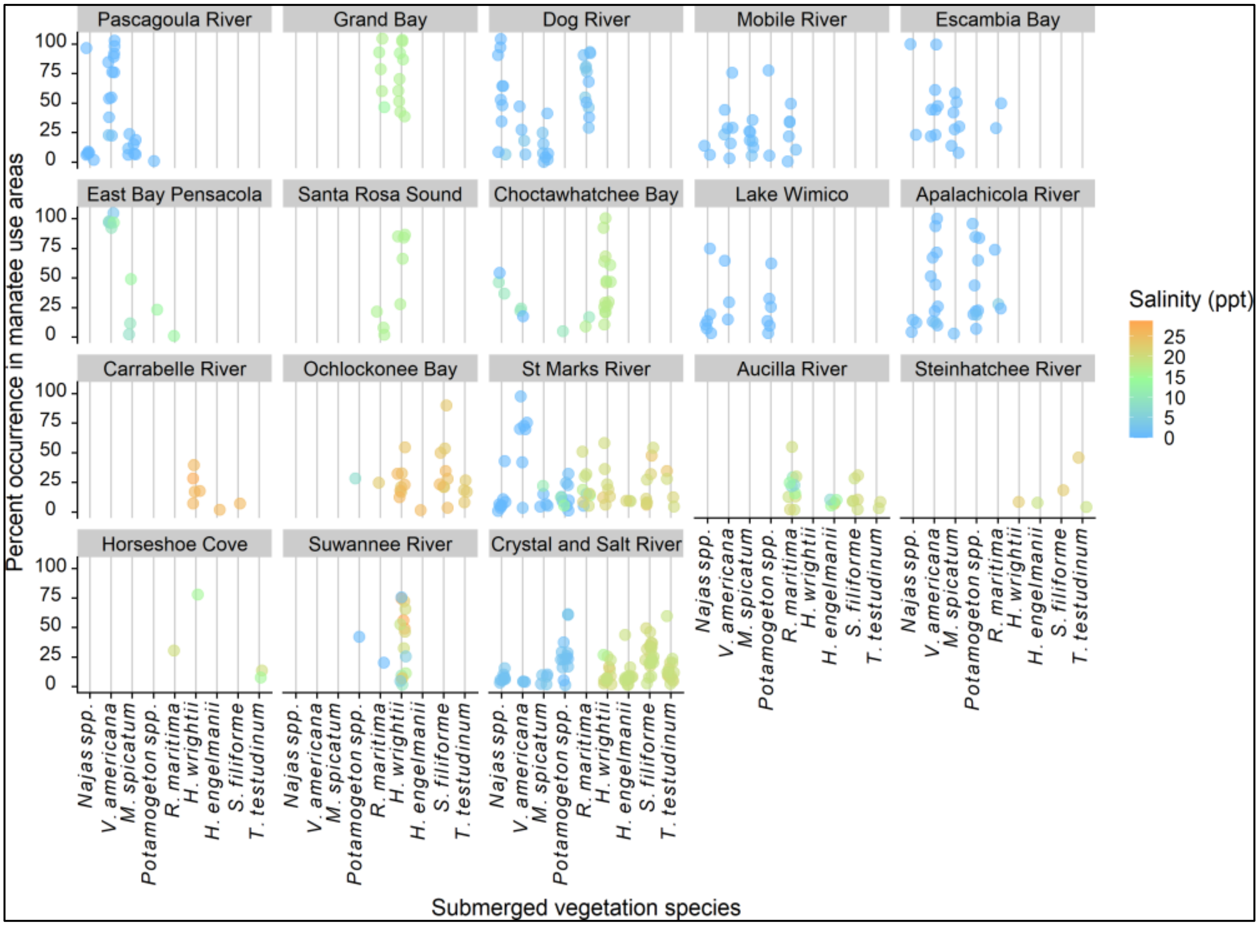

Figure 191. Plot of submerged aquatic vegetation species (or genera) found in each Area of Interest (gray labels).

Each jittered dot indicates one sampling location where the species was found, corresponding to the percentage of the benthic substrate covered by that species. Color indicates salinity of the sampling location at the time of sampling.

4 Discussion

Manatee movements in the northern Gulf of Mexico are characterized primarily by their need to return to protected warm water refuges in Florida each winter. This is realized by long migrations in the spring away from Crystal River National Wildlife Refuge and Wakulla Springs westward along the coast. Failure to return to one of Florida's warm water refuges in the fall would likely lead to cold stress and death (Bossart et al. 2003; Laist et al. 2013; Hardy et al. 2019), barring rescue. This scenario has been increasing in recent years (e.g. Alexander 2014 Nov 25) as the Florida manatee population has increased with a corresponding increase in movements to the west. The telemetry and sighting data showed the expected strong correlation between migratory movements and seasonality, with regions farther west having a more limited warm season activity range. Outliers to this pattern, seen especially in the sighting data, likely point to manatees that were most at risk of cold-stress syndrome and death.

The regions in the east, from St. Marks to Crystal River, have been called "the best hope for the long-term existence of this endangered species" due to the large amounts of unexploited habitat and sparse human development (Powell and Rathbun 1984). They feature a wide shallow shelf with widespread submerged aquatic vegetation. In these regions, manatees showed travel paths and habitat use that ranged up to several kilometers away from the shoreline. In these and other regions, travel paths tended to be in deeper water, farther offshore than habitat use areas. These forays far from shore were once thought to be rare, but these data show how common these movements are under certain circumstances. Several of the tagged manatees, returning to Crystal River in the fall, made directed movements that cut across most of the Big Bend, traversing up to 100 kilometers away from shore. Five of the sightings recorded for this study were reports from offshore oil platforms or ocean-going vessels, hundreds of kilometers offshore in more than 4-kilometer deep water (Table B-1). These documented offshore sightings are part of a long-distance dispersal behavior (accidental or directed) related to Florida manatees documented traveling across open water to locations including the Bahamas (Melillo-Sweeting et al. 2011), Cuba (Alvarez-Alemán et al. 2010), and more recently, the Yucatan peninsula in Mexico (Morales-Vela et al. 2021). It is not known if these deep-water dispersal movements are evidence of manatees making poor decisions, getting lost or disoriented from their intended destination, or purposeful directed movements.

In regions without the broad Florida shelf (Apalachicola and westward), habitat use areas were concentrated in broad estuaries with wetland habitat, and the travel paths were very close to shore, or where available, within the Intracoastal Waterway. While open-water crossings were seen in most of the regions, they were exceedingly rare. Nevertheless, in regions with vessel traffic, these rare crossings may expose manatees to an elevated risk of watercraft strike leading to injury or mortality. Boat strike is consistently one of the leading causes of manatee mortality in Florida (Ackerman et al. 1995; Wright 1995; Bonde and Flint 2017), and one of the tagged manatees in this study was struck and killed by a vessel while crossing Mobile Bay (DISL 2015 Sep 18). Data from the retrieved telemetry tag showed that the strike occurred in the dredged ship channel. Closer to shore, boat strike from small vessels in shallow water is more of a factor than impacts from large vessels; and in shallow water, manatees may have less opportunity to avoid watercraft (Rycyk et al. 2018). Florida waterways are governed by a system of speed regulations, some of which are specifically enacted for manatee protection (FWC 2021), but we are unaware of any specific statutory manatee-specific zones outside of Florida. Many locations where manatees have been sighted or tracked are in protected waters (e.g. Padre Island National Seashore, Gulf Islands National Seashore, among many others), and while these waters often have helpful water quality or habitat protection measures in place, none have manatee-specific protection measures to our knowledge.

We collected manatee location and movement data using methodology with "complementary biases." Telemetry data shows individual behavior and detailed habitat location choices for individual animals, but without a sufficiently large and diverse sample of individuals, the overall distribution can be biased toward individual home ranges. Sighting data, like aerial survey results, tends to be complementary to the bias shown by telemetry data in that they can show the distribution of a significant fraction of all animals in a given area, but do not allow for inferences about habitat choices or movement patterns. Sighting reports can give information about manatee use in areas outside of regular monitoring or movement areas, but tend to be heavily biased toward populated areas. There is an educational component to sighting reports as well, where areas that are targeted by natural resource departments or researchers with educational campaigns and prominently displayed contact information to report sightings tend to have a greater number of reports. We attempted to leverage the strengths of each data type in this study while comparing results to the complementary data type where possible to avoid or at least identify biased results. In this way we strive to present the most complete picture of manatee movements and habitat use in the northern Gulf of Mexico.

5 Conclusions

Florida manatees have been documented in all areas of the Gulf coast, including Texas, Louisiana, Mississippi, and Alabama. Sightings of manatees traveling and using habitat resources in the northern Gulf of Mexico have been increasing in recent years, and may be encountered in all nearshore waters, with the highest likelihood centered in the summer months. Several distinct spatial and temporal use patterns were described herein, in relation to their potential for conflict with shipping or other energy operations:

- The highest traveling movement rates were in spring and fall, and resource use peaked in summer. Manatees that venture along the Gulf coast in warmer seasons must return to Florida before winter.
- The highest density of manatee resource use was close to wetlands and estuaries where foraging resources are found.
- Freshwater forage areas were used disproportionately compared to marine forage in regions where both were available. This may demonstrate feeding preference. The abundance of freshwater habitats in the NGOM may be a behavioral draw for manatees to make seasonal migrations to the west each year.
- Manatees were generally found within shallow waters less than 4 m deep (as utilized in this study), except when actively traveling. They were almost always found within 1,000 m of shore (often much closer). However, manatees can forage farther offshore across the wide shallow shelf along the Big Bend of Florida, and they have been documented far offshore on rare occasions.
- Shallow water without nearby deep escape routes has been documented to have a higher potential for conflict with small craft, including fishing and pleasure boats. Much of the manatee use areas, especially foraging locations, falls into this category.
- Where available, manatees traveled more often within the Intracoastal Waterway rather than the open Gulf. These narrow waterways are more sheltered from waves and currents, but may be potential conflict areas with vessel traffic if manatees are not able to avoid vessels.
- Two manatees tracked for this study were confirmed killed by large vessels in Mobile Bay: one in the main shipping channel, and another in an unknown location. Where travel corridors cross active shipping lanes (such as within Mobile Bay), manatees may be at higher risk for injury.
- Operation of offshore, deep-water energy infrastructure, including oil and gas wells, wind turbines or ships are unlikely to conflict with manatee movements or behavior, due to distance from shore and water depth far beyond normal manatee behavior.
- Little is still known of manatee movements west of Mississippi Sound, including the Delta region of Louisiana and all of Texas, due to the rarity of manatee occurrence. Sightings from the area give some information that corroborates general habitat use patterns, but detailed GPS tracks from several animals would be necessary to inform habitat use and movement details.

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Appendix A: Cooperators and contacts

Table A-1. List of cooperating agencies and organizations that contributed manatee sighting data or other information for this report

State	Name	Type	Address
TX	US Fish & Wildlife Service	Federal	6300 Ocean Dr.; USFWS Unit 5837, Corpus Christi, TX 78412-5837
TX	US Army Corps of Engineers	Federal	USACE Galveston District, 2000 Fort Point Road, Galveston, TX 77550
TX	Texas Parks and Wildlife Department - Headquarters	State	Wildlife Division, 4200 Smith School Rd, Austin, TX 78744
TX	Ziphius EcoServices	NGO	8112 Springmoss Drive, Plano, Texas 75025 USA
TX	National Park Service - Padre Island National Seashore	Federal	20301 Park Rd 22, Corpus Christi, TX 78418
TX	US Fish & Wildlife Service - Laguna Atascosa National Wildlife Refuge	Federal	22688 Buena Vista Blvd Los Fresnos, TX 78566
TX	USFWS – Lower Rio Grande Valley NWR	Federal	3325 Green Jay Road Alamo, TX 78516
TX	Texas Parks and Wildlife Department - Brownsville	State	5460 Paredes Line Road, Suite 201, Brownsville, TX 78526
TX	University of Texas Rio Grande Valley - Coastal Studies Laboratory	NGO	100 Marine Lab Drive, South Padre Island, Texas 78597
TX	Sea Turtle Inc.	NGO	P.O. Box 3987, South Padre Island, TX 78597
TX	South Padre Island Dolphin Research & Sealife Nature Center	NGO	110 N. Garcia St., Port Isabel, Texas 78578
TX	University of Texas-Pan American Coastal Studies Laboratory, South Padre Island	NGO	100 Marine Lab Dr, South Padre Island, TX 78597
TX	USFWS - Aransas NWR	Federal	1 Wildlife Cir, Austwell, TX 77950
TX	USFWS Corpus Christi	Federal	Permanently Closed
TX	Texas Parks and Wildlife Department – Rockport Coastal Fisheries Field Office	State	824 S. Fuqua St., Rockport, TX 78382
TX	Texas Parks and Wildlife Department – Corpus Christi	State	Natural Resource Center, Suite 2500 6300 Ocean Drive, Unit 5845. Corpus Christi, TX 78412
TX	Texas Parks and Wildlife Department – Pt. O'Connor Coastal Fisheries Field Office	State	P. O. Box 688, 418 S. 16th Street Port O'Connor, TX 77982

