

Movement of Largemouth Bass in Northern Chesapeake Bay: Relevance to Sportfishing Tournaments

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Abstract.—Largemouth bass *Micropterus salmoides* have been displaced as far as 50 km from where they were caught in Chesapeake Bay tidewater angling tournaments. Two concerns are whether largemouth bass return to capture areas or whether they stockpile at tournament release sites. To answer these questions, movements of 82 largemouth bass tagged with radio transmitters and 146 largemouth bass tagged with streamer tags were observed during 1991–1995. Fish were collected by boat electrofishing near two disparate tournament weigh-in stations on the eastern and western shores of northern Chesapeake Bay. Some largemouth bass (43 radio-tagged, 58 streamer-tagged) were displaced 15–21 km to the other station; controls (39 radio-tagged, 88 streamer-tagged) were released where they were caught. Movement patterns were similar for displaced largemouth bass: 43% from the Susquehanna River (western shore) and 33% from the Northeast River (eastern shore) exhibited directed movement towards initial capture areas by returning to their original capture areas. Among the controls, only 4% of Susquehanna River and 6% of Northeast River fish traveled to the opposite shore, demonstrating that return movement was not random. For displaced bass that returned to original capture areas, those released in the spring tended to return within 3 months, whereas bass released in the fall returned within 7–12 months. For both groups, this typically occurred when water temperatures were between 12.0°C and 22.5°C. Most radio-tagged largemouth bass (64%) were located more than 0.5 km from their release sites (i.e., the designated stockpiling zone) 7 d after release. The final located positions for radio-tagged largemouth bass averaged 9.6 km from the release sites, and 95% were at least 0.5 km from the release sites. Results from our study demonstrate that displaced largemouth bass tend to return to their capture areas and that short-term stockpiling of largemouth bass at tournament release areas was possible, but that long term stockpiling did not occur.

Largemouth bass *Micropterus salmoides* caught during sportfishing tournaments and released near tournament weigh-in stations are often displaced considerable distances from their capture areas (Lantz and Carver 1976; Seibold 1991; Richardson 1996). Failure of displaced fish to return to where they were caught or their accumulation (stockpiling) around tournament weigh-in sites might have negative consequences for largemouth bass populations and associated fisheries. Reported homing (return) rates of displaced largemouth bass range between 27% and 100% (Hasler and Wisby 1958; Parker and Hasler 1959; Peterson 1975; Mesing and Wicker 1986; Seibold 1991). Most studies concerning the movement of largemouth bass have been conducted in lakes, impoundments and freshwater rivers. These studies may not be represen-

tative of the behavior of largemouth bass in the freshwater and oligohaline tidal environments, such as the rivers, estuaries, and marshes of the Chesapeake Bay. Our objectives were to determine movement patterns of largemouth bass in northern Chesapeake Bay and assess the impacts of competitive angling tournaments on largemouth bass distribution.

Study Site

Research was conducted in the tidal fresh and oligohaline waters of 12,200 ha of the northern Chesapeake Bay north of Spesutie Island on the western shore and Turkey Point on the eastern shore and including portions of the Susquehanna and Northeast rivers (Figure 1). The northern Bay is a complex open system with major stream channels extending from the Susquehanna and Northeast rivers southward through the Susquehanna Flats. Mean tidal amplitude is approximately 0.6

