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White shark (Carcharodon carcharias) predation on an adult Atlantic sturgeon (Acipenser oxyrinchus): first direct evidence from Gulf of Maine

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Abstract

Atlantic sturgeon (*Acipenser oxyrinchus*) are threatened under the United States Endangered Species Act in the Gulf of Maine (GoM), where natural sources of adult mortality remain poorly documented. We report a stranded adult female Atlantic Sturgeon (224-cm total length) recovered in Scarborough, Maine, USA, with injury consistent with predation by a juvenile white shark (*Carcharodon carcharias*) and inconsistent with vessel strike. Bite-mark analysis indicated a shark of at least 2.6 m total length, matching juveniles increasingly documented in nearby Saco Bay. The stranding coincided with peak seasonal white shark activity within known sturgeon foraging area, supporting predation as the most parsimonious cause of death. Predation on adult Atlantic sturgeon has only been known via tooth-mark injuries on surviving individuals in Canadian weir fisheries making this the first direct evidence of the interaction in the GoM. As white sharks expand into warming GoM waters, such encounters may become more frequent, highlighting the need for continued monitoring of shifting predator-prey dynamics.

Introduction

Acipenser oxyrinchus (Atlantic sturgeon) is a large-bodied living fossil; this long-lived, anadromous species retains distinctive primitive adaptations (e.g. cartilaginous skeletons, heterocercal caudal, electroreceptive pores, protrusive mouths) (Smith and Clugston 1997; Breece et al. 2021; Teeter et al.1980; Miller 2004). Adults typically occupy coastal waters and estuaries along the Atlantic coast of the United States, predominately utilizing areas around and within major river outflows (Stein et al. 2004; Novak et al. 2017). Over the past century, like many diadromous species, Atlantic sturgeon have suffered substantial declines in abundance due to anthropogenic hardships (e.g. overfishing, habitat degradation, and bycatch in commercial fisheries) resulting in an overall listing status of endangered under the United States Endangered Species Act (ESA) (Smith and Clugston 1997; NOAA 2012a). However, the Gulf of Maine (GoM) distinct population segment (DPS) yields the most robust of the U.S. occurring population and is classified as ESA threatened (NOAA 2012b). Despite increased conservation and monitoring efforts in recent decades, the population remains depleted, and natural sources of mortality remain scant (ASMFC 2024).

Carcharodon carcharias (white shark) is an infamous cosmopolitan macropredator known to prey on a variety of teleost and elasmobranch species, as well as marine mammals (Clark et al. 2023). White sharks have a broad distribution within the GoM, with recent studies indicating marked preference for shallow coastal waters when present (Davis et al. 2025). The northward range expansion of white sharks in the Northwest Atlantic has been goaded by warming water temperatures, population recovery, and/or increasing pinniped prey (Bastien et al. 2020; Curtis et al. 2014), increasing the likelihood of co-occurrence with Atlantic sturgeon. While predation by white sharks on large-bodied teleosts has been documented in several systems, records of interactions between white sharks and Atlantic sturgeon remain scarce (Boldrocchi et al. 2017; Le Croizier et al. 2020). Predation on Atlantic sturgeon is generally restricted to the larval and juvenile stages, where individuals are the prey window of a broader suite of predators (e.g. catfish, carp, striped bass, birds of prey, sharks, sea lamprey) (Hilton and McGrath 2021;

Bunch et al. 2021). Once sturgeon reach maturity, their size and scutes dissuade most predators, making any observed predation attempt on an adult notable. Dadswell and Rulifson (2021) collated the only extant record of such predation, involving sturgeon captured in the commercial weir fishery of the Minas Basin, Nova Scotia, Canada, where surviving individuals presented tooth-mark injuries consistent with shark predation attempts.

In GoM coastal environments, white sharks and sturgeon may overlap in unprecedented densities, yet their interactions remain undocumented. Here, we describe the stranding, necropsy findings, and bite-mark analysis in detail, providing the first documented regional evidence of this interaction and contributing to our understanding of predator-prey dynamics and mortality sources of adult GoM Atlantic sturgeon.