State	Name	Type	Address
TX	Texas Parks and Wildlife Department – Rockport	State	715 Business, Hwy 35 N Bypass, Rockport, TX 78382
TX	Texas Marine Mammal Stranding Network (TMMSN)	NGO	Corpus Christi
TX	University of Texas, Marine Science Institute	NGO	750 Channel View Dr, Port Aransas, TX 78373
TX	NOAA Galveston	Federal	Galveston, TX Field Office
TX	USFWS Texas Coastal Ecological Services Field Office - Clear Lake	Federal	17629 El Camino Real, Suite 211, Houston,TX 77058
TX	Texas Parks and Wildlife Department – Dickinson Coastal Fisheries Field Office	State	1502 FM 517 Rd E, Dickinson, TX 77539
TX	Texas Parks and Wildlife Department – . Port Arthur Coastal Fisheries Field Office	State	601 Channelview Dr, Port Arthur, TX 77640
TX	Texas Marine Mammal Stranding Network	NGO	4700 Avenue U, Galveston, TX 77551
LA	Bureau of Ocean Energy Management	Federal	1201 Elmwood Park Blvd., New Orleans, Louisiana 70123
LA	Environmental Enforcement Division, Bureau of Safety and Environmental Enforcement	Federal	1201 Elmwood Blvd., MS GE 466, New Orleans, LA 70123
LA	Louisiana Department of Wildlife and Fisheries Wildlife Division ,	State	2000 Quail Dr. Baton Rouge, Louisiana 70808
LA	Louisiana ESField Office/FWS	State	646 Cajundome Blvd, Suite 400, Lafayette, LA 70506
MS	Grand Bay National Estuarine Research Reserve	Federal	6005 Bayou Heron Road, Moss Point, MS 39562
MS	US Fish and Wildlife Service, Grand Bay Coastal Resources Center	Federal	6005 Bayou Heron Road, Moss Point, MS 39562
MS	US Fish and Wildlife Service, Mississippi ES Field Office	Federal	6578 Dogwood View Parkway, Jackson, MS 39213
MS	Mississippi Department of Marine Resources	State	1141 Bayview Avenue Biloxi, Mississippi 39530
MS	Mississippi Department of Environmental Quality	State	515 East Amite Street, Jackson, MS 39201
MS	Institute for Marine Mammal Studies	NGO	P.O. Box 207, Gulfport, MS 39502, Physical Address:, 10801 Dolphin Lane , Gulfport, MS 39503
AL	USFWS Alabama Field Office	Federal	1208 Main Street, Daphne, AL 36526
AL	Alabama Department of Conservation and Natural Resources	State	64 N. Union Street, Montgomery, Alabama 36130
AL	Alabama Division of Wildlife & Freshwater Fisheries	State	30571 Five Rivers Boulevard, Spanish Fort, AL 36527
AL	Dauphin Island Sea Lab	NGO	101 Bienville Blvd., Dauphin Island, AL 36528
FL	USFWS Jacksonville, Florida Field Office	Federal	7915 Baymeadows Way, Suite 200, Jacksonville, FL 32256-7517

State	Name	Type	Address
FL	USFWS Panama City Field Office	Federal	1601 Balboa Avenue, Panama City, FL 32405
FL	USGS Southeast Ecological Science Center	Federal	7920 NW 71st St. Gainesville, FL 32653
FL	Florida Fish and Wildlife Conservation Commission	State	Bryant Building, 620 S Meridian St, Tallahassee, FL 32399
FL	Sea 2 Shore / Clearwater Marine Aquarium Research Institute	NGO	249 Windward Passage, Clearwater, FL 33767

Appendix B: Manatee sighting records

Table B-1. Locations and descriptions of manatees in the western Gulf of Mexico reported during the study period, or found in records

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
TX	1	-97.42955	26.55383	8/13/2004	Estimated location; Port Mansfield Harbor		Reported in am
TX	1	-97.42947	26.55123	9/5/2004	at end of \D\" dock near covered boat stalls in Pt. Mansfield Harbor"		Alone; in pm
TX	1	-97.50510	26.32800	9/15/2004	Estimated location; Arroyo City, off end of dock in the Arroyo Colorado		Traveling upstream
TX	1	-97.42864	26.55379	10/5/2004	Estimated location; Port Mansfield small craft basin		Surfaced next to pier where hose was running, appeared to be drinking
TX	2	-97.43250	26.54997	10/8/2004	Port Mansfield Harbor near Get-A-Way Lodge		2 Tms
TX	1	-97.23432	27.60029	10/23/2004	13917 Man O War Street, Padre Isles		Tm actively swimming, rolling, blowing water and making sounds
TX	1	-97.06381	27.84173	11/3/2004	off Robert's Point Park in ship channel in Port Aransas, 27 50.482, 97 03.825		Heading toward Corpus Christi Bay
TX	1	-97.04541	28.01979	11/9/2004	Estimated location; Rockport, TX	DUTX00003	Drinking from hose
TX	1	-97.07509	27.99121	11/9/2004	Cove Harbor B/tw Aransas Pass and Rockport, near Bob's bait stand		Scarred, lots of barnacles
TX	1	-97.42677	26.55665	5/1/2005	Estimated location; Port Mansfield	DUTX00002	Alone
TX	1	-97.42840	26.55560	6/21/2005	Port Mansfield	DUTX00002	Alone
TX	1	-96.98910	28.13309	1/5/2011	Rockport, TX	TX_010511)01	Alone, cold stressed
TX	1	-97.38757	27.79309	9/20/2012	near Lawrence Street T-Head		Spotted in pm

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
TX	1	-97.36725	27.85177	9/20/2012	near Indian Point on Neuces Bay		Spotted in am
TX	1	-94.85150	29.27770	10/6/2012	Offatts Bayou near Moody Gardens		Alone
TX	1	-94.77896	29.31332	6/12/2013	Galveston Bay		
TX	1	-97.05728	27.84166	7/1/2013	Estimated location; Teal Harbor, Port Aransas		Drinking
TX	1	-97.39934	27.81241	7/14/2013	Estimated location; Corpus Christi Harbor, Koch #1 Dock		
TX	1	-94.94680	29.32160	6/15/2014	Estimated location; Pierce Marsh, W. Galv. Bay; b/tw Bayou Vista & Harbor Walk diversion;29.321604,94.94680 1		1st sighting of season; reported by kayak fisherman
TX	1	-95.65740	28.75270	7/13/2014	Estimated location; Mitchell's Cut near Sargent, TX		Swimming from Intracoastal Waterway into Gulf
TX	1	-96.31556	28.42528	7/16/2014	Estimated location; 28 25 31, 96 18 56; in the surf		
TX	1	-94.94310	29.32354	7/22/2014	Estimated location; cal in Bayou Vista subdivision, Hitchcock, TX; 29.323540, 94.943103		Small Tm ~4-5 ft; stated it has been in area for at least a month prior
TX	1	-97.20833	26.06333	7/28/2014	cal subdivision near Port Isabel; 26 03.803,97 12.5 (26.063333,97.208333)		10 ft, good condition; 2 kayakers had reported a Tm in same vicinity 2 weeks ago
TX	1	-97.20720	26.06480	7/29/2014	Port Isabel; Long Island Village subdiv.; cal directly across from Southpoint Mari		Drinking from hose; pictures and video
TX	1	-97.17220	26.12910	8/1/2014	~1pm at dock at Parrot Eyes Restaurant and Water Sports		8-10 ft; picture
TX	1	-97.14340	26.06620	8/5/2014	Estimated location; possible sighting outside of jetties on South Padre Island		Reporter said \eating bait on top of the water\""
TX	1	-97.22431	27.84708	8/9/2014	Oxychem Plant docks in Ingleside, TX; ~27.847075, 97.224313		Alone; 8-9 ft; picture

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
TX	1	-97.03280	28.06410	8/14/2014	Inn of Fulton Harbor; along seawall directly in front of Inn just E. of long pier		Video; eating off piling
TX	1	-97.09440	27.96920	8/16/2014	209 Starboard Ave., Palm Harbor, Rockport, TX		8-10 ft; video
TX	1	-97.09470	27.96940	8/16/2014	205 Starboard Ave., Palm Harbor, Rockport, TX		Reported as 4-5 ft; follow up on report indicated this was erroneous
TX	1	-94.81785	29.75489	11/25/2014	Warm water outfall at NRG Energy Cooling reservoir, North Trinity Bay	TB435; TTB-140 \Trinidad\""	Rescued on 11/25/14; had been observed in same area since 11/23/14
TX	1	-97.07492	27.99354	3/21/2016	Cove Harbor b/tw Aransas Pass and Rockport; 27.993543, -97.074918		Water too murky to get photos; alone; may have been seen the previous week
TX	1	-97.25690	27.68614	4/19/2016	Corpus Christi val Air Station; 27°41'09.5\N 97°15'25.3\"W"		Alone; 6-7 ft.
TX	1	-97.09586	28.07161	8/26/2018	Salt Lake, Copano Bay, Aransas County		Alone; video (Robyn Cobb, FWS)
TX	1	-95.06019	29.19778	8/29/2018	Estimated location; Alligator Point, West Bay, Galveston County		Alone; traveling west (Heidi Whitehead, TMMSN)
LA	1	-90.05745	30.34972	7/16/1999	Pontchartrain Yacht Club, in channel that feeds from Bayou Castine to Bay		
LA	1	-89.80287	29.54387	9/8/1999	Tm caught in shrimp net and released alive		
LA	4	-90.08827	30.32022	10/10/2000			
LA	1	-88.86211	27.31832	10/15/2001	Offshore; 130 miles ESE of Venice, LA in Block 85 over Mississippi Canyon, ~5000'		Alone; spotted by workers laying pipe off a barge; picture taken
LA	1	-90.16016	30.37711	1/9/2002			
LA	1	-90.09500	30.34100	1/9/2003			
LA	1	-89.94495	29.64043	1/11/2003			
LA	1	-90.59480	30.36520	9/22/2003			

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
LA	1	-90.86118	30.34178	9/11/2004			
LA	3	-89.77783	30.20440	11/10/2007	Lakeshore Estates subdivision, area of 970 Lakeshore Blvd., Slidell		3 Tms viewed for a couple of hours
LA	1	-89.78015	30.20582	12/2/2007	Lakeshore Estates subdivision directly behind 970 Lakeshore Blvd, Slidell		Alone
LA	1	-90.02830	27.19000	11/4/2009	Offshore; Green Canyon Block 787, 120 mi S of LA, 5000-6000' deep; 27.1900N, 90.0283W		Large adult, no scars, hanging around lee side of offshore production platform
LA	1	-93.23060	30.22602	11/22/2009	Lake Charles		Possibly same one previously spotted
LA	1	-89.79681	30.22354	7/2/2011	Clipper Estates cals, Slidell, St. Tammany cty		Alone, swimming calves of this gated community
LA	1	-90.33353	29.69039	8/26/2011			
LA	1	-90.33020	29.68450	8/27/2011	Temple Bay in Lake Salvador b/tw LaFourche & St. Charles Parish's		Alone, 10-12'
LA	1	-90.14200	27.32267	3/20/2013	Offshore; Green Canyon Block 653, 27 19 35.545, 90 08 51.943, 4356' deep		Spotted off platform
LA	1	-89.79434	30.21626	8/7/2013	Grand Lagoon, Oak Harbor		Alone
LA	1	-91.87927	27.94333	12/18/2013	Offshore; 27.94333N, 91.87927W		Alone; 142m deep; by observer on a seismic ship
LA	1	-93.28333	26.82000	4/10/2014	Offshore; 26.82000N, 93.28333W		Possible manatee ~200 miles offshore; large, round, gray mass, approx. 1.5m in length, large bulbous head and tail, pects.
LA	3	-90.87569	30.34335	9/28/2014	Estimated location; Amite River, Livingston Parish		2-4 Tms seen by local resident near boat dock; LDWF
LA	1	-89.92714	30.31020	10/28/2014	Estimated location; Bayou Lacombe, St. Tammany Parish		Alone; spotted by LDWF Aquatic Veg Control, and LDWF Fisheries staff

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
LA	1	-89.90114	30.01296	10/31/2014	Estimated location; Bayou Bienvenue along Great Wall; Chalmette	CR675	Report with picture from fisherman
LA	1	-93.24763	30.24150	11/8/2014	Estimated location; Calcasieu River; Westlake		Picture
LA	1	-93.31899	30.16688	11/15/2014	Estimated location; Calcasieu River; headed upstream toward a reported WW site		WW site? Reportedly sustained a Tm during winter 2010
LA	1	-92.18500	29.77944	12/9/2014	Intracoastal Waterway near Intracoastal City, LA (29 46' 46.29\, 92 11' 6.55\")"		6-8'; heading east
LA	1	-89.86444	30.25066	6/6/2015	St. Tammany Parish; Bayou Bonfouca, 50 meters from Lake Pontchartrain		From Keri Landry LDWF
LA	1	-90.15447	30.40497	6/20/2015	St. Tammany Parish; upper Tchefuncte River near Hwy 22		From Keri Landry LDWF
LA	1	-90.63640	30.37290	8/1/2015	Livingston Parish; upper Tickfaw River, between Horse Bluff and Tickfaw State Park		From Keri Landry LDWF
LA	1	-90.52560	30.41780	8/1/2015	Livingston Parish; upper Tickfaw River, 9 miles upriver from the mouth of Lake Maurepas		From Keri Landry LDWF
LA	1	-90.06227	30.34856	5/9/2016	Mandeville Yacht Club; alone; 30.348558°, -90.062274°		Moving down inside seawall, \big grass flat off the west of the bayou there\"; http://www.nola.com/outdoors/index.ssf/2016/05/mandeville_resident_spots_seas.html "
LA	1	-90.06227	30.34856	5/19/2016	Estimated location;		
LA	1	-91.18682	29.71878	11/25/2016	Estimated location;		
LA	1	-90.64750	27.79524	1/30/2017	Offshore		
LA	1	-90.41011	30.30885	8/26/2017	Manchak, North Pass, Lake Maurepas		Came up by vessel in North Pass; picture
LA	2	-90.07963	30.35732	9/27/2017	Mandeville Lakefront		