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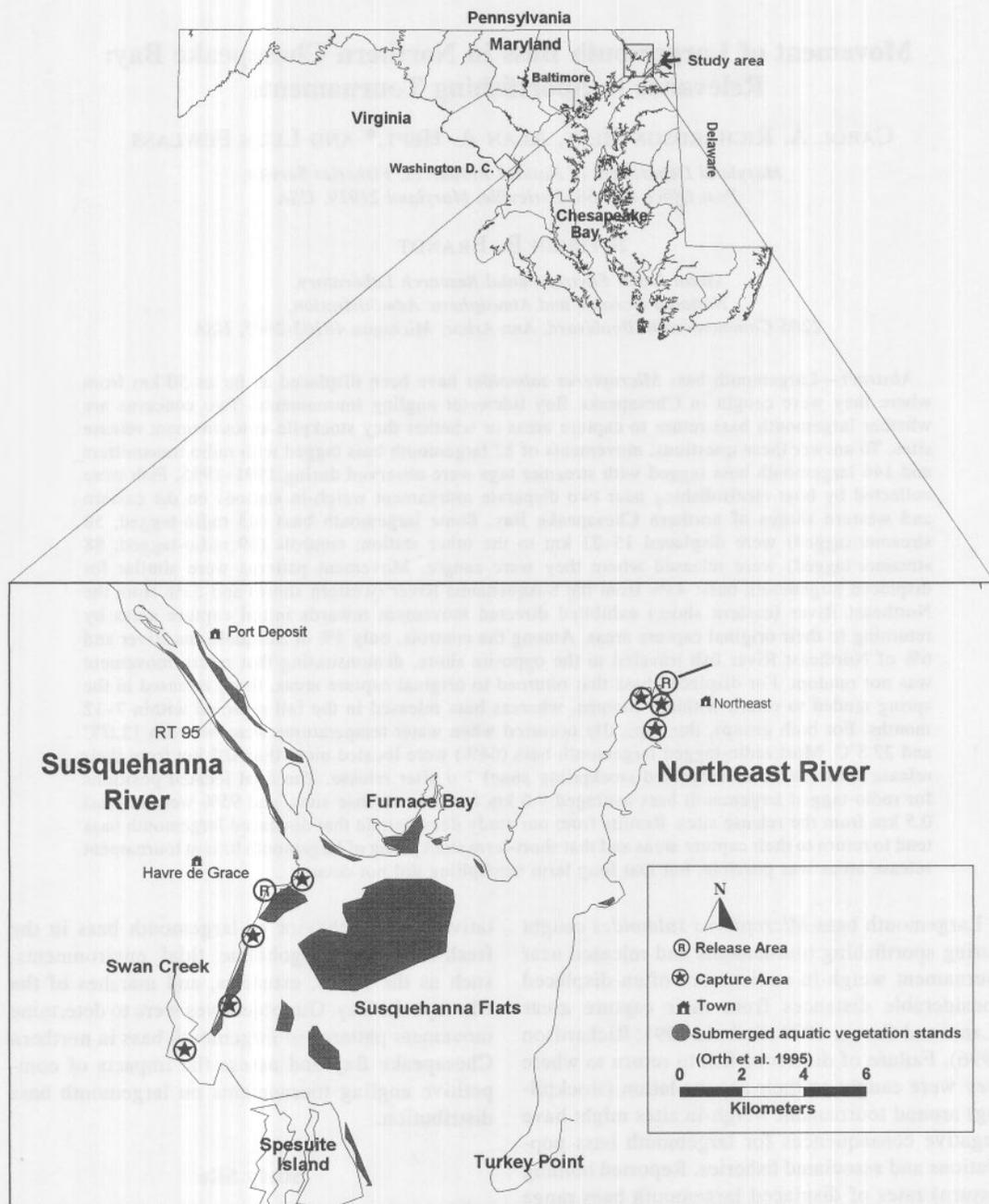


FIGURE 1.—Map of the northern Chesapeake Bay study area (12,200 ha), including location of submerged aquatic vegetation (SAV) stands.

m, and salinity is typically less than 1 ppt (Stroup and Lynn 1963). Maximum water depth (20 m) for the northern bay occurs in the Susquehanna River. The Susquehanna Flats, spanning 11 km from the western to eastern shores and covering approxi-

mately 8,000 ha of open water, has a mean depth of less than 1 m at mean low tide. The mouth of the Susquehanna River has high flow rates (615 m^3/s) and scattered structure, such as pilings and piers, whereas the Northeast River has low flow

TABLE 1.—Numbers of displaced (D) and control (C; not displaced) largemouth bass tagged with radio transmitters (RT) and streamer tags (ST) for the Susquehanna (SUS) and Northeast river (NE) study portions of the northern Chesapeake Bay, 1991–1995.

