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NOTE

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Abstract

In 2003, the U.S. distinct population segment of smalltooth sawfish *Pristis pectinata* was listed as endangered under the U.S. Endangered Species Act (ESA). At that time, little was known about its habitat use patterns and, although required as part of the ESA, critical habitat could not be officially designated. Subsequently, studies were conducted that identified some of the specific habitats and environmental conditions important for the species. Facilitating recruitment into the adult population by protecting the species' nurseries was identified in the recovery plan as the key conservation objective, which would be supported by the designation of critical habitat. The location of nurseries was determined by applying published criteria developed for identifying elasmobranch nursery areas to a decade of encounter data. These largely nontraditional data were composed primarily of encounters voluntarily reported by the public to members of the recovery team. The

nursery habitats essential to the conservation of the species were identified as those adjacent to red mangroves *Rhizophora mangle* and euryhaline habitats with water depths ≤ 0.9 m. Ultimately, two broad areas in southwest Florida that contain these habitats were designated as critical habitat for juvenile smalltooth sawfish: the Charlotte Harbor Estuary unit (896 km²) and the Ten Thousand Islands/Everglades unit (2,505 km²).

The smalltooth sawfish *Pristis pectinata* was common in the coastal zone of the United States at the turn of last century, ranging from Texas to North Carolina and rarely as far as New York (Bigelow and Schroeder 1953). Primarily through undocumented and incidental capture in various fisheries, the population has likely declined by up to 95% since that time and today is only regularly observed in the waters off south Florida

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(Seitz and Poulakis 2002; Simpfendorfer 2002; Poulakis and Seitz 2004). Because of this population decline and gross range reduction, the U.S. National Marine Fisheries Service (NMFS) received a petition from the Center for Marine Conservation (now the Ocean Conservancy) requesting listing of the North American population of smalltooth sawfish as endangered under the U.S. Endangered Species Act (ESA). Subsequently, NMFS conducted a formal status review (NMFS 2000) and on April 1, 2003, the U.S. distinct population segment of smalltooth sawfish was listed as endangered (NOAA 2003).

At the time of listing, little information was available on smalltooth sawfish habitat use and critical habitat could not be determined. Scientific research was initiated to identify specific habitats and environmental conditions important for the species; however, the immediate need to designate critical habitat due to ESA regulations prompted the use of nontraditional data sources. Because the smalltooth sawfish is a relatively large and unique species, encounters with it by anglers and boaters are memorable and often well documented by photography and video, and the public is often willing to respond to solicitations by researchers for encounter information (e.g., Seitz and Poulakis 2002). This approach has been used to designate critical habitat for other easily identifiable, data-poor species (Takekawa and Beissinger 1989; Turner et al. 2004). Because facilitating recruitment into the adult population by protecting the species' nurseries was identified in the recovery plan as the key conservation objective which would be supported by the designation of critical habitat (NMFS 2009), juvenile smalltooth sawfish were the focus of the critical-habitat analysis.

The ESA defines critical habitat as

(i) specific areas within the geographical area occupied by the species [...] on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species [...] essential for the conservation of the species.

Under the ESA, the NMFS is responsible for determining whether certain species within their jurisdiction are threatened or endangered and for designating critical habitat for such species. Herein, the best available data were used to identify specific areas in the species' occupied range where those physical and biological features essential to the conservation and recovery of juvenile smalltooth sawfish were located.

METHODS

Due to the paucity of standardized fishery-independent data for smalltooth sawfish, 721 encounter reports (representing 1,102 sawfish) from the National Sawfish Encounter Database (NSED) collected between 1998 and 2008 were analyzed. The ongoing NSED contains records of sightings and captures of smalltooth sawfish by commercial and recreational fishers, researchers, and the general public. These records are obtained by researchers from a variety of government and nongovernment entities. Details on the methods used for encounter data

collection, refinement, and validation are reported in Wiley and Simpfendorfer (2010).

The "geographical area occupied" in the definition of critical habitat was interpreted as being the range of the species at the time of listing. The NSED records indicated that the range of smalltooth sawfish in the United States at the time of listing (April 1, 2003) was peninsular Florida (Figure 1).