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
LA	1	-90.40920	30.02211	7/23/2018	Bonnet Carre Spillway; Norco, LA		Video of Tm gliding past crabbers at dusk near boat ramp off Airline Hwy
LA	1	-89.93321	30.00848	5/30/2019			
MS	1	-89.19585	30.40192	5/19/2003	Estimated location; Wolf River, 1 mile S of I-10, Harrison County		Alone
MS	1	-89.46328	30.38613	11/11/2008	Estimated location;		
MS	1	-88.56848	30.47849	5/13/2009	Estimated location; Cunningham Lake, East Pascagoula River		Alone
MS	1	-88.59634	30.47079	5/13/2009	Buzzard Bayou, 30.47079, 88.59634	MS51309.01	Alone, adult
MS	3	-88.60941	30.39901	5/16/2009	Estimated location; West Pascagoula River near powerlines		3 Tms
MS	1	-88.61173	30.43523	5/31/2009	West Pascagoula River, 30.435207, 88.61165	MS53109.02	Alone, adult
MS	1	-89.14602	30.34408	6/6/2009	Long Beach mari fishing pier, Long Beach, 30.344126, 89.14608	MS60609.04	Alone, adult, <20' from bank, traveling west
MS	1	-88.88951	30.39096	6/10/2009	Mississippi Sound, Biloxi, 30.390951, 88.88951	MS61009.03	Alone, adult, stayed 10 minutes then traveled west
MS	2	-88.72300	30.44203	7/14/2009	Old Ft. Bayou, Ocean Springs, 30.442003, 88.72312	MS71409.05	1 or 2 adults
MS	1	-88.62658	30.44955	7/28/2009	West Pascagoula River, 30.449549, 88.62658	MS72809.06	Alone, adult
MS	1	-88.82778	30.41950	8/9/2009	Old Ft. Bayou bridge, Ocean Springs, 30.4195, 88.82778	MS80909.07	Alone, adult, traveling east up bayou
MS	1	-88.82348	30.40642	8/10/2009	Ocean Springs inner harbor, 30.406418, 88.82348	MS81009.08 & .09	Alone, adult, swimming around harbor, drinking from hose; 2 reports over 2 hour period
MS	2	-88.61437	30.47202	8/13/2009	Crane Lake, W. Pascagoula River, 30.47202, 88.614365	MS081309.10	Cow-calf pair

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
MS	1	-88.90257	30.41282	8/16/2009	Biloxi Bay, 30.412817, 88.902565	MS081609.11	Surfaced close to pier
MS	1	-88.46140	30.36234	8/25/2009	Bangs Bayou, Pascagoula, 30.362339, 88.4614	MS82509.12	Headed towards Bangs Lake
MS	1	-89.26642	30.36452	9/13/2009	Estimated location; Wolf River and DeLifle? Bayou, Bay St. Louis		Alone, resting
MS	2	-88.60588	30.38564	11/6/2009	Estimated location; West Pascagoula River; just out of Bayou that connects to City Park		Cow with calf
MS	1	-88.61120	30.38791	6/10/2011	Mary Walker Bayou, Gautier, MS	CR054	Alone
MS	3	-88.54364	30.41634	6/20/2016			
MS	1	-88.55405	30.34777	11/25/2018	Yazoo Lake, Pascagoula		Alone; spotted on and off for 5 days prior to this in small marine
AL	1	-88.25789	30.40113	7/1/2000	Estimated location; Bayou LaBatre	CR054	
AL	2	-87.93148	30.48526	8/31/2001	Estimated location; Pt. Clear	TB186 Trigger/Sideswip e	Scarred, with one other
AL	1	-87.97012	30.78128	1/12/2005	Chuckfee Bay at Raft River, 30 46.877, 87 58.207		Alone, unusual to see Tm here at this time
AL	3	-87.59098	30.30383	7/28/2005	Intracoastal Waterway, Wolf Bay Branch, Perdido Bay, 30 18.23, 87 35.459		3 manatees traveling east
AL	2	-88.09205	30.56613	9/13/2005	Dog River, Mobile, 30 33.968, 88 05.523		2, one larger other smaller
AL	1	-87.54451	30.30415	6/4/2006	Estimated location; Intracoastal Waterway, Arnica Bay, 2 miles west of Bear Point Mari		Alone, AD
AL	1	-88.01031	30.68495	6/12/2006	along US 90 across from Battleship Park near Tensaw River mouth		Alone, AD

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
AL	2	-88.09398	30.63272	6/27/2006	Estimated location; Dog River??, heading toward no-wake zone approx. 500 yds down river		
AL	1	-88.12217	30.58983	8/10/2006	Mouth of Halls Mill Creek at Dog River		Alone, juvenile
AL	5	-88.13378	30.57340	8/20/2006	Rabbit Creek, Rattleske Bayou near bridge @ Rangeline Rd.		5 adults
AL	5	-88.13173	30.58278	8/22/2006	Estimated location; Rattleske Bayou close to junction with Rabbit Creek		5 adults
AL	2	-88.12999	30.57721	9/2/2006	Rabbit Creek, Schwartz Landing boat ramp		2 adults hanging around Schwartz Landing
AL	2	-88.13182	30.57506	9/3/2006	Estimated location; Rabbit Cr., b/tw Schwartz Landing on Rabbit Cr. Dr. and Rangeline Dr.		2 adults, observed for 45 minutes
AL	4	-88.13890	30.56770	9/3/2006	Rabbit Creek, 30.5677, 88.1389		4-5 Tms including calf
AL	3	-88.13560	30.57180	9/11/2006	Rabbit Creek, 30.5718, 88.1356		3 Tms, Cow with calf pair & sub Adult, feeding
AL	1	-88.11355	30.60604	9/11/2006	Dog River	CR123 Ellie	
AL	3	-88.13525	30.57223	9/22/2006	Rabbit Creek approx. 200 yds upstream of Rangeline Rd. bridge		3 Tms feeding at inlet at bend in creek
AL	6	-87.53319	30.31540	10/24/2006	Estimated location; Arnica Bay, off Perdido Bay, connected to Intracoastal Waterway, 30 10.30, 87 32.00		6 Tms
AL	12	-87.92520	30.86710	5/24/2007	McReynolds Lake, Mobile, AL, 30.8671, 87.9252	61907.29	
AL	6	-88.14883	30.60467	7/1/2007	Halls Mill Creek, 30 36.28, 88 8.93	70107.38	6 Tms, photos, some w/ scars
AL	10	-88.13483	30.60645	7/12/2007	Halls Mill Creek, RR trestle	71307.48	10 Tms, approx. 4 AD & 6 calves

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
AL	3	-88.11811	30.43805	7/13/2007	West Fowl River, 1/2 mile from bridge	71607.49	2 AD, 1 calf
AL	1	-87.53308	30.32059	7/14/2007	Arnica Bay, Pirates Cove Mari	71407.55	Alone, AD
AL	1	-87.91465	30.52452	7/20/2007	south side of Fairhope Municipal Pier	72307.5	Alone
AL	1	-87.58147	30.30027	7/30/2007	Intracoastal Waterway, Wolf Bay, 30 18 016, 87 34 888	73007.53	1 Ad, heading N to Wolf Bay from Intracoastal Waterway
AL	2	-88.13666	30.58470	8/2/2007	Rattleske Bayou, Theodore, AL map attached	80207.56	2 adults also spotted on 8/3/07 (080307.62)
AL	3	-88.13201	30.57958	8/4/2007	Rabbit Creek, 30 34.75, 88 08.00	80407.68	3 Tms floating slowly by
AL	5	-88.13673	30.58248	8/4/2007	Rattleske Bayou, 5226 Todd Acres Dr.	80407.58	4-6 Ads
AL	1	-88.01938	30.67158	8/4/2007	Mobile River, 30 40.00, 88 02.00	80407.57	Alone
AL	4	-88.13781	30.58197	8/5/2007	Rattleske Bayou, Theodore, AL, 30 34.55, 88 08.13	80507.61	2 adults and 2 calves
AL	2	-87.96667	30.78333	8/5/2007	Chuckfee Bay/Raft River, 30 47, 87 58	80507.59	Cow with calf
AL	3	-88.13045	30.58489	8/17/2007	Rabbit Creek, 30 35.25, 88 08.50	81707.71	3 Ads
AL	1	-87.92593	30.79634	8/17/2007	Gravine Creek, Spanish Ft., 30 47.75, 87.55.50	81707.69	1 Ad, sighter was gator hunting
AL	2	-87.92400	30.80450	8/17/2007	Tenesaw/Mobile River cutoff, 30 48.27, 87 55.44	81707.7	2 Ads
AL	5	-88.08821	30.57670	8/18/2007	Dog River, near Hoppe Launch, 30 34.50, 88 05.00	81807.63	2 ADs, 3 calves, rolling and playing in mud
AL	3	-88.11667	30.59000	8/19/2007	Rabbit Creek, Dog River, 30 35.40, 88 07.00	81907.72	3 Ads
AL	2	-88.09029	30.57369	8/20/2007	mouth of Perch Creek @ Dog River, 30 34.50, 88 05.25	82007.66	2 Ads
AL	2	-88.01667	30.67917	8/20/2007	USS Alabama, Battleship Park, 30 40.75, 88 01.00	82007.64	2 Ads near aircraft pavillion
AL	3	-88.12083	30.59167	8/26/2007	Rabbit Creek, Dog River, 30.35.50, 88 07.25	82607.74	3 Ads

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
AL	1	-87.68310	30.27962	8/28/2007	Intracoastal Waterway, Gulf Shores, 30 17, 87 41	82807.75	1 Ad traveling west
AL	1	-88.04036	30.85481	1/4/2009	Steele Creek, 30.854813, 88.04036	10409.01	Alone, barnacles on back
AL	1	-88.03388	30.85902	1/5/2009	Gunnison Creek, 30.859016, -88.03388	10509.03	Alone; heading north
AL	1	-88.01281	30.83423	1/8/2009	Catfish Bayou, 30.834232, 88.01281	10809.04	Alone, 2 white round shape scars on back *note says to check out MS coal burning power plant warm water discharge*
AL	1	-88.01281	30.83423	1/21/2009			
AL	1	-88.26384	30.39708	4/22/2009	Bayou LaBatre, 30.397078, 88.26384	42209.07	Alone, AD, traveled into inlet to end then back out and traveled north
AL	1	-87.69399	30.27940	4/25/2009	Intracoastal Waterway, Gulf Shores, 30.279402, 87.69399	42509.08	Alone, AD, in basin then entered Intracoastal Waterway and traveled east
AL	1	-88.11334	30.44316	4/26/2009	Fowl River, Mobile, 30.443157, 88.113335	42609.09	Alone, AD, traveling east
AL	1	-88.13429	30.59680	5/2/2009	Halls Mill Creek, Mobile, 30.596798, 88.134285	50209.1	Alone, AD
AL	1	-88.13415	30.59800	5/3/2009	Halls Mill Creek, Mobile, 30.598001, 88.13415	50309.11	Alone, AD, in calf then moved SE toward main Dog River
AL	1	-87.93732	30.48179	5/16/2009	Point Clear, Mobile, 30.481785, 87.93732	51609.12	Alone, AD
AL	1	-87.57195	30.27612	5/24/2009	Cotton Bayou, W of Zeke's Mari, 30.27612, 87.571945	52409.13	Traveling east fairly fast
AL	1	-88.00637	30.68271	5/29/2009	mouth of Tensaw River, 30.68271, 88.00637	52909.14	Alone, AD, by seawall, went under bridge heading to Tensaw River
AL	2	-88.00637	30.68271	6/1/2009	Mobile Bay Cswy @ Oysterellas, 30.68271, 88.00637	60109.16	2 tms, one smaller than other

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
AL	1	-88.00637	30.68271	6/1/2009	mouth of Tensaw River, 30.68271, 88.00637	60109.15	On bar on N side of old causeway over Mobile River Delta
AL	1	-87.79746	30.22957	6/4/2009	Gulf of Mexico, Gulf Shores, 30.229572, 87.79746	60409.17	Surfaced just off beach
AL	1	-87.57300	30.30100	6/6/2009	in Bay LaLaunch by Sapling Pt. heading west, 30.301, 87.573	60609.18	Surfaced twice to breath, heading west
AL	1	-87.95764	30.67514	6/7/2009	Chacalochee Bay, 30.675142, 87.95764	60709.19	Alone, swimming east
AL	2	-87.95919	30.67537	6/8/2009	Pass Picada, 30.675373, 87.95919	60809.21	2 ADs, traveling west to east through pass
AL	2	-87.96721	30.67944	6/8/2009	Chacalochee Bay, 30.679438, 87.96721	60809.2	2 ADs, scarred, rolling around waving tails
AL	1	-87.91505	30.59986	6/9/2009	Mobile Bay, Daphne, 30.599857, 87.915054	60909.3	Mayday Park pier
AL	1	-88.01409	30.68153	6/12/2009	Mobile Bay off deck of USS Alabama, 30.68153, 88.01409	61209.22	Saw off deck of USS Alabama
AL	1	-88.09557	30.63078	6/13/2009	Dog River, 30.630775, 88.09557	61309.23	Saw head surface several times
AL	1	-87.99726	30.67821	6/15/2009	Mobile Bay by causeway, 30.678213, 87.99726	61509.24	
AL	1	-87.96545	30.67333	6/18/2009	Mobile Bay, Ed's Seafood, Cswy, 30.673332, 87.96545	61809.25	No scars or barnacles
AL	2	-87.91912	30.63663	6/20/2009	D'Olive Bay, Daphne, 30.636627, 87.91912	62009.26	Possible cow with calf
AL	1	-87.92690	30.65364	6/20/2009	Blakely River, Daphne, 30.65364, 87.9269	62009.35	Alone, AD, headed south, then came back
AL	1	-88.10273	30.45576	6/21/2009	outside mouth of old Fowl River, 30.455763, 88.10273	62109.27	In shallow water in Mobile Bay just outside mouth of old Fowl R. headed north
AL	1	-87.95809	30.67507	6/21/2009	Pass Picada off deck of Bluegill Restaurant, 30.675074, 87.95809	62109.31	