Tagging period and tag type	Susquehanna		Northeast		Both rivers		
	D	C	D	C	D	C	All fish
Tagging 1 (fall 1991)							
RT	0	2	4	0	4	2	6
ST	0	0	0	0	0	0	0
Tagging 2 (spring 1992)							
RT	0	3	8	0	8	3	11
ST	0	4	0	0	0	4	4
Tagging 3 (spring 1993)							
RT	9	8	10	8	19	16	35
ST	14	15	5	12	19	27	46
Tagging 4 (Fall 1993)							
RT	5	4	7	14	12	18	30
ST	20	21	19	36	39	57	96
All years							
RT	14	17	29	22	43	39	82
ST	34	40	24	48	58	88	146
All fish	48	57	53	70	101	127	228

rates (1 m³/s) and numerous pilings and piers (1984 U.S. Geological Service, water resources flow data).

On the western shore of the northern bay mixed stands of submerged aquatic vegetation (SAV), consisting primarily of Eurasian watermilfoil *Myriophyllum spicatum*, hydrilla *Hydrilla verticillata*, and wildcelery *Vallisneria americana*, extend downstream through the Susquehanna River and across the Susquehanna Flats to Spesutie Island (Figure 1). Stands decline in abundance and plant density from the western shore across the Susquehanna Flats to the eastern shore. Very little to no SAV is found throughout the Northeast River and downstream along the eastern shore to Turkey Point (Orth et al. 1995).

Methods

Largemouth bass were collected ($N = 123$) from September 1991 to December 1993 by boat electrofishing near the headwaters of the Northeast River (NE) on the eastern shore and between the mouth of the Susquehanna River and Swan Creek (SUS) along the western shore ($N = 105$; Figure 1). Lengths of these bass ranged 232–518 mm (mean = 400 mm, SD = 61); their weights ranged 308–2,718 g (mean = 1,129 g, SD = 489). Eighty-two fish were tagged with both radio transmitters and streamer tags (SUS = 31, NE = 51) and 146 fish were tagged with streamer-tags only (SUS = 74, NE = 72). Streamer-tags offered a reward to anglers for providing catch information; they received a Maryland tidal bass conservation hat and letter of thanks from the tidal bass research group.

Fish were either displaced between 15 and 21 km to opposite shores or released at their capture sites as controls (Table 1). The two selected release sites for displaced fish were located where most northern bay sportfishing tournaments release their largemouth bass (Figure 1).

To determine whether movement (return) of displaced fish to their original capture area could be considered intentional behavior we used chi-square with Williams' correction (Sokal and Rohlf 1987) to test the difference between the numbers of control and displaced largemouth bass that traveled to opposite shores of the bay. Largemouth bass were considered moving to opposite shores if they crossed Furnace Bay and then remained within that shore area. Furnace Bay is positioned between the Northeast River and the Susquehanna River (Figure 1).

Largemouth bass released at tournament weighing locations may produce concentrations of bass at these sites (stockpiling). The number of largemouth bass at these release sites could increase after 7 d because northern Bay fishing tournaments are normally conducted on consecutive weekends. In our study we considered tagged fish to be stockpiled if they were located within a 0.5-km radius of the release site on the seventh day after being released. Fish release sites for the northern bay tournaments are primarily at boat marinas. We assumed fish located more than 0.5 km from the release point would continue their emigration from this site.

To examine dispersal from the release site for displaced and control fish with transmitters, we

measured the distance from the release site to their last recorded location. Student's *t*-test was used to analyze the difference between sample means. The daily and longest distances moved (m/d) were determined for each radio-tagged fish. For displaced radio-tagged fish, linear regression analysis was performed to evaluate the relationship between the location distance (km) from release site and days after release. We conducted statistical analyses ($\alpha = 0.05$) with the Statistical Analysis System program (SAS Institute 1990).

