Essential Habitat of smalltooth sawfish (*Pristis pectinata*).

Colin Simpfendorfer
Center for Shark Research
Mote Marine Laboratory
1600 Ken Thompson Parkway
Sarasota, FL 34236

Phone: (941) 388 4441
Email: colins@mote.org

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Introduction

The smalltooth sawfish, *Pristis pectinata*, is one of seven species of sawfish known worldwide. Its range includes the western Atlantic from New Jersey to Brazil, including the Gulf of Mexico and Caribbean islands, the eastern Atlantic from the Mediterranean to Cameroon, southwest Indian Ocean off South Africa, northern Indian Ocean from the Red Sea to Bangladesh, northern Australia and the Philippines. Throughout its range populations have been substantially reduced, with the IUCN listing the worldwide population as Endangered. Despite its widespread occurrence, *P. pectinata* has been poorly studied and information on the critical habitat elements is almost non-existent in the literature.

In response to the need for data on which to base conservation actions for smalltooth sawfish, Mote Marine Laboratory (MML) began a research project in 1999. This project is documenting the distribution, abundance, movements, habitat utilization, genetics and population dynamics of smalltooth sawfish. This project is funded by the National Marine Fisheries Service's Protected Species Division, Disney Wildlife Conservation Fund and the National Geographic Society. The study includes surveys using various fishing techniques, acoustic and satellite telemetry, a public reporting database, measurement of genetic diversity and population modeling. This project is ongoing, but some of the information has been published (Simpfendorfer 2000) or presented at scientific meetings (Simpfendorfer and Castro 2001).

In December 1999 the National Marine Fisheries Service (NMFS) was petitioned to place smalltooth and largetooth sawfish on the Endangered Species List (ESL). After reviewing the available data NMFS concluded that there was a need to place smalltooth sawfish on the ESL as Endangered. A proposed rule was published in April 2001, with an ensuing period of public comment. The process of listing an endangered species often involves designating Critical Habitat for the species. The regulations relating to the ESL describe five elements of Critical Habitat:

1. space for individual and population growth, and for normal behavior
2. food, water, air, light, minerals, and other nutritional or physiological requirements
3. cover or shelter
4. sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and
5. habitats that are protected from disturbance or are representative of historic geographical and ecological distributions of a species.

This document examines the essential habitat elements for smalltooth sawfish, with the aim of using these data to designate critical habitat. This analysis draws largely on the results of the MML sawfish research project. The report first outlines the sources of data, and then examines each of the important habitat elements identified. The analysis is based on the best available information. Given further research on smalltooth sawfish, understanding of essential habitat will improve.

Data sources

Due to the limited data available in the literature the analysis undertaken in this report is based mostly on data from the MML sawfish project. Four sources of data were used:

- published literature
- MML sawfish survey data
- MML sawfish telemetry data
- MML sawfish reporting database

The three MML data sources are described in more detail below.

MML sawfish survey

Field surveys for sawfish undertaken by MML staff began in June 2000 and are ongoing. A variety of survey methods are used, including longline, rod and reel, gillnet and setlines. The principal method of surveying was longline, with rod and reel, and gillnets the next most common. Although rod and reel was less commonly used it was more successful at capturing sawfish – a result of working closely with experienced fishing guides who use only rod and reel (Table 1).

Table 1: Numbers of survey sets by gear type and the numbers of sawfish captures for MML sawfish surveys, June 2000 to October 2001.

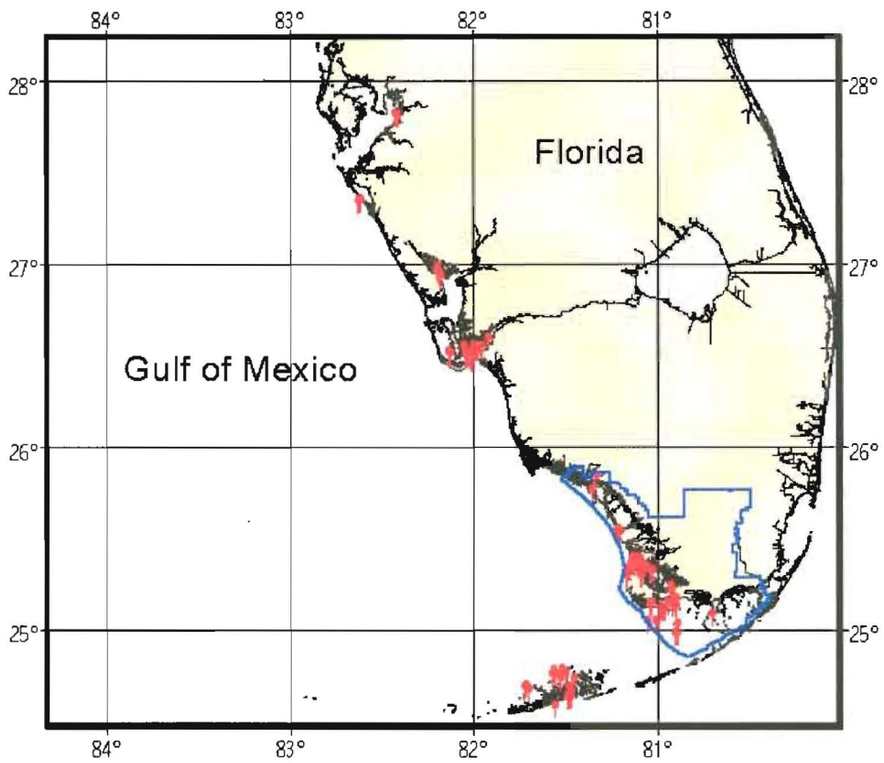
Gear type	Number of sets	Number of sawfish
Longline	177	4
Rod and reel	22	6
Gillnet	12	1
Setline	3	0

Details of the survey methods were:

- Longlines – between 460 and 760 m in length with between 25 and 70 circle and j-style hooks. Most lines were baited with mullet, but herring, jacks and ladyfish were also used. Longlines were soaked for 1 - 2 hours.
- Rod and reel – a variety of gear was used. Hooks were j-style with a steel leader. Bait was mullet, jack herring or lady fish.
- Gillnets – two styles of gillnet were used. Firstly a 400 m bottom set net with a uniform 4 5/8 inch stretched mesh, and secondly a 400 m bottom set net with mesh size varying from 3 inch to 9 inch. Gillnets were soaked for one hour, but checked regularly for animals.
- Setlines – set lines were constructed of a concrete anchor joined to a surface float via heavy rope. A heavy monofilament leader approximately 5 m in length was attached to the anchor and allowed to swivel freely. Hooks were circle style and baited with mullet.

