



Original research article

A subtropical embayment serves as essential habitat for sub-adults and adults of the critically endangered smalltooth sawfish



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ABSTRACT

Identifying essential habitat for large, mobile endangered species is difficult, particularly marine species where visual observations are limited. Though various methods of telemetry are available, each suffers from limitations and only provides satisfactory information over a specific temporal or spatial scale. Sawfish are one of the most imperilled groups of fishes, with every species worldwide listed as endangered or critically endangered. Whereas movements of juvenile sawfish are fairly well studied, much less is known about adults due to their rarity and the challenging environments they live in. Previous encounter records have identified Florida Bay in the Everglades National Park as a potentially important habitat for adults of the critically endangered smalltooth sawfish (*Pristis pectinata*). We used a combination of acoustic and satellite telemetry, as well as conventional tagging, to determine patterns of movement and residency by sub-adult and adult sawfish. Over short time periods, movements appeared primarily tidal driven with some evidence that animals moved into shallow water during the ebbing or flooding tides. Adult sawfish sexually segregated seasonally with males found by mangrove-lined canals in the spring and females predominantly found in outer parts of the bay. Males migrated from canals starting in late May potentially as temperatures increased above 30° C. Some males and females migrated north during the summer, while others may have remained within deeper portions of Florida Bay. Male sawfish displayed site fidelity to Florida Bay as some individuals were recaptured 1–2 years after originally being tagged. We hypothesize that mating occurs in Florida Bay based on aggregations of mature animals coinciding with the proposed mating period, initial sexual segregation of adults followed by some evidence of females moving through areas where males show seasonal residency, and a high percentage of animals showing evidence of rostrum inflicted injuries. The combination of methods providing movement data over a range of spatial and temporal scales reveals that sub-tropical embayments serve as essential habitat for adult smalltooth sawfish.

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1. Introduction

A critical component of conservation management is an understanding of the movements and habitat use of the species in question. Knowledge of an animal's spatial ecology can predict the ability of protected areas to conserve the species, and highlight the frequency and location of interactions between the species and human activity in addition to potential sources of mortality (e.g. [Simpfendorfer et al., 2010](#), [Lambertucci et al., 2014](#) and [Nawaz et al., 2014](#)). Large carnivores can be particularly challenging to conserve as they may move over large distances, often crossing protected area and even geopolitical boundaries where conservation regulations may vary ([Lambertucci et al., 2014](#); [Yorio, 2009](#)). For these animals it may be extremely difficult to provide complete protection over their entire life cycle, and instead managers must focus on protecting habitats important for foraging, mating, parturition, and juvenile development (e.g. [Cooke, 2008](#), [Lambertucci et al., 2014](#) and [Yorio, 2009](#)).

Conservation of large marine animals may be even more complicated as protected areas are usually small relative to the animal's scale of movements, and it is hard to identify the role of particular habitats to the animal's life cycle ([Devitt et al., in press](#); [Yorio, 2009](#)). A variety of tools can be used to quantify the movements of marine species. The various forms of telemetry each provide data over a range of spatial and temporal scales, but each leaves data-gaps. Satellite telemetry for example can provide movement data over months to a year but the spatial resolution of animal locations may have large errors. Alternatively, acoustic telemetry can provide data with high spatial resolution (e.g. active tracking) but only over short time periods (days) or single point locations over months to years (passive telemetry). Studies that combine multiple forms of telemetry with a single species in a single location are rare ([Holland et al., 2001](#); [Meyer et al., 2010](#)). Ultimately, to fully comprehend the role a habitat plays, movements must be measured over short and long time frames which combined with life history information can determine the potential function of that habitat.

The sawfishes are a group of large batoid elasmobranchs and are considered some of the world's most imperilled fishes ([Dulvy et al., 2014](#)). The characteristic rostrum is particularly susceptible to entanglement and is also a target in the curio trade. Sawfish also heavily use coastal habitats and are sensitive to issues associated with habitat modification, fisheries bycatch and pollution ([Dulvy et al., 2014](#); [Seitz and Poulakis, 2006](#); [Simpfendorfer et al., 2010](#); [Waters et al., 2014](#)). Combined, these factors have led to precipitous declines in sawfish populations worldwide and currently all five species are listed as endangered or critically endangered by the International Union for the Conservation of Nature (IUCN) Red List ([Dulvy et al., 2014](#)).

The smalltooth sawfish (*Pristis pectinata*) reaches almost 600 cm in length and is the only species found regularly in the United States ([Poulakis et al., 2014](#)). While historic records are distributed along the US east coast as far north as New York, sawfish are now only found reliably along the coast of southern Florida and it is estimated that the population size may have declined to 5% of what it was at the time of European settlement ([NMFS, 2000](#); [Poulakis and Seitz, 2004](#); [Simpfendorfer et al., 2010](#)). These declines lead to smalltooth sawfish being classified as Critically Endangered by the IUCN ([Carlson et al., 2014](#)) and Endangered under the US Endangered Species Act in 2003 ([NMFS, 2003](#)). Due to the fragmented distribution of the species worldwide, smalltooth sawfish are considered one of the species most at risk of extinction having shown a range contraction of 81% ([Dulvy et al., 2014](#)).

However, southwest Florida still has a viable population of sawfish and is considered a 'lifeboat' due to the strict legal protections provided ([Dulvy et al., 2014](#)). Furthermore, despite the drastic reduction in population size, recent population viability models predict that due to rapid growth rates, sawfish populations can recover if the appropriate management plans are implemented ([Carlson and Simpfendorfer, 2014](#); [Simpfendorfer et al., 2008b](#)). The spatial ecology of sawfishes in Florida has been studied using two basic methods: telemetry and encounter records from the public (e.g. [Simpfendorfer et al., 2011](#) and [Wiley and Simpfendorfer, 2010](#)). These data show that there are ontogenetic shifts in movements and habitat use, with neonates and juveniles using rivers and estuaries as nursery grounds, and adults using coastal habitats ([Carlson et al., 2014](#); [Simpfendorfer et al., 2011](#); [Waters et al., 2014](#); [Wiley and Simpfendorfer, 2010](#)).

Most information is regarding neonate and juvenile life stages as there are far fewer encounter records for individuals > 300 cm. Adults only make up 8% of reported encounters, primarily because they inhabit deeper murky water where they are less likely to be seen ([Waters et al., 2014](#)). Satellite tagged adults are more mobile than juveniles but still spend 96% of their time shallower than 10 m depth, and show relatively high levels of residency to areas of southern Florida ([Carlson et al., 2014](#)). There remains a considerable gap in our knowledge of the spatial ecology of adult sawfishes and it has already been recognized that this is an area where more research should be focused ([Norton et al., 2012](#); [Waters et al., 2014](#)).

Adult sawfish encounters are frequently reported from Florida Bay, a large lagoonal estuary situated adjacent to the Everglades and the Florida Keys ([Poulakis and Seitz, 2004](#); [Waters et al., 2014](#)). Florida Bay could be a key habitat for adult sawfish, but encounter data are only static in nature and do not trace the behaviour of individuals. Establishing if a habitat is important requires distinguishing it from transitory habitats and an understanding of the movements of individuals over multiple time scales. A combination of active and passive acoustic telemetry, satellite telemetry, and conventional tagging were used to determine how adult sawfish use Florida Bay over short (days) and medium (months) temporal scales. Our specific questions were (a) over short time scales, are sawfish movements related to diel and/or tidal periods? (b) how long do adult sawfish reside in the bay and do they show site fidelity? (c) does male/female behaviour differ? (d) what are the potential functions of Florida Bay to smalltooth sawfish?

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