

NOAA FISHERIES SMALLTOOTH SAWFISH MONITORING SURVEY-FY22
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 2022 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-2021-SCI-0037, and EVER-2022-SCI-0021.

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 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 surveys and coastal waters of the Florida Keys were categorized into five sub-regions (north to south, Figure 1): 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.

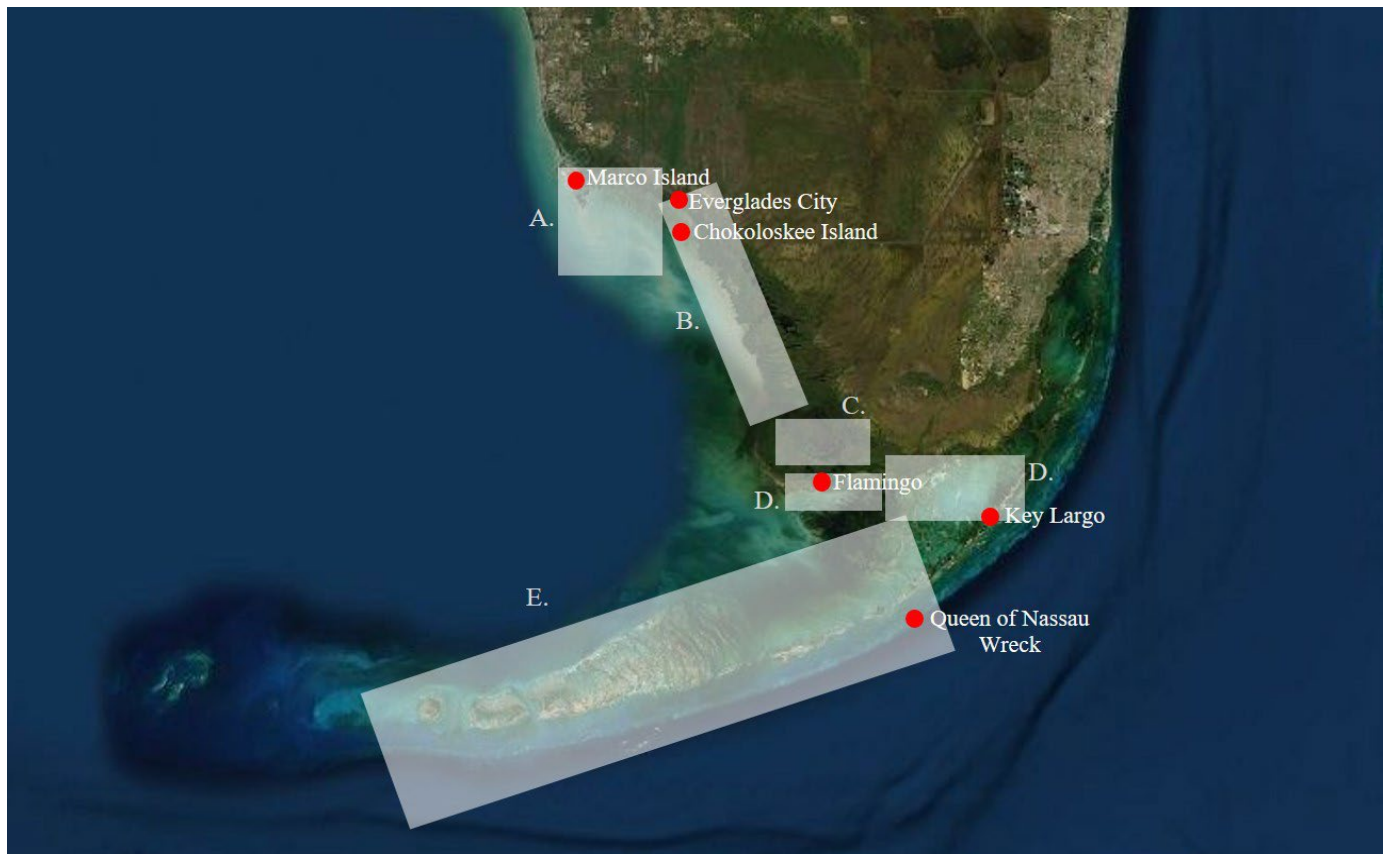


Figure 1. Five sub-regions of the 2022 NOAA Fisheries Panama City Laboratory smalltooth sawfish gillnet survey (north to south): A. Ten Thousand Islands National Wildlife Refuge, B. Northern Everglades National Park, C. Whitewater and Coot Bays, and D. Florida Bay. Florida State University bottom longline survey regions include C. Whitewater and Coot Bays, D. Florida Bay and E. Florida Keys National Marine Sanctuary, 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). Animals near 200 cm STL were considered potential candidates for satellite tag attachment via the loop-harness method (Carlson et al. 2013). Two types of satellite tags were available for attachment: MiniPAT (pop-up archival transmitting tag) and SPOT (Smart Position or Temperature Transmitting) tag (©Wildlife Computers Inc.). The miniPATs were programmed to record and store information on geolocation, temperature, and depth every 60 seconds and were programmed to release from the animal 105 days after deployment, at which time all data from the tag will be transmitted to Argos satellites. The SPOT tag is a near real-time tag where information on geolocation is transmitted to Argos satellites when the tag breaks the water's surface. The battery life on the SPOT tags is estimated to be approximately six months. In addition to satellite tags, 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 87-140 cm STL. Sawfish ≥ 145 cm STL were implanted with V16 (16 mm diameter, 17.3 g wet, battery life 3650 days, code transmission every 70-150 seconds) or V16-4x (16 mm diameter, 10.3 g wet, battery life 3650 days, code transmission every 80-160 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. Release

time was 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 recorded using the vessel's sonar. Water clarity was measured using a secchi disc and tidal stage was recorded.

