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Movement of flathead catfish in the Missouri River: examining opportunities for managing river segments for different fishery goals

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Abstract The dispersal patterns of 2939 flathead catfish, *Pylodictis olivaris* (Rafinesque), were determined within a 90-km section of the Missouri River, USA. Fish were captured by electric fishing and tagged in early June each year from 1999 through 2001. Dispersal was determined via angler tag returns between 1999 and 2001 or by subsequent recapture during sampling 1 or 2 years after initial tagging (June 2000 or 2001). Dispersal was localised for the majority of the 370 flathead catfish recaptured in the Missouri River. Over 80% of recaptures were within 5 km of tagging location, and 94% were within 20 km of tagging location. Maximum displacement was 160 km. To examine differences in movement patterns of various sized fish, flathead catfish were placed into one to three size groups (305–380, 381–507, or ≥508 mm). A significant difference ($P < 0.001$) was detected in dispersal patterns among the three size groups; the largest size group moved greater distances than either of the smaller size groups. Movements average 4.5, 5.6 and 12.6 km for small, medium, and large size classes, respectively. Dispersal movements of flathead catfish in the Missouri River appeared to be localised, suggesting that different sections of the Missouri River could be managed for different fishery goals for flathead catfish to accommodate a variety of angler types and desires.

KEYWORDS: fisheries management, flathead catfish, movement, tagging.

Introduction

Catfish species are becoming increasingly important to anglers in the USA (USDC/USDI 1996), and flathead catfish, *Pylodictis olivaris* (Rafinesque), has been described as a popular and important component of many fisheries (McCoy 1955; Mayhew 1969; Quinn 1993). However, there is a paucity of information on population dynamics of flathead catfish to aid management (Quinn 1993). Additionally, many anglers are not satisfied with the emphasis placed on catfish management by agencies responsible for this task (Arterburn, Kirby & Berry 2001). For the last century, catfish management has aimed at satisfying the majority of anglers, and little effort has been placed on managing this valuable resource, particularly in large lotic systems (Pugh & Schramm 1999). This philosophy has traditionally sought to provide maximum sustained harvest and generally not promoted high-quality fishing opportunities. This type of management provides good fishing opportunities for most people, but may not optimise maximum growth potential of catfish or desires of some anglers who seek large fish.

In a recent survey, both anglers and biologists from the Mississippi River basin (Arterburn *et al.* 2001) agreed that trophy catfish, in particular blue catfish, *Ictalurus furcatus* (LeSueur), and flathead catfish, are important angling resources worthy of more intensive management. Biologists have been successful in managing for quality-sized fish for a variety of species such as largemouth bass, *Micropterus salmoides* (Lacépède), (Weithman & Anderson 1977), muskellunge, *Esox masquinongy* (Mitchell), (Cornelius & Margenau 1999), and trout, *Oncorhyncus* spp. (Shetter & Alexander 1965). While biologists surveyed agreed that growing larger catfish was a worthy goal, they also agreed that they had more questions than answers, and the issue needed further study before implementing additional regulations (Cofer, Kirby & Arterburn 2002).

The lower Missouri River has been an important catfish fishery for several decades (Weithman & Fleener 1988), but little information exists on recreational

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aspects of this fishery other than limited creel survey information (Stanovick 1999). The Missouri Department of Conservation (MDC) began an angler exploitation study on flathead catfish in 1999 to gain insight into this important component of the fishery. The study also provided an opportunity to gain information on flathead catfish movements within the Missouri River via angler tag returns and recapture of tagged fish by MDC. Knowledge of fish dispersion patterns can contribute to effective management of fish populations. Fish exhibiting limited movement are more likely to respond positively to management strategies compared with more nomadic species. Thus, movement information on flathead catfish is important in determining the spatial scale at which to manage this species in the Missouri River as a high-quality fishery if angler interest dictates. Specific objectives of this study were to examine: (1) overall dispersal distances of flathead catfish from the Missouri River; (2) differences in dispersal distances and direction (i.e. upstream or downstream) among various sized flathead catfish from the Missouri River; and (3) differences in dispersal distances over time for flathead catfish from the Missouri River.

