NOAA FISHERIES SMALLTOOTH SAWFISH MONITORING SURVEY-FY23
Relative Abundance and Essential Fish Habitat Studies for Smalltooth Sawfish, *Pristis pectinata*, in Southwest Florida, USA

Andrea M. Kroetz and John K. Carlson
NOAA Fisheries
Southeast Fisheries Science Center
Panama City Laboratory
3500 Delwood Beach Road
Panama City, FL 32408

R. Dean Grubbs
Florida State University Coastal and Marine Laboratory
3618 Hwy 98
St. Teresa, FL 32358

REPORT TO NOAA FISHERIES SOUTHEAST REGIONAL OFFICE
263 13th Avenue South
St. Petersburg, Florida 33701

BACKGROUND

Life history characteristics, abundance, habitat use, movement, and migration patterns are necessary to facilitate the recovery of the U.S. Distinct Population Segment (DPS) of smalltooth sawfish, *Pristis pectinata.* A multi-disciplinary approach focusing research on action items listed in the Smalltooth Sawfish Recovery Plan (NOAA 2009a) has occurred since 2009. One of the high priority tasks outlined in the plan is abundance and recruitment of juvenile sawfish. In addition, identifying habitat use and movements of both juvenile and mature sawfish are of high priority. One of the most important regions for young-of-the-year (YOY) and small juveniles is coastal southwest Florida (Seitz and Poulakis 2002, Poulakis and Seitz 2004, Simpfendorfer and Wiley 2005, Wiley and Simpfendorfer 2007). This report describes the results from the 2023 NOAA Fisheries Panama City Laboratory juvenile smalltooth sawfish monitoring survey in southwest Florida from Marco Island to Florida Bay as well as the large juvenile and mature sawfish survey conducted by Florida State University spanning Everglades National Park (including Florida Bay) and inshore/offshore of the Florida Keys, both conducted under protected species permit #ESA 22078, EVER-2022-SCI-0021, and EVER-2023-SCI-0019.

METHODS

Surveys

Areas surveyed via gillnets were located within the Ten Thousand Islands/Everglades Unit of designated critical habitat (74 FR 45353; NOAA 2009b) in southwest Florida from Marco Island to Florida Bay. Areas surveyed by bottom longline gear included Tampa Bay and spanned the lower portion of the Ten Thousand Islands/Everglades Unit of designated critical habitat from Florida Bay to both inshore and offshore of the Florida Keys (Figure 1). Backwaters within the region of gillnet and longline surveys and coastal waters of the Florida Keys were categorized into six sub-regions (north to south, Figure 1): Tampa Bay, Ten Thousand Islands National Wildlife Refuge (TTINWR), Northern Everglades National Park (NENP: Chokoloskee Island to the entrance of the Rodgers-Broad River), Whitewater and Coot Bays, Florida Bay including the Flamingo region, and the Florida Keys National Marine Sanctuary (FKNMS) and inshore/offshore of Florida Keys.

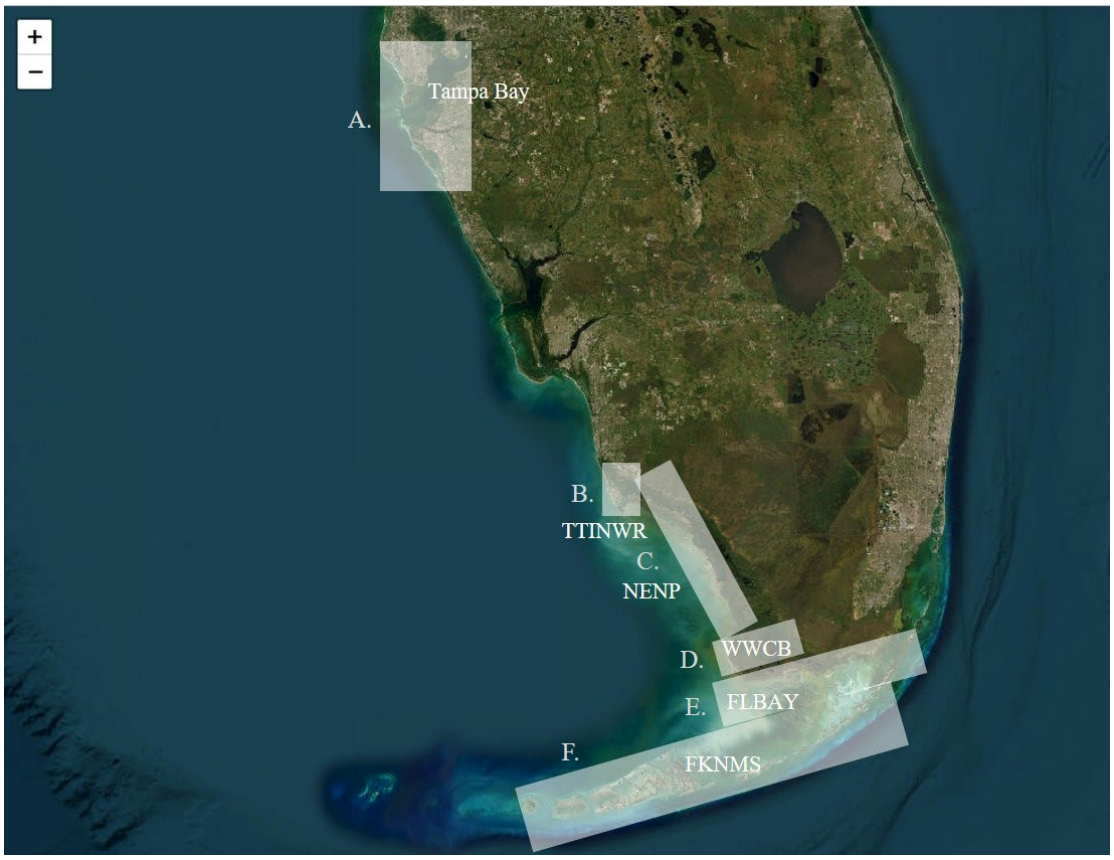

Figure 1. Six sub-regions of the 2023 NOAA Fisheries Panama City Laboratory smalltooth sawfish gillnet survey and Florida State University bottom longline survey (north to south): A. Tampa Bay, B. Ten Thousand Islands National Wildlife Refuge, C. Northern Everglades National Park, D. Whitewater and Coot Bays, E. Florida Bay, and F. Florida Keys National Marine Sanctuary (FKNMS),

Inshore/offshore Florida Keys.

Specific sampling locations within sub-regions were determined by (1) previous surveys (Wiley and Simpfendorfer 2007, Bethea et al. 2015 and references therein, Kroetz et al. 2019 and references therein), (2) queries of the public encounter data where sawfish have been reported available from the Smalltooth Sawfish Recovery Implementation Team via Florida Fish and Wildlife Conservation Commission Charlotte Harbor Field Laboratory Port Charlotte, FL, and (3) arbitrary sampling conducted in documented critical habitat type (e.g., mangrove fringed mud flats less than 1.0 m at mean high tide for gillnets).

Gillnets and bottom longline sampling gear were used in the surveys. Due to space (i.e., small channels, shallow mud flats, and beaches around mangrove islands and keys), gillnets were 5 ft (1.5 m) deep and either 100 or 200 ft long (30.5 or 61.0 m) with a mesh size of 4.0 in (10.2 cm). Nets had a continuous float and lead line, were anchored at each end with one eight-pound mushroom anchor, and marked with large surface buoys at each end. Nets were fished one at a time, monitored continuously, soaked for at least 1.0 hour, and checked for catch every 0.5 hours or immediately if any animals were observed in the gear. All sets were made during daylight hours. Gillnet set soak time was defined from the time the gear entered the water to the time the gear was completely removed from the water. Catch-per-unit-effort (CPUE) was defined as the number of sawfish of each life stage caught in each sub-region divided by gillnet set soak time (standardized to gillnet hour). CPUE for the bottom longline survey was calculated as the number of sawfish/hooks and was calculated by sub-region. Large juvenile and mature sawfish were combined for analysis.

Bottom longline gear was deployed in deeper areas to capture large juvenile and mature smalltooth sawfish. Longlines consisted of a 4.0 mm monofilament mainline that was anchored on each end and marked with a buoy bearing the permit numbers. A standard set included 50 gangions consisting of a stainless-steel tuna clip with an 8/0 stainless steel swivel attached to 2.5 m of 300 kg monofilament that was attached to 16/0 circle hooks. The hooks were baited with ladyfish (*Elops saurus*) and soak times were one hour. The line was hauled in the order and direction it was set and smalltooth sawfish were sampled as they were caught during retrieval.

Sample collection, tagging, and recaptures

Captured smalltooth sawfish were measured (rostral length, RL; precaudal length, PCL; fork length, FL; stretched total length, STL, in cm), sexed (if male, inner and outer right clasper length, CL, measured in cm), and life history stage assessed: neonate defined by an open yolk-sac scar and/or remnants of the protective sheath around the rostral teeth; YOY had a closed yolk-sac scar and were <150 cm STL, and juvenile were ≥150 cm STL, following Simpfendorfer et al. 2008. Mature individuals were defined by total length as indicated by most recent analysis of sex hormone data (James Gelsleichter, University of North Florida, personal communication). Rostral teeth were counted (left and right, independently) and a 1.0 g piece of a pelvic fin was removed from new captures only and archived in EtOH for genetic research. A 1.0 g muscle biopsy was taken from sawfish, stored in a cryovial, and frozen for trophic ecology analyses. A 1-5 ml blood sample was taken for reproductive and stress hormone analyses as well as for heavy metal contamination (sent our colleague, Dr. James Gelsleichter, at the University of North Florida in Jacksonville, FL). When observed, fecal matter was collected and preserved by freezing for trophic analysis. New captures were tagged externally under the first dorsal fin with either a plastic-headed or metal-headed streamer dart-tag (©Hallprint Fish Tags) and internally at the base of either the first or second dorsal with a PIT-tag (©Digital Angel & Biomark). Three types of ©Vemco coded acoustic tags were surgically implanted in juvenile and adult sawfish. Sawfish were implanted with V13 (13 mm diameter, 6.5 g wet, battery life between 1492-1737 days, code transmission every 100-180 seconds) tags if the animal was between 75-90 cm STL. Sawfish between 100-200 cm STL were implanted with V16-4x (16 mm diameter, 10.3 g wet, battery life 3650 days, code transmission every 80-160 seconds) and sawfish ≥201 cm STL were implanted with V16 (16 mm diameter, 17.3 g wet, battery life 3650 days, code transmission every 70-150 seconds) tags. Recaptured animals were distinguishable by the presence of an external tag, the presence of an internal PIT tag upon thorough scanning, and/or the absence of the small trailing edge of the right pelvic fin. Recaptured animals were examined in the same manner as new captures and missing external tags were replaced. After examination and tagging, all animals were photographed (dorsal and ventral) and released with the time noted.

