Demography and Connectivity of Sea Turtles at Three Distinct Habitats in the Gulf of Mexico

Final Report

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Inwater Research Group

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I. Cumulative Progress to Date

Final Results from the Marquesas Keys Sampling

We conducted three sampling efforts on the green turtle foraging grounds west of the Marquesas Keys between 8/15-8/18/17, 6/11-6/13/2018 and 8/20-8/25/2018 for a total of 13 field days. On each trip we completed the entirety of the 36 km standardized grid which consists of six, 6 km long transects where each transect line is 1 km apart from each other. During these standardized transects, 320 turtles were sighted, consisting of 102 adult green turtles (Chelonia mydas), 211 sub adult green turtles, five juvenile green turtles and two loggerhead sea turtles (Caretta caretta).

These transect data were entered into Distance Sampling software and the extrapolation analysis showed that the 30 km² foraging area had a density of approximately 132 green turtles per square kilometer (95% CI 1947-6929), indicating that there were an estimated 3,988 green turtles present during this sampling period. This analysis further breaks down the estimation by size class, resulting in approximating 1,421 adults (95% Confidence Interval range 476-4222) and 2,567 sub adults (95% CI 835-7676) present on the foraging grounds west of the Marquesas Keys.
Sea turtle sightings west of the Marquesas Keys, August 2017

Green turtle sightings west of the Marquesas Keys, June 2018

Green turtle sightings west of the Marquesas Keys, August 2018
In addition to the grid transects, we conducted 41.9 km of Haphazard unmarked non-linear transects (HUNTs) during capture efforts in 2017 and 2018. On these transects we observed 47 green turtles (1.12 turtles per km/transect), consisting of 10 adults and 37 sub adults. We also observed two adult and two sub adult loggerheads. There were an additional two Kemp’s ridley (Lepidochelys kempii) and two hawksbill (Eretmochelys imbricata) sea turtles observed off transect.

Of the 47 green turtles observed on HUNTs west of the Marquesas, 16 individuals were captured using the rodeo method. Captures included nine adults and seven sub adults. Green turtles that were captured ranged in straight carapace length (SCL) between 68.5 – 101.5 cm ($\bar{x} = 87.1$ cm, SD 11.9). There were an additional two juvenile green turtles (< 65.0 cm SCL) captured in Mooney Harbor, a shallow lagoon surrounded by the Marquesas Keys. Since 2004, we have captured 101 green turtles (51 adults, 50 sub adults) west of the Marquesas Keys that ranged from 66.5 – 108.5 cm SCL ($\bar{x} = 88.2$ cm, SD 10.6).

The foraging grounds west of the Marquesas Keys are unique because there are no known green turtle aggregations in the Gulf of Mexico or the Caribbean Basin with the density of sub adult and adult green turtles found at this site. Until this foraging ground was discovered in 2004, observations of adult green turtles outside of nesting season were rare. Sub adult green turtle observations were equally as rare year round. Data we’ve collected from one of the longest running sea turtle capture programs in U.S. shows this lack of adult and sub adult animals. Below is a graphic representation of green turtle size frequency capture data (n=6,490) collected at the St. Lucie Power Plant in Florida. We combined it with data (n=101) collected from the foraging ground west of the Marquesas Keys, showing how these data begin to fill in the size frequency gap that existed in Florida before 2004.

Nine of the 16 green turtles captured west of the Marquesas were adult animals and sex determinations could be made visually. Of those nine, there were six females and three males. There were also seven immature green turtles captured. Samples were collected from three of these turtles and they were determined to be females based on analysis by Southeastern Louisiana University. Excluding the undetermined gender of four green turtles, we had a 3:1 female to male ratio of green turtles captured during this report period. Looking at the historical sex determination data collected for green turtles in the Key West National Wildlife Refuge (KWNWR) and west of the Marquesas, we captured 99 females and 45 males for a female to male ratio of 2.2:1. Both time periods showed a significant female bias among sampled green turtles.