Like many other marine species, smalltooth sawfish use specific habitats commonly referred to as nurseries. The recovery plan states that protecting nurseries is important to the recovery of the species (NMFS 2009), but the locations of these areas were not specified. To identify specific areas that may have met the definition of critical habitat, defining what constituted a nursery for smalltooth sawfish was necessary. Heupel et al. (2007) were critical of defining nursery areas for sharks and related species, such as sawfish, based solely on single occurrences of juvenile fish. Instead, these authors argued that nurseries are areas of increased productivity which can be indicated by natal homing or philopatry and that juveniles in such areas should show a high level of site fidelity. Heupel et al. (2007) proposed that nursery areas can be defined based on three primary criteria: (1) juveniles are more common in those areas than in other areas, i.e., density in those areas is greater than the mean density over all areas; (2) juveniles have a tendency to remain in or return to such areas for extended periods (weeks or months); and (3) the areas or habitat are repeatedly used across years. The criteria for defining a nursery area proposed by Heupel et al. (2007) were applied to juvenile smalltooth sawfish encounter data to determine the location(s) of nurseries.

To apply the first Heupel et al. (2007) criterion, following the procedures of Simpfendorfer and Wiley (2005), ESRI ArcView 9.3 software with the Spatial Analyst Density tool was used to calculate the density of all juvenile (<200 cm TL; NMFS 2009) encounters between 1998 and 2008 in 1-km² grids statewide. ArcView calculated the density in animals per square km within 10 km² grids. The <200 cm TL size was chosen because it included the "very small" and "small" size-classes as defined in the recovery plan (NMFS 2009). Encounters occurring during targeted (nonrandom) research efforts were excluded to remove any bias. The Spatial Analyst Zonal Statistics tool was used to determine the mean density of all grids statewide, and those grids with greater densities than the statewide mean (0.045/km²) were displayed (Figure 2). At the time of the analysis, there were limited data for any quantitative comparisons between the nursery areas and all other areas; therefore, applying the second Heupel et al. (2007) criterion to smalltooth sawfish nurseries could not be done. To apply the third Heupel et al. (2007) criterion, juvenile encounters were mapped by year (1998–2008) to determine where repeat use occurred. The resulting nursery areas were demarcated with the nearest publicly identifiable boundary (e.g., boundary of established parks and preserves), structure (e.g., road, lock, or barrier island), or reference point or line on a standard topographic map that was external to the outermost boundary of the 1-km² encounter density grids.

