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Movements of Spotted Seatrout (*Cynoscion nebulosus*) in Mississippi Coastal Waters Based on Tag–Recapture

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Movement patterns of spotted seatrout (*Cynoscion nebulosus*) were evaluated in Mississippi coastal waters by an angler-based tagging study from 1995 through 1999. During this period, 505 anglers tagged 15,206 spotted seatrout, the majority of which (84%) did not meet the state's legal minimum size limit of 14 inches (356 mm) total length. Overall, 408 (2.7%) tagged fish were recaptured and reported to project personnel. Over 90% of these recaptured fish moved less than 10 km from site of tagging to site of recapture (mean = 3.0 ± 0.41 km), and 82% moved less than 3 km. The greatest movement from tagging to recapture site by any fish was 60 km over a period of 200 d, and only three fish (0.7%) moved 50 km or more. Study results suggest that spotted seatrout in Mississippi waters comprise a nonmigratory fish stock, as has been found for this species in coastal waters of neighboring states along the U.S. Gulf of Mexico.

Spotted seatrout (*Cynoscion nebulosus*), a member of the family Sciaenidae (drums), inhabits coastal waters of the U.S. Atlantic Ocean and Gulf of Mexico (Shipp, 1986; Hoese and Moore, 1998) but reportedly is most abundant in the Gulf of Mexico (Gulf) from the west coast of Florida to Texas (Tabb, 1966; Mercer, 1984). *Cynoscion nebulosus* is generally found in estuarine waters as an inhabitant of seagrass beds during warm months and deep depressions during colder months (Gulf States Marine Fisheries Commission, 2001). Spotted seatrout is one of the most important recreational fishery species in the Gulf, particularly in Mississippi, where it is the most highly sought coastal sport fish (Deegan, 1990). Because of its popularity as a sport fish and its importance to the coastal Mississippi economy (United States Department of Interior, 1998), management of spotted seatrout in Mississippi requires application of the most current available scientific data.

Tagging studies have been widely used to estimate movement patterns of numerous fish species. In general, reported recaptures of tagged fish can provide valuable insight into the movements of individuals of a particular stock, which in turn may be useful in identifying geographic management jurisdictions of a species. Authors of previous spotted seatrout studies in Gulf waters have reported limited geographic movement for the species in Louisiana (Adkins et al., 1979), Florida (Iverson and Tabb, 1962), and Texas (Baker and Matlock, 1993; Bowling, 1996); however, movement patterns of spotted seatrout within Mississippi waters have not been documented. In 1995, the Mississippi Spotted Seatrout Tag-and-Release Program was initiated by the Gulf Coast Research Laboratory (GCRL) and the Mississippi Department of Marine Resources (DMR) to determine the movements of *C. nebulosus* in Mississippi coastal waters.

Materials and Methods

Spotted seatrout in this study were tagged by volunteer recreational hook-and-line anglers. Anglers were provided a tagging kit that contained a tagging instruction booklet, a stainless steel tag applicator, and 10 high-visibility yellow, plastic-tipped dart tags (streamer length = 7.6 cm) manufactured by Hallprint Pty. Ltd., Australia. Each streamer displayed a unique tag number, the GCRL address, and a contact phone number. Individual tags were attached to a tagging data card, which displayed a corresponding tag number. Data cards requested the following information: tagging date, release location, total length (TL) of fish in inches and whether TL was measured or estimated, and the angler's name and address. Following tagging, anglers mailed data cards to project personnel, who compiled the tagging data. Posters informing the public about the project and procedures for reporting the recapture of a tagged fish were placed on piers and at boat launches along the Mississippi coast.