Survey sets have been carried out between Tampa Bay and the outer Florida Keys, with the majority in the Everglades National Park (Figure 1). Gillnets were used as a survey technique north of the Caloosahatchee River (26.4°N). The majority of sets occurred inside the Everglades National Park (ENP), with 129 sets (60.3%) inside the ENP.

Figure 1: Location of sawfish surveys in southwest Florida between June 2000 and October 2001. Red markers indicate the location of sets; the blue line is the boundary of the Everglades National Park.

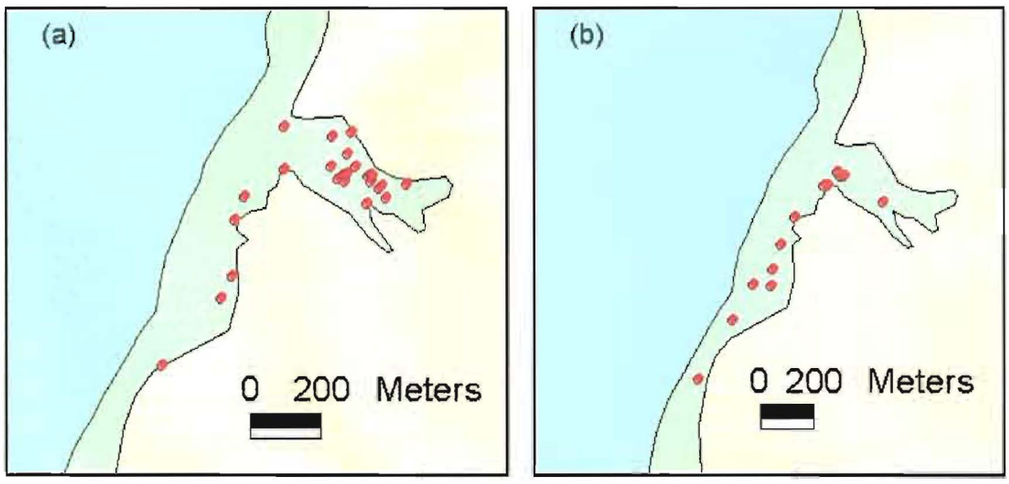


MML sawfish telemetry studies

As part of the MML sawfish project acoustic telemetry has been used to study movements, site fidelity and habitat utilization. These studies have involved fitting sawfish with acoustic tags that transmit a coded signal on 69 kHz. These animals are both actively tracked after release and relocated and re tracked at later dates when possible. Environmental conditions are collected during tracking to help define habitat preferences. Acoustic telemetry studies are still underway and only preliminary data are available. To date eight sawfish have been fitted with acoustic tags and relocated up to 5

months after release. Some individuals were tracked for very short periods. The telemetry results from two animals are shown in Figure 2.

Figure 2: Results of active tracking and relocating of (a) a 142 cm female sawfish released 19th of June 2001 and relocated over a period of five months, and (b) a 180 cm female released on the 19th of June 2001 and relocated over a three day period. Red points indicate sawfish locations; yellow areas are land, green areas depths less than 30 cm (from mean lower water), and blue areas depths between 30 cm and 100 cm (from mean low water).



MML sawfish reporting database

The Mote sawfish reporting database was established in 2000 to compile information on the distribution and abundance of sawfish. The intention of this section of the sawfish research project was to provide data beyond that which was achievable using surveys. The data that is included in the database comes from a variety of sources, including:

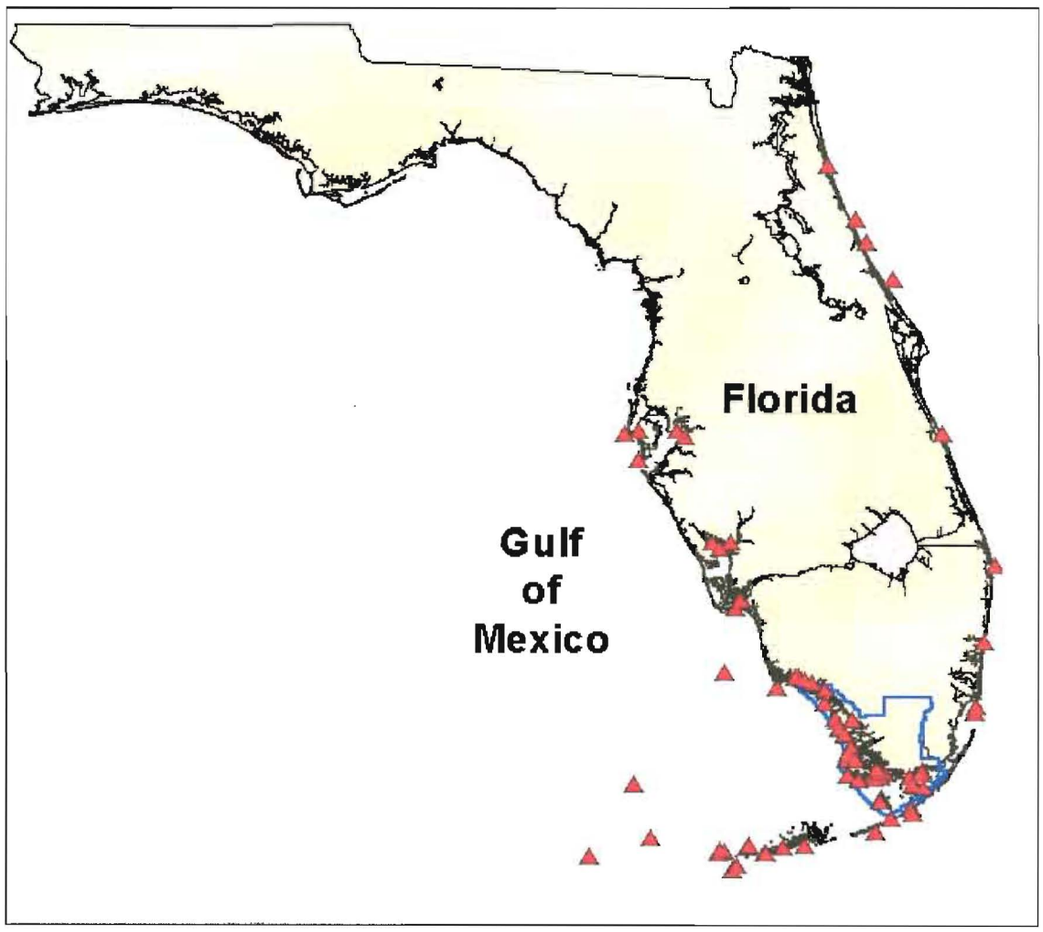
- reports from the public
- data from fishing guides
- data from the MML Gulf Coast Shark Census
- data from the Florida Museum of Natural History Shark Fishery Observer Program
- data from other researchers
- published reports.