Transmitters and transmitter attachment.—Radio transmitters (11–22 g) weighing less than 2% of the fish wet weight were implanted into the body cavity of largemouth bass. Minimum transmitter battery-life expectancy was 4 months for fish tagged in fall 1991 and 6–13 months for fish tagged after 1991. Transmitters were obtained from Advanced Telemetry Systems, Inc. (Isanti, Minnesota). The surgical procedures used to implant radio transmitters were the same as those described by Richardson et al. (1997). To reduce handling and holding stress, radio transmitter insertion was accomplished within 3–5 min. Fish were then placed in a 378-L recovery tank in water containing 0.26 mL/L Stress Coat for 1–3 h before release.

Radio-tracking data collection.—The approximate area covered during a typical radio-tracking episode (1 episode = 1 d) was 9,100 ha. To the north, this area included Port Deposit on the Susquehanna River and the confluence of Northeast Creek on the Northeast River and to the south Spesutie Island and Turkey Point (Figure 1). Each fish was identified by a unique transmitter frequency within the 48–49 MHz range. Largemouth bass were located during tracking episodes by using a boat-mounted Yagi antennae and a hand-held directional loop antennae.

During 1991–1993, fish were tracked by boat an average of three times a week for the first 2 months after release, two times a week for the next 2 months, and once a week thereafter. During 1994–1995, largemouth bass were tracked three times a week during the first month and an average of once a week thereafter. Largemouth bass were tracked 4–20 months after being released, i.e., until the batteries expired or the fish was harvested by anglers. Surface water temperature ($^{\circ}\text{C}$) was measured where a fish was located, except during adverse weather conditions. When a bass was located, its position was marked on a map of the study area and the geodetic coordinates (latitude/longitude) were determined using a portable Lorán C. The Geodetic coordinates were converted to Uni-

TABLE 2.—Chi-square analysis ($\alpha = 0.05$; $df = 1$) of the number of bass crossing (BC) and not crossing (BN) the northern Chesapeake Bay by tag type, (radio-tagged [RT], streamer-tagged [ST]), 1991–1995.

Group and tag type	Bass movements (number)			χ^2
	BN	BC	Total	
Susquehanna				
RT	25	5	30	
ST	15	6	21	1.03
Northeast				
RT	39	12	51	
ST	11	6	17	0.91
Combined				
RT	64	17	81	
ST	26	12	38	1.57

versal Transverse Mercator (UTM) system coordinates, from which distances moved were calculated using a computer program developed by Ackerman et al. (1990). The mean distance a largemouth bass moved per day when it traveled from one location to another (m/d) was measured as a straight line between two observations divided by the number of days between observations. When shorelines interrupted a straight line distance, the distance moved was calculated using the shore boundary (measured with U.S. Geological Survey 7.5 min quadrangle maps).

Results

Movement

Tagging method (streamer-tagged versus radio-tagged) did not influence the probability of detection for largemouth bass crossing the bay; there was no significant difference ($P > 0.05$) between tag type for fish that crossed the bay for the SUS, NE, and combined data (Table 2). Thus, all subsequent chi-square analyses were done by individual group and then pooled if significance of individual tests were in agreement.

There was a significant difference ($P < 0.05$) between the number of SUS displaced and control largemouth bass that traveled to opposite shores of the bay (radio-tagged bass only, streamer-tagged bass only, and pooled data). Overall 43% (10 of 23) of the displaced largemouth bass traveled at least 15–21 km to their original capture areas. Conversely, only 4% (1 of 27) of the control fish traveled to the opposite shore, indicating that movement of displaced bass to their original capture site was not random (Table 3). The NE data also showed a significant difference ($P < 0.05$) between the number of NE displaced and control bass that traveled to opposite shores of the bay

TABLE 3.—Chi-square analysis of the number of displaced (D) and control (C) largemouth bass crossing (BC) and not crossing (BN) the northern Chesapeake Bay after release. Data are from the Susquehanna River and Northeast River areas for radio-tagged and streamer-tagged bass (angler reports) and pooled tag types, 1991–1995.