RESULTS

A total of 148 gillnet sets were made over 23 sampling days in April, July, and November (Figure 2), capturing 1 neonate, 22 YOY, and 1 juvenile smalltooth sawfish (n=24, Table 1). The CPUE by life stage and sub-region can be found in Table 3. Generally, animals were captured in very shallow (0.2 - 0.8 m) and warm (23.2 - 32.1 °C) water and in a wide range of salinities (3.3 - 39.3) and large range of dissolved oxygen concentrations (3.01 - 9.56 mg/L). All animals were captured against red and black mangrove shoreline, primarily on a mudflat. A fin clip was taken from every animal, a muscle biopsy for stable isotopes was collected from 22 of the animals, blood for heavy metal contamination examination from 8 animals, and 12 were internally acoustically tagged. One animal was considered a recapture as colleagues from FWC in Charlotte Harbor had captured, sampled, and tagged this animal (with our acoustic tag) two weeks prior to our capture (Table 1).

A total of 56 bottom longline sets were made over 10 sampling days on three trips in February, April, and September (Figure 3) capturing 10 smalltooth sawfish; 7 mature males, 1 immature male, 1 immature female, and 1 male was lost at the boat (n=10, Table 2). The CPUE by sub-region can be found in Table 3. Generally, the sawfish were captured between 2.6-3.6 m of water that was on average 28.3 °C, had DO of 5.7 mg/L, and average salinity of 34.1. A fin clip and muscle biopsy were taken and blood was drawn from each sawfish and all were internally acoustically tagged.

Our collaborators at the Field School captured two sawfish in Biscayne Bay, FL via scientific longlines (Figure 4). One mature male was captured in April and one juvenile female was captured in May (Table 2). A fin clip and muscle biopsy were taken from both animals and each were internally acoustically tagged.

The smallest sawfish captured in 2022 was caught in Everglades National Park (71.0 cm STL, female) and the largest was caught in the same location and same gillnet set (150.0 cm STL, female; Table 1). The largest sawfish captured on longline was in Everglades National Park in the East Cape Canal (418.0 cm STL male). It is notable that four sawfish were captured in Ponce de Leon Bay in April (Table 2). No sawfish were tagged with satellite tags.



Figure 2. Distribution of all gillnet sets in the 2022 NOAA Fisheries Panama City Laboratory smalltooth sawfish gillnet survey (n=148). Red circles indicate a gillnet set and yellow circles are locations of positive smalltooth sawfish captures (n=24).

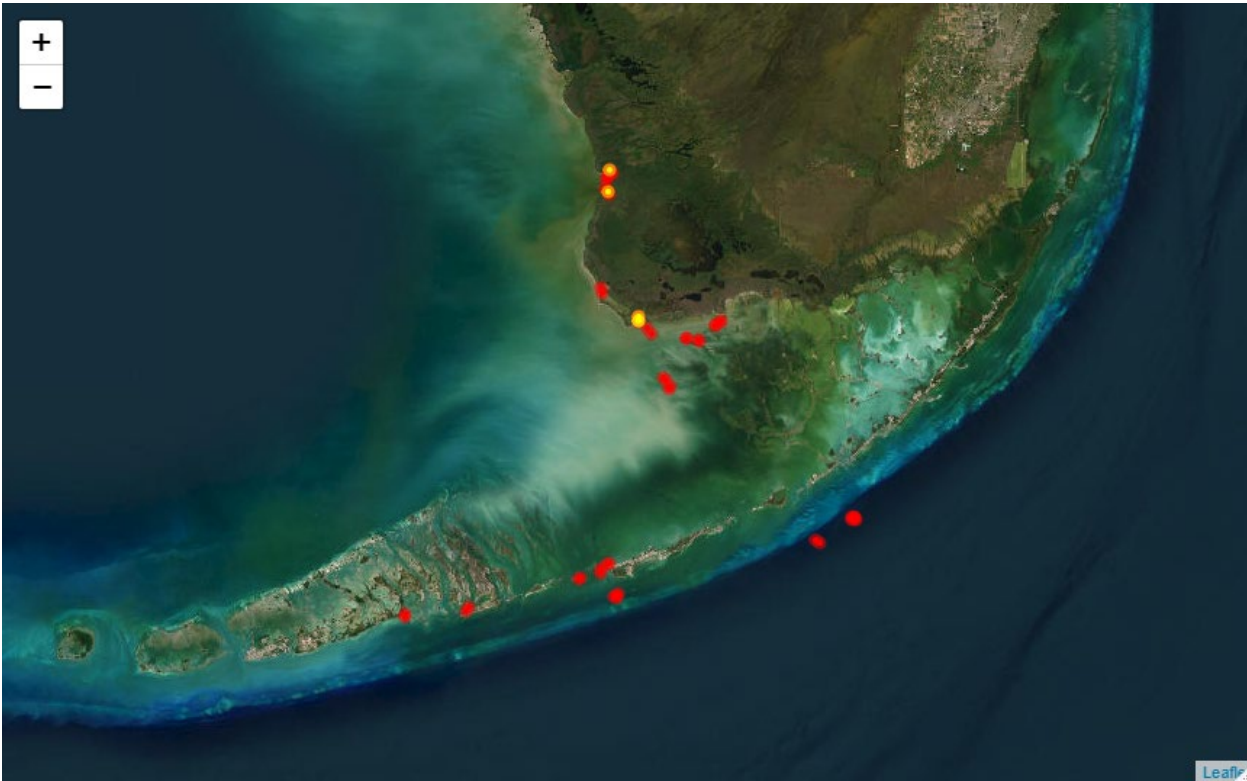


Figure 3. Distribution of bottom longline sets in the 2022 NOAA Fisheries Panama City Laboratory/Florida State University smalltooth sawfish bottom longline survey (n=56). Red circles indicate a bottom longline set and yellow circles are locations of positive smalltooth sawfish captures (n=10).



Figure 4. Location of the two (n=2) captured sawfish in Biscayne Bay, FL by the Field School. These sawfish were captured in close proximity to Key Biscayne.

Gillnet Sets

Ten Thousand Islands National Wildlife Refuge (TTINWR)

Monitoring in this sub-region was conducted in April, July, and November via 38 gillnet sets over six sampling days. Sets were made around Panther Key, Faka Union Bay, Pumpkin Bay, Grocery Creek, and Goodland Bay (Figure 5).

