Inter-river Migration of Striped Bass in Western Kentucky

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Abstract: Fifteen radio-tagged striped bass (*Morone saxatilis*) were tracked to determine seasonal, inter-river distribution patterns, and habitat use in the vicinity of the Ohio, Tennessee, Cumberland, and Mississippi rivers from November 1992 to November 1993. All 4 river systems were used by study fish during 1 or more seasons. Two fish inhabited only 1 river during the entire survey, while 13 fish used up to 3 river systems. Inter-river movement occurred primarily during November–December (36%) and April–May (58%), which coincided with highest movement periods. Striped bass distribution was skewed toward tailwaters and study segments immediately downstream. General habitats annually included channel borders (47%), tailwaters (37%), and heated discharges (7%); however, specific habitats included open bottom substrates (29%), tailwater boils (28%), and woody debris and trees (24%). Availability of suitable summer habitat (i.e., tailwaters) was considered a major limiting factor to the expansion of this striped bass fishery.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 50:62-78

The Kentucky Department of Fish and Wildlife Resources (KDFWR) began stocking striped bass in the Ohio River in 1975 to utilize an abundant gizzard shad (*Dorosoma cepedianum*) and threadfin shad (*D. petenense*) prey base and to increase sportfish diversity. Over 10 million striped bass fingerlings have been released since 1975 in 8 navigation pools bordering Kentucky with an annual stocking objective of 4 fingerlings/ha (Henley 1991). Creel surveys conducted in Ohio River pools and tailwaters from 1980 to 1988 indicated 16% of all anglers sought striped bass; 74% of the striped bass were caught in tailwaters (Henley 1995). Harvest has not consistently met the harvest objectives of 1.1 kg/ha or a 10% increase in total sportfish yield annually (Jackson (1985). The KDFWR hypothesized movements of striped bass could be contributing to the seasonal and sporadic nature of this fishery.

Telemetry has been used to describe striped bass distribution in reservoirs (Combs and Pletz 1982, Farquhar and Gutreuter 1989), reservoir tailwaters (Lamprecht and Shelton 1986), and coastal plain rivers (Wooley and Crateau 1983, Kynard and Warner 1987, Van Den Avyle and Evans 1990). The Ohio River navigational locks and dams are unique because they create a series of rapidly flushing reservoirs where the tailwaters of 1 pool flow directly into the impounded area of the next pool. My telemetry study was conducted to document seasonal distribution and habitat use of striped bass in a unique area (confluence of 4 river systems) to assist anglers in locating striped bass during portions of the year not normally associated with striped bass harvest (i.e., late fall, winter, and early spring).

The author wishes to thank D. Bell, R. Rold, J. Turley, J. Bell, B. Quire, W. L. Davis, T. Farmer, B. Collins, M. Criswell, and D. Snyder for their help in striped bass acquisition and telemetry tracking. Special thanks to B. T. Kinman for his guidance and assistance in study design, field operations, and editing this manuscript. I also thank S. Czajkowski and M. Metz for their help in designing and developing the figures and slides use to present this paper. This project was funded through Federal Aid in Sport Fish Restoration Project F-40, Subsection III, Study II of KDFWR.

Methods

The study areas were below Kentucky Dam on the Tennessee River (Tennessee River km, TRK 36.1), Barkley Dam on the Cumberland River (Cumberland River km, CRK 49.3), Smithland Locks and Dam (Ohio River km, ORK 1,481.4–1,582.3), and that portion of the Mississippi River from river kilometer (MRK) 1,443.5 to 1,540.3 (Fig. 1). The Tennessee and Cumberland rivers were divided into approximately 8-km study segments, while the Ohio and Mississippi rivers were sectioned into 16-km study segments (Fig. 2). Tailwater boundaries extended from the dam to a convenient line of demarcation just downstream from the dam. Tailwater and study segment areas were determined from topographical maps using a digital compensating polar planimeter. Study segment area for the Mississippi River was not determined.

Striped bass were captured in the tailwaters of Kentucky Lake (TRK 36.1), Barkley Lake tailwaters (CRK 49.3), and Smithland Dam (ORK 1,481.4) during October and November 1992. A total of 42 striped bass were captured by electrofishing or hook and line from Kentucky Lake tailwater ($N = 14$), Barkley Lake tailwater ($N = 16$), and Smithland Lock and Dam ($N = 12$). Captured striped bass were sedated for approximately 15 minutes in a 100-mg/liter solution of tricaine methanesulfonate (MS-222), measured (to the nearest 0.25 cm), weighed (to the nearest 0.04 kg), and scales were removed for age and growth determination. Sex of fish was not determined. Radio transmitters were inserted into the abdominal cavity along a 3.8-cm line adjacent to the belly midline following procedures similar to those of Hart and Summerfelt (1975) and Moss (1985). Povidine-iodine (10%) solution was used topically around the incision as a prophylactic anti-infective agent. A Floy tag was placed posteriorly to the dorsal fin as an external marker to indicate a $50 reward for transmitter return.