When a tag recovery was reported, the following data were requested: tag number, recapture date, recapture location, fish length (TL), and the reporting angler's name and address. If a recaptured fish was released, the angler was asked whether the tag was removed from the fish or left intact. Time-at-liberty for recaptured fish was determined by calculating

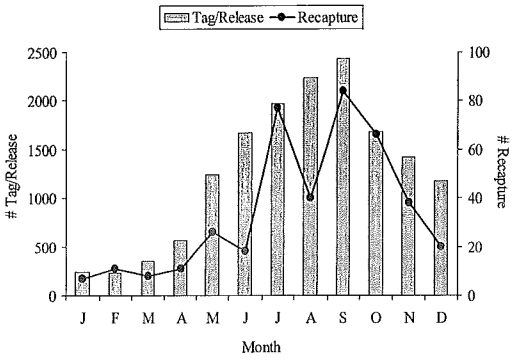


Fig. 1. Total number of spotted seatrout tagged and released (left y-axis) and recaptured (right y-axis) by month for years 1995 to 1999, combined.

the number of weeks between when the fish was tagged and when it was recaptured. Distance (km) between the tagging and recapture locations (movement) was measured as accurately as possible on the basis of the most direct aquatic route between the two reported locations.

Fish length (mm), time-at-liberty (wk), and movement (km) are presented as mean ± standard error. The relationship of fish length and time-at-liberty to movement was investigated by attempting to model these measurements, with fish length and time-at-liberty as the independent variables and movement as the response variable. Each of the independent variables was regressed against movement for both raw data and $\log_{10}$-transformed data in separate linear regression models (SPSS, 1999). In additional analyses, a negative binomial model (SAS, GENMOD) was used to relate the independent variables to movement (Ingram, 2001). Tests were considered significant at $P < 0.05$.

Results

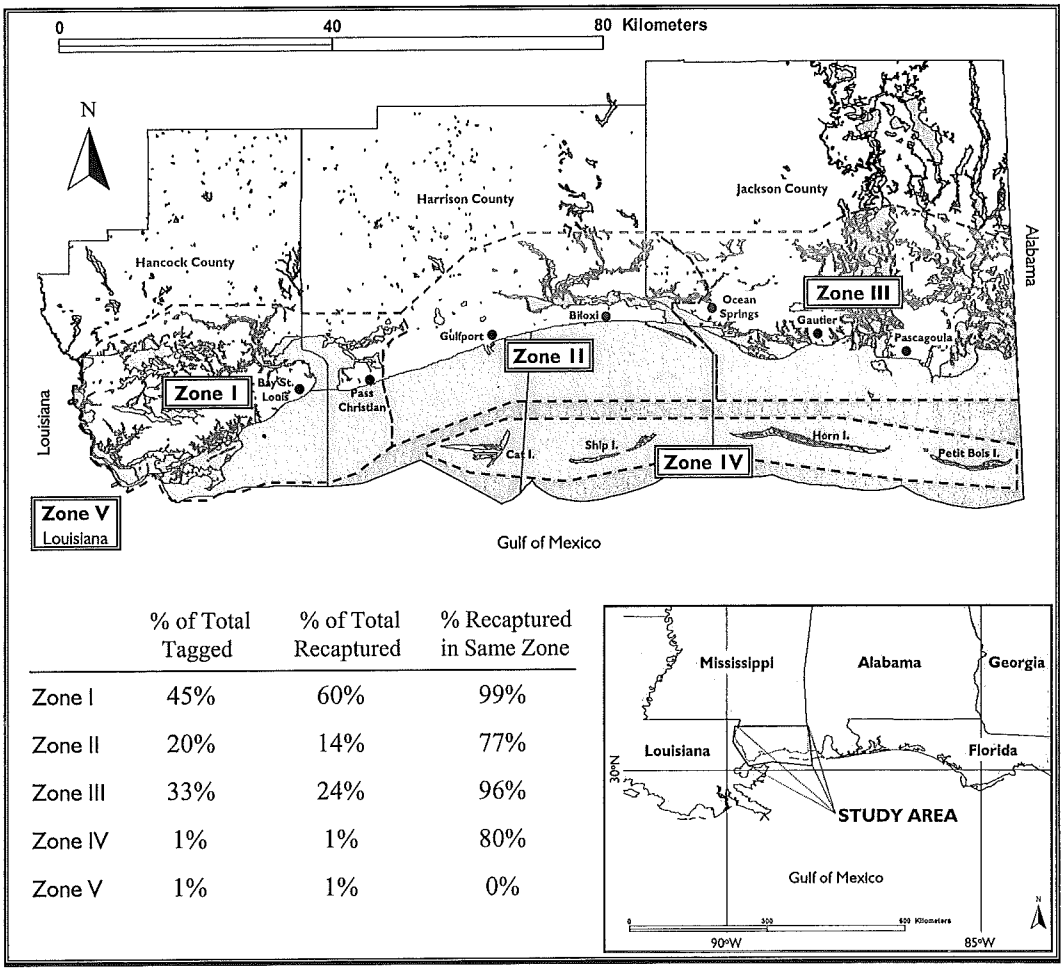
From 1995 through 1999, 505 anglers tagged and released a total of 15,206 spotted seatrout in Mississippi coastal waters, and 408 (2.7%) of those fish were reported as recaptured. The number of spotted seatrout tagged and released (mean = 3,041.2 fish/yr) and recaptured (mean = 81.2 fish/yr) fluctuated from year to year, with 1999 and 1996 yielding the most tagged (n = 4,590) and recaptured fish (n = 170), respectively. The lowest number in any given year for both tagged (n = 586) and recaptured (n = 6) fish was observed in 1995, the first year of the study. Most fish were tagged (91%) and recaptured (91%) from May through Dec. (Fig. 1), historically the most active period for the Mississippi recreational fishery. Analysis of recapture data revealed no apparent seasonal patterns of movement for spotted seatrout in this study.

