Short-Term and Seasonal Movements of Brook Trout in the Upper Savage River Watershed, Garrett County, Maryland

Matthew T. Sell[1], Alan A. Heft[1], David C. Kazyak[2], Robert H. Hilderbrand[2], and Raymond P. Morgan II[2]

[1]Maryland Department of Natural Resources, Inland Fisheries Management 301 Braddock Road, Frostburg, MD, USA 21532
[2]Appalachian Laboratory, University of Maryland Center for Environmental Science, 301 Braddock Road, Frostburg, MD 21532

Abstract—We used radio telemetry to determine movement patterns of adult Brook Trout *Salvelinus fontinalis* in the upper Savage River, Garrett County, Maryland. The lower main-stem river is a stocked fishery (daily creel of 5 trout), whereas the rest of the watershed is managed as wild trout water, artificial lures only, with no harvest of Brook Trout. Our objective was to determine if fluvial Brook Trout use the lower reaches of the river seasonally, where they are susceptible to harvest. Sixteen large Brook Trout (> 240 mm total length) were implanted with radio tags and located regularly over the tag lifespan (~1 year). Most fish (10 of 16) migrated upstream (>100 m) to upper river reaches or tributaries in late spring as lower main-stem water temperatures neared 20°C. The mean upstream movement was 5.9 km, with one individual exceeding 11 km. Some fish (2 of 16) moved <100 m, remaining in relatively deep pools near their tagging location. All tagged Brook Trout were sedentary from late June into October, moving only slightly (<100 m) to spawn. After spawning all but two of the migratory fish quickly moved (within 7 d) back to the general areas in the main-stem river where they were tagged; many (7 of 10) returned to the same pool. Consequently, fluvial Brook Trout mobility and the timing of their movements make them susceptible to angling harvest in the lower main-stem Savage River.

Introduction

The upper Savage River (USR) is the only remaining Brook Trout *Salvelinus fontinalis* watershed in Maryland to allow unrestricted movement throughout the watershed. Due to declining populations, great measures have been taken to conserve the Brook Trout in the Savage River watershed (Heft et al. 2006), including a no-harvest, artificial-lure-only regulation, which began in 2007 for most of the watershed.

In addition to the more common stream resident fishes, we have recently discovered a population of large, fluvial Brook Trout that seasonally inhabit the lower reaches of the USR. This mobile component remains poorly characterized and seasonally inhabits the only reach that remains open to Brook Trout harvest – the Savage River Put and Take management area (SRPT) (Figure 1).

Prior to the new regulation (pre-2007), anglers rarely reported catching large Brook Trout (>200mm total length) in the SRPT. Since the regulation change, there has been a substantial increase in angler reports of large Brook Trout being captured, supported by Maryland DNR sampling data which has shown an increase in the average and maximum size of Brook Trout in the system (Hilderbrand 2012). As the size and number of Brook Trout have increased, angler reports and current creel survey information (Sell et al. 2012) suggest that a relatively large number of adult Brook Trout are being harvested in the SRPT. Additionally, it is likely that Brook Trout harvest is particularly high during the spring months (March through May) when angling pressure is at its highest and surface water temperatures are best suited for Brook Trout habitation in the main-stem USR.

Our objectives were to determine the movement patterns of Brook Trout in the main-stem USR watershed using radio telemetry and determine their susceptibility to harvest in the SRPT. We tested the hypothesis that Brook Trout in the put-and-take section of the USR inhabit the area seasonally and migrate to thermal refugia when summer water temperatures exceed their thermal limitations.

Study Site

The USR is a large watershed located in east-central Garrett County, Maryland and is part of the larger North Branch of the Potomac River drainage. The watershed covers approximately 300 km^2 and ranges in elevation from 290 m at its mouth to over 850 m at its origin. Most (53%) of the watershed area is within state-owned property, including the Savage River State Forest and is mostly mixed deciduous and coniferous forest. Some low density residential homes (seasonal camps in the lower portion of the watershed and some residential homes in the upper third) and a moderate amount of agriculture in the headwaters comprise the remaining land cover (Figure 1).