A programmable, scanning receiver (Challenger Model 2000, Advanced Telemetry Systems, Inc.) operating on 48 MHz was used to locate positions of striped bass. A 4-element (low frequency), 48–50-MHz, yagi antenna was used to track striped

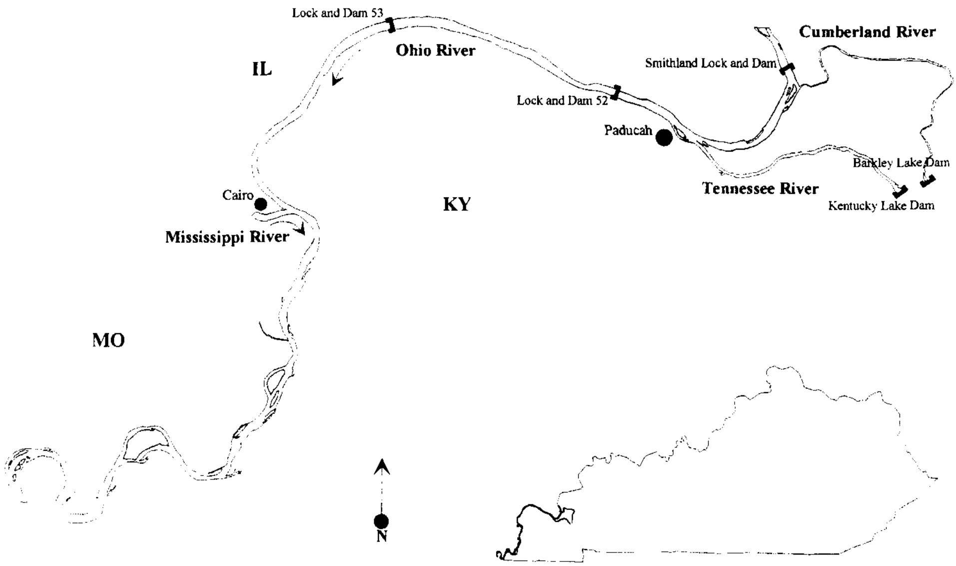

Figure 1. Striped bass telemetry study area including the Cumberland River (below Barkley Lake Dam, river kilometer 49.4), Tennessee River (below Kentucky Lake Dam, river kilometer 36.1), Ohio River (below Smithland Lock and Dam, river kilometer 1,481.4), and the Mississippi River from Cairo, Illinois to the Kentucky-Tennessee state border (river kilometer 1,540.3–1,443.5). Map is not to scale.

bass from a boat and 2-loop antennae (30–55-MHz) were used during aircraft searches. Model 5A transmitters (48 MHz; 45 g air weight) were selected for their 420- to 520-day operating time.

Striped bass locations were determined from combined aerial and boat surveys. Aerial surveys were conducted a minimum of once/month during the first 6 months of the study to locate striped bass within and egressing from the primary survey area. Boat surveys were made 3–4 days every 2 weeks per each selected season (summer, June–August 1993; fall, November 1992 and September–November 1993; winter, December 1992–February 1993). Weekly surveys were made during April and May (spawning season). The entire study area was searched by boat at least once during each boat survey. Fish were tracked as extensively as possible; however, estimates of total striped bass movement were not made on a continuous basis (day to day) and can only be considered as minimum estimates of movement used for determining trends. The following information was recorded each time a fish location was determined: fish number, date, depth, distance from shore (using a Rangematic 1200 range finder), river kilometer (to the nearest 0.2 km using a navigation or topographical map), river level, secchi disk depth, and surface water temperature.