Information was collected on two male and one female YOY smalltooth sawfish that were captured on mudflats and the two males were internally acoustically tagged with a 4 to 5-year acoustic tag (Table 1; Figure 5). No recaptures occurred in this sub-region in 2022. Other elasmobranchs captured in this sub-region included bull (*Carcharhinus leucas*), spinner (*C. brevipinna*), bonnethead (*Sphyrna tiburo*), and lemon (*Negaprion brevirostris*) sharks (Table 4).



Figure 5. Distribution of 2022 gillnet sets in the Ten Thousand Islands National Wildlife Refuge (TTINWR) sub-region (n=38). Red circles indicate a gillnet set and yellow circles indicate sets with positive smalltooth sawfish captures (n=2).

Northern Everglades National Park (NENP)

Monitoring in this sub-region was conducted in April, July, and November via 25 gillnet sets over six sampling days (Figure 6). Sets were made around Chokoloskee Island, and in Turner and Lopez Rivers (Figure 6). Information was collected on one neonate, 18 YOY, and one juvenile smalltooth sawfish (n=20) captured around Chokoloskee Island (Table 1; Figure 6). Of the eight animals captured in this region in July, ~12 animals were seen swimming in the shallows prior to the net set. Two of the animals were corralled into the net while the other 6 swam into the net while the other animals were being worked up. These animals would not be considered as randomly captured and would be excluded from the yearly relative abundance estimates. Eight 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 2022 as it was previously captured, sampled, and tagged by FWC colleagues two weeks prior. Other elasmobranchs captured in this sub-region included bull sharks (*C. leucas*) cownose rays (*Rhinoptera bonasus*) (Table 4).



Figure 6. Distribution of 2022 gillnet sets in the northern Everglades National Park (NENP) sub-region (n=25). Red circles indicate gillnet sets and yellow circles indicate sets with positive smalltooth sawfish captures (n=20).

Whitewater and Coot Bays,

Monitoring in the Whitewater and Coot Bays sub-regions was conducted in April, July, and November via 19 gillnet sets over three days of sampling (Figure 7). No smalltooth sawfish were captured in these sub-regions and a bull sharks (*C. leucas*) was the only elasmobranchs captured (Table 4).

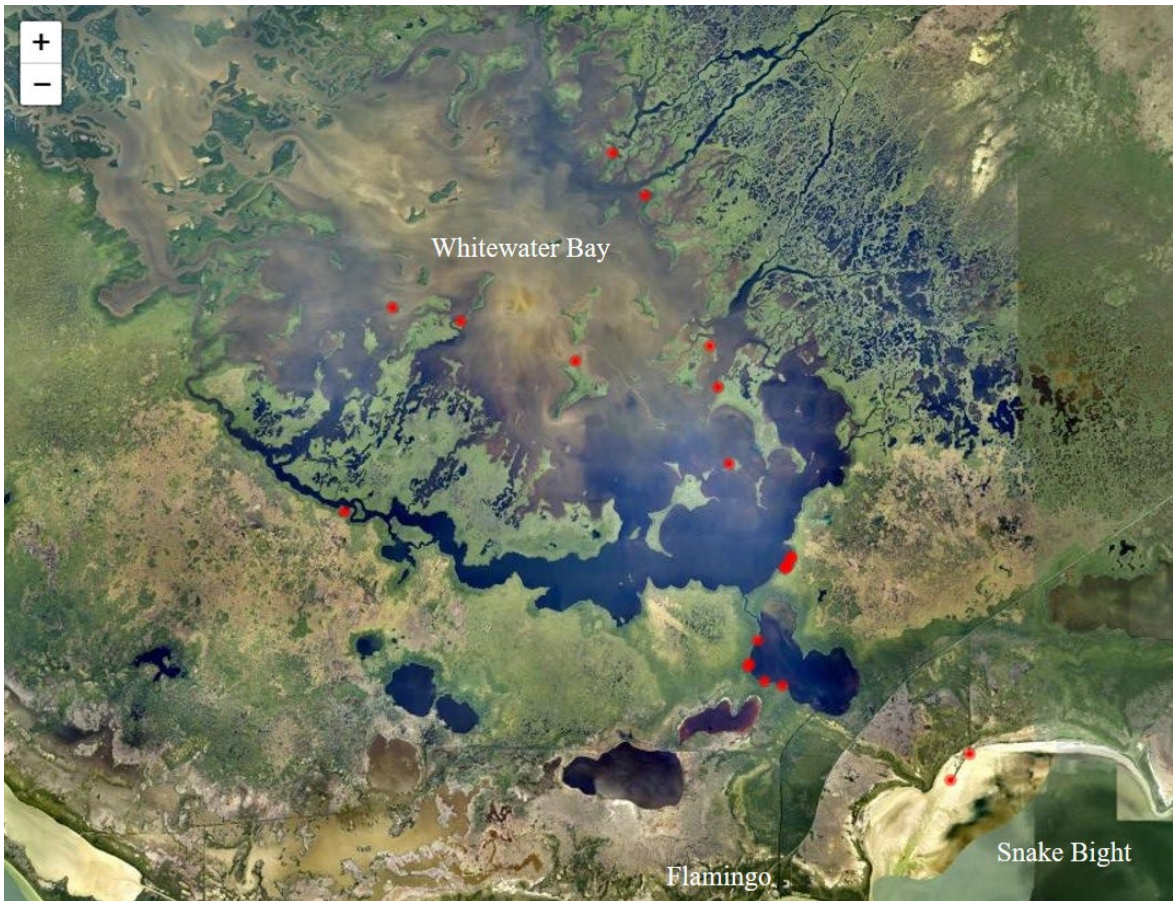


Figure 7. Distribution of 2022 gillnet sets in the Whitewater and Coot Bays (WWCB) sub-regions (n=19). Red circles indicate gillnet sets.

Florida Bay (including Flamingo)

Monitoring in the Florida Bay sub-region was conducted in April, July, and November via 66 gillnet sets over nine days of sampling. Sets were made along the shoreline near Flamingo, in Snake Bight, and at many keys throughout Florida Bay (Figure 8). Exploration in this sub-region was greatly expanded from previous years and one smalltooth sawfish was captured in this sub-region in Little Madeira Bay. Other elasmobranchs captured included bull (*C. leucas*), blacktip (*C. limbatus*), lemon (*N. brevirostris*), bonnethead (*S. tiburo*), and nurse (*Ginglymostoma cirratum*) sharks and Atlantic stingrays (*Hypanus sabinus*) (Table 4).