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
AL	1	-87.98682	30.67616	6/21/2009	Mobile Bay off cswy, 30.676163, 87.986824	62109.29	Alone, AD, slow travel north
AL	1	-87.50871	30.29816	6/26/2009	Bayou St. John, Bear Pt., Orange Bch., 30.298159, 87.50871	62609.32	Alone, AD, surface to breathe
AL	1	-87.50871	30.29816	6/26/2009	Ono Island cal, Orange Bch., 30.299889, 87.48055	62909.33	Alone, traveling from cal into Intracoastal Waterway
AL	5	-87.96942	30.67757	6/27/2009	Pass Picada, Choccalotta Bay, 30.677565, 87.96942	62709.36	5 tms, socializing, cavorting, poss. Mating
AL	1	-87.48055	30.29989	6/29/2009			
AL	1	-88.00370	30.68168	6/29/2009	mouth of Tensaw River, 30.681679, 88.0037	62909.37	Alone, AD, traveling west
AL	1	-87.75061	30.28206	6/30/2009	Intracoastal Waterway, Gulf Shores, 30.282063, 87.75061	63009.34	Alone, AD
AL	1	-88.09256	30.56710	7/5/2009	Dog River, 30.567102, 88.09256	70509.38	
AL	1	-88.02504	30.69222	7/9/2009	Polecat Bay; cswy near I-10 off ramp, 30.69222, 88.02504	70909.39	Alone, AD
AL	1	-87.55619	30.27449	7/11/2009	Perdido Pass, Orange Bch, 30.274487, 87.55619	71109.4	
AL	1	-88.05468	30.60719	7/12/2009	Mobile Bay,pier off runway @ Brookley Field, 30.60719, 88.05468	71209.41	Alone, AD
AL	2	-87.92181	30.62556	7/18/2009	Mobile Bay, Daphne, 30.625557, 87.92181	71809.45	2 ADs, socializing
AL	3	-87.94389	30.69570	7/18/2009	Apalachee River, 30.6957, 87.943886	71809.42	2 ADs & 1 calf, body scars
AL	1	-87.66821	30.24854	7/22/2009	Gulf of Mexico, Gulf Shores State Park Pier, 30.248535, 87.668205	72209.43	Alone, AD, 30 yds from shore, E side of SP pier, swam under pier
AL	1	-88.08777	30.56507	7/23/2009	Dog River bridge, 30.565073, 88.08777	72309.46	Alone, AD, headed into Mobile Bay under Dog River bridge
AL	2	-88.14042	30.60414	7/25/2009	Halls Mill Creek, Mobile, 30.604143, 88.14042	72509.47	2 ADs

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
AL	1	-87.95764	30.67463	7/25/2009	Pass Picada ditch, 30.67463, 87.95764	72509.48	Alone, AD, in ditch off Pass on side of Bluegill Restaurant
AL	1	-88.13142	30.60263	7/26/2009	Halls Mill Creek, 30.602627, 88.13142	72609.49	Alone, AD
AL	1	-88.14213	30.60458	7/27/2009	Halls Mill Creek, 30.604576, 88.14213	72709.51	Alone, AD, large (1 ft.) scar on back
AL	1	-88.13695	30.60584	7/27/2009	Halls Mill Creek, 30.605837, 88.13695	72709.5	Alone, AD
AL	3	-88.08907	30.56520	7/28/2009	Dog River, 30.5652, 88.08907	72809.65	3 ADs, scars
AL	1	-88.13532	30.57235	7/28/2009	Rabbit Creek, 30.572348, 88.13532	72809.52	Alone, AD
AL	1	-87.51782	30.30026	7/29/2009	Bayou St. John, Orange Bch., 30.30026, 87.517815	72909.53	Alone, AD
AL	1	-88.13637	30.59817	8/5/2009	Halls Mill Creek, cal @ Point Rd., 30.598166, 88.13637	80509.54	Alone, young adult, traveling
AL	1	-87.66819	30.24844	8/7/2009	Gulf of Mexico, Gulf Shores State Park Pier, 30.248438, 87.66819	80709.57	Alone, AD, just off beach traveling west in 6' of water
AL	1	-88.13304	30.59785	8/7/2009	Halls Mill Creek, cal @ Point Rd., 30.59785, 88.13304	80709.56	Alone, large AD, slow travel, possible feeding
AL	1	-88.10162	30.57159	8/9/2009	Dog River, 30.571587, 88.101616	80909.63	Alone, AD, swam through pilings on dock
AL	1	-88.13319	30.60374	8/11/2009	Halls Mill Creek, 30.603737, 88.13319	80709.55	Alone, AD, calmly traveling south
AL	1	-88.13300	30.59800	8/12/2009	Dog River, Halls Mill Creek, cal along Point Rd., 30.598, 88.133	81209.58	Alone, AD, traveling west in cal
AL	1	-88.00813	30.68624	8/13/2009	Delvan Bay, Mobile Bay, 30.68624, 88.008125	81309.66	Alone, AD
AL	2	-88.00356	30.68856	8/13/2009	Tensaw River N of I-10, 30.688557, 88.00356	81309.59	2 ADs, in area for a while
AL	1	-88.01899	30.69087	8/13/2009	Polecat Bay, 30.690868, 88.018988	81309.64	Alone, AD

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
AL	1	-88.08820	30.56482	8/16/2009	Dog River near mouth, 30.56482, 88.0882	81609.61	Swimming out of mouth of Dog River, heading south
AL	1	-88.13987	30.60460	8/16/2009	Halls Mill Creek, Hippie Beach, 30.6046, 88.13987	81609.6	Alone, AD, traveling from Hippie Bch. Upstream toward I-10
AL	1	-88.02485	30.66464	8/18/2009	Mobile Bay, 30.66464, 88.02485	81809.67	Alone, AD
AL	1	-87.53483	30.28155	8/22/2009	Old River, Orange Bch., 30.28155, 87.53483	82209.69	Alone, AD, body scars, hanging over grass beds in 2' of water
AL	1	-88.09341	30.56851	8/22/2009	Dog River, 30.56851, 88.09341	82209.68	
AL	1	-88.11366	30.44305	9/15/2009	Fowl River bridge, 30.443054, 88.11366	81509.62	Alone, AD, Tm stayed in area for a while
AL	1	-88.12868	30.58435	8/4/2011	Estimated location; Rattlesnake Bayou	CR054	
AL	1	-88.12868	30.58435	8/4/2011	Estimated location; Rattlesnake Bayou	CR643	
AL	1	-88.25636	30.40159	10/20/2011	Estimated location; Bayou LaBatre	CR054	
AL	1	-87.68460	30.27957	12/21/2012	Home Port Mari, Gulf Shores		
AL	1	-87.66705	30.24745	3/28/2015	30.247449, 87.667048	CR054	Several sighting reports of her traveling from FL-AL state line to Gulf Shores, AL
AL	5	-88.13245	30.57482	7/10/2016			
AL	1	-87.80357	30.46590	12/16/2017			
FL	1	-87.17613	30.37447	8/7/2007	Pensacola Bay, Gulf Breeze end of bridge off pier	FL80707.60	Traveled past bridge heading south along shoreline moving further into Bay
FL	1	-86.73572	30.40837	9/19/2012	Mariners Cove, Florosa, Santa Rosa Sound	CR054	
FL	1	-87.22686	30.40335	12/14/2013	Behind Joe Patti's Seafood, 524 South B Street, Pensacola		Alone; reported by sheriff's office to FWC; pictures
FL	1	-86.32778	30.38965	12/16/2013	Estimated location;		

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
FL	1	-85.70978	30.09978	5/23/2015	Estimated location;		
FL	1	-86.50412	30.38962	9/23/2016	Estimated location; Destin Harbor		Alone
FL	1	-85.72089	30.13193	10/7/2016	Estimated location; intersection of Grand Lagoon and Panama City pass on the north side		In grass, surfaced a couple of times
FL	1	-85.62043	30.28519	1/26/2017	Gainer Bayou, off North Bay, Panama City		Report indicates Tm has been there since 1/14/17
FL	1	-85.64928	30.14233	3/9/2017	St. Andrew Bay Yacht Club; near boat ramp		Alone
FL	1	-85.76319	30.14565	3/16/2017	Regency Towers, 5801 Thomas Dr., PC Beach		Alone
FL	1	-85.63044	30.14097	3/17/2017	Estimated location; Eastern Shipbuilding, Panama City		Alone
FL	2	-87.43870	30.30982	5/22/2017	Holiday Harbor Mari, Pensacola		2 Tms
FL	1	-85.90356	30.22709	7/10/2017	Landmark Holiday Beach Resort, Panama City Bch		Swimming between her and the pier to the east
FL	4	-84.89352	29.72099	9/21/2017	Cat Point, Eastpoint moving into East Bay	TPH-13 Hitch	With 3 others heading into East Bay
FL	2	-86.60069	30.46182	11/30/2017	Chula Vista Bayou, SW of Eglin AFB		Cow with calf pair, been around for 3 days
FL	1	-85.70387	30.17740	3/19/2018	Lake Huntington, Panama City, St. Andrew Bay		Alone, feeding
FL	3	-86.44863	30.40136	3/29/2018	Estimated location;		
FL	3	-85.42519	29.95373	4/2/2018	Estimated location; Mexico Beach boat ramp		3 Tms and one is wrapped in rope
FL	1	-85.60494	30.10555	5/7/2018	Long Point Condo's east side Tyndall Pkwy		Alone, floating up the Bay
FL	1	-85.60422	30.10520	9/5/2018	Estimated location; East Bay, Tyndall AFB bridge, Panama City		Alone, heading into East Bay

State	Number of manatees	Longitude	Latitude	Date	Location	Sighting ID	Comment
FL	4	-86.43720	30.50594	9/26/2018	Estimated location; Rocky Bayou, Niceville, Okaloosa Co.		4 Tms-2 may be smaller; using a crab trap as a scratcher

Note: tm is *Trichechus manatus*.

Appendix C: Manatee carcass records

Table C-1. Manatee carcasses reported from locations in the western Gulf of Mexico during the study period, or found in records and not otherwise published.

State	Longitude	Latitude	Date	Sighting ID	Comment
TX	-95.91729	28.66448	1/29/2013	NA	TMMSN
LA	-91.75900	29.84120	12/15/1999	LA9901 aka-TB136 "4W"	Carcass recovered FWC; 295 cm male; Natural-cold stress
LA	-90.00669	30.04181	3/18/2012	NA	Tissue & skull collected
LA	-90.59755	29.43059	12/4/2012	BGG-20121204-LA002 aka TB288 "Wigwam"	Carcass recovered LDWF; 330 cm male; badly decomposed; undetermined
LA	-89.83039	30.20992	6/21/2013	NA	Carcass never recovered
LA	-89.95347	29.22979	11/12/2013	DAO20131112-LA004	Carcass discovered while pulling in a shrimp trawl in 10-12 feet of water; collected by LDWF
LA	-90.44480	29.42415	1/26/2017	KEL20170126	Recovered; LADWF; Natural-cold stress
LA	-93.34542	29.80208	12/17/2018	CDB-20181218-LA001	Undetermined; LADWF; too decomposed
MS	-88.54803	30.42154	12/28/2010	MMSN122810.03 aka CR613	Carcass recovered DISL; 285 cm male; Natural-cold stress
MS	-88.57891	30.38260	7/9/2013	MSN070913.03 aka CR709	Carcass recovered DISL; 321 cm female; Watercraft impact, acute
MS	-88.55951	30.43090	12/11/2015	MSN121115.03 aka TB561	Carcass recovered DISL; 307 cm male; Natural-red tide
AL	-88.03827	30.51928	6/6/2005	NA	Bones of manatee observed
AL	-88.19210	30.24793	2/2/2009	MMSN020309.01	NA
AL	-87.55389	30.29865	1/25/2010	MMSN012510 aka CH279	Carcass recovered DISL; 303 cm male; Natural-cold stress/shock
AL	-87.55016	30.27892	5/13/2012	MSN51312.08	NA