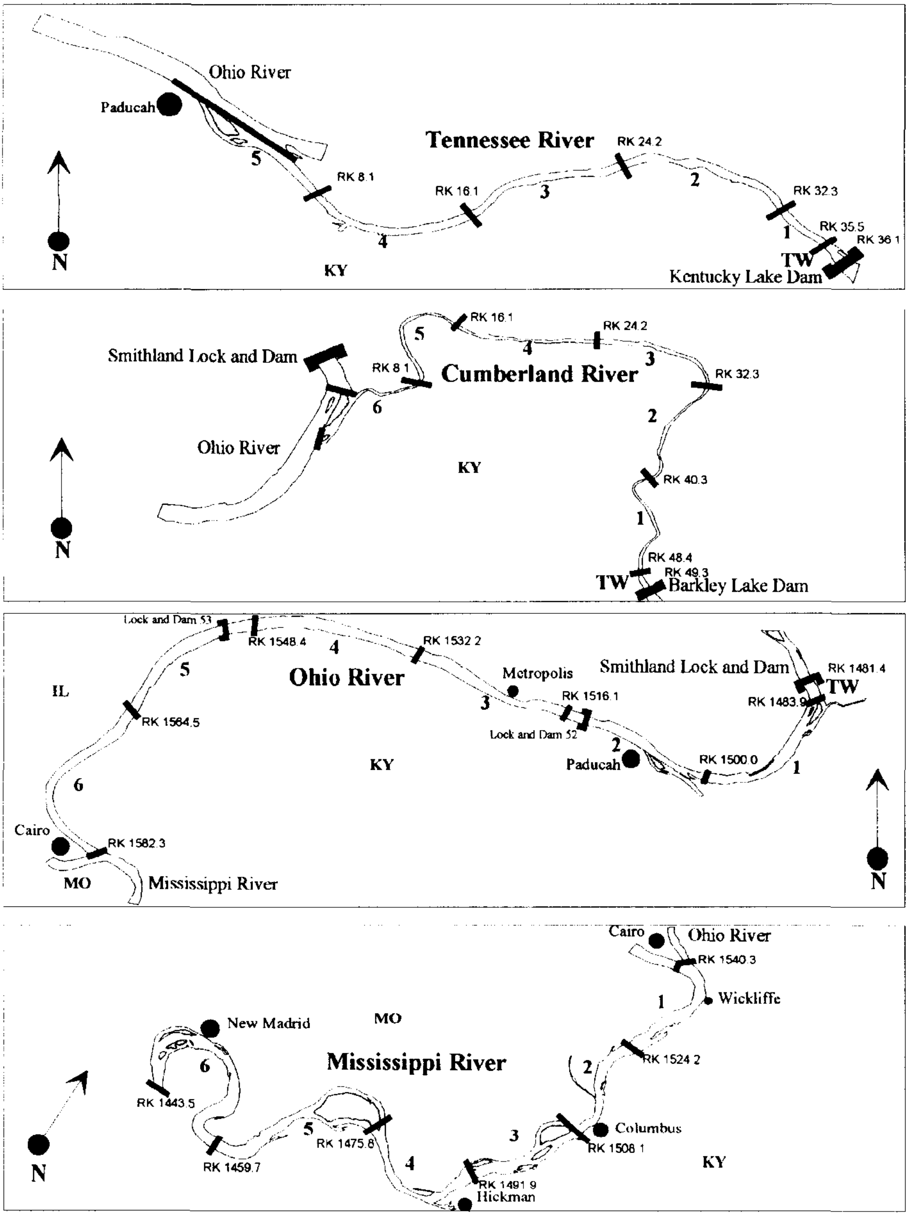

Figure 2. Study segments and river kilometers (RK) used to determine the distribution of 15 striped bass in the Ohio, Tennessee, Cumberland, and Mississippi rivers. Maps are not to scale.

Habitat was determined at 2 levels for each fish location. Macrohabitat was used to describe the general location. Tailwater was defined as the area immediately below a lock or dam. Channel borders were arbitrarily defined as 30.5 m from either shore. Main channel habitats included open water between channel borders (>30.5 m from shore). Backwaters were areas with little or no current adjacent to the channel border. Man-made structures were characterized by submerged weirs, dikes, and dams (e.g., Lock and Dam 52). Plumes were defined as discharges from power plants or industrial facilities. Microhabitat described the substrate or feature in the target fish's immediate vicinity. Boils described the agitated waters found immediately below tainter gates, hydroelectric, and lock discharges in tailwater areas. Open bottom substrates were channel border areas without visible cover and consisted of open mud, sand, bedrock, or gravel. Woody debris and trees consisted of fallen trees, stumps, and inundated trees along river channel borders. Areas outside channel borders were described as floodplain (flooded land and trees) and tributaries. Rip rap was in the pools where pipelines and cables crossed under the river and in the tailwater areas as shoreline protection. Mooring cells, bridge abutments, and submerged weirs were included in an other category.

SAS-PC (SAS Inst. 1988) and LOTUS 123 Revision 3 were used for data analyses. Only data from fish located ≥5 months were used in analyses. A chi-square analysis was used to examine striped bass preference or avoidance of study segments in Ohio, Tennessee, and Cumberland rivers in proportion to their area and occurrence (Neu et al. 1974).

Results

Fifteen of 42 implanted striped bass were tracked ≥5 months from November 1992 through November 1993 (Table 1). These fish averaged 67.6 cm long (total length), 4.2 kg in mass, and 4 years of age.

Overall distribution of striped bass in the study area was defined by 3 broad movement scenarios (Table 2). Two study fish (13%) remained in the river in which they were implanted for the entire study period. Both fish were in the 2 smaller rivers (i.e., Cumberland and Tennessee rivers). Seven fish (47%) either moved immediately after implantation or spent the winter in their source river before migration; however, all these fish returned and spent the summer in their source river. Six fish (40%) moved out of the source river immediately after implantation and never returned. Fish exhibiting the latter 2 patterns were characterized by movement between 2 or 3 rivers.

Some interchange of striped bass between river systems appeared to occur seasonally. Thirteen fish (87%) were observed in their source rivers during November 1992 (Table 2). A brief period of movement between rivers occurred in December and early January, as the proportion of fish found in their source river ranged from 47% to 53%. Fish remained stationary from late January through March. A period of intense inter-river movement was observed during April (spawning season). From May through October, most study fish returned to tailwater sites where they had been tagged.

Table 1. Implantation and physical data for striped bass monitored 5–12 months in the lower Ohio River, November 1992 through November 1993.

Fish	Tagging date	Expiration date	Total length (cm)	Weight (kg)	Age	Reason for termination
			Cumberland River Implant site			
310	29 Oct 92	21 Aug 93	65.0	3.5	4	Creeled
430	29 Oct 92	17 Jun 93	67.6	3.8	4	Emigration
830	29 Oct 92	20 Sep 93	74.7	5.5	4	Creeled
870	26 Oct 92	16 Nov 93	64.8	3.6	4	End of study
			Ohio River Implant Site			
190	03 Nov 92	07 Sep 93	64.5	3.5	4	Creeled
290	03 Nov 92	20 Oct 93	69.3	2.9	4	Not determined
390	03 Nov 92	16 Nov 93	66.3	3.6	4	End of study
440	03 Nov 92	29 Jun 93	63.0	3.1	4	Not determined
670	03 Nov 92	06 Jun 93	64.8	3.7	4	Not determined
950	03 Nov 92	10 Aug 93	63.0	3.2	4	Not determined
			Tennessee River Implant Site			
270	02 Nov 92	18 May 93	74.2	5.8	4	Not determined
350	20 Oct 92	27 July 93	70.6	4.4	4	Not determined
540	20 Oct 92	01 Oct 93	59.9	5.9	4	Creeled
911	02 Nov 92	27 Jul 93	67.6	4.5	4	Not determined
990	22 Oct 92	07 Oct 93	76.4	5.7	4	Not determined
Mean			67.6	4.2	4	

Table 2. River source and location data for implanted striped bass in the lower Ohio River, November 1992 through November 1993. OH = Ohio River; TN = Tennessee River; CU = Cumberland River; MS = Mississippi River.