Methods and Results

On September 19, 2023, a 2.24-m female Atlantic sturgeon was reported moribund and stranded on an exposed sandbar just south of Scarborough River, Maine, USA (43.537961° N, 70.335264° W) (Fig. 1b). The individual later succumbed to its injuries and was collected by Scarborough Police Animal Control and transported to the University of New England under salvage permit (NOAA NMFS Sturgeon Tissue Salvage Permit 21858-01). Bite impressions and wound channels measured using photos with scale taken during necropsy enabled bite-mark analysis.

Necropsy revealed extensive predation-related crescent-shaped injury concentrated on the left side of the body (Fig. 1c), including large-scale loss of dermis, visceral fat, and musculature accompanied by jagged wound margins and associated trailing lacerations (Fig. 1a); the right side showed additional lacerations, punctures, and fin damage (for additional necropsy details see Supplementary Materials).

The pattern and distribution of these injuries were inconsistent with vessel strike (e.g. propeller or turbine interaction), which typically produces regularly spaced parallel cuts, and instead closely resembled halfmoon-shaped tooth-mark injuries previously attributed to white shark predation (Balazik et al. 2012; Nisa-Castro-Neto et al. 2026).

Discussion

Cumulatively, the bite circumference (BC), interdental distance (IDD), and wound morphology are most consistent with *Carcharodon carcharias* and inconsistent with other coastal shark species known to occur within the GoM (Lowry et al. 2009; Collette and Klein-Macphee 2002). The IDD, tooth morphology and bite arc, fall outside the published range for porbeagle (*Lamna nasus*), and shortfin mako (*Isurus oxyrinchus*), while the broad, crescentic slicing wound pattern precludes basking shark(*Cetorhinus maximus*), spiny dogfish (*Squalus acanthias*), thresher shark (*Alopias vulpinus*), blue shark (*Prionace glauca*), and sand tiger shark (*Carcharias taurus*) (Pollerspöck and Straube 2020; Moyer et al. 2026).

These same measurements allowed us to estimate the approximate size of the shark involved, as IDD and BC are commonly derived from bite-damage patterns (Clua and Reid 2018). Using three images of known scale, we collected both measurements (1 BC, 2 IDD); we then applied length-relationship calculations of Lowry et al. (2009) for white shark to derive an approximate total length (TL). Given that the entire tooth-bearing portion of the jaw did not imprint into the sturgeon, an estimation based on BC likely underestimates shark size (Lowry et al. 2009); the wound margins and rake marks in the sturgeon's flesh instead offered a more reliable basis for the IDD calculation (BC and IDD calculations are provided in the Supplementary Materials). This analysis, predicated on the wound-margin and rake-mark measurements, indicated a shark of at least 2.6 m TL.

This estimate is consistent with average size (2.45 m TL) reported for juvenile white sharks measured opportunistically in land-based catch events in Saco Bay, ME, where coastal juvenile observations have become more common since 2023 (Nguyen, unpublished data). White sharks are known to undergo a distinct ontogenetic shift in jaw circumference and thickness at approximately 2 m precaudal length (region dependent), coinciding with a dietary transition toward more robust prey (Hunt et al. 2026; Hussey et al. 2012; Grainger et al. 2020). The involved shark was likely at or just beyond this threshold, consistent with the jaw strength necessary to target a large-bodied, heavily armored prey item.

Necropsy findings, combined with white shark size estimation, indicate that sturgeon mortality resulted from a significant bite to the posterior caudal region that provoked fatal hypovolemic shock, causing the sturgeon to beach itself. White shark feeding ethology is well documented, the literature indicates the species frequently favors initial bites to the ventral posterior of large prey items (Tricas 1985). Further evidence indicates that initial contact with large-bodied prey serves to wound or kill rather than feed, a strategy theorized to reduce the shark's risk of injury from a struggling prey item (Tricas and McCosker 1984; Klimley 1994; Martin et al. 2005). Adult sturgeon are both large-bodied and capable of inflicting significant injury (Wilson et al. 2009); their sharp osseous scutes further constitute a defense that necessitates a cautious predatory approach. The 'Bite, Spit, Wait' strategy is consistent with the shark size and prey morphology (Tricas and McCosker 1984). Many sharks bear deep predation-related scarring, consistent with the risk associated with subduing formidable prey (Anderson et al. 2025).