Elasmobranchs other than sawfish were measured (PCL, FL, and STL in cm for sharks; disc-width, DW, in cm for batoids), sexed, assigned a life stage, tagged externally under the first dorsal fin with a plastic-headed streamer dart-tag (sharks <120 cm STL; ©Hallprint Fish Tags.) or metal-headed streamer dart tag (sharks ≥120 cm STL; ©Hallprint Fish Tags) and released. Neonates were defined as having an open umbilical scar and YOY were defined as having a closed,

but visible, umbilical scar. Mature individuals were defined based on macro-analysis or published accounts of 50% size-at-maturity (Branstetter 1987, Branstetter and Stiles 1987, Brown and Gruber 1988, Snelson et al. 1988, Castro 2000, Henningsen and McEachran 2000, Henningsen 2002, Carlson et al. 2003, Lombardi-Carlson et al. 2003). Captured teleosts were measured (FL and/or STL in cm) and released. A 1.0 g muscle biopsy was taken from captured elasmobranchs and teleosts for trophic ecology analyses.

Essential fish habitat profiles
For each gillnet set, surface water temperature (°C), salinity, and dissolved oxygen (mg l^{-1}) were recorded using an YSI Pro2030 environmental meter (YSI Inc. /Xylem Inc.). Average depth (in meters) was calculated using gear start and end points recorded from the vessel's depth finder. Water clarity was measured using a secchi disc (depth of the photic zone in cm) and tidal stage and orientation of the set (i.e., against the shoreline) were noted. Qualitative information was gathered on bottom type (e.g., mud, sand, set on mudflat/slope) and it was noted if a sawfish was seen at net set. For each longline set, water temperature (°C), salinity, and dissolved oxygen (mg l^{-1}) were recorded at the surface, mid-depth and on bottom using an YSI Pro2030 environmental meter (YSI Inc. /Xylem Inc.). Minimum and maximum depth (in meters) was records using the vessel's sonar. Water clarity was measured using a secchi disc and tidal stage was recorded.

RESULTS

A total of 86 gillnet sets were made over 13 sampling days in April, June, and September (Figure 2), capturing 13 YOY and 1 juvenile smalltooth sawfish (n=14, Table 1). The CPUE by life stage and sub-region can be found in Table 3. Generally, animals were captured in shallow (0.3 – 1.0 m) and warm (24.7 - 33.1 °C) water and in relatively narrow ranges of salinities (24.4 – 38.8) and dissolved oxygen concentrations (4.3 – 5.73 mg/L). Sawfish were captured against red and black mangrove shoreline, primarily on a mudflat, with one animal captured on a sand and shell beach. A fin clip and muscle biopsy were taken from all animals for genetic and trophic ecology research, respectively, and 13 were internally acoustically tagged. Of the 14 sawfish samples, one was a recapture (captured twice in 2023). The female was originally captured and acoustically tagged in April and was recaptured five months later in the same location. This individual had a fully healed surgery scar (Table 1).

A total of 116 bottom longline sets were made over 19 sampling days on five trips in January, February, May, June, and September (Figure 3) capturing 4 smalltooth sawfish; 3 mature females and 1 mature male (n=4, Table 2) in the primary survey region. Additionally, longline surveys not part of the sawfish monitoring survey captured 3 animals; 2 mature males in the Keys with the Bimini Biological Field Station research team [co-PI Kroetz was aboard to tag under permit] and 1 mature female off of Seahorse Key in the Big Bend region of northwest Florida for a total of 7 sawfish for the longline survey (Table 2, Figure 3; co-PI Grubbs conducted survey under permit). Longlines conducted in the Big Bend region by co-PI Grubbs are annual surveys for local elasmobranchs and sets were standardized to those used in sawfish monitoring; thus, this region was included in CPUE. The CPUE by sub-region can be found in Table 3. Generally, the sawfish were captured between 4.3-11.0 m of water that was warm (25.2-26.3 °C), had a range of DO between 6.29-7.4 mg/L, and a salinity range of 31.2-36.2. A fin clip and muscle biopsy were taken and blood was drawn from each sawfish; all animals were internally acoustically tagged.

The smallest sawfish captured in 2023 was caught in Everglades National Park (75.0 cm STL, male) and the largest was caught in the same location later on in the sampling year (153.0 cm STL, female; Table 1). The largest sawfish captured on longline was in the Florida Keys at 7 mile bridge in Marathon (416.0 cm STL female). It is notable that four sawfish were captured at this location in February (Table 2). No sawfish were tagged with satellite tags.

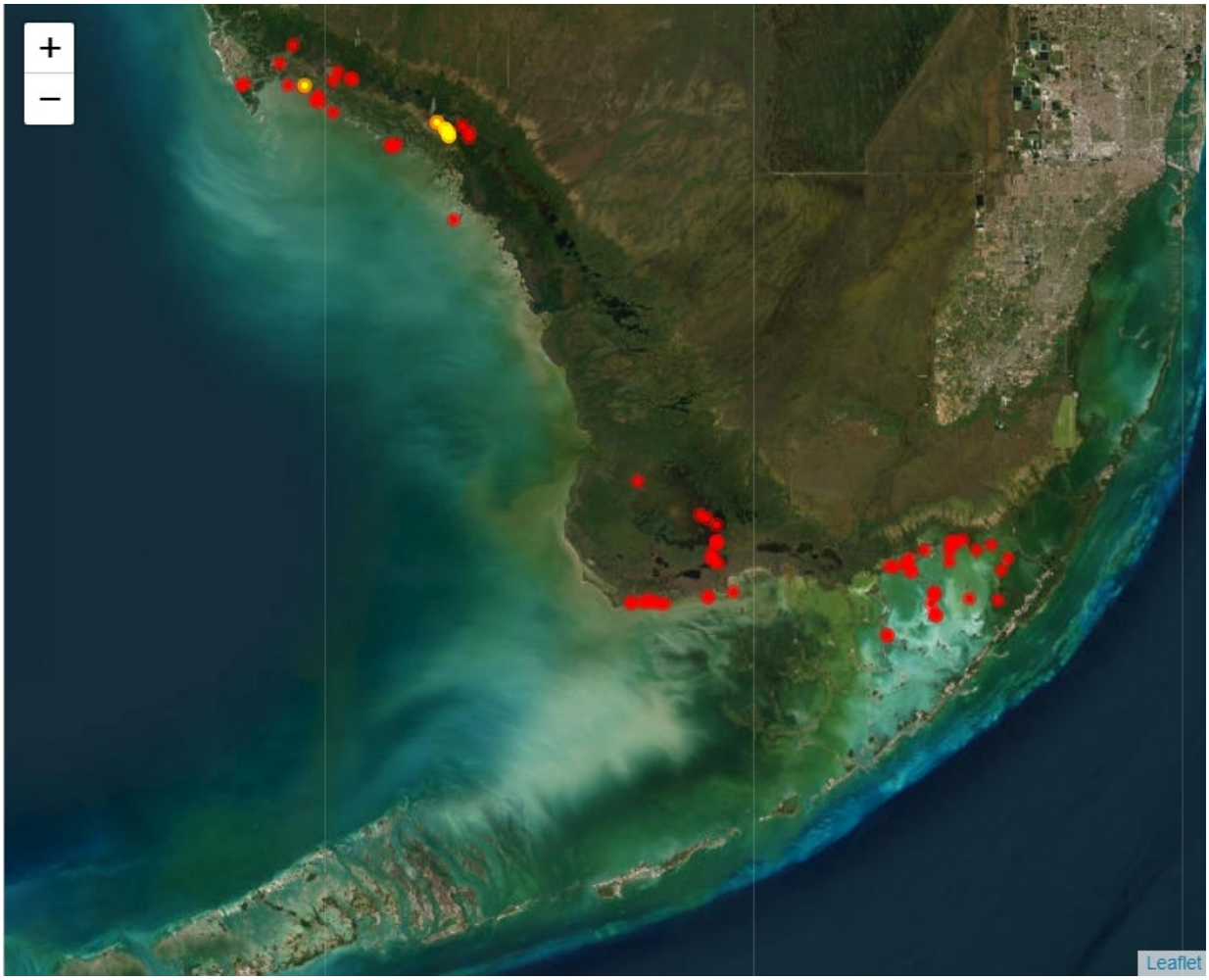

Figure 2. Distribution of all gillnet sets in the 2023 NOAA Fisheries Panama City Laboratory smalltooth sawfish gillnet survey (n=86). Red circles indicate a gillnet set and yellow circles are locations of positive smalltooth sawfish captures (n=14).

