Kemp's Ridley and Green Sea Turtle Tagging for Availability Bias Analysis

2024

Progress Report

PREPARED BY

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Cover Photo Credit:

A satellite tag is deployed on a Kemp's ridley (*Lepidochelys kempii*) sea turtle as part of the Kemp's ridley and green turtle availability bias study supported by the U.S. Navy. Photographed by Andie Fisher (project partner Inwater Research Group) taken under Florida State Marine Turtle Permit 24-125.

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Table of Contents

Figures

Tables

Appendices

Acronyms and Abbreviations

ACNWR	Archie Carr National Wildlife Refuge
Cm	*Chelonia mydas*
cm	centimeter
CRW	correlated random walk
FL	Florida
g0	availability bias
GA	Georgia
GAM	Generalized Additive Model
ID	Identification
IRG	Inwater Research Group
IRL	Indian River Lagoon
km	kilometer
Lk	*Lepidochelys kempii*
m	meter
MA	Massachusetts
MD	Maryland
Navy	United States Navy
NSF	National Science Foundation
NY	New York
PI	Principal Investigator
PTT	Platform Transmitter Terminal
REU	Research Experience for Undergraduates
SCL	straight carapace length
SD	Standard Deviation
UCF	University of Central Florida
U.S.	United States

1. Introduction and Background

1.1 Need for Availability Bias Data

Availability bias, or the time animals are unavailable to be detected by visual surveys, is a critical component for accurately estimating abundance in density spatial models (Laake et al. 1997), which are used for conservation and environmental compliance purposes. For air-breathing animals at sea, such as sea turtles and marine mammals, the proportion of time spent below the surface can range from 5 to 90 percent, depending on species, season, and animal behavior (Mansfield 2006, Roberts et al. 2022, DiMatteo et al. 2024). As such, if availability bias estimates are not applied to density spatial models, abundance may be underestimated by as much as an order of magnitude in some cases, hindering conservation efforts, and significantly underestimating the potential impacts of human activities. Applying robust availability bias estimates to spatial density models should be considered "best available science" and actively pursued for the newer generations of density spatial models being produced.

In the past, availability bias was often applied as a single, static number, the mean proportion of time spent below the surface based on depth profiles of tagged animals, or another similar metric (Roberts et al. 2016, Becker et al. 2020). However, animal dive behavior can vary widely by season, habitat, and life stage, and more complex treatments that represent animal availability as spatially varying surfaces can be applied to density spatial models. Several frameworks have been implemented for sea turtles, including spatiotemporal regression models (Hatch et al. 2022) and Generalized Additive Models (GAMs) that relate dive behavior to environmental covariates (Roberts et al. 2022), which allow for cautious extrapolation of availability bias estimates into unsampled areas and times.

On the East Coast of the United States (U.S.), four species of sea turtle can commonly be found: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), and leatherback (*Dermochelys coriacea*), all listed as threatened or endangered under the Endangered Species Act. Loggerhead availability has been studied on the East Coast (Hatch et al. 2022), and large databases of animal tag data are extant. Leatherback tagging is ongoing within the region, sponsored by the National Marine Fisheries Service and other private organizations, with some initial studies of leatherback availability starting to be published (Rogers et al. 2024).

Within the same region, a critical gap exists for dive data appropriate for availability bias estimates for Kemp's ridley and green turtles, in part because these species are smaller and difficult to tag with depth recorders, given the size of these tags historically. Recent advances in tag technology, namely smaller tags that still have onboard pressure sensors, have made it possible to tag these species with the necessary hardware and in the numbers required to generate robust availability bias estimates. Previous density spatial models within the region (DiMatteo et al. 2024) used availability bias estimates from the Gulf of Mexico (Roberts et al. 2022). These datasets are undesirable as environmental relationships, and dive behaviors, may not be appropriate to transfer between regions, so this type of extrapolation should only be undertaken if local estimates are not available.

1.2 Approach to Data Collection and Analysis

The study team proposed deploying up to 50 Wildlife Computers satellite-linked telemetry tags per year for 3 years, split evenly between Kemp's ridley and green sea turtles (or as encounters allow), at several sites along the East Coast ranging from Florida (FL) to Massachusetts (MA). In partnership with several rehabilitation and research groups, the study team aims to collect and record sea turtle behavioral data in multiple representative environments and times of year.

Selected sites ensure that track data represents both temperate and subtropical habitats and conditions (e.g., Florida and the mid-Atlantic year-round habitats, and Northeast/New England seasonal habitats). Tagging will be performed by organizations with existing in-water capture, nesting beach, and rehabilitated animal tagging permits and sampling platforms. Year 4 will be the capstone analysis, fitting a GAM, or other appropriate statistical framework, relating environmental covariates to dive behavior. The GAM framework is appealing because it allows the extrapolation of the model into unsampled times/areas, with appropriate caution.

Designing the study from the ground up with availability bias surface models as the end goal will allow the study team to program tags for maximum efficiency and consistency, and with these models in mind. Within other regions, availability bias estimates have been derived from an ad hoc mixture of tag data with different data collected and duty cycles (DiMatteo et al. 2022), complicating analyses and increasing uncertainty in estimates. Tagging at multiple sites along the East Coast will ensure all tags can be deployed each year, in different habitats; tags can be reallocated between years to different areas/species as needed to ensure parity in species and habitat sampling as much as is feasible. Both dive histogram data and behavior data (e.g., dive and surface intervals) will be collected at appropriate depths for availability bias calculations.

The intended products for this study are availability bias models for Kemp's ridley and green sea turtles, derived from in situ tag data deployed on animals within the Area of Interest, and integrated into existing sea turtle density estimates. The Area of Interest is displayed in **Figure 1** and roughly represents the U.S. Navy Atlantic Fleet Training and Testing Study Area, limited to the northward extent of summer strandings of Kemp's ridley turtles, which venture slightly farther north than green turtles (Massachusetts Audubon Society 2024).

The Area of Interest extends just north of Cape Cod, MA, to the north, the eastern boundary of the U.S. Exclusive Economic Zone to the east, the middle of the Florida Strait to the south, and the United States coastline to the west, including several larger embayments such as Chesapeake Bay, Delaware Bay, and Long Island Sound. Data from outside the Area of Interest may be included in the study (e.g., western Florida Keys) if environmental conditions could be reasonably expected to match conditions within the Area of Interest.

Figure 1. The Area of Interest roughly corresponds to the U.S. Navy Atlantic Fleet Training and Testing Study Area East Coast stratum, limited to the northward extent of summer strandings of Kemp's ridley turtles (source: Massachusetts Audubon Society 2024).

The anticipated availability bias models will describe the proportion of time animals are expected to be within 2 meters (m) of the surface, a common threshold for where sea turtles are visible to aerial observers, the most common type of survey data incorporated into U.S. Navy (Navy) density estimates. Other thresholds such as 3- and 4-m depth cutoffs, or modeling surface and dive intervals, which can be used to generate platform specific availability bias estimates, may be explored as time allows.

The temporal resolution of predictions will depend in part on the amount of data collected but will be at least seasonal to capture major changes in the environment of the waters off the East Coast, which occur seasonally. If possible, availability bias predictions will be made monthly for each species to match the temporal scale of sea turtle density estimates produced for Navy use.

In addition to being directly applicable to existing density spatial models, the tagging data the models are derived from will offer substantial research potential for the broader environmental compliance and scientific community. The tag data can be used to explore two- and three-dimensional home ranges of both species, informing the general ecology of the species, overlapping with Navy ranges and other natural resources, being used in mitigation studies for dredging, being paired with stable isotope studies, and providing an ecological baseline for species behavior within the region, to give several examples.

As this project has just started, this report provides information on the tags deployed to date, and simple visual and tabular summaries of the data collected thus far. Future reports will expand in complexity as more data are collected.

2. Methods

2.1 Animal Acquisition

Wildlife Computers SPLASH10 telemetry tags will be deployed annually, starting June 2024 (Year 1), and totaling approximately 150 tags, split evenly among two species of turtles, greens and Kemp's ridleys, if feasible. No animals smaller than 30-centimeter (cm) straight carapace length (SCL) will be tagged as this is the smallest size generally considered to be visible from aerial survey platforms. In Year 1, the study team obtained 60 tags for deployment. The goal is to deploy tags on a range of turtle sizes to best represent size-based physiological differences in behavior. Planned Year 1 field sites for animal acquisition include the Archie Carr National Wildlife Refuge (ACNWR) nesting beach (Melbourne Beach and Brevard County, FL); Trident Submarine Basin, Port Canaveral, FL; Indian River Lagoon (IRL) south of Sebastian Inlet (Indian River County, FL); Jensen Beach, FL, nesting beach as well as the St. Lucie Power Plant intake canal.

Project Principal Investigators (PIs) are also working with project partners to deploy satellite tags on turtles from other active in-water or rehabilitation entities in FL, Georgia, Maryland, New York, and Massachusetts, pending confirmation of permit and staff availability with each project partner. For Year 1, the study team focused initially on field sites in FL since they were already permitted and staffed for this project. At this time, only the University of Central Florida (UCF) and Inwater Research Group (IRG) are tagging wild-caught turtles; all other project partners anticipate tagging rehabilitated turtles (**Table 1**), mostly Kemp's ridleys to be sourced from New England and mid-Atlantic regions during the winter cold stun season (December to March of any given year, with anticipated turtle releases from January to May).

2.1.1 Project Partners

The study team currently has seven potential project partners, including Co-PI Mansfield's lab at the UCF. Of these, two (UCF and IRG) have field-based programs where turtles are encountered in the wild on their natural nesting beaches or through in-water capture. The remaining five partners are rehabilitation facilities spanning from FL to MA. **Table 1** lists the project partners that have been provisioned with tags to date or that the study team plans to provision with tags. The final distribution of tags will be determined once cold stuns from northern areas are transported to rehabilitation centers. Waiting until the study team is sure animals are available minimizes the number of times tags need to be transported and ensures extra tags can be deployed rapidly as opportunities arise. Note that all turtles in this study will be healthy; a veterinarian will evaluate any rehabilitated turtle prior to tagging and release.

Table 1. List of project partners along with sampling location, anticipated species tagged, number of tags provided (Year 1), and anticipated deployment period (months).

Project partner	Location	Target species	Number of tags allocated	Deployed to date	Turtle source	Anticipated deployment period
UCF	Port Canaveral to Sebastian Inlet, FL	Greens	15	14	Wild caught	Seasonally for adult female greens, year-round for juvenile greens
IRG	St. Lucie Power Plant, Jensen Beach, FL	Kemp's ridleys and greens	10	2	Wild caught	December – May
Loggerhead MarineLife Center	Juno Beach, FL	Kemp's ridleys	5	0	Rehabilitation	December – May (cold stun rehabilitation)
Georgia Sea Turtle Center	Jekyll Island, GA	Kemp's ridleys and greens	10	0	Rehabilitation	January – May (cold stun rehabilitation)
National Aquarium	Baltimore, MD	Kemp's ridleys and greens	10	0	Rehabilitation	January – May (cold stun rehabilitation)
New York Marine Animal Rescue	Long Island, NY	Kemp's ridleys and greens	10	0	Rehabilitation	January – May (cold stun rehabilitation)
New England Aquarium	Boston, MA	Kemp's ridleys	0	0	Rehabilitation	January – May (cold stun rehabilitation)

Key: GA = Georgia; MD = Maryland; NY = New York

2.2 Tagging Methodology

Up to 60 Wildlife Computers SPLASH10 satellite tags were allocated for Year 1 deployments. These are Argos tags with depth sensors and depth profile capabilities. All tags were programmed with the same configuration (see **Appendix A**) to maximize data collection for availability bias models; tag dive data products will allow the study team to calculate the dive statistics required for availability bias modeling, such as percent time below a depth threshold as well as dive and surface intervals. Tags were all tested to ensure they functioned and set to "stand-by" mode in anticipation of deployment. All tags were painted with Trilux 33 anti-foulant prior to tag attachment.

Tags were attached to turtles using a standardized approach that is consistent across all turtles in this study. The anterior portion of the carapace was first cleaned of sediment and algae. Coarse sandpaper was used to scuff up the transmitter attachment site, typically the first and second vertebral scutes, plus the first and second costal scutes on both sides of the vertebral scutes. Transmitters were not placed on the peak of the carapace but along the centerline of the turtle. For both species, transmitters were attached using fiberglass resin and cloth, followed by a steel-reinforced epoxy putty (e.g., Sonic-Weld) per the New England Aquarium protocol outlined by the Wildlife Computers tag attachment epoxy kits sold with their satellite tags. One or two additional coats of an ablative, anti-fouling paint (e.g., Interlux Micron 66 or Trilux 33) were applied to the transmitter and attachment site to minimize growth of barnacles and other epibiota, thereby reducing drag and extending transmitter life.

The direct attachment process takes approximately 1.5 to 2 hours or less. For turtles captured in-water, all turtles were ultimately released close to where they were captured and within no more than 3 hours per federal permitting guidelines.

All turtle handling and tagging activities followed the respective state and federal protected species permitting guidelines as well as Institutional Animal Care and Use Committee protocols (as required) maintained by each project participant/partner. Relevant permit numbers are in the Acknowledgements section.

2.3 Location Processing

Argos satellite locations, which were collected from the Wildlife Computer SPLASH10 tags used here, have well-documented elliptical errors associated with them (Douglas et al. 2012, CLS 2024). These locations were also collected irregularly in time, due to factors such as dive behavior, satellite coverage, tag duty cycles, and weather. Irregular collection times and location error together can negatively impact studies involving animal location (Bradshaw et al. 2007).

Methods to moderate Argos location errors and regularize collection times have existed for decades (Austin et al. 2003) and are an important data management tool for studies dependent on animal locations, such as this study. This study uses the R package *animotum* (Jonsen et al. 2020, 2023), which uses Template Model Builder (Auger-Méthé et al. 2017) to rapidly fit correlated random walk (CRW) and movement process models to Argos and Global Positioning System data, accounting for location errors and predicting animal locations at regular (or user specified) time intervals.

For each tag deployment, locations within the first 48 hours post-release were removed to account for changes in animal behavior associated with tagging and release. A CRW model was fitted in *animotum* for each tag, with prediction time steps at 4-hour intervals, matching the times dive histograms were collected. The maximum speed (vmax) parameter was set to 1.25 meters per second in accordance with hardshell turtle data presented in the *animotum* vignettes. Gaps in transmission longer than 5 days were not predicted on the premise the animal could not be reasonably localized over that span.

In addition to matching the dive histogram collection intervals, the 4-hour time step is a convenient interval to aggregate dive behavior data. This is based on considerations such as filtering out nighttime dive data (which is not applicable to visual survey data) and localizing animals at a scale where they cannot reasonably be expected to move to radically different habitats in that time span.

CRW models were assessed to ensure convergence, and qualitatively assessed based on model plots and visual examination of predicted locations. At this time, locations on land were not filtered because the study team may implement methods to force locations over water, to minimize dive data loss, in the future.

2.4 Availability Bias Calculations

Two types of dive data were collected by the tags: histogram data, in which depth records were aggregated in 4-hour intervals reporting the proportion of the 4-hour interval the animal spent in each histogram depth bin; and behavior data, in which dive and surface intervals in seconds were recorded. The depth sensor sampled depth at a frequency of 1 hertz and recorded depths to the nearest 0.5 m.

Histogram depth bins were 2, 3, 4, 5, 10, 15, 20, 25, 30, 40, 50, 60, and 100 m. The first several bins were defined in 1-m increments to facilitate the calculation of availability bias at several depth thresholds, which would correspond to different viewing conditions during aerial surveys. The ability to sight sea turtles at depth (and how deep) can vary based on animal size and survey conditions (Fuentes et al. 2015, Barco et al. 2018), and is rarely estimated in situ during surveys. The depth at which sea turtles can be sighted from survey platforms is generally considered to vary from 0 to 4 m, with animals being available to be seen only at the surface in the worst survey conditions.

Dives for the dive behavior data were defined as when the animal descended deeper than 2 m and remained at depth for at least 30 seconds. Tags were programmed to slightly prioritize the transmission of histogram data to ensure at least one data type was collected consistently (see **Appendix A** for a sample report detailing how each tag was programmed).

Dive histograms were associated to interpolated locations based on time, and only histograms in which the majority of the sampling period occurred during daylight hours were retained. Sea turtle behavior can vary significantly between daytime and nighttime (Hochscheid 2014), and surveys used to support sea turtle density spatial models only occur during daylight hours. Availability bias was calculated at 2-, 3-, and 4-m depth thresholds by summing the proportion of time spent in the appropriate bins for each threshold.

For behavior data, dive and surface intervals were linked to the closest location by date and time, and behavior records that could not be matched to a location within 4 hours were removed, as were dive and surface records that were not during daylight hours. For each location with dive and surface intervals associated with it, availability was calculated as follows:

sum of all dive times / (sum of all dive times + sum of all surface intervals)

Availability bias, also referred to as "g0" after the common distance sampling nomenclature (despite g0 technically including both availability and perception bias components), was summarized in several ways for the various depth bins and data types. Availability bias estimates were calculated for individuals; by species; and then by sex, age class (juvenile versus adult), month, and depth, all of which were segregated by species to account for differences in foraging and dive behavior between species. Depth classes were defined as shallow (0–10 m), shallow shelf (10–50 m), deep shelf (50–200 m) and deep (>200 m) in order to examine how availability bias may change with available depths.

The standard deviations of availability bias estimates are presented. However, given the low number of tags deployed to date (*n*=16), including only one Kemp's ridley tag, the study team believed interpreting measures of uncertainty would be premature. However, the study team did feel presenting some summaries of the data collected thus far would orient the reader to project goals, despite the extremely preliminary nature of these analyses.