Materials and methods

The Missouri River is the longest in the United States at 3768 km. River slope varies from about 38 m km^{-1} in the Rocky Mountains (upper basin) to an average of 0.17 m km^{-1} in the Great Plains (middle basin) and central lowlands (lower basin). The Missouri River has a drainage area that encompasses about 1 327 000 km^2 or about one sixth of the continental United States (Fig. 1). The drainage basin is generally arid and subject to seasonal and long-term droughts because of the dominance of the Great Plains physiographic region. Annual discharge at the mouth is about 7.0×10^{10} m^3. Modifications to the Missouri River have been immense and ongoing for over 150 years. Bank stabilisation and channelisation have occurred along the entire lower 1178 km of river, primarily for commercial navigation. Six mainstem reservoirs have been constructed between river kilometres 1305 and 2851. These reservoirs impound 9 150 000 ha m, and they were constructed for flood control, hydropower, navigation, irrigation, water supply, and recreation.

Flathead catfish were collected with a pulsed DC electric fishing boat (3–4 A; 170–200 V; 40% duty cycle; < 20 pulses s^{-1}) that was followed by a chase boat about 50 m behind. Electric fishing was conducted in an upstream direction and fish were collected within a 92-km section of the Missouri River between river kilometres 695–787 near St Joseph, Missouri (Fig. 1) during the first two weeks of June in 1999, 2000 and 2001. Effort was evenly distributed along the study reach. This section of the Missouri River was selected because of its proximity to an urban area with a high concentration of fishing effort (St Joseph, Missouri) and the relatively high number of public river accesses for angler use. Barriers to fish movement are non-existent in this area. The nearest dam on the mainstem Missouri River is 518 km upstream (Fig. 1), and most tributaries near the study have few, if any, obstructions.

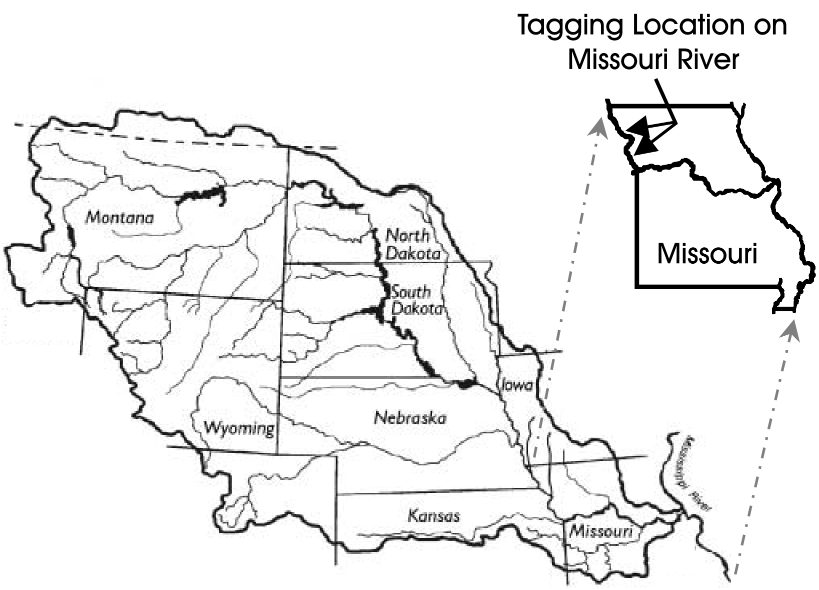

Figure 1. Flathead catfish tagging study area on the Missouri River, 1999–2001.

Flathead catfish were collected near shore along shallow (< 1.5 m) mud banks on inside bends of the river, along steep (approximately 3:1 slope) revetted rock banks on outside bends of the river, or along the numerous rock dykes on inside river bends that assist in maintaining the commercial navigation channel. Flathead catfish were measured (total length, TL mm), and marked with individually numbered Carlin dangler tags attached to the middle of a stainless steel wire. The two wire ends were inserted below the dorsal fin between dorsal pterygiophores. The two wire ends encompassed at least one dorsal pterygiophore, and thus, were well secured to the fish. This tagging method was tested on 38 flathead catfish held in a hatchery pond for 1 year with no tag loss (V. Travnichek, unpublished data). Flathead catfish were collected along the entire 92-km section of the Missouri River, and fish were marked and released within 3.2 km of their collection site. The river kilometre where each fish was tagged and released was determined from navigation charts and river kilometre markers along the river.