The USR system consists of the main-stem upper Savage River from the Savage River Reservoir upstream to the headwaters, eight named tributaries, and many unnamed tributaries. Water chemistry and habitat are typical of freestone Appalachian streams. The main-stem USR experiences low summer flows and water temperatures that typically exceed 20° C (Figure 3), the upper temperature tolerance for Brook Trout (Fisher and Sullivan 1958; Power 1980; Hartman and Cox 2008). Upper Savage River tributaries have maximum water temperatures that rarely exceed 20° C and support fish assemblages representative of high gradient coldwater Appalachian streams, whereas main-stem USR assemblages are more diverse and representative of low to moderate gradient, Appalachian streams (MD DNR 2005). Brook Trout are the only wild salmonid species within the watershed. Stocked Rainbow Trout *Oncorhynchus mykiss* are typically confined to the main-stem USR, have negligible survival, and no reproduction. Brown Trout *Salmo trutta* stocking was discontinued in the mid-1980s, and they are now considered extirpated from the USR system.

Methods

Fifteen large (> 240mm) Brook Trout were collected by angling from the put-and-take management area on the USR during the period of February 2 through February 22, 2012. Additionally, one Brook Trout was collected during this same time period in a tributary stream (Poplar Lick) to investigate the possibility that there are stream resident "tributary fish" in the USR tributaries.

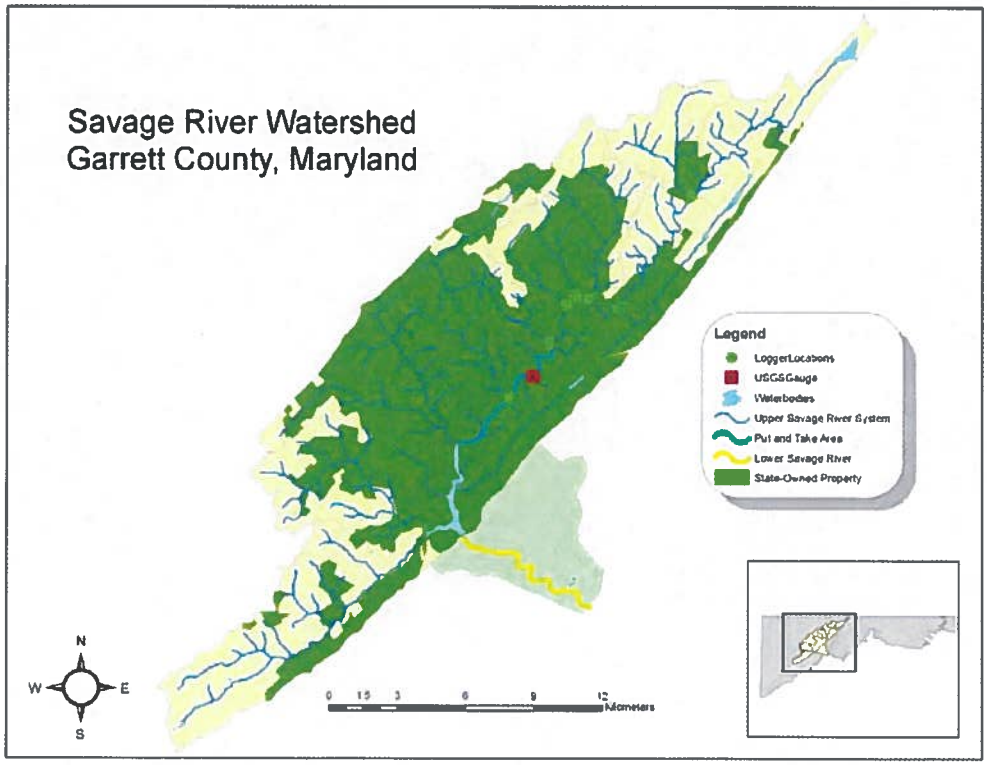

Figure 1. Study area, showing state-owned property and temperature logger locations.