3. Results

3.1 Deployments

Sixteen turtles have been satellite tagged to date (June to December 2024; **Table 2**). All turtles were captured from the central and southeast Florida coast (**Figure 2**). The UCF deployed 14 tags, including 7 on adult female green turtles (96.2 to 109.5 cm SCL) found nesting within the ACNWR during June and July 2024, 4 on small juvenile green turtles (32.3 to 45.4 cm SCL) captured at Trident Submarine Basin during late July 2024, and 3 larger juvenile green turtles from the IRL (45.4 - 53.6 cm SCL) during July through December 2024.

Four of the adult females nesting within the ACNWR and one of the Trident Basin juvenile green turtles were recaptured turtles who had been previously flipper tagged and encountered by the UCF. Additionally, one adult male green turtle (85.0 cm SCL), and one subadult Kemp's ridley (55.6 cm SCL) from the St. Lucie Power Plant intake canal were satellite tagged by IRG. Should any of the satellite tagged turtles in this study be recaptured by any project partner, the turtles will not be re-tagged as part of this study; the study team aims for 150 distinct individuals tagged.

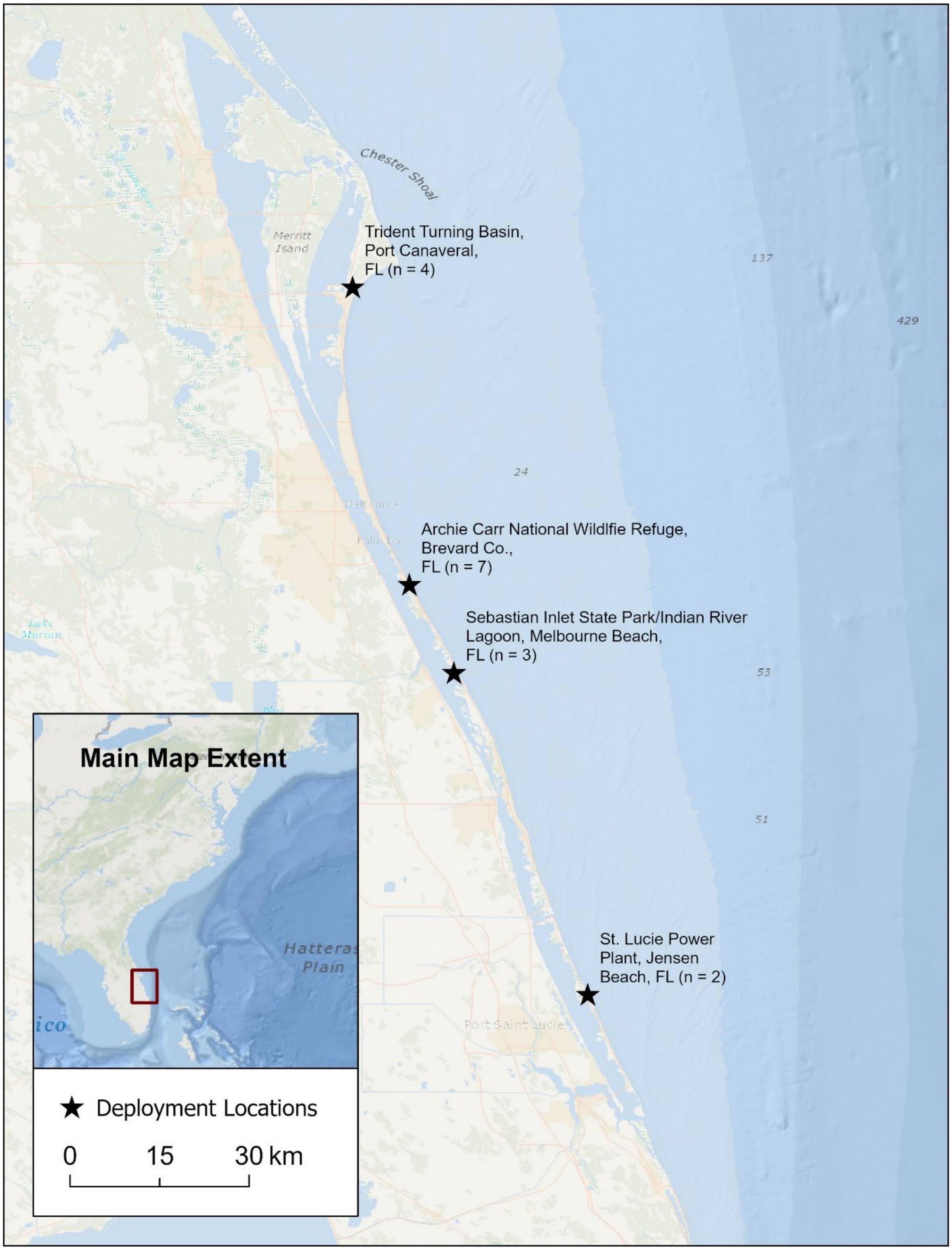

Figure 2. Deployment locations for the release of turtles that were satellite tagged from June to December 2024.

Table 2. Deployment summaries (tag status current as of 19 November 2024) – summary meta-data for each satellite tag deployed.

PTT	Deploying organization	Date deployed	Deployment location	Species	Turtle SCL	Turtle age class	Turtle sex	Recapture	Turtle name	Status
264822	UCF	19 June 2024	ACNWR, Brevard County, FL	Cm	101.9	Adult	Female	Yes	Kalvin	Active
264819	UCF	19 June 2024	ACNWR, Brevard County, FL	Cm	96.2	Adult	Female	No	Blanco	Inactive
264815	UCF	19 June 2024	Archie Carr NWR, Brevard County, FL	Cm	97.0	Adult	Female	No	Aldunce	Inactive
264820	UCF	20 June 2024	Archie Carr NWR, Brevard County, FL	Cm	97.0	Adult	Female	Yes	Cheung	Active
264825	UCF	20 June 2024	Archie Carr NWR, Brevard County, FL	Cm	98.0	Adult	Female	Yes	Dasgupta	Inactive
264816	IRG	29 June 2024	St. Lucie Power Plant, Jensen Beach, FL	Cm	85.0	Adult	Male	No	Denton	Inactive
264837	UCF	9 July 2024	IRL, Melbourne Beach, FL	Cm	53.6	Juvenile	Unknown	No	Diongue	Inactive
264818	IRG	20 July 2024	St. Lucie Power Plant, Jensen Beach, FL	Lk	55.6	Juvenile	Unknown	No	Dodman	Inactive
264827	UCF	21 July 2024	ACNWR, Brevard County, FL	Cm	109.5	Adult	Female	No	Geden	Active
264834	UCF	21 July 2024	ACNWR, Brevard County, FL	Cm	99.4	Adult	Female	Yes	Garschagen	Inactive
264823	UCF	26 July 2024	Trident Turning Basin, Port Canaveral, FL	Cm	32.3	Juvenile	Unknown	No	Hayward	Inactive
264839	UCF	26 July 2024	Trident Turning Basin, Port Canaveral, FL	Cm	39.6	Juvenile	Unknown	No	Jones	Inactive
264831	UCF	27 July 2024	Trident Turning Basin, Port Canaveral, FL	Cm	40.5	Juvenile	Unknown	No	Krinner	Inactive
264826	UCF	27 July 2024	Trident Turning Basin, Port Canaveral, FL	Cm	40.9	Juvenile	Unknown	Yes	Jotzo	Inactive
264830	UCF	13 August 2024	IRL, Melbourne Beach, FL	Cm	45.4	Juvenile	Unknown	No	Krinner	Inactive
264851	UCF	5 September 2024	IRL, Melbourne Beach, FL	Cm	48.2	Juvenile	Unknown	No	Lee	Inactive

Key: PTT = Platform Transmitter Terminal; Cm = *Chelonia mydas*; Lk = *Lepidochelys kempii*

3.2 Tag Disposition

In Year 1, the study team received 60 SPLASH 10 tags to distribute among the project partners. See **Table 1** for tags distributed to date and **Table 2** for tags deployed to date. During early 2025, the study team will provide 10 tags to the Georgia Sea Turtle Center, and up to 10 tags each to the Baltimore Aquarium and New York Marine Animal Rescue Center (**Appendix B**). Tag distributions may be modified somewhat depending upon the upcoming cold stun season and the distribution of cold stun animals to rehabilitation centers along the East Coast. **Appendix B** provides tag serial numbers and the current location of all 60 tags.

3.3 Turtle Locations

As of the writing of this report, approximately 24,000 Argos locations were collected from the 16 tags deployed to date (**Figure 3**), three of which are still actively transmitting. Green turtle locations comprised the vast majority of locations, with only 700 Kemp's ridley locations collected from a single tag.

The CRW models fitted to each tag converged. Model fit statistics and plots were examined for each tag, and no indications of poor fit or structural issues with predictions occurred. Approximately 7,000 predicted locations were created at 4-hour intervals (**Figure 3**), covering the 16 deployments. No large temporal gaps were noted, indicating that turtles were surfacing regularly, and transmissions from the tags were being received frequently. Maps of Argos locations and predicted locations at 4-hour intervals for individual deployments can be found in **Appendix C** (**Figure C-1** to **Figure C-16**).

Locations ranged from the FL/Georgia border in the north, to the southern Florida Keys in the south. Most animals stayed close to shore; however, two animals— "Dodman" (Platform Transmitter Terminal [PTT] 264818), a Kemp's ridley; and "Cheung" (PTT 264820), a green—ranged away from the shore, providing samples in waters not frequented by other animals to date. Dodman (PTT 264818; **Appendix C**, **Figure C-3**) was released at the St. Lucie Power Plant and remained on the continental shelf, but spent several weeks using mid-shelf waters. Cheung (PTT 264820; **Appendix C**, **Figure C-5**), an adult nesting female, spent several weeks close to the ACNWR before moving off the continental shelf, looping up and around to northern FL, and then moved south along the FL coast, eventually reaching the Florida Keys.

Multiple tags deployed in inland waters, such as the IRL and Trident Basin, did not range outside these areas. These were smaller, juvenile green turtles and provide an important source of information on smaller and/or male individuals. Many of the predicted CRW locations for these individuals were on land (**Appendix C**), an issue the study team plan to rectify as the *animotum* modeling process is refined.

Locations were recorded from June to November for green turtles and from July to September for the single Kemp's ridley turtle. Deep shelf and deep waters were poorly sampled, with only 10 and 9 daytime, 4-hour locations falling in these waters, respectively, all from a single green turtle (Cheung, PTT 264820). Shallow waters and shallow shelf depths were better sampled, with approximately 1,700 and 550 daytime, 4-hour locations, falling in these waters, respectively.

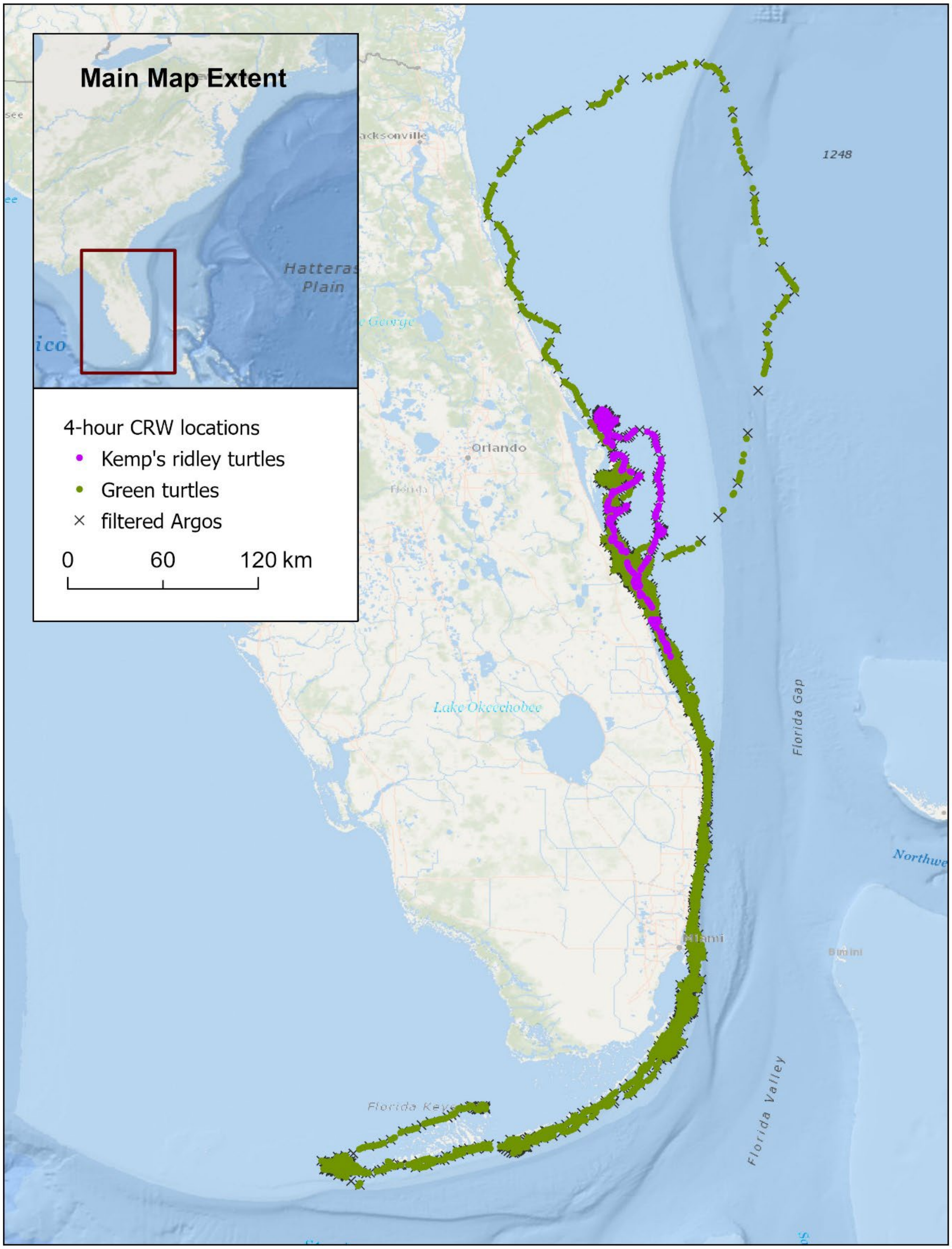

Figure 3. Correlated random walk locations for all 16 tagged turtles.

3.4 Availability Bias

Daytime, 4-hour, CRW locations with associated dive data are presented in **Figure 4** and **Figure 5** for green turtles, and **Figure 6** for Kemp's ridley turtle(s). Locations with histogram dive data (2-m depth bin) are shown in **Figure 4** through **Figure 6** as an example. Locations with dive behavior data associated with them were similar. For animals that traveled to the Florida Keys (all adult green turtles, **Figure 4**), availability bias values derived from the 2-m depth bin histogram were generally lower than 0.4, indicating the animals spent most of the time at depth. This is consistent with the Florida Keys being identified as an area having abundant seagrass beds where green turtles are known to forage (Sloan et al. 2022, Welsh and Mansfield 2022). The availability bias estimates based on the same data for juvenile green turtles in inland waters of the FL central coast showed animals spending more time in shallower depths. The one Kemp's ridley turtle spent most of its time below 2-m depth, with average availability bias estimates below 0.1, regardless of the data or depth cutoff used.

Availability bias estimates for individuals varied widely, from a minimum of 0.06 in the 2-m depth bin for the Kemp's ridley turtle, to 1.0 for several green turtles using the 3- and 4-m depth histogram data (**Table 3**). Availability bias estimates at or close to 1.0 were largely from juvenile green turtles that remained in or near inland waters, indicating they spent most of their time within 3 to 4 m of the surface.

Mean individual availability bias estimates based on histogram data at the 2-, 3-, and 4-m depth were 0.51, 0.60, and 0.64, respectively, increasing as more of the water column was included, as expected. The number of histograms used to calculate estimates ranged from 49 to 370, with a mean of 144. Availability bias histogram estimates for the 2-m depth appeared similar to the dive behavior derived estimates (dives were considered to have begun when the animal dove below 2 m), though this was not tested statistically. The number of locations with dive behavior data was slightly lower on average (n=142) than the number of locations with histogram data, perhaps reflecting the lower priority of those Argos messages.

Mean availability bias by species was 0.42 and 0.06 based on the 2-m histogram data for green and Kemp's ridley turtles, respectively (**Table 4**). The study team recommends the reader interpret the results for Kemp's ridley turtles cautiously, as only one animal has been tagged to date. Summaries in **Table 4** for Kemp's ridleys are presented for information purposes only and should not be used for management. Similarly, only one confirmed male green turtle has been tagged to date; given the variation in individual behavior (**Table 3**), comparisons by sex in **Table 4** are presented for informational purposes only.

Based on initial availability bias averages, juvenile green turtles appear to spend more time at shallow depths than adult green turtles (**Table 4**). The availability bias estimates for green turtles were higher during warmer months and lower during cooler months; data is not available for all months. These data currently cover predominantly coastal FL so relationships elsewhere may be different. Green turtles were more available in shallow waters than shallow shelf waters, perhaps reflecting the more limited three-dimensional habitat. At this early date, the study team did not test this statistically and results should be considered preliminary. The study team does not offer interpretation of the results from deeper waters, given the low sample size at this point.