The minimum size of flathead catfish generally harvested by anglers was 305 mm, and this was determined from harvest information from previous creel surveys along the Missouri River (J. Stanovick, personal communication). Thus, this was the minimum size of fish used for this study. To encourage tag returns by anglers, tags were marked on one side with 'MO CONS DEPT REWARD ($5–100)'. The reward, $5, 20, or 100 US, was randomly assigned to individual tag numbers regardless of fish size; rewards were mailed to anglers after tags were returned. Anglers catching a tagged fish provided information regarding length and weight of fish, date and location caught, and whether or not the fish was harvested. Information regarding the tagging project was publicised both locally and across the state of Missouri. Information was posted locally at boat ramps, river accesses and bait shops, and regional and state-wide coverage of the project was publicised through state-wide newspaper, radio, and TV press releases each year the fish were tagged to inform anglers and to encourage tag returns. Dispersal information was also gathered by recapture of tagged fish in subsequent electric fishing samples during 2000 and 2001 (fish recaptured via further sampling during the same year they were tagged were ignored). Distance moved (km) for each fish recaptured was determined, although it was recognised that fish may have moved greater distances than calculated as only the distance moved between tagging and recapture was known.

To examine differences in dispersion patterns of various sized fish, flathead catfish were placed into one of three size groups (305–380, 381–507 or ≥508 mm). One-way analysis of variance (ANOVA) with a Bonferroni multiple comparison test was used to determine if significant differences ($\alpha < 0.05$) existed in mean movement among the three size groups. Direction of movement (i.e. upstream or downstream) from the original tagging location was also determined and proportions of fish showing directional movement were compared with a Z test ($\alpha < 0.05$). A two tailed t test was used to determine if significant differences ($\alpha < 0.05$) existed in mean distance moved between the two directions. To examine differences in dispersal patterns over time, flathead catfish were placed into one of five categories based on length of time between marking and recapture (i.e. < 1, 1–3, 3–12, 12–24 or > 24 months). ANOVA with a Bonferroni multiple comparison test was used to determine if significant differences ($\alpha < 0.05$) existed in mean movement among the five time periods.

Results

A total of 2939 flathead catfish ranging in size from 305 to 1118 mm TL was tagged. Dispersal was determined for 370 flathead catfish in the Missouri River from tag returns by anglers ($n = 277$) and marked fish recaptured by the MDC ($n = 93$). Overall, mean distance travelled by flathead catfish was 6.5 km, and minimal movement was detected for most flathead catfish. Twenty percent of the flathead catfish were recaptured at their tagging location (Fig. 2; Table 1). Over 80% of the tag returns were within 5 km of tagging location, and 89% were within 10 km of tagging location (Fig. 2). Less than 25 of the 370 recaptured flathead catfish moved over 20 km, and only six of these fish moved over 50 km (Fig. 2). Maximum dispersal was 161 km (Table 1), and it

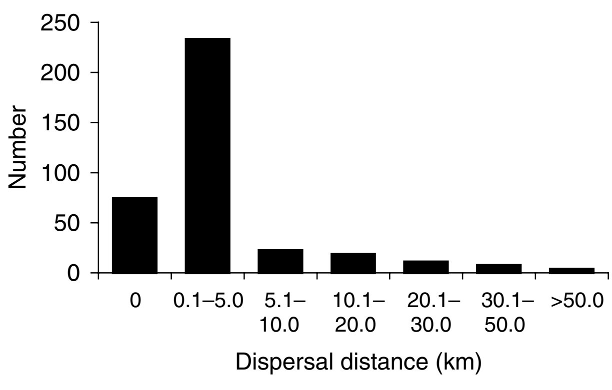

Figure 2. Distance moved by flathead catfish tagged in the Missouri River, 1999–2001.