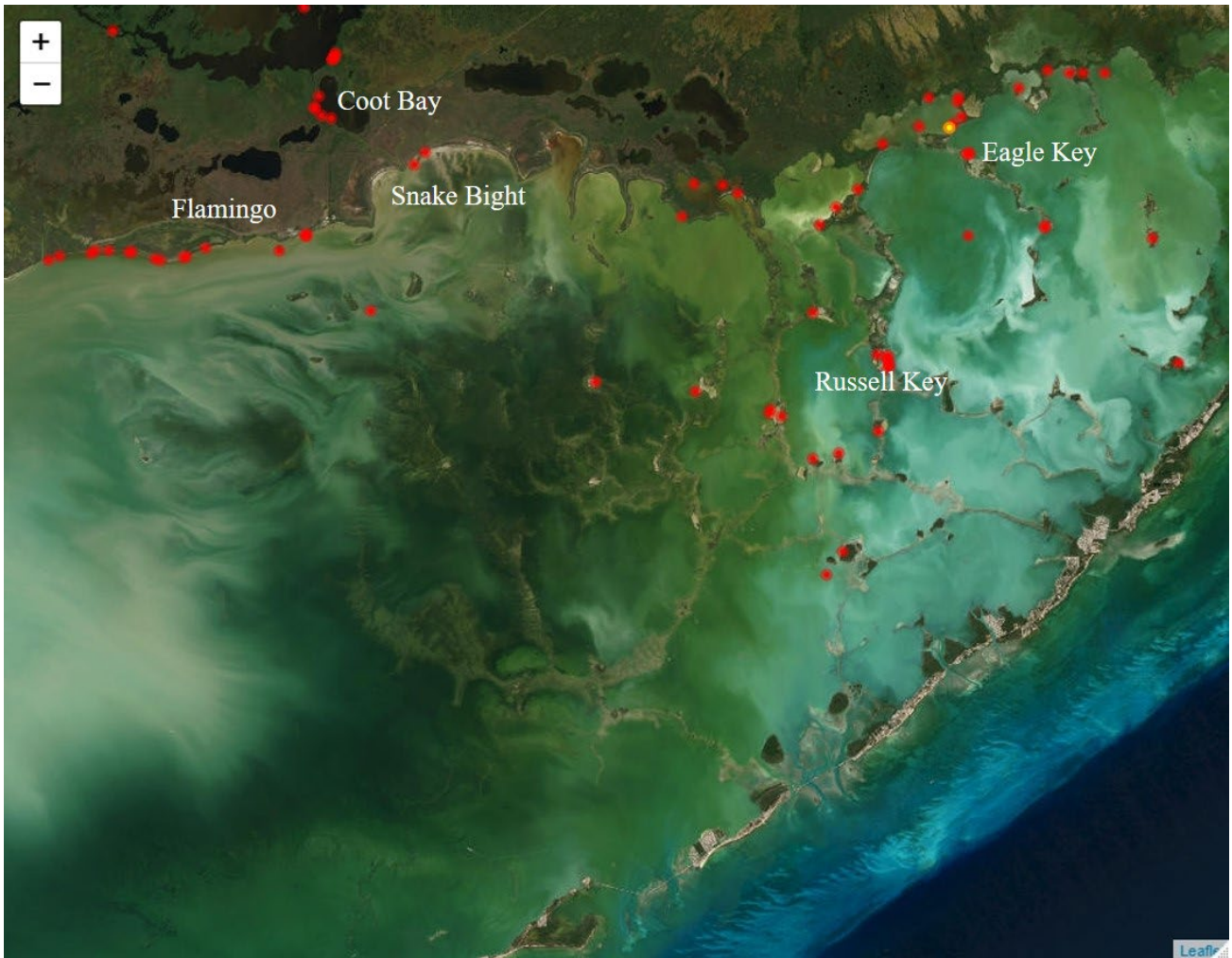


Figure 8. Distribution of 2022 gillnet sets in the Florida Bay sub-region (n=66). Red circles indicate gillnet sets and yellow circles indicate sets with positive smalltooth sawfish captures (n=1).

Bottom Longline

Southern Everglades National Park (SENP)

Thirty-five bottom longline sets were made in the southern portion of Everglades National Park sub-region in February and April (Figure 9). Ten smalltooth sawfish were captured within park boundaries at in Ponce de Leon Bay (n=5) and East Cape Canal (n=5) (Table 2). Nine sawfish were implanted with 10-year acoustic tags; 8 males and one female. One male sawfish broke off the line at the boat and was unable to be worked up. Other elasmobranchs captured in this region 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*), silky (*C. falciformis*), sandbar (*C. plumbeus*), and finetooth (*C. isodon*) sharks and southern stingray (*H. americanus*) (Table 6).



Figure 9. Distribution of bottom longline sets within Everglades National Park boundaries (e.g., sets within Florida Bay) in 2022 (n=35). Red circles indicate bottom longline sets and yellow circles indicate sets with positive smalltooth sawfish captures (n=10; 1 lost at the boat).

Florida Keys National Marine Sanctuary-Inshore/Offshore Florida Keys

Twenty-one bottom longline sets were made in the Florida Keys National Marine Sanctuary and inshore/offshore Florida Keys sub-region in February, April, and September (Figure 10). No smalltooth sawfish were captured in this sub-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*), scalloped hammerhead (*S. lewini*), great hammerhead (*S. mokarran*), bonnethead (*S. tiburo*), tiger (*Galeocerdo cuvier*), and sandbar (*C. plumbeus*) sharks (Table 6).



Figure 10. Distribution of bottom longline sets within the inshore/offshore Florida Keys (n=21) sub-region. Red circles indicate bottom longline sets.