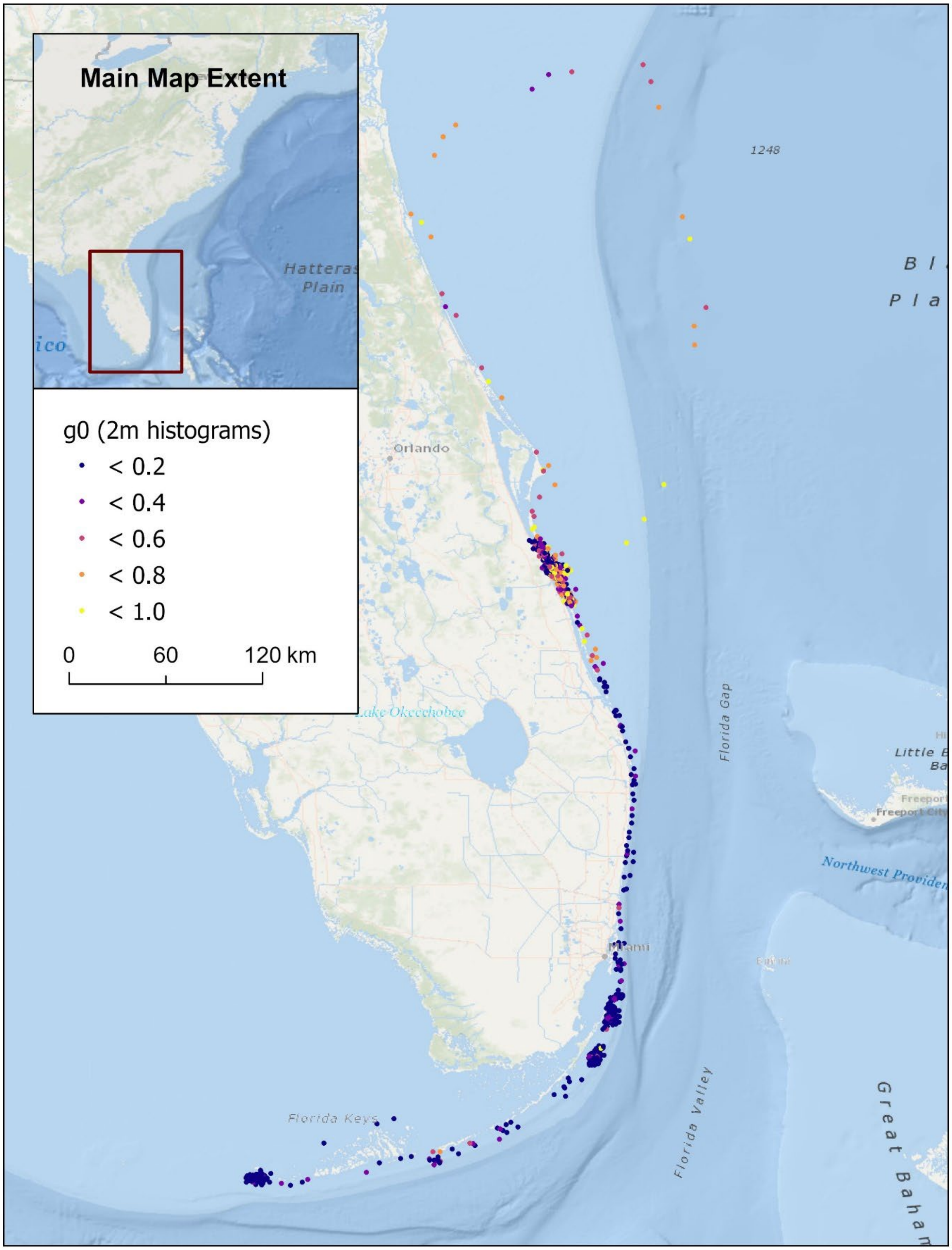

Figure 4. Interpolated daytime *Chelonia mydas* adult locations with associated availability bias data.

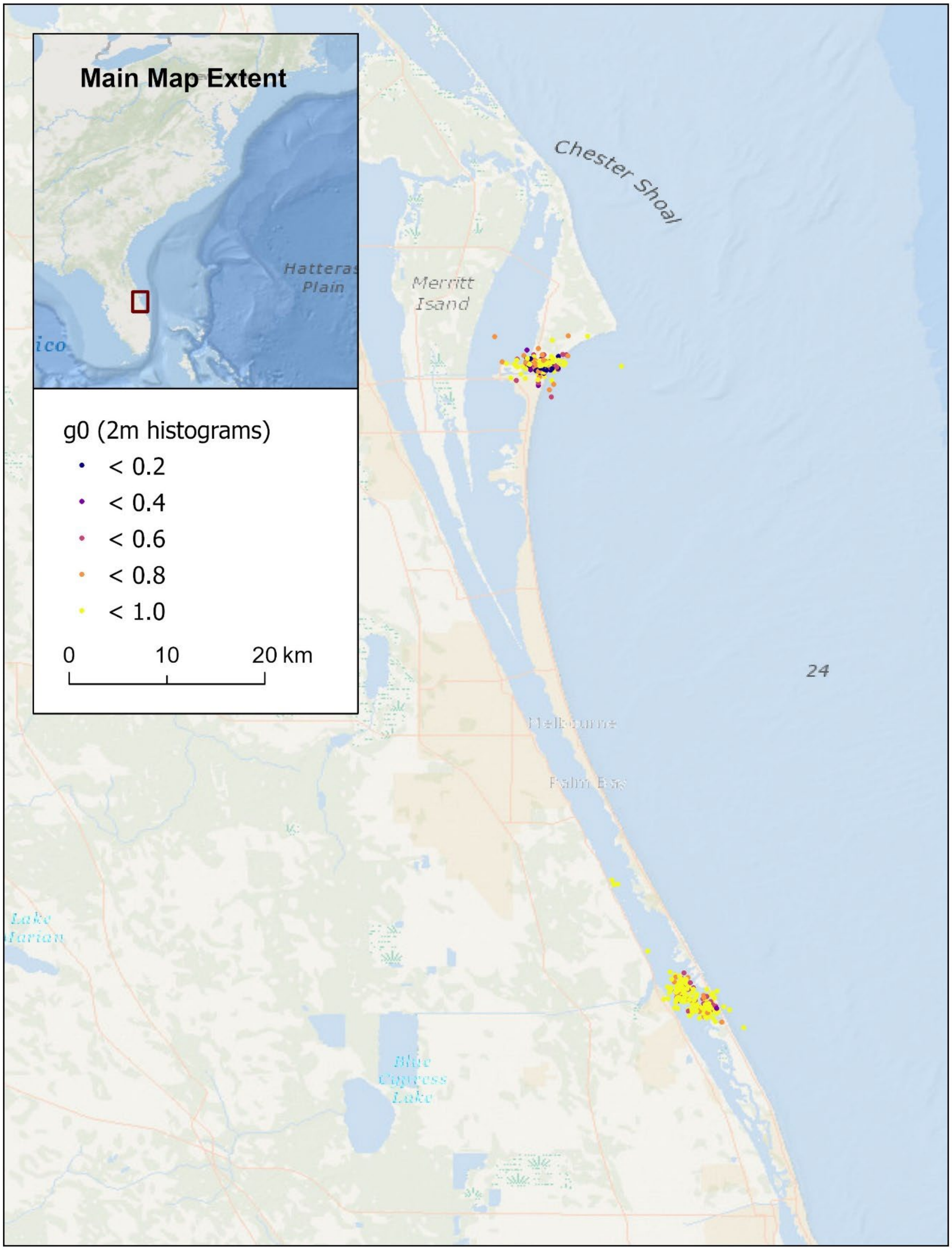

Figure 5. Interpolated daytime *Chelonia mydas* juvenile locations with associated availability bias data.

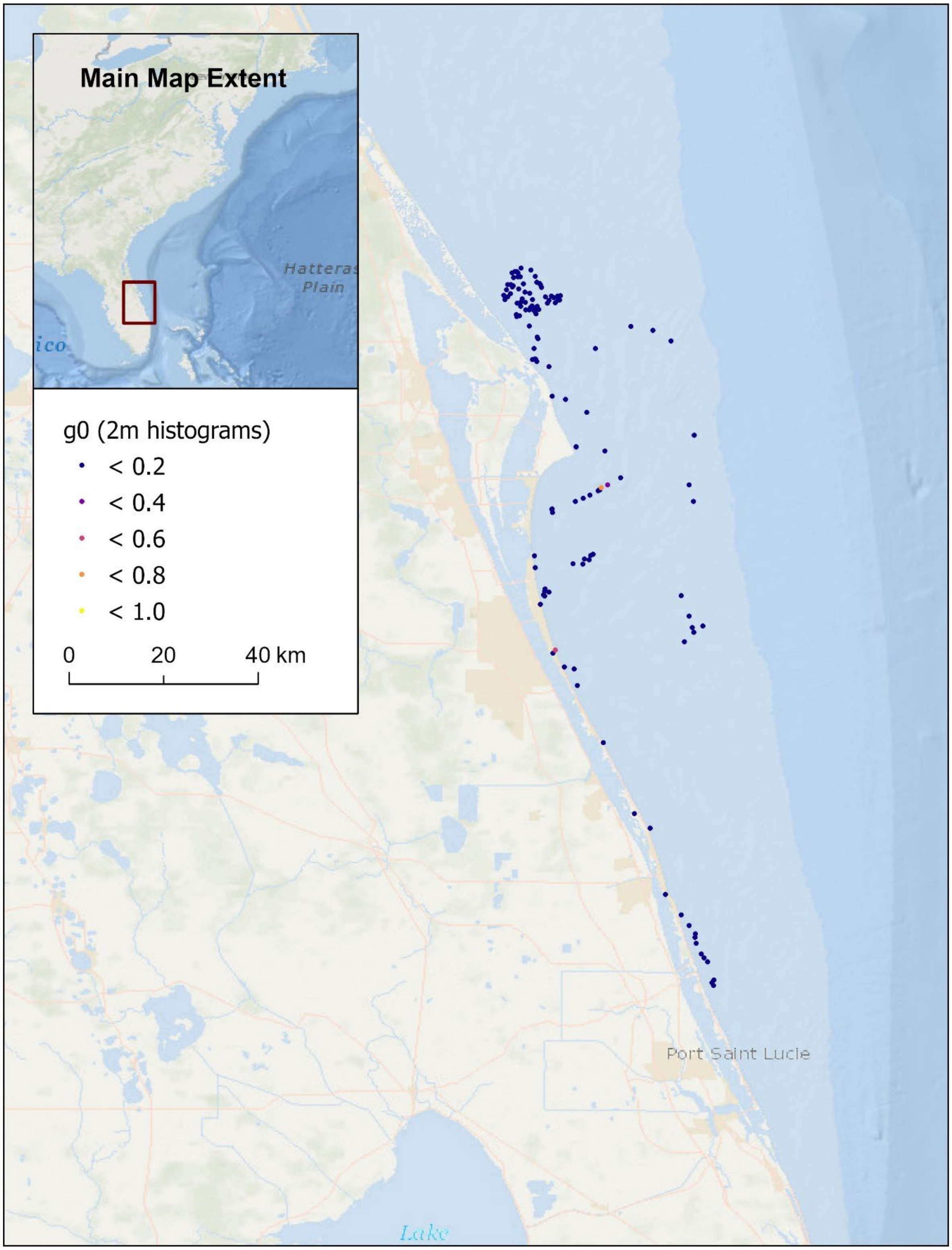

Figure 6. Interpolated daytime *Lepidochelys kempii* locations with associated availability bias data.

Table 3. Individual availability bias estimates.

PTT turtle ID	Species	g0 (2-m histogram)	g0 (3-m histogram)	g0 (4-m histogram)	# histograms	g0 (2-m behavior)	# behavior locations
264815	Cm	0.38 ± 0.30 SD	0.50 ± 0.33 SD	0.59 ± 0.34 SD	125	0.39 ± 0.31 SD	153
264816	Cm	0.08 ± 0.02 SD	0.10 ± 0.04 SD	0.16 ± 0.10 SD	64	0.09 ± 0.04 SD	114
264819	Cm	0.56 ± 0.26 SD	0.67 ± 0.28 SD	0.72 ± 0.28 SD	97	0.59 ± 0.29 SD	104
264820	Cm	0.28 ± 0.28 SD	0.37 ± 0.31 SD	0.50 ± 0.33 SD	352	0.32 ± 0.30 SD	389
264822	Cm	0.32 ± 0.29 SD	0.40 ± 0.34 SD	0.45 ± 0.36 SD	370	0.32 ± 0.30 SD	411
264823	Cm	0.88 ± 0.23 SD	0.92 ± 0.22 SD	0.92 ± 0.22 SD	71	0.50 ± 0.34 SD	22
264825	Cm	0.35 ± 0.32 SD	0.44 ± 0.34 SD	0.55 ± 0.37 SD	270	0.33 ± 0.32 SD	304
264826	Cm	0.65 ± 0.27 SD	0.77 ± 0.27 SD	0.82 ± 0.26 SD	50	0.54 ± 0.35 SD	52
264827	Cm	0.25 ± 0.28 SD	0.29 ± 0.29 SD	0.33 ± 0.30 SD	250	0.25 ± 0.28 SD	278
264830	Cm	0.73 ± 0.19 SD	0.97 ± 0.06 SD	1.00 ± 0.01 SD	76	0.54 ± 0.29 SD	21
264831	Cm	0.65 ± 0.27 SD	0.74 ± 0.26 SD	0.78 ± 0.25 SD	86	0.57 ± 0.30 SD	74
264834	Cm	0.49 ± 0.34 SD	0.54 ± 0.35 SD	0.59 ± 0.35 SD	172	0.47 ± 0.31 SD	132
264837	Cm	0.86 ± 0.14 SD	1.00 ± 0.01 SD	1.00 ± 0.01 SD	49	0.81 ± 0.13 SD	6
264839	Cm	0.66 ± 0.33 SD	0.77 ± 0.32 SD	0.81 ± 0.32 SD	91	0.41 ± 0.30 SD	60
264851	Cm	0.90 ± 0.13 SD	0.98 ± 0.05 SD	1.00 ± 0.01 SD	55	0.62 ± 0.32 SD	5
264818	Lk	0.06 ± 0.07 SD	0.07 ± 0.09 SD	0.07 ± 0.09 SD	132	0.06 ± 0.08 SD	142

Key: ID = Identification, Cm = *Chelonia mydas*, Lk = *Lepidochelys kempii*, SD = Standard Deviation

Table 4. Availability bias summaries aggregated across several metrics.

Summary	g0 (2-m histogram)	g0 (3-m histogram)	g0 (4-m histogram)	# histograms	g0 (2-m behavior)	# behavior locations
Species						
Chelonia mydas (Cm)	0.42 ± 0.34 SD	0.51 ± 0.37 SD	0.58 ± 0.37 SD	2,178	0.35 ± 0.31 SD	2,125
Lepidochelys kempii (Lk)	0.06 ± 0.07 SD	0.07 ± 0.09 SD	0.07 ± 0.09 SD	132	0.06 ± 0.08 SD	142
Sex						
Female (Cm)	0.34 ± 0.31 SD	0.42 ± 0.34 SD	0.50 ± 0.35 SD	1,636	0.34 ± 0.31 SD	1,771
Male (Cm)	0.08 ± 0.02 SD	0.10 ± 0.04 SD	0.16 ± 0.10 SD	64	0.09 ± 0.04 SD	114
Unknown (Cm)	0.75 ± 0.26 SD	0.86 ± 0.24 SD	0.89 ± 0.23 SD	478	0.52 ± 0.32 SD	240
Unknown (Lk)	0.06 ± 0.07 SD	0.07 ± 0.09 SD	0.07 ± 0.09 SD	132	0.06 ± 0.08 SD	142
Age Class						
Adult (Cm)	0.33 ± 0.31 SD	0.41 ± 0.34 SD	0.49 ± 0.35 SD	1,700	0.33 ± 0.31 SD	1,885
Juvenile (Cm)	0.75 ± 0.26 SD	0.86 ± 0.24 SD	0.89 ± 0.23 SD	478	0.52 ± 0.32 SD	240
Juvenile (Lk)	0.06 ± 0.07 SD	0.07 ± 0.09 SD	0.07 ± 0.09 SD	132	0.06 ± 0.08 SD	142

Summary	g0 (2-m histogram)	g0 (3-m histogram)	g0 (4-m histogram)	# histograms	g0 (2-m behavior)	# behavior locations
Month						
6 (Cm)	0.38 ± 0.26 SD	0.48 ±0.32 SD	0.53 ± 0.34 SD	136	0.43 ± 0.31 SD	151
7 (Cm)	0.58 ± 0.32 SD	0.69 ± 0.32 SD	0.75 ± 0.30 SD	558	0.52 ± 0.33 SD	543
8 (Cm)	0.51 ± 0.35 SD	0.60 ± 0.36 SD	0.65 ± 0.36 SD	669	0.41 ± 0.33 SD	594
9 (Cm)	0.29 ± 0.30 SD	0.37 ± 0.35 SD	0.45 ± 0.36 SD	447	0.22 ± 0.22 SD	414
10 (Cm)	0.23 ± 0.29 SD	0.28 ± 0.31 SD	0.37 ± 0.33 SD	281	0.15 ± 0.16 SD	302
11 (Cm)	0.11 ± 0.11 SD	0.15 ± 0.16 SD	0.25 ± 0.25 SD	87	0.15 ± 0.15 SD	121
7 (Lk)	0.06 ± 0.03 SD	0.07 ± 0.03 SD	0.07 ± 0.03 SD	19	0.07 ± 0.04 SD	26
8 (Lk)	0.07 ± 0.09 SD	0.07 ± 0.12 SD	0.08 ± 0.13 SD	71	0.07 ± 0.11 SD	71
9 (Lk)	0.05 ± 0.02 SD	0.05 ± 0.01 SD	0.06 ± 0.01 SD	42	0.05 ± 0.02 SD	45
Depth Class						
Deep (Cm)	0.69 ± 0.14 SD	0.74 ± 0.12 SD	0.76 ± 0.11 SD	9	0.70 ± 0.09 SD	9
Deep shelf (Cm)	0.21 ± 0.29 SD	0.27 ± 0.28 SD	0.33 ± 0.28 SD	9	0.22 ± 0.28 SD	10
Shallow shelf (Cm)	0.39 ± 0.31 SD	0.47 ± 0.35 SD	0.53 ± 0.36 SD	513	0.38 ± 0.31 SD	530
Shallow (Cm)	0.43 ± 0.35 SD	0.52 ± 0.38 SD	0.59 ± 0.37 SD	1,647	0.34 ± 0.31 SD	1,576
Shallow shelf (Lk)	0.06 ± 0.07 SD	0.06 ± 0.07 SD	0.06 ± 0.07 SD	114	0.06 ± 0.07 SD	119
Shallow (Lk)	0.08 ± 0.10 SD	0.10 ± 0.17 SD	0.12 ± 0.19 SD	18	0.09 ± 0.12 SD	23

Key: Cm = *Chelonia mydas*, Lk = *Lepidochelys kempii*, SD = Standard Deviation

4. Discussion

Though the results presented in this report are extremely preliminary and based on a small sample size, the study team has taken the first steps toward providing robust, defensible availability bias estimates for Kemp's ridley and green sea turtles on the East Coast, with the eventual goal of providing not just point estimates, but surfaces of availability bias, varying in space and time. The current study results should be interpreted with caution, given the small number of deployments to date, which limits the available information both spatially and temporally. Particular caution should be taken with the results for Kemp's ridley and male green turtles, both with only one deployment each to date.