The records in the database extend back into the 1950s, but are mostly for the 1999 - 2001 period. For the current exercise only records for the last ten years were considered so that the data reflect relatively recent occurrences. Interpretation of these data must be

done carefully, as they do not result from equal observation effort in all areas. However, by having multiple data sources this problem is partially overcome.

The database currently contains 110 reports relating to 207 sawfish. Most reports relate to individual sawfish, but some contain reports of multiple animals. For the past ten years (from 1991 onwards) there are 101 reports related to 146 sawfish (Figure 3). The majority of reports come from people engaged in recreational or commercial fishing (66.0%). However, other activities when sawfish were encountered included research (19.8%), diving or snorkeling (6.6%), boating (3.8%) and other (4.8%).

Figure 3: Reported sawfish encounters post-1991 (red triangles) from the Mote Marine Laboratory sawfish reporting database. The blue line marks the boundary of the Everglades National Park.

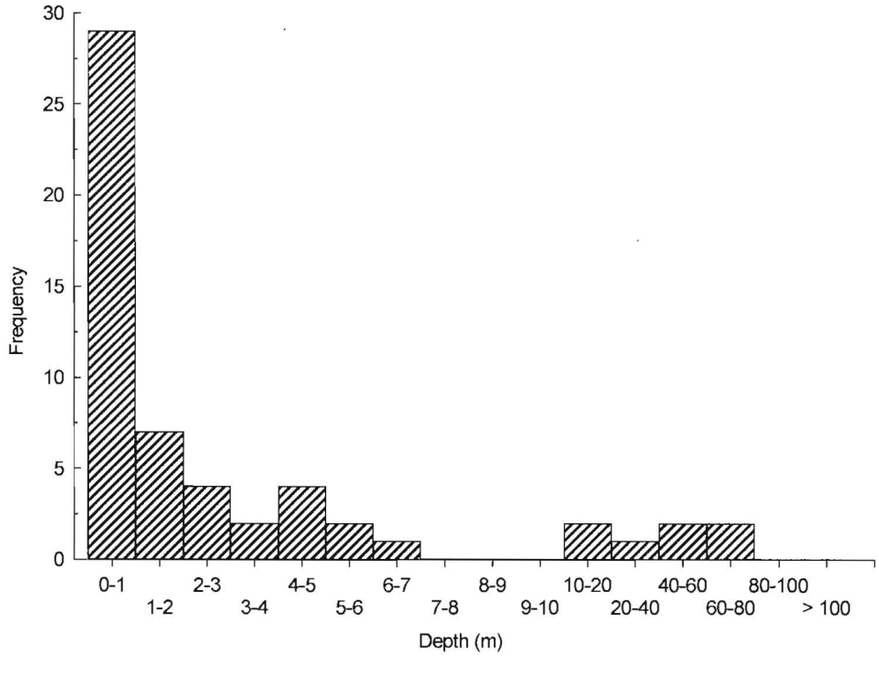


I. Description of essential habitat elements

Depth

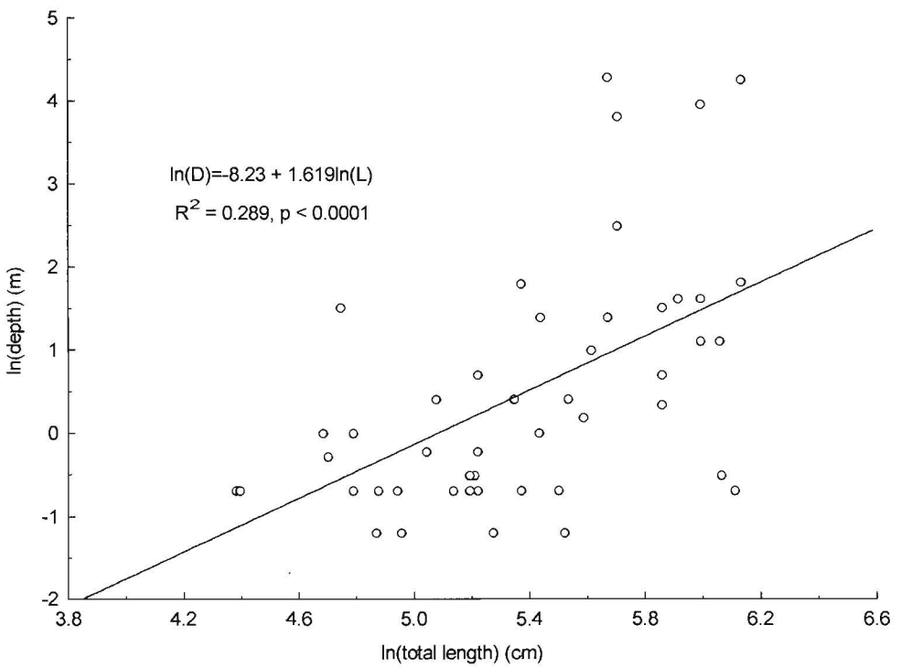
The literature for North American waters suggests that smalltooth sawfish occur in waters less than 10 m deep (e.g. Boschung 1979; Adams and Wilson 1995). Similarly, Bigelow and Schroeder (1953) reported that this species is "almost exclusively restricted to the immediate vicinity of land and to water only a few feet deep". These observations are largely consistent with the data in the MML sawfish reporting database that show the majority of specimens observed in waters less than 7 m deep (Figure 4). In fact, almost half of the specimens were observed in waters less than one meter deep. However, the MML data also indicate that smalltooth sawfish do occur in deeper water, with records from as deep as over 70 m. Examination of the relationship between the depth at which sawfish were observed and their estimated size using log-transformed data indicates that larger animals are more likely to occur in deeper waters (Figure 5). This is not a simple case of offshore migration as animals grow. Large animals are also observed in very shallow water, it appears more that the smaller (and so younger) animals are restricted to shallow waters, while large animals roam over a much larger depth range. It remains to be seen how much time sawfish of different sizes spend at different depths, however, the availability of archival tags will enable the collection of these types of data and will provide a much greater understanding of the depth distribution.

Figure 4: Depth frequency distribution for sawfish encountered in the MML sawfish reporting database.



Further evidence of the importance of very shallow water to young sawfish is provided by the preliminary telemetry data (Figure 2). All sawfish less than two meters in length that have been tracked to date have remained in water less than 1.5 m deep, and spend most of their time at depths less than 1.0 m.

Figure 5: Relationship between sawfish length and encounter depth. Data for 46 individuals encounters that contained reliable depth and length data.