ACOUSTIC & SATELLITE TELEMETRY

Twenty-three smalltooth sawfish were internally tagged with acoustic tags in 2022: 11 young-of-the-year, 3 juveniles, 1 maturing, and 8 mature (Tables 1, 2). Thirteen 10-year and 10 4- to 5-year acoustic tags were implanted in smalltooth sawfish. Since internal implementation of acoustic tags began in 2016, a total of 109 sawfish have been tagged throughout the Ten Thousand Islands National Wildlife Refuge, Everglades National Park, and Florida Keys. Of these animals, 30 were YOY, 32 were juvenile, 12 were maturing individuals, and 35 were mature. Thirteen sawfish have been tagged by collaborators at The Field School (n=4 total) and FWC Charlotte Harbor (n=9 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 2022 is 30 (Figure 11). Five new receivers were deployed in Everglades National Park: two around the Chokoloskee area and three in Florida Bay. A total of 205,696 detections were downloaded from receivers during the 2022 deployment year; 85,628 detections were from 55 individual sawfish and 120,068 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). Eighty-six of our 109 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) have been detected on NOAA (n=29 receivers) and on collaborative iTAG and FACT (n > 400 receivers) acoustic receivers throughout the years (2016-current; Figure 12), a 79% success of detection. Sawfish detected on collaborating institution receivers ranged from Apalachicola, Florida to Charleston, South Carolina. Our acoustic receivers have detected 14 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. This highlights the importance of our array and scientific contributions to collaborative acoustic telemetry entities in both the Gulf of Mexico and Atlantic Ocean.

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 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 11. Distribution of NOAA VR2W acoustic receivers throughout Ten Thousand Islands, northern Everglades National Park, and Florida Bay (n=30).

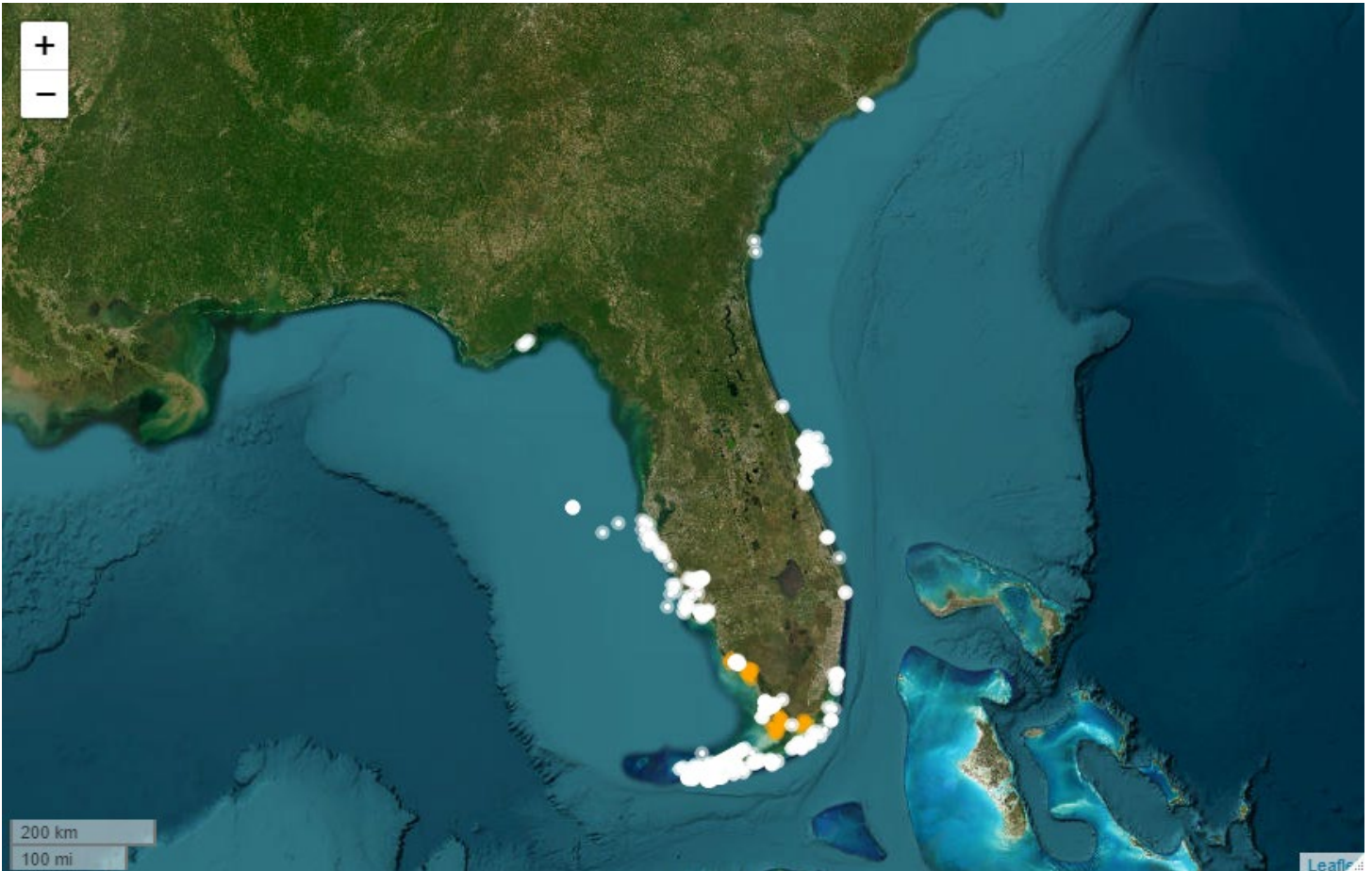


Figure 12. Distribution of Vemco VR2W receivers of NOAA (N=29; orange circles) and of other collaborative institutions (N >400; white circles; iTAG, FACT, OTN) that acoustically tagged sawfish have been detected on.

CONCLUSIONS

This was the first year since COVID-19 pandemic travel restrictions were put in place in 2020 that the gillnet survey was able to fully operate and as a result, 24 small sawfish were captured. The bottom longline survey sampled fewer days than in previous years due to damage to the primary research vessel, leading to the loss of about 9 sampling days, however, 10 large sawfish were still caught. Additionally, collaborators from The Field School were able to sample and tag two smalltooth sawfish captured in Biscayne Bay, FL, making four total sawfish tagged in this area. A total of 36 sawfish were captured in 2022: 23 of those sawfish had an acoustic tag surgically implanted with an additional 9 tagged by FWC for a total of 32 sawfish implanted with acoustic tags. Thirty acoustic receivers have been maintained throughout Ten Thousand Islands/Everglades National Park and data (85,628 detections) on 55 individual sawfish and from 14 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 109 tagged sawfish, we will continue to build upon 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.