Despite the preliminary nature of the results, some initial inferences can potentially be drawn from the Year 1 data. Availability generally increased as the depth threshold at which animals were assumed to be able to be seen increased. This is to be expected as more of the water column is considered to be visible. The availability bias estimates from the 2-m depth histograms and dive behavior were similar. Though this was not yet tested statistically, it serves as an independent check that the availability bias calculations are accurate since they use the same depth threshold, but data are aggregated in different ways.

Some initial indications are that for green turtles, availability is different by age class (**Figure 4** and **Figure 5**) and month (**Table 4**), which has important implications for how availability bias is applied to density estimates. Monthly estimates of availability, or finer if sea turtles are shown to respond to more ephemeral habitat features, will be required to accurately account for availability, possibly with some accommodation of the age structure of the population. FL waters, and some limited offshore data, are the only areas of interest sampled by this project thus far, so relationships may differ within other areas, particularly northern seasonal habitats where animals move into and out of annually and where seasonal variations in the depth of the thermocline occur.

Smaller juvenile green turtles captured and released in inland waters often did not range far from their release locations. While this is an important age class to sample and a potentially important source of male turtles, the study team will need to weigh these considerations with the need to broadly sample geographic and environmental space. More discussion is provided in **Section 4.2** Plans for Future Deployments.

4.1 Comparison to Other Availability Bias Estimates

Availability bias for green turtles has been examined within other regions. Thomson et al. (2013) found that green turtles had extended dive times during winter in Shark Bay, Western Australia, and that abundance would be underestimated during winter and overestimated during summer if uniform availability was assumed. They did not report an average measure of availability.

Fuentes et al. (2015) reported availability bias estimates of approximately 0.05 for adult and subadult green turtles in the Torres Strait, located between northern Australia and Papua New Guinea. Roberts et al. (2022) found that green turtles tagged in the Gulf of Mexico spent approximately 19 percent of their time at the surface (availability bias of 0.19) with the surface defined as depths of 0 to 2 m. Higher availability was associated with the spring season, shallow depths, warmer than average sea surface temperatures, and stronger temperature fronts. These data, though not the associated model, were used as a proxy for availability for East Coast green turtles in DiMatteo et al. (2024) as the closest and best available substitute.

In general, the study team's preliminary estimates of green turtle availability are higher than other published estimates, but this could be due to any number of reasons, including available habitat, differences in environment, and age classes tagged. The study team would like to avoid drawing conclusions at this early stage and present these other estimates for reference only. Future analyses will try to separate these differences as more data are collected.

Roberts et al. (2022) also estimated availability for Kemp's ridley turtles tagged in the Gulf of Mexico. They estimated an average availability bias of 0.18 from 63 tagged animals, and found Kemp's ridleys occupied a broader environmental niche regarding availability compared to green and loggerhead turtles within the same region. No other estimates of Kemp's ridleys' availability exist in the literature. These estimates were previously used as a proxy for East Coast availability in DiMatteo et al. (2024). Since the study team has only tagged one Kemp's ridley turtle to date and given the variability in individual dive behavior (**Table 3**), comparisons would be ill-advised at this time.

4.2 Plans for Future Deployments

4.2.1 Year 1 Tags

Forty-four of 60 tags purchased during Year 1 have yet to be deployed. Five were provided to IRG in 2024 (**Table 1**), and IRG has deployed two to date. Five were provided to Loggerhead MarineLife Center, but none have yet to be deployed. Both of these organizations are based in FL, and the study team has asked them to prioritize tagging Kemp's ridley turtles and male green turtles opportunistically as these animals are rarer at the nesting beaches and in-water research sites covered by Co-PI Dr. Kate Mansfield. These project partners will continue to prioritize Kemp's ridleys and male green turtles for the remainder of Year 1.

Dr. Mansfield continues to have twice-monthly sampling in the IRL and will try to deploy an additional 2 to 3 tags on larger juvenile green turtles during the coming months. If needed, additional tags can also be deployed on smaller juvenile green turtles encountered in Trident Basin during UCF's planned winter sampling during the last weekend in February 2025.

Most of the other extant Year 1 tags have been earmarked for deployments on rehabilitated turtles from regions north of FL. The exact species mix for these tags will be determined by available turtles from the upcoming cold stun season; however, Kemp's ridley will be a high priority as they are also most likely to cold stun. Year 1 tags were received by late May and early June 2024, after the time of year cold stunned animals are generally released (February to April). Cold stunned animals come from waters north of Cape Hatteras, North Carolina, as waters cool. Strandings occur if animals do not move south to warmer waters quickly enough. Cold stunned animals are housed in rescue and rehabilitation centers and transported to southern rescue centers with available capacity as needed. Releases occur as waters warm, usually April to May in northern waters and February to March in southern waters. This, combined with two hurricanes and a low nesting year for green turtles on FL beaches, limited the study team's ability to deploy tags to date.

Cold stunned animals are just starting to arrive at rescue centers as of the writing of this report, as northern waters appear to have stayed warm unusually late this year. Over the next few months, as animals strand and are transported south as needed, the study team will work with rescue center partners to distribute tags and finalize tagging plans. Co-PI Dr. Mansfield will be bringing tags to the Southeast Region Sea Turtle Meeting in early February to transfer them to project partners.

4.2.1 Years 2 and 3 Tags

For Year 2, the study team's highest priorities are Kemp's ridley turtles and northern deployments, which were hindered this year by receiving tags after cold stunned animals were released, U.S. Fish and Wildlife Service limitations on what size animals can be tagged (currently limited to animals 50 cm and greater for northern collaborators) and delays in permitting. The study team is actively working with northern collaborators to modify their permits to allow animals as small as 30 cm to be tagged. The study team will also work with Wildlife Computers to see if the next batch of tags can be modified to reduce drag and weight (i.e., remove the four "towers" in each corner of the tags whose function is to protect the antenna while adding drag and weight to the tags).

In the south, the study team may switch focus away from smaller green turtles tagged in inland waters, and focus more on larger green turtles and individuals captured at sea, to more broadly sample geographic and environmental space. The study team will continue to tag animals entrained in the St. Lucie Power Plant intake and work with IRG to modify their permits as needed to increase sample sizes or to also include adult female green turtles.

Year 3 plans will be dependent upon the mix of tags deployed in Years 1 and 2, and speculation at this point is premature. However, the study team will aim to have as robust a mix of species, age classes, and sexes as is feasible.

4.3 Future Analyses and Uses

For the remainder of Year 1, the study team will continue to refine the code used to generate availability bias estimates from the dive data as well as re-analyzing the data prior to the Marine Species Monitoring Program annual review meeting in April. Additionally, Co-PIs Andrew DiMatteo and Dr. Mansfield will analyze deployments at the end of Year 1 to guide deployment priorities for Year 2.

Future analyses include enhancing the location processing analysis to force points over water and minimize data loss; moving from a CRW model to a movement persistence or Hidden Markov model approach, which could allow inference on whether and how dive behavior changes with animal behavioral state; interpreting variability in availability bias estimates; and assessing the environment currently sampled by tags versus the environment throughout the Area of Interest. The latter can guide future tag deployment priorities.

For any nesting, adult, female green turtle satellite tagged by UCF, Dr. Simona Ceriani of the Florida Fish and Wildlife Commission has UCF collecting skin, egg, and scute samples from these turtles for a statewide foraging ecology and stable isotope analysis. Track data from these turtles will be shared with Dr. Ceriani to inform isoscape models for green turtles nesting in the western North Atlantic. Aside from Dr. Ceriani, no collaborators have made the study team aware of planned or active analyses using these data.

Data from tags deployed by UCF will be used as a training tool for a summer National Science Foundation Research Experience for Undergraduates (NSF REU) student working with Co-PI Dr. Mansfield's laboratory. These data will help the NSF REU student learn basic animal movement analyses and mapping techniques. Pending UCF's admissions decisions, Dr. Mansfield may also have an incoming doctoral student interested in turtle movement data for a broader population-based modeling exercise incorporating stable isotope (foraging ecology), genetics, and health data derived from blood samples to better predict regional population trends. The study team anticipates that as more tags are deployed and deployments finish, more collaborators will begin to use the data.

5. References

Auger-Méthé, M., C.M. Albertse, I.D. Jonsen, A.E. Derocher, D.C. Lidgard, K.R. Studholme, W.D. Bowen, G.T. Crossin, and J.M. Flemming. 2017. Spatiotemporal modelling of marine movement data using Template Model Builder (TMB). *Marine Ecology Progress Series* 565:237–249. Accessed at https://doi.org/10.3354/meps12019.

Austin, D., J.I. McMillan, and W.D. Bowen. 2003. A three-stage algorithm for filtering erroneous Argos satellite locations. *Marine Mammal Science* 19:371–383. DOI10.1111/j.1748-7692.2003.tb01115.x.

Barco, S.G., M.L. Burt, R.A. DiGiovanni Jr., W.M. Swingle, and A.S. Williard. 2018. Loggerhead turtle *Caretta caretta* density and abundance in Chesapeake Bay and the temperate ocean waters of the southern portion of the Mid-Atlantic Bight. *Endangered Species Research* 37:269–287. Accessed at https://doi.org/10.3354/esr00917.

Becker, E.A., K.A. Forney, D.L. Miller, P.C. Fiedler, J. Barlow, and J.E. Moore. 2020. *Habitat-based density estimates for cetaceans in the California Current Ecosystem based on 1991-2018 survey data*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-638.

Bradshaw, C.J.A., D.W. Sims, and G.C. Hays. 2007. Measurement error causes scale-dependent threshold erosion of biological signals in animal movement data. *Ecological Applications* 1(7):628–638. DOI10.1890/06-0964.

CLS (Collecte Localisation Satellites). 2024. Argos user's manual. Accessed 20 November 2024 at https://www.argos-system.org/wp-content/uploads/2023/01/CLS-ArgosWeb-User-Manual.pdf.

DiMatteo, A., A. Cañadas, J. Roberts, L. Sparks, S. Panigada, O. Boisseau, A. Moscrop, C.M. Fortuna, G. Lauriano, D. Holcer, H. Peltier, V. Ridoux, J.A. Raga, J. Tomás, A.C. Broderick, B.J. Godley, J. Haywood, D. March, R. Snape, R. Sagarminaga, and S. Hochscheid. 2022. Basin-wide estimates of loggerhead turtle abundance in the Mediterranean Sea derived from line transect surveys. *Frontiers in Marine Science* 9(930412). 10.3389/fmars.2022.930412.

DiMatteo, A., J.J. Roberts, D. Jones, L. Garrison, K.M. Hart, R.D. Kenney, W.A. McClellan, K. Lomac-MacNair, D. Palka, M.E. Rickard, K.E. Roberts, A.M. Zoidis, and L. Sparks. 2024. Sea turtle density surface models along the United States Atlantic coast. *Endangered Species Research* 53:227–245. Accessed at https://doi.org/10.3354/esr01298.

Douglas, D.C., R. Weinzierl, S. Davidson, R. Kays, M. Wikelski, and G. Bohrer. 2012. Moderating Argos location errors in animal tracking data. Methods in *Ecology and Evolution* 3:999–1007. Accessed at https://doi.org/10.1111/j.2041-210X.2012.00245.x.

Fuentes, M.M.P.B., I. Bel, R. Hagihara, M. Hamann, J. Hazel, A. Huth, J.A. Seminoff, S. Sobtzick, and H. Marsh. 2015. Improving in-water estimates of marine turtle abundance by adjusting aerial survey counts for perception and availability biases. *Journal of Experimental Marine Biology and Ecology* 471:77–83. Accessed at https://doi.org/10.1016/j.jembe.2015.05.003.

Hatch, J.M., H.L. Haas, C.R. Sasso, S.H. Patel, and R.J. Smolowitz. 2022. Estimating the complex patterns of survey availability for loggerhead turtles. *Journal of Wildlife Management* 86:e22208. Accessed at https://doi.org/10.1002/jwmg.22208.

Hochscheid, S. 2014. Why we mind sea turtles' underwater business: A review on the study of diving behavior. *Journal of Experimental Marine Biology and Ecology* 450:118–136. Accessed at https://doi.org/10.1016/j.jembe.2013.10.016.

Jonsen, I.D., T.A. Patterson, D.P. Costa, P.D. Doherty, B.J. Godley, W.J. Grecian, C. Guinet, X. Hoenner, S.S. Kienle, P.W. Robinson, S.C. Votier, S. Whiting, M.J. Witt, M.A. Hindell, R.G. Harcourt, and C.R. McMahon. 2020. A continuous-time state-space model for rapid quality control of Argos locations from animal-borne tags. *Movement Ecology* 8:31. Accessed at https://doi.org/10.1186/s40462-020-00217-7.

Jonsen, I.D., W.J. Grecian, L. Phillips, G. Carroll, C. McMahon, R.G. Harcourt, M.A. Hindell, and T.A. Patterson. 2023. aniMotum, an R package for animal movement data: Rapid quality control, behavioural estimation and simulation. *Methods in Ecology and Evolution* 14:806–816. Accessed at https://doi.org/10.1111/2041-210X.14060.

Laake, J., J. Calambokidis, S. Osmek, and D. Rugh. 1997. Probability of detecting harbor porpoise from aerial surveys: estimating g(0). *The Journal of Wildlife Management* 61(1):63–75.

Mansfield, K.L. 2006. Sources of mortality, movements and behavior of sea turtles in Virginia. PhD dissertation, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia.

Massachusetts Audubon Society. 2024. Sea Turtle Sightings Map. Online Database. Accessed 11 November 2024 at https://seaturtlesightings.org/speciesmap.html.

Roberts, J., B. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, L.P. Garrison, K.D. Mullin, T.V.N. Cole, C.B. Khan, W.A. McClellan, D.A. Pabst, and G.G. Lockhart. 2016. Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. *Scientific Reports* 6:22615. Accessed at https://doi.org/10.1038/srep22615.

Roberts, K.E., L.P. Garrison, J. Ortega-Ortiz, C. Hu, Y. Zhang, C.R. Sasso, M. Lamont, and K.M. Hart. 2022. The Influence of Satellite-Derived Environmental and Oceanographic Parameters on Marine Turtle Time at Surface in the Gulf of Mexico. *Remote Sensing* 14:4534. Accessed at https://doi.org/10.3390/rs14184534.

Rogers, R., K.H. Choate, L.M. Crowe, J.M. Hatch, M.C. James, E. Matzen, S.H. Patel, C. R. Sasso, L.A. Siemann, and H.L. Haas. 2024. Investigating leatherback surface behavior using a novel tag design and machine learning. *Journal of Experimental Marine Biology and Ecology* 576. Accessed at https://doi.org/10.1016/j.jembe.2024.152012.

Sloan, K.A., D.S. Addison, A.T. Glinsky, A.M. Benscoter, and K.M. Hart. 2022. Inter-Nesting Movements, Migratory Pathways, and Resident Foraging Areas of Green Sea Turtles (*Chelonia mydas*) Satellite-Tagged in Southwest Florida. *Frontiers in Marine Science* 8. DOI=10.3389/fmars.2021.775367.

Thomson, J.A., A.B. Cooper, D.A. Burkholder, M.R. Heithaus, and L.M. Dill. 2013. Correcting for heterogeneous availability bias in surveys of long-diving marine turtles. *Biological Conservation* 165:154–161. Accessed at https://doi.org/10.1016/j.biocon.2013.06.005.

Welsh, R.C., and K.L. Mansfield. 2022. Intraspecific spatial segregation on a green turtle foraging ground in the Florida Keys, USA. *Marine Biology* 169:22. Accessed at https://doi.org/10.1007/s00227-021-04012-9.