Table 1. Movement (in km) of various sized flathead catfish in the Missouri River 1999–2001

	Movement direction						
	Downstream			Upstream			
Size group (mm)	*n*	Mean	Maximum	*n*	Mean	Maximum	None
305–380	58	6.5	71	58	5.0	48	34
381–507	80	7.6	50	49	5.2	21	24
≥508	27	4.8	45	25	28.7	161	15
Total *n*	165			132			73
Percentage	44			36			20

occurred over an 87-day period. Another flathead catfish moved 113 km up a tributary, the Nodaway River, over a 33-day period. Most fish were caught by anglers in the mainstem Missouri River, but seven fish were caught in tributary streams.

Distance travelled for various sized flathead catfish (305–380, 381–507 or ≥ 508 mm), regardless of dispersal direction, was significantly different ($P = 0.0006$; d.f. = 2, 367; $F = 7.63$) among the three size groups, and was greatest for the largest size group. Dispersal distance averaged 4.5, 5.6 and 12.6 km for small, medium, and large size classes, respectively. When dispersal direction was examined, there was a significant ($P < 0.001$; d.f. = 2, 129; $F = 14.23$) upward trend in dispersal for larger-sized flathead catfish that moved upstream (Table 1); however, no significant difference ($P = 0.40$; d.f. = 2, 162; $F = 0.91$) was found among size groups for flathead catfish that moved downstream (Table 1). No significant difference ($P = 0.14$; d.f. = 171; $t = 1.48$) was observed between mean dispersal length for fish moving upstream (9.5 km) and downstream (6.8 km). However, a greater proportion ($P < 0.01$) of flathead catfish moved downstream (56%) for those flathead catfish that exhibited movement.

Differences in dispersal patterns over time were also examined. Flathead catfish were placed into one of five categories based on length of time between being tagged and being recaptured (i.e. < 1, 1–3, 3–12, 12–24 or > 24 months). No significant difference ($P = 0.17$; d.f. = 4, 365; $F = 1.51$) in average movement among time periods was found (Table 2). However, there did appear to be an upward trend in distance moved for those fish that were tagged and at-large for a greater length of time.

Table 2. Mean and maximum movement (in km) of flathead catfish over time in the Missouri River 1999–2001

Time period at large	Mean movement (km)	Maximum movement (km)	*n*
< 1 month	3.2	24	64
1–3 months	7.3	161	100
3–12 months	6.3	50	35
12–24 months	6.1	97	138
> 24 months	11.1	110	33

Discussion

Dispersal of flathead catfish in the Missouri River was localised for most fish, and these results are consistent with the few studies conducted on flathead catfish movements in lotic system. One of the earliest studies on flathead catfish movement in streams showed that about half of the 43 recovered fish moved < 2 km, 77% moved < 16 km, and no fish moved further than 40 km (Funk 1957). Grace (1985), using telemetry, found that mean home range of 14 flathead catfish in the Missouri River was 10.5 km. Pugh & Schramm (1999) noted that 17 of 18 flathead catfish in the lower Mississippi River were recaptured within 1 km of their release site, and the other fish was recaptured < 6 km from its release site. Dames, Coon & Robinson (1989) noted that 14 of 16 flathead catfish moved less than 14 km in the Missouri River and a tributary stream, Perche Creek. However, the other two recaptured fish moved considerable distances, 100 and 313 km. Dobbins, Cailteux & Nordhaus (1999) examined movements of introduced flathead catfish in the Apalachicola River in Florida, and they found 96% of fish were recaptured within 8 km of the tagging location. Finally, Skains & Jackson (1993) determined from telemetry that the linear range of flathead catfish in two Mississippi streams ranged from 0.48 to 1.85 km. Additionally, they tagged 219 flathead catfish in these two streams; eleven of these fish were recaptured, and they moved less than 3 km from release sites.