ACKNOWLEDGEMENTS

Thank you to S. Olijnyk, B. Moore, and all of the park rangers at the Everglades National Park Gulf Coast Visitor Center in Everglades City, FL, and the Flamingo Visitor Center in Homestead, FL. Special thanks to Adam Brame and Angela Somma for helping to secure funding. We thank Adam Brame, Matthew Bernanke, Emma Jackson, Hannah Morales, Breanna Phillips, Annsli Hilton, Ezra Holbrook, and Jesse Stovall for assistance with gillnet fieldwork. We thank Ashley Dawdy, Blake Hamilton, and Annais Bonilla-Johnson for assistance in organizing longline sampling trips and assistance in the field. We also thank Vital Heim, Matthew Bernanke, Emily Sapp, Jasmine Nyce, Kylie Bostick, Wyatt Albert, and Kristin Palmrose for assistance longline sampling. Satellite images were created using R statistical platform via the leaflet package. Reference to trade names does not imply endorsement by NOAA Fisheries. Research in this report follows Protected Species Permit #SEFSC-NMFS-ESA-22078. Permission to conduct research in Everglades National Park was approved by EVER-2021-SCI-0037 and EVER-2022-SCI-0021. Gillnet and Longline sampling were also conducted under Florida Special Activities Licenses SAL-22-1292-SRP and SAL-22-1345-SRP, respectively, and longline sampling within the NOAA Florida Keys National Marine Sanctuary was approved under FKNMS-21-066.

LITERATURE CITED

Bethea, D.M., G.A. Casselberry, and J.K. Carlson (2015) NOAA NMFS SMALLTOOTH SAWFISH MONITORING REPORT-FY15 Relative Abundance and Essential Fish Habitat Studies for Smalltooth Sawfish, *Pristis pectinata*, in Southwest Florida, USA. An Internal Report to NOAA Southeast Regional Office. National Marine Fisheries Service Panama City Laboratory Contribution 15-20

Branstetter, S. (1987) Age and growth estimates for blacktip, *Carcharhinus limbatus*, and spinner, *C. brevipinna*, sharks from the northwestern Gulf of Mexico. *Copeia* 1987(4):964-974

Branstetter, S. and R. Stiles (1987) Age and growth estimates of the bull shark, *Carcharhinus leucas*, from the northern Gulf of Mexico. *Environmental Biology of Fishes* 20(3):169-181

Brown, C.A. and S.H. Gruber (1988) Age assessment of the lemon shark, *Negaprion brevirostris*, using tetracycline validated vertebral centra. *Copeia* 1988 (3):747-753

Carlson, J.K., E. Cortes and D.M. Bethea (2003) Life history and population dynamics of the finetooth shark

(*Carcharhinus isodon*) in the northeastern Gulf of Mexico. Fishery Bulletin 101(2):281-292

Carlson, J.K., S.J.B. Gulak, C.S. Simpfendorfer, R.D. Grubbs, J.G. Romine and G.H. Burgess (2013) Habitat use and movement patterns of smalltooth sawfish, *Pristis pectinata*, determined using pop-up satellite archival tags. Aquatic Conservation 24(1): 104-117

Castro, J. (2000) The biology of the nurse shark, *Ginglymostoma cirratum*, off the Florida east coast and the Bahama Islands. Environmental Biology of Fishes 58:1-22

Graham, J, A.M. Kroetz, G.R. Poulakis, R.M. Scharer, J.K. Carlson, S. Lowerre-Barbieri, D. Morley, E.A. Reyier, R.D. Grubbs. 2021. Large-scale space use of large juvenile and adult smalltooth sawfish *Pristis pectinata*: implications for management. Endangered Species Research 44:45-59.

Graham, J., A.M. Kroetz, G.R. Poulakis, R.M. Scharer, J.K. Carlson, S. Lowerre-Barbieri, D. Morley, E.A. Reyier, R.D. Grubbs. 2022. Commercial fishery bycatch risk for large juvenile and adult smalltooth sawfish (*Pristis pectinata*) in Florida waters. Aquatic Conservation: Marine and Freshwater Ecosystems, 1-16. <https://doi.org/10.1002/aqc.3777>

Henningsen, A.D. and J.D. McEachran (2000) Notes on Reproduction in the Southern Stingray, *Dasyatis americana* (Chondrichthyes: Dasyatidae), in a Captive Environment. Copeia 2000(3):826-828

Henningsen, A. D. (2002) "Age and growth in captive southern stingrays, *Dasyatis americana*." Annual Meeting American Elasmobranch Society, Kansas, Missouri. July 2002

Kroetz, A.M., J.K. Carlson, and R.D. Grubbs (2019) NOAA FISHERIES SMALLTOOTH SAWFISH MONITORING SURVEY-FY19. Relative Abundance and Essential Fish Habitat Studies for Smalltooth Sawfish, *Pristis pectinata*, in Southwest Florida, USA. An Internal Report to NOAA Southeast Regional Office. National Marine Fisheries Service Panama City Laboratory Contribution 20-01

Lombardi-Carlson L.A., E. Cortés, G.R. Parsons and C.A. Manire (2003) Latitudinal variation in life-history traits of bonnethead sharks, *Sphyrna tiburo*, (Carcharhiniformes: Sphyrnidae) from the eastern Gulf of Mexico. Marine and Freshwater Research 54:875-883

NOAA (2009a) Recovery plan for smalltooth sawfish (*Pristis pectinata*). NMFS, Smalltooth Sawfish Recovery Team, Silver Spring, Maryland. 102pp Available: sero.nmfs.noaa.gov/pr/SmalltoothSawfish.htm.

NOAA (2009b) Critical habitat for the endangered distinct population segment of smalltooth sawfish. Federal Register 74:169 (45353–45378). Available: sero.nmfs.noaa.gov/pr/SmalltoothSawfish.htm.