Appendix A. Sample Tag Programming Report

Host Settings	
MK10Host version	1.27.0002
User Name	Ka333757
Time And Date Settings	
PC Date (UTC)	12 Jun 2024 at 19:09:11
Tag Date	12 Jun 2024 at 19:09:10
PC UTC offset	4 hours
General Settings	
Tag's Serial Number	24A0493
Password	MK10
User's Identifier	...
Argos Ptt number	264805 (82BE15F Hex) Uplink / LUT id: 8367:95
Repetition Intervals	15s (at-sea); 88s (haulout)
Number of Argos transmissions	397
Tagware version	1.27c
Hardware version	10.5
Battery Configuration	2 x AA
Battery Capacity (from manufacturer's datasheet)	4000mAh
Battery is not classified as dangerous goods	
Deploy from Standby on Depth Change?	Yes
Owner	Wildlife Computers 8310 154th Ave NE, Suite 150 Redmond, WA 98052 USA +1-425-881-3048
Bytes of archive data collected	0
Bytes of histogram and profile data collected	0
Data to Archive Settings	
Depth	1 second
Internal Temperature	never
External Temperature	1 second
Depth Sensor Temperature	never
Light Level	never
Battery Voltage	never
Wet/Dry	1 second
Wet/Dry Threshold	Dynamic (initial value = 80)
Sampling Mode	Wet or Dry
Automatic Correction of Depth Transducer Drift	Using first dry reading
Data to Transmit Settings	
Histogram Selection	
Histogram Data sampling interval	1 seconds
Dive Maximum Depth (m), 14 bins	2; 5; 10; 15; 20; 25; 30; 35; 40; 50; 60; 70; 80; >80
Dive Duration, 14 bins	3 mins ; 5 mins ; 10 mins ; 20 mins ; 30 mins ; 40 mins ; 60 mins ; 80 mins ; 100 mins ; 120 mins ; 180 mins ; 240 mins ; 273 mins 2secs; >273 mins 2secs
Time-at-Temperature (C), 14 bins	8; 10; 12; 14; 16; 18; 20; 22; 24; 26; 28; 30; 32; >32

Time-at-Depth (m), 14 bins	2; 3; 4; 5; 10; 15; 20; 25; 30; 40; 50; 60; 100; >100
20-min time-line	disabled
Hourly % time-line (low resolution)	disabled
Hourly % time-line (high resolution)	enabled
Dry/Deep/Neither time-lines	Disabled
PAT-style depth-temperature profiles	disabled
Deepest-depth-temperature profiles	disabled
Light-level locations	disabled
Histogram Collection	
Hours of data summarized in each histogram	4
Histograms start at GMT	00:00
Do not create new Histogram-style messages if a tag is continuously dry throughout a Histogram collection period	is disabled
Time-Series Messages	
Generation of time-series messages	is disabled
Dive & Timeline Definition	
Depth reading to determine start and end of dive	2m
Ignore dives shallower than	2m
Ignore dives shorter than	1m
Depth threshold for timelines	2m
Behavior Messages	
Generation of behavior messages	is enabled
Stomach Temperature Messages	
Generation of stomach temperature messages	is disabled
Haulout Definition	
A minute is "dry" if Wet/Dry sensor is dry for any ***value*** seconds in a minute	30
Enter haulout state after ***value*** consecutive dry minutes	10
Exit haulout state if wet for any ***value*** seconds in a minute	30
Transmission Control	
Transmit data collected over these last days	7
Pause transmissions if haulout exceeds	never pause
Transmit every eighth day if transmissions are paused	is enabled
Collection days	
January	1 - 31
February	1 - 29
March	1 - 31
April	1 - 30
May	1 - 31
June	1 - 30
July	1 - 31
August	1 - 31
September	1 - 30
October	1 - 31

November	1 - 30
December	1 - 31
Relative transmit Priorities	
Histogram, Profiles, Time-lines, Stomach Temperature	high (3 transmission(s))
Fastloc and Light-level Locations	none (0 transmission(s))
Behavior and Time-Series	med (2 transmission(s))
Status	Every 20 transmissions
When to Transmit Settings	
Initially transmit for these hours regardless of settings below	24
Transmit hours	0 - 23
Transmit days	
January	1 - 31
February	1 - 29
March	1 - 31
April	1 - 30
May	1 - 31
June	1 - 30
July	1 - 31
August	1 - 31
September	1 - 30
October	1 - 31
November	1 - 30
December	1 - 31
Daily Transmit Allowance	
January	500 [Accumulate, Optimize for battery life]
February	500 [Accumulate, Optimize for battery life]
March	500 [Accumulate, Optimize for battery life]
April	500 [Accumulate, Optimize for battery life]
May	500 [Accumulate, Optimize for battery life]
June	500 [Accumulate, Optimize for battery life]
July	500 [Accumulate, Optimize for battery life]
August	500 [Accumulate, Optimize for battery life]
September	500 [Accumulate, Optimize for battery life]
October	500 [Accumulate, Optimize for battery life]
November	500 [Accumulate, Optimize for battery life]
December	500 [Accumulate, Optimize for battery life]
Channel Settings	
Depth	Channel: 0; Range: -40m to 1000m; Resolution: 0.5m; ADaddress: 02; Settling Delay: 1.5ms
Correction factors	0.0e0, 1.0, 3.0 1.155e-10, 3.863e-7, 0.9392, 1.289 0.0e0, 0.0e0, 1.0, 0.0
Errors	None
Compensation factors	7.643e-9, -3.297e-5, 0.0735, -52.97
Errors	None
Internal Temperature	Channel: 1; Range: -40C to 60C; Resolution: 0.05C; ADaddress: 04; Settling Delay: 0.5ms
Correction factors	9.466e-8, 0.0002, 0.001 9.137e-7, -1.313e-4, 1.0014, -0.245

	0.0e0, 0.0e0, 1.0, 0.0
Errors	None
External Temperature	Channel: 2; Range: -40C to 60C; Resolution: 0.05C; ADaddress: 03; Settling Delay: 0.5ms
Correction factors	8.767e-8, 0.0002, 0.001 2.921e-6, -2.179e-4, 1.0048, -0.18 0.0e0, 0.0e0, 1.0, 0.0
Errors	None
Depth Sensor Temperature	Channel: 3; Range: -40C to 60C; Resolution: 0.05C; ADaddress: 05; Settling Delay: 0.5ms
Correction factors	1.62e-7, 0.0003, 0.001 4.157e-6, -2.264e-4, 1.004, 0.036 0.0e0, 0.0e0, 1.0, 0.0
Errors	None
Light Level	Channel: 4; Range: 0 to 256; Resolution: 0.25; ADaddress: 12; Settling Delay: 3.5ms
Compensation factors	0.0e0, 0.0e0, 0.0, 0.
Errors	None
Battery Voltage	Channel: 14; Range: 0V to 5V; Resolution: 0.0048V; ADaddress: 13; Settling Delay: 1.5ms
Wet/Dry	Channel: 15; Range: 0 to 255; Resolution: 1; ADaddress: 21; Settling Delay: 1.5ms

Messages:

Appendix B. Disposition of All Extant Tags

Table B-1. Disposition of all extant tags.

PTT	Serial #	Status	Holding organization	Point of contact
264805	24A0493	Awaiting distribution	University of Central Florida	K. Mansfield
264806	24A0495	Awaiting distribution	University of Central Florida	K. Mansfield
264807	24A0506	Awaiting distribution	University of Central Florida	K. Mansfield
264808	24A0507	Awaiting distribution	University of Central Florida	K. Mansfield
264809	24A0518	Awaiting distribution	University of Central Florida	K. Mansfield
264810	24A0519	Awaiting distribution	University of Central Florida	K. Mansfield
264811	24A0508	Awaiting distribution	University of Central Florida	K. Mansfield
264812	24A0531	Awaiting distribution	University of Central Florida	K. Mansfield
264813	24A0541	Awaiting distribution	University of Central Florida	K. Mansfield
264814	24A0545	Awaiting distribution	University of Central Florida	K. Mansfield
264815	24A0831	Deployed	University of Central Florida	K. Mansfield
264816	24A0489	Deployed	Inwater Research Group	R. Welsh
264817	—	Distributed	Inwater Research Group	R. Welsh
264818	24A0491	Deployed	Inwater Research Group	R. Welsh
264819	24A0494	Deployed	University of Central Florida	K. Mansfield
264820	24A0526	Deployed	University of Central Florida	K. Mansfield
264821	—	Awaiting distribution	University of Central Florida	K. Mansfield
264822	24A0528	Deployed	University of Central Florida	K. Mansfield
264823	24A0529	Deployed	University of Central Florida	K. Mansfield
264824	—	Distributed	Loggerhead MarineLife Center	J. Perrault
264825	24A0532	Deployed	University of Central Florida	K. Mansfield
264826	24A0533	Deployed	University of Central Florida	K. Mansfield
264827	24A0534	Deployed	University of Central Florida	K. Mansfield
264828	—	Distributed	Loggerhead MarineLife Center	J. Perrault
264829	—	Awaiting distribution	University of Central Florida	K. Mansfield
264830	24A0537	Deployed	University of Central Florida	K. Mansfield
264831	24A0538	Deployed	University of Central Florida	K. Mansfield
264832	—	Distributed	Loggerhead MarineLife Center	J. Perrault
264833	—	Distributed	Loggerhead MarineLife Center	J. Perrault
264834	24A0544	Deployed	University of Central Florida	K. Mansfield
264835	—	Distributed	Inwater Research Group	R. Welsh
264836	—	Distributed	Inwater Research Group	R. Welsh
264837	24A0546	Deployed	University of Central Florida	K. Mansfield
264838	—	Distributed	Loggerhead MarineLife Center	J. Perrault
264839	24A0548	Deployed	University of Central Florida	K. Mansfield
264840	24A0557	Awaiting distribution	University of Central Florida	K. Mansfield
264841	24A0558	Awaiting distribution	University of Central Florida	K. Mansfield
264842	24A0559	Awaiting distribution	University of Central Florida	K. Mansfield
264843	24A0560	Awaiting distribution	University of Central Florida	K. Mansfield
264844	24A0561	Awaiting distribution	University of Central Florida	K. Mansfield

PTT	Serial #	Status	Holding organization	Point of contact
264845	24A0562	Awaiting distribution	University of Central Florida	K. Mansfield
264846	24A0563	Awaiting distribution	University of Central Florida	K. Mansfield
264847	24A0564	Awaiting distribution	University of Central Florida	K. Mansfield
264848	24A0565	Awaiting distribution	University of Central Florida	K. Mansfield
264849	24A0566	Awaiting distribution	University of Central Florida	K. Mansfield
264850	24A0567	Awaiting distribution	University of Central Florida	K. Mansfield
264851	24A0568	Deployed	University of Central Florida	K. Mansfield
264852	24A0569	Awaiting distribution	University of Central Florida	K. Mansfield
264853	24A0571	Awaiting distribution	University of Central Florida	K. Mansfield
264854	24A0579	Awaiting distribution	University of Central Florida	K. Mansfield
264855	24A0580	Awaiting distribution	University of Central Florida	K. Mansfield
264856	24A0581	Awaiting distribution	University of Central Florida	K. Mansfield
264857	24A0582	Awaiting distribution	University of Central Florida	K. Mansfield
264858	24A0583	Awaiting distribution	University of Central Florida	K. Mansfield
264859	24A0677	Awaiting distribution	University of Central Florida	K. Mansfield
264860	24A0680	Awaiting distribution	University of Central Florida	K. Mansfield
264861	24A0681	Awaiting distribution	University of Central Florida	K. Mansfield
264862	24A0707	Awaiting distribution	University of Central Florida	K. Mansfield
264863	24A0708	Awaiting distribution	University of Central Florida	K. Mansfield
264864	24A0735	Awaiting distribution	University of Central Florida	K. Mansfield

Key: PTT = Platform Transmitter Terminal

Appendix C. Figures for Individual Tags

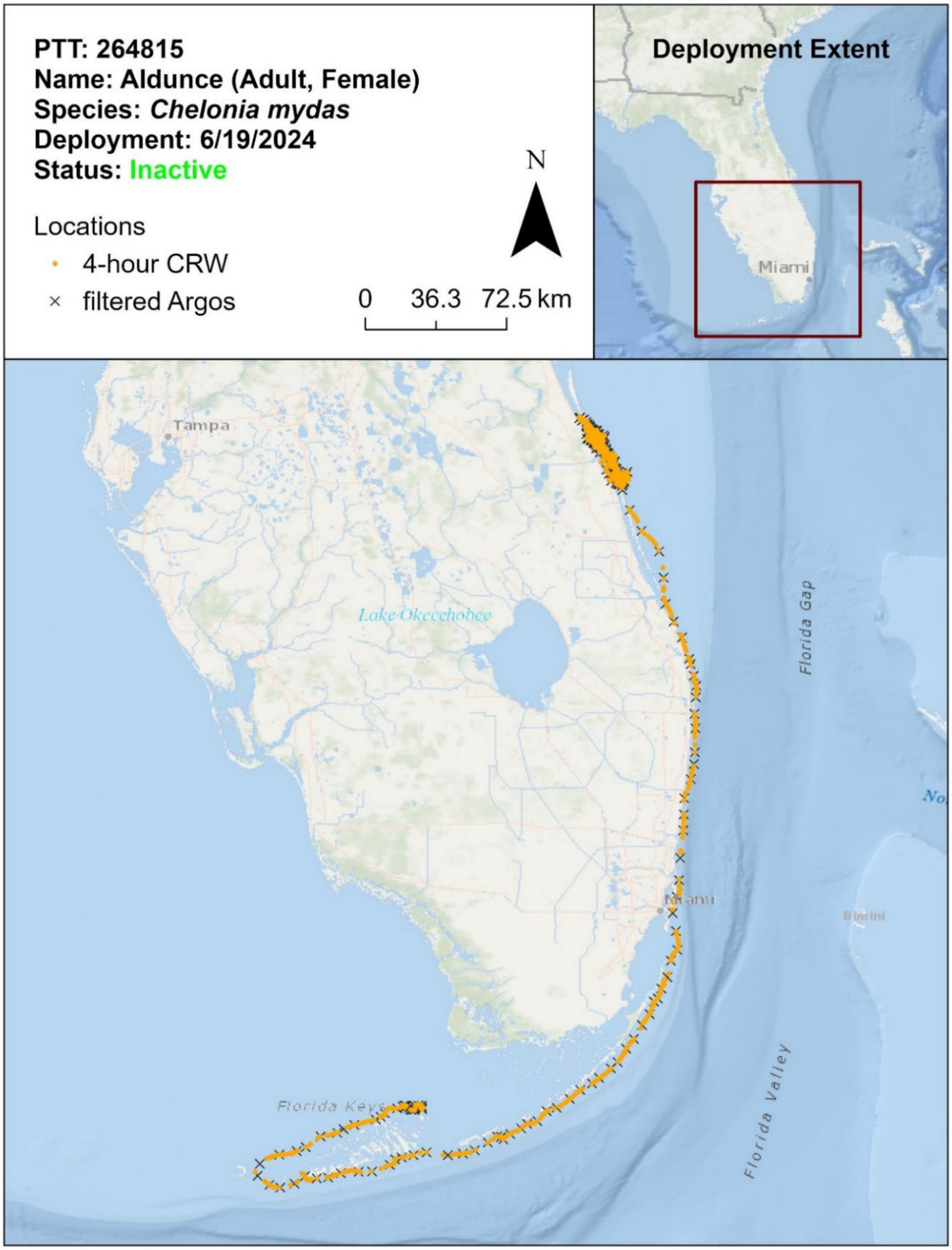

Figure C-1. Argos and 4-hour correlated random walk (CRW) locations for Platform Transmitter Terminal (PTT0 264815.

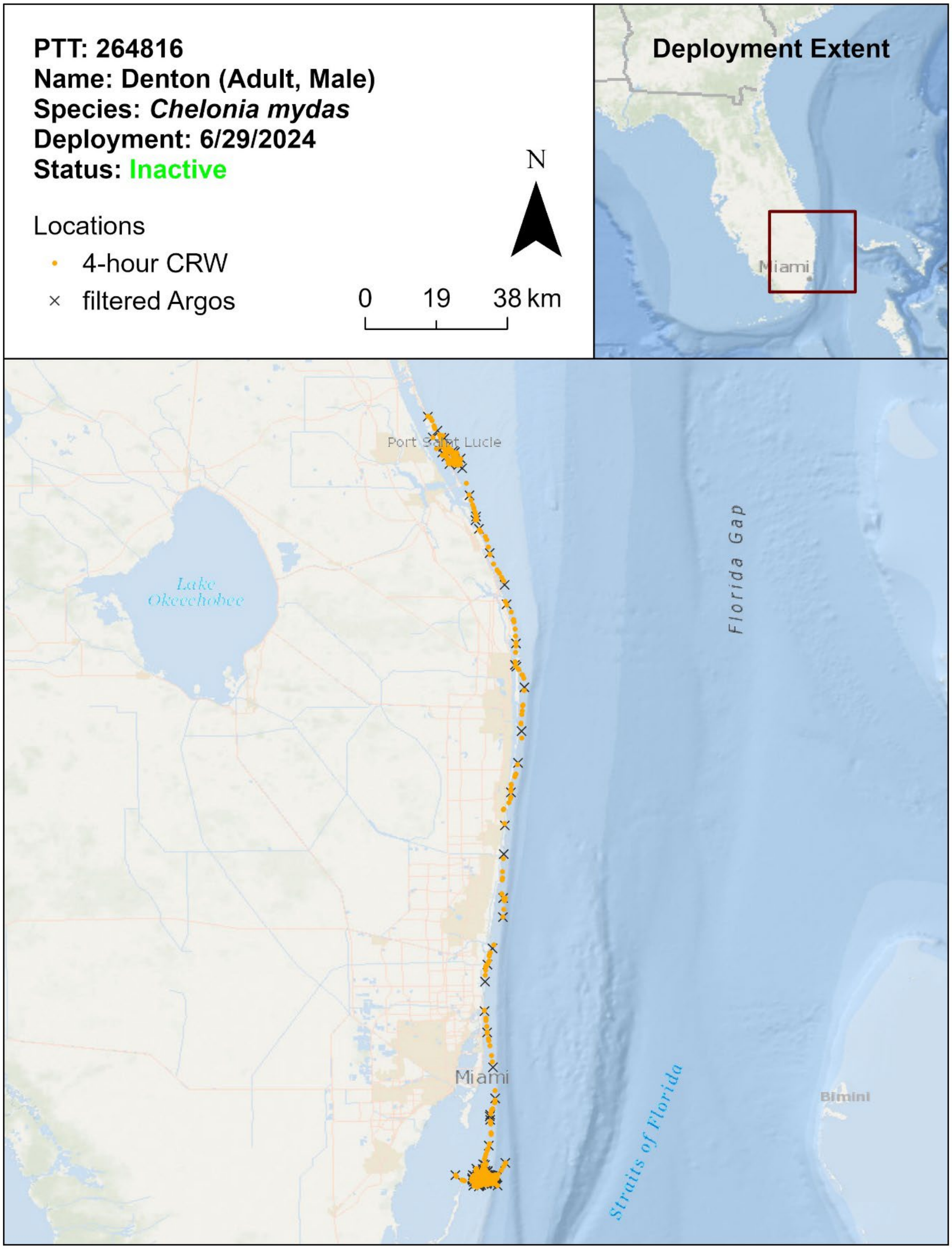

Figure C-2. Argos and 4-hour CRW locations for PTT 264816.