Conclusion: That shallow coastal waters represent essential habitat for smalltooth sawfish. In particular, waters less than one meter are possibly very important, especially as nursery areas.

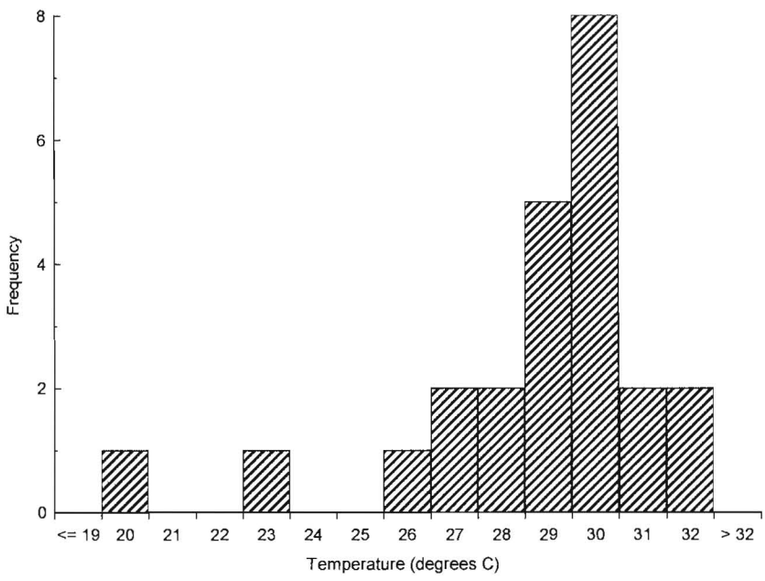
Temperature

There is limited temperature data available in the literature for smalltooth sawfish. The only specific report was that provided by Bigelow and Schroeder (1953) which suggested that the lower level of their temperature tolerance is 16 – 18 °C. Less specific information is available through data that indicates that smalltooth sawfish have historically migrated northwards along the Atlantic coast of the US in late spring, occupying the coastal waters of Georgia, South Carolina, North Carolina and Virginia (Adams and Wilson 1995), and reaching as far north as New Jersey on occasion (Bigelow and Schroeder 1953). Adams reported that all of the animals that migrated north during

summer were large (>4 m). Given that maturity of smalltooth sawfish occurs at between 3 and 4 m, it appears that only mature animals migrated. There have been no recent records of sawfish north of Florida in summer months and it appears that few, if any, animals currently undertake this migration. However, if conservation efforts are successful and the population rebuilds it is possible that this migration may again become important for mature animals.

Mote Marine Laboratory data (Figure 6) indicated that smalltooth sawfish were captured or observed over a temperature range from 19.7 to 31.5 °C, with the most observations between 29 and 31 °C. One interesting phenomenon suggested by the MML survey and reporting database data is that sawfishes may use thermal refuges during winter when water temperatures are low. In early January 2001 a report of a sawfish in the warm water outflow of the Apollo Bay power plant was received. This is an area where that other shark species (especially juvenile bull sharks) and manatees use as a thermal refuge (M. Heupel pers. comm.; Tarr 1999). Sampling that was carried out in response to this report captured a smalltooth sawfish adjacent to the outfall in an area with elevated water temperatures. This animal was captured in 22.9 °C water, while the temperature outside the plume was less than 17.7 °C. Water temperatures inside the outfall where the original sawfish report was made exceeded 28 °C. It was determined based on size and other characteristics that the reported sawfish and the captured sawfish were different animals. These data suggest that sawfish may utilize warm water sources such as thermal outflows from power stations during colder months to enhance their survival, or are trapped by surrounding low water temperatures from which they would normally migrate. Insufficient data are available on the thermal tolerances of sawfish to understand the impact of the use of these thermal refuges but it requires further investigation. However, there was an unconfirmed report of two sawfish being killed in the Hillsborough River during a cold-snap in January 2001 (Ondercin pers. comm.). Significant use of these areas by sawfish may disrupt their normal migratory patterns.