River area and tag type	Bass type	Bass movements (number)			χ^2 ^a
		BN	BC	Total	
Susquehanna	D	13	10	23	11.8
Pooled	C	27	1	28	
Susquehanna	D	8	5	13	7.68
Radio-tagged	C	17	0	17	
Susquehanna	D	5	5	10	4.28
Streamer-tagged	C	10	1	11	
Northeast	D	24	12	36	7.56
Pooled	C	30	2	32	
Northeast	D	21	8	29	7.13
Radio-tagged	C	22	0	22	
Northeast	D	3	4	7	2.49
Streamer-tagged	C	8	2	10	

^a Significant at $\chi^2 = 3.84$, $\alpha = 0.05$, $df = 1$.

(radio-tagged bass, and pooled data). Even though there was not a significant difference for streamer-tagged bass (Table 3), data were still pooled and analyzed for all NE bass because the streamer-tagged bass sample size was small ($N = 10$). Overall, 33% (12 of 36) of the displaced largemouth bass returned to their original capture areas, but only 6% (2 of 32) of the control fish traveled to the opposite shore, indicating that movement of displaced bass to their original capture site was not random.

Largemouth bass displaced in the northern Chesapeake Bay took from 5 d to 2 years to return to their capture areas. Bass displaced during spring (1992 and 1993) tended to return within 3 months whereas largemouth bass displaced in fall 1993 returned 7–12 months after release. Radio transmitters used in fall 1991 had batteries that expired within 4 months, much less than the amount of time that was observed for largemouth bass displaced in fall 1993 to return to their capture sites. This may explain the seemingly contradictory findings that no radio-tagged largemouth bass displaced in fall 1991 returned to their capture sites during the 4-month radio-tracking period.

Fish with Transmitters

For radio-tagged SUS and NE largemouth bass there was a significant difference ($P < 0.05$) between the means of final location distance from the release site for control (SUS = 2.8, NE = 2.1) and displaced (SUS = 8.0, NE = 10.4) bass, regardless of whether the displaced bass returned to

original capture areas (Figures 2, 3). There were not significant differences ($P > 0.05$) between the mean final distances away from release sites for NE versus SUS controls and NE versus SUS displaced bass.

Largemouth bass displaced during the spring were located back at their capture sites 10–197 d after release (mean = 65 d), whereas bass displaced during the fall were located at their capture sites 5–372 d (mean = 228 d) after release. The majority (73%) returned when water temperatures increased or decreased between 12.0°C and 22.5°C.

A movement pattern unique to NE control bass was observed during 1993 and 1994. Four NE radio-tagged control bass traveled between 19.0 and 22.5 km to opposite shores of the bay and then returned to their original release area. These four largemouth bass were among six fish originally captured and released in the Northeast River in December of 1993. All four fish crossed the bay in April and May of 1994, and all four fish traveled back to the Northeast River between October and December of 1994. The remaining 35 control bass (NE and SUS) did not exhibit this movement pattern.

Estimated mortality of radio-tagged largemouth bass was low (2.4%; 2 of 82). Two fish were concluded to have died, one immediately after release and the other 1 month after release, when the location of the radio transmitter signal did not change for the life of the battery. In addition, radio contact was lost with three fish that were either harvested by anglers or the radio transmitter batteries expired prematurely. Two years was the maximum known survival period for radio-tagged bass (angler reported).

Angler Reports

From May 1992 to May 1995 anglers caught 24 of 82 (29%) radio-tagged largemouth bass and 38 of 147 (26%) streamer-tagged bass. Nine of 17 (53%) displaced largemouth bass with streamer-tags were caught in their original capture areas by anglers. Three of 21 (14%) control fish with streamer tags were caught by anglers on shores opposite from where they had originally been captured and released.