More fish were tagged (n = 6,824) and recaptured (n = 243) between the Mississippi–Louisiana state border and Pass Christian (Zone I) than any other area of the Mississippi coast (Fig. 2). The Ocean Springs–Gautier–Pascagoula (Zone III) area accounted for 5,046 tagged fish and 97 recaptures, whereas the area between Pass Christian and Biloxi (including Deer Island, Biloxi Back Bay, and Fort Bayou; Zone II) had 2,997 tagged fish and 51 recaptures. The barrier islands (Ship, Horn, and Cat islands; Zone IV) accounted for 90 tagged fish, with five recaptures occurring there. Only five tagged fish were recaptured in Louisiana (Zone V), and none were recaptured in Alabama. Collectively, over 99% of tagged fish remained in Mississippi waters, and 93% were recaptured in the same geographic zone where they were tagged (Fig. 2).

Since 1995 the recreational spotted seatrout fishery in Mississippi has been regulated by a minimum size limit of 14 inches (356 mm) TL (Mississippi Department of Marine Resources, 1999), and the majority of fish tagged in this study (84%) were between 254 and 352 mm TL (Fig. 3a). Only four spotted seatrout 610 mm TL or greater were tagged, three in the eastern Mississippi Sound, near Pascagoula (648, 635, and 622 mm TL), and one at Ship Island (610 mm TL). None of those fish were reported as recaptured. The length–frequency distribution for recaptured fish also showed high numbers of small fish (Fig. 3b), TL ranging from 203 to 527 mm (mean = 328.0 ± 2.86).

Linear regression analysis of fish length to movement for both raw ($R^2 = 0.027$; $P = 0.001$) and $\log_{10}$-transformed ($R^2 = 0.030$; $P < 0.001$) data indicated no meaningful relationship between the two variables, as was the case for time-at-liberty and movement for raw ($R^2 = 0.080$; $P < 0.001$) and transformed ($R^2 = 0.104$; $P < 0.001$) data. Time-at-liberty and movement data were "zero-inflated," with most of the data points skewed toward very low values. Although these types of data have been modeled by fitting the data to a negative binomial distribution (Ingram, 2001), the independent variables were highly insignificant ($P < 0.0001$) in predicting the response variable (movement) in this type of model.

Time-at-liberty for recaptured fish was generally short-term, and 81% of all recaptures occurred within 8 wk of tagging (Fig. 4). Two



	% of Total Tagged	% of Total Recaptured	% Recaptured in Same Zone
Zone I	45%	60%	99%
Zone II	20%	14%	77%
Zone III	33%	24%	96%
Zone IV	1%	1%	80%
Zone V	1%	1%	0%

Fig. 2. Map of the study area along Mississippi's coastline showing the percentage of spotted seatrout tagged (n_{total} = 15,087) and recaptured (n_{total} = 407) within each designated geographic zone. Note: third column represents the percentage of fish recaptured in the same geographic zone where they were tagged.

spotted seatrout were recaptured more than 1 yr after tagging (54 and 59 wk). One of those fish moved 18 km from its original tagging location, whereas the other was recaptured exactly where it had been tagged. Time-at-liberty for all recaptured fish ranged from <1 to 59 wk (mean = 5.7 ± 0.43).