Captured fish were immediately transported to an in-stream live well where they were measured. Fish ≥240mm, total length (TL) were then tagged. The minimum size threshold of 240 mm was determined using long-term Brook Trout length-weight relationship developed by the MD DNR in the USR system. Tagging above this threshold ensured that the tag weight was always below 2.5% of the fish's total weight (Winter 1983; Swanberg 1997).

Brook Trout were anesthetized using a diluted (1 ml clove: 2 L water) clove oil solution (buffered with ethanol, 1:10), checked for injuries, and abdominally implanted with a radio tag (Advanced Telemetry Systems model F1170, 45 pulses per minute). Fish were allowed to recover in an in-stream live well for approximately 15 min and were returned to their place of capture.

Tracking was initiated on March 1, 2012 after the tagged trout were at large for at least 2 weeks and continued until the tags had expired (~1 year). We used a directional loop antenna along the entire main stem and eight major tributaries to the USR. Initially, tracking occurred at least once weekly, slowed to biweekly when fish movements slowed or stopped, and again resumed weekly when movements resumed. From late September through the end of November, tracking was conducted weekly to determine any movements associated with spawning activity.

The exact location of tagged fish was recorded using a hand-held GPS unit. The general habitat type where the fish was located was recorded (i.e. deep pool, run, riffle and whether woody debris or other gross instream habitat was present) and water temperature was measured at each location. Brook Trout locations were downloaded to ArcGIS (v. 10.0), where movement distances were calculated.

Continuous summer water temperature data were collected at 1-h intervals using HOBO brand in-stream devices in the eight tributaries of the USR as well as at multiple locations in the main-stem USR (Figure 1). Data were collected from June through August and were used to determine mean and maximum summer water temperatures. Annual main-stem water temperatures were obtained from the U.S. Geological Service (USGS) gauging station (gauge #01596500) located near the middle of the put-and-take section (J. Dillow, U.S. Geological Survey, personal communication) (Figure 1).

Results

Trout Movements

We obtained long-term data (> 3 months) from 12 of the 16 tagged Brook Trout, but the four remaining trout disappeared by mid-May and were assumed to have been harvested. Of the 12 Brook Trout tracked long-term, eight made large-scale movements (>500 m) away from their capture locations, and two made moderate upstream movements (100-500 m). Movements by these 'mobile fish' all occurred during the early summer coincident with water temperatures approaching 20°C. Movements back into the main-stem river during the late fall were not temperature related, but rather, appear to be closely tied to the conclusion of spawning. Two of the 12 trout remained resident within 100 m of their capture location for the entire period, where they remained in large pools throughout the summer. The 'tributary fish' in Poplar Lick was sedentary throughout the study.

Migratory fish moved an average of 5.9 km upstream and into either the upper reaches of the main-stem river (n=4), into Poplar Lick (n=4), or the Little Savage River (n=2). After their initial migration, these trout exhibited sedentary tendencies throughout the summer months. During the fall spawning period, small movements upstream or downstream occurred. After spawning, most of the migratory fish (8 of 10) quickly returned to the area where they were tagged, seven of whom returned to the same pool where they were collected (Figure 2).

Localized movements for both migratory and resident trout were generally diurnal and restricted to the riffle areas immediately adjacent to the pools where they were tagged. These movements were typically less than 50 m and seemed to be related to feeding activity rather than directed movement.

The following is a summary of four representative and remarkable migratory fish movements.

Fish 041 was caught and tagged on February 21, 2012 in a large pool downstream of Westernport Road and was located on six separate occasions during the study period. This fish remained in the original pool for the majority of the spring and early summer until it was found in early July in the little Savage River, ~4.7 km from where it was tagged. It remained there until October 10, 2012, when it was found ~600 m upstream

in an area on the Little Savage River known locally as "Jacob's Ladder", and was observed building a redd. On November 20, 2012 this trout was found <50 m from the pool in which it was tagged.