Stockpiling

Most radio-tagged largemouth bass moved outside the 0.5-km delineated stockpiling area within 7 days of release: 64% of all releases, 60% (24 of 40, two fish not initially located) of the displaced

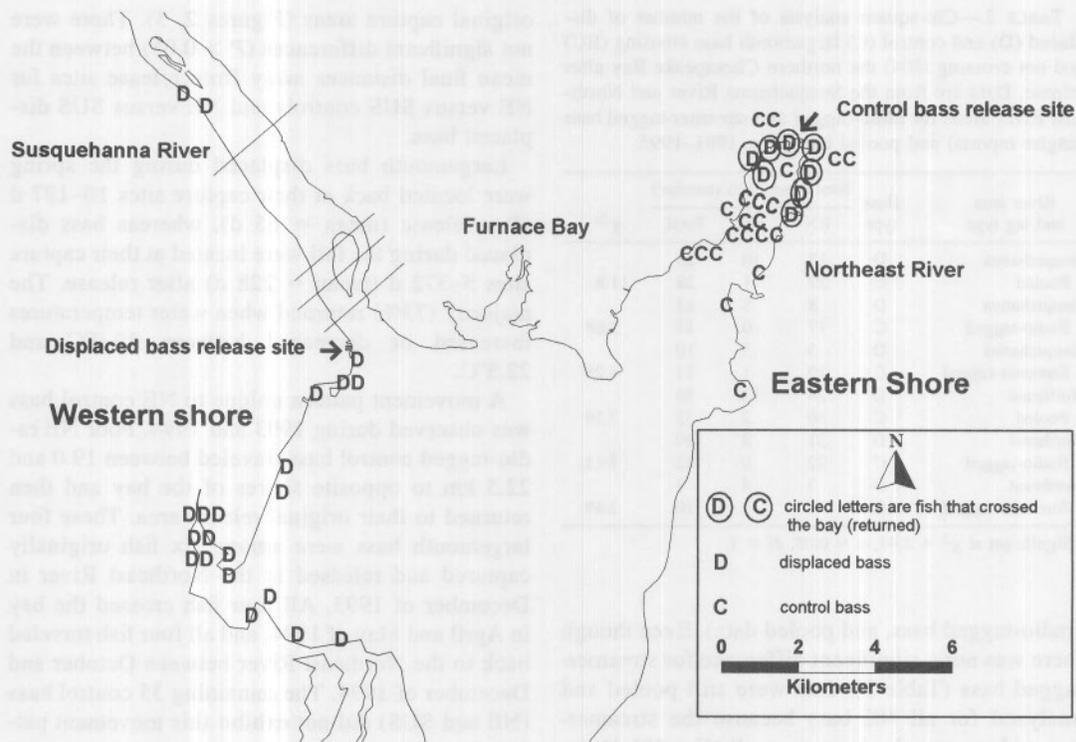


FIGURE 2.—Final northern Chesapeake Bay locations of radio-tagged largemouth bass that were captured in the Northeast River (eastern shore) and displaced (D) 15–21 km to the western shore compared with controls (C) released at the capture site; final locations based on angler harvests of tagged bass and radio-tracking data, 1991–1995.

bass, and 70% (23 of 33, six fish not initially located) of the control bass. As time progressed bass tended to disperse even further from the release sites. By the end of our study 95% of all radio-tagged displaced and control bass were outside the stockpiling area. For 78 radio-tagged bass, mean daily distance moved ranged from 10 to 1,456 m/d (mean = 310 m/d; SD = 292) and longest movements ranged from 91 to 8,370 m/d (mean = 1,617 m/d; SD = 1,371).

Regression analysis was used to develop a predictive model for displaced radio-tagged bass to estimate distance away from release site by day after release. River-specific regressions showed overlapping confidence intervals, so data were pooled to develop a single model: $\log_{10}(\text{distance (m)}) = 0.671 + 0.288 (\text{number of days after release})$, where $r^2 = 0.35$ and $\alpha = 0.05$.

