



First documented occurrences of the shortnose sturgeon (*Acipenser brevirostrum*, Lesueur, 1818) in the Saco River, Maine, USA

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Summary

During sampling efforts to study the more abundant Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, between May of 2009 and November of 2011, four shortnose sturgeon were captured in gill nets near the mouth of the Saco River, Maine. Two of these individuals were tagged with acoustic transmitters to monitor their movement within the Saco River. Additionally, six shortnose sturgeon that had been tagged with acoustic transmitters in the Merrimack River, Massachusetts were detected on the acoustic array deployed within the Saco River and its estuary over this time period. These incidences represent the first verified documentation of shortnose sturgeon within this estuary.

Introduction

The shortnose sturgeon, *Acipenser brevirostrum*, was commercially harvested in the US from the late 19th to the early 20th century (NMFS, 1998). This directed harvest, coupled with deteriorating water quality in riverine habitats and construction of dams, restricted passage to spawning grounds, leading to drastic declines in shortnose sturgeon abundance (NMFS, 1998). Due to these circumstances, the shortnose sturgeon was designated an endangered species in 1967, a status it retains today.

Currently, the geographic distribution of *Acipenser brevirostrum* encompasses large rivers along the majority of the East Coast of the United States (US), extending to the St. Johns River in New Brunswick, Canada (NMFS, 1998). Historically, populations of shortnose sturgeon were reputed to display the life history characteristics of a freshwater amphidromous species (Taubert, 1980; Buckley and Kynard, 1985; Kieffer and Kynard, 1996; Bain, 1997). These fish were thought to spend the majority of their lifecycle in discrete areas of large natal rivers with limited movement into estuarine or marine waters (Buckley and Kynard, 1985; Kieffer and Kynard, 1993). Specimens are rarely captured in coastal marine waters and were not typically considered coastal migrants (Dadswell et al., 1984; Bain et al., 2007). However, more recent studies have found that movements between major river systems in the northeastern US are more common than previously thought and that habitat connectivity may be an important consideration for the recovery of this species throughout its range (Fernandes et al., 2010; Zydlewski et al., 2011).

In the northeastern US, populations of shortnose sturgeon have been studied in several rivers. These include the

Penobscot River (Fernandes et al., 2010; Zydlewski et al., 2011) and the Kennebec-Androscoggin-Sheepscoot complex in Maine (Squiers et al., 1982), as well as the Merrimack (Kieffer and Kynard, 1993, 1996) and Connecticut rivers (Taubert, 1980; Buckley and Kynard, 1985) in Massachusetts. The Saco River represents a midpoint between these southern and northern rivers of New England. The Saco River is also known to host a population of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) during the summer months (J. A. Sulikowski, unpubl. data), a species that frequently inhabits many of the same major rivers as shortnose sturgeon. Despite this location and potentially suitable habitat, shortnose sturgeon have never been documented in this river system. Herein, we present the first description of the endangered shortnose sturgeon within this river system and possible implications for the life history and management of this species.

Materials and methods

Study area

Sampling for this study focused on the estuarine portion of the Saco River as it enters its associated bay (Fig. 1). The Cataract Dam joins the cities of Saco and Biddeford at a distance of about 10 river kilometers (rkm) from the mouth of the river (Brothers et al., 2008). This dam separates the tidally-influenced estuary from upstream portions of the river and presents an impassable boundary for sturgeon. As a result, the study area is limited to the stretch of river downstream of this barrier. At the mouth of the river, two jetties have been constructed that extend about 1.5 km from the natural mouth of the river into Saco Bay.

Acoustic receiver array

An array of seven VEMCO VR2W receivers (VEMCO Division AMIRIX Systems Inc., Nova Scotia, Canada) was deployed in this lower reach of the Saco River (Fig. 1) to monitor movement of fish tagged with acoustic transmitters. The maximum detection range of a VR2W receiver is influenced by bathymetry and environmental conditions (such as turbidity), however it is usually between 900 and 1000 m (VEMCO). Given that the greatest river width at a receiver location is 330 m, it was assumed that the receivers covered the width of the river at each location. Each year from 2009 to 2011, receivers were deployed in the Saco River in early April or May and remained in the water throughout the