Fish 280 was caught and tagged on February 7, 2012 in a large pool near the mouth of Bear Pen Run and was located on 10 separate occasions during the study . It remained in the pool where it was tagged until it was found in early July near the headwaters of Poplar Lick, ~11.1 km upstream. The trout remained there until November 6, 2012, when it was found in the pool where it was originally tagged. This trout moved the farthest of any migratory fish.

Fish 411 was caught and tagged on February 2, 2012 in a logjam near the USGS gauging station on the USR and was located on 11 separate occasions during the study . Initially the fish remained at its tagging location until July 5, 2012 when it was located ~6.3 km upstream in a large main stem pool. It remained there throughout the fall and was last found in the same location on November 26, 2012. This was one of only two migratory fish that did not return to the area it was tagged after spawning.

Fish 421 was caught and tagged on February 2, 2012 in the Poplar Lick tributary and was located on 12 separate occasions during the study period. It remained in the same pool throughout the study period.

Temperature

Temperatures in the main-stem USR were suitable for Brook Trout throughout most of the year (Figure 3). However, by mid-June daily maximum water temperatures regularly exceeded 20°C, and remained elevated until early September. Tributary water temperatures were elevated above those of previous years. The average and maximum monthly temperatures exceeded 20°C in many of the major tributaries, including Poplar Lick, but remained noticeably cooler than the main-stem USR, and only occasionally exceeded 20°C. Thus, we believe the tributaries provided adequate thermal refugia despite elevated temperatures.

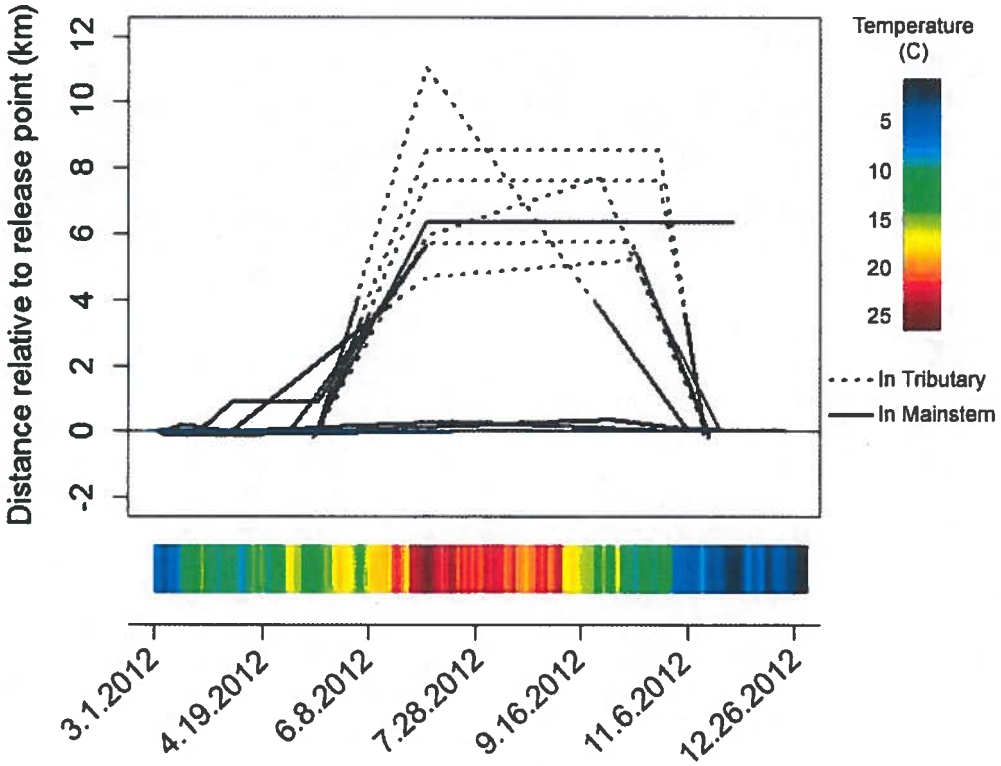

Figure 2. Movements of all tagged Brook Trout, relative to their point of release. Maximum daily temperatures shown in color bar.