Figure 6: Frequency histogram of water temperatures at which smalltooth sawfish were observed. Data based on the results of Mote Marine Laboratory (MML) surveys, telemetry studies and encountered by other researchers (Florida Marine Research Institute and Rookery Bay National Estuarine Research Reserve).



Conclusion: That smalltooth sawfish occur over a range of temperatures but appear to prefer water temperatures greater than 18 °C.

Salinity

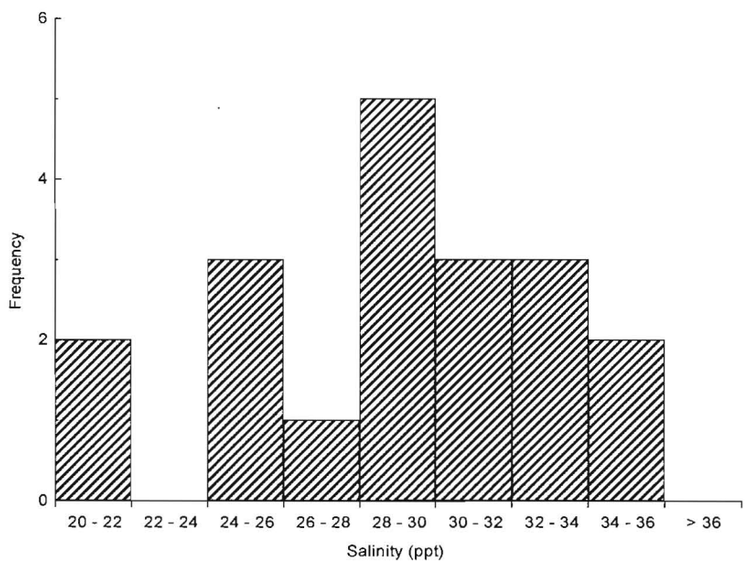
Smalltooth sawfish are known to be euryhaline (i.e. tolerate a broad range of salinities) (Compagno and Cook 1995). In Central American a resident population of smalltooth sawfish occurred in Lake Nicaragua, along with a larger population of largetooth sawfish (Marden 1944; Miller 1966, Bussing 1976). The status of this population is currently unknown, but the more common largetooth sawfish have been almost extirpated from this lake (Thorson 1982). There are no reports of resident freshwater smalltooth sawfish in the US. However, there are a number of reports of these animals occurring in fresh and brackish water in the lower reaches of rivers and estuaries. Jordan and Evermann (1896) reported their occurrence in the lower reaches of the Mississippi River, Goode (1884) reported them in the freshwaters of the St John's River, Florida, as far up as Jacksonville (when Jacksonville was much smaller than the present day), and Yarrow (1877) reported that they commonly occurred in the brackish waters of rivers and estuaries in North Carolina. Similar reports have been made throughout most of the range of the smalltooth sawfish (e.g. Wallace 1967; Compagno and Cook 1995). The literature, especially

reports that juveniles occur most frequently in lower salinity and freshwaters, suggesting that this may be a characteristic of nursery areas.

Mote Marine Laboratory data show that smalltooth sawfish were caught or observed in waters with salinities between 21.4 and 34.7 ppt (Figure 7). The observations were spread fairly evenly across this range. These data reflect the euryhaline nature of this species suggested in the literature.

Many of the sawfish captured in MML surveys, or reported in the MML database, were in or close to rivers and creek mouths. While this is seen as a critical element it is not possible to separate the importance of this factor from that of salinity, since lower salinities occur at the points of freshwater input. Similarly it is not possible to separate this factor from that of prey availability that may be related to salinity or river/creek mouths. Understanding of these inter-relationships will require many more years of study. For the purposes of this document the importance of river/creek mouths is considered separately because of the complex relationship of these factors that extend beyond the relationship to salinity.

Figure 7: Frequency histogram of salinities at which smalltooth sawfish were observed. Data based on the results of Mote Marine Laboratory (MML) surveys, telemetry studies and encountered by other researchers (FMRI and Rookery Bay National Estuarine Research Reserve).

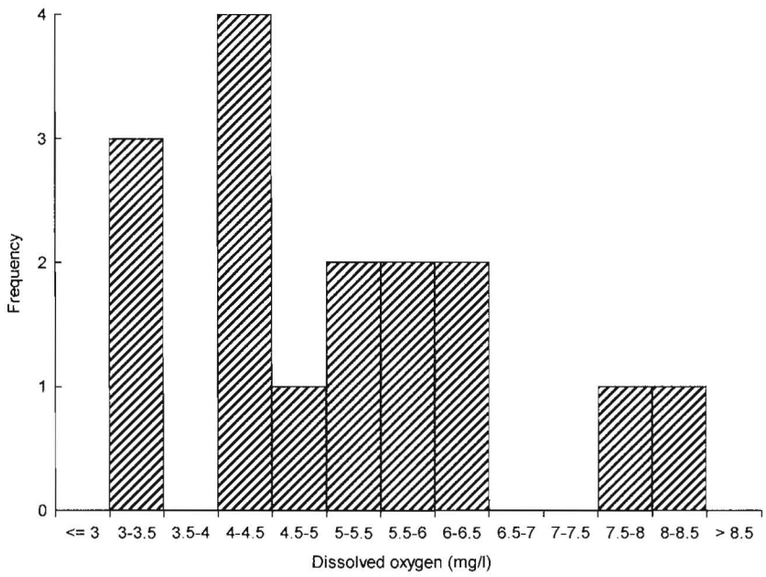


Conclusion: That smalltooth sawfish occur in waters with a broad range of salinities, from freshwater to full seawater. Juveniles may show preference for low salinity water, but this remains to be thoroughly tested. Lower salinity areas thus may be an essential element of the habitat of juvenile smalltooth sawfish.

