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Habitat Use and Movements of Juvenile Shortnose Sturgeon in the Savannah River, Georgia–South Carolina

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Abstract.—During 1999–2000, 28 juvenile (<56 cm total length) shortnose sturgeon *Acipenser brevirostrum* were captured in the lower Savannah River, Georgia−South Carolina, and acoustic transmitters were implanted in or attached to 15 of them. The juveniles were located only between river kilometers (rkm; measured from the mouth of the river) 31.2 and 47.5, in salinities of 0.1‰ to (briefly at high tide) 17.6‰, and at depths of 2.1–13.4 m. The fish used two small areas very intensively. When water temperatures were above 22°C, the fish moved upriver; they aggregated particularly at rkm 47.5 when temperatures were greatest, and the average salinity at this location was 0.1‰. When water temperatures were below 22°C, the fish moved downriver into Savannah Harbor and used approximately 2-km segments of the Front and Middle rivers just upriver of their confluence at rkm 31.5. Here they encountered higher salinities (mean, 5.4‰) than during warm months. During the period of lowest water temperatures, the fish aggregated just inside the mouth of the Middle River in a hole separated from the deeper Front River by a sill. Movements related to tide stage or diel phase were not observed. Fish carrying transmitters with a depth option were always located on or near the bottom (±1.5-m transmitter accuracy). No juveniles were recorded as far downriver as the nursery area identified in a study conducted about a decade earlier, perhaps due to changes in hydrographic conditions that were induced by harbor modifications. The cool-season habitat is in the portion of the harbor to be impacted by further modifications. The relative abundance of juveniles suggests that recruitment has not increased despite an apparent increase in the adult population from the stocking of hatchery-reared fish during 1985–1992.

The shortnose sturgeon *Acipenser brevirostrum* inhabits Atlantic coast rivers from New Brunswick, Canada, to northern Florida (Vladykov and Greeley 1963), and at least 16 populations of the fish have been identified (Kynard 1997). This species, together with the sympatric Atlantic sturgeon *A. oxyrinchus*, was harvested extensively for its flesh and eggs (caviar). Most populations are now depleted or extirpated, and the species is listed as endangered in the United States. Population declines are believed to be the result of overharvesting (including ongoing bycatch mortality) combined with habitat loss from damming and water quality degradation (Collins et al. 2000).

A number of studies have focused on the biology of adult shortnose sturgeon throughout the range of the species (e.g., Collins and Smith 1995; Moser and Ross 1995; Kynard et al. 2000), and juveniles have been studied in laboratory settings (e.g., Jenkins et al. 1995; Richmond and Kynard 1995). However, little information is available on the abundance, movements, or habitat use of juvenile shortnose sturgeon in the wild. The only information on nursery habitat in the southern portion of the species' range is from the lower Savannah River (Georgia−South Carolina) where a ship-turning basin in the harbor was identified as the center of abundance (Hall et al. 1991; Smith and Collins 1998). Since then, Savannah Harbor has undergone a number of modifications that have affected its hydrography and water quality, and additional modifications are planned. The impacts of past modifications on shortnose sturgeon nursery habitat are not known, but water quality models predict that planned harbor alterations will both increase the salinity and decrease the dissolved oxygen concentration in the previously identified nursery habitat (GPA 1998). Here we present the results of a study designed to evaluate the status and distribution of juvenile shortnose sturgeon in the Savannah River.

Study Area

The Savannah River originates in the mountains of North Carolina, South Carolina, and Georgia, and for much of its length it serves as a boundary between the latter two states. The river is impounded at a number of points; the dam farthest downriver is near Augusta, Georgia, at river kilometer (rkm; measured from the mouth) 300. The

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river is used for a variety of recreational, industrial, and municipal purposes. Much of the lower river is bordered on the north by the Savannah River National Wildlife Refuge and on the south by the city of Savannah. The maximum and minimum mean annual freshwater discharges since 1962 are 5,920 and 980 m^3/s, respectively. Savannah Harbor is a deepwater port with considerable industrial development. Tides are semidiurnal (with a mean range of 2.4 m in the harbor), and tidal influence currently extends upriver approximately 75 km. A portion of the lower river branches into the Front, Middle, and Back rivers, the former of which is the primary branch and the one on which port facilities are located. The shipping channel is presently dredged to a depth of approximately 13 m. The shortnose sturgeon nursery area was previously identified as being in the Front River in the Kings Island Turning Basin (KITB) at rkm 29.0–30.5 (Hall et al. 1991).