Fish	Source	Nov 1992	Dec	Jan 1993	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	*N* rivers used
310	CU	CU	CU	CU	CU	CU	CU	CU	CU	CU					1
430	CU	CU	CU/OH	MS	MS	MS	MS	MS	MS						3
830	CU	CU	CU	CU	CU	CU	CU/OH	OH/CU	CU	CU	CU	CU			2
870	CU	CU/OH	OH	OH	OH	OH	OH/TN	OH	OH/TN	TN	TN	TN	TN	TN	3
190	OH	OH	OH/MS	MS	MS	MS	MS	MS/OH	OH/CU	CU	CU	CU			3
290	OH	OH	OH/MS	MS	MS	MS	MS/OH	OH	OH	OH	OH	OH	OH		2
390	OH	OH	OH/TN	TN	TN	TN	TN	TN/OH	OH	OH	OH	OH	OH	OH/TN	2
440	OH	OH	OH	OH	OH	OH	OH/CU	CU/OH	OH						2
670	OH	OH/CU	CU/OH	CU	CU	CU	CU	CU	CU	CU/OH	OH	OH	OH	OH/CU	2
950	OH	OH	OH	OH	OH	OH	OH/CU	CU/OH	OH	OH	OH				2
270	TN	TN	TN/OH	OH	OH	OH	OH	OH							2
350	TN	TN	TN	TN	TN	TN	TN	TN/OH/CU	CU	CU					3
540	TN	TN	TN	TN	TN	TN	TN/OH/CU	CU/OH/TN	TN	TN	TN	TN			3
911	TN	TN	TN/OH	CU	CU	CU	CU	CU/OH	OH	OH					3
990	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	1

Mean rates of striped bass movement appeared to coincide with water temperature. Movement increased during November–December ($\bar{x}$ = 10.3–12.9 km/fish/month; $\bar{x}$ = 11.0 C) (Fig. 3), when fish moved from summer to winter sites. Movement was limited during January–March ($\bar{x}$ = 3.14–4.8 km/fish/month; $\bar{x}$ = 7.8 C), then increased in April and May ($\bar{x}$ = 9.7–11.8 km/fish/month) as water temperatures warmed ($\bar{x}$ = 13.7 C). Movement peaked in June ($\bar{x}$ = 18.2 km/fish/month; $\bar{x}$ = 26.1 C). Least movement ($\bar{x}$ = 0.2–0.5 km/fish/month; $\bar{x}$ = 29.9 C) occurred in July and August. Movement patterns again increased ($\bar{x}$ = 2.9–3.7 km/fish/month) in late September–October as tailwater temperatures declined ($\bar{x}$ = 22.9 C) and striped bass moved into winter locations.

Striped bass distribution was skewed toward tailwaters and the first 2 or 3 study segments immediately downstream. Use of upstream study segments was generally greater than expected based on proportional area within each study segment (Table 3). Conversely, overall use of downstream study segments was less than expected.

Winter Patterns

Striped bass moved from implantation sites (tailwaters) into winter locations in late November and December. Eight study fish moved from original stocking sites into other river systems (Table 2). Striped bass wintering in the Ohio River moved between inundated Lock and Dam 52 in study segment 2 (36.4%; Table 4) and a heated discharge plume of a power plant located in study segment 3 (50.0%). Fish in the Tennessee River were concentrated (83.9%) in study segment 2 located approximately 4.8–12.9 km downstream of the tailwater. The remaining sitings in this river were located farther downstream. Study fish in the Cumberland River were closely

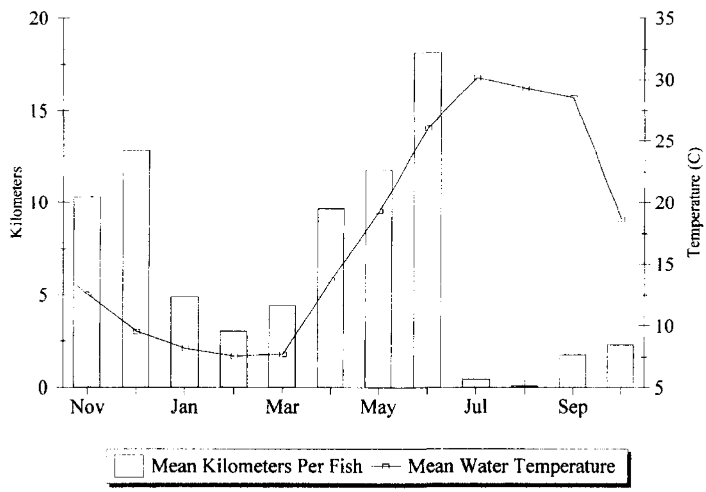

Figure 3. Movement in mean kilometers for striped bass (minimal estimates) and surface water temperatures in the Ohio, Tennessee, and Cumberland rivers, Kentucky, November 1992 through October 1993.

