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Population Size Estimates of Sturgeon in the Suwannee River, Florida, U.S.A.

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An inventory of the Gulf of Mexico sturgeon (*Acipenser oxyrinchus de sotoi*) population in the Suwannee River was conducted from 1986 to 1997. Sturgeon were collected using gill nets as the fish migrated from the ocean into the river during their annual spring migrations. The average population size for sturgeon was estimated at 3,152 ± 369 individuals using the Jolly-Seber capture–recapture model for open populations. Annual population estimates ranged from 2,097 to 5,312 individuals over a 10-yr period. The Suwannee River sturgeon population may represent one of the last viable populations of the species and may require special management. Habitat restoration, protection, and establishment of a population augmentation and replenishment program for the species is advocated.

Worldwide, the history of sturgeon fisheries has been one of overexploitation, habitat destruction, and demise. By the turn of the century, most commercially important fisheries were closed and many stocks were considered extirpated (Doroshov, 1985; Barannikova, 1987; Steffens et al., 1990). In the southeastern United States, the Gulf of Mexico sturgeon (*Acipenser oxyrinchus de sotoi*) represented an important commercial fishery (Huff, 1975). During the late 1800s and early 1900s the sturgeon fishery dramatically declined (Huff, 1975), most likely due to overfishing. Habitat destruction, deterioration of water quality, pesticides, and river damming exacerbated the decline (Wooley and Crateau, 1985). Several decades ago, states bordering the Gulf of Mexico began regulating the sturgeon fishery, and in 1984 the taking of sturgeon was prohibited in Florida. In 1991, the species was classified as threatened under the auspices of the Endangered Species Act (Federal Register, 1991).

Although catch statistics for Gulf of Mexico sturgeon demonstrated a decline in numbers and the species was legally protected, little is known on the status of populations. In this article we report an estimate of Gulf of Mexico sturgeon abundance in the Suwannee River, FL. Sturgeon in the Suwannee River are believed to be one of the last remaining viable populations of the species (Gilbert, 1992).

MATERIALS AND METHODS

Sturgeon fishing and tagging activities in the Suwannee River were described in detail by Carr et al. (1996). Sturgeon were captured using anchored gill nets (45.7 m long × 3.9 m deep, stretch mesh size 25.4 cm) during their annual spring migrations from the ocean into the river, primarily during March and April (Chapman and Carr, 1995; Carr et al., 1996). Sturgeon were tagged every year from 1986 to 1997; however, fishing effort varied from year to year. During 1986–89, three to nine gill nets were used. This method resulted in sturgeon mortalities up to 5%. The primary cause of death was attributed to prolonged soak times for the nets (tended twice a day). To prevent further deaths, the number of gill nets was reduced to three from 1990 to 1996, and only one net was used in 1997. Although the nets were anchored, they were checked every 2 hr and mortalities were reduced to less than 1%. In 1997 only one fish died out of 145 captured.

After capture, sturgeon were weighed on a top-loading spring scale (± 0.1 kg) and measured (± 0.1 cm) for fork (FL) and total (TL) lengths. External Monel metal-alloy band tags (National Band and Tag Co., Freeport, KY), were attached to the base of the anterior edge of the dorsal fin.

Annual population size was estimated using the Jolly-Seber capture–recapture model for open populations (Jolly, 1965; Seber, 1973). This model assumed the population was open to recruitment and immigration as well as mortality and permanent emigration between sampling occasions. Estimates of population size were corrected for bias following Seber (1973). For this study, the Jolly-Seber method was more appropriate than methods requiring a closed population assumption, such as the commonly used Peterson capture–recapture model, since the assumption of no recruitment or mortality over a 12-yr survey was unrealistic. Trends in population size over time were investigated with weighted regression analysis, using the reciprocals of the standard errors of the population size estimates as weights. Theoretically,

TABLE 1. Mark and recapture data matrix for Gulf of Mexico sturgeon in the Suwannee River, FL.