Methods

During August 1999–December 2000, shortnose sturgeon were captured using anchored gill and trammel nets of various lengths and mesh sizes. The most commonly used gear were gill nets with 7.62-cm stretch mesh, generally fished during slack water associated with high or low tides. Sampling began in the KITB (the historic aggregation area) and expanded to cover rkm 27–60 as current information on fish movements was obtained. Most sampling took place during the day, but some overnight net sets were also conducted during cool months.

The captured fish were measured for total length (TL) and fork length (FL) to the nearest millimeter. Fish were then placed in a tank with flow-through river water. Each fish received passive integrated transponder (PIT) and dart tags at the base of the dorsal fin. Fifteen juveniles received either an acoustic transmitter measuring 28.0 mm × 8.0 mm and weighing 2.5 g (in water) or a depth-indicating acoustic transmitter measuring 45.0 mm × 9.5 mm and weighing 3.0 g (in water). Both transmitter types had life spans of 60 d and frequencies of 71–75 kHz. Transmitters were sterilized in iodine solution prior to surgical implantation. The abdominal incision was closed using sterile, nonabsorbable sutures, and a thin layer of petroleum jelly was placed over the incision. The fish were released at their original capture sites. Location, depth, salinity, dissolved oxygen, and temperature (surface and bottom) were recorded. In a few cases where surgery was inappropriate due to stress from capture or high water temperatures (Moser et al. 2000), the transmitters were attached externally using a modified dart tag.

The fish were tracked from boats using acoustic receivers and both directional and omnidirectional hydrophones. Searches were conducted at least once per week and focused on the Front and Middle rivers. In cases where fish were not initially detected, the Back River was also searched. Latitude/longitude (from Global Positioning System instruments), surface and bottom water quality parameters (salinity, temperature, and dissolved oxygen), and depth were recorded for each location where a fish was detected.

Results

A total of 497 gill and trammel net collections were made, for a total sampling effort of 198 net-hours (1 net-hour = 91.4 m of net fished for 1 h). Fifty-seven shortnose sturgeon were captured; 28 fish were juveniles (defined as <56 cm TL; Collins and Smith 1995) ranging from 37.2 to 54.5 cm TL, of which two were later recaptured. Days at large for the two recaptured fish were 8 and 90, and both appeared healthy.

Juvenile shortnose sturgeon were found between rkm 31.2 and 47.5, in salinities of 0.1 to (briefly at high tide) 17.6‰, and at depths of 2.1–13.4 m. The fish exhibited a clear seasonal pattern of habitat use (Figure 1). When water temperatures were below 22°C, almost all fish were located near the confluence of the Front and Middle rivers at rkm 31.5. Although there was use of both branches of the river up to 2 km upriver from the confluence, during the coldest period the fish aggregated in a hole with a depth of 8 m just inside the mouth of the Middle River. At temperatures above 22°C, the fish moved upriver and aggregated especially at rkm 47.5 during the warmest period. This area is characterized by a deep (6.5 m, compared with 3.4–3.7 m nearby) hole on the outside of a bend, with a shallow sand bar on the inside of the bend. The two aggregation areas similarly displayed relatively little variation in any of the water quality parameters that were measured when fish were present (Table 1).

Discussion

Juvenile shortnose sturgeon exhibited obvious seasonal upriver−downriver migrations. Juveniles moved upriver during periods of warm (>22°C) water temperatures and downriver during periods of lower water temperatures, and this behavior was confirmed during two consecutive years. The fish