Table 3. Proportion of observed and expected observations per study segment for striped bass across seasons within the Ohio, Tennessee, and Cumberland rivers, November 1992 through November 1993.

River study segment[a]	Total area (ha)	Proportion of total area	Proportion observed in area	Proportion expected in area	χ^2
		Ohio River			
Tailwater	281	0.027	0.579	0.027	1,298.6[b]
1	1,555	0.148	0.088	0.148	2.8
2	1,212	0.115	0.158	0.115	1.8
3	1,847	0.176	0.149	0.176	0.5
4	2,019	0.192	0.018	0.192	18.1[b]
5	1,752	0.167	0.000	0.167	19.0[b]
6	1,650	0.157	0.000	0.157	17.9[b]
7	193	0.018	0.009	0.018	0.6
Totals	10,508	1.000	1.000	1.000	1,359.3[b]
		Tennessee River			
Tailwater	22	0.016	0.309	0.016	874.8[b]
1	131	0.094	0.056	0.094	2.5
2	312	0.223	0.481	0.223	48.8[b]
3	315	0.225	0.056	0.225	20.6[b]
4	318	0.227	0.019	0.227	30.9[b]
5	303	0.216	0.080	0.216	13.9[b]
Totals	1,402	1.000	1.000	1.000	991.5[b]
		Cumberland River			
Tailwater	29	0.036	0.311	0.036	341.3[b]
1	105	0.129	0.262	0.129	22.7[b]
2	109	0.134	0.177	0.134	2.3
3	116	0.142	0.049	0.142	10.1[b]
4	127	0.156	0.043	0.156	13.6[b]
5	120	0.147	0.110	0.147	1.6
6	208	0.256	0.049	0.256	27.4[b]
Totals	815	1.000	1.000	1.000	419.0[b]

[a]See Figure 2 for study segment locations.
[b]Significant at $P < 0.05$; df = 1.

associated with the tailwater (21.4%) and study segments 1 and 2 downstream of the tailwater (46.5%). Fish located in study segment 1 were associated with an outside bank that had submerged rock spoil deposited along the shore during channel maintenance dredging.

Three striped bass moved from the Ohio (2) and Cumberland (1) rivers into the Mississippi River during December. Two of the 3 fish were associated with a 13.0-km stretch of river near Columbus, Kentucky, in river study segments 2 (14.3%) and 3 (71.4%) (Table 4). A third fish was near the Kentucky/Tennessee border in study segment 6 (14.3%). Fish typically remained within 30.5 m of shore (75.0%) and along the Kentucky shoreline except during flooding events when fish were regularly found away from the channel border on the inundated flood plain.

Habitats used by striped bass during the winter varied with individual fish and

Table 4. Study segment sitings (with percentages in parentheses) of 15 striped bass, by season in the Ohio, Tennessee, Cumberland, and Mississippi rivers, western Kentucky, November 1992 through November 1993.

		Study segments[a]									
River	Tailwater	1	2	3	4	5	6	7	8	9	10
					Winter						
Ohio		1 (4.5)	9 (36.4)	13 (50.0)	2 (9.1)						
Tennessee			46 (83.9)	5 (9.7)	2 (3.2)	2 (3.2)					
Cumberland	10 (21.4)	14 (28.6)	8 (17.9)	2 (3.6)	10 (21.4)		3 (7.1)				
Mississippi			1 (14.3)	5 (71.4)			1 (14.3)				
					Spring						
Ohio	27 (68.4)		6 (15.8)	6 (15.8)							
Tennessee	12 (28.1)	1 (3.1)	27 (62.5)	3 (6.2)							
Cumberland	22 (40.0)	8 (14.3)	8 (14.3)	5 (8.6)	2 (2.8)	3 (5.7)	8 (14.3)				
Mississippi			3 (20.0)	10 (66.7)			2 (13.3)				
					Summer						
Ohio	25 (100.0)										
Tennessee	25 (100.0)										
Cumberland	21 (87.5)			2 (8.3)		1 (4.2)					
Mississippi											1 (100.0)
					Fall						
Ohio	18 (68.7)	7 (25.0)	2 (6.2)								
Tennessee	15 (61.1)		7 (27.8)	3 (11.1)							
Cumberland	9 (41.7)	9 (41.7)		2 (8.3)			2 (8.3)				
Mississippi											

[a]See Figure 2 for study segment locations.

river system. Channel border habitats (74.8%) were occupied in greater frequency by study fish in all rivers (Fig. 4). Several specific macrohabitats were used by striped bass. Tailwaters were only used by fish in the Cumberland and Tennessee rivers (7.0%). Fish in the Tennessee and Ohio rivers used near-shore discharges (13.0%), while those in the Ohio and Mississippi rivers used man-made structures (i.e., winged dikes and inundated locks and dams; 4.3%). Microhabitats used by study fish included open bottom substrates (42.9%) and woody debris and trees (40.3%) found along the channel border (Fig. 5). Only fish in the Barkley Lake tailwater used boils (7.6%) associated with the hydroelectric or dam discharges during the winter. Striped bass locations were typically within 30.5 m of shore in water ranging from 1.3 to 12.5 m deep.