Time of last capture	Time of capture											
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1986		28[a]	32	25	34	11	6	3	2	2	2	0
1987			31	26	28	8	8	0	2	2	0	0
1988				30	38	18	6	2	4	4	0	1
1989					28	23	6	0	5	8	1	0
1990						27	31	5	11	8	0	4
1991							24	2	13	10	0	0
1992								4	12	11	3	1
1993									6	9	2	1
1994										18	3	6
1995											4	1
1996												4
Total	317	262	360	467	606	315	329	145	290	276	158	107
Tagged and released	275	206	216	187	344	201	218	107	203	203	148	107

[a] Number of recaptures. For example, 28 of the sturgeon captured in 1987 were recaptures from 1986.

population size estimates obtained from the Jolly-Seber model are not statistically independent; however, for this study, the calculated correlations between successive years were negligible (≤ 0.005), so they were treated as statistically independent for the regression analysis. Annual population estimates were restricted to the portion of the population vulnerable to the mesh size of the net and sturgeon migrating through the East Pass section of the river mouth [see Huff (1975) and Carr et al. (1996) for a description of the Suwannee River mouth and fishing areas].

Trends in the size structure of the sturgeon population over time were explored by regressing weight and TL (indicators of age) on year captured. Only data from initial captures of sturgeon were used to avoid nonrepresentative sampling. Sturgeon weight was transformed using a square root transformation prior to regression analysis to better meet the assumption of homogeneity of variance.

TABLE 2. Population size estimates of sturgeon in the Suwannee River, FL ($\bar{x} \pm$ SE; Jolly-Seber statistic).

Year	Estimated number
1987	2,473 ± 471
1988	2,144 ± 279
1989	3,055 ± 405
1990	3,049 ± 372
1991	2,097 ± 318
1992	2,832 ± 549
1993	5,312 ± 1,724
1994	2,898 ± 648
1995	3,370 ± 1,563
1996	4,295 ± 2,592

RESULTS

During a 12-yr sampling period, 3,632 sturgeon were caught and 2,415 were tagged and released (Table 1). Annual sturgeon population estimates in the Suwannee River ranged from 2,097 to 5,312 individuals over a period of 10 yr (Table 2). However, the linear and quadratic weighted regression models of the estimated population size on year were not statistically significant ($P = 0.1465$ and $P = 0.3429$, respectively). The average population size from 1987 to 1996 was estimated at 3,152 ± 369 individuals.

The linear and quadratic regression models of weight and TL on year of capture were not statistically significant (weight: $P = 0.1093$ and $P = 0.2630$; TL: $P = 0.7493$ and $P = 0.1283$), indicating the average size of captured sturgeon did not change over the 12-yr sampling interval (Table 3). The lightest fish we captured weighed 3.0 kg and the shortest was 75.9 cm FL. The heaviest fish we could practically weigh was 81.0 kg, and the longest was 210.8 cm TL.

DISCUSSION

Our sturgeon inventory in the Suwannee River indicated that the population size has been stable and has not changed since regulatory measures were imposed in 1984 at the state level (Florida) and in 1991 at the federal level. The 10-yr average of 3,152 individuals is

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TABLE 3. Average weight and total length ($\bar{x} \pm$ SE) of Gulf of Mexico sturgeon (initial captures only) in the Suwannee River, FL.

Year	Number	Weight (kg)	Total length (cm)
1986	108	14.8 ± 0.6	129.7 ± 1.4
1987	86	14.5 ± 0.5	130.3 ± 1.4
1988	89	15.6 ± 0.6	135.8 ± 1.5
1989	87	18.6 ± 0.9	141.1 ± 1.9
1990	99	12.7 ± 0.6	127.6 ± 1.5
1991	95	15.5 ± 0.9	132.9 ± 2.2
1992	91	13.6 ± 0.5	128.7 ± 1.5
1993	83	13.8 ± 0.6	130.0 ± 1.4
1994	101	18.9 ± 0.7	141.1 ± 1.3
1995	105	20.3 ± 1.0	142.8 ± 2.1
1996	84	11.2 ± 0.8	116.0 ± 2.3
1997	87	18.5 ± 1.4	134.9 ± 2.6