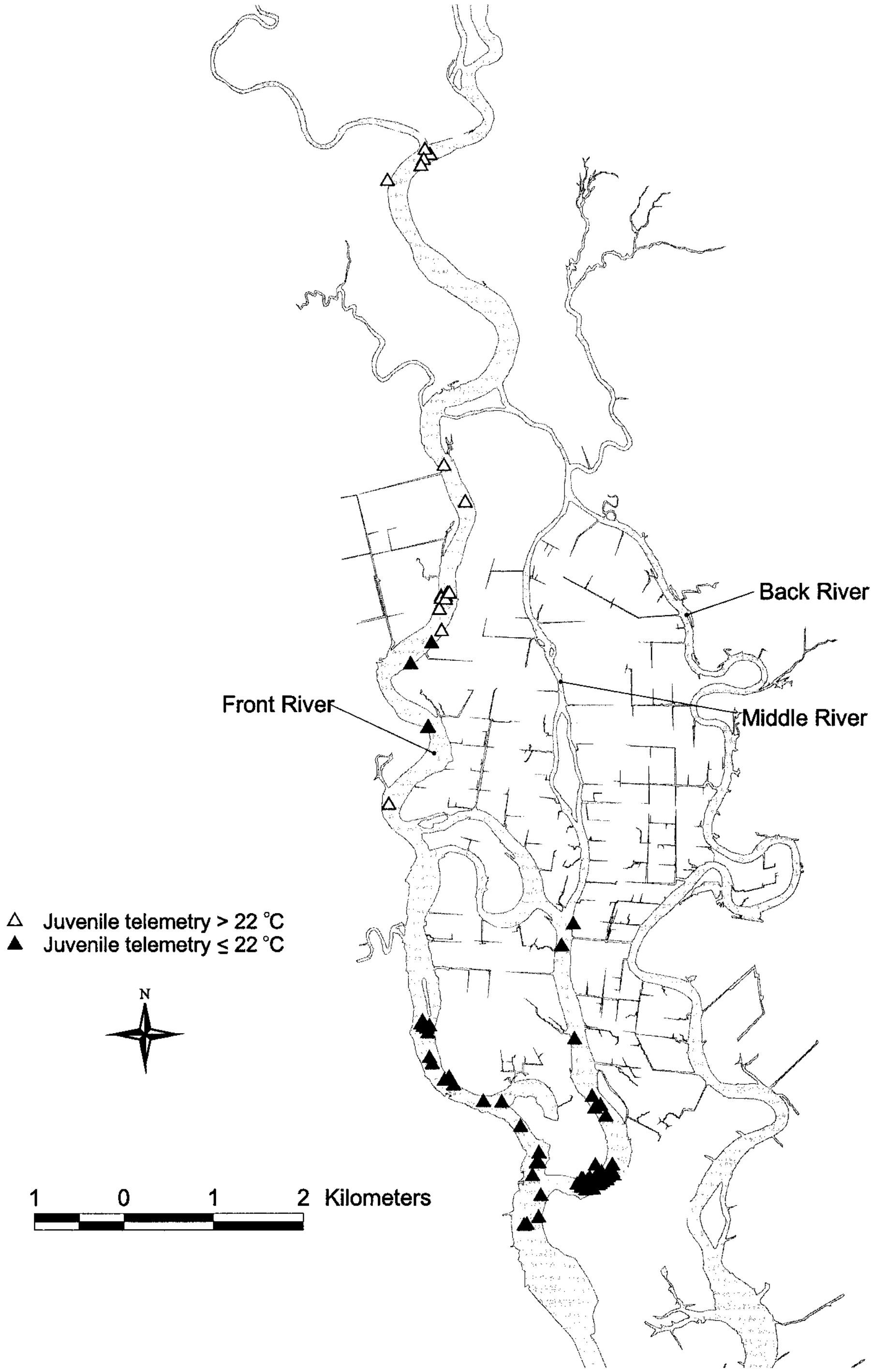

FIGURE 1.—Locations of juvenile shortnose sturgeon in the Savannah River, South Carolina–Georgia, as determined by acoustic telemetry.

TABLE 1.—Mean (standard deviation) bottom water quality parameters observed when fish were present at two seasonally used nursery sites for juvenile shortnose sturgeon in the Savannah River, South Carolina–Georgia.