Discussion

Our findings indicate that largemouth bass inhabiting the tidal environment of the northern Chesapeake Bay tend to return to their site of cap-

ture after being displaced up to 21 km. This is in agreement with findings from previous research conducted on bass in freshwater environments (Hasler and Wisby 1958; Parker and Hasler 1959; Peterson 1975; Mesing and Wicker 1986) and with Seibold (1991), who reported homing of displaced largemouth bass in the tidal Potomac River, geomorphologically a much different habitat than the northern Chesapeake Bay. Our results also support previous research that reported largemouth bass capable of moving long distances (Dequine and Hall 1950; Moody 1960; Quinn et al. 1978).

We suggest that the movement of displaced and control largemouth bass may be influenced by the environment in which they were initially captured, and thus, movement behavior of bass (displaced or not) within a population may vary, depending on location. The seasonal migratory movement, possibly related to spawning, that we observed for four radio-tagged control bass from the Northeast River and observed in other studies (Elser 1960) further supports our contention that not all bass in a tidal population exhibit the same movement pat-

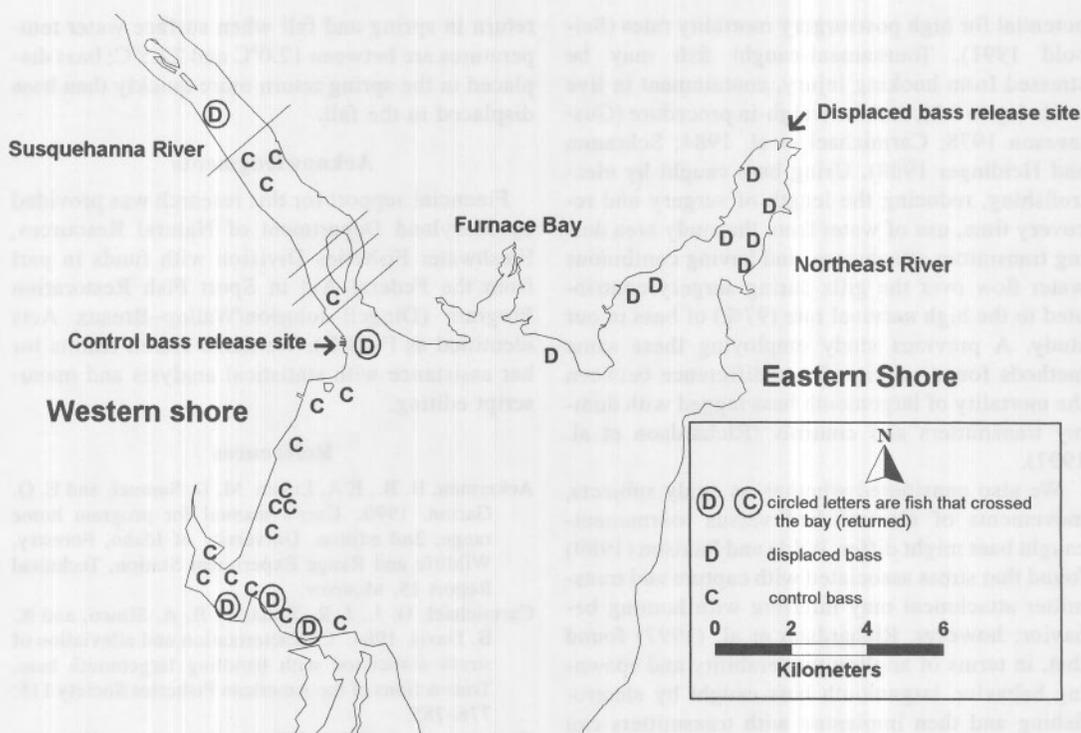


FIGURE 3.—Final northern Chesapeake Bay locations of radio-tagged largemouth bass that were captured in the Susquehanna River (western shore) and displaced (D) 15–21 km to the eastern shore compared with controls (C) released at the capture site; final locations based on angler harvests of tagged bass and radio-tracking data, 1991–1995.