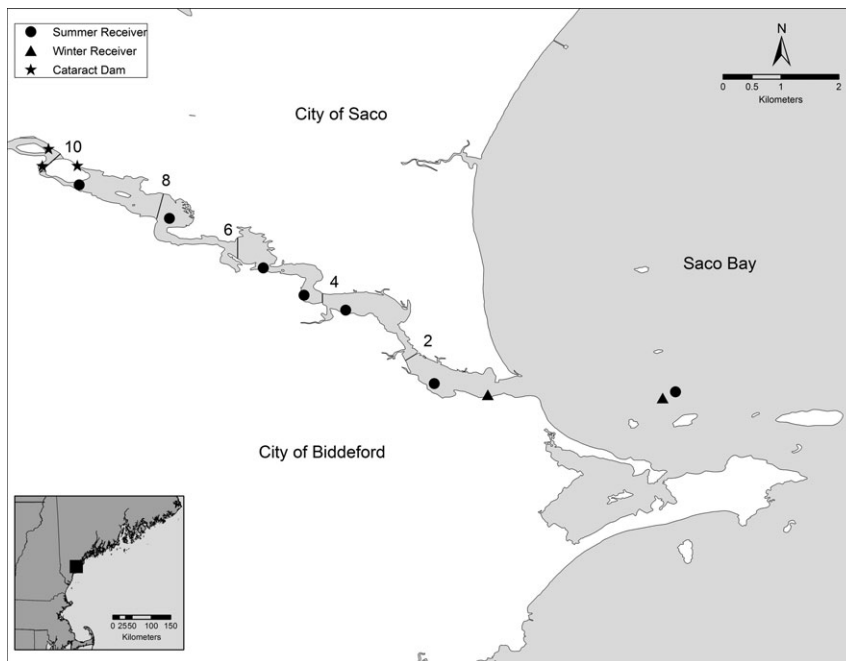


Fig. 1. Location of acoustic receiver array, Saco River estuary, Maine, summer (May–November) and winter (December–April), 2009–2011. Black rectangle insert = area of array. Approximately river kilometers denoted with numbers along Southern edge of the river

summer and autumn until their removal in late November or early December. Two acoustic receivers were positioned near the mouth of the river from November through May each year to monitor passage of fish into and out of the river over the winter months.

Field sampling methods

Net sampling was conducted twice a month between May and November from 2009 to 2011. Bottom-set monofilament gill nets 100 m long \times 2 m deep and with stretched mesh sizes of 15.2 cm and 30.5 cm were used to capture sturgeon (Atlantic and shortnose) of varying sizes. Fishing was conducted at low tide and nets were set perpendicular to the jetties at the mouth of the river. Gear was allowed to soak for a maximum of 30 min to minimize stress to captured individuals. Captured sturgeon were held in a floating net pen (2.1 m \times 0.9 m \times 0.9 m) attached to the side of the boat until processing.

Each fish was individually brought onboard and placed in a holding tank measuring 2.1 m \times 0.5 m \times 0.4 m. External measurements, including total length (TL), fork length (FL), head length (HL), interorbital width (IOW), and mouth width (MW) were obtained. Three fish were implanted with passive integrated transponder (PIT) tags for long-term identification. PIT tags were injected in the fleshy base of the dorsal fin using a MK10 implanter (Biomark, Boise, ID) with a 6-gauge stainless steel needle. External T-bar tags were implanted in the opposite side of the base of the dorsal fin using a Mark III tagging gun (Avery Dennison Corporation, Pasadena, CA). Two shortnose sturgeon captured in the Saco River were surgically implanted with coded VEMCO V16 acoustic transmitters with a nominal delay of 240 s (minimum 170 s, maximum 310 s) and an estimated battery life of 2993 days. Transmitters were inserted through a 5 cm c-shaped incision on the ventral surface approximately 10 cm anterior of the vent. A single polydioxanone (absorbable) suture was used to close the incision. Individuals were returned to the net pen for recovery and observation, and remained there until they were deemed fit for release.

Results

Field sampling

A total of four shortnose sturgeon, ranging in total length from 81.0 to 92.5 cm, were captured in gill nets set in the Saco River between June of 2009 and June of 2011. The first capture occurred on 16 June 2009 (81.0 cm TL), the second occurred on 30 August 2010 (86.0 cm TL), the third on 25 May 2011 (92.5 cm TL) and the fourth on 9 June 2011 (83.0 cm TL). All shortnose were returned to the Saco River at the location of capture with no outward signs of stress. VEMCO V16 acoustic tags were surgically implanted in the sturgeon captured on 30 August 2010 (SNS A) and 9 June 2011 (SNS B) to monitor movement within the Saco River.