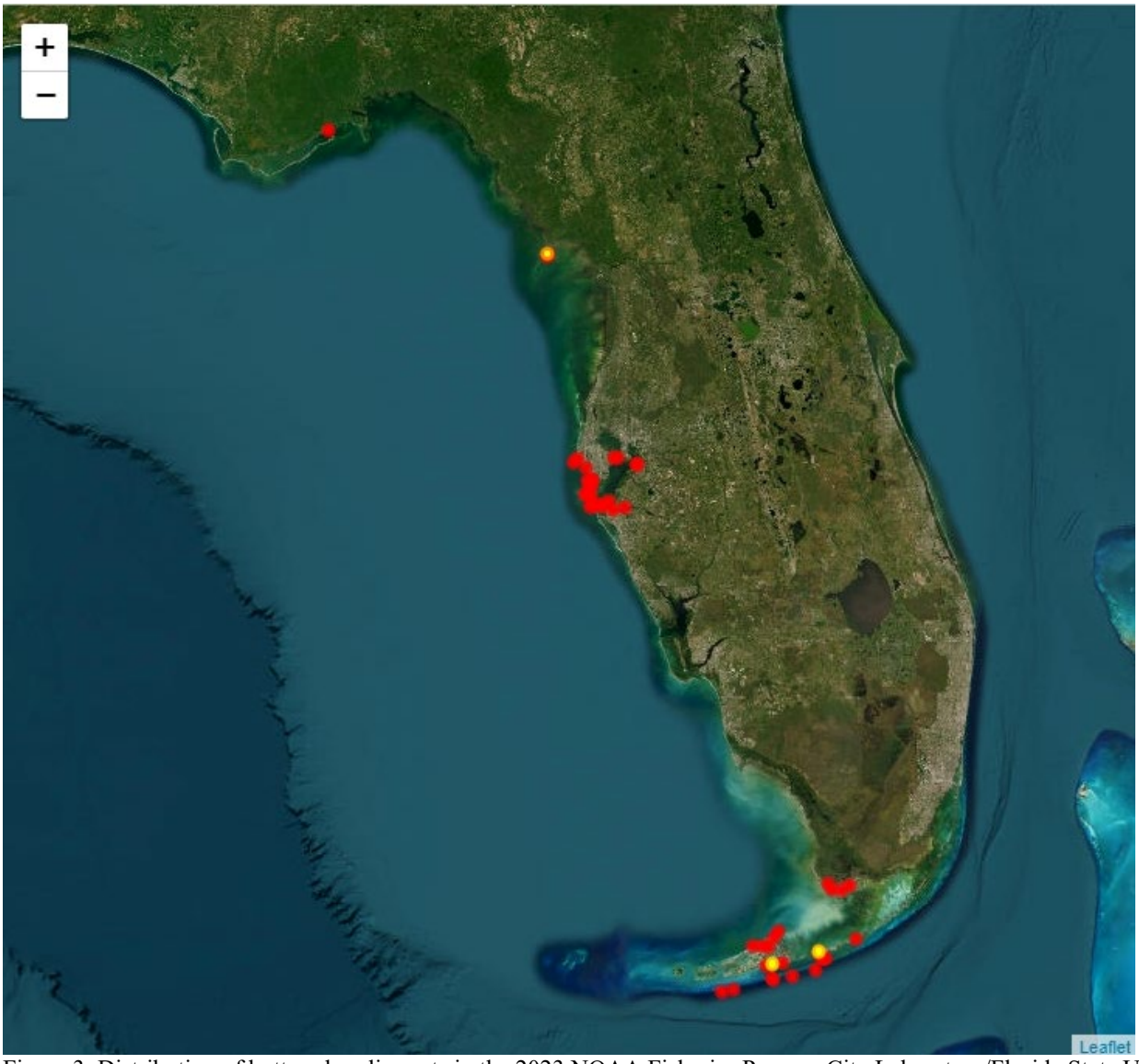

Figure 3. Distribution of bottom longline sets in the 2023 NOAA Fisheries Panama City Laboratory/Florida State University smalltooth sawfish bottom longline survey (n=116). Red circles indicate a bottom longline set and yellow circles are locations of positive smalltooth sawfish captures (n=7).

Gillnet Sets

Ten Thousand Islands National Wildlife Refuge (TTINWR)

Monitoring in this sub-region was conducted in September via 15 gillnet sets over two sampling days. Sets were made around Panther Key, Faka Union Bay, Pumpkin Bay, Grocery Creek, and Goodland Bay (Figure 4). Information was collected on one male YOY smalltooth sawfish that was captured on a beach sandspit near Turtle Key. The sawfish was observed swimming along the shoreline and it was corralled into the gillnet. This animal would not be considered as randomly captured and would be excluded from the yearly relative abundance estimates. The sawfish was internally acoustically tagged with a 10-year acoustic tag (Table 1). No recaptures occurred in this sub-region in 2023. Other elasmobranchs captured in this sub-region included bonnethead (*Sphyrna tiburo*) and lemon (*Negaprion brevirostris*) sharks (Table 4).

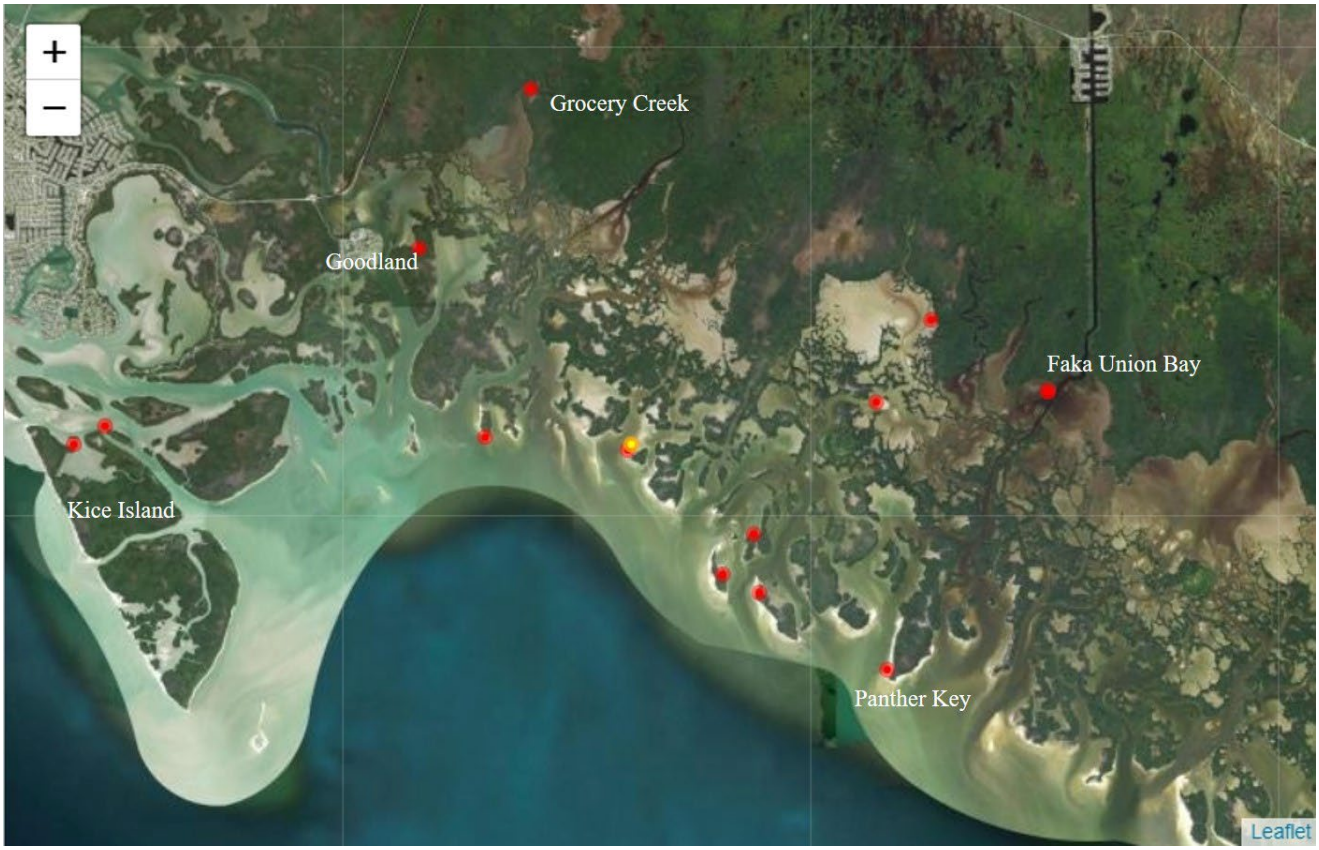

Figure 4. Distribution of 2023 gillnet sets in the Ten Thousand Islands National Wildlife Refuge (TTINWR) sub-region (n=15). Red circles indicate a gillnet set and yellow circles indicate sets with positive smalltooth sawfish captures (n=1).

Northern Everglades National Park (NENP)

Monitoring in this sub-region was conducted in April and September via 18 gillnet sets over three sampling days. Sets were made around Chokoloskee Island, in Turner River, Mud Bay, Pavilion Key, and Kingston Key (Figure 5). Seven of the sets were made from the shoreline around Chokoloskee Island (e.g., nets were walked from the shore out into the water without a vessel) and 10 sawfish were captured in this manner. Information was collected on 12 YOY and one juvenile smalltooth sawfish (n=13), all captured around Chokoloskee Island (Table 1; Figure 5). Ten animals were implanted with a 4 to 5-year acoustic tag while two were implanted with a 10-year acoustic tag. One recapture occurred in this sub-region in 2023 as it was previously captured, sampled, and tagged in April 2023. Five months later, the sawfish was recaptured in the same location and had a fully healed surgery scar (Figure 6). This animal grew from 77.0 cm STL at capture to 100 cm STL at recapture. Additionally, our collaborators at Florida Fish and Wildlife Conservation Commission (FWC) internally acoustically tagged three YOY sawfish with NOAA tags off of Chokoloskee Island (Table 1). No other elasmobranchs were captured in this sub-region (Table 4).