tern. The possibility that there may be groups of bass in the same freshwater body that exhibit different movement patterns has previously been described by Fetterolf (1952), Funk (1957), Moody (1960), and Miller (1975). In water bodies with widely variable geomorphology, such as the northern Chesapeake Bay, we believe it is likely that groups of bass within a population will exhibit differing movement behaviors. When considering management options to mitigate sportfishing tournament impacts, fisheries managers will need to know whether groups of bass within a population exhibit different movement patterns and the extent to which those patterns are influenced by water body type (tidal, nontidal, trophic status), size, and habitats.

The observed movement of fish away from release sites in our study suggests that long-term stockpiling of largemouth bass at release sites is unlikely because 95% of all bass with transmitters left the area by the end of the study. Fewer displaced fish remained at the release sites compared with control fish, and displaced fish, regardless of

whether they returned to their capture area, moved farther away from the release site than control fish. However, because 36% of released bass were still within 0.5 km (radius) of their release site after 1 week it is possible that short-term stockpiling at tournament release sites can occur. Possible consequences include exceeding the carrying capacity at the release site and increasing fish vulnerability to anglers. We believe the probability of this happening decreases as time progresses because both displaced and control fish continue to disperse from the release sites. Fisheries managers concerned with the possibility of short-term stockpiling occurring at a specific release site will need to consider the size and frequency of tournaments utilizing the release site, and the habitat surrounding the release site. The predictive model we developed for determining per-day distances that displaced bass move away from release sites may be useful to managers considering such impacts.

Largemouth bass caught by electrofishing were used as radiotelemetry study specimens instead of tournament-caught fish because the latter have the

potential for high postsurgery mortality rates (Seibold 1991). Tournament-caught fish may be stressed from hooking injury, containment in live wells (up to 8 h), and the weigh-in procedure (Gustaveson 1978; Carmichael et al. 1984; Schramm and Heidinger 1988). Using bass caught by electrofishing, reducing the length of surgery and recovery time, use of water from the study area during transmitter attachment, and having continuous water flow over the gills during surgery contributed to the high survival rate (97%) of bass in our study. A previous study employing these same methods found no significant difference between the mortality of largemouth bass tagged with dummy transmitters and controls (Richardson et al. 1997).

We also considered whether, as study subjects, movements of electrofished versus tournament-caught bass might differ. Wilde and Paulson (1989) found that stress associated with capture and transmitter attachment may interfere with homing behavior; however, Richardson et al. (1997) found that, in terms of angling vulnerability and spawning behavior, largemouth bass caught by electrofishing and then implanted with transmitters can be expected to behave similarly to any other largemouth bass. Crumpton (1985) also found no difference in swimming movement between bass with transmitters and controls. This suggests that bass collected by electrofishing have similar movement patterns to those caught during sport fishing tournaments.

Management Implications

Additional studies on the movement behavior of largemouth bass may demonstrate more about the mechanism that largemouth bass use to return to their capture areas and why bass prefer returning to their capture site as opposed to remaining at release sites, especially sites with suitable habitat. Our study results suggest that fisheries managers consider the following when contemplating impacts of angling competitions on bass populations: (1) displaced largemouth bass can return to their site of capture, traveling up to at least 21 km; (2) long-term stockpiling (within 0.5 km of release site) of largemouth bass at tournament release sites is unlikely, but short-term stockpiling is possible; (3) movements of largemouth bass may differ within a population, possibly due to factors such as specific habitat variables and spawning migrations; and (4) water temperature affects the likelihood, timing, and rate of movement of displaced largemouth bass. The majority of displaced bass

return in spring and fall when surface water temperatures are between 12.0°C and 22.5°C; bass displaced in the spring return more quickly than bass displaced in the fall.

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