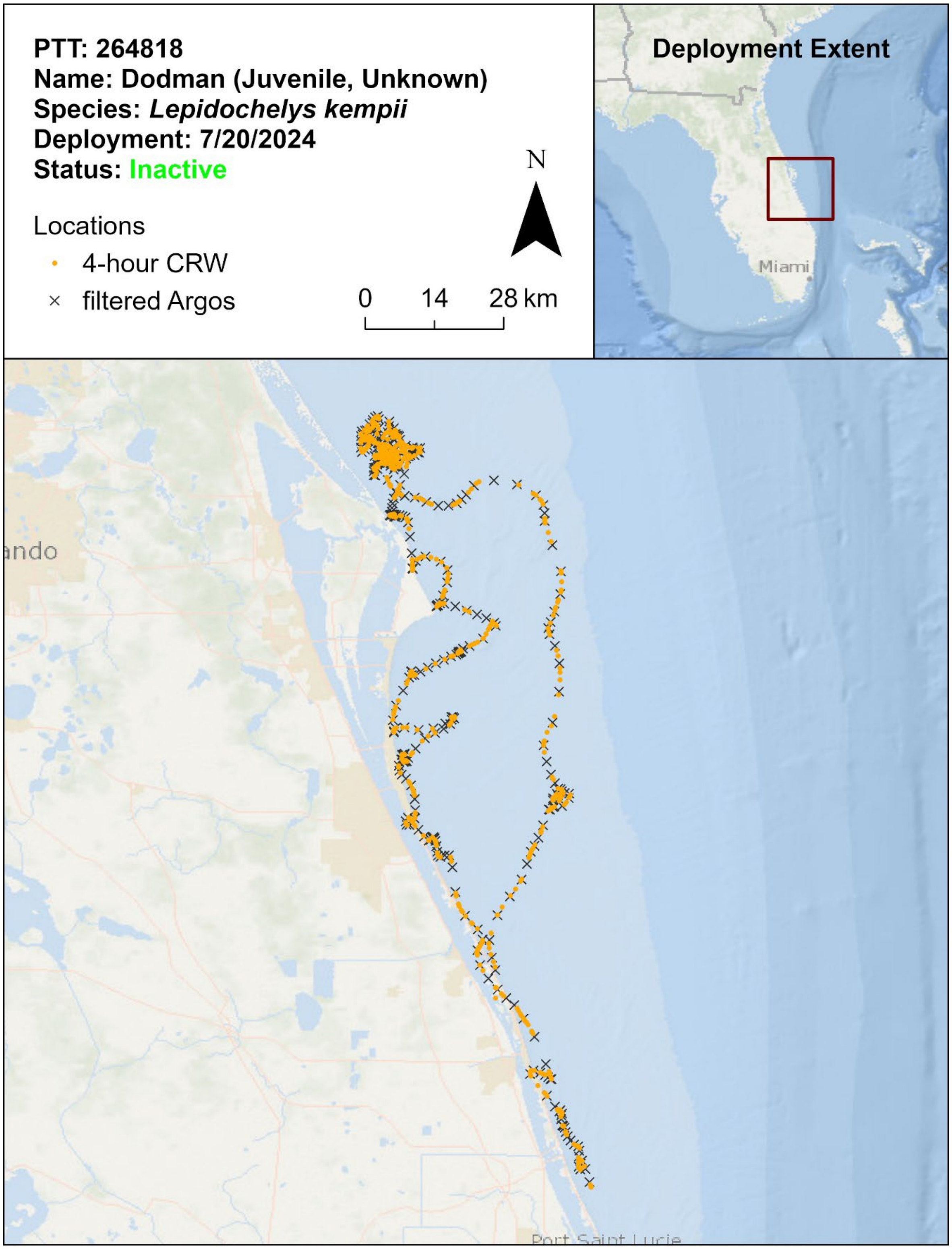

Figure C-3. Argos and 4-hour CRW locations for PTT 264818.

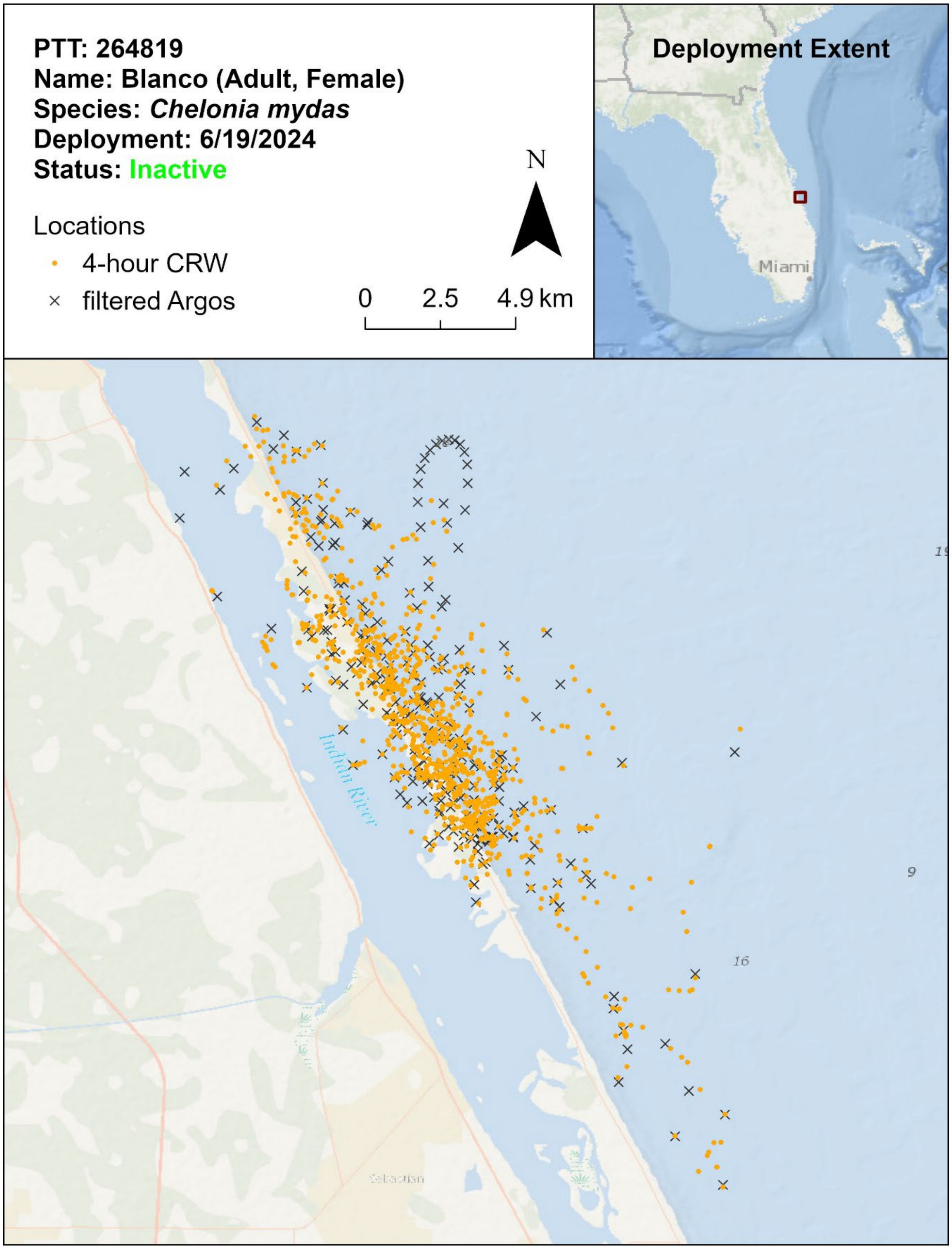

Figure C-4. Argos and 4-hour CRW locations for PTT 264819.

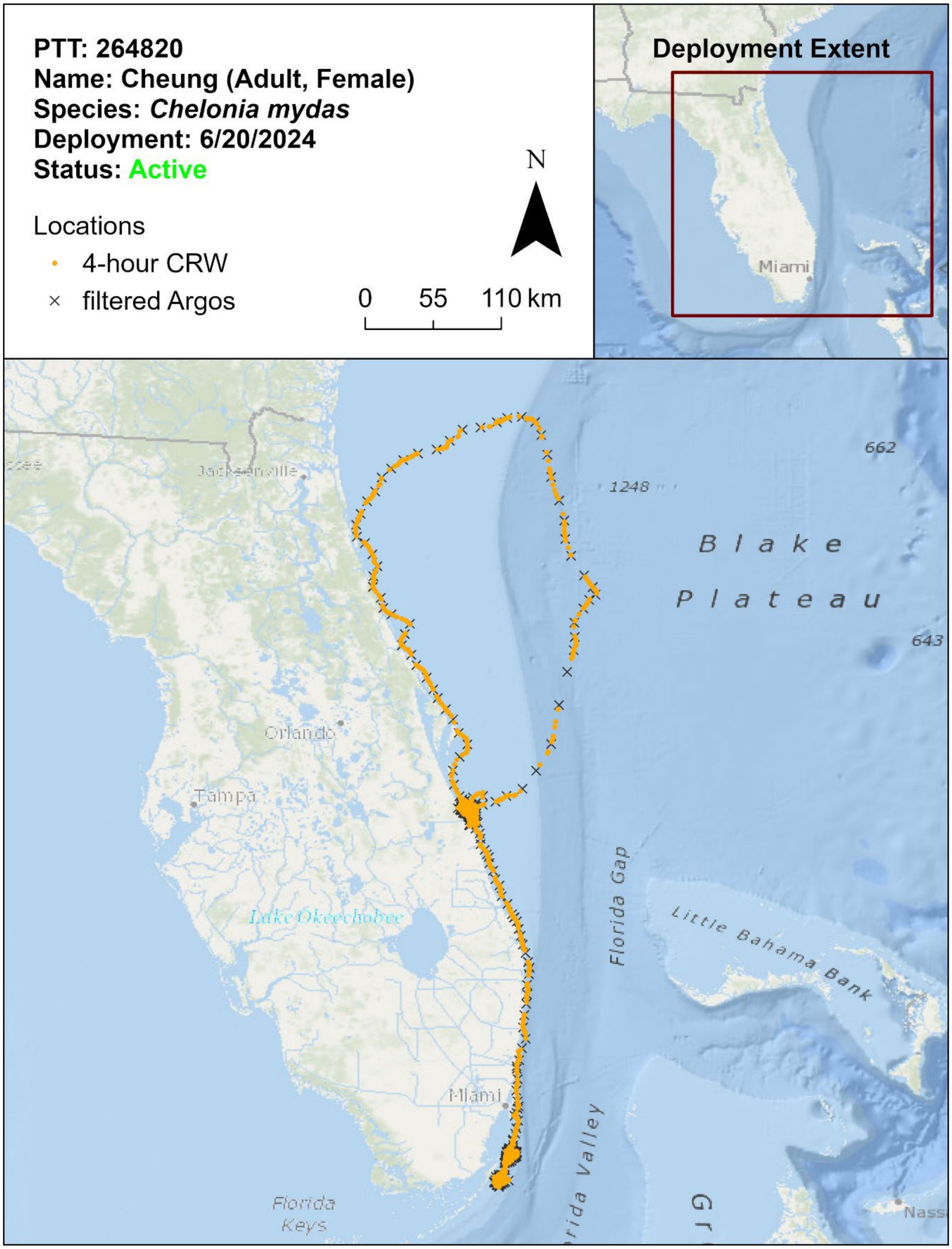

Figure C-5. Argos and 4-hour CRW locations for PTT 264820.

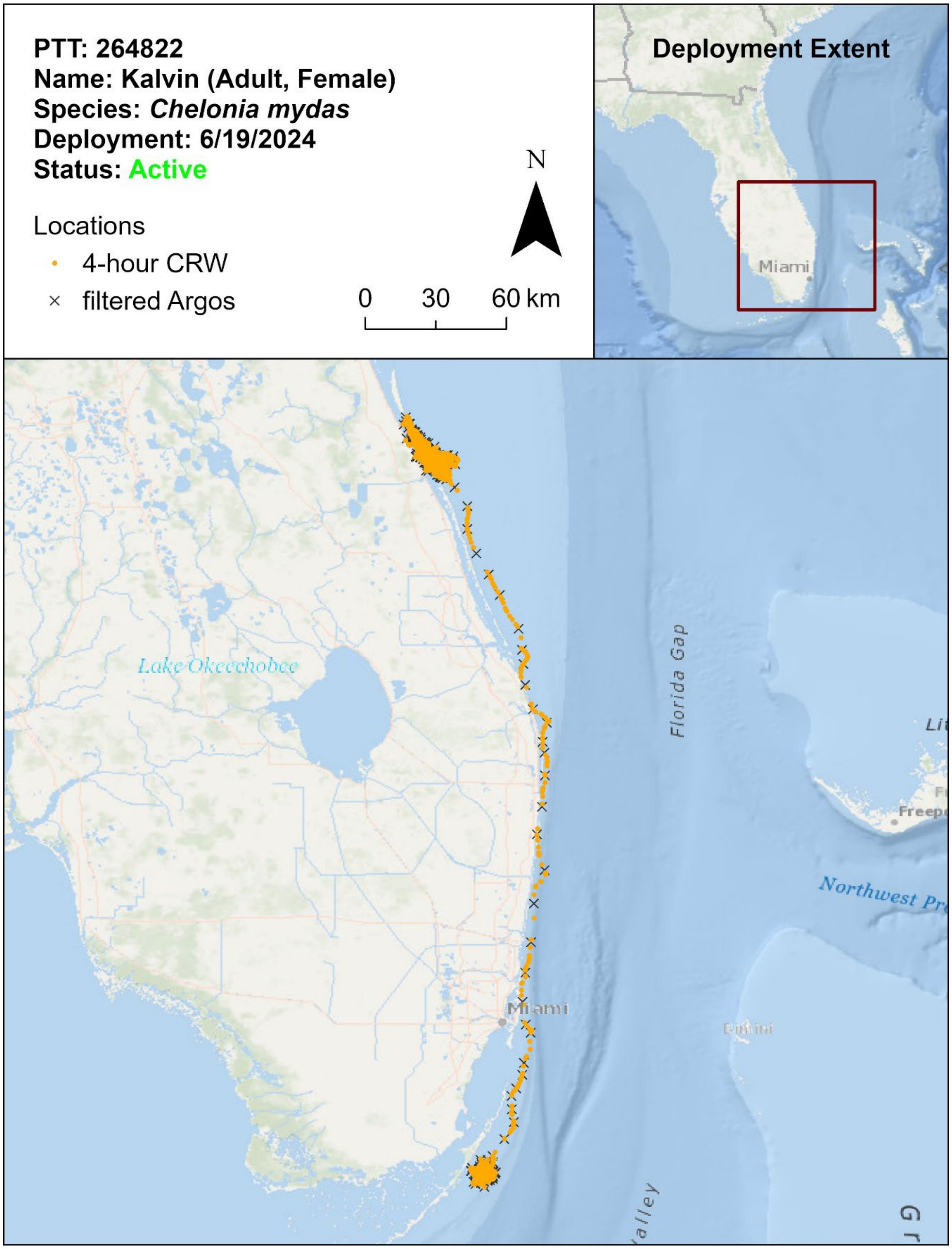

Figure C-6. Argos and 4-hour CRW locations for PTT 264822.

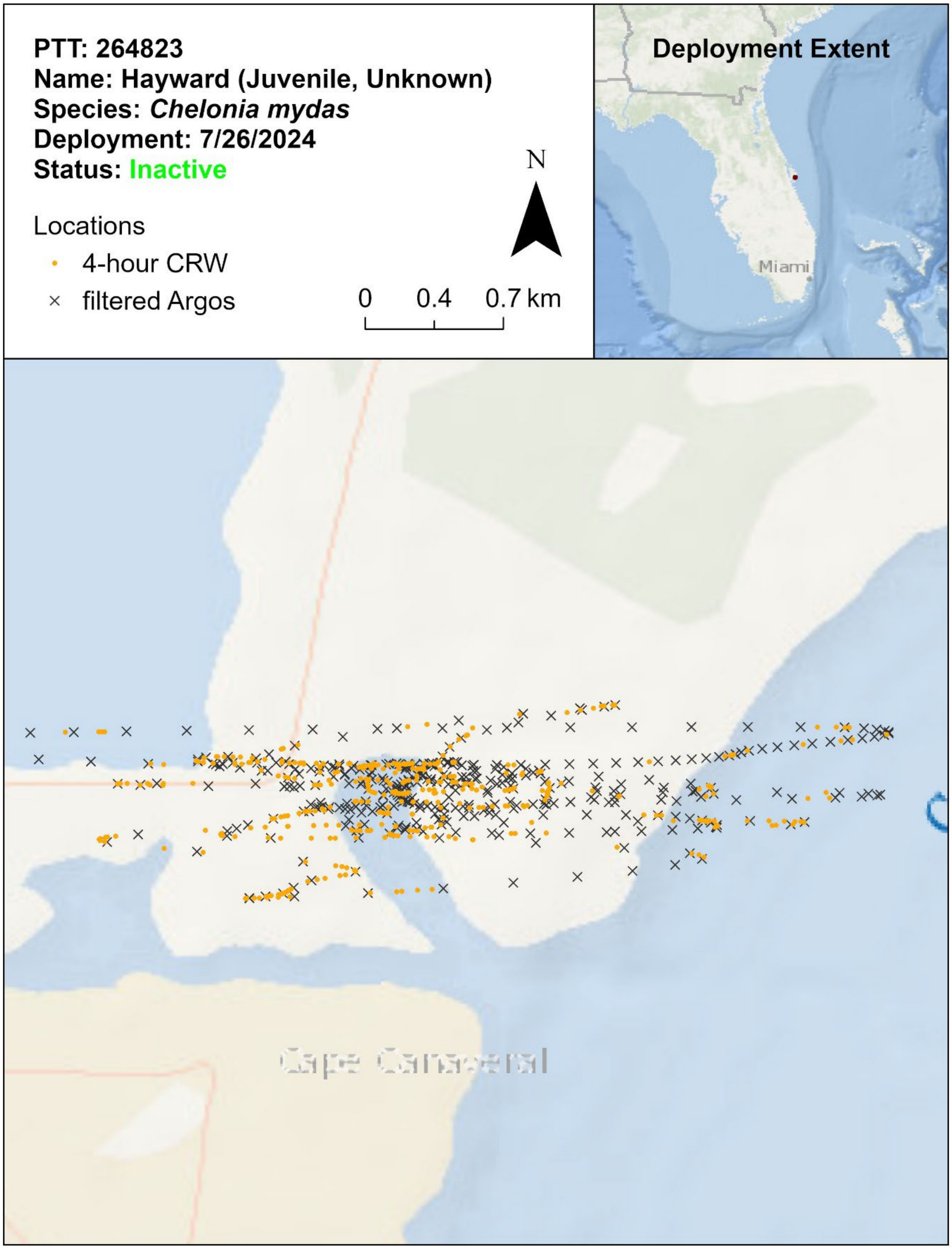

Figure C-7. Argos and 4-hour CRW locations for PTT 264823.