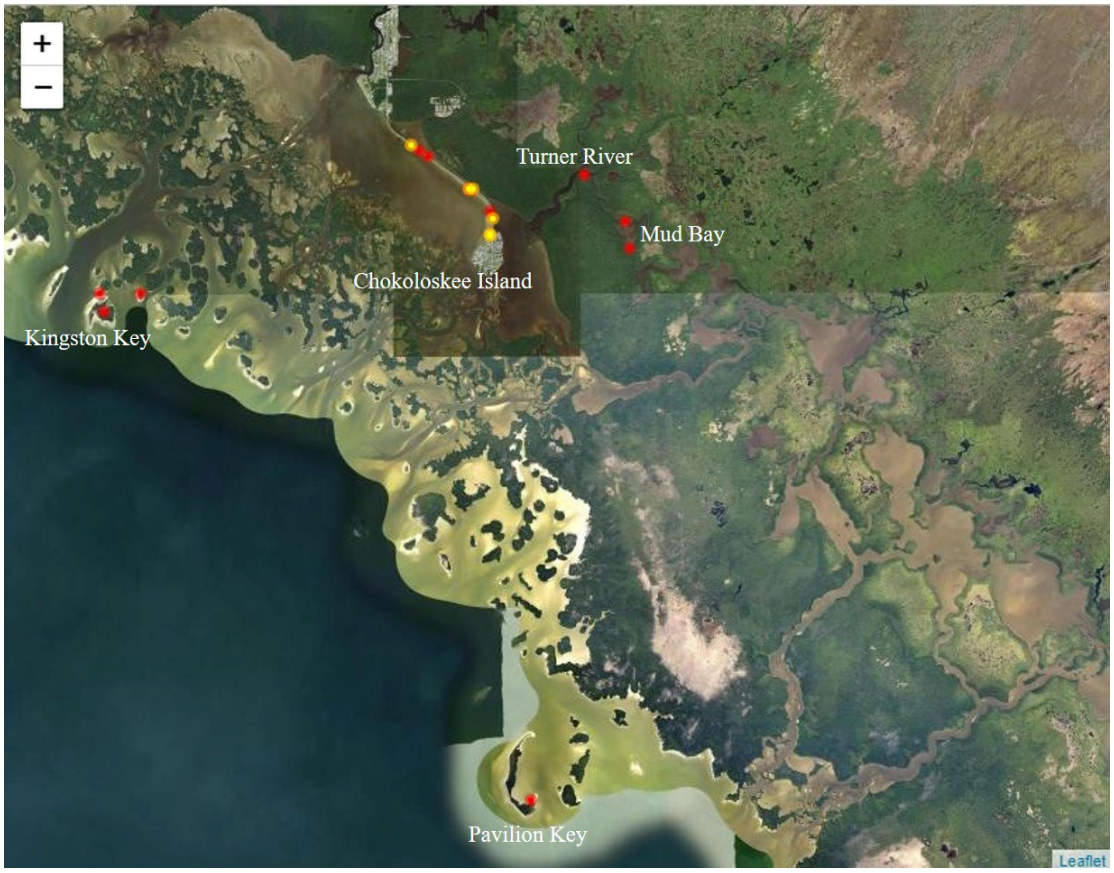

Figure 5. Distribution of 2023 gillnet sets in the northern Everglades National Park (NENP) sub-region (n=18). Red circles indicate gillnet sets and yellow circles indicate sets with positive smalltooth sawfish captures (n=13).

Figure 6. A fully healed surgery scar on a young-of-the-year female sawfish (77 cm STL at capture; 100 cm STL at recapture) after five months at liberty. Sutures completely dissolved and the incision site is healed over and looks healthy.

Whitewater and Coot Bays,
Monitoring in the Whitewater and Coot Bays sub-regions was conducted in June and September via 12 gillnet sets over two days of sampling (Figure 7). No smalltooth sawfish were captured in these sub-regions and bull sharks (*C. leucas*) were the only other elasmobranchs captured (Table 4).

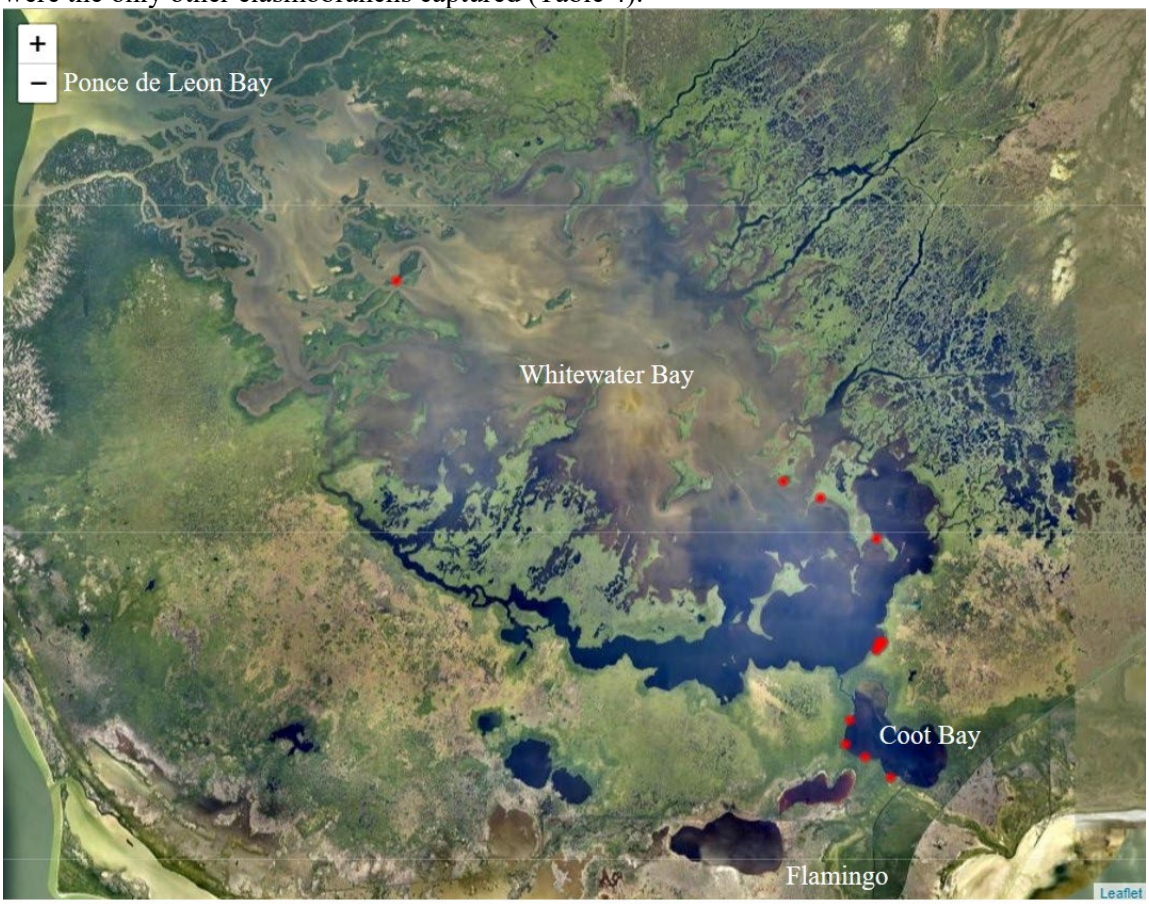

Figure 7. Distribution of 2023 gillnet sets in the Whitewater and Coot Bays (WWCB) sub-regions (n=12). Red circles indicate gillnet sets.

Florida Bay (including Flamingo)
Monitoring in the Florida Bay sub-region was conducted in June and September via 41 gillnet sets over five days of sampling. Sets were made along the shoreline of Florida Bay and near Flamingo (Figure 8), Eagle Key, Park Key, Trout Cove, and at many other keys throughout Florida Bay (Figure 9). Exploration in this sub-region was greatly expanded from previous years although no smalltooth sawfish were captured in this sub-region. Other elasmobranchs captured included bull (*C. leucas*), blacktip (*C. limbatus*), and lemon (*N. brevirostris*) sharks (Table 4).

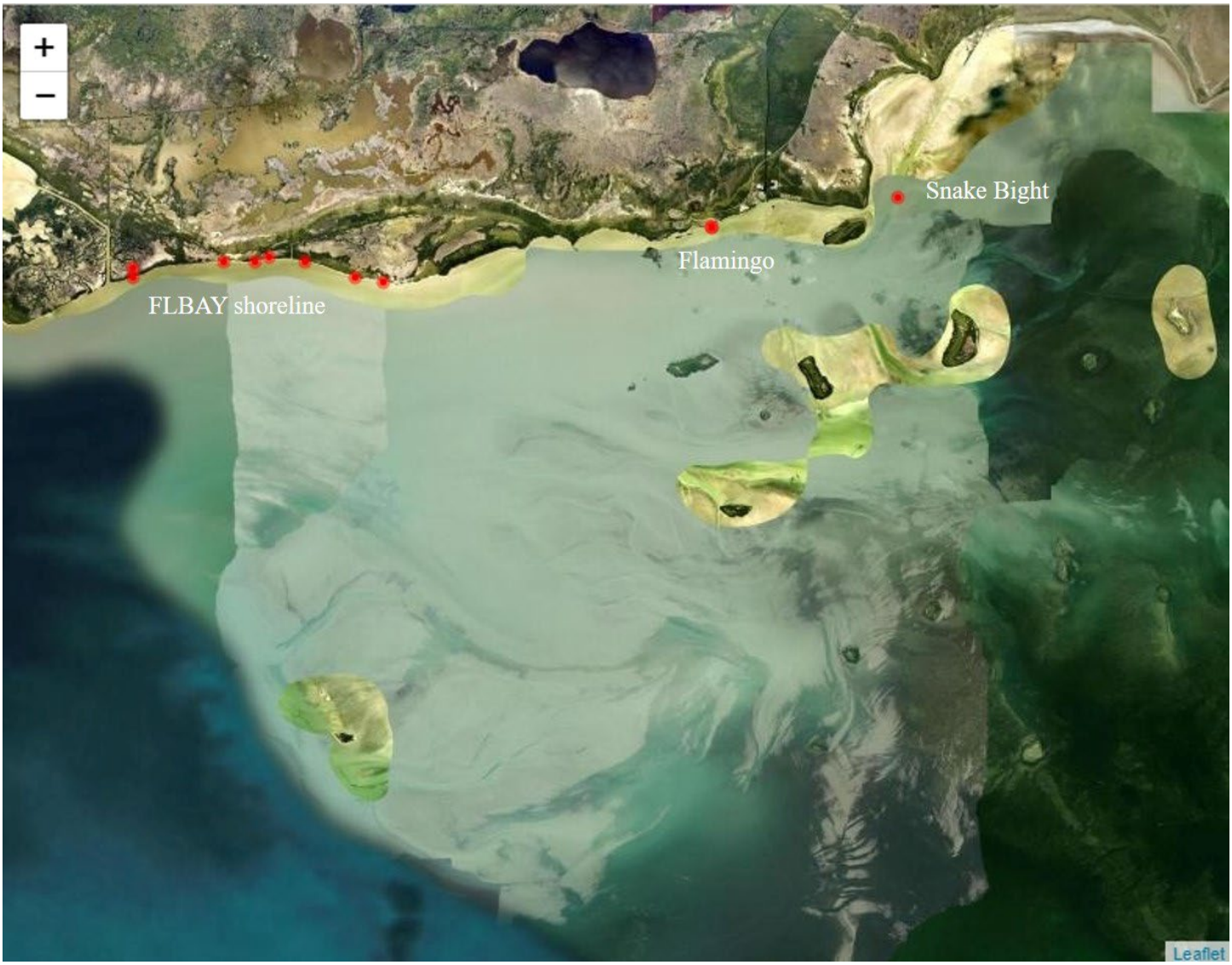

Figure 8. Distribution of 2023 gillnet sets in the Florida Bay sub-region along the shoreline (n=41). Red circles indicate gillnet sets.