Hunting success is influenced by a range of factors, including light, wind, turbidity, prey species, and predator maturity (Fallows et al. 2016; Hammerschlag et al. 2006; Towner et al. 2016; Huveneers et al. 2015). Notably, turbidity may have contributed to this predation attempt, as the event occurred within 48 hr of a storm; such systems are common during the fall and typically produce high surf and turbid waters in the following days. White sharks are theorized to exploit turbidity transiently when foraging (Ryan et al. 2019). This timing also coincided with the regional peak white shark activity (Davis et al. 2025; Table S1).

Further, telemetry studies in southern Maine detected Atlantic sturgeon in Saco Bay and the Scarborough River during July-November (Wippelhauser et al. 2017), with the Saco River Estuary (SRE) serving as distinct foraging area where adults feed before migrating to the Kennebec River to spawn,

then returning to resume foraging (Hylton et al. 2018; Novak et al. 2017). This pattern of foraging ahead of shelf-ward migration aligns with the necropsied sturgeon's presumptive timeline. This seasonal overlap, paired with the unique wound characteristics described above support white shark predation as the most parsimonious explanation for this stranding event.

We note a potential shifting predator landscape in one of the fastest warming marine theatres, where sturgeon have long been considered functionally invulnerable to predation. GoM warming is associated with regime shifts of many key species (Pershing et al. 2021); as juvenile white sharks continue to expand their seasonal presence in the GoM unabated, the potential for encounters with the region's Atlantic sturgeon may increase accordingly. This raises broader concern for other large-bodied, benthic, or slow-moving species within GoM that may similarly experience novel or increased predation pressure as distributions shift (e.g. Shortnose sturgeon;*Acipenser brevirostrum* , Atlantic torpedo; *Tetronarce nobiliana*, skate; *Raja sp.*, Atlantic halibut; *Hippoglossus hippoglossus*, harbor porpoise; *Phocoena phocoen*a, ocean sunfish; *Mola mola*).

Top-down effects of large predators on prey space use and foraging behavior are well established in the literature in both terrestrial and marine ecosystems (Wirsing et al. 2007; Wirsing and Ripple 2010; Laundre et al. 2010). An emerging predation risk from white sharks in the Gulf of Maine would be expected to produce analogous shifts in behaviors (i.e. sturgeon migration timing, staging behavior, and feeding habitat use). These changes could otherwise be misattributed to habitat, temperature, or anthropogenic drivers.

Documenting natural predation events such as this one is critical for characterizing baseline sources of sturgeon mortality. Such records also help anticipate climate-associated expansion of white sharks (Franks et al. 2021; Allegue et al. 2025) and prepare researchers for shifting predator-prey dynamics in a region undergoing rapid environmental change. Continued necropsy-based monitoring of stranded sturgeon, paired with genetic confirmation of predator identity where feasible (e.g. metabarcoding via wound swab), will help refine estimates of frequency and regional significance of this interaction. Future work elucidating regional juvenile white shark diet composition should be considered to estimate importance of sturgeon in their diet. This finding also has direct and practical implications for the regions ongoing sturgeon telemetry studies. Predation risk should be explicitly considered as a factor shaping tagged individuals' movement and detections (or lack thereof). We recognize that our report is only one record of predation; nonetheless, it may inform future studies evaluating trophic linkages and shifting predator-prey relationships. As such, we consider this report a valuable and ecologically meaningful contribution to ongoing sturgeon and shark research in the region.

Declarations

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photographs. Any opinions, findings, or recommendations expressed in this article are strictly related to the authors and do not reflect positions and policies of affiliated institutions.

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Data Availability: Data is available upon request.