State	Longitude	Latitude	Date	Sighting ID	Comment
AL	-88.10087	30.62529	6/19/2013	NA	Calf carcass - DISL
AL	-87.95406	30.79985	1/19/2014	MSN011914.03 aka TB432	Carcass recovered DISL; 333 cm male; Natural-cold stress
AL	-88.09768	30.47526	8/21/2015	MSN082115.02 aka CR267 "Zewie"	Carcass recovered DISL; 337 cm male; Watercraft impact acute
AL	-88.04550	30.55650	7/16/2016	MSN071616.01 aka CR123 "Ellie"	Carcass recovered DISL; 347 cm female; Undetermined
AL	-88.03771	30.67681	11/14/2018	MSN111418.03 aka CR813 "Hoth"	Carcass recovered DISL; male; Watercraft-blunt trauma
AL	-88.16670	30.25275	12/18/2018	MSN121818.04	Carcass recovered DISL; male; N shore Dauphin Isl.; Natural-cold stress
FL	-85.48273	29.95813	11/25/2012	MNW1262 aka CR140	Carcass recovered FWC; 318 cm male; Natural-cold stress
FL	-85.70360	30.20027	3/25/2013	MNW1319 aka-MI180	Carcass recovered; 305cm, 480kg.
FL	-85.64986	30.12028	3/26/2013	NA	Carcass recovered
FL	-85.09644	29.71773	12/15/2013	MNW1363	10' male beached; photos
FL	-84.51186	29.91606	12/20/2013	MNW1364	Carcass recovered, 280cm male; badly decomposed
FL	-86.22054	30.41310	12/30/2013	MNW1366	Carcass recovered DISL
FL	-87.12522	30.36357	1/7/2014	MNW14002 aka TB186 "Trigger"	Carcass recovered DISL; 293 cm male
FL	-85.66502	30.12886	2/20/2017	NA	Photos; mod decomposed
FL	-83.97986	30.11670	1/18/2018	NA	NA
FL	-82.60140	28.87866	1/26/2018	MNW18017 aka CR848 "Steely"	Carcass recovered FWC; 303 cm male; Natural
FL	-84.21141	30.15159	10/13/2018	MNW18126	1st reported 03Oct18 as crab trap entanglement but found dead after Hurricane Michael
FL	-85.11523	29.78973	11/8/2006	MNW0644 aka CR224 "Bechtol"	Carcass recovered FWC; 316 cm male; Natural-cold stress suspect

Appendix D: Manatee Individual Photo-identification System (MIPS) records

Table D-1. Photo-identified manatees documented in locations west of Florida

Nineteen of the 59 previously identified manatees that had been recorded north of Crystal River NWR were located and tagged during this study.

Manatee ID	Sex	Documented by	Known mortality
CR054	F	USGS, Edward Ball Wakulla Springs State Park, DISL, FWC	No
First documented		Last documented	
1/10/1978	Crystal River; USGS	7/2/2017	Rattlesnake Bayou
Comments			
Westernmost sighting: MS. Jan78-Jan00 Crystal River & Homosassa River-USGS 64 sightings (37 Crystal River & 27 Homosassa River) 9 calves; Jul00 Bayou LaBatre, AL-Public; Dec00-Dec02 Crystal River & Homosassa River-USGS 8 sightings (7CR & 1 Homosassa River) Dec02 with 10th calf; Dec03-Dec06 Crystal River & Homosassa River-USGS 8 sightings (1 Crystal River & 7 Homosassa River); Aug2008 Wakulla River-USGS, with 11th calf; May-Aug09 Edward Ball Wakulla Springs State Park-USGS, Wilbur, Calleson (3 sightings); Jan10 Crystal River-USGS (3 sightings) with 11th calf; Nov10 Edward Ball Wakulla Springs State Park-Wilbur; May11 Wakulla River-USGS 2 sightings; Jun11 Mary Walker Bayou, Pascagoula, MS; Aug11 Mobile Bay, AL- DISL; Oct11 Bayou LaBatre-Public; Nov-Dec11 Edward Ball Wakulla Springs State Park-Wilbur & USGS (4 sightings); Sep12 Santa Rosa Sound, Navarre, FL-Public; Mar13 Crystal River-USGS; Sep-Nov13 Edward Ball Wakulla Springs State Park-Wilbur & USGS (6 sightings); Jan14 Crystal River-USGS free-tagged; Feb14 Homosassa River-USGS; Jun-Jul14 Mobile Bay, AL-USGS & Public; Aug14 St. George Sound, FL-USGS; Sep14 Edward Ball Wakulla Springs State Park-USGS; Mar16 Bartow power plant, Tampa Bay-FWC belt only; Aug-Sep16 Mobile Bay, AL-USGS, DISL, Public (4 sightings); Dec16 Edward Ball Wakulla Springs State Park-USGS retagged; Jan17 Bartow power plant, Tampa Bay-FWC; Jul17 Mobile Bay, AL-DISL; Sep17 Dog Island, St. George Sound, FL-USGS all gear recovered			
Manatee ID	Sex	Documented by	Known mortality
CR140	M	USGS	Yes
First documented		Last documented	
12/19/1978	Crystal River; USGS	11/27/2012	Mexico Bch, Panama City, Tyndall AFB
Comments			
Westernmost sighting: AL. Dec78-Dec08 Crystal River-USGS 49 sightings; Jun09 Tensaw R. delta, Mobile Bay-Public; Nov12 Mexico Beach recovered dead - FWC			
Manatee ID	Sex	Documented by	Known mortality
CR123	F	USGS, DISL	Yes
First documented		Last documented	
12/18/1979	Crystal River; USGS	7/16/2016	Dog River, Mobile Bay, AL
Comments			
Westernmost sighting: AL. Dec79-Feb06 Crystal River & Homosassa River-USGS 74 sightings (70 Crystal River & 4 Homosassa River); 9/11/06 Dog River, AL-public; Jan07 Crystal River-USGS; Aug-Sep07 Dog River-public; Dec07-Mar08 Crystal River-USGS; Aug08 Mobile Bay-public; Oct08-Feb09 Crystal River-USGS; Sep09 Chacaloochee Bay, Mobile, AL caught during DISL captures and belt removed; Dec09-Feb11 Crystal River-USGS; Aug11 2 sightings Rattlesnake Bayou-DISL; Jul-Sep13 6 sightings Dog River, Mobile Bay-DISL; Jan16 Crystal River-USGS; Jul16 Dog River, AL recovered dead -DISL; 10 calves-USGS			
Manatee ID	Sex	Documented by	Known mortality
CR159*	M	USGS	No
First documented		Last documented	

1/2/1980	Crystal River; USGS	3/23/2018	Crystal River
Comments			
Westernmost sighting: AL. Jan80-Apr08 Crystal River & Homosassa River-USGS 66 sightings (64 Crystal River & 2 Homosassa River); Aug09 Pensacola Beach, FL-Public; Dec09-Mar17 -USGS 15 sightings-USGS; Mar18 Crystal River USGS removed all gear			
Manatee ID	Sex	Documented by	Known mortality
CR161*	M	USGS	No
First documented		Last documented	
1/10/1981	Crystal River; USGS	6/1/2016	Perdido Bay, AL
Comments			
Westernmost sighting: AL. Jan81-Dec13 Crystal River-USGS 58 sightings (55 at Crystal River, 1 Crystal River Energy Complex, 1 Homosassa River, 1 Withlacoochee); Jun16 Perdido-USGS			
Manatee ID	Sex	Documented by	Known mortality
CR224	M	USGS	Yes
First documented		Last documented	
11/6/1982	Crystal River; USGS	11/9/2006	Lake Wimico
Comments			
Westernmost sighting: AL. Nov82-Jan03 Crystal River & Homosassa River-USGS 45 sightings; Sep03 & Oct04 McReynolds Lake, Tensaw Basin, Mobile, AL-Public; Jan05 Crystal River-USGS; Nov06 Lake Wimico recovered dead - FWC			
Manatee ID	Sex	Documented by	Known mortality
CR284	M	USGS, FWC	No
First documented		Last documented	
1/12/1984	Crystal River; USGS	12/17/2010	Bartow power plant
Comments			
Westernmost sighting: AL. Jan84-Dec04 Crystal River & Homosassa River USGS 32 winter sightings (6 Crystal River & 26 Homosassa River); Feb05 Anclote River-FWC; Dec05 Bartow power plant-FWC; Feb06 Homosassa River-USGS; Aug06 Dog River, Mobile Bay, AL-Public; Mar07 Crystal River-USGS; Feb08 Homosassa River-USGS; Dec08 Bartow power plant-FWC; Feb09 Crystal River-Stacy Dunn; Sep10 St. Marks River-Public; Dec10 Bartow power plant-FWC			
Manatee ID	Sex	Documented by	Known mortality
CR289*	M	USGS, Edward Ball Wakulla Springs State Park	No
First documented		Last documented	
1/13/1984	Crystal River; USGS	2/14/2018	Crystal River
Comments			
Westernmost sighting: MS. Jan84-Jan08 Crystal River-USGS 22 sightings; Jul08 Edward Ball Wakulla Springs State Park-Wilbur; Dec08-Feb11 Crystal River-USGS 9 sightings (tagged 3/23/10); Jul11 Mobile Bay belt assembly recovered-Public; Nov11-Feb16 Crystal River-USGS 17 sightings(tagged 1/25/12); Jun16 Choctawhatchee Bay captured and released with gear; Jan17 Crystal River-USGS; Feb18 Crystal River-USGS removed all gear			
Manatee ID	Sex	Documented by	Known mortality
CR267	M	USGS, DISL	Yes
First documented		Last documented	
11/13/1987	Crystal River; USGS	8/21/2015	Mobile Bay, AL
Comments			
Westernmost sighting: AL. Nov87-Jan08 Crystal River-USGS 28 sightings; Jun09 Tensaw River delta, Mobile Bay, AL-Public; Dec09-Jan10 Crystal River-USGS 5 sightings; Jun10 Wakulla & St. Marks R. USGS; Aug10 Dog R., AL captured & tagged by DISL; Dec10-Feb11 Crystal River-USGS 4 sightings; Nov11 Crystal River-USGS no gear attached; Jan12-Jan15 Crystal River-USGS 15 sightings-free tagged 1/17/14; 8/19/15 LL; 8/21/15 AL recovered dead - DISL, no gear attached			

Manatee ID	Sex	Documented by	Known mortality
CR268	M	USGS	No
First documented		Last documented	
12/17/1987	Crystal River; USGS	2/28/2006	Crystal River
Comments			
Westernmost sighting: AL. Dec87-Feb03 Crystal River & Homosassa River-USGS 33 sightings (31 Crystal River & 2 Homosassa River); Sep03 McReynolds Lake, Tensaw Basin, Mobile, AL-Public; Mar05, Dec05 & Feb06 Crystal River-USGS			
Manatee ID	Sex	Documented by	Known mortality
CR293*	M	USGS	No
First documented		Last documented	
3/16/1988	Crystal River; USGS	2/14/2018	Crystal River
Comments			
Westernmost sighting: AL. Mar88-Feb15 Crystal River & Homosassa River-USGS 46 sightings (44 Crystal River & 2 Homosassa River); May15 cap & tagged-USGS Lake Wimico; Aug15 Ochlockonee Bay-USGS; Jan16 Crystal River-USGS; Feb16 Homosassa River-USGS; Jun16 Perdido Bay, AL-USGS; Sep16 Carrabelle-USGS; May17 south of Panama City Bch-USGS; Feb18 Crystal River-USGS removed all gear			
Manatee ID	Sex	Documented by	Known mortality
CR286*	M	USGS, DISL	No
First documented		Last documented	
11/29/1988	Crystal River; USGS	6/9/2017	Rattlesnake Bayou
Comments			
Westernmost sighting: AL. Nov88-Mar14 Crystal River & Homosassa River-USGS 46 sightings (36 Crystal River & 10 Homosassa River); Jun14 Fowl River, Mobile Bay, AL-USGS; Mar15 Homosassa River-USGS; Sep16 W Fowl River, Mobile Bay, AL-DISL; May-Jun17 Moore Creek, Dog R., Rattlesnake Bayou, Mobile Bay, AL-DISL 3 sightings			
Manatee ID	Sex	Documented by	Known mortality
CR351	M	USGS, DISL	No
First documented		Last documented	
1/11/1991	Crystal River; USGS	5/11/2017	Panama City Beach
Comments			
Westernmost sighting: AL. Jan91-Nov07 Crystal River & Homosassa River-USGS 29 sightings (28 Crystal River & 1 Homosassa River); Sep14 Dog River, AL tagged-DISL; May17 Panama City Beach-USGS no gear attached			
Manatee ID	Sex	Documented by	Known mortality
CR344*	M	USGS	No
First documented		Last documented	
10/17/1991	Crystal River; USGS	5/11/2017	Panama City Beach
Comments			
Westernmost sighting: AL. Oct91-Feb10 Crystal River-USGS 25 sightings; Jun10 Wakulla River-USGS; Dec13-Crystal River-USGS; Jun16 Perdido Bay, AL-USGS; May17 Panama City Beach-USGS			
Manatee ID	Sex	Documented by	Known mortality
TB136	M	FWC	Yes
First documented		Last documented	
10/6/1992	Old Tampa Bay/FWC	12/15/1999	LA
Comments			
Westernmost sighting: LA. Oct92-Mar97 TECO Electric power plant & Old Tampa Bay-FWC 9 sightings; Dec99 recovered dead - FWC			