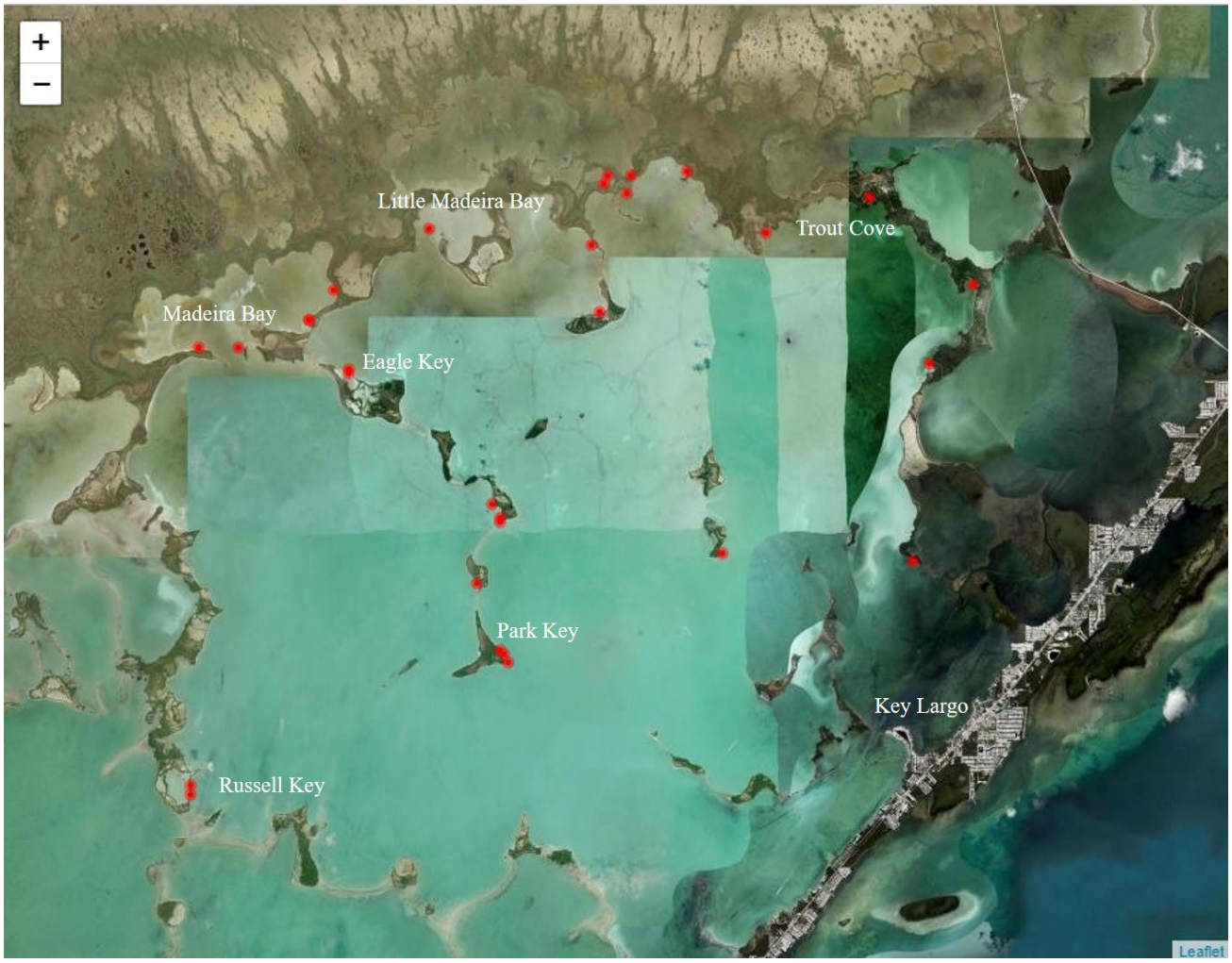

Figure 9. Distribution of 2023 gillnet sets in the Florida Bay sub-region at many keys throughout the bay (n=41). Red circles indicate gillnet sets.

Bottom Longline

Southern Everglades National Park (SENP)

Eight bottom longline sets were made in the southern portion of Everglades National Park sub-region in northern Florida Bay in February (Figure 10). No sawfish were captured in this region. Other elasmobranchs captured in this region include blacknose (*C. acronotus*), blacktip (*C. limbatus*), bull (*C. leucas*), nurse (*G. cirratum*), lemon (*N. brevirostris*), and tiger (*Galeocerdo cuvier*) (Table 6).

Figure 10. Distribution of bottom longline sets within Everglades National Park boundaries (e.g., sets within Florida Bay) in 2023 (n=8). Red circles indicate bottom longline sets.

Florida Keys National Marine Sanctuary-Inshore/Offshore Florida Keys

Forty bottom longline sets were made in the Florida Keys National Marine Sanctuary and inshore/offshore Florida Keys sub-region in February and September (Figure 11). Four smalltooth sawfish were captured in this sub-region at 7-mile bridge; 3 mature females and one mature male (Table 2). All of the sawfish were implanted with 10-year acoustic tags. Additionally, 2 mature males were tagged in this region at Cudjoe Channel in April while collaborating with the Bimini Biological Field Station on their bottom longline research survey. These sawfish were also tagged with 1-year acoustic tags. Other elasmobranchs captured from bottom longline sets include blacknose (*C. acronotus*), blacktip (*C. limbatus*), bull (*C. leucas*), Atlantic sharpnose (*R. terraenovae*), nurse (*G. cirratum*), lemon (*N. brevirostris*), scalloped hammerhead (*S. lewini*), great hammerhead (*S. mokarran*), bonnethead (*S. tiburo*), tiger (*Galeocerdo cuvier*), and sandbar (*C. plumbeus*) sharks (Table 6).

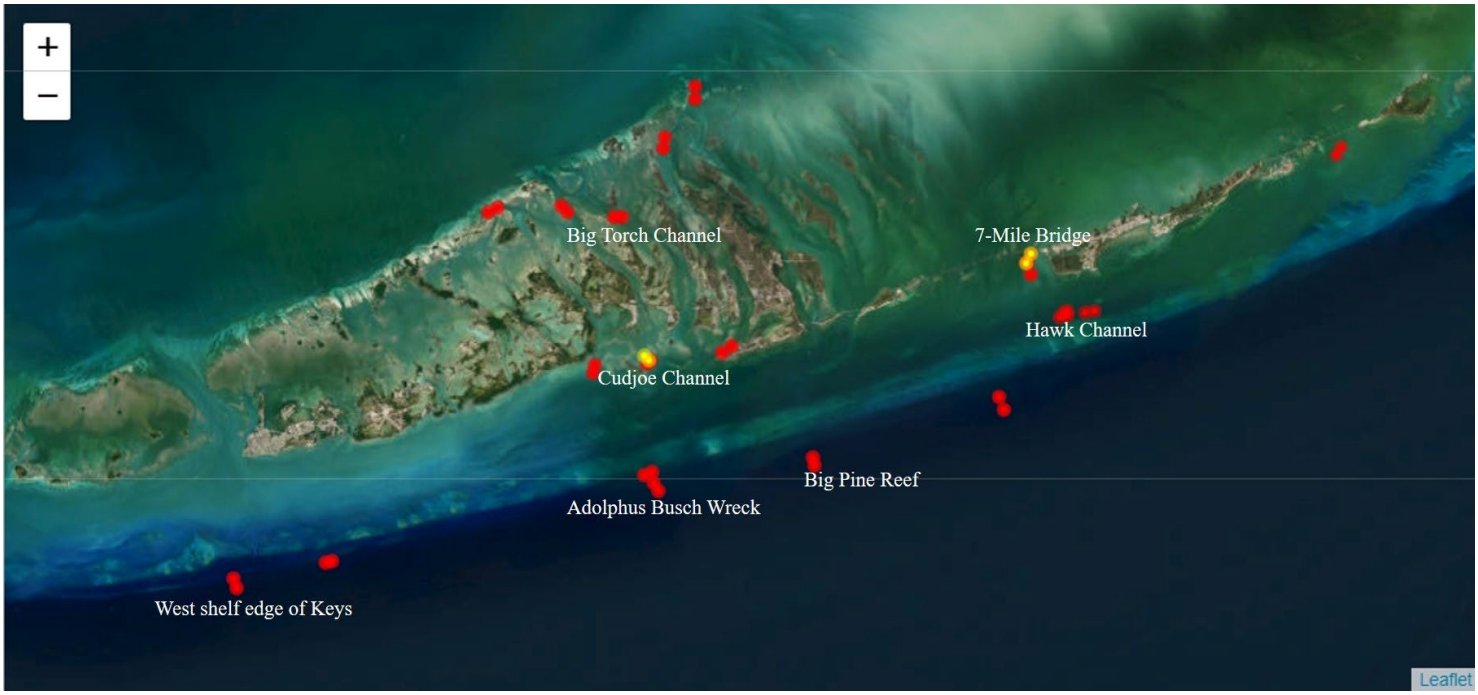

Figure 11. Distribution of bottom longline sets within the inshore/offshore Florida Keys (n=40) sub-region. Red circles indicate bottom longline sets and yellow circles indicate sets with positive smalltooth sawfish captures (n=6).

Tampa Bay

Sixty bottom longline sets were made in the Tampa Bay sub-region of northwest Florida in January and May (Figure 12). No sawfish were captured in this region. Other elasmobranchs captured from bottom longline sets include blacknose (*C. acronotus*), blacktip (*C. limbatus*), bull (*C. leucas*), Atlantic sharpnose (*R. terraenovae*), nurse (*G. cirratum*), and lemon (*N. brevirostris*) (Table 6).