Spring Patterns

Study segments occupied during the winter period were also used by study fish during early spring (March; Table 4). By April and May, movement was observed from winter sites into tailwater areas. Inter-river movement of striped bass was greatest during April (24%) and May (29%) (Table 2). Eleven fish used the Ohio River as a movement corridor between rivers. The majority of locations (86%) were in Smithland and Barkley lake tailwater areas (uppermost tailwaters). Only 1 fish remained in the Kentucky Lake tailwater during spring.

Striped bass in the Mississippi River were located within 8.0 km of each other in study segment 3 (66.7%; Table 4) just downstream of Columbus, Kentucky, during most of the spring. Movement out of the Mississippi River occurred in late May. One of the 2 Ohio River source fish returned to the Ohio River and the other to the Cumberland River. The third (Cumberland River source) emigrated down the Mississippi River in June and was last located near Caruthersville, Missouri (MRK 1,345.5).

A diversity of habitats were used by striped bass during the spring. Fish used channel border macrohabitats (48.6%; depth range 6.1–13.1 m) in the spring, as they remained in winter-like distribution until late March (Fig. 4). Tailwater use increased in April (32.2%). Striped bass in the Mississippi and Ohio rivers frequented the inundated flood plain (7.4%; $\bar{x}$ depth 1.2 m). Use of tributary streams (3.0%) was observed in the Tennessee and Cumberland rivers, with no use of the flood plain macrohabitats. Microhabitats used in early spring (March) were primarily open bottom substrates (26.1%) and woody debris and trees (24.8%) associated with the near-shore area (Fig. 5). As fish moved into the tailwater areas in April and May, they used boils (38.6%) associated with dam and hydroelectric facilities ($\bar{x}$ depth 10.2 m).

Summer Patterns

Summer distribution of striped bass was limited to the Smithland Lake tailwater ($N = 25$; 100.0%), Barkley Lake tailwater ($N = 21$; 87.5%), or Kentucky Lake tailwater ($N = 25$; 100.0%), which comprised 3% of the total area available (excluding the Mississippi River) (Table 4). No fish moved upstream beyond any of the dams. Striped bass in each tailwater used the swiftest water associated with the dam or hydroelectric

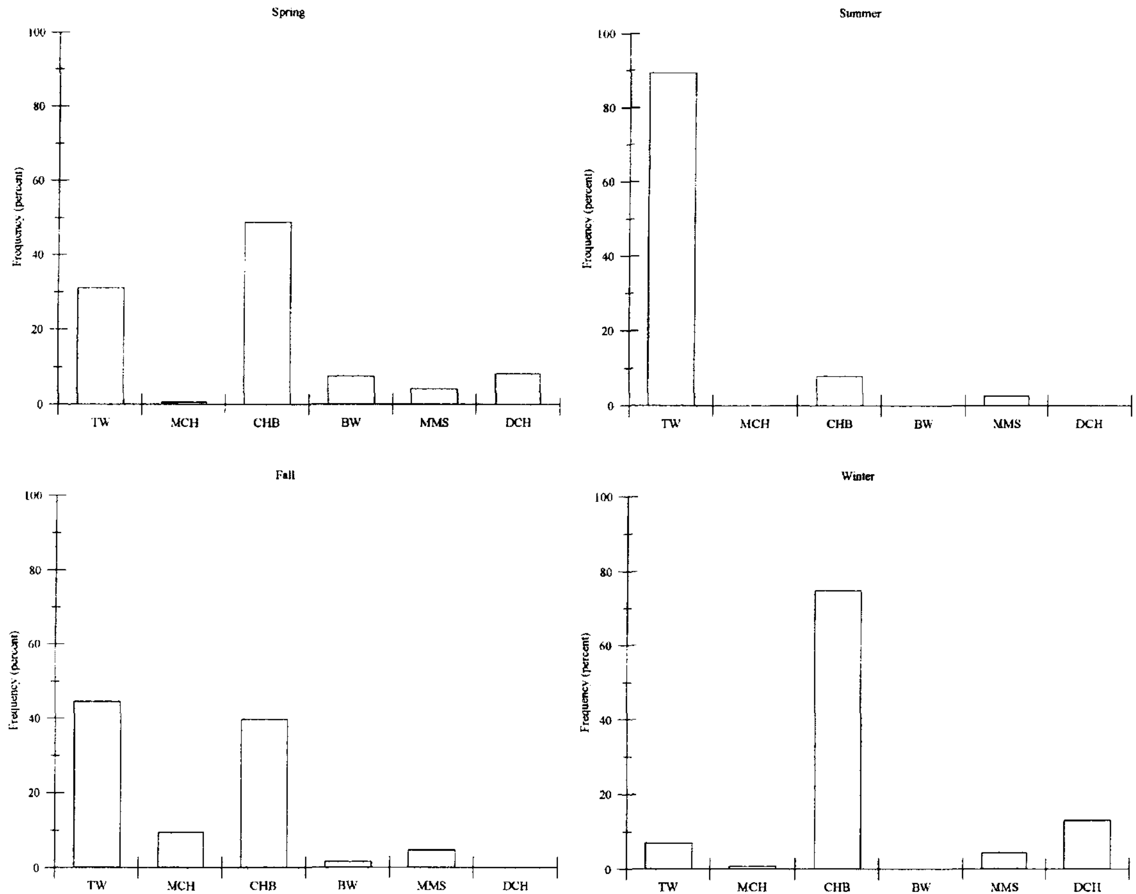

Figure 4. Seasonal use frequencies of macrohabitats occupied by striped bass in the Ohio, Tennessee, Cumberland, and Mississippi rivers, Kentucky, November 1992 through November 1993. TW = tailwater; MCH = main channel; CHB = channel border; BW = backwater; MMS = man-made structure; DCH = discharge.