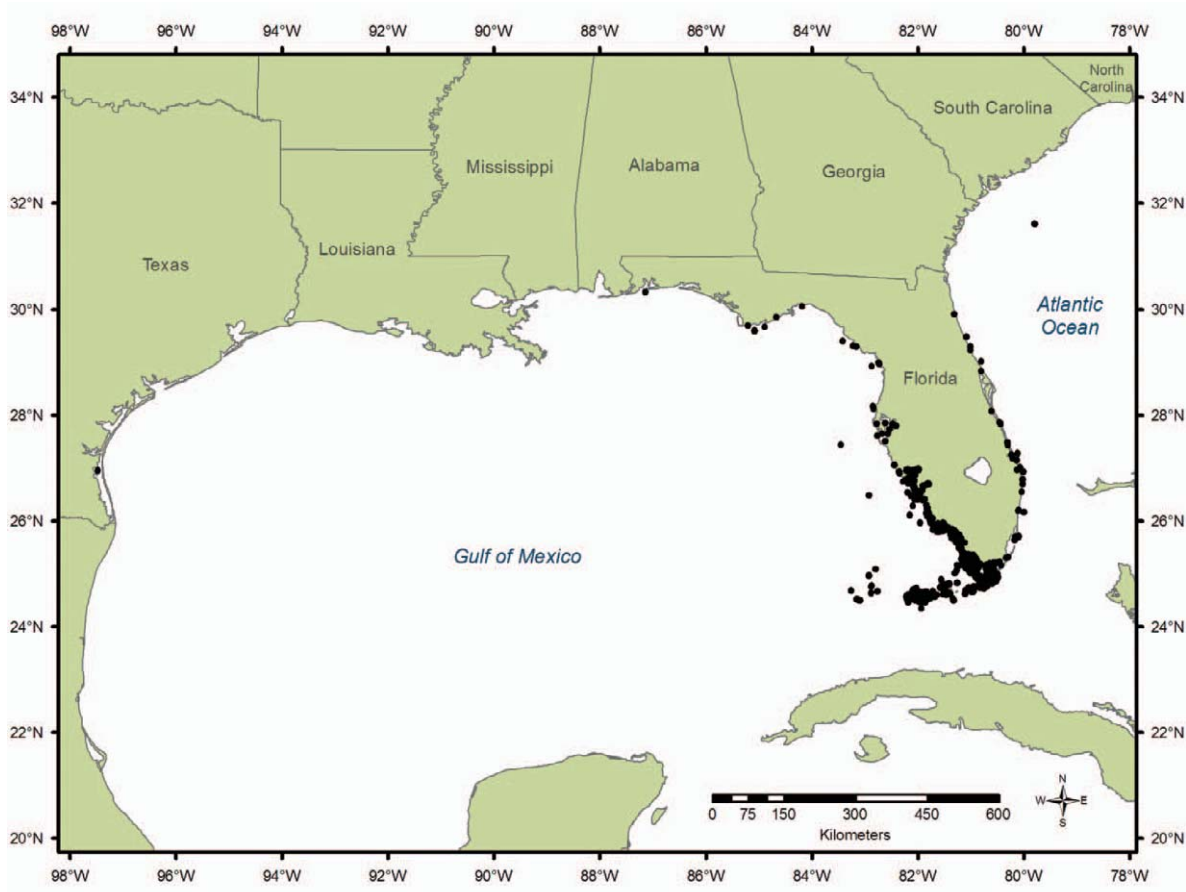


FIGURE 1. Range of smalltooth sawfish for the critical habitat analysis, as determined from National Sawfish Encounter Database records, 1998–2003.

As defined by the ESA, the physical and biological features which had the strongest correlation with juvenile smalltooth sawfish encounters were determined to be the essential features for the critical habitat designation: water depths ≤ 0.9 m, red mangrove *Rhizophora mangle* shorelines, and euryhaline areas (Simpfendorfer 2006; Wiley and Simpfendorfer 2010).

RESULTS

Encounter data indicated that there were three distribution groups of juvenile smalltooth sawfish. The first group consisted of individuals in scattered individual encounters with no indication of repeat or multiple use of an area (e.g., areas north of Charlotte Harbor, in the panhandle of Florida, and along the east coast of Florida). The second group consisted of multiple individuals within an area but ones that were geographically scattered with no consistent or continuous pattern of repeat use over years (e.g., in the Florida Keys, which largely lacked juvenile encounters in 2008). The third group consisted of both single and multiple individuals that exhibited use of the same location through notably higher densities of encounters (Figure 2) and repeated use year after year (i.e., areas from Charlotte Har-

bor south through the Ten Thousand Islands and Everglades to Florida Bay). The juvenile encounters in the third group were the only ones which met the Heupel et al. (2007) nursery criteria, and these encounters were the focus of the analysis.

Five groups of 1-km² grids with higher mean juvenile densities than the statewide mean were produced: one in upper Charlotte Harbor, one in the Caloosahatchee River, and three from the Ten Thousand Islands through Florida Bay (Figure 2). These groups were not subdivided into multiple smaller nursery areas but for several reasons were combined into two larger units. First, the Heupel et al. (2007) framework does not indicate whether or how discrete nurseries within a large area of juvenile use might be identified. Second, our knowledge of juvenile smalltooth sawfish movements was limited. Third, both areas consist of interconnected environmental systems with no barriers to prohibit sawfish movement throughout the area. Finally, limiting nursery boundaries to discrete habitat grids represented only by past encounters would not best serve the conservation objective of facilitating population growth through juvenile recruitment.

Approximately 3,401.3 km² were designated in two units of juvenile critical habitat (Figure 3). The Charlotte Harbor