Over 92% of the spotted seatrout tagged in this study moved less than 10 km, and 82% moved less than 3 km (Fig. 5). Mean distance traveled for the 406 recaptured fish with sufficient data to calculate movement was 3.0 ± 0.41 km, and only three recaptured fish moved 50 km or more (Table 1). Limited movement of less than 15 km was reported for 82% of all long-term (>26 wk) recaptures (n = 23), with 65% of these fish moving less than 10 km. Of the 118 recaptured fish that were of regulation size or greater, 84% moved less than 10 km, and 61% moved less than 3 km.

Patterns of longitudinal movement by spotted seatrout were difficult to assess, because only 8 of the 406 recaptured fish (2.0%) had moved more than one geographic zone (Fig. 2) to the east or west. A general pattern of westerly movement was predominant in these eight recaptures, as five spotted seatrout moved from Mississippi to Louisiana waters and one moved from eastern Mississippi (Gautier) to the west (Bay St. Louis). A general easterly movement was exhibited by the remaining two fish, one of which traveled from Bay St. Louis to Pascagoula and the other from Bay St. Louis to Cat Island (east-southeast).

Over the course of the study, seven spotted seatrout were recaptured on more than one

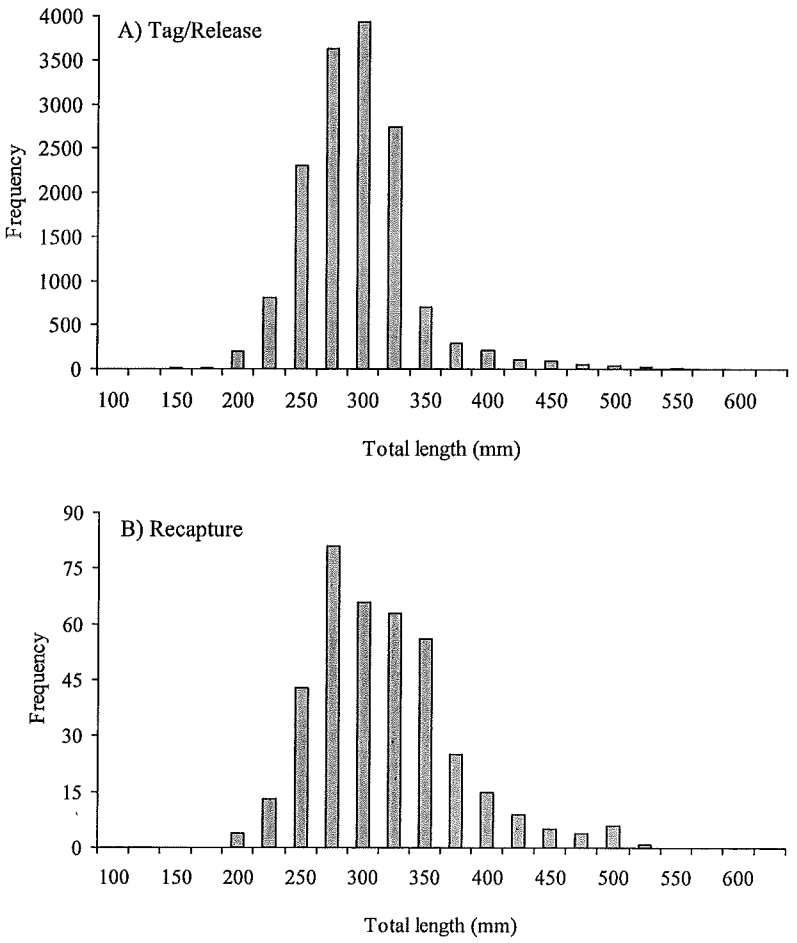


Fig. 3. (A) Length frequency (in 25-mm intervals) of all tagged spotted seatrout (n = 15,204). (B) Length frequency (in 25-mm intervals) of all recaptured spotted seatrout (n = 391).

occasion (multiple recaptures), and all those fish were caught at the same location as tagging for each recapture event. Five tagged spotted seatrout were caught twice in Bay St. Louis, three within 2 wk of tagging and two within 4 wk, and one fish was recaptured twice in Biloxi over a 3-wk period. Only one tagged fish was caught on three separate occasions, each time in Bay St. Louis over a 4-wk period.