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Figures

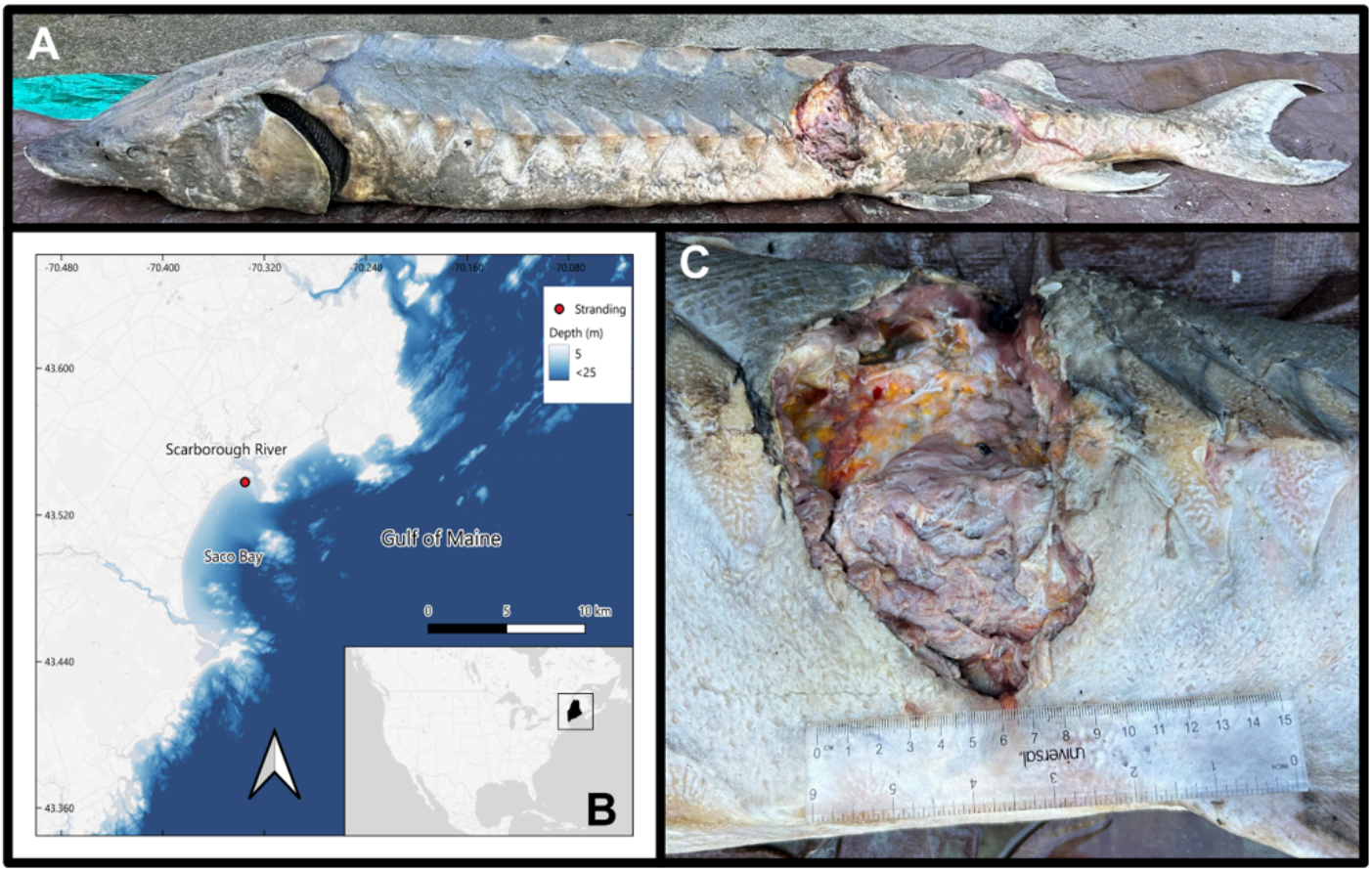


Figure 1

(A) Full body photo of left side of adult Atlantic sturgeon (*Acipenser oxyrinchus*) showing both inflicted areas (B) Map of stranding location (red dot) where sturgeon was recovered (C) White shark bite circumference (BC), with scale

Supplementary Files

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