Dissolved oxygen

No data on the relationship between smalltooth sawfish occurrence and dissolved oxygen level could be located in the literature. MML data show that sawfish were captured or tracked in water with a dissolved oxygen level between 3.18 and 8.14 mg/l (Figure 8). Observations were made fairly evenly over the range from 3 to 6 mg/l, with few at levels above 6 mg/l. The lower limit of dissolved oxygen tolerance of smalltooth sawfish has never been established.

Figure 8: Frequency histogram of dissolved oxygen levels at which smalltooth sawfish were observed. Data based on the results of Mote Marine Laboratory (MML) surveys, telemetry studies and encountered by other researchers (FMRI and Rookery Bay National Estuarine Research Reserve).



Conclusion: That there is insufficient data to make conclusions about the importance of dissolved oxygen level as an essential element of smalltooth sawfish habitat.

Food resources

The feeding habitats of smalltooth sawfish have been poorly studied. However, the data that are available indicate that fish are the most important component of the diet. Sawfish use their saw to strike at fish – either killing or wounding them (Breder 1952). The fish are then consumed after being rubbed off the saw on the bottom (if required). Norman and Fraser (1937) suggested that the saw was mostly used to slash through schooling fish. However, Breder (1952) also demonstrated that sawfish are capable of using their saw to

strike accurately at individual fish. Mullet are considered to be the most common prey of sawfish in southwestern Florida, while fishing guides also report good success with jacks and ladyfish. In addition to fish, small smalltooth sawfish also consume crustaceans (mostly shrimp and crabs) that they locate by grubbing on the bottom with their saw.

All of these major prey groups are widely distributed and abundant in shallow coastal waters over the current range of the smalltooth sawfish. It is unlikely that in most areas of Florida that the distribution of smalltooth sawfish would be limited by the availability of these prey

Conclusion: That mullet, jacks and ladyfish may be the primary food resources utilized by smalltooth sawfish. Areas where these resources are plentiful may be essential habitat elements for this species.

Mangroves

Along the southwest coast of Florida many of the reported encounters with smalltooth sawfish were made close, or very close, to mangroves. Juvenile animals in particular appear to be very closely associated with mangroves. This may simply be a result of a depth preference which brings sawfish close to shore, and hence mangroves. Given that smalltooth sawfish occur (or at least occurred) regularly in areas without mangroves (e.g. lower reaches of the St. Johns River in northeast Florida) it is likely that this association is not critical. However, there is sufficient data available to conclude that mangroves to provide smalltooth sawfish with protection, food resources or other resources. Interestingly, all encounters in the MML sawfish reporting database for animals less than 200 cm in length occurred less than 250 m from mangroves, except for a small animal reported from a marsh area in St. Augustine.

Conclusion: That mangroves may be an important habitat element for smalltooth sawfish.

River and creek mouths

Reports in the literature (e.g. refs) and MML data indicates that many sawfish are encountered in the vicinity of river or creek mouths. The MML data shows that sawfish were reported either adjacent to, or in the lower reaches of the following rivers or creeks in south-west Florida: Peace, Myakka, Caloosahatchee, Blackwater, Pumkin, Little Wood, Faka Union, Fakahatchee, East, Ferguson, Barron, Turner, Lopez, Huston, Chatham, Lostmans, Rodgers, Broad, Harney, Shark and Little Shark Rivers, and also Big Sable Creek, East Cape Canal and Slagle Ditch.

The causative reasons of the occurrence at river and creek mouths is difficult to isolate. Many factors may be involved – salinity may be lower, aquatic vegetation is present, specific prey may be more abundant, etc. However, no matter what the cause, it is apparent that these habitats are very important to smalltooth sawfish and conservation efforts will need to focus on these areas.

Conclusion: That river and creek mouths are a very important habitat element for smalltooth sawfish.

Shallow banks and protected mangrove coves

Data from the MML sawfish reporting database and MML sawfish telemetry indicate that shallow banks in protected mangrove coves are areas where juvenile sawfish congregated on high tides. Most of these banks dry at low tide. Many of the records in the MML sawfish reporting database for animals less than 100 cm in length were made in these types of areas. These are preliminary data that require further investigation, but suggest either a feeding or protection function for juvenile sawfish in nursery areas.

Conclusion: That shallow banks in protected mangrove coves are essential elements for juvenile smalltooth sawfish.

Channels through shallow habitats

Anecdotal information provided by fishing guides and commercial fishermen suggest that deep channels through shallow flats in Florida Bay and the Florida Keys may represent an important habitat for large smalltooth sawfish. Some of these reports suggest aggregations of adults (possibly for mating) in these channels during the full moons in February and March. At present there is some data to support these suggestions, but further research will be required.

Conclusion: That channels through shallow habitats may be essential habitat for adult sawfish, possibly in relation to mating aggregations.

Significance of results

We are limited in our assessment of the essential habitat elements of smalltooth sawfish by the scarcity of data. The current assessment should be seen only as the first step in defining essential habitat, with future research targeted at improving the data. The current analysis applies mostly to southwest Florida were most of the research by MML has focused. However, given effective conservation strategies for sawfish and

subsequent increases in the population more detailed work outside of this region will be required as the range expands in the Gulf of Mexico and along the Atlantic coast. The identification and protection of critical habitat outside of the current range will be required if sawfish recovery is to occur in these areas.

The current assessment has identified the following factors as possible essential elements that will help in the definition of critical habitat for smalltooth sawfish:

- depth
- temperature
- salinity
- food resources
- river and creek mouths
- mangroves
- channels
- shallow banks in protected mangrove coves

In all likelihood several of these factors will be inter-related, but with the current data it is not possible to determine the relative importance of each.

Since smalltooth sawfish are highly mobile animals, as evidenced by the historic migrations along the Atlantic coast, areas designated critical habitat will need to large.