Discussion

The results of this study suggest that spotted seatrout in Mississippi coastal waters comprise a population of limited geographic movement. Over 90% of the recaptured fish in this study exhibited movement of less than 10 km, and overall movement patterns did not vary extensively with fish length or time-at-liberty. Of the 406 recaptured spotted seatrout, only three had moved 50 km or more, each in a general westerly direction.

This study relied on anglers to tag spotted seatrout; consequently, our data were biased by fishing effort. For example, the low fishing effort during the months of Jan. through April leaves a considerable gap in our knowledge of spotted seatrout movement from late winter through early spring, although spotted seatrout in other areas of the Gulf reportedly move into deeper waters during these months (Adkins et al., 1979). The popularity of some geographic areas as favored spotted seatrout angling locations also probably biased data on the spatial distribution of tagged and recaptured fish. Nevertheless, study results provide meaningful insight into movements of spotted seatrout in Mississippi coastal waters.

The reported recapture rate for spotted seatrout in this study (2.7%) was similar to that

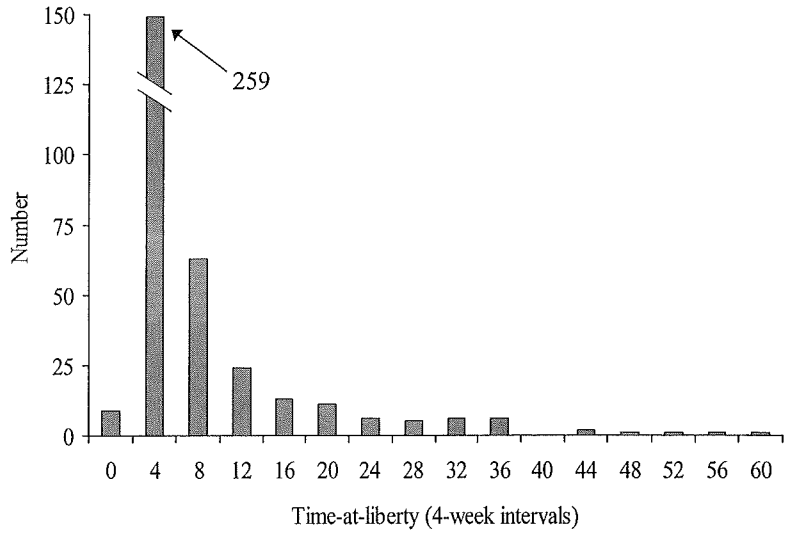


Fig. 4. Time at liberty (in 4-wk intervals) of recaptured spotted seatrout (n = 406) from 1995 through 1999, combined.

reported for Louisiana (1.2%; Adkins et al., 1979) but was considered low compared with recapture rates reported for spotted seatrout in western Florida (10.8%; Moffett, 1961), Alabama (12.2%; Alabama Department of Conservation and Natural Resources, Marine Resources Division, Gulf Shores/Dauphin Island, Alabama, unpubl. data), and Texas (6.5%; Bowling, 1996). A key factor to consider in any tagging study when assessing the recapture rate is tag retention by the target species (Bergman et al., 1992). Prior research in Mississippi (Warren, 1998) evaluated short-term (<1 mo) tag retention in spotted seatrout and reported a retention rate of 100% for fish over 205 mm TL. Based on those data, short-term tag loss was probably not a contributing factor to the relatively low recapture rate in this study. No known studies have addressed long-term tag retention for spotted seatrout, but 23 recaptured fish in this study had retained dart tags for more than 6 mo after tagging (two after more than 1 yr). The relatively low recapture rate in this study was probably due in part to diffusion of the tagged fish into a proportionally large population and also nonreporting by local anglers of tagged fish that were recaptured. Although over 15,000 fish were tagged