Manatee ID	Sex	Documented by	Known mortality
TB023	0	FWC	No
First documented		Last documented	
12/30/1993	TECO Electric power plant/FWC	7/1/2017	Dog River, Mobile Bay, AL
Comments			
Westernmost sighting: AL. Dec93-Mar13 TECO Electric power plant-FWC 11 sightings (some gaps in years); Jul17 Dog River, Mobile Bay, AL-Public			
Manatee ID	Sex	Documented by	Known mortality
CR581	M	USGS, DISL	No
First documented		Last documented	
12/13/1994	Crystal River; USGS	1/20/2016	Crystal River
Comments			
Westernmost sighting: AL. Dec94-Jan10 Crystal River-USGS 17 sightings; Aug10 Dog River, AL-DISL captured & tagged; Dec10 Crystal River-USGS 2 sightings w/gear; Feb11 Crystal River-USGS sighted with no gear attached; Feb12 Crystal River-USGS; Aug12 Polecat Bay, AL-DISL captured & tagged; Nov14 Crystal River-USGS; Jan16 Crystal River-USGS no gear attached			
Manatee ID	Sex	Documented by	Known mortality
SB070	M	MML, FWC	Yes
First documented		Last documented	
6/6/1995	Sarasota Bay, MML	1/23/2002	Santa Rosa Island
Comments			
Westernmost sighting: FL Panhandle-Pensacola. Jun95 Sarasota Bay-MML 6 sightings; Jan02 Santa Rosa Islandrecovered dead-DEP			
Manatee ID	Sex	Documented by	Known mortality
CR398	F	FWC,USGS	No
First documented		Last documented	
12/6/1995	Harris Co., TX, rescue	2/24/1999	Sebastian River
Comments			
Westernmost sighting: TX. Dec95 rescued; 4/23/96 Released from HSSWP-FWC; Feb97 Biscayne Bay-USGS; Feb99 PEPP-USGS; Mar99 Sebastian River-FWC			
Manatee ID	Sex	Documented by	Known mortality
TB163	M	FWC, MML, USGS	No
First documented		Last documented	
7/10/1996	Tampa Bay/FWC	11/21/2019	Bartow power plant, Tampa
Comments			
Westernmost sighting: AL. Jul96-Jan01 Tampa Bay & Bartow power plant-FWC 5 sightings (4 Tampa Bay & 1 Bartow);Jul01-Aug01 Sarasota Bay-MML; Jan03-Feb04 Anclote River-FWC 7 sightings; Feb-Mar05 TECO Electric power plant-FWC 2 sightings; Dec05-Feb07 Bartow power plant-FWC 3 sightings; Feb07-Mar07 Tampa Bay-FWC 3 sightings; Mar08-Jan13 Bartow power plant-FWC 4 sightings; Jun13 Alabama-Public (FWC); Dec13 Choctawhatchee Bay-Public(FWC); Jan16 and Jan17 Bartow power plant-FWC 2 sightings; May2017 Panama City Beach-USGS; Nov19 Bartow power plant-FWC			
Manatee ID	Sex	Documented by	Known mortality
SB227	M	FWC, MML	No
First documented		Last documented	
7/15/1996	Sarasota Bay, FWC	2/5/2019	Bartow power plant, Tampa
Comments			

Westernmost sighting: AL. Jul96 Palma Sola Bay, Sarasota Bay-FWC; Jan99 Ft. Myers power plant-MML; Mar99 Matlacha Isles-FWC; Jun00 Pansy Bayou, Sarasota Bay-FWC; Nov00-Jan01 TECO Electric power plant-FWC 3 sightings; Mar01 Matlacha Isles-MML; Jan03 TECO Electric power plant-FWC; Mar03 Matlacha Isles-MML; Dec03 Bartow power plant-FWC; Jan04 Florida Power and Light (FPL) Fort Meyers power plant-MML; Feb05 Matlacha Isles-MML; 14Dec05 Bartow power plant-FWC; 28&30Dec05 TECO Electric power plant-FWC; 01Feb06 Matlacha Isles-MML; 15Feb06 FPL Fort Meyers power plant-MML; 14Mar06 Matlacha Isles-MML; Jun07 Terra Ceia Bay, Tampa Bay-FWC; Jan-Mar08 TECO Electric power plant-FWC 7 sightings; May08 Palma Sola Bay, Sarasota Bay-FWC; Jan09 TECO Electric power plant-FWC; Mar09 FPL Fort Meyers power plant-MML; Jan10 TECO Electric power plant-FWC; Mar10 Matlacha Isles-MML; Jun10 Anna Maria Isl., Sarasota Bay-MML; Oct10 Boca Ciega Bay, Tampa Bay-FWC; Mar11 Matlacha Isles-MML; Jun13 Palma Sola Bay, SARASOTA BAY-FWC; Nov13 Boca Ciega Bay, Tampa Bay-FWC; Jan14 TECO Electric power plant-FWC; Nov14 TECO Electric power plant-FWC; Feb15 FPL Fort Meyers power plant-MML; Jan16 Bartow power plant-FWC; Apr16 Anna Maria Isl, Sarasota Bay-MML; May16 Sarasota Bay-FWC&MML 2 sightings; Jul16 Manatee River, Tampa Bay-FWC; Jun17 Dog River, Mobile Bay, AL-Public 3 sightings; Jan18 TECO Electric power plant-FWC 3 sightings; Feb18 FPL Fort Meyers power plant-MML; Nov18&Feb19 Bartow power plant-FWC 2 sightings			
Manatee ID	Sex	Documented by	Known mortality
TB432	M	FWC, USGS, Edward Ball Wakulla Springs State Park	Yes
First documented		Last documented	
12/12/1996	TECO Electric power plant/FWC	1/19/2014	AL
Comments			
Westernmost sighting: AL. Dec96-Mar08 TECO Electric power plant-FWC 35 sightings; May08 Wakulla River-USGS; Jun08 Edward Ball Wakulla Springs State Park-Wilbur; Dec10-Mar13 TECO Electric power plant-FWC 5 sightings; Jan14 AL recovered dead - DISL			
Manatee ID	Sex	Documented by	Known mortality
TB186	M	FWC, DISL, Edward Ball Wakulla Springs State Park	Yes
First documented		Last documented	
2/19/1997	TECO Electric power plant/FWC	1/6/2014	Santa Rosa Sound
Comments			
Westernmost sighting: AL. Feb97-Feb00 TECO Electric power plant-FWC 13 sightings; Mar00-Apr01 Old Tampa Bay-FWC 3 sightings; Aug01 Point Clear, AL-DISL; Dec05-Feb07 TECO Electric power plant-FWC 4 sightings; Dec07 Old Tampa Bay-FWC; Mar08 TECO Electric power plant-FWC 2 sightings; Jul08 Edward Ball Wakulla Springs State Park-Wilbur; Nov08-Mar13 TECO Electric power plant-FWC 3 sightings; Jan14 Santa Rosa Sound recovered dead - DISL			
Manatee ID	Sex	Documented by	Known mortality
CR503*	M	USGS	No
First documented		Last documented	
12/16/1998	Crystal River; USGS	5/9/2017	Lake Wimico
Comments			
Westernmost sighting: AL. Dec98-Feb99 Crystal River & Homosassa River-USGS 3 sightings (2 Crystal River & 1 Homosassa River); May99 Lower Chassahowitzka River-USGS; Nov99-Feb03 Crystal River & Homosassa River-USGS 6 sightings (4 Crystal River & 2 Homosassa River); Feb-Mar04 MSSP-USGS 4 sightings; Dec04-Jan16 Crystal River & Homosassa River-USGS 31 sightings (11 Crystal River & 20 Homosassa River); Jun16 Perdido Bay, AL-USGS; Jul16 Choctawhatchee Bay-USGS; Feb17 Homosassa River-USGS; May17 Lake Wimico-USGS			
Manatee ID	Sex	Documented by	Known mortality
CR571*	M	USGS	No
First documented		Last documented	
1/8/1999	Crystal River; USGS	5/17/2017	Lake Wimico
Comments			

Westernmost sighting: MS. Jan99-Mar14 Crystal River & Homosassa River-USGS 29 sightings (16 Crystal River & 13 Homosassa River); Jun16 Choctawhatchee Bay-USGS captured and tagged; Aug16 Dog River, AL-USGS; May17 Intracoastal Waterway west of Lake Wimico-USGS; Jun17 Lake Wimico-USGS gear recovered			
Manatee ID	Sex	Documented by	Known mortality
CR693*	F	USGS	No
First documented		Last documented	
1/26/2000	Crystal River; USGS	1/26/2016	Crystal River
Comments			
Westernmost sighting: FL Panhandle-Destin. Jan00-Jan10 Crystal River-USGS 8 sightings (few gaps in winters, longest not sighted was for 3 consecutive years); Apr10 Wakulla River-USGS; Jan11 Crystal River-USGS; Aug12 Wakulla River-USGS; Aug15 Choctawhatchee Bay-USGS; Jan16 Crystal River-USGS			
Manatee ID	Sex	Documented by	Known mortality
CR658	M	USGS	No
First documented		Last documented	
1/12/2001	Crystal River; USGS	6/26/2009	Tensaw River delta, AL
Comments			
Westernmost sighting: AL. Jan01 Crystal River-USGS 2 sightings; Jun09 Mobile Bay, AL-Public			
Manatee ID	Sex	Documented by	Known mortality
TB439	M	FWC, DISL	No
First documented		Last documented	
8/28/2001	Old Tampa Bay/FWC	12/15/2014	TECO Electric power plant
Comments			
Westernmost sighting: AL. Aug01-Nov02 Culbreath Key, Old Tampa Bay-FWC 4 sightings; Dec05-Feb06 TECO Electric power plant-FWC 2 sightings; Jun06 Culbreath Key, Old Tampa Bay-FWC; Mar10-Jan12 TECO Electric power plant-FWC 2 sightings; Apr12 Boca Ciega Bay-FWC; Aug12 AL-DISL captured and tagged; Nov12-Dec12 Culbreath Key, Old Tampa Bay & TECO Electric power plant-FWC 3 sightings (1 CK & 2 TECO Electric power plant); Jan13 Bartow power plant-FWC 2 sightings; Feb13-Dec14 TECO Electric power plant-FWC 9 sightings; 12/15/14 TECO Electric power plant-FWC sighting no tag, belt and tether only			
Manatee ID	Sex	Documented by	Known mortality
SB145	M	MML, FWC	Yes
First documented		Last documented	
10/8/2001	Sarasota Bay, MML	3/13/2012	Choctawhatchee Bay
Comments			
Westernmost sighting: FL Panhandle-Destin. Oct01 Sarasota Bay-MML rescued due to red tide; Jun02 released in Sarasota Bay-FWC; Dec03-Jan04 FPL Fort Meyers power plant-MML & FWC 5 sightings; Mar04 Tampa Bay-FWC; Dec04 TECO Electric power plant-FWC; Nov05 Sarasota Bay-MML; Dec05-Jan06 TECO Electric power plant-FWC 3 sightings; Jan-Feb07 FPL Fort Meyers power plant-FWC & MML 2 sightings; Jun07 Manatee River, Tampa Bay-FWC; Dec09-Mar10 FPL Fort Meyers power plant-MML 7 sightings; Mar12 Choctawhatchee Bay recovered dead-FWC			
Manatee ID	Sex	Documented by	Known mortality
TB435	M	FWC, MML, USGS	No
First documented		Last documented	
12/7/2001	Old Tampa Bay/FWC	2/1/2018	TECO Electric power plant
Comments			
Westernmost sighting: TX. Dec01-Jan 14 at TECO Electric power plant/Tampa area-FWC&MML 33 sightings; rescued in Trinity Bay, TX on 11/25/14; released at TECO Electric power plant 3/4/15-USGS; used Tampa/TECO Electric power plant through 3/2/16; Aug16 Sanibel-USGS removed all gear; TECO Electric power plant Jan 17, Jan & Feb 18-FWC			
Manatee ID	Sex	Documented by	Known mortality