Figure 12. Distribution of bottom longline sets within the Tampa Bay sub-region of Florida (n=60). Red circles indicate bottom longline sets.

Big Bend in northwest Florida

Eight bottom longline sets were made in the Big Bend region of northwest Florida in May and June (Figure 13). These longline sets were not conducted as part of the sawfish monitoring survey with the intent to capture and tag sawfish, but rather as part of an annual summer course for undergraduate students taught by co-PI Grubbs in collaboration with the University of Florida. During this course, standardized bottom longline sets (i.e., same as longline sets used to capture sawfish) were conducted off of Seahorse Key near Cedar Key in which 1 mature female sawfish was captured. This female was implanted with a 10-year acoustic tag (Table 2), making this the first sawfish both captured and internally tagged this far north on the Gulf coast of Florida since our surveys began in 2009.

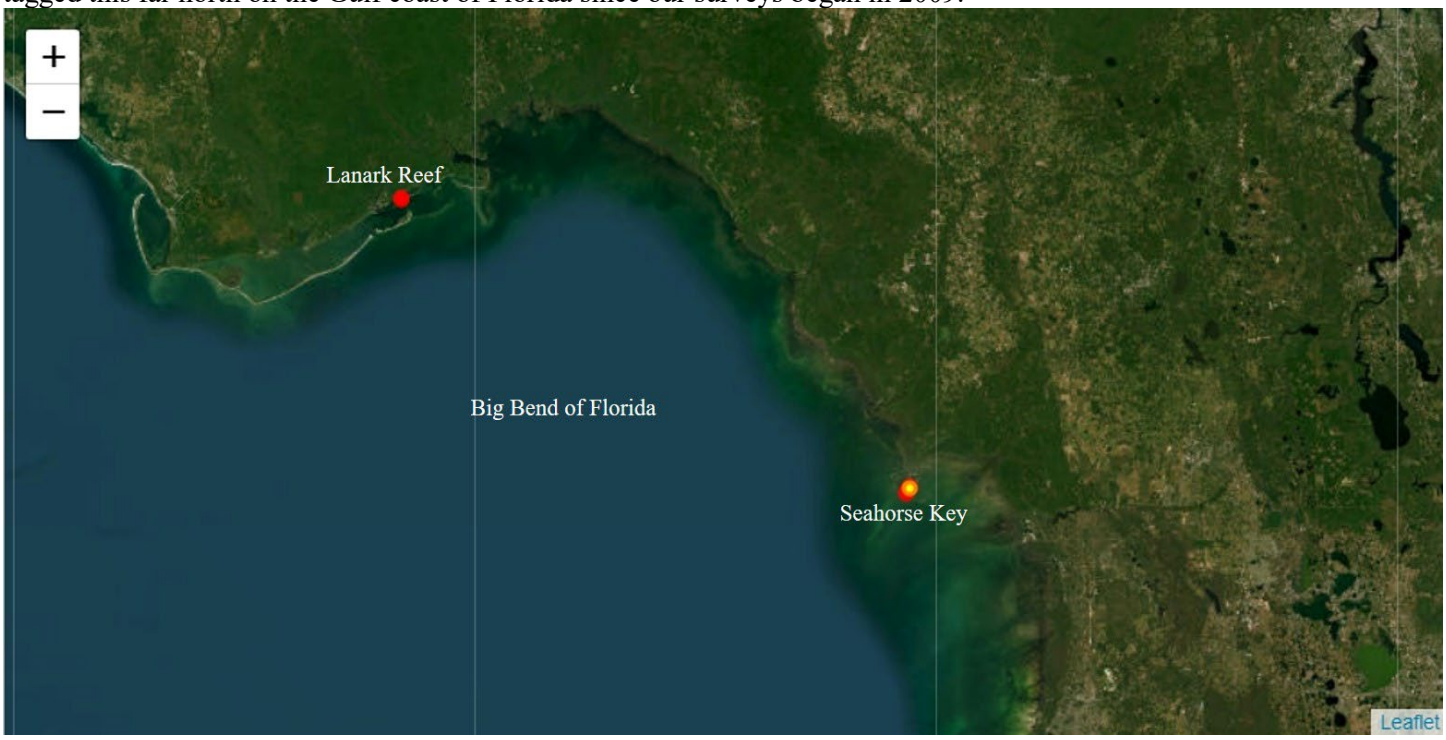

Figure 13. Distribution of bottom longline sets within the Big Bend sub-region of Florida (n=8). Red circles indicate bottom longline sets and yellow circles indicate sets with positive smalltooth sawfish captures (n=1).

ACOUSTIC & SATELLITE TELEMETRY

Twenty-three smalltooth sawfish were internally tagged with acoustic tags in 2023: 15 young-of-the-year, 1 juvenile, and 7 mature (Tables 1, 2). Twelve 10-year and 11 4- to 5-year acoustic tags were implanted in smalltooth sawfish. Since internal implementation of acoustic tags began in 2016, a total of 132 sawfish have been tagged throughout the Ten Thousand Islands National Wildlife Refuge, Everglades National Park, and Florida Keys. Of these animals, 45 were YOY, 33 were juvenile, 12 were maturing individuals, and 42 were mature. Seventeen sawfish have been tagged by collaborators at The Field School (n=4 total) and FWC Charlotte Harbor (n=13 total).

The total number of Innovasea (formerly Vemco) VR2W acoustic receivers deployed throughout the Ten Thousand Islands National Wildlife Refuge and Everglades National Park for 2023 is 27 (Figure 14). One new receiver was deployed in Everglades National Park at the entrance of Broad River, which has long been a location of sawfish reports and is an area in which acoustic coverage is needed (Figure 14). A total of 241,460 detections were downloaded from receivers during the 2023 deployment year; 157,283 detections were from 49 individual sawfish and 84,177 were from a variety of other species. Both NMFS Panama City and FSU are part of collaborative acoustic tracking networks (e.g., iTAG, FACT, and OTN) expanding the area by which sawfish can be detected (e.g., throughout the Gulf of Mexico, Florida Keys, and up the Atlantic coast). One-hundred of our 132 acoustically tagged sawfish (n=9 tagged in 2016, n=23 for 2017, n=5 for 2018, n=10 for 2019, n=5 for 2020, n=25 for 2021, n=32 for 2022, n=23 for 2023) have been detected on NOAA (n=33 receivers) and on collaborative iTAG and FACT (n > 700 receivers) acoustic receivers throughout the years (2016-current; Figure 15), a 76% success of detection. Sawfish detected on collaborating institution receivers ranged from Apalachicola, Florida to Charleston, South Carolina. Our acoustic receivers have detected 20 different species of marine animals ranging from the American alligator (*Alligator mississippiensis*) to goliath grouper (*Epinephelus itajara*) (Table 7) that have been tagged by state, federal, and university researchers, totaling 446,078 detections from 2016-

present; total sawfish detections from 2016-present are 260,141. This highlights the importance of our array and scientific contributions to collaborative acoustic telemetry entities in both the Gulf of Mexico and Atlantic Ocean.

Three individuals acoustically tagged were recaptured in our survey (n=1) and by our colleagues at FWC (n=2). All three individuals had fully healed surgery scars; the incisions were clean, the sutures completely dissolved, and there were no signs of infection for any of the animals (Figure 16). Two individuals were captured approximately one-month post tagging (Figure 16A) and one was captured 5 months post tagging (Figure 16B). These recaptures confirm that sawfish heal well and relatively quickly post-surgery and that the method of tagging is successful.

Building on our previous publications (Graham et al. 2021, 2022), analyses are underway using a much larger data set to further assess areas of elevated bycatch risk and those that may be designated as Critical Habitat. Social network analyses of adult sawfish will to try and identify potential locations used for mating and detailed habitat use information will be evaluated. Telemetry data for YOY and small juvenile sawfish are being evaluated for changes in habitat use with ontogeny, potentially identifying a general size at which juveniles begin to make migrations. This will inform upon previous knowledge regarding home range and nursery areas and potentially identify any high-use areas previously undocumented.

Figure 14. Distribution of NOAA VR2W acoustic receivers throughout Ten Thousand Islands, northern Everglades National Park, and Florida Bay (n=27).