Limited dispersion of flathead catfish was noted in this study. However, the sampling effort for recaptures was confined to the 92 km study section of the

Missouri River. Additionally, most of media and public awareness efforts towards anglers were conducted in the vicinity of the study area. Thus, dispersal patterns of flathead catfish may be biased in this study because tagged fish may have moved great distances, but because of lack of public awareness outside the study reach, tag detection and reporting rates by anglers may have been limited.

Results from this study showed that flathead catfish greater than 508 mm moved on average 12.6 km, and average distance moved for this size group was about twice that observed for smaller sized flathead catfish. Past research indicated that home range for a variety of fishes increases with body size (Minns 1995). This trend was also shown for flathead catfish. Skains (1992) found that in the Tallahatchie River, Mississippi, larger flathead catfish (> 600 mm) had larger home ranges compared with smaller sized fish (< 600 mm). However, no difference was found between the two size classes in the big Black River, Mississippi (Skains 1992).

Twenty percent of the flathead catfish in this study were collected in close proximity to their tagging location, and thus showed no dispersal. Additionally, 44% of the flathead catfish moved in a downstream direction and 36% moved upstream. Coon & Dames (1989) noted similar directional movement patterns in Perche Creek, Missouri. They found that 18–22% of flathead catfish did not move at all. They also noted that more flathead catfish moved downstream (47–67%) compared with upstream (11–35%). Funk (1957) found that about half (53%) of the flathead catfish in his study did not move at all. However, he also noted more dispersal downstream (33%) compared with upstream (14%).

Most flathead catfish in this study exhibited limited dispersal within the Missouri River, but a few fish moved long distances. Funk (1957) proposed that native populations of stream fishes comprised two segments, a sedentary group and a mobile group. Other studies showed similar results. Over half of the resident Japanese charr, *Salvelinus leucomaenis* (Pallas), marked in a Japanese stream remained in the pool they were initially captured in for up to 365 days, while other fish moved at least 4 km (Nakamura, Maruyama & Watanabe 2002). Most Patagonian toothfish, *Dissostichus eleginoides* (Smitt), from the Indian Ocean moved less that 28 km over a 3-year period, but four fish were recaptured between 390–1916 km from the original tagging location (Williams, Tuck, Constable & Lamb 2002). Finally, Starr, Heine, Felton & Cailliet (2002) found that subadults of bocaccio, *Sebastes paucispinis* (Ayres), were more mobile than adults, and as the fish increased in size they became more sedentary. This information was important with regards to designing marine reserves to assist in protecting this species. Fishery managers need to recognise that these different life history strategies may exist within a population, and thus, they should use this information to assist them in designing effective management strategies for various fisheries.

While biological information is important in managing any fishery, sociological information regarding anglers is also needed. There is growing recognition that outdoor recreation participants display a wide variation in their experiences, avidity, expertise, commitment, economic expenditures and social interactions within a given activity, and that these factors are related to expectations and preferences of the recreationists (Ditton, Loomis & Choi 1992; Salz, Loomis & Finn 2001). This variation and specialisation has been shown in anglers (Hahn 1991; Allen & Miranda 1996; Ditton 1996), and many of these specialised anglers prefer catching trophy-sized fish (Hampton & Lackey 1976; Arlinghaus & Mehner 2003). The MDC currently manages several species to provide anglers opportunities to catch quality-sized individuals in specified management zones by imposing large minimum length limits and/or reducing or eliminating harvest. Special management areas are in place for muskellunge, rainbow trout, *Oncorhynchus mykiss* (Walbaum), brown trout, *Salmo trutta* L., blue catfish, smallmouth bass, *Micropterus dolomieu* (Lacépède), rock bass, *Ambloplites rupestris* (Rafinesque), and warmouth, *Lepomis gulosus* (Cuvier), and these areas provide different angling experiences for the diverse angling public in Missouri.