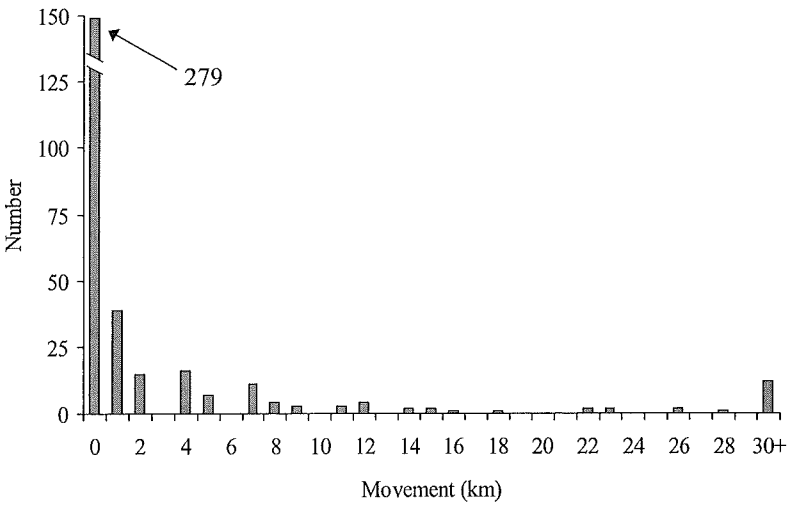


Fig. 5. Frequency distribution of movement (km) by recaptured spotted seatrout (n = 406).

TABLE 1. Movements of 50 km or more by spotted seatrout tagged in Mississippi coastal waters. TR, tag and release data; RC, recapture data.

Location	Date	Fish length (mm)	Movement data		
			Distance traveled (km)	Compass direction	Time-at-liberty (d)
TR: Gautier	29 Oct. 1997	325	60	W	200
RC: Bay St. Louis (west)	13 May 1998	381			
TR: Biloxi, Back Bay	20 Oct. 1997	305	50	SW	212
RC: Grand Pass, LA	20 May 1998	311			
TR: Biloxi, Back Bay	19 Dec. 1996	305	50	W	138
RC: Bay St. Louis (east)	7 May 1997	305			

in this study from 1995 to 1999, an estimated 2.5 million spotted seatrout were landed in Mississippi waters over this time period (National Marine Fisheries Service, Fisheries Statistics and Economics Division, Silver Spring, Maryland, pers. comm.), yielding a small proportion (0.6%) of tagged versus nontagged individuals in the fishery. The low probability of recapturing a tagged fish once it was dispersed back into the population was likely the primary factor leading to the low recapture rate observed in this study. In addition, even though spotted seatrout tagging notifications were posted along the Mississippi Coast, anglers may not have reported recaptured spotted seatrout to project personnel for a variety of reasons. Reward systems have been credited with increasing tag recovery reporting rates (Scott et al., 1990); however, no such rewards were offered for reporting recaptures in this study.

The limited movement observed for spotted seatrout in Mississippi waters suggests that these fish may comprise a northern Gulf subpopulation. This assumption is supported by recent genetic analyses of spotted seatrout stocks (Ramsey and Wakeman, 1987; Gold et al., 1999), which suggest regional variation in the gene pool of spotted seatrout in the Gulf of Mexico. Gold et al. (1999) found significant differences in the mitochondrial DNA haplotype frequencies of spotted seatrout between western Gulf and eastern Gulf samples, across the northern Gulf, and among sites within the northern Gulf and concluded that spotted seatrout in the northern Gulf are divided spatially into distinct subpopulations.

In conclusion, spotted seatrout in Mississippi waters appear to comprise a nonmigratory fish stock, on the basis of the high percentage of fish that moved less than 10 km (92%) and the lack of any movement greater than 60 km. Our general findings are in agreement with the limited movement reported for spotted seatrout in coastal waters of Louisiana (Adkins et al., 1979), Florida (Iverson and Tabb, 1962), Texas (Baker and Matlock, 1993), and Alabama. The limited movement of spotted seatrout in each of the five U.S. Gulf states and the existence of genetically and spatially distinct subpopulations in the northern Gulf indicate that spotted seatrout in the U.S. Gulf of Mexico should not be managed as a single stock.

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