Acoustic telemetry

Fish tagged in Saco river. The first shortnose sturgeon (SNS A) surgically implanted with an acoustic tag was released into the Saco River on 30 August 2010 (Table 1). This individual remained in the river for approximately 18 days, departing on 17 September. Over this period, SNS A utilized the entire study area (up to rkm 9.5). SNS A returned to the Saco River on 3 July 2011 and remained in the river for 9 days, exiting the system on 12 July. In 2011, this sturgeon used a smaller portion of the study area, venturing to rkm 6.

The second shortnose sturgeon (SNS B) was implanted with an acoustic tag and released in the Saco River on 9

Table 1
Tagging and observation dates (dd/mm/yy), shortnose sturgeon (*Acipenser brevirostrum*), acoustically tagged in Saco River, Maine

Fish ID	Date tagged	Exited Saco	Date returned to Saco
SNS A	30/08/10	17/09/10	03/07/11
SNS B	09/06/11	02/11/11	NYD

'NYD' = fish return 'not yet documented'. Fish were assigned IDs of SNS A (shortnose sturgeon A) and SNS B (shortnose sturgeon B) to differentiate between/among individuals. 'Furthest Upriver' = position of acoustic receiver furthest inland at which the individual was detected.

June 2011. This individual remained in the study area for 146 day before departing on 2 November 2011. The farthest upriver this sturgeon ventured over this time period was to rkm 6. Neither of the two shortnose sturgeon tagged in the Saco River have been detected on receiver arrays in other river systems.

Fish tagged in other rivers. The Saco River acoustic receiver array detected six individual shortnose sturgeon that had been implanted with transmitters upon prior capture in the Merrimack River, Massachusetts. These immigrant tag detections occurred between 6 April 2010 and 1 November 2011 (Table 2). No shortnose tagged in other systems were detected in the Saco, but some of the Merrimack (tagged) fish that entered the Saco were previously or subsequently detected in additional river systems in the Gulf of Maine.

The first Merrimack-tagged sturgeon (SNS #1) to arrive in the Saco River was a female with late-stage eggs that was last detected in the Merrimack on 3 April 2010. This fish was detected just inside the mouth of the Saco River 53 times on 6 April before departing the study site the same day. This fish was then detected in the Kennebec River, Maine from 12 April to 5 May 2010. It subsequently returned to Saco Bay on 9 May 2010, almost 1 month after it was last detected in the system. Upon returning to the study site, this fish was detected in Saco Bay 12 times over an hour and a half before exiting the study area again on the same day.

The second immigrant shortnose (SNS #2) was last detected in the Merrimack on 6 April 2010 and arrived in the Saco River 3 days later. Receivers logged 1280 detections between 9 and 11 April 2010. After departing the Saco River, this individual moved north and was detected in the Kennebec system on 18 April. It remained in this system until 2 May 2010. It then returned south to the Saco River on 8 May and subsequently remained in the system until 9 May and detected on receivers up to rkm 5.5.

The third shortnose (SNS #3) in the Saco River was last detected in the Merrimack on 28 March 2010. This individual initially traveled north past the Saco River and was detected in the Kennebec River from 6 to 30 April 2010. This fish was subsequently detected on receivers at the mouth of the Saco River 39 times on 3 May 2010 before departing the study area.

The fourth Merrimack-tagged shortnose (SNS #4) to be detected in the study area was last detected in the Merrimack on 18 October 2010. It remained in the estuary for only a brief period of time. This fish was detected on a receiver in Saco Bay five times on 20 October before moving on. It was then detected on a single receiver in the Casco Bay from 25 to 27 October 2010. This fish was detected in the Kennebec

River the following spring and remained in that system from 24 April to 12 December 2011.

A fifth Merrimack-tagged shortnose sturgeon (SNS #5) was last detected in that river on 15 April 2011 and detected in the Saco River on 20 April 2011. This individual remained in the river for approximately four days, departing the Saco River on 24 April. During its residency in the river, this animal was detected on all receivers up to the Cataract Dam (rkm 9.5). This animal then continued north and was detected in the Kennebec River from 4 to 24 May 2011.

The sixth and final sturgeon (SNS #6) from the Merrimack to be detected in the Saco was last detected in the Merrimack on 13 April 2011. This animal then migrated north and entered the Kennebec River on 22 April 2011. It remained in this system for 85 days before exiting on 16 July 2011. SNS #6 then traveled south and arrived at the mouth of the Saco River on 21 July 2011. This individual remained in the system for several months, utilizing the entire study area and exiting the system on 1 November 2011.