CR720	M	USGS, Edward Ball Wakulla Springs State Park, DISL	No
First documented		Last documented	
12/2/2002	Crystal River; USGS	5/27/2017	Rattlesnake Bayou, AL
Comments			
Westernmost sighting: AL. Dec02-Feb08 Crystal River-USGS 8 sightings; Jun08 Edward Ball Wakulla Springs State Park-Wilbur; Feb10 & Nov12 Crystal River-USGS 2 sightings; May17 Rattlesnake Bayou, AL-DISL			
Manatee ID	Sex	Documented by	Known mortality
TB288	M	FWC, MML	Yes
First documented		Last documented	
1/29/2003	TECO Electric power plant/FWC	12/4/2012	LA
Comments			
Westernmost sighting: LA. Jan03-Feb12 TECO Electric power plant, Bartow, Sarasota and surrounding area-FWC&MML 35 sightings; 11/15/04 AA size; 11/1/12 LA-Public; 12/4/12 LA recovered dead- LDWF			
Manatee ID	Sex	Documented by	Known mortality
CR629*	M	USGS	No
First documented		Last documented	
2/7/2003	Homosassa River; USGS	6/19/2015	Mobile Bay, AL
Comments			
Westernmost sighting: AL. Feb03-Feb15 Crystal River & Homosassa River 13 winter sightings (12 Homosassa River & 1 Crystal River) USGS; Jun15 Mobile Bay delta, AL-USGS			
Manatee ID	Sex	Documented by	Known mortality
CH279	M	MML, FWC	Yes
First documented		Last documented	
3/28/2003	Charlotte Harbor/MML	1/27/2010	AL
Comments			
Westernmost sighting: AL. Mar03-Jul04 Charlotte Harbor & Sarasota Bay-MML 7 sightings; Dec04-Jan09 TECO Electric power plant-FWC 19 sightings (15 TECO Electric power plant, 3 Tampa Bay, 1 Warm Mineral Springs); Jan10 AL recovered dead - DISL			
Manatee ID	Sex	Documented by	Known mortality
TB294	M	FWC, USGS, DISL	No
First documented		Last documented	
12/22/2003	TECO Electric power plant/FWC	8/30/2013	Halls Mill Cr, Mobile Bay, AL
Comments			
Westernmost sighting: AL. Dec03-Mar09 TECO Electric power plant-FWC 24 sightings; Jun09 Wakulla River-USGS; Dec09-Jan12 TECO Electric power plant-FWC 7 sightings; Jun12 Claiborne Lock, AL-Public (FWC); Jan13-Mar13 TECO Electric power plant-FWC 3 sightings; Jul13-Aug13 Dog River & Halls Mill Creek-DISL 5 sightings			
Manatee ID	Sex	Documented by	Known mortality
CR767*	M	USGS, FWC	No
First documented		Last documented	
1/10/2004	Crystal River; USGS	1/12/2019	Crystal River
Comments			
Westernmost sighting: FL Panhandle-Destin. Jan04-Dec13 Crystal River-USGS 9 sightings, no sightings b/tw winter 04'-winter 08'; Sep15 Choctawhatchee Bay-USGS captured and tagged; Jan17 Crystal River-USGS 2 sightings 1/31/17 USGS removed all gear; May17 Panama City Beach-USGS; Jan19 Crystal River-FWC			

Manatee ID	Sex	Documented by	Known mortality
CR734	M	FWC, USGS, DISL	No
First documented		Last documented	
1/13/2004	TECO Electric power plant/FWC	12/11/2017	Crystal River
Comments			
Westernmost sighting: AL. Jan04-Mar05 TECO Electric power plant-FWC 16 sightings; Feb06 Crystal River-USGS; Dec07 Crystal River-USGS; Feb12 Crystal River-USGS; Jan14 Crystal River-USGS; Feb16 Crystal River-USGS; May-Jun17 Moore Creek & Halls Mill Creek, Mobile Bay, AL-DISL; Dec17 Crystal River-USGS			
Manatee ID	Sex	Documented by	Known mortality
CR675	M	USGS, DISL	No
First documented		Last documented	
1/23/2004	Homosassa River; USGS	8/6/2016	Rattlesnake Bayou, AL
Comments			
Westernmost sighting: LA. Jan04-Feb10 Crystal River & Homosassa River-USGS 5 sightings (4 Homosassa River & 1 Crystal River); Jul10 Gulf Shores, AL-SMC; Dec10 Homosassa River-USGS 2 sightings; Jan13 Homosassa River-USGS; Oct14 Chalmette, LA-Public; Jan16 Crystal River-USGS; Aug16 Rabbit Creek, Dog River, AL-Public; Aug16 Rattlesnake Bayou, Mobile Bay, AL-DISL			
Manatee ID	Sex	Documented by	Known mortality
CR633	M	USGS, DISL, Edward Ball Wakulla Springs State Park	No
First documented		Last documented	
2/20/2004	Crystal River; USGS	5/17/2017	Intracoastal Waterway W of Lake Wimico
Comments			
Westernmost sighting: AL. Feb04-Nov08 Crystal River & Homosassa River 4 sightings (3CR & 1 Homosassa River; nothing b/tw Dec04 & Jan08)-USGS; Aug10 Spanish River, AL-DISL captured and tagged; 11Aug11 Wakulla River-USGS retagged; 31Aug11 Wakulla River-Public, all gear recovered; Aug12 Polecat Bay, AL-DISL captured and retagged; Dec13 & Jan14 Crystal River-USGS belt only; Feb14 Edward Ball Wakulla Springs State Park-Wilbur belt only; May17 Intracoastal Waterway W of Lake Wimico-USGS no belt attached			
Manatee ID	Sex	Documented by	Known mortality
CR673*	M	USGS	No
First documented		Last documented	
2/27/2004	MSSP/USGS	2/14/2018	Crystal River
Comments			
Westernmost sighting: AL. Feb04 MSSP-USGS; Feb08 Crystal River-USGS captured at health assessments; Mar08 MSSP-USGS; Mar09 MSSP-USGS; Feb12 Crystal River-USGS; Jun12 Wakulla River-USGS size class=MA; Jun16 Chocktawhatchee Bay-USGS captured and tagged, size class=LA; Jan17 Crystal River-USGS; Feb18 Crystal River-USGS removed all gear			
Manatee ID	Sex	Documented by	Known mortality
CR613	M	USGS	Yes
First documented		Last documented	
1/20/2005	Homosassa River; USGS	12/28/2010	Moss Pt., Pascagoula R., MS
Comments			
Westernmost sighting: MS. Jan05-Jan08 Homosassa River & Crystal River-USGS 5 sightings (1Homosassa River & 4 Crystal River); Dec10 MS recovered dead - DISL			
Manatee ID	Sex	Documented by	Known mortality
CR643	M	USGS, DISL	No

First documented		Last documented	
2/23/2006	Crystal River; USGS	2/14/2018	Crystal River
Comments			
Westernmost sighting: LA. Feb06-Mar09 Crystal River-USGS 8 sightings; Aug11 Rattlesnake Bayou Mobile Bay, AL-DISL; Mar13 Crystal River-USGS; Jul13 Moore Creek, Mobile Bay, AL-DISL; Dec13 Crystal River-USGS captured and tagged; Aug14 Rattlesnake Bayou, Mobile Bay, AL gear recovered-DISL; Feb16 Crystal River-USGS free tagged; Mar17 Crystal River-USGS; Mar17 Suwannee River-USGS; Nov17 Crystal River-Dunn belt only; Jan18 Crystal River-USGS retagged; Feb18 Crystal River-USGS removed all gear			
Manatee ID	Sex	Documented by	Known mortality
CR813	M	USGS, FWC	Yes
First documented		Last documented	
1/5/2007	Crystal River; USGS	11/14/2018	Mobile River shipping channel
Comments			
Westernmost sighting: AL. Jan07 Crystal River-USGS captured at Crystal River health assessments; Feb12 Crystal River-USGS 2 sightings; Jan&Mar14 Homosassa River-USGS 2 sightings; Feb17 Southport, North Bay, Bay Co. (Panhandle) rescued; Jun17 released Crystal River-USGS tagged; Aug17 tag recovered-DISL Mobile Bay delta, Spanish River; Dec17 Crystal River-USGS retagged; Jan18 Homosassa River-USGS removed all gear; Nov18 recovered dead Mobile Bay, AL-DISL			
Manatee ID	Sex	Documented by	Known mortality
CR610*	M	USGS, Edward Ball Wakulla Springs State Park	No
First documented		Last documented	
1/26/2007	Crystal River; USGS	2/14/2018	Crystal River
Comments			
Westernmost sighting: MS. Jan07-Mar12 Crystal River-USGS 14 sightings; Aug12 USGS Wakulla R; Jun13 Edward Ball Wakulla Springs State Park-Wilbur; Feb16 Crystal River-USGS; Aug16 Dog River, AL-Public; Sep16 Dog River, AL-USGS; Dec16 Crystal River-USGS net-tagged; May17 East Bay, Apalach & W of Lake Wimico (2 sightings) USGS; Feb18 Crystal River-USGS removed all gear			
Manatee ID	Sex	Documented by	Known mortality
CR783	M	USGS, DISL	No
First documented		Last documented	
2/19/2007	Crystal River; USGS	1/31/2017	Crystal River
Comments			
Westernmost sighting: AL. Feb07-Feb12 Crystal River-USGS 3 sightings (winter 07, 08 & 12); Jul-Aug16 Rattlesnake Bayou & Dog River, AL-DISL 4 sightings; Sep16 Orange Beach, AL-DISL; Jan17 Crystal River-USGS			
Manatee ID	Sex	Documented by	Known mortality
CR735*	M	USGS, DISL	No
First documented		Last documented	
3/7/2007	Crystal River; USGS	7/28/2013	Dog River, AL
Comments			
Westernmost sighting: AL. Mar07-Nov12 Crystal River-USGS 11 sightings; Jul13 Dog River, AL-USGS & DISL			
Manatee ID	Sex	Documented by	Known mortality
CR585	F	Edward Ball Wakulla Springs State Park, USGS	Yes
First documented		Last documented	
1/13/2008	Edward Ball Wakulla Springs State Park/Wilbur	1/15/2011	Johnsons Beach, Pensacola
Comments			

Westernmost sighting: FL Panhandle-Pensacola. Jan08-Nov10 Edward Ball Wakulla Springs State Park-Wilbur & USGS 13 sightings every winter; Jan11 Johnsons Beach, Pensacola recovered dead - DISL			
Manatee ID	Sex	Documented by	Known mortality
CR909*	0	USGS	No
First documented		Last documented	
11/20/2008	Homosassa River; USGS	7/28/2016	Choctawhatchee Bay
Comments			
Westernmost sighting: FL Panhandle-Destin. Nov08-Jan15 Homosassa River-USGS 6 sightings; Jul16 Choctawhatchee Bay-USGS			
Manatee ID	Sex	Documented by	Known mortality
CR709	F	USGS	Yes
First documented		Last documented	
11/25/2008	Crystal River; USGS	7/9/2013	Marsh Lake, Pascagoula R., MS
Comments			
Westernmost sighting: MS. Nov08-Feb09 Crystal River-USGS 4 sightings; Jul13 MS recovered dead - DISL			
Manatee ID	Sex	Documented by	Known mortality
CR772*	M	USGS	No
First documented		Last documented	
11/25/2008	Crystal River; USGS	6/1/2016	Perdido Bay, AL
Comments			
Westernmost sighting: AL. Nov08-Feb16 Crystal River & Homosassa River-USGS 13 sightings (12 Crystal River & 1 Homosassa River); Jun16 Perdido Bay, AL-USGS			
Manatee ID	Sex	Documented by	Known mortality
CR710	F	USGS, DISL	No
First documented		Last documented	
12/23/2008	Homosassa River; USGS	6/2/2017	Dog River, Mobile Bay, AL
Comments			
Westernmost sighting: AL. Dec08-Jan09 Homosassa River-USGS 2 sightings; Sep09 Chacaloochee Bay, AL-DISL captured and tagged; Jan10 Crystal River Energy Complex-USGS; Feb11 Crystal River-USGS; May11 East Bay, Apalachicola-USGS; Jan12 Crystal River-USGS sighted with no tagging gear; Jan-Feb13 Edward Ball Wakulla Springs State Park-USGS; Dec13 Crystal River-USGS; Jul-Aug16 Rabbit Creek & Rattlesnake Bayou, Mobile Bay, AL-DISL; May-Jun17 Rabbit Creek, AL-Public, Moore Creek and Dog River, AL-DISL			
Manatee ID	Sex	Documented by	Known mortality
TB359	0	FWC	No
First documented		Last documented	
1/18/2009	TECO Electric power plant/FWC	2/1/2018	TECO Electric power plant
Comments			
Westernmost sighting: AL. Jan09-Mar10 TECO Electric power plant & Boca Ciega Bay-FWC 9 sightings (7 TECO Electric power plant & 2 BCB); Oct10 Old Tampa Bay-FWC; Nov10 Bartow power plant-TECO Electric power plant; Dec10 TECO Electric power plant-FWC 3 sightings; Feb11-Jan12 Bartow power plant-FWC 2 sightings; Jan13-Feb15 TECO Electric power plant-FWC 7 sightings; Dec15 Bartow power plant; Jun17 Dog River, AL-SMC (FWC); Jul17 Dog River & Halls Mill Creek, AL-Public (FWC); Feb18 TECO Electric power plant-FWC			
Manatee ID	Sex	Documented by	Known mortality
CR848	M	USGS, DISL	Yes
First documented		Last documented	

