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Evaluation of the Fish Community and Related Ecological Features of the Middle Branch River, Osceola County

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Abstract.–An evaluation of the Middle Branch River was conducted between 1998 and 2001 to assist in developing resource management decisions. Fish species composition, fish abundance, fish biomass, water temperatures, and water discharge and yield were evaluated. Water quality habitat was degraded downstream of Marion Impoundment. The fish community of the river changed from primarily cold-coolwater species upstream of Marion Impoundment to primarily cool-warmwater species downstream of the impoundment. Coldwater habitat could be restored in approximately 16 miles of the Middle Branch River by removing the detrimental water quality effects of Marion Dam and Impoundment.

Introduction

The Middle Branch River, located in Osceola County in the northern portion of Michigan's Lower Peninsula, is one of the principal tributaries of the Muskegon River (Figure 1). The entire length of the Middle Branch River (33 miles) is a designated trout stream, and a 7.3 mile section extending upstream from Marion Impoundment to 60th Avenue is designated as a Blue Ribbon Trout Stream by the Department of Natural Resources.

Management options provided in the Muskegon River Watershed Assessment (O'Neal 1997), and the Muskegon River Watershed Plan (O'Neal 2003) recommend that the Middle Branch River be managed for cold water fisheries, and that efforts be made to restore water quality in reaches that may be impaired. Discussions between the Michigan Department of Natural Resources and the Village of Marion regarding issues related to Marion Dam have been ongoing since publication of the assessment. Marion Dam was originally constructed in 1893 to service the lumbering industry. Presently, the dam/impoundment is used only for recreation. Additional information was needed to assist in decision making on restoration activities and to aid in planning.

This report provides a brief evaluation of relevant ecological features and biological potential of the Middle Branch River, and is intended to help in developing goals for natural resource protection and restoration. Special emphasis was placed on fisheries and the effects of Marion Dam and Impoundment.

Methods

Catchment Description

The catchment composition of the Middle Branch River is a mixture of moderate relief coarse end moraines, coarse till plains, with some outwash plains. The stream channel is sporadically-confined by morainic features within a broad glacial-fluvial valley. The stream is classified mesotrophic, with moderate nutrients. Land cover of the catchment is a mixture of forest, light agriculture, with some wetlands especially in the headwaters (Seelbach et al. 1997).

Landscape-based groundwater velocity models developed by Baker et al. (2003) indicate that the Middle Branch River catchment has geologic and topographic characteristics that provide relatively high groundwater velocities. Groundwater inputs are highest in the upper and middle portions of the river. These groundwater velocities suggest that the Middle Branch River has relatively high base flows and moderate peak flows.

Physical Measures

To assess present physical conditions, reach gradient and stream flow was measured at nine sampling stations. These stations were located at 80th Avenue, 20 Mile Road, 50th Avenue, 21 Mile Road, just upstream of Marion Impoundment, Marion Dam discharge, M-66 south of Marion, M-61, and ½ mile upstream of the confluence with the Muskegon River (Figure 1). Water temperatures were collected at a subset of these sites.

Reach gradient was determined for each site using USGS 1:24,000 scale topographic maps. Stream discharge was measured at each site during July 2001 using an electronic Global Flow Probe manufactured by Global Water Instrumentation. Analysis of USGS stream flow data from the Clam River gauging station at Vogel Center (13 miles from the Middle Branch at Marion) indicated that July stream flows for 2001 were below normal (mean discharge for July 2001 = 74.9; mean July discharge from 1966 to 2001 = 90.3 cfs). Based on this information it was assumed that observed discharge patterns in the Middle Branch River reasonably approximated base-flow conditions.

Base-flow yield was calculated by dividing base-flow discharge by catchment area. Individual upstream catchment boundaries were delineated for each site based upon subwatershed divides mapped by the MDNR from USGS 1:24,000 scale topographic maps. Watershed boundaries were then locally modified for each site using a 3 arc-second digital elevation model (at a scale of 1:250,000). Catchment areas were measured using ArcView (ESRI Inc.).