similar to previously published estimates of 2,500 individuals (Carr et al., 1996) and 3,500 individuals estimated two decades earlier by P. Meylan (1977). Although it appeared there was an increasing trend in the population size, the regression of estimated population size on year was not statistically significant. The high estimate of 5,312 ± 1,724 sturgeon in 1993 was attributed to a reduction in the number of captured fish, unpredictable sturgeon movements, and a disruption in sampling efforts caused by a severe storm system that brought freezing temperatures and floods to the region. Large standard errors in later years were attributed to a reduction in the number of captured fish due to a decrease in the number of gill nets used. We believe that any error bias on the population estimate that was caused by the type of tag or tagging technique was small. We consider the Monel metal band a suitable long-term tag for use on sturgeon field studies. Although few in number, studies on evaluation of tagging techniques for sturgeon indicate that modified Carlin tags (similar to the Monel tag) attached to the dorsal fin had an 82–100% retention rate with no mortalities (Smith et al., 1990). Long-term retention of T-bar anchor tags used on Gulf of Mexico sturgeon was about 60% (Clugston, 1996). We never observed tag shedding during capture or preferential net entanglement by tagged fish. Trauma was minimal when the tags were attached and little tissue damage was apparent upon recapture.

Management of sturgeon requires a special approach because of peculiarities in their life history—in particular, their prolonged life span and reproductive cycle. The oldest estimated age for a Gulf of Mexico sturgeon is 42 yr (Huff, 1975); however, its allopatric subspecies, the Atlantic sturgeon *A. oxyrinchus*, is estimated to live 60 yr (Van Den Avyle, 1984). Similar to other sturgeon, Gulf of Mexico sturgeon sexually differentiate at a late age, approximately 2–4 yr old and 50–70 cm FL (Huff, 1975). Females of this species become sexually mature between 8 and 17 yr old and males between 7 and 21 yr old (Huff, 1975). Iteroparous Atlantic sturgeon females may spawn every 2 or 3 yr and males may spawn annually (Van Den Avyle, 1984). These spawning intervals may be similar for individuals in the Gulf of Mexico subspecies (F. A. Chapman, unpub. obs.).

As the sturgeon population matures, a complex structure of fish of different ages and stages of sexual maturity assembles. When the reproductive composition of Gulf of Mexico sturgeon in the Suwannee River was surveyed in 1972–73, the average age of fish was 8 yr, but 74% of the migrating females and 34% of the males were sexually immature (Huff, 1975). Of the entire stock, only 4% of the females were ripe (or had spawned) and approximately 15% of the males were considered ripe (Huff, 1975).

The lightest fish we captured weighed 3.0 kg and the shortest was 75.9 cm FL. Since sturgeon in this size range are at least 4 yr old and sexually differentiated (Huff, 1975), our estimate of the Suwannee River sturgeon population is based on subadult and adult fish. Although not a true assessment of the total population size, our estimate may reflect an index of the effective or viable size of this sturgeon population—those population numbers needed to maintain genetic variability and a high probability of persistence for a prolonged period of time (over 100 yr). Assuming that gill net size selectivity remained the same (e.g., by sex and season) and since the average size of the captured sturgeon did not change over the 12-yr sampling period, we surmised that this sturgeon population was stable and viable.

With approximately 3,500 subadults and adults, the Suwannee River sturgeon population does not appear to have a positive population growth and may be very close to a minimum effective population size of breeding individuals. The sturgeon population is characterized by a large proportion of nonreproductive individuals and the number of offspring produced could vary substantially among the ripe stock. This situation is exacerbated by the lack of viable sturgeon populations throughout

much of the species range, in particular those of adjacent drainages to the Suwannee River.

The sturgeon stocks in the Gulf of Mexico require a careful program of population and habitat management. An inventory of the Suwannee River population, including the smaller size classes of fish (sexually undifferentiated fish), is required. Also, a thorough population viability analysis combining genetic and demographic studies may be necessary. Special consideration should be placed for the establishment of a limited sturgeon artificial propagation program for population augmentation and replenishment where populations are below a viable number.

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