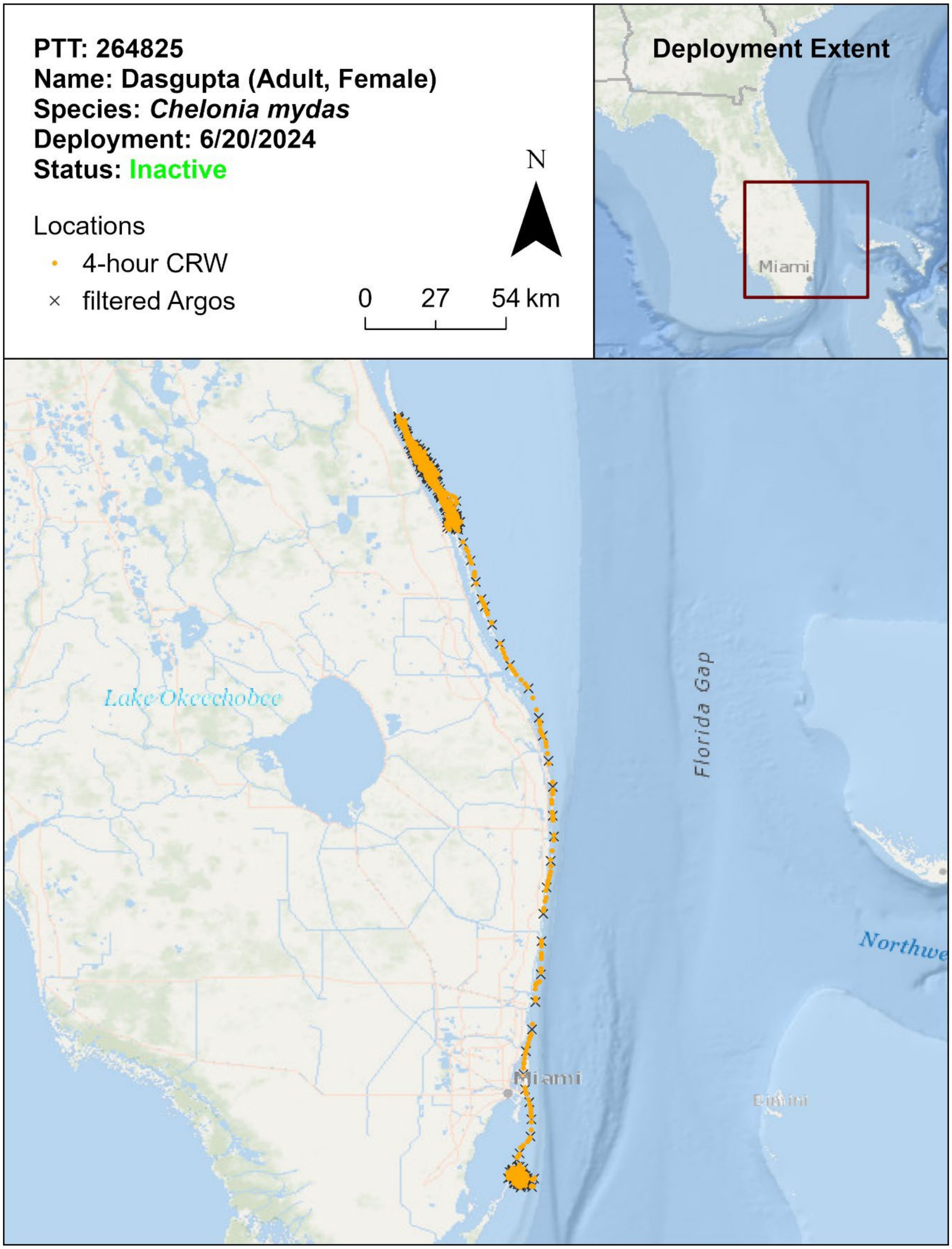

Figure C-8. Argos and 4-hour CRW locations for PTT 264825.

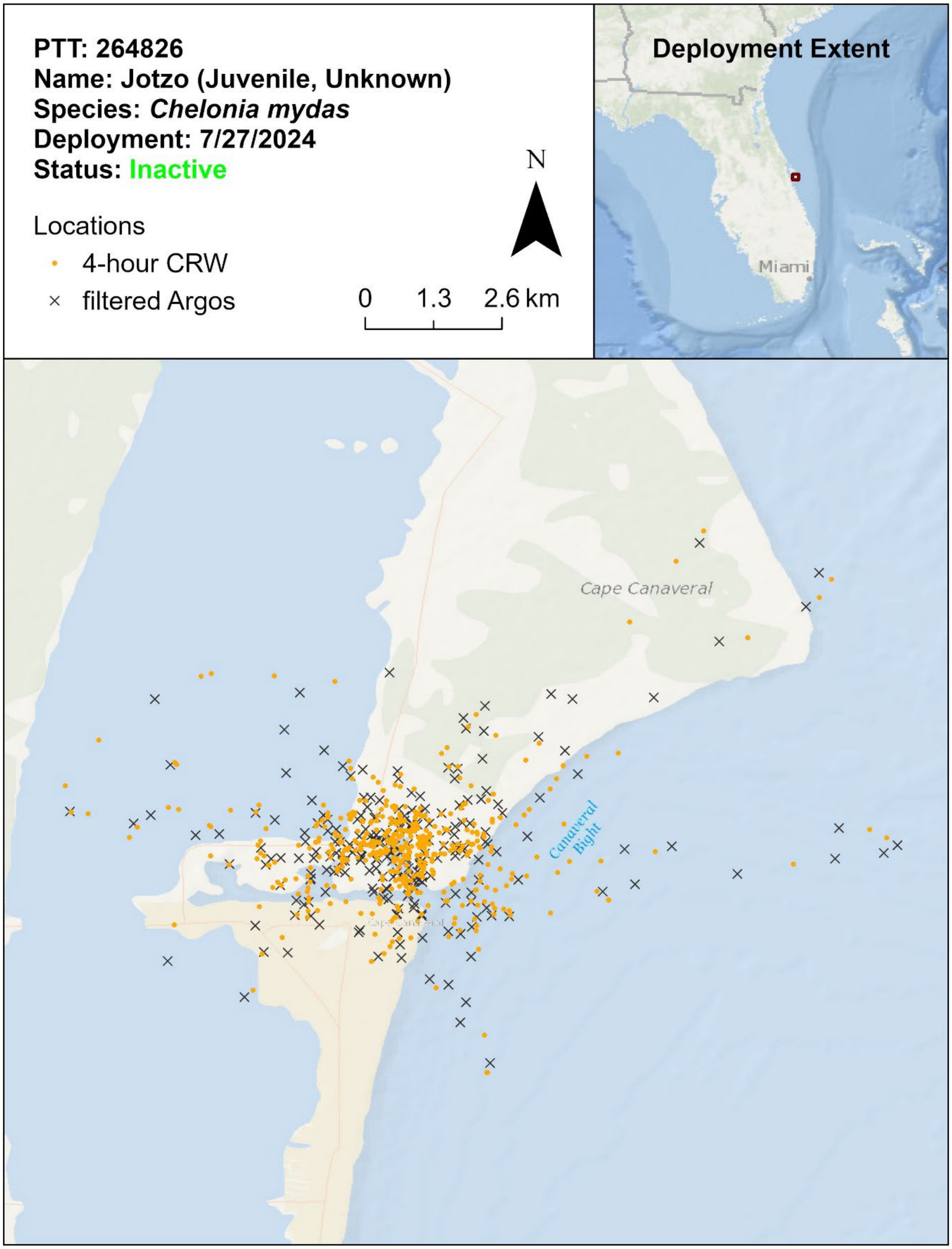

Figure C-9. Argos and 4-hour CRW locations for PTT 264826.

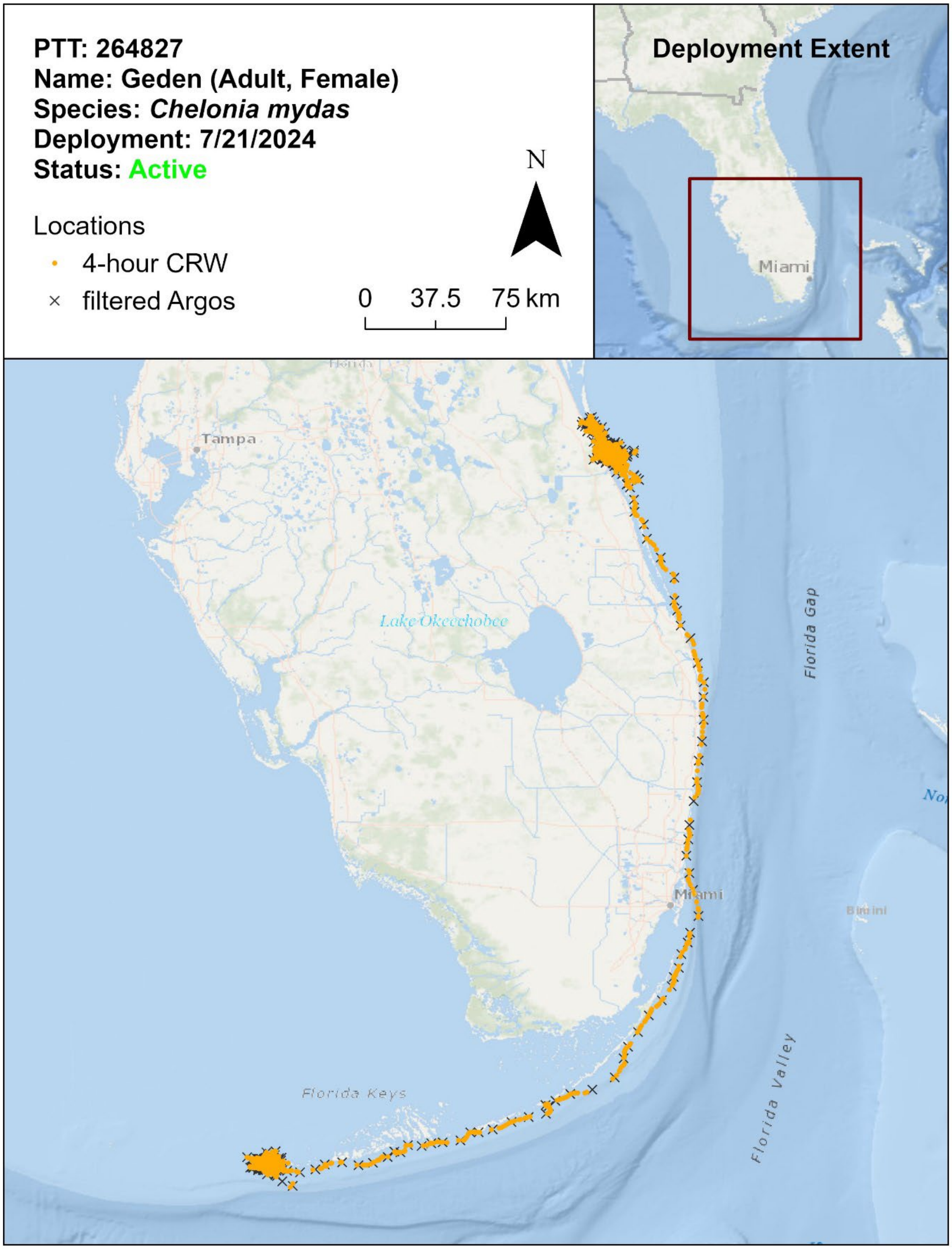

Figure C-10. Argos and 4-hour CRW locations for PTT 264827.

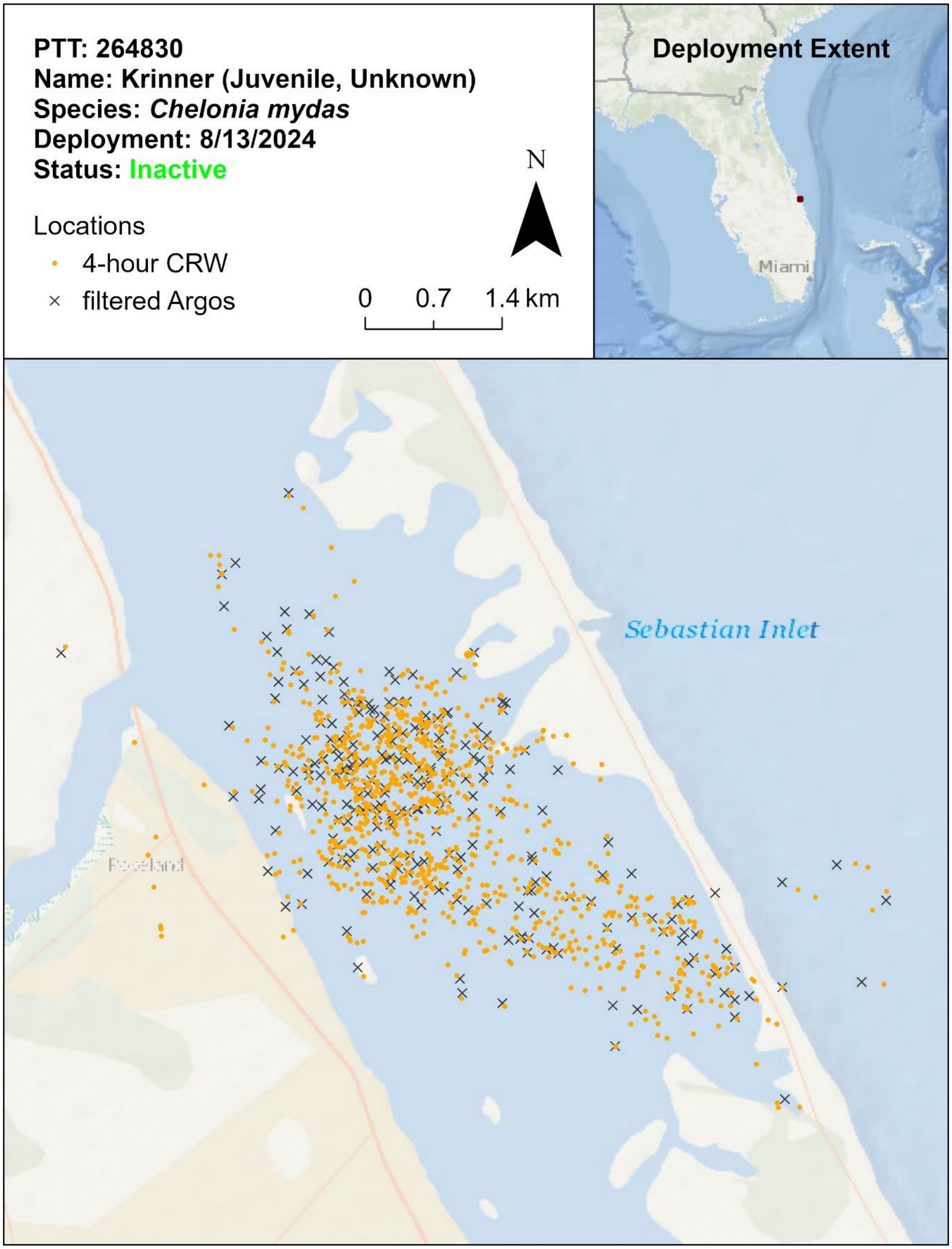

Figure C-11. Argos and 4-hour CRW locations for PTT 264830.