II. Mapping of essential habitat areas and habitat elements

Based on the descriptions of essential habitat elements and the data on sawfish occurrences areas of importance to smalltooth sawfish were mapped using a GIS. Two levels of habitat designation were undertaken:

1. Essential habitat. These areas were designated based on the geographic areas that were considered essential for the survival of the sawfish population. The areas are large due to the mobility and low density of sawfish.
2. Essential habitat elements. Mapping of these areas was based on the occurrence of specific habitat elements described in section I, and areas where groups of sawfish have been reported or caught. These areas were typically smaller than the critical habitat areas.

These designations were based on the best available data at the time of analysis. Additional data will provide an improved understanding and identify other areas that are important to the smalltooth sawfish population.

Essential Habitat areas

Five critical habitat areas were defined (Figure 9). A brief description of these areas is given below:

Tampa Bay

Tampa Bay represents the current northern limit of the smalltooth sawfish's distribution. Reports are regularly received of sawfish in this area. Sawfish have been caught in this area throughout the year. Recovery of the sawfish population will see an increasing number of sawfish inhabiting this area.

Charlotte Harbor

Sawfish are regularly reported in the Charlotte Harbor region, especially near the mouths of the Peace, Myakka and Caloosahatchee Rivers. The waters of San Carlos Bay at the southern end of Charlotte Harbor are suspected to support a population of mid-sized animals. This area contains a large amount of habitat suitable for sustaining a sawfish population, including shallow waters, mangroves, river mouths and large prey populations.

Everglades, Florida Bay, Biscayne Bay and Florida Keys

This area represents the center of abundance for smalltooth sawfish in US waters and contains vast areas of suitable habitat, including shallow waters, mangroves, river mouths, low salinity areas, channels through shallow banks, and abundant prey. This area is essential to the long-term survival of sawfish. The presence of the Everglades National Park, the Biscayne Bay National Park, and the Florida Keys National Marine Sanctuary provides a good framework for the protection of sawfish.

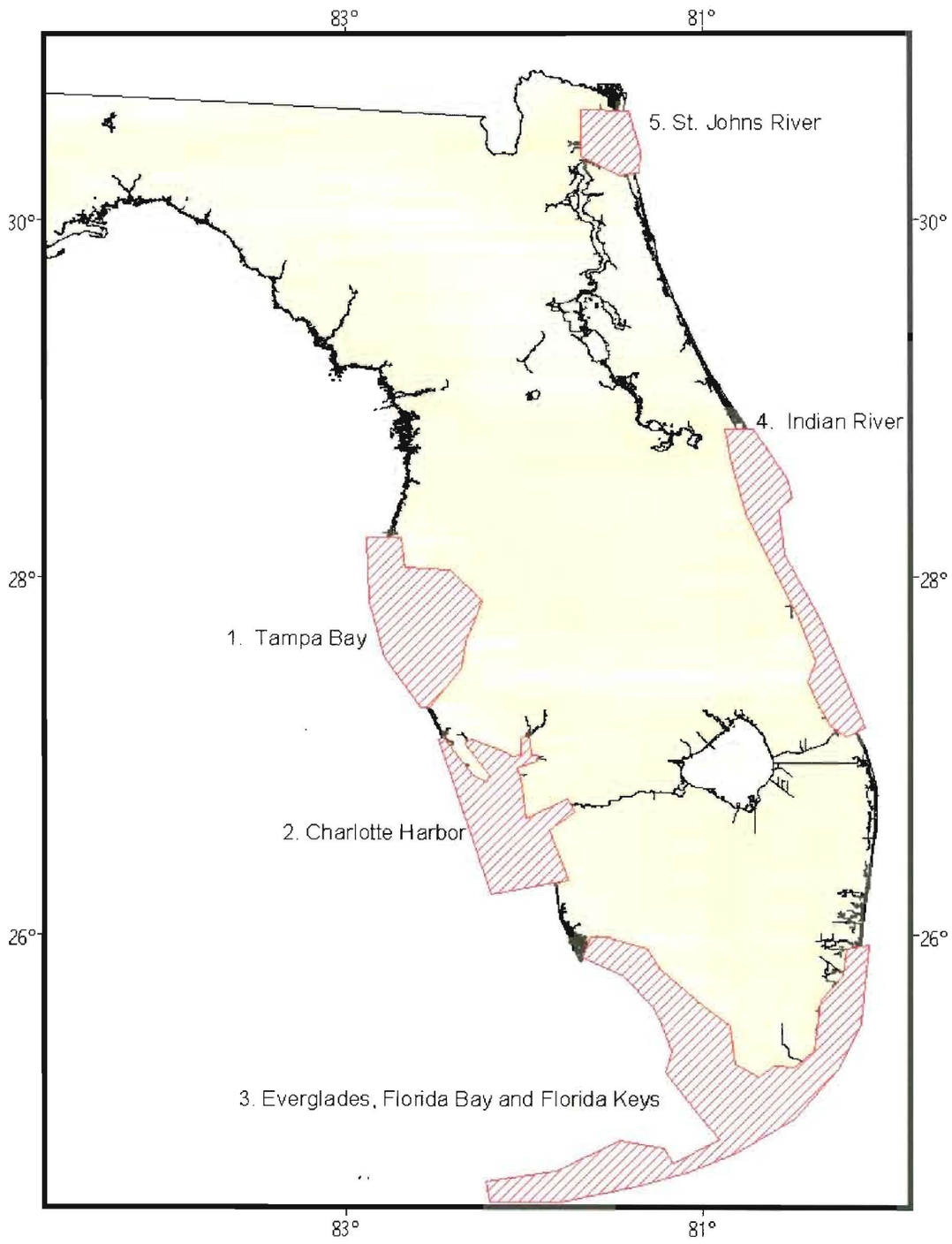
Indian River

This area was historically important to smalltooth sawfish with a large resident population present in the late 1800s. Although Snelson and Williams (1981) suggested that sawfish were extirpated from this area, there continue to be occasional reports from this area. This area was designated because this area may again become important if the sawfish population recovers.