Discussion

Few studies have examined the fish community in the Saco River estuary. One long-term study by Reynolds and Casterlin (1985) found that the Saco River estuary and Saco Bay hosts at least 18 different species of fish as well as a variety of crustaceans, echinoderms and mollusks. Additionally, a two-year study by Furey and Sulikowski (2011) from 2007 to 2008 documented 24 fish species inhabiting the estuarine reaches of this system, including two Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Although those studies suggest that the Saco River estuary is an important habitat for other species of fish, *Acipenser brevirostrum* had not previously been reported in the system prior to the current study. Use of the Saco estuary by this endangered species suggests this watershed might serve an important habitat function.

Brief movements into and out of the estuary by six shortnose sturgeon tagged in the Merrimack River indicates that the Saco River may serve as a stopover site on a larger migration among rivers in the Gulf of Maine. The timing of these stopovers suggests a potential link to spawning. This is most clearly illustrated by SNS #1 and SNS #2, both of which entered the Saco River while travelling to and returning from the Kennebec River. Several other shortnose sturgeon either briefly entered the Saco River estuary at the beginning of April before departing and entering the Kennebec River system or were detected in the Kennebec River before returning south to the Saco River. This time window of absence from the Saco River or entry into the Kennebec River (April–May) is consistent with the known period of spawning in the Kennebec/Androscoggin system (Squiers

Table 2

Observation dates (dd/mm/yy), shortnose sturgeon (*Acipenser brevirostrum*), acoustically tagged in Merrimack River, Massachusetts and recorded in other river systems in Gulf of Maine, April 2010–November 2011

Fish ID	Depart Merrimack	Arrive Saco	Depart Saco	Arrive Kennebec	Depart Kennebec	Arrive Saco	Depart Saco
SNS #1	03/04/10	06/04/10	06/04/10	12/04/10	05/05/10	09/05/10	09/05/10
SNS #2	06/04/10	09/04/10	11/04/10	18/04/10	02/05/10	08/05/10	09/05/10
SNS #3	28/03/10			06/04/10	30/04/10	03/05/10	03/05/10
SNS #4	18/10/10	20/10/10	20/10/10	24/04/11	12/12/11		
SNS #5	15/04/11	20/04/11	24/04/11	04/05/11	24/05/11		
SNS #6	13/04/11			22/04/11	016/07/11	21/07/11	01/11/11

Fish were assigned IDs of SNS #1–6 (shortnose sturgeon #1–6) to differentiate between and among individuals.

et al., 1982). Moreover, all shortnose sturgeon tagged in the Merrimack, with the exception of SNS #5, were known to be females with late-stage eggs that should have been approaching spawning condition as described by Kieffer and Kynard (2012). None of these fish were detected in freshwater reaches of the Saco, suggesting that spawning did not occur in this system.

One individual tagged in the Merrimack River (SNS #6) and both individuals tagged in the Saco River demonstrated extended residence times and movements throughout the Saco system. The period of residence for two of these fish (SNS A during its return year and SNS #6 in its tagging year) occurred too late in the year to likely be tied to a spawning movement (Dadswell et al., 1984; Buckley and Kynard, 1985; Kieffer and Kynard, 1996). The remaining Saco River fish (SNS B) was tagged too late in 2011 to know whether it was resident in the system during the spring of its capture year (as is true for SNS A), and it is not known at the time of writing if and when it might reenter the system (unlike SNS A). Extended summer residence in the Saco estuary is likely more consistent with use of the system for foraging.

On several occasions, shortnose sturgeon that entered the Saco River only ventured as far as rkm 6. This location represents one of the widest portions of the river accessible to sturgeon and would be expected to have a lower flow velocity than other portions of the study area. It is not currently known why several of the fish ended their upriver movements at this point and additional study is necessary to determine if this area serves a specific function or limitation for some individuals.

Historically it was thought that shortnose sturgeon do not typically make coastal migrations (Dadswell et al., 1984). However, Fernandes et al. (2010) and Zydlewski et al. (2011) found that this species undertakes regular, seasonal migrations between the Kennebec River complex and the Penobscot River, with short ventures into smaller coastal rivers in Maine. This discovery, coupled with our findings, indicates that the movements and population ecology of *Acipenser brevirostrum* in the northeastern United States is more complex than previously thought. Furthermore, the repeated occurrence of shortnose sturgeon in the Saco River during consecutive years suggests that this estuary may be an important habitat for this species on both short (days) and long (months) time scales. Indeed, intermediate rivers like the Saco may require careful consideration under the current management scenario, since it is possible that they are in part responsible for enabling the unique migratory ecology of this species in the Gulf of Maine.

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