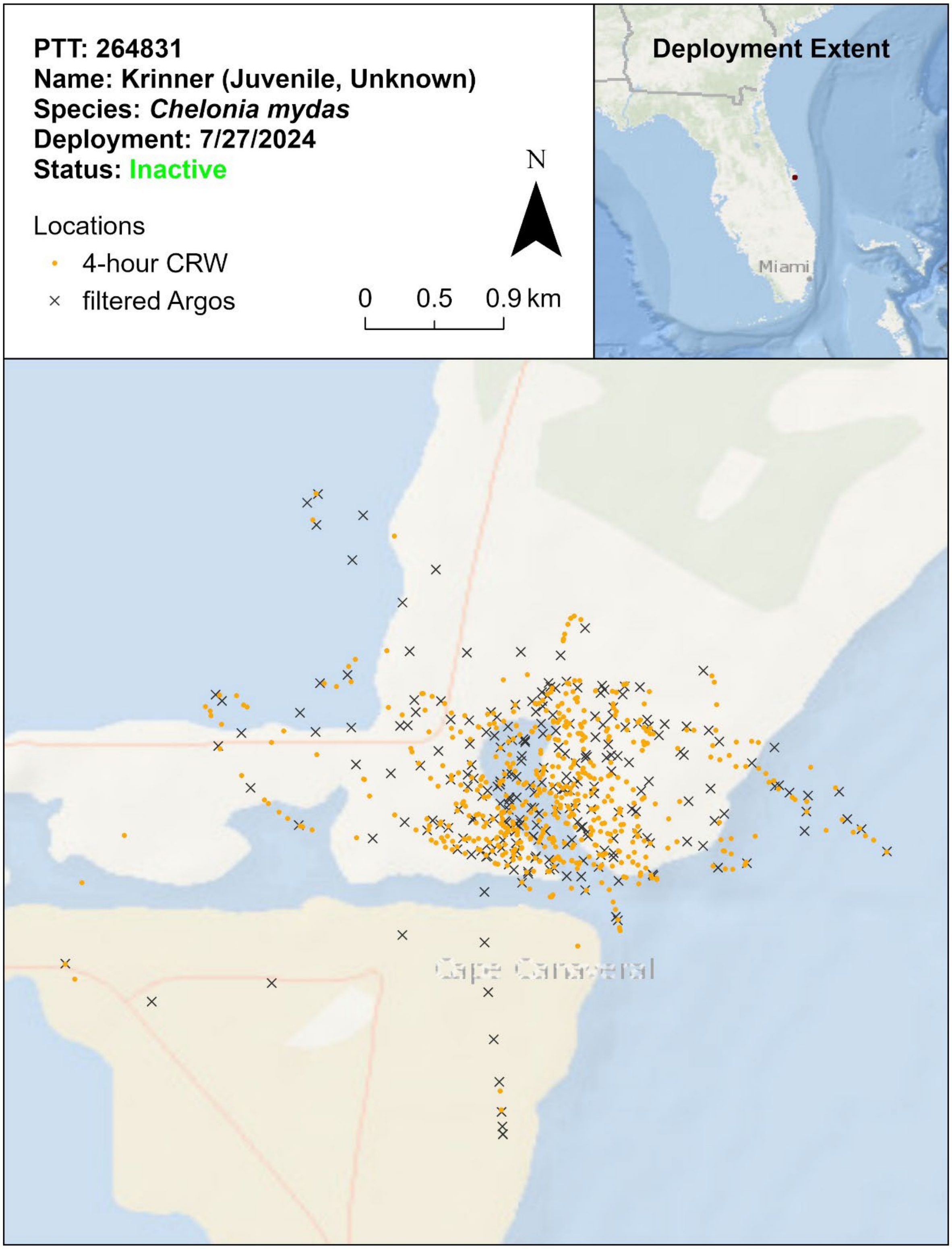

Figure C-12. Argos and 4-hour CRW locations for PTT 264831.

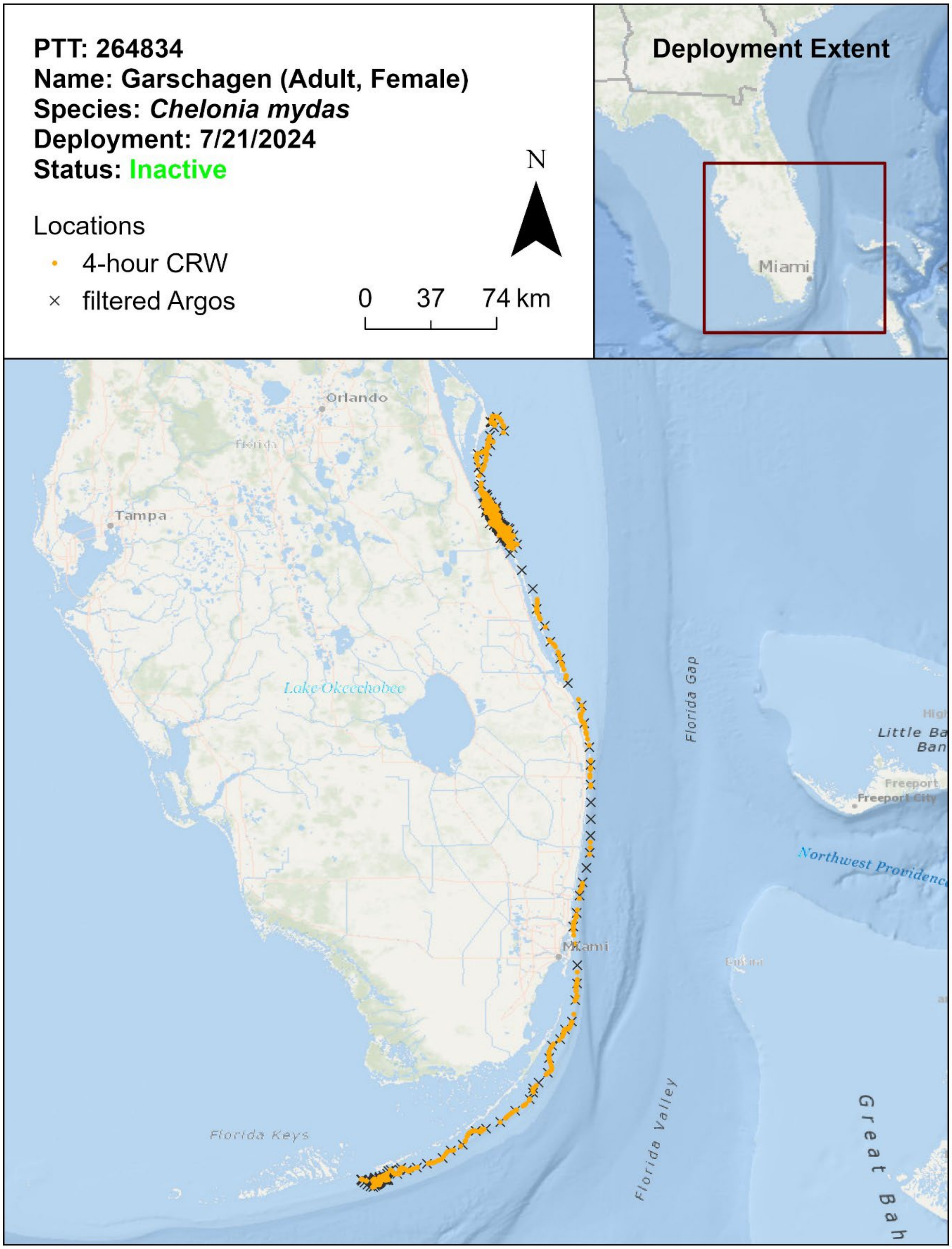

Figure C-13. Argos and 4-hour CRW locations for PTT 264834.

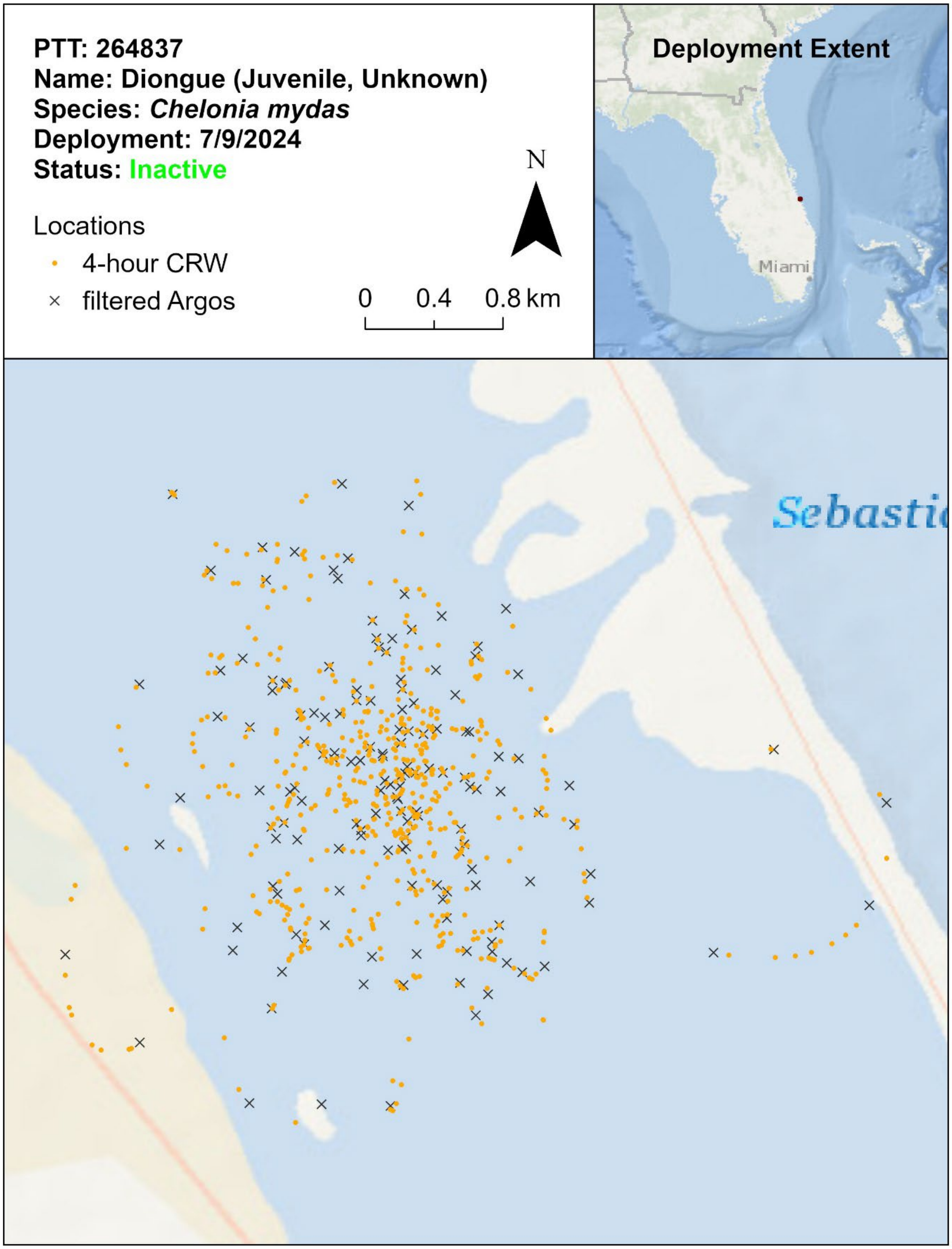

Figure C-14. Argos and 4-hour CRW locations for PTT 264837.

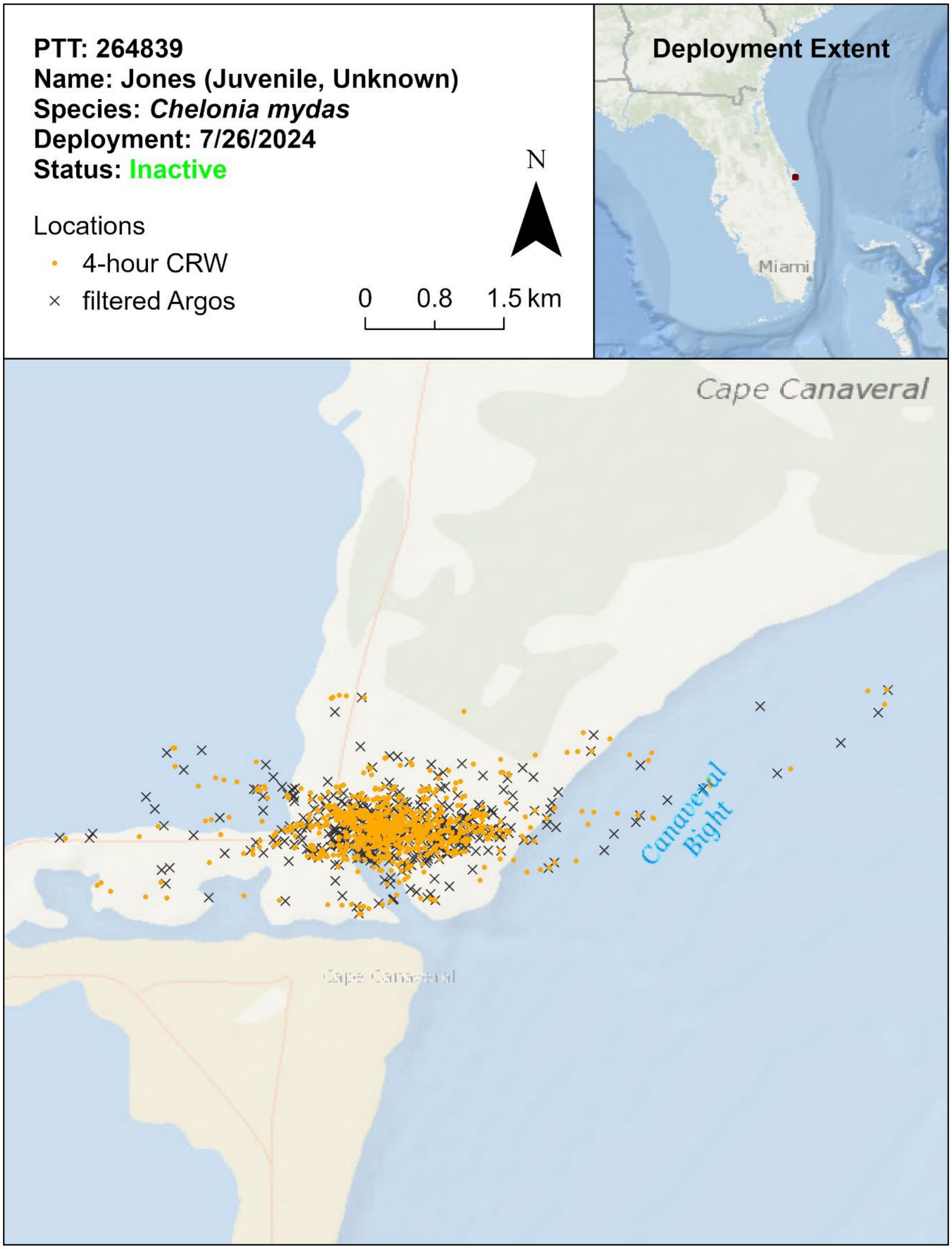

Figure C-15. Argos and 4-hour CRW locations for PTT 264839.

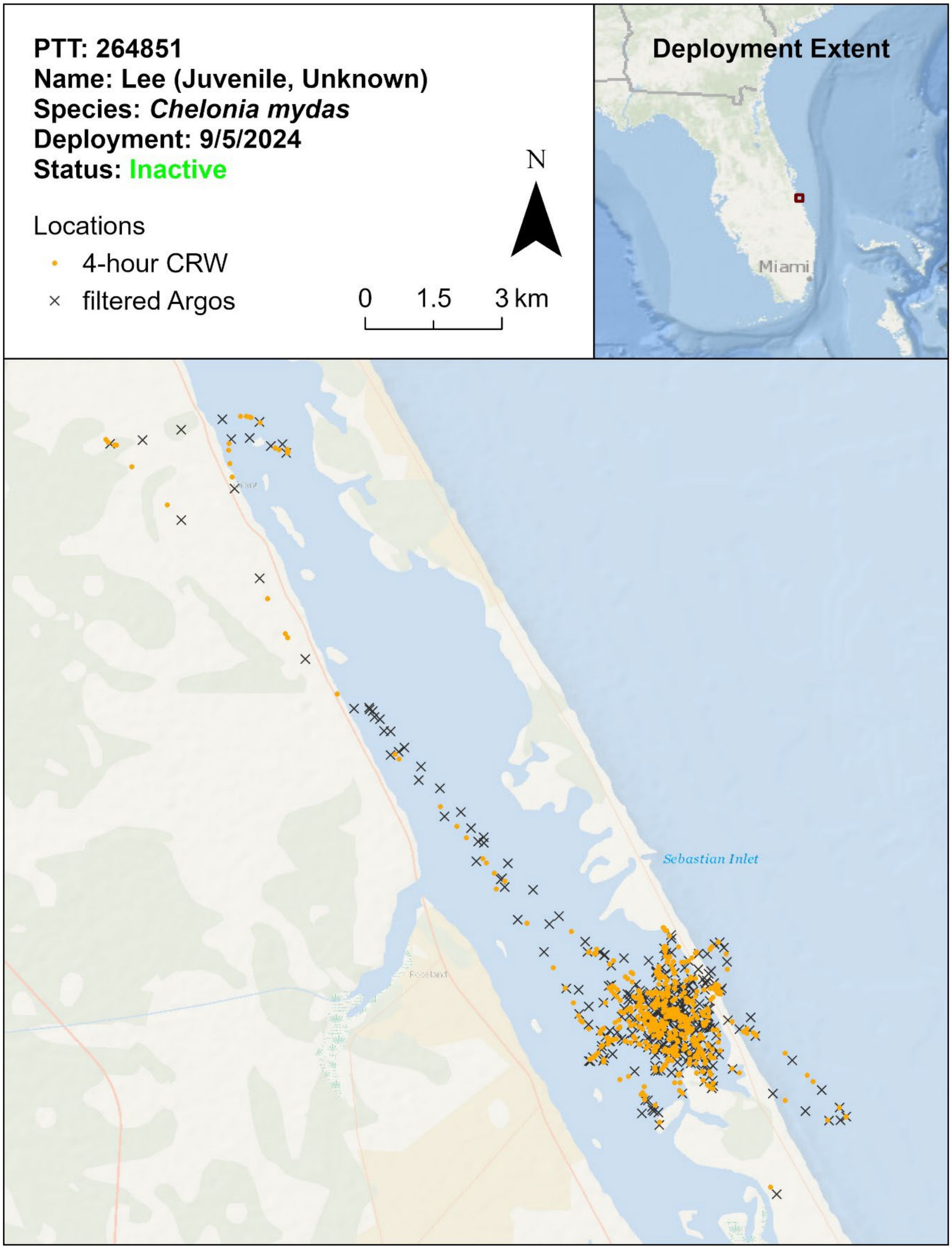

Figure C-16. Argos and 4-hour CRW locations for PTT 264851.