Conclusions and Management Implications

Brook Trout in the USR main stem exhibited strong seasonal movements, often migrating long distances and frequently into tributaries. Migrations were coincident with increasing water temperature during late spring and at the conclusion of spawning during late fall. Our data suggests the USR population complex contains a continuum of movement strategists similar to salmonids elsewhere (Gowan et al. 1994; Hilderbrand and Kershner 2000; Curry et al. 2002; Petty et al. 2005 2012) with a mix of resident, semi-mobile, and highly mobile fish. However, the degree to which the various movement 'strategists' change behaviors or function as a single population, meta-population, or discrete populations is unknown and the subject of ongoing research.

The timing of residency in the USR main-stem suggests the fluvial Brook Trout are susceptible to harvest, as they reside in the put and take management area during the spring fishing season. Creel surveys confirm harvest of large Brook Trout, and include an angler who reported harvesting a radio-tagged Brook Trout during the spring 2013. Regardless of whether these fluvial fish contribute genetically to the viability of the resident population in tributaries, they form an important part of the USR Brook Trout complex, as the large females may contribute disproportionately more to recruitment because fecundity scales non-linearly with length (Power 1980). Therefore, better information on susceptibility to harvest is needed to maintain a viable fluvial component for both the population and recreational angling.

The radio telemetry data have allowed a better understanding of how Brook Trout use the entire USR system, as well as identified critical reaches for growth, reproduction, and survival – a point further emphasized by the high site fidelity exhibited in the fluvial component of the population. We now realize the USR Brook Trout complex is a highly connected system that cannot be managed as independent reaches or tributaries without considering the responses of those actions cascading to influence other connected streams. Although a few of the tributaries to the USR are contained within state-owned property, many are

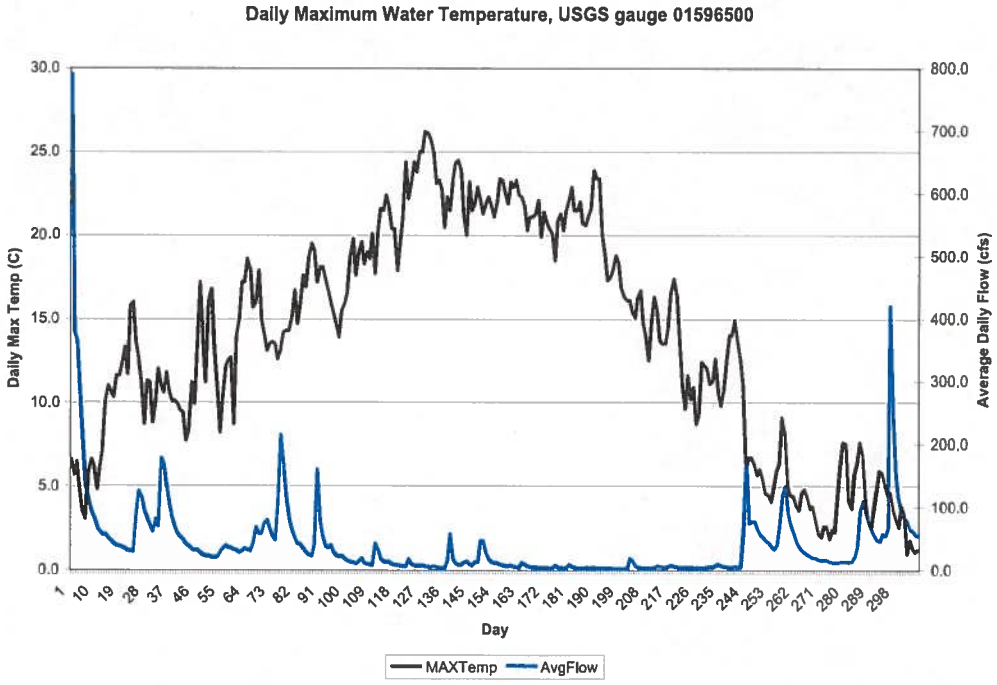

Figure 3. Annual daily maximum water temperatures and average daily flows on the mainstem USR during the study period, as recorded at the USGS gauging station (01596500). Day 1 = March 1, 2012.