St. Johns River

This area was described as an important nursery area for sawfish around the turn of the century, with small animals occurring in lower salinity areas on the river around Jacksonville. This area has been designated because of its historic importance.

Figure 9: Essential Habitat areas for smalltooth sawfish.



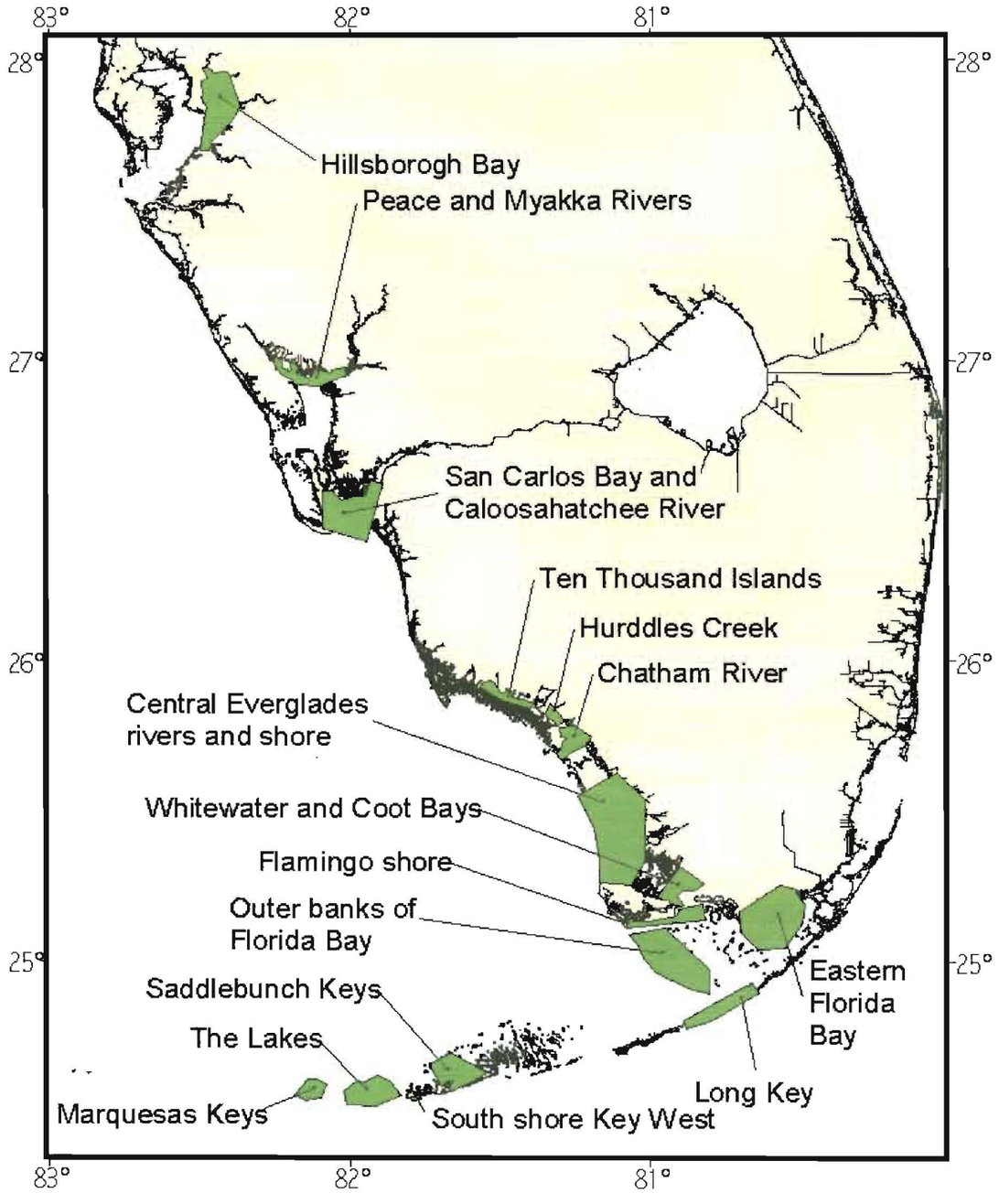
Essential habitat elements

Seventeen essential habitat elements were designated, ranging from Tampa Bay to the Marquesas Keys (Figure 10). Sawfish are known to occur in all of these areas to varying degrees, and each has specific habitat attributes outlined in Table 2.

Table 2: Essential habitat elements designated for smalltooth sawfish. Current abundance based on data from the MML sawfish reporting database.

Essential habitat areas	Area (km^2)	Current sawfish abundance	Habitat elements
Hillsborough Bay	275.2	*	River mouths, mangroves
Peace and Myakka Rivers	111.0	*	River mouths, mangroves
San Carlos Bay and Caloosahatchee River	305.3	**	River mouth, mangroves, prey
Ten Thousand Islands	59.6	**	Mangroves, river mouths, prey
Hurddles Creek	27.6	**	Depth, salinity, mangroves, nursery area
Chatham River	87.9	**	River mouths, mangroves, prey
Central Everglades rivers and shore	692.6	***	River mouths, mangroves, prey, nursery area
Whitewater and coot bays	110.4	**	Salinity, mangroves, nursery area
Flamingo shore	94.6	***	Mangroves
Eastern Florida Bay	406.2	***	Salinity, mangroves, nursery area
Outer banks of Florida Bay	365.9	***	Channel areas in shallow banks, mating area, prey
Long Key	136.3	***	Mangroves, many sawfish reports
Saddlebunch Keys	156.6	**	Mangroves, depth
South shore of Key West	4.7	**	Many reported sawfish
The Lakes	160.0	*	Depth, channels through shallows
Marquesas Keys	60.9	*	Depth, channels through shallow banks

Figure 10: Essential habitat elements for smalltooth sawfish.



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