We analyzed the carbon and nitrogen stable isotope values of 228 loggerheads and 153 green turtles captured at the KWNWR study site between 2002 and 2015. Loggerhead epidermis samples (n=45) had $\delta^{13}C$ values ranging from –20.6 ‰ to –5.8 ‰ and $\delta^{15}N$ values from 3.4 ‰ to 9.4‰. Loggerhead red blood cell (RBC) samples (n=223) had $\delta^{13}C$ values ranging from –21.3 ‰ to –8.5 ‰ and $\delta^{15}N$ values from 0.2 ‰ to 9.9‰. Green turtle epidermis samples (n=45) had $\delta^{13}C$ values ranging from –15.9 ‰ to –6.6 ‰ and $\delta^{15}N$ values from 3.7 ‰ to 8.1‰. Green turtle RBC samples (n=108) had $\delta^{13}C$ values ranging from –18.7 ‰ to –7.8 ‰ and $\delta^{15}N$ values from 1.2 ‰ to 7.7‰.

The isotopic niche of the two species overlapped regardless of the tissue used. Surprisingly, we found no differences in $\delta^{13}C$ and $\delta^{15}N$ between loggerheads and green turtles. Mean loggerhead size (SCL$_{nt}$) was 73.5cm (SD ± 9.2cm) and ranged between 52.4cm and 102.6cm; thus, the aggregation we sampled was comprised mostly of subadults and adults and to a lesser extent juveniles. Mean green turtle size (SCL$_{nt}$) was 50.6 cm (SD ± 14.9cm) and ranged between 25.5cm and 74.5cm; thus, all individual examined were juveniles.

In contrast to other studies, we found no relationship between body size and $\delta^{15}N$ values for either species. Both species showed a wide range of nitrogen values suggesting plasticity in diet among individuals deserving further investigation. A subset of loggerheads (n=15) was sampled repeatedly (2-8 years among sampling events) and isotopic values remained remarkably consistent for all but one individual suggesting temporal stability of the isotopic baseline, an hypothesis that should be further investigated with a larger sample size of recapture individuals and the use of both bulk and amino acid isotope analysis. The KWNWR (this study site) and Florida Bay are the two primary foraging areas located in shallow waters used by adult loggerheads nesting in Florida. Thus, this study (a comprehensive isotopic characterization of loggerheads residing at the KWNWR) provides information that will improve current isoscapes and geographic assignment models for Northwest Atlantic loggerheads.

**Final Results from Big Bend Sampling**

In 2017 we conducted a total of 15 days of sampling for sea turtles in the Big Bend region of Florida during May, June and September. In this time period we conducted 18.0 km of fixed transects and observed 144 green turtles, six Kemp’s ridleys and four loggerheads for an Sightings Per Unit Effort (SPUE) of 8.0 green turtles, 0.3 Kemp’s ridleys and 0.2
loggerheads/km of transect. These data were not analyzed using Distance Sampling software because the transects were recently established and would have to be run more than once to obtain significant abundance extrapolations.

HUNTs were also conducted during sampling in 2017 and were usually associated with our capture efforts. A total of 118.8 km of HUNTs were performed during these sampling trips and 223 green turtles, 40 Kemp’s ridleys and nine loggerheads were observed. SPUE was calculated at 1.9 green turtles, 0.3 Kemp’s ridleys and 0.1 loggerheads/km of transect.

During HUNTs in the southern region of our study area we found numerous large sub adult green turtles in the deeper waters (3-5 meters) of the Homossasa River Channel. This is a unique discovery considering that sightings and captures of sub adult green turtles in Florida are rare. The only other area in Florida that has high numbers of sub adult animals is our other study site in the Marquesas Keys. This is also the only area where we have found sub adult animals in close proximity to juvenile turtles (< 1 km) that are found in shallow water habitat throughout the Crystal River study site. In a future study we hope to attach satellite transmitters to animals captured in the Homossasa Channel to see if they use the area as developmental habitat or for short term use on their migration further south.

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Fixed transect sightings by species, Crystal River Site 2017
A total of 107 sea turtles were captured in 2017 including 59 green turtles, 41 Kemp’s ridleys, six loggerheads and one hawksbill. Green turtles ranged in SCL from 26.4-74.0 cm with a mean of 40.1 cm (SD±9.9). Loggerheads ranged in SCL from 63.9 – 96.0 cm with a mean of 82.1 cm (SD±11.9). Kemp’s ridleys ranged from 20.0 – 53.6 cm in SCL with a mean of 45.9 cm (SD±7.0) and the one hawksbill we captured had a SCL of 40.5 cm.

The size classes of the six loggerheads captured in 2017 were similar to the size of 15 loggerheads we captured between 2013 and 2017. Green turtle and Kemp’s ridley size frequencies of captured animals in 2017 had a similar pattern that matched the long term size class of turtles captured between 2013 and 2017. See below for graphs of each species and the size class comparisons between 2017 and 2013-2017.