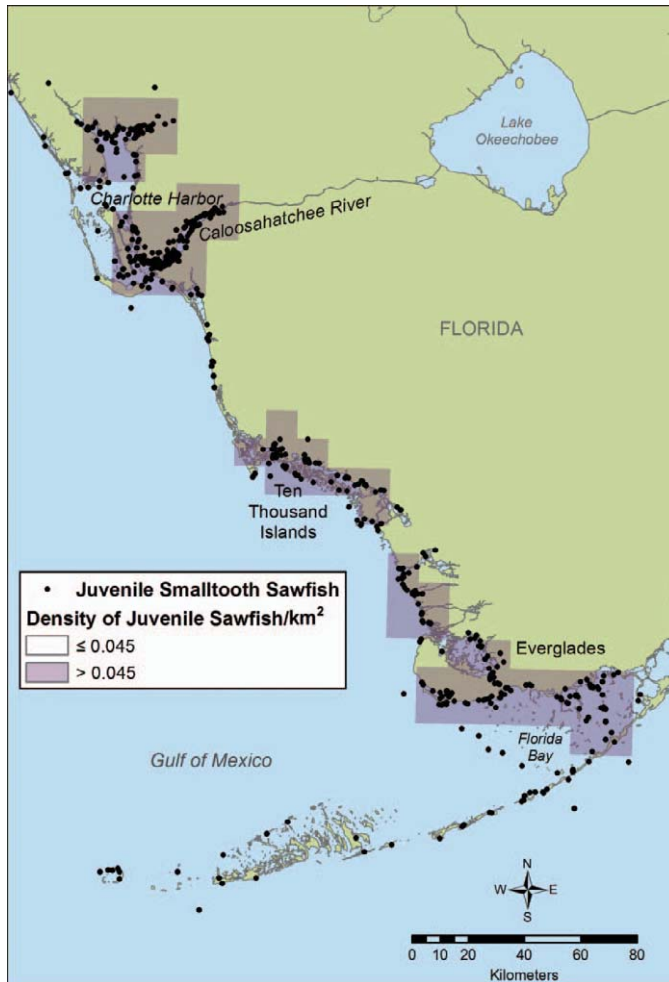


FIGURE 2. Encounter densities (sightings/km²) within 10-km² grids with densities greater than the statewide mean (0.045/km²), 1998–2008. The <200 cm size was chosen to represent juveniles because it included the “very small” and “small” size-classes as defined in the recovery plan (NMFS 2009).

Estuary unit comprises 896.2 km² (Figure 4) and includes portions of Charlotte Harbor, Gasparilla Sound, Pine Island Sound, Matlacha Pass, San Carlos Bay, Estero Bay, and the Peace, Myakka, and Caloosahatchee rivers. The Ten Thousand Islands/Everglades unit comprises 2,505.1 km² (Figure 5) and includes portions of the Ten Thousand Islands, Everglades National Park, and Florida Bay. Specific boundaries of the critical-habitat units can be found in NOAA (2009).

DISCUSSION

The first challenge of designating critical habitat for smalltooth sawfish was the lack of comprehensive scientific data on the species. Critical habitat designation for species that are understudied sometimes requires the use of nontraditional data; in this study, encounter data largely derived from the public were used. While subject to certain caveats, encounter data have been successfully used to evaluate habitat use and determine critical habitat for other recognizable species. For example, sight-

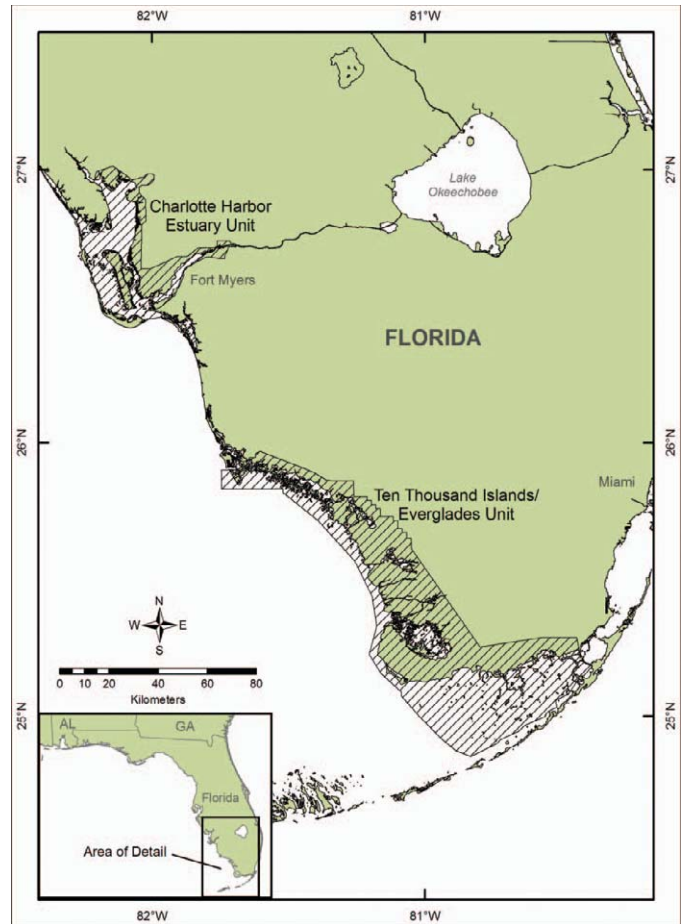


FIGURE 3. Locations of the two designated smalltooth sawfish critical-habitat areas in southwest Florida.