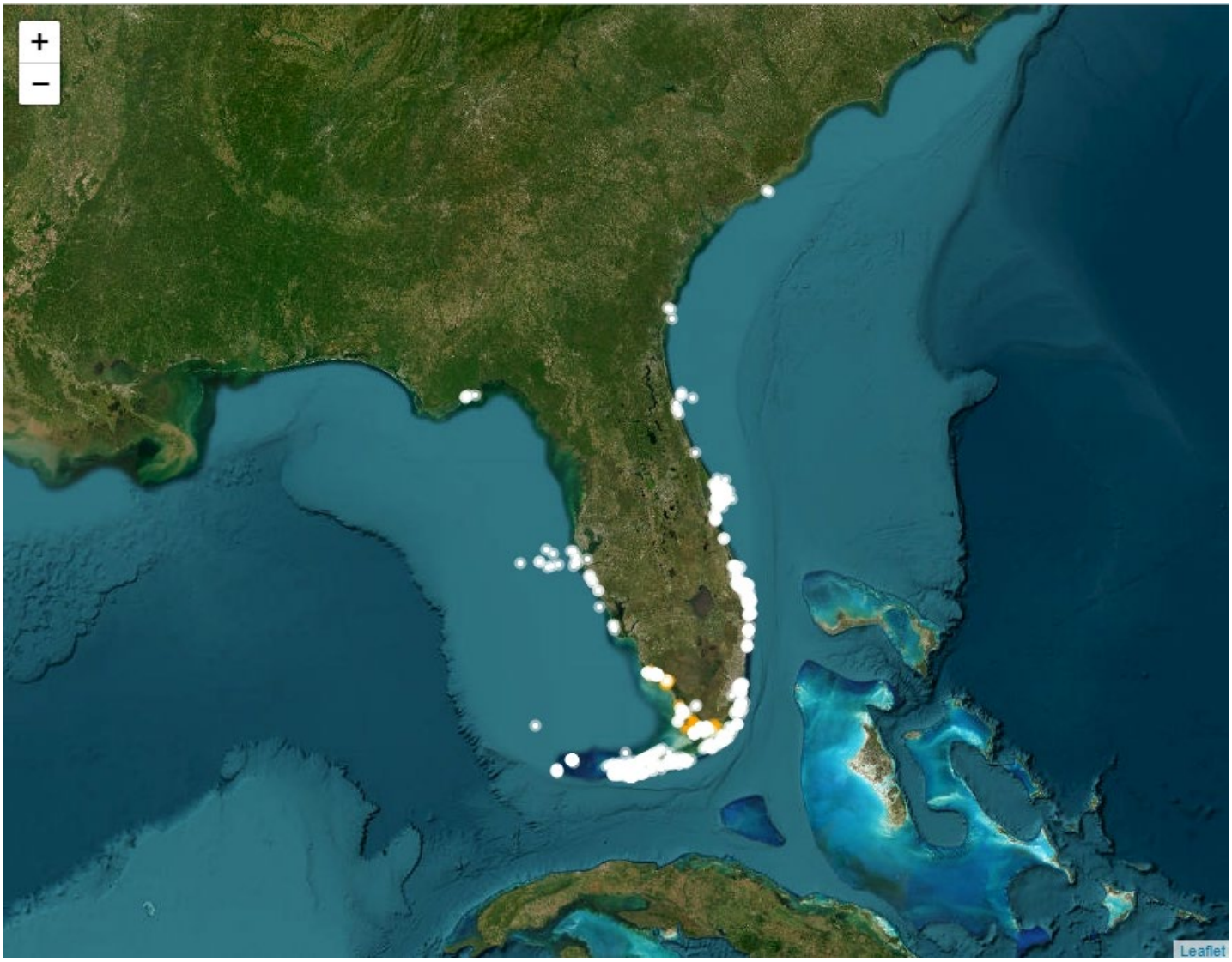

Figure 15. Distribution of Vemco VR2W receivers of NOAA (N=33; orange circles) and of other collaborative institutions (N >700; white circles; iTAG, FACT, OTN) that acoustically tagged sawfish have been detected on.

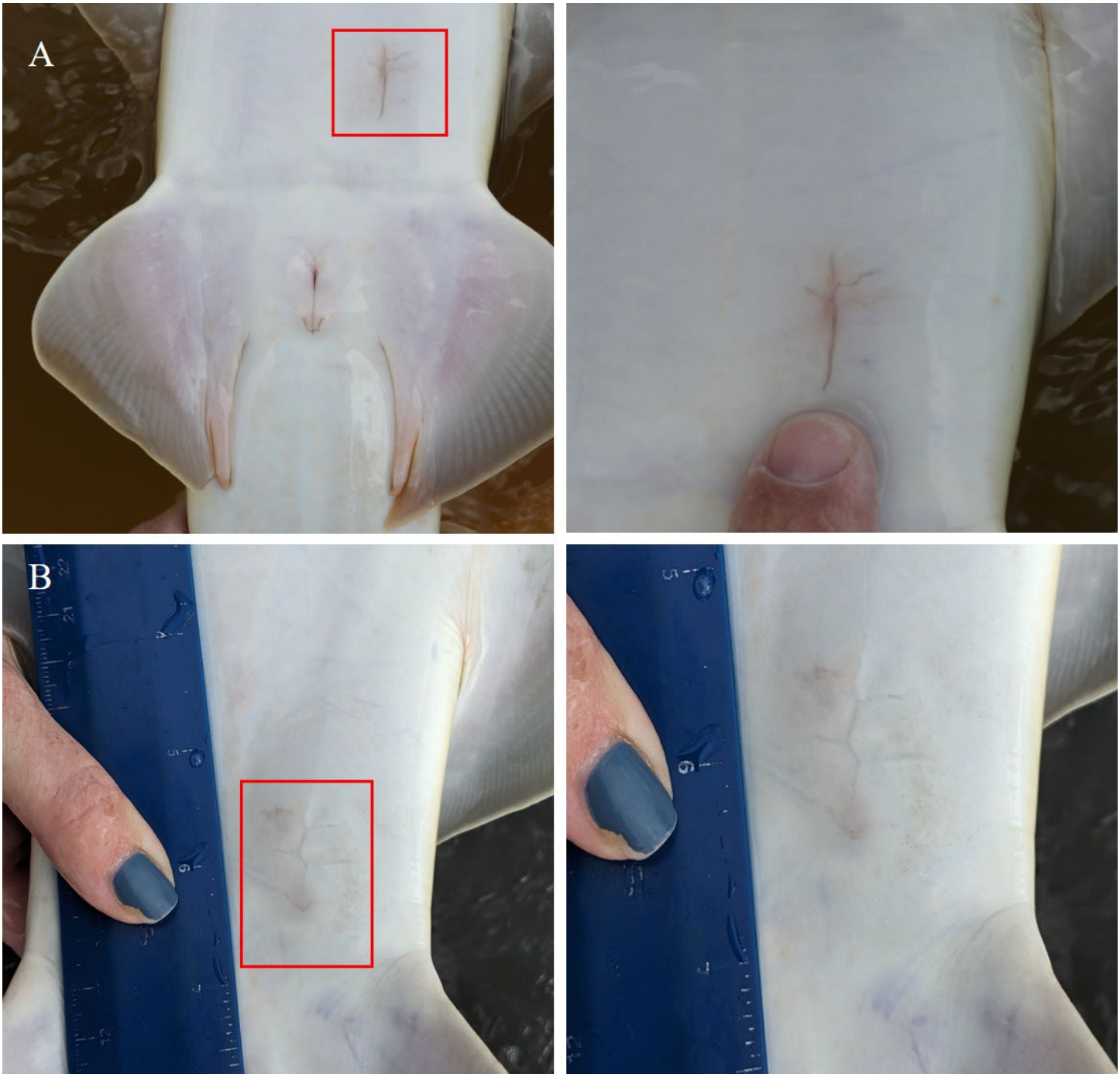

Figure 16. Photographs of two individual young-of-the-year sawfish that were recaptured one-month (A; top row) and 5 months (B; bottom row) post-internal tagging. The incision site is fully healed, the sutures completely dissolved, and no infection is apparent. In the bottom photographs, the incision site is barely visible after 5 months of healing.

CONCLUSIONS

Motor issues with the R/V Pristis greatly affected the gillnet survey, which resulted in only one complete sampling trip (i.e., sampling both Florida Bay and NENP) in September. The gillnet survey in April was completed by walking nets from the shoreline from Chokoloskee Island, which resulted in the capture and tagging of 10 sawfish. The bottom longline survey sampled more days in the Tampa Bay region in 2023, but overall above normal sampling days and number of sets. A total of 20 sawfish were captured in 2023: all 20 sawfish had an acoustic tag surgically implanted with an additional 3 tagged by FWC for a total of 23 sawfish implanted with acoustic tags. Twenty-seven acoustic receivers have been maintained throughout Ten Thousand Islands/Everglades National Park and data (241,460 detections) on 49 individual sawfish and from a variety of different species have been collected on our receivers, showing the importance of this acoustic array to collaborative research entities. Analysis on a tagged large sawfish (>200 cm STL; details in the 2020

report) indicate that these animals are migrating up both the east and west coast of Florida typically migrating north in the summer and south in the winter. Three regions were identified as important areas for sawfish movement and migration: Boca Grande, the Florida Keys, and Cape Canaveral (Graham et al. 2021; Graham et al. 2022). Future research areas should focus on identifying specific habitat features of these identified high-use regions as they could be evaluated as potential Critical Habitat for large sawfish.

Monitoring of sawfish movements and habitat use via satellite and acoustic telemetry is providing invaluable information on this endangered species. Ongoing research investigating changes in habitat use over ontogeny (i.e., sawfish sized 1.0 m to 2.0 m STL) will be valuable to determine at what size juvenile sawfish move out of their nursery habitat, where they migrate to, and potentially identify additional areas of Critical Habitat. As more smalltooth sawfish are acoustically tagged, monitoring continues, and as more colleagues deploy acoustic receivers in their respective study areas, we expect to see an increase in acoustic detections along the coast of the Gulf of Mexico and up the Atlantic coast, which will provide more detailed information about habitat use and migration patterns across all life stages.

FUTURE DIRECTIONS

The goal of the Smalltooth Sawfish Recovery Plan (NOAA 2009a) is to rebuild and assure the long-term viability of the U.S. DPS of smalltooth sawfish in the wild, allowing a reclassification from endangered to threatened status (i.e., downlisting) and ultimately recovery and removal from protection under the ESA (i.e., delisting). Three main objectives were identified to develop the recovery criteria for smalltooth sawfish; the most relevant to our monitoring surveys being substantial increases in abundance.

Since 2009, these surveys have monitored smalltooth sawfish recruitment and juvenile abundance as well as adult abundance in southwest Florida, within the Ten Thousand Islands/Everglades Unit of designated critical habitat (74 FR 45353; NOAA 2009b). As funds allow, monitoring in the three southernmost sub-regions should be continued, using smaller vessels (e.g., kayaks or paddleboards) to gain access to the very shallow areas where immature animals may be residing and are inaccessible to motorized vehicles. Additional monitoring should occur at Lostmans River, the entrance to Rodgers-Broad Rivers, the western portions of Whitewater Bay, and Ponce de Leon Bay if funds were appropriated for houseboat rental and supplies, making multi-day trips to these extremely remote areas possible. In addition, sampling up the Atlantic coastline would expand the survey to include areas where sawfish encounters and detections are occurring more frequently. As this species begins to recover, expansion of this survey to include other recovery regions (NOAA 2009a) would allow for close monitoring of the recovering population.

Acoustic monitoring and maintenance of receivers will continue and acoustic tag deployment in YOY, juvenile, and adult sawfish will continue, funding permitting. As more telemetry data are collected from our 132 tagged sawfish, we will continue to build upon on our previous publications and analyze data to answer many research questions relating to habitat use, migration, mating locations, high-use areas, and potential designations/refinement of Critical Habitat.

