

America's Second-Largest Estuary is a Lagoon Full of Sharks

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"The Manner of Their Fishing" by John White.



It's a bit of a cliché to reference the movie *Jaws* when talking about sharks, but I'm going to do it anyway. There's a pivotal scene where the giant White Shark is spotted moving into a salt pond, where it proceeds to terrorize the children of protagonist Chief Martin Brody. While no sharks are in the business of regularly eating humans, at least part of this scene is realistic: sharks do make use of inshore, estuarine environments like lagoons, bays, and the lower portions of rivers. Despite the fact that sharks are generally thought to stay out in the ocean, many species are not only comfortable entering estuaries, they actually depend on them. Some species make extensive use of estuaries as shelter from predators and/or a place to grab a bite themselves.

So it should come as no surprise that North Carolina's Pamlico Sound, part of the Albemarle-Pamlico estuary (the second-largest in the continental U.S. after Chesapeake Bay) offers a lot of potential real estate for sharks. Unlike Chesapeake Bay, Pamlico Sound is a lagoon, which means it's wide, shallow, mostly water, and connected to the ocean via fairly small inlets between barrier islands. It straddles the transition zone marked by Cape Hatteras between temperate and subtropical marine ecosystems, and the amount of seagrass growth there is second only to Florida in sheer area. This estuary is already well-known for its importance as habitat for such varied (as well as tasty and/or fun to catch) species as Blue Crab, Penaeid shrimps, Flounder, and Red Drum. However, the sharks of Pamlico Sound have mostly been known by scattered reports and sightings from fishermen. That is, until my co-authors and I were able to look through a nice data set to get an idea of which sharks are present in the sound and where in the estuary they might like to be. The results are now published in PLOS One, and here's a quick summary of how we got them.

Pamlico Sound is big place, and much too large for one person to cover adequately looking for sharks. Fortunately, the North Carolina Division of Marine Fisheries (NCDMF), the state agency responsible for monitoring and managing saltwater fisheries, conducts extensive sampling within the estuary to keep tabs on the biology and ecology of the species targeted by North Carolina fishermen. They identify and measure everything they can, and this includes a large number of sharks. For our purposes, we used catch and environmental data collected by the NCDMF gillnet and longline surveys, which account for a lot of the shark data collected by the agency and between them cover the entire perimeter of Pamlico Sound.

Between 2007 and 2014 there were 2048 sharks of 12 species captured in the Pamlico Sound surveys, six of which we identified as the principal species due to their consistent presence and abundance in survey catches. These were the Atlantic Sharpnose Shark, Blacktip Shark, Bull Shark, Sandbar Shark, Smooth Dogfish, and Spiny Dogfish.

The next step was a whole lot of statistical modeling, which fortunately was mostly automated thanks to a slick R package (*gbm.auto*) developed by co-author Simon Dedman and his colleagues. We used boosted regression tree modeling to figure out the preferred environmental ranges for each of the six principal species, which we then used to generate maps that predicted the likelihood of encountering each species across the estuary. Regression trees work by identifying environmental "cut points" between high and low likelihood of a shark being present and branching from there. The trees include all the environmental factors recorded during the surveys (in our case depth, water temperature, salinity, dissolved oxygen, distance from the nearest inlet, and distance from the nearest seagrass bed) and the end result is the combination of environmental ranges in which you have the highest likelihood of finding a shark. For example, this type of analysis would tell you that a Blacktip Shark is more likely to be found in areas with temperatures between 20 and 30 °C *and* salinity greater than 20 parts per thousand. Because there can be a lot of variability each time you run an individual tree model,

the “boosted” part comes from the stats software replicating the trees hundreds to thousands of times, getting a little better at it each time, until it comes up with the combination of environmental ranges with the least potential to give you a weird result.

The distribution of potential shark habitat within Pamlico Sound tells us a lot about how each species is making use of the estuary. Four of the six species (Sharpnose, Blacktip, Sandbar, and Spiny Dogfish) showed a pattern I like to call “inlet hugging,” which is defined by a preference for higher salinities and closer proximities to the inlets. As you’d expect, these are primarily ocean-going sharks not known for traveling far into brackish water, so they’re likely ducking into the inlets to feed or seek temporary shelter but aren’t spending much time inside the estuary. These species do differ by season, with Spiny Dogfish occurring almost exclusively during winter, Sandbar Sharks occurring most often in the fall, and the Sharpnose and Blacktip Sharks sharing the summer (it’s worth noting that Blacktip Sharks occasionally eat Sharpnose Sharks).

Things get more interesting with the Bull Shark, which has the ability to tolerate lower salinities and seems to prefer the western side of Pamlico Sound, but not necessarily up into the Neuse and Pamlico Rivers. This species also prefers warm water and occurs during the summer. You’ll be hearing more about what this species is doing in Pamlico Sound in the very near future.

Finally, the Smooth Dogfish, which was by far the most common shark caught in the NCDMF surveys (by number this species account for over half the total number of sharks caught) preferred higher salinities and summer conditions but its potential habitat almost perfectly overlapped the seagrass beds hugging the inshore side of the Outer Banks. Smooth Dogfish primarily feed on crustaceans like shrimp and crabs and most of the individuals caught in NCDMF surveys were small juveniles. Pamlico Sound may represent a major nursery for this species, and it’s likely that young Smooth Dogfish spend a lot of time in those extensive seagrass beds feeding on the small crustaceans hiding in them.

It’s neat to know where sharks might like to hang out, but there are some very practical uses of all these pretty maps. Spatial management, the practice of managing natural resources by area, is becoming increasingly important in the marine field not only for fisheries management, but coastal and offshore development. This is why this project has inspired or directly lead to further research on the sharks of North Carolina’s estuaries, including an already-published survey of Back and Core Sounds (supported by NC Sea Grant) and an ongoing survey of the lower Cape Fear River (supported by the NC Aquarium Society). This kind of information can identify areas of particular importance to a species so they can be properly considered when fishing, building an offshore wind farm, building some houses on the shore nearby, and even deciding how to manage runoff far upstream. Knowing which areas are actually important to a species is crucial when siting marine protected areas at both small and large scales. And all this speaks to the importance of good, basic biological survey information collected by agencies.

If nothing else, it’s humbling to know that the rivers flowing through parts of North Carolina as far from the coast as Raleigh and Greenville connect the people there to a lagoon full of sharks.

Article Questions:

1. Estuaries are often used by sharks. Why do they use these areas?
2. The Pamlico Sound is part of what estuary?
3. What type of data is collected by the NCDMF?
4. What conditions are preferred by the blacktip sharks?
5. Describe “inlet hugging”.
6. The most common shark in the Pamlico Sound is the smooth dogfish. What organisms do they depend on for food?