ings hotlines were established and used for assessing dispersal and habitat for snail kite *Rostrhamus sociabilis* (Takekawa and Beissinger 1989). In addition, Turner et al. (2004) created critical habitat designations for Nelson bighorn sheep *Ovis canadensis nelsoni* based on sightings information from the Santa Rosa Mountains. While effort distribution could bias data and habitat designations, Simpfordorfer and Wiley (2005) analyzed the number of registered fishers in Florida by county to determine whether fishing effort affected the distribution of sawfish encounters and found no strong correlation between the distribution of fishers and encounter locations. Thus, the National Sawfish Encounter Database represented the best source of data to use for the critical habitat designation.

Facilitating recruitment into the adult population by protecting nurseries was identified in the recovery plan as the key conservation objective that would be supported by critical habitat designation (NMFS 2009). Too often, studies of marine fish merely look for areas of high concentration of individuals and label these as critical (Heithaus 2007). Using the Heupel et al. (2007) framework provided a means to overcome the challenge of defining current nurseries. Unfortunately, applying the

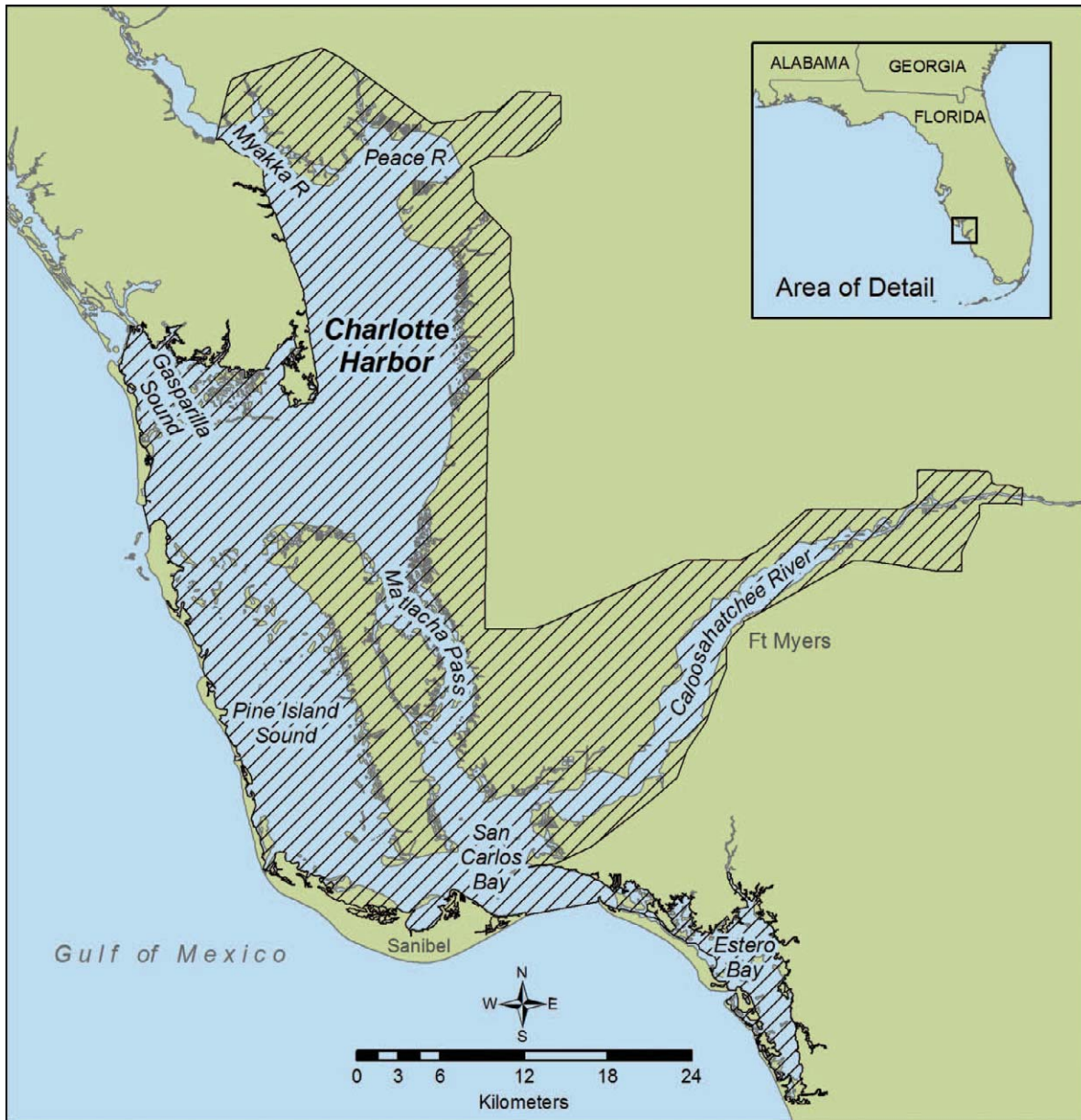


FIGURE 4. The Charlotte Harbor Estuary unit of critical habitat for juvenile smalltooth sawfish. See NOAA (2009) for detailed boundary descriptions.

second Heupel et al. (2007) criterion to smalltooth sawfish nurseries (that site fidelity is greater than the mean site fidelity for all areas) could not be performed due to the paucity of long-term movement data available at the time. However, subsequent research supports the second Heupel et al. (2007) criterion and the overall critical habitat designation. For example, large areas initially coded as highly suitable habitat for juveniles by Simpfendorfer (2006) were located in the designated nursery areas, and studies have shown that juvenile smalltooth sawfish (up to ~2.5 m TL; Simpfendorfer et al. 2010, 2011; Poulakis et al. 2011) have small activity spaces and remain within the critical-habitat areas for at least their first 3 years.