Results from sex determination analysis conducted by Southeastern Louisiana University indicate a high female bias among all species sampled. Loggerheads had a 3:1 female to male ratio (n=4). Green turtles had a 21:1 female to male ratio (n=22) and Kemp’s ridleys had a 5.3:1 female to male ratio (n=19). The one hawksbill captured in 2017 was identified as a female.

Fibropapillomatosis (FP) rate among green turtles at this site was extremely high with 78% of the turtles captured having visible tumors. This is higher than in some of our other study sites in Florida in the Indian River Lagoon (56%) and Lake Worth Lagoon (52%). It is perplexing that the FP rate is this high in a seemingly pristine open water habitat compared to the degraded conditions of the Indian River and Lake Worth lagoons. No other species of sea turtles captured at the Crystal River site had visible signs of FP.

During 2017 we had two recapture events of one Kemp’s ridley and one green turtle. We also captured four turtles that were tagged by other researchers, two Kemp’s ridleys and one green turtle that were originally tagged by Florida State University in the same area and one hawksbill originally tagged by Clearwater Marine Aquarium.

We analyzed the carbon and nitrogen stable isotope values of 78 sea turtles captured at the Crystal River study site. The majority of the samples were collected in 2014 (n=39) and 2015 (n=32), while only 2 and 5 turtles were sampled in 2016 and 2017, respectively. Loggerhead epidermis samples (n =5) had $\delta^{13}C$ values ranging from –17.7 ‰ to –12.9 ‰ and $\delta^{15}N$ values from 5.4 ‰ to 8.3‰. Green turtle epidermis samples (n =41) had $\delta^{13}C$ values ranging from –15.35 ‰ to –12.0 ‰ and $\delta^{15}N$ values from 4.2 ‰ to 8.2‰. Kemp’s ridley epidermis samples (n =32) had $\delta^{13}C$ values ranging from –17.5 ‰ to –12.3 ‰ and $\delta^{15}N$ values from 4.9 ‰ to 8.8‰.

The isotopic niche of all three species overlapped to some extent and green turtle niche fell entirely within Kemp’s ridley niche. We found no differences in $\delta^{13}C$ and $\delta^{15}N$ between Kemp’s ridleys and green turtles. Thirty-five of the 41 green turtles measured less than 45cm (SCLnt) and the remaining six individuals had SCLnt ranging from 66.5 cm to 76.2 cm. All Kemp’s ridleys were juveniles (SCLnt range: 34.1-56.5cm). Small green turtles (SCLnt <45cm) and Kemp’s ridleys showed a wide range of nitrogen values suggesting plasticity in diet among individuals.

Differently from other studies, we found no relationship between body size and $\delta^{15}N$ values. For a subset of Kemp’s ridleys (n=23), red blood cells (RBC) samples were analyzed to investigate the isotopic relationship between the two tissues in this species. Kemp’s ridley RBC samples (n =23) had $\delta^{13}C$ values ranging from –20.6 ‰ to –13.9 ‰ and $\delta^{15}N$ values from 2.9 ‰ to 8.8‰.

We found a significant linear relationship between epidermis and RBC for both $\delta^{13}C$ and $\delta^{15}N$; however, sample size was relatively small and the relationship between the two tissues should be further investigated. To our knowledge, no other isotopic data are available for sea turtles foraging in this important developmental habitat; thus, this work provides an important baseline for future studies looking at migratory connectivity of sea turtles in the Gulf of Mexico, including ontogenetic shifts from oceanic to neritic habitat.
GOM, Pelagic

During our pelagic work off of Venice, Louisiana, we partnered with Dr. Kate Mansfield from the University of Central Florida (UCF) to aid in her tracking study of neonate sea turtles in sargassum habitat. Our first sampling was conducted on June 6th and 7th, 2017. We conducted 38.2 km of visual transects for sea turtles in sargassum habitat 50-80 km offshore of Venice. During these transects, we observed two green turtles and one unidentified species. Sightings per unit effort were calculated at 0.07 turtles/km transect. The low number of observations of neonate sea turtles was likely due to the sparse coverage of sargassum in the areas we surveyed. We did manage to capture two neonate green turtles and Dr. Mansfield and her graduate students attached solar satellite tags to each before release. The SCLs of these small green turtles were 15.2 and 19.7 cm.