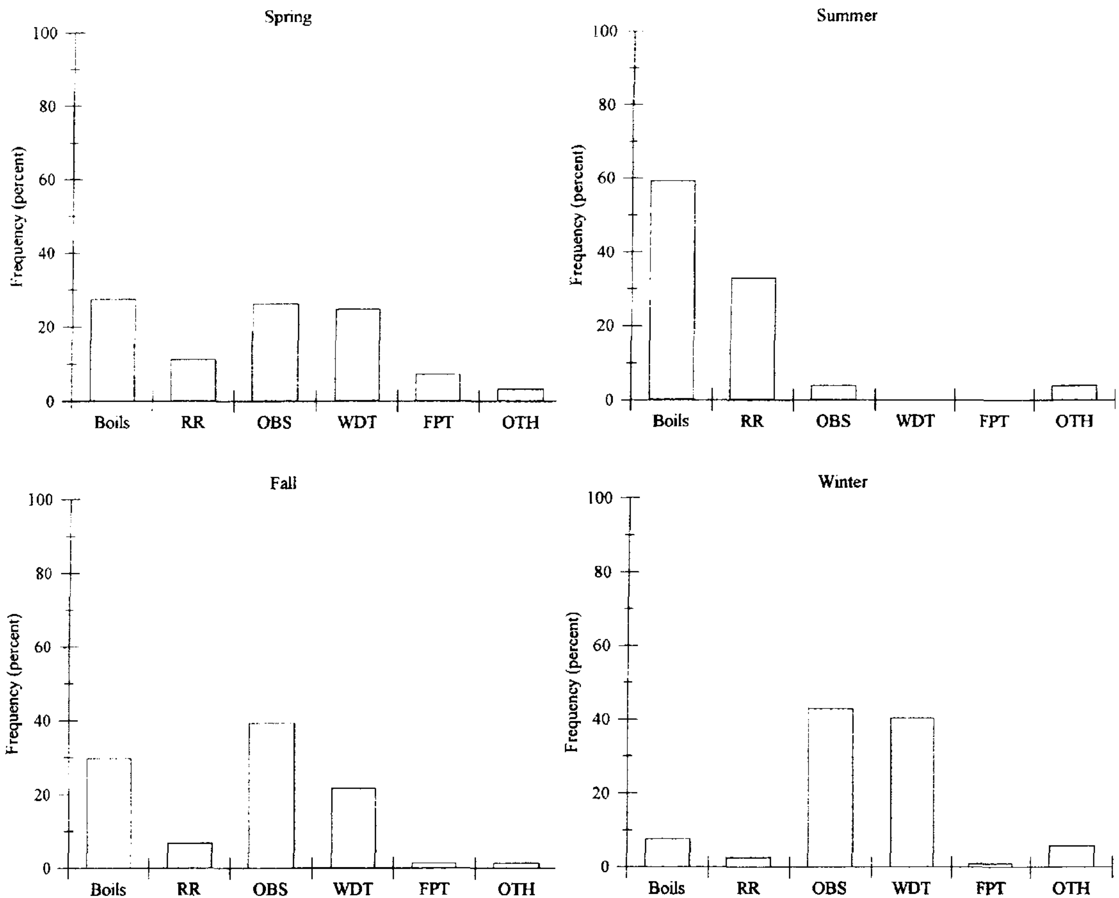

Figure 5. Seasonal use frequencies of microhabitats occupied by striped bass in the Ohio, Tennessee, Cumberland, and Mississippi rivers, Kentucky, November 1992 through November 1993. Boils = gate, hydroelectric, lock discharge; RR = rip rap; OBS = open bottom substrates; WDT = woody debris/trees; FPT = floodplain and tributaries; OTH = other.

plant discharges. Fish were not restricted to the near-shore areas and occupied depths ranging from 7.3 to 14.0 m.

During summer, striped bass extensively used tailwater habitats (89.5%; Fig. 4). Channel borders (7.9%) were used only during June. Microhabitats occupied included boils associated with dam gates and hydroelectric discharges (59.2%) and rip rap along tailwater shorelines (32.9%; Fig. 5).

Fall Patterns

Striped bass remained associated with tailwater areas throughout September–October (Table 4). By November 1993, only 4 study fish remained active and they began moving downstream from tailwater areas. These fish occupied near-shore areas associated with main stem study segments. Two of the 4 fish changed rivers, similar to patterns observed the previous November.

Striped bass concentrated in tailwater macrohabitats during most of the fall (44.4%) and only began to utilize channel borders (39.7%) in late October (Fig. 4). Several fish were observed on gravel flats and bars (9.5%) near the main channel during low flow periods. Winter microhabitat use by study fish was similar to that during the spring (Fig. 5). Boils located below dams were occupied during early fall (36.5%); however, as fish began moving out of tailwater areas and along channel borders, use of open bottom substrates (39.2%) and woody debris and trees (21.6%) increased by October.