Hoekstra et al. (2002) recommended that critical habitat be designated biologically as a suite of habitat characters. Red mangrove shorelines and shallow euryhaline habitats with water depths ≤ 0.9 m were identified as essential to the conservation of smalltooth sawfish because they provide nursery area functions (NMFS 2009). While the primary purpose of staying in such shallow water is likely to avoid predators, these shallow waters also provide warm water temperatures that may be used to maximize growth rates (Simpfendorfer et al. 2008). Very small juveniles (<1 m estimated total length) use red mangrove habitats (Simpfendorfer and Wiley 2005; Simpfendorfer et al. 2010; Poulakis et al. 2011), moving into the prop roots during



FIGURE 5. The Ten Thousand Islands/Everglades unit of critical habitat for juvenile smalltooth sawfish. See NOAA (2009) for detailed boundary descriptions.

periods of high tide. Mangroves are an important habitat for many species of fish (e.g., Thayer et al. 1987; Faunce and Serafy 2006) and likely provide ample, diverse foraging resources for smalltooth sawfish as well as refuge from predators.

Smalltooth sawfish occupy euryhaline habitats, which may provide several benefits. Euryhaline waters are productive environments that support an abundance and variety of potential prey resources (fishes such as mugilids and clupeids and crustacean species such as pink shrimp *Farfantepenaeus duorarum*). While no encounters occurred in areas of permanent freshwater, many were near sources of freshwater inflow such as river mouths (e.g., Seitz and Poulakis 2002; Wiley and

Simpfendorfer 2010; Poulakis et al. 2011). Juvenile smalltooth sawfish may require salinity regimes with specific freshwater inputs, but data on these requirements do not currently exist. However, recent research has shown that juveniles remain within the nurseries under a wide range of environmental conditions and they have affinities for warm water temperatures ($>30^{\circ}\text{C}$), moderate salinities (18–30 practical salinity units), moderate dissolved oxygen concentrations ($>6\text{ mg/L}$), and shallow water depths ($<1\text{ m}$) (Poulakis et al. 2011). These data may be useful targets for managers in shaping the habitats and freshwater inputs in and around the critical-habitat areas.