In July we conducted sampling 70-90 km offshore of Venice, Louisiana for three days: the 24th, 25th, and 26th. We again partnered with Dr. Kate Mansfield of UCF and chartered a 60’ Hatteras used as our research vessel. During this sampling period we conducted 73.8 km of visual transects in pelagic sargassum habitat. On this trip, sargassum habitat was more abundant than previous June trip. On the visual surveys we conducted, we observed 13 green turtles and one hawksbill resulting in an SPUE of 0.19 turtles/km of transect. Of the 14 turtles observed during transects, we captured eight of the green turtles observed and the one hawksbill. Green turtles captured in July ranged in size from 17.5-19.1 cm SCL with a mean SCL of 18.3 cm. The hawksbill turtle we captured was 17.7 cm in SCL. Measurements were taken for each turtle and solar satellite tags were attached by the UCF research team before release.

On November 7 and 8, 2017, we conducted pelagic sampling for neonate sea turtles using our 27’ twin-hull research vessel 80-110 km offshore of Cortez on the west coast of Florida. Visual transects spanned 45.9 km over pelagic habitat that contained mixed clumps of sargassum and drifting sea grass. On these transects we observed three green turtles for an SPUE of 0.07 turtles/km. No sea turtles were captured on this sampling trip.

Overall we conducted sampling efforts in pelagic Gulf of Mexico (GOM) waters during seven days in 2017. On 157.9 km of visual transects, we observed 18 green turtles, one hawksbill, and one sea turtle unidentified to species resulting in a cumulative SPUE of 0.13 turtles/km of transect. Of the sea turtles observed on transect, we captured 10 green turtles and one hawksbill. Green turtles ranged in size from 15.2-19.7 cm SCL with a mean of 18.1 cm. The one hawksbill captured had a SCL of 17.7. Tracks of the nine turtles satellite tagged are being published by Dr. Mansfield and were not available for this report. Due to the small size of the turtles captured, blood samples were not taken for genetics or stable isotopes.
Connectivity

The three sites we sampled in this study showed strong connectivity among the geographically distinct aggregations of sea turtles. Looking at size frequencies of green turtles at all three sites shows the progression from their neonate life stage in the pelagic GOM to their juvenile stage in neritic habitat along Florida’s GOM coast to sub adult and adult life stages found in deeper coastal waters off of Florida’s GOM coast. This progression of life history profiles in the GOM demonstrates that anthropogenic threats to any one segment of these developmental and foraging habitats could have significant impacts on the green turtle population in the GOM and the Caribbean Basin.

![Graph showing size frequency of green turtles at different sites.]


Genetic connectivity between these study sites emphasizes the importance of green turtles found in the GOM to nesting beach populations found in Mexico, Nicaragua, Florida, and the Caribbean Basin. This underscores how threats affecting green turtles in the GOM can have a serious impact on nesting beach populations hundreds of kilometers away. The genetic composition of green turtles at the Crystal River site and the KWNWR are strikingly similar with over 50% of turtles having haplotype CM-A3.1 (Costa Rica/Mexico/Florida/Cuba). Costa Rica is likely the largest contributor to the genetic makeup of this group, because nesting beaches in Tortuguero are one of the most productive in the world.
Green turtle natal beach origin based on genetic analysis of samples collected at the Crystal River study site (n=81) 2013-2017 and the Key West NWR (n=217) 2004-2018.

We have observed the connection between green turtles in the GOM and nesting beaches in Mexico and Costa Rica during our work on the foraging grounds west of the Marquesas Keys. In 2008, we captured an adult green turtle that was originally tagged while nesting on a beach in Tortuguero, Costa Rica in 2005. She was later observed nesting on the same beach in June and August, 2013. This turtle was one of two turtles that we’ve captured on Marquesas foraging grounds that were originally tagged on a nesting beach in Costa Rica. We have also tagged two adult green turtles that were later found nesting on beaches in Quintana Roo, Mexico. This highlights the importance of the foraging grounds west of the Marquesas to green turtle nesting populations in other countries thousands of kilometers away.
II. Project Partners

- Dr. Simona Cerriani, Florida Fish and Wildlife Commission
- Dr. Brian Shamblin, University of Georgia
- Dr. Justin Perrault, Loggerhead MarineLife Center
- Dr. Kate Mansfield, University of Central Florida
- Melanie Stadler, Brevard Zoo
- Carrie McNally, New England Aquarium

III. Project Timeline

Timeline for projects associated with this grant are as follows:

- Big Bend/Crystal River: Completed
- GOM Pelagic: Completed
- Marquesas Keys: Completed

IV. Outreach Activities

During this report period we have been working on publications and presentations that will describe results from our sea turtle research in the Big Bend region of Florida and the Marquesas Keys. Two of our biologists presented these results at the International Sea Turtle Symposium in Kobe, Japan in February 2018. Ryan Welsh gave an oral presentation titled “Density Surface Modeling to Determine Distribution and Spatial Segregation of Large Green Turtles on a Foraging Ground” and Cody Mott presented a poster at the symposium describing the species and size class partitioning seen in sea turtles of the Big Bend. We are currently working on a manuscript on sea turtles of the Big Bend region of Florida to be submitted to the journal “Endangered Species Research” by March of 2019. Data from this project will also be presented at the next International Sea Turtle Symposium in Charleston, South Carolina in 2019.

Please see below for examples of social media posts we used to engage the public in our research activities.
This week Inwater Research Group is in the Key West National Wildlife Refuge and NOAA Florida Keys National Marine Sanctuary. Our team of biologists is studying large subadult and adult green turtles that forage in the sea grass beds near the Marquesas Keys.

This year’s focus is on determining how many turtles inhabit the area by conducting extensive visual surveys and captures. Check out the photos of this amazing adult female green turtle!

This project is funded in part by a grant awarded from the Sea Turtle Grants Program. The Sea Turtle Grants Program is funded from proceeds from the sale of the Florida Sea Turtle License Plate. Learn more at www.helpingseaturtles.org. The project was also funded in part by the Gulf of Mexico Alliance - Gulf Star Grant and an Anonymous Donor.
Last week we completed our second research trip of the year to Crystal River, Florida. Over the course of 5 days, we captured and collected data from 50 turtles! Part of the focus of this trip included collecting oral and cloacal swabs from Kemp’s ridley and green sea turtles as part of a collaborative research project with the New England Aquarium.

We have one more trip for this project in the fall. We’ll be sure to keep you updated with our progress!

This research wouldn’t have been possible without generous support from an Anonymous Donor. This project was also funded in part by a grant from the Gulf of Mexico Alliance and a grant from the Sea Turtle Grants Program.

The Sea Turtle Grants Program is funded from proceeds from the sale of the Florida Sea Turtle License Plate. Learn more at www.helpingseaturtles.org
The wonderful folks at Two-Head Video joined us for a day off of the Marquesas Keys to document some of the work we have been doing on the adult green turtle foraging grounds in the area. See the album for just a few sneak peaks of photos from their trip. We can’t wait to see the finished video product once it’s released. Thanks for coming along guys!

Second shoot in Key West this year is a wrap. We got to document the crew of Inwater Research as they gathered data on sea turtles and profile the folks at Daie and Thyme who are committed to the Straw on Demand program.
It was another successful summer research season for us here at Inwater!!
We were fortunate to take two research trips to the Key West National
Wildlife Refuge and the NOAA Florida Keys National Marine Sanctuary.
During both trips we were able to perform surveys to assess population
levels of foraging (non-nesting) adult green turtles, and to continue our
demography, capture-mark-recapture studies, and general health
assessments of the turtle populations in the area. Click through the photos to
see stories of some of the interesting turtles we encountered!
These trips were made possible through your donations, the Sea Turtle
License Plate Grants Program (www.helpingseaturtles.org), the Gulf of
Mexico Alliance Gulf Star grants program and an Anonymous donor!
V. Supporting Materials

Photographs

Adult green turtle captured in June 2018 west of the Marquesas Keys
Research vessel working west of the Marquesas Keys, 2018

Jumping on adult green turtles, Marquesas 2018
Great hammerhead west of the Marquesas, 2018

Measuring adult male green turtle west of the Marquesas Keys, 2018
Taking sample from green turtle for stable isotope analysis, 2018

Adult male green turtle captured west of the Marquesas Keys in August 2017
Green turtle capture Marquesas, 2017

Sub-adult green turtle west of the Marquesas Keys, August 2017
Capturing green turtles west of the Marquesas

Green turtle foraging plot west of the Marquesas Keys.
Juvenile hawksbill captured near the Marquesas Keys, November 2017

Juvenile Kemp’s ridley, offshore of Crystal River, August 2017
Adult female loggerhead offshore of Crystal River, August 2017

VI. Plan for Next Reporting Period

N/A

VII. Project Budget and Expenditures
Please see attachment