Poulakis, G.R. and J.C. Seitz (2004) Recent occurrence of the smalltooth sawfish, *Pristis pectinata* (Elasmobranchiomorphi: Pristidae), in Florida Bay and the Florida Keys, with comments on sawfish ecology. Florida Scientist 67:27-35

Poulakis, G.R., P.W. Stevens, A.A. Timmers, T.R. Wiley and C.A. Simpfendorfer (2011) Abiotic affinities and spatiotemporal distribution of the endangered smalltooth sawfish, *Pristis pectinata*, in a south-western Florida nursery. Marine and Freshwater Research 62:1165-1177

Seitz, J.C. and G.R. Poulakis (2002) Recent occurrence of sawfishes (Elasmobranchiomorphi: Pristidae) along the southwest coast of Florida (USA). Florida Scientist 65:256–266

Simpfendorfer, C.A., G.R. Poulakis, P.M. O'Donnell, and T. Wiley (2008) Growth rates of juvenile smalltooth sawfish *Pristis pectinata* Latham in the western Atlantic. Journal of Fish Biology 72:711–723

Simpfendorfer, C.A. and T. Wiley (2005) Identification of priority areas for smalltooth sawfish conservation. Mote Marine Technical Report 1021

Snelson, Jr, F.F., S.E. Williams-Hooper and T.H. Schmid (1988) Reproductive ecology of the Atlantic stingray, *Dasyatis sabina*, in Florida coastal lagoons. *Copeia* 1988(3):729-739

Wiley, T. and C.A. Simpfendorfer (2007) The development and implementation of protocols to monitor the relative abundance of juvenile smalltooth sawfish. Mote Marine Technical Report 1229

Table 1. Details for smalltooth sawfish captures in the 2022 NOAA Fisheries Panama City Laboratory Juvenile Smalltooth Sawfish Monitoring Survey (n=24). 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 one sawfish that was a recapture, originally tagged by partners at FWC and tagged with a NOAA acoustic tag.

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
11-Apr	002-2022-02-001	FLBAY	Little Madeira Bay	25.185	-80.610	0.4	74	M	YOY	T1406	982000364937831	Gillnet	-	FC
15-Apr	030-2022-01-002	NENP	Mud Bay	25.816	-81.326	0.6	145	M	YOY	SS00002	982000364963335	Gillnet	62114*	FC, M, B
17-Apr	040-2022-01-001	TTINWR	Dredge Spoil Island	25.900	-81.518	0.2	75.5	F	YOY	T1408	982000364968168	Gillnet	-	FC, M, B
18-Apr	051-2022-01-002	NENP	Chokoloskee Island West	25.828	-81.364	0.8	71	F	YOY	T1410	982000364963802	Gillnet	-	FC, M, B
	051-2022-01-003	NENP	Chokoloskee Island West	25.828	-81.364	0.8	79	M	YOY	T1411	982000364937998	Gillnet	-	FC, M, B
	051-2022-01-004	NENP	Chokoloskee Island West	25.828	-81.364	0.8	73.5	F	Neonate	T1412	982000365057775	Gillnet	-	FC, M, B
	051-2022-01-005	NENP	Chokoloskee Island West	25.828	-81.364	0.8	73	F	YOY	T1413	982000364963996	Gillnet	-	FC, M, B
	051-2022-01-006	NENP	Chokoloskee Island West	25.828	-81.364	0.8	77.5	M	YOY	T1414	982000365057998	Gillnet	-	FC, M
	051-2022-01-007	NENP	Chokoloskee Island West	25.828	-81.364	0.8	77	F	YOY	T1415	982000364963913	Gillnet	-	FC, M
	051-2022-01-008	NENP	Chokoloskee Island West	25.828	-81.364	0.8	77	F	YOY	T1416	982000364967525	Gillnet	-	FC, M, B
	051-2022-01-009	NENP	Chokoloskee Island West	25.828	-81.364	0.8	150	F	Juvenile	SS00024	982000364884248	Gillnet	7345*	FC, M, B
22-Jul	081-2022-01-01	NENP	Chokoloskee Island West	25.818	-81.360	0.3	100	M	YOY	SD00702	982000364844193	Gillnet	23753	FC, M
	081-2022-01-02	NENP	Chokoloskee Island West	25.818	-81.360	0.3	90	M	YOY	SD00717	982000364967618	Gillnet	20865	FC, M
	081-2022-01-03	NENP	Chokoloskee Island West	25.818	-81.360	0.3	74	F	YOY	SD00722	982000364965964	Gillnet	-	FC, M
	081-2022-01-04	NENP	Chokoloskee Island West	25.818	-81.360	0.3	75	M	YOY	SD00704	982000364923519	Gillnet	-	FC, M
	081-2022-01-05	NENP	Chokoloskee Island West	25.818	-81.360	0.3	87.5	M	YOY	SD00724	982000364923468	Gillnet	23750	FC, M
	081-2022-01-06	NENP	Chokoloskee Island West	25.818	-81.360	0.3	87	F	YOY	SD00710	982000364891230	Gillnet	23749	FC, M
	081-2022-01-07	NENP	Chokoloskee Island West	25.818	-81.360	0.3	87.5	F	YOY	FWC Blank roto	989001030726687	Gillnet	20855†	
	081-2022-01-08	NENP	Chokoloskee Island West	25.818	-81.360	0.3	71.5	M	YOY	SD00718	982000364967351	Gillnet	-	FC, M
	083-2022-01-01	NENP	Mud Bay	25.816	-81.326		103	F	YOY	SD00719	982000364937466	Gillnet	23748	FC, M
	084-2022-01-01	NENP	Turner River	25.831	-81.338	0.4	89	M	YOY	SD00713	982000364967954	Gillnet	23754	FC, M
23-Jul	085-2022-01-01	TTINWR	Grocery Creek	25.951	-81.615	0.4	94	M	YOY	SD00701	982000365058492	Gillnet	23755	FC, M
24-Jul	093-2022-01-01	TTINWR	Dredge Spoil Island	25.900	-81.517	0.4	106	M	YOY	SD00712	982000365058372	Gillnet	23756	FC, M
9-Nov	142-2022-01-01	NENP	Chokoloskee Island East	25.828	-81.364	0.6	94.5	M	YOY	SD00822	982000364835834	Gillnet	59326	FC, M

Table 2. Details for smalltooth sawfish captures in the 2022 NOAA Fisheries Panama City Laboratory/ Florida State University juvenile and mature sawfish bottom longline survey (n=9) and captures from collaborators at the Field School (n=2). Note that one animal was lost at the boat in the Florida State University longline survey and thus not included in the table. Sub-regions are noted and Area indicates a specific location within the sub-region. Sub-regions are abbreviated: SENP= Southern Everglades National Park, FLBAY = Florida Bay. Latitude and longitude are in decimal degrees, depth in meters, lengths are stretched total length (STL), and sex (M= Male, F= Female). Life stage of maturing indicates that a female is on the cusp of being a mature based on size and hormone analyses (Gelsleichter unpublished data). Samples taken are abbreviated: FC = fin clip, B = blood, M= muscle biopsy. An asterisk (*) indicates an animal that was tagged by the Field School.