The lack of recent repeat or high-density use by smalltooth sawfish precluded designating historically important areas that contained the essential habitat features and met the classification of highly suitable habitat as defined by the ESA (e.g., Tampa Bay and the Indian River Lagoon; see NOAA 2009). Because the habitat features are essential to the conservation of the species based on the nursery functions they provide, they are currently considered essential only when smalltooth sawfish are present in nurseries, so these other areas do not meet the Heupel et al. (2007) definition of a nursery. Nursery areas cannot be located based solely on the occurrence of shallow depths and euryhaline salinity regimes, as juveniles are not commonly or repeatedly found everywhere these features are present. Red mangroves may also not be determinative of nursery area function, as the Florida Keys contain mangroves, yet juvenile use of this region has been variable. Additionally, historic information suggests that juveniles were found in the lower St. Johns River (NMFS 2009), which does not support red mangroves. The recovery plan (NMFS 2009) indicates that the establishment of nursery areas outside of southwest Florida is necessary for recovery, but the temporal or spatial distribution of future sawfish nurseries cannot be determined. However, Poulakis et al. (2011) documented mortalities of juvenile smalltooth sawfish in south Florida following the passage of strong cold fronts. These data highlight the rangewide threat of temperatures below 12°C to smalltooth sawfish recovery, and these temperature effects may provide clues to the locations of estuarine systems where long-term nurseries can be reestablished.

Because nursery protection alone is typically not enough to ensure the stability of exploited populations or the recovery of depleted ones (Kinney and Simpfendorfer 2008), data are needed on the habitat use, site fidelity characteristics, and breeding locations of larger smalltooth sawfish. Additionally, critical habitats must be distinguished from transitory habitats that may not be crucial to growth, mating, or feeding (Grubbs and Musick 2007), but current encounter and research data provide limited insight into adult smalltooth sawfish habitat use. Encounter data, observations on commercial longline vessels, and fishery-independent sampling in the Florida Straits indicate that adult sawfish occur in numerous habitat types (e.g., mangroves and coral reefs), in varying salinities and temperatures, and from shallow coastal to deep shelf waters (Seitz and Poulakis 2002; Poulakis and Seitz 2004; Simpfendorfer and Wiley 2005; Wiley and Simpfendorfer 2010; Carlson, unpublished data). Seitz and Poulakis (2002) reported that one adult sawfish, identifiable by its broken rostrum, was captured in the same location over a month. This suggests that adults may have some level of site fidelity for relatively short periods; however, the possible historic occurrence of seasonal migrations along the U.S. East Coast also suggests that adults are more mobile than juveniles (NMFS 2009). While management strategies must include plans for the protection of young size-classes in nursery areas and older members of the population beyond nurseries (Kinney and Simpfendorfer 2008), the limited information on

adult smalltooth sawfish habitat use makes critical habitat undeterminable for them at this time.

Habitat destruction is one of the key factors affecting the distribution of smalltooth sawfish, and urbanization has resulted in substantial habitat losses (NMFS 2000). Red mangroves and shallow euryhaline habitats are susceptible to impacts from activities including dredging and disposal activities, coastal maritime construction, land development and its associated runoff, and alteration of natural freshwater discharges to coastal habitats. Combined with natural factors (e.g., major storm events and red tides), these activities can significantly affect the quality and quantity of the essential habitats identified by this study and their ability to provide nursery functions for smalltooth sawfish. The effects of storms on mangroves, salinity, and water depth are natural, and salinity regimes and mangroves in southwest Florida may be altered by projects such as those implemented under the Comprehensive Everglades Restoration Project. The use of artificial habitats by juvenile smalltooth sawfish, such as the canal systems in the Caloosahatchee River (Poulakis et al. 2011), may affect the maintenance of these areas (e.g., the timing of dredging). Thus, the essential habitat features will require special management and protection in the designated areas. If special management needs aren't addressed, the functional elimination of nurseries through habitat destruction could push populations to a tipping point where suitable nursery areas become a limiting factor to recovery (Kinney and Simpfendorfer 2008).

The critical-habitat rule for juvenile smalltooth sawfish became effective on October 2, 2009 (NOAA 2009). If new information on smalltooth sawfish biology and ecology identifies habitats or areas in addition to those currently designated, the NMFS may consider revising this critical habitat designation. The collaborative relationship between scientists and the public has been valuable for maximizing our knowledge and protection of this species and is important to maintain for future recovery efforts. Ongoing survey and satellite tagging studies should yield valuable data on adult habitat use that may support a designation of critical habitat for that age-class in the future. As the smalltooth sawfish was the first elasmobranch listed under the ESA, this critical habitat designation may provide a framework for designating critical habitats for other listed species.

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