River kilometer	Dissolved oxygen (mg/L)	Water temperature (°C)	Salinity (‰)
31.5	7.84 (1.40)	14.8 (3.8)	5.3 (4.3)
47.5	6.85 (0.65)	25.0 (3.1)	0.1 (0.0)

aggregated tightly during the warmest and coolest periods, occupying river sections less than 1 km in length. The hole occupied inside the mouth of the Middle River during winter was not as deep as the dredged channel in the nearby Front River, but the hole was separated from the channel by a relatively shallow area and generally held less saline water than did the channel, especially at high tide. Water quality data suggest that the shallow area functioned as a sill between the hole and the Front River channel and minimized salinity fluctuations associated with the tidal cycle. Although a juvenile was found briefly in salinity as high as 17.6‰, this was at high tide during a period of low water temperatures and appeared to be an isolated incident. Previous studies indicate that shortnose sturgeon, especially juveniles, prefer very low salinities but can tolerate higher salinities for periods that vary directly with age and inversely with temperature (Jenkins et al. 1995; Collins et al. 2000).

Previous studies conducted during 1985–1993 identified the KITB as the nursery habitat for shortnose sturgeon juveniles, and seasonal movements were not observed (Hall et al. 1991; Smith and Collins 1998). For example, in August–September 1992, 13 juveniles were captured in the KITB at water temperatures of 26–28°C (Collins, unpublished data), indicating that the upriver migration in summer observed in the present study is probably not in response to rising temperature alone. In the present study no juveniles were ever located as far downriver as the KITB. This suggests that harbor modifications during the intervening period (e.g., channel deepening in 1994) resulted in water quality or hydrographic changes that caused the fish to abandon the previously occupied nursery area. The present nursery area is fragmented, with seasonal upriver−downriver movements occurring between two areas. Kynard et al. (2000) tracked five hatchery-reared juvenile shortnose sturgeon released into the Connecticut River and reported seasonal habitat shifts, but the seasonal migration of wild juveniles to specific small river reaches has not previously been reported. Depth-indicating transmitters showed these fish to be demersal during both periods of residency and periods of migration.

Direct comparisons of the relative abundance (catch per effort) of juvenile shortnose sturgeon in this study with previous studies in the Savannah River (Hall et al. 1991; Smith and Collins 1998) are problematic. The behavior of the fish, together with differences in the sampling design and gear types, make it difficult to assume equivalency among studies in units of effort. It is worth noting, however, that Smith and Collins (1998) made 129 net sets targeting juvenile shortnose sturgeon and captured 53 wild juveniles plus 29 hatchery-reared juveniles. In the present study, 497 net sets produced 28 juveniles. Although circumstantial, this suggests that the abundance of juvenile shortnose sturgeon in the Savannah River has declined. The behavior of the hatchery-reared fish stocked during 1985–1992, together with a histological examination of gonad biopsies, indicate that these fish have matured and are supplementing the spawning stock (Collins et al. 1999; Smith et al. 2002). It appears that increasing the number of spawners has not resulted in an increased recruitment of juveniles, suggesting a recruitment bottleneck that is perhaps associated with a decline in water quality as proposed by Collins et al. (2000).

Planned modifications to the Savannah Harbor include a further deepening of the channel and turning basins. Water quality models predict this will result in substantial declines in dissolved oxygen levels and an increase in the salinity in the harbor, which includes the area used by juvenile shortnose sturgeon when the water temperature is below 22°C (GPA 1998). Such a consequence may force the sturgeon to abandon the present cool-period nursery habitat. Being forced to use another, perhaps marginal, habitat could negatively impact the condition or increase the mortality of the fish and thus further reduce the recruitment of this endangered species.

In summary, the nursery habitat for juvenile shortnose sturgeon in the Savannah River is now upriver of the previously reported location. Further, the juveniles make seasonal migrations of approximately 16 km, moving even farther upriver during warm months. The area occupied during cool months is likely to be affected by the proposed harbor modifications, while it is unknown whether the warm season habitat farther upriver will be impacted. The demersal nature of these fish makes them vulnerable to bottom water quality degradation and perhaps to direct mortality from dredging operations. The apparent decline in the abundance of juveniles relative to a previous study suggests no increase in recruitment over the past decade despite the addition to the spawning stock of now-mature hatchery-reared shortnose sturgeon. The identification and correction of a possible recruitment bottleneck may be imperative to the continued existence of this population.

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