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Table 1. Details for smalltooth sawfish captures in the 2023 NOAA Fisheries Panama City Laboratory Juvenile Smalltooth Sawfish Monitoring Survey (n=14). Captures are all via gillnet and are listed in chronological order by date caught. Sub-regions are abbreviated: TTINWR = Ten Thousand Islands National Wildlife Refuge, NENP = Northern Everglades National Park, FLBAY = Florida Bay. Area indicates a specific location within the sub-region, latitude and longitude are in decimal degrees, water depth in meters, lengths are stretched total length (STL), sex (M= Male, F= Female), and life stages are abbreviated: YOY = young-of-the-year, Samples taken are abbreviated: FC = fin clip, M = muscle biopsy, B = blood. An asterisk (*) denotes a 10-year acoustic tag and all others are a 4 to 5-year acoustic tags. A (†) denotes the original capture of the one sawfish that was recaptured (††). The last three rows indicate the sawfish that were captured and tagged by FWC colleagues with NOAA acoustic tags (n=3).

Date	Animal #	Sub-Region	Area	Latitude (N)	Longitude (W)	Depth (m)	STL (cm)	Sex	Life Stage	Dart Tag No.	PIT Tag No.	Method	Acoustic Tag	Samples Taken
1-Apr	001-2023-01-001	NENP	Chokoloskee Island West	25.838	-81.379	0.3	83.5	F	YOY	T0750	982000364843982	Gillnet	23758	FC, M
	003-2023-01-001	NENP	Chokoloskee Island West	25.828	-81.365	0.5	78.5	M	YOY	T0749	982000364968089	Gillnet	23759	FC, M
	005-2023-01-001	NENP	Chokoloskee Island West	25.818	-81.360	0.4	79.7	M	YOY	SD00801	982000364938014	Gillnet	23761	FC, M
	005-2023-01-002	NENP	Chokoloskee Island West	25.818	-81.360	0.4	75	M	YOY	T0746	982000365058721	Gillnet	23757	FC, M
	005-2023-01-003	NENP	Chokoloskee Island West	25.818	-81.360	0.4	77	F	YOY	T0745	982000364937931	Gillnet	23762†	FC, M
	005-2023-01-004	NENP	Chokoloskee Island West	25.818	-81.360	0.4	89.5	M	YOY	T0744	982000364891373	Gillnet	23763	FC, M
	006-2023-01-001	NENP	Chokoloskee Island East	25.821	-81.359	1.0	81.5	M	YOY	T0743	982000364937979	Gillnet	23760	FC, M
	006-2023-01-002	NENP	Chokoloskee Island East	25.821	-81.359	1.0	80.5	F	YOY	T0742	982000364937963	Gillnet	20863	FC, M
	006-2023-01-003	NENP	Chokoloskee Island East	25.821	-81.359	1.0	79.5	M	YOY	SD00807	982000364964281	Gillnet	20862	FC, M
	007-2023-01-001	NENP	Chokoloskee Island East	25.828	-81.364	0.4	78	F	YOY	SD00802	982000364883653	Gillnet	20861	FC, M
11-Sep	067-2023-01-01	TTINWR	Keys_TTINWR	25.891	-81.596	0.4	110.4	M	YOY	SD00817	982000410280784	Gillnet	55265	FC, M
13-Sep	086-2023-01-01	NENP	Chokoloskee Island West	25.818	-81.360	0.7	100	F	YOY	SD001098	982000364937931	Gillnet	23762††	M
	086-2023-01-02	NENP	Chokoloskee Island West	25.818	-81.360	0.7	133	F	YOY	SD000146	982000410285959	Gillnet	55264*	FC, M
	086-2023-01-03	NENP	Chokoloskee Island West	25.818	-81.360	0.7	153	F	Juvenile	SD000193	982000410287703	Gillnet	55267*	FC, M
11-Oct	FWC-2023-01	NENP	Lumber Key	25.759	-81.378	0.3	128.2	F	YOY	Blank roto	989001030726740	Gillnet	55263*	FC
	FWC-2023-02	NENP	Lumber Key	25.759	-81.378	0.3	114.8	F	YOY	Blank roto	989001030726761	Gillnet	55266*	FC
	FWC-2023-03	NENP	Chokoloskee Island West	25.818	-81.360	0.1	81.4	F	YOY	Blank roto	989001030726737	Gillnet	20866	FC

Table 2. Details for smalltooth sawfish captures in the 2023 NOAA Fisheries Panama City Laboratory/ Florida State University juvenile and mature sawfish bottom longline survey (n=7). Note that two animals were captured and tagged while co-PI Kroetz was on a colleague's survey and are thus not included in CPUE (denoted with *). One animal was captured on a standardized longline survey by co-PI Grubbs outside of the normal sampling locations for sawfish, but were included in CPUE due to standardization of the sets (denoted with †). Sub-regions are noted and Area indicates a specific location within the sub-region. Sub-regions are abbreviated: Keys = Coastal Florida Keys. Latitude and longitude are in decimal degrees, depth in meters, lengths are stretched total length (STL), and sex (M= Male, F= Female). Samples taken are abbreviated: FC = fin clip, B = blood, M= muscle biopsy.

Date	Animal #	Sub-Region	Area	Latitude (N)	Longitude (W)	Depth (m)	STL (cm)	Sex	Life Stage	Dart Tag No.	PIT Tag No.	Method	Acoustic Tag (10 year)	Samples Taken
6-Feb	PP-23-015	Keys	7 Mile Bridge Channel	25.700	-81.462	10.5	391	F	Mature	P012202	982000364937480	Longline	62344	FC, M, B
	PP-23-016	Keys	7 Mile Bridge Channel	25.700	-81.462	10.5	373	F	Mature	P012213	982000365092795	Longline	62339	FC, M, B
	PP-23-017	Keys	7 Mile Bridge Channel	25.700	-81.462	10.5	416	F	Mature	P010774	982000364963480	Longline	62341	FC, M, B
	PP-23-018	Keys	7 Mile Bridge Channel	25.700	-81.462	11.0	362	M	Mature	P012204	982000364937913	Longline	62338	FC, M, B
2-Apr	PP-23-44	Keys	Cudjoe Key Channel	24.624	-81.467	4.3	349	M	Mature	SS00006	982000365089102	Longline	62345*	FC, M, B
	PP-23-53	Keys	Cudjoe Key Channel	24.624	-81.467	4.3	415	M	Mature	SS00020	982000364937976	Longline	62343*	FC, M, B
6-Jun	PP-23-051	Big Bend	Seahorse Key	29.099	-83.052	5.0	407	F	Mature	P010764	982000410284839	Longline	62350†	FC, M, B

Table 3. A summary of the CPUE (number of sawfish per soak hour) for the gillnet survey and CPUE (number of sawfish/hooks) for the bottom longline survey. Young-of-the-year= YOY, TTINWR = Ten Thousand Islands National Wildlife Refuge, NENP = Northern Everglades National Park, WWCB = Whitewater and Coot Bays, FLBAY = Florida Bay, FL KEYS = Florida Keys (Inshore/Offshore Florida Keys), TB = Tampa Bay. Sexes are combined and neonate and young-of-the-year sawfish are combined for the gillnet survey and juvenile and mature sawfish are combined for the bottom longline survey.

	Life Stage	TTINWR	NENP	WWCB	FLBAY
Gillnet					
	Neonate	0	0	0	0
	YOY	0.1	0.81	0	0
	Juvenile	0	0.07	0	0

		FLBAY (ENP)	FL KEYS	BIG BEND	TB
Bottom Longline	Juvenile & Mature	0.2	0	0.25	0

Table 4. List of elasmobranch species that were incidental catches in gillnet sets. Species and the number captured are listed for each sub-region. Abbreviations are TTINWR = Ten Thousand Islands National Wildlife Refuge, NENP = Northern Everglades National Park, WWCB = Whitewater and Coot Bays, FLBAY= Florida Bay.

Species	**TTINWR**	**NENP**	**WWCB**	**FLBAY**	**Total**
Carcharhinus leucas	0	0	11	1	12
Carcharhinus limbatus	0	0	0	2	2
Negaprion brevirostris	1	0	0	39	40
Sphyrna tiburo	1	0	0	0	1
Grand Total	**2**	**0**	**11**	**42**	**55**

Table 5. List of teleost species that were incidental catches in gillnet sets. Species and the number captured are listed for all sub-regions combined (Ten Thousand Islands National Wildlife Refuge, Northern Everglades National Park, Whitewater and Coot Bays, Florida Bay).

Species	Total
Archosargus probatocephalus	1
Arius felis	2
Barge marinus	4
Caranx hippos	10
Centropomus undecimalis	3
Elops saurus	1
Eugerres plumieri	10
Gerres cinereus	1
Lobotes surinamensis	1
Megalops atlanticus	21
Mugil cephalus	7
Pogonias cromis	6
Sciaenops ocellatus	1
Trachinotus falcatus	1
Grand Total	**69**

Table 6. List of elasmobranch species that were incidental catches in bottom longline sets.

Species	Total Captured
Carcharhinus acronotus	39
Carcharhinus leucas	28
Carcharhinus limbatus	41
Carcharhinus plumbeus	3
Galeocerdo cuvier	7
Ginglymostoma cirratum	37
Negaprion brevirostris	16
Rhizoprionodon terraenovae	35
Sphyrna lewini	1
Sphyrna mokarran	8
Sphyrna tiburo	3
Grand Total	**218**

Table 7. List of species tagged by state, federal, and university researchers that have been detected on the NOAA acoustic telemetry array since its establishment in 2017.

Species	Common Name
Carcharhinus acronotus	Blacknose shark
Carcharhinus leucas	Bull shark
Carcharhinus limbatus	Blacktip shark
Galeocerdo cuvier	Tiger shark
Negaprion brevirostris	Lemon shark
Aetobatus narinari	Spotted eagle ray
Megalops atlanticus	Atlantic tarpon
Epinephelus itajara	Goliath grouper
Caranx hippos	Crevalle jack
Centropomus undecimalis	Common snook
Albula vulpes	Bonefish
Lutjanus griseus	Grey snapper
Trachinotus falcatus	Permit
Sciaenops ocellatus	Red drum
Micropterus salmoides	Florida largemouth bass
Archosargus probatocephalus	Sheepshead
Menticirrhus americanus	Southern kingfish
Lobotes surinamensis	Atlantic tripletail
Cynoscion nebulosus	Spotted sea trout
Alligator mississippiensis	American alligator

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