2/3/2010	Crystal River; USGS	1/26/2018	Crystal River
Comments			
Westernmost sighting: AL. Feb10 Crystal River-USGS 2 sightings; Sep14 Perch Creek, AL-DISL captured and tagged; Jan15 Crystal River-USGS sighted with no gear attached; Aug16 Rattlesnake Bayou, AL-DISL; May 17 S of Panama City beach inlet-USGS; Jan18 Crystal River recovered dead-FWC			
Manatee ID	Sex	Documented by	Known mortality
CR827	F	USGS, DISL	No
First documented		Last documented	
1/3/2012	Crystal River; USGS	2/25/2016	Crystal River
Comments			
Westernmost sighting: AL. Jan12-Jan14 Crystal River-USGS 3 sightings; Jan15 Magnolia Springs, AL-DISL rescued; Mar15 Crystal River-DISL tagged and released; Jan16 Crystal River-USGS sighted with no gear attached; Jan-Feb16 Crystal River-USGS 2 sightings			
Manatee ID	Sex	Documented by	Known mortality
CR802	M	USGS, DISL, Edward Ball Wakulla Springs State Park	No
First documented		Last documented	
2/15/2012	Crystal River; USGS	3/14/2014	Homosassa River
Comments			
Westernmost sighting: AL. Feb12 Crystal River-USGS; Oct13 Gulf Shores, AL-DISL; Nov-Dec13 Edward Ball Wakulla Springs State Park-Wilbur 2 sightings; Mar14 Homosassa River-USGS			
Manatee ID	Sex	Documented by	Known mortality
TB561	M	Edward Ball Wakulla Springs State Park	Yes
First documented		Last documented	
2/26/2012	TECO Electric power plant/Public	12/11/2015	MS
Comments			
Westernmost sighting: MS. Feb12 TECO Electric power plant-Public; Dec13-Feb14 Edward Ball Wakulla Springs State Park-Wilbur; Dec15 MS recovered dead - DISL			
Manatee ID	Sex	Documented by	Known mortality
TB655	M	FWC, DISL, USGS	No
First documented		Last documented	
1/2/2013	TECO Electric power plant/FWC	11/27/2017	TECO Electric power plant
Comments			
Westernmost sighting: AL. Jan13 TECO Electric power plant-FWC; Jul13 Dog River, AL-DISL; Aug16 Dog River, AL-Public (FWC); May17 Panama City Beach-USGS; May-Jun17 Dog River, AL-Public & SMC 3 sightings (2 Public & 1 SMC); Nov17 TECO Electric power plant-FWC			
Manatee ID	Sex	Documented by	Known mortality
CR786*	M	USGS	No
First documented		Last documented	
2/11/2013	Crystal River; USGS	2/15/2018	Crystal River
Comments			
Westernmost sighting: AL. Feb-Mar13 Crystal River-USGS 2 sightings; Jun16 Perdido Bay, AL-USGS; Jun16 Jolly Bay, Choctawhatchee Bay-USGS captured and tagged; May17 Intracoastal Waterway W of Lake Wimico-USGS; Feb18 Crystal River-USGS removed all gear			
Manatee ID	Sex	Documented by	Known mortality

CR899	M	USGS, DISL	No
First documented		Last documented	
3/22/2016	Homosassa River; USGS	9/5/2017	Dog River, AL
Comments			
Westernmost sighting: AL. Mar16 Homosassa River-USGS 1 sighting; Sep17 Dog River, AL-DISL captured and tagged			

Appendix E: Individual manatee tagging bouts

Table E-1. Individual manatee tagging bouts

Bouts are defined as the date when a GPS tag was attached to a manatee, to the date when the tag stopped transmitting, was removed, or broke free from the manatee. Total tracking effort included in this study was 139 bouts from 36 manatees.

Tracking ID	Manatee name	Sex	Bout number	On date	Off date	Number of days
TCR-05	PILO	M	2	11/7/2006	1/4/2007	58
TCR-05	PILO	M	4	6/9/2011	7/2/2011	23
TCR-05	PILO	M	5	8/11/2011	8/29/2011	18
TCR-05	PILO	M	6	8/31/2011	12/30/2011	121
TCR-10	EBB	F	1	5/22/2008	1/13/2009	236
TCR-10	EBB	F	2	1/13/2009	4/4/2009	81
TCR-11	CR505	F	1	5/14/2008	6/1/2008	18
TCR-12	ELLIE	F	1	1/12/2009	6/9/2009	148
TCR-12	ELLIE	F	3	6/10/2009	7/15/2009	35
TCR-13	CR018	M	1	1/12/2009	5/7/2009	115
TCR-13	CR018	M	2	5/7/2009	12/8/2009	215
TCR-13	CR018	M	3	12/8/2009	3/9/2010	91
TCR-13	CR018	M	4	3/9/2010	9/16/2010	191
TCR-13	CR018	M	5	9/16/2010	1/12/2011	118
TCR-13	CR018	M	6	1/12/2011	5/4/2011	112
TCR-13	CR018	M	7	5/4/2011	7/27/2011	84
TCR-13	CR018	M	8	8/11/2011	8/12/2011	1
TCR-13	CR018	M	9	8/31/2011	9/8/2011	8
TCR-13	CR018	M	10	12/8/2011	4/19/2012	133
TCR-19	DASH	M	1	3/23/2010	7/24/2010	123
TCR-19	DASH	M	2	12/7/2010	5/12/2011	156
TCR-19	DASH	M	3	5/12/2011	7/6/2011	55
TCR-19	DASH	M	4	1/25/2012	6/21/2012	148
TCR-19	DASH	M	5	11/28/2012	6/11/2013	195
TCR-19	DASH	M	6	12/2/2013	6/10/2014	190
TCR-19	DASH	M	7	6/10/2014	8/27/2014	78
TCR-19	DASH	M	8	8/27/2014	9/18/2014	22
TCR-19	DASH	M	9	6/21/2016	10/5/2016	106
TCR-19	DASH	M	10	10/13/2016	11/1/2016	19
TCR-19	DASH	M	11	11/1/2016	1/9/2017	69
TCR-19	DASH	M	12	1/9/2017	3/21/2017	71
TCR-19	DASH	M	13	3/21/2017	10/19/2017	212
TCR-19	DASH	M	14	10/19/2017	2/14/2018	118

Tracking ID	Manatee name	Sex	Bout number	On date	Off date	Number of days
TCR-23	BIG BEN	M	1	12/4/2013	6/12/2014	190
TCR-23	BIG BEN	M	2	6/12/2014	8/13/2014	62
TCR-23	BIG BEN	M	3	2/9/2016	4/1/2016	52
TCR-23	BIG BEN	M	4	8/10/2016	8/16/2016	6
TCR-23	BIG BEN	M	5	1/9/2017	4/22/2017	103
TCR-23	BIG BEN	M	6	1/24/2018	2/14/2018	21
TCR-24	CR054	F	1	1/30/2014	7/31/2014	182
TCR-24	CR054	F	2	7/31/2014	2/20/2015	204
TCR-24	CR054	F	3	8/10/2016	9/11/2016	32
TCR-24	CR054	F	4	12/15/2016	4/11/2017	117
TCR-24	CR054	F	5	7/25/2017	8/23/2017	29
TCR-25	BERT (CR159)	M	1	1/20/2015	2/22/2015	33
TCR-25	BERT (CR159)	M	2	12/10/2015	2/20/2016	72
TCR-25	BERT (CR159)	M	3	3/21/2017	5/26/2017	66
TCR-25	BERT	M	4	7/25/2017	1/7/2018	166
TCR-27	CR610	M	1	12/13/2016	5/10/2017	148
TCR-27	CR610	M	2	5/10/2017	7/10/2017	61
TCR-27	CR610	M	3	7/25/2017	10/19/2017	86
TCR-27	CR610	M	4	10/19/2017	2/14/2018	118
TCR-28	HOTH	M	1	6/13/2017	8/11/2017	59
TCR-28	HOTH	M	2	12/19/2017	1/4/2018	16
TMA-003	ZEWIE (CR267)	M	1	1/17/2014	6/17/2014	151
TMA-003	ZEWIE (CR267)	M	2	11/24/2014	6/19/2015	207
TMA-003	ZEWIE (CR267)	M	2	6/19/2015	8/20/2015	62
TPH-01	IZZY	F	1	6/19/2008	2/10/2009	236
TPH-01	IZZY	F	2	2/10/2009	7/6/2009	146
TPH-01	IZZY	F	3	7/21/2009	1/15/2010	178
TPH-01	IZZY	F	4	1/15/2010	6/22/2010	158
TPH-01	IZZY	F	5	6/22/2010	10/12/2010	112
TPH-02	ZIP	M	1	12/8/2009	3/9/2010	91
TPH-02	ZIP	M	2	3/9/2010	7/21/2010	134
TPH-02	ZIP	M	3	1/12/2011	5/18/2011	126
TPH-02	ZIP	M	4	12/8/2011	6/18/2012	193
TPH-03	TWO NOTCH	M	1	12/9/2009	6/2/2010	175
TPH-03	TWO NOTCH	M	2	6/2/2010	8/21/2010	80
TPH-03	TWO NOTCH	M	4	12/9/2011	1/23/2012	45
TPH-04	COONTIE	F	1	6/2/2010	6/20/2010	18
TPH-05	GETTY	F	1	6/3/2010	6/24/2010	21
TPH-05	GETTY	F	2	7/6/2010	9/24/2010	80
TPH-05	GETTY	F	3	1/14/2011	6/8/2011	145

Tracking ID	Manatee name	Sex	Bout number	On date	Off date	Number of days
TPH-05	GETTY	F	4	6/8/2011	6/9/2011	1
TPH-05	GETTY	F	5	6/9/2011	7/24/2011	45
TPH-05	GETTY	F	6	8/10/2011	8/17/2011	7
TPH-05	GETTY	F	7	9/1/2011	12/30/2011	120
TPH-06	MUSE	F	1	5/3/2011	7/7/2011	65
TPH-06	MUSE	F	2	7/13/2011	11/19/2011	129
TPH-06	MUSE	F	3	12/30/2011	6/13/2012	166
TPH-07	TAZ	M	1	6/8/2011	12/8/2011	183
TPH-07	TAZ	M	2	12/8/2011	6/12/2012	187
TPH-08	GORDO	M	1	12/9/2011	6/6/2012	180
TPH-08	GORDO	M	2	2/18/2013	9/2/2013	196
TPH-09	HERMAN	M	1	1/27/2012	6/11/2012	136
TPH-09	HERMAN	M	2	6/13/2012	6/13/2012	0
TPH-09	HERMAN	M	3	6/20/2012	1/19/2013	213
TPH-10	SMARK	M	1	5/19/2015	6/29/2015	41
TPH-10	SMARK	M	2	1/13/2016	5/16/2016	124
TPH-10	SMARK	M	3	5/26/2016	10/20/2016	147
TPH-10	SMARK	M	4	10/20/2016	12/22/2016	63
TPH-11	SOPPY	M	1	5/19/2015	12/31/2015	226
TPH-11	SOPPY	M	2	1/6/2016	6/19/2016	165
TPH-11	SOPPY	M	3	6/19/2016	11/1/2016	135
TPH-11	SOPPY	M	4	10/13/2016	11/2/2016	20
TPH-11	SOPPY	M	5	11/2/2016	1/9/2017	68
TPH-12	MYSTEE	F	1	5/19/2015	5/25/2015	6
TPH-12	MYSTEE	F	2	6/15/2015	7/11/2015	26
TPH-12	MYSTEE	F	3	11/12/2015	1/22/2016	71
TPH-12	MYSTEE	F	4	2/10/2016	7/29/2016	170
TPH-12	MYSTEE	F	5	12/2/2016	12/12/2016	10
TPH-13	HITCH	M	1	5/20/2015	12/1/2015	195
TPH-13	HITCH	M	2	12/1/2015	6/1/2016	183
TPH-13	HITCH	M	3	6/1/2016	9/15/2016	106
TPH-13	HITCH	M	4	9/15/2016	3/29/2017	195
TPH-13	HITCH	M	5	3/29/2017	10/18/2017	203
TPH-13	HITCH	M	6	10/18/2017	2/14/2018	119
TPH-14	BUGS	F	1	5/21/2015	12/8/2015	201
TPH-14	BUGS	F	2	12/8/2015	6/3/2016	178
TPH-15	DELTA GIRL	F	1	6/16/2015	8/15/2015	60
TPH-15	DELTA GIRL	F	2	12/9/2015	1/26/2016	48
TPH-15	DELTA GIRL	F	3	2/18/2016	3/22/2016	33
TPH-15	DELTA GIRL	F	4	3/22/2016	7/29/2016	129

Tracking ID	Manatee name	Sex	Bout number	On date	Off date	Number of days
TPH-16	CR186	F	1	6/16/2015	12/1/2015	168
TPH-16	CR186	F	2	12/1/2015	3/21/2016	111
TPH-16	CR186	F	3	12/2/2016	5/9/2017	158
TPH-16	CR186	F	4	5/9/2017	8/19/2017	102
TPH-17	TPH-17	F	1	6/16/2015	6/27/2015	11
TPH-17	TPH-17	F	2	2/18/2016	2/20/2016	2
TPH-18	TALLYHO	M	1	6/18/2015	7/19/2015	31
TPH-18	TALLYHO	M	2	9/17/2015	1/20/2016	125
TPH-18	TALLYHO	M	3	1/20/2016	8/9/2016	202
TPH-18	TALLYHO	M	4	8/9/2016	11/23/2016	106
TPH-19	BILLY JOE	M	1	9/16/2015	12/9/2015	84
TPH-19	BILLY JOE	M	2	12/9/2015	5/28/2016	171
TPH-19	BILLY JOE	M	3	12/12/2016	1/31/2017	50
TPH-20	ESCAMBIA	M	1	6/20/2016	12/21/2016	184
TPH-20	ESCAMBIA	M	2	12/22/2016	5/18/2017	147
TPH-20	ESCAMBIA	M	4	1/10/2018	2/14/2018	35
TPH-21	RUMPUS	M	1	6/20/2016	1/9/2017	203
TPH-21	RUMPUS	M	2	1/9/2017	1/31/2017	22
TPH-21	RUMPUS	M	3	1/31/2017	5/9/2017	98
TPH-21	RUMPUS	M	5	9/27/2017	2/15/2018	141
TPH-22	CHOCTAW	M	1	6/21/2016	10/6/2016	107
TPH-23	NOJOY	M	1	6/22/2016	1/10/2017	202
TPH-23	NOJOY	M	2	1/10/2017	2/17/2017	38
TPH-23	NOJOY	M	3	2/17/2017	5/21/2017	93
TTB-140	TRINIDAD	M	1	3/4/2015	8/7/2015	156
TTB-140	TRINIDAD	M	2	2/18/2016	8/26/2016	190

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