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
2-Feb	PP-22-017	FLBAY	Outside East Cape Canal	25.122	-81.059	1.6	263	F	Juvenile	P011841	982000364938023	Longline	1650	FC, M, B
5-Apr	PP-22-129	SENP	Ponce de Leon Bay	25.350	-81.124	3.3	377	M	Mature	P011227	982000364937615	Longline	1649	FC, M, B
	PP-22-130	SENP	Ponce de Leon Bay	25.350	-81.124	3.3	402	M	Mature	P011237	982000364963467	Longline	20874	FC, M, B
	PP-22-131	SENP	Ponce de Leon Bay	25.350	-81.124	3.3	377	M	Mature	P011246	982000364937802	Longline	62346	FC, M, B
	PP-22-146	SENP	Pristis Creek - Ponce Bay	25.386	-81.122	2.6	276	M	Juvenile	P011242	982000364938201	Longline	62348	FC, M, B
6-Apr	PP-22-178	FLBAY	East Cape Canal	25.135	-81.066	3.4	405	M	Mature	P012176	982000364937497	Longline	62347	FC, M, B
	PP-22-196	FLBAY	East Cape Canal	25.128	-81.066	3.6	417	M	Mature	P011430	982000364963685	Longline	62335	FC, M, B
	PP-22-199	FLBAY	East Cape Canal	25.128	-81.066	3.6	392	M	Mature	P011448	982000364937529	Longline	62337	FC, M, B
	PP-22-200	FLBAY	East Cape Canal	25.128	-81.066	3.6	418	M	Mature	P011439	982000364843726	Longline	62334	FC, M, B
9-Apr	FS-2022-01	Biscayne Bay	Key Biscayne	25.716	-80.173	3.0	379	M	Mature	P009410	982000364963834	Longline	7342*	FC, M
3-Jun	FS-2021-02	Biscayne Bay	Key Biscayne	25.694	-80.180	3.0	341	F	Maturing	P009409	982000364843629	Longline	7341*	FC, M

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). 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	0.00	0.04	0.00	0.00
	YOY	0.25	0.97	0.00	0.01
	Juvenile	0.00	0.04	0.00	0.00
		FLBAY (ENP)	FL KEYS		
Bottom Longline	Juvenile & Mature	0.57	0.00		

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
<i>Carcharhinus brevipinna</i>	1	0	0	0	1
<i>Carcharhinus leucas</i>	6	4	1	1	12
<i>Carcharhinus limbatus</i>	0	0	0	1	1
<i>Ginglymostoma cirratum</i>	0	0	0	2	2
<i>Negaprion brevirostris</i>	1	0	0	39	40
<i>Sphyrna tiburo</i>	1	0	0	19	20
<i>Hypanus sabinus</i>	0	0	0	1	1
<i>Rhinoptera bonasus</i>	0	6	0	0	6
Grand Total	9	10	1	63	83

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
<i>Arius felis</i>	7
<i>Bagre marinus</i>	23
<i>Caranx hippos</i>	18
<i>Centropomus undecimalis</i>	11
<i>Elops saurus</i>	3
<i>Eugerres plumieri</i>	9
<i>Lutjanus griseus</i>	1
<i>Megalops atlanticus</i>	4
<i>Mugil cephalus</i>	9
<i>Pogonias cromis</i>	4
<i>Sciaenops ocellatus</i>	2
<i>Selene vomer</i>	3
<i>Synodus foetens</i>	1
<i>Trachinotus falcatus</i>	5
Grand Total	100

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

Species	Total Captured
<i>Carcharhinus acronotus</i>	30
<i>Carcharhinus falciformis</i>	1
<i>Carcharhinus isodon</i>	1
<i>Carcharhinus leucas</i>	59
<i>Carcharhinus limbatus</i>	119
<i>Carcharhinus plumbeus</i>	16
<i>Galeocerdo cuvier</i>	2
<i>Ginglymostoma cirratum</i>	14
<i>Hypanus americanus</i>	1
<i>Negaprion brevirostris</i>	62
<i>Rhizoprionodon terraenovae</i>	27
<i>Sphyrna lewini</i>	10
<i>Sphyrna mokarran</i>	14
<i>Sphyrna tiburo</i>	2
Grand Total	358

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
<i>Megalops atlanticus</i>	Atlantic tarpon
<i>Carcharhinus leucas</i>	Bull shark
<i>Epinephelus itajara</i>	Goliath grouper
<i>Caranx hippos</i>	Crevalle jack
<i>Centropomus undecimalis</i>	Common snook
<i>Galeocerdo cuvier</i>	Tiger shark
<i>Carcharhinus acronotus</i>	Blacknose shark
<i>Aetobatus narinari</i>	Spotted eagle ray
<i>Albula vulpes</i>	Bonefish
<i>Carcharhinus limbatus</i>	Blacktip shark
<i>Lutjanus griseus</i>	Grey snapper
<i>Trachinotus falcatus</i>	Permit
<i>Sciaenops ocellatus</i>	Red drum
<i>Micropterus salmoides</i>	Florida Largemouth Bass
<i>Alligator mississippiensis</i>	American alligator
<i>Archosargus probatocephalus</i>	Sheepshead
<i>Menticirrhus americanus</i>	Southern kingfish
<i>Lobotes surinamensis</i>	Atlantic tripletail