Discussion

Striped bass are characteristically known for substantial seasonal movements (Combs and Peltz 1982, Lamprecht and Shelton 1986). Movement of fish between 2 or more river systems was exhibited by most striped bass in this study, while a small percentage remained in 1 river only. Reservoir striped bass often utilize riverine portions of the reservoir to stage and attempt spawning in spring; however, they typically move back down into the main reservoir near the dam in summer (Farquhar 1985, Cheek et al. 1985, Farquhar and Gutreuter 1989). Striped bass in this study were observed utilizing specific areas in loose concentrations in portions of rivers blocked by upstream dams. Most appeared to prefer the 2 tailwater areas farthest upstream (i.e., Smithland and Barkley lake tailwaters). Lower sections of each river were used only during fish movements between rivers. Movement of striped bass into different rivers or tailwaters in early spring may be related to fish seeking suitable spawning sites (Combs and Peltz 1982, Lamprecht and Shelton 1986, Hampton et al. 1988) and was accentuated by the impassability of dams. Exclusive use of the upper areas of a navigation pool by *Morone* spp. has been observed elsewhere in the Ohio River (Henley 1991, Vallazza et al. 1994). Striped bass in several southeast rivers either remain in the upper portions of rivers or move upstream following spawning (Dudley et al. 1977, Wooley and Crateau 1983).

Fish in each study river, when not in a tailwater, were associated with habitats along the channel border. Similarly, striped bass in other riverine situations preferred near-shore habitats that feature eddies (i.e., trees, stumps, rip rap, tributary mouths, or bars) (Combs and Peltz 1982, Cheek et al. 1985, Lamprecht and Shelton 1986). However, preferences for physical habitat characteristics have been shown to change as water temperatures increase in summer (>25 C; Cheek et al. 1985). Coutant (1983, 1985) and Van Den Avyle and Evans (1990) postulated that the carrying capacity of a body of water for striped bass was proportional to availability, quantity, and quality of summer habitats. Tailwaters are very important to *Morone* spp. during the summer by providing favorable ambush habitats that concentrate abundant prey species and provide adequate dissolved oxygen (Lamprecht and Shelton 1986, Braschler et al. 1988, Vallazza et al. 1994). Striped bass in this study were concentrated in 3 tailwater areas from late June through September, which comprised approximately 3% of the available river area (excluding the Mississippi River). Summer habitat constrictions may also contribute to slower growth rates, loss of body condition, reduced fecundity, parasitism, and, in extreme cases, mortalities (Matthews 1985, Axon and Whitehurst 1985, Lantz 1986, Coutant 1987, Zale et al. 1990). Summer stress mortality was not documented for any of the core study fish in this study, although it has been observed elsewhere in the Ohio River (Henley 1991). These mortalities typically occur in late summer and fall during cessation of feeding due to physiological responses of fish to excessive summer temperatures or separation of striped bass from prey while seeking cooler water temperatures (Cheek et al. 1985, Van Den Avyle and Evans 1990, Zale et al. 1990).

Two-thirds of the 42 fish implanted with transmitters in this study were not found after 170 days. Downstream losses in the Mississippi River were possibly undetected because aircraft surveys did not begin until December 1992. Wooley and Crateau (1983) documented that lost study fish had moved >100 km downstream. Commercial harvest of tagged striped bass is also a possibility, because the area below the Smithland Lake tailwater (including the mouth of the Cumberland River) was heavily fished by commercial gill netters.

Management Implications

Striped bass have been consistently stocked in the Ohio River since 1975 at rates up to 4 fish/ha/year. Only tailwaters below navigation locks and dams have developed seasonal striped bass fisheries (Henley 1995). Plans call for continued striped bass stocking in the lower Ohio, Cumberland, and Tennessee rivers. The contribution of stocked fish remains unknown; conceivably adult striped bass in this area could be the product of natural reproduction, downstream migration from the Ohio River, or from other states' stocking programs in the drainage. The propensity of striped bass for large scale movement patterns in an open river system negatively influences the development of a consistent fishery for more than a few months duration. Movement of adult striped bass among the 4 rivers and the loss of nearly 67% of the tagged fish (most likely through emigration) suggests the need to treat this area as an entire unit in cooperation with adjoining states when developing future fishery management plans.

This fishery will likely remain a tailwater fishery because the largest concentrations of striped bass were located in the tailwater areas during the major recreational season (summer). Potential exists, however, for anglers to catch these fish during other seasons by concentrating fishing efforts along channel borders typically within 8 km of tailwaters. Striped bass inhabited areas of cover and open substrates within 30 m of shore during late fall, winter, and early spring. Fishing opportunities could be enhanced by placing structure (e.g., rock piles) along shorelines to produce eddies. Trees, stumps, and snags should be left in place to provide cover. Gravel and rock spoil from dredging of the navigational channel could be piled in deeper water just off shore (within 30 m) to provide holding sites for striped bass and prey species. Commercial and industrial development of shore areas should be minimized within the first 8 km of tailwaters. However, if developments are allowed, natural near-shore cover should be left above and below developed areas and artificial substrates (rock piles and large boulder rip rap) added to mitigate the losses associated with developments. When possible, barge mooring sites and discharges should be made accessible to boat anglers.

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