not, but still have the potential to influence the entire fishery. Minimizing thermal gains in those areas by maintenance or establishment of riparian buffers and removal of heat sinks, such as small ponds, needs to occur. Likewise, two major tributaries are completely disconnected from the USR during low summer flows. This eliminates miles of potential thermal refugia during the summer months and could be rectified with habitat restoration. Such remediation and the subsequent cooling effects would help to maximize the amount of available habitat to the USR Brook Trout population, provide more reliable thermal refugia, and reduce main-stem temperatures during the summer.

Acknowledgements

We would like to thank the Maryland Department of Natural Resources, Trout Unlimited, and Garrett Community College for contributing financially and physically to this research. We would specifically like to thank the Western Maryland Regional Offices of Inland Fisheries under Alan Klotz and John Mullican for their invaluable assistance with the collection of Brook Trout for tagging and Garrett College student Ryan Cooper for his tireless efforts in tracking fish.

References

Curry, R. A., D. Sparks, and J. van de Sande. 2002. Spatial and temporal movements of a riverine Brook Trout population. Transactions of the American Fisheries Society 131:551-560.

Fisher, K. C., and C. M. Sullivan. 1958. The effect of temperature on the spontaneous activity of speckled trout before and after lesions of the brain. Canadian Journal of Zoology 36:49–63.

Gowan, C. M., K. Young, K. D. Fausch, and S. C. Riley. 1994. Restricted movement in resident stream salmonids: a paradigm lost? Canadian Journal of Fisheries and Aquatic Sciences 51:2626-2635.

Hartman, K. J., and M. K. Cox. 2008. Refinement and testing of a Brook Trout bioenergetics model. Transactions of the American Fisheries Society 137:357–363.

Heft, A. A. 2006. Maryland Brook Trout Management Plan.

Hilderbrand, R. H., and J. L. Kershner. 2000. Movement patterns of stream-resident cutthroat trout in Beaver Creek, Idaho-Utah. Transactions of the American Fisheries Society 129:1160-1170.

Hilderbrand, R. H. 2012. Assessing the effectiveness of the Savage River Brook Trout regulations – sampling year 2012. Annual report to Maryland Department of Natural Resources Fisheries Service, unpublished.

MD DNR (Maryland Department of Natural Resources). 2005. Survey and management of Maryland's fishery resources. Annual (2005) and final (2001-2005) performance report: 219-393.

Petty, J. T., P. J. Lamothe, and P. M. Mazik. 2005. Spatial and seasonal dynamics of Brook Trout populations inhabiting a central Appalachian watershed. Transactions of the American Fisheries Society 134: 572-587.

Petty, J. T., J. L. Hansbarger, B. M. Huntsman, and P. M. Mazik. 2012. Brook Trout movement in response to temperature, flow, and thermal refugia within a complex Appalachian riverscape. Transactions of the American Fisheries Society 141:1060-1073.

Power, G. 1980. The brook charr, Salvelinus fontinalis. Pages 141–203 *in* E. K. Balon, editor. Charrs, salmonid fishes of the genus Salvelinus. Dr. W. Junk, The Hague, The Netherlands.

Sell, M. T., and Heft, A. A. 2012. An evaluation of use, techniques, demographics, and fishing success by anglers in the Savage River put and take management area. Report to Maryland Department of Natural Resources Fisheries Service, unpublished.

Swanberg T. R. 1997. Movements and habitat use by fluvial bull trout in the Blackfoot River, Montana. Transactions of the American Fisheries Society 126:735-746.

Winter, J. D. 1983. Underwater biotelemetry. Pages 371-395 *in* L. A. Nielsen, D. L. Johnson, and S. S. Lampton, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.