Mayhew (1969) indicated that flathead catfish are commonly considered big game from an angling standpoint, and many anglers accept the low productivity often associated with fishing for flathead catfish for the opportunity to catch a few, exceptionally large fish. Arterburn, Kirby & Berry (2002) indicated that 75% of all anglers they surveyed within the Mississippi River basin were in favour of developing trophy flathead catfish fisheries, yet only 65% of those anglers surveyed were in favour of more stringent regulations to produce trophy opportunities for flathead catfish. Similar to basin-wide results, 75% of Missouri resident anglers surveyed were in favour of developing trophy flathead catfish fisheries, while only 61% were in favour of more stringent regulations to produce trophy opportunities for flathead catfish (Arterburn *et al.* 2001).

Assuming it is desirable to manage a segment of the flathead catfish population for larger-sized individuals, one would need to identify where the best opportunities are located to produce trophy-size individuals. State agency experts and anglers both identified the Missouri River as one of the best systems for producing large flathead catfish (Arterburn *et al.* 2002). Another piece of information needed would be at what spatial scale to apply special management strategies. Skains & Jackson (1993) suggested that flathead catfish management be on a local level (i.e. 2-km segments). However, Coon & Dames (1989) and Pugh & Schramm (1999) suggested managing flathead catfish on a larger scale (i.e. managing river systems separately). Results from this study indicate that flathead catfish moved very little in the Missouri River, and a 50-km reach of the Missouri River might be an appropriate length of river to manage for different fishery goals for flathead catfish. This reach length would be appropriate for the Missouri River because of movement patterns of flathead catfish within this system and for enforcement purposes. Major landmarks would be necessary for anglers to determine beginning and ending points of special management zones. Bridge crossings would be a likely marker on the Missouri River. However, bridge crossings on the Missouri River in rural areas are not common and occur at irregular intervals of about 45 km. Thus, based on both flathead catfish movement patterns and distances between bridge crossings, a 50-km reach seems to be an appropriate length to manage for different fishery goals for flathead catfish in the Missouri River.

Few studies have incorporated dispersal patterns of fish and then used this information in an adaptive approach to begin managing fisheries to meet different desires of the anglers. However, some studies have suggested managing fisheries on a more localised scale. Miranda (1999) classified 349 reservoirs in the United States using cluster analysis, and suggested that reservoirs within each of the five clusters could be managed for a different goal. However, it was noted that region-wide policies for reservoirs within a cluster should be resisted because of large variability in harvest among reservoirs within a region. Williams *et al.* (2002) found that Patagonian toothfish showed limited movement, and current management and assessment programmes that treat these fisheries independently from one another among various sections of the Indian Ocean are valid.

Anderson & Nehring (1984) examined special regulation zones for rainbow and brown trout in a Colorado stream, and they found that biomass, size structure, overall catch rate and catch rate of trophy-sized fish were all greater in the management zone compared with control areas without special regulation. While Anderson & Nehring (1984) did not establish management zones based on movement patterns of the trout within their study area, they likely presumed that the fishes had limited movement Gerking (1959). Finally, Lake Tanganyika hosts one of the largest inland fisheries in Africa, and it is a significant source of food and livelihood to millions of people dwelling both inside and outside the basin. However, effective management is difficult because of competing interests of commercial, recreational and subsistence fisheries as well as different nations each having some management authority over the lake (Molsa, Reynolds, Coenen & Lindqvist 1999). Characteristics of Tanganyika's fish stock dynamics, as well as distribution and composition of its fisheries across national divides call for management calibrated at the scale of the entire lacustrine system, but management approaches must also be capable of adjustment to meet episodes of localised stock fluctuation (Molsa *et al.* 1999).

Catfish angling is growing in popularity, and there is growing recognition of trophy potential of flathead catfish, channel catfish, *Ictalurus punctatus* (Rafinesque), and blue catfish (Arterburn *et al.* 2002). Catfish anglers place more emphasis on catch and harvest compared with anglers fishing for other species (Wilde & Ditton 1999). However, fisheries managers need to be aware of specialised angler group preferences to prevent problems associated with simply managing for the 'average' catfish angler (Schramm, Forbes, Gill & Hubbard 1999), a practice that has generally guided catfish management for the last century. Successful strategies for managing catfish populations to improve trophy opportunities have not been documented, but movement information on flathead catfish indicates that managing specialised fisheries in segments of the Missouri River is possible.

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