Water temperature data were collected at hourly intervals with continuous temperature recorders manufactured by Onset Computer Corporation (Stowaway XTI, range 23.0 to 98.6 °F, +- 0.6 °F). Temperature data were collected at various sites during 1998, 1999, and 2001. Field calibrations of recorders were made using an Ashcroft Precision Handheld RTD Thermometer (range -60 to 750 °F, +-0.5 °F). Observed water temperatures from the discharge of Marion Dam were compared to Michigan Surface Water Quality Standards (MAC R 323.1041 – R 323.1117 promulgated pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994, PA 451, as amended). To determine if observed water temperatures below Marion Dam exceeded the 2 ºF allowable increase set by Michigan Surface Water Quality Standards, 1.2 ºF was added to account for monitor precision (i.e., 3.2 ºF was used to evaluate compliance to the Standard).

Biological Measures

Fish samples were collected upstream of Marion Impoundment (50th Avenue), and downstream of Marion Dam (M-66 and M-61) during summer 1998 by Michigan Department of Natural Resources personnel using standard boat mounted stream electro-fishing gear. Fish numbers were estimated using Peterson mark-recapture procedures. Biomass was estimated using standard length-weight equations for Michigan fishes (Schneider 2000).

Results

Gradient

The Middle Branch River has an average gradient of 6.8 ft/mi, similar to the other principal tributaries and to the middle portion of the mainstem Muskegon River (Figure 2). This gradient provides riffle pool sequences with good hydraulic diversity, and good fisheries habitat in Michigan streams. Stream gradient under Marion Impoundment averages 6.9 ft/mi.

Hydrology

Discharge increased from headwaters to mouth, with the exception of one site (Figure 3). Generally, increases in discharge were greatest in the upper and middle portions of the river, consistent with groundwater velocity model descriptions. There was a decrease of 6.4 cubic feet per second (cfs) across the Marion Dam Impoundment. Based on average yield in the stream, there should have been a 0.8 cfs increase in discharge on this river segment. The combination of the loss and expected gain represents an estimated 16.8% loss of total stream discharge across the impoundment in Marion, on July 26, 2001.

Base-flow yield values at nine stations were compared to the 95% summer flow exceedence values for Michigan's Lower Peninsula coldwater streams (data provided by Paul Seelbach, Michigan Department of Natural Resources, personal communication). Water yields for the Middle Branch River were within limits typically found for other Michigan coldwater streams, with the exception of the most upstream site at 80th Avenue (Figure 4).

Water Temperatures

Water temperatures were colder in the upper portion of the river, increased significantly below Marion Dam, then stabilized and sometimes cooled somewhat in downstream reaches (Figure 5). This pattern was consistent for all three years.

Water temperatures upstream of Marion Impoundment and downstream of Marion Dam were compared to Michigan Surface Water Quality Standards. The number of hourly readings exceeding the monthly Standard was much greater downstream of Marion Dam than upstream of the impoundment (Table 1). Marion impoundment increased summer monthly average temperatures from 5.9 ºF to 7.6 ºF downstream of Marion Dam during the three-year period. The 2 ºF Water Quality Standard was exceeded in 93.0% to 97.7% of total hourly readings (Figure 6).

Fisheries

Trout biomass was significantly greater upstream of the impoundment (Figure 7). Juvenile trout were absent from sites downstream of Marion Impoundment. It is probable that trout were migrating into the lower reaches from segments upstream of Marion Impoundment.

Twenty-one species of fish were collected (Table 2). The fish community upstream of Marion principally contained species that preferred cold to cool water temperatures, while the fish community downstream of Marion had greater diversity and contained a majority of species that preferred cool to warm water temperatures.

Discussion and Recommendations

Results of this evaluation indicate that the Middle Branch River is a coldwater stream capable of supporting coldwater species throughout most of its length. Currently, however, discharge, water temperature, and fish community composition in the lower half of the river are impaired by Marion Dam Impoundment. The results of the present study are consistent with the findings of Lessard (2000) who also concluded that Marion Dam had significant effects on the water temperatures, fish community composition, and invertebrate community composition in the Middle Branch River.

Three years of water temperature evaluations revealed Marion Impoundment was increasing water temperatures in the Middle Branch River. The one measurement of discharge indicated water losses were occurring across the impoundment. The measured changes in summer discharge and water temperature below Marion Dam resulted from the physical changes associated with impounding the river. Physical changes such as increased stream width, decreased water velocity, and reduced shading from vegetation, result in increased evaporative losses and increased water temperature in the impoundment. Additional information is needed to determine how extensive alterations in discharge are throughout the year, and these are especially a concern during the summer months when discharge is often low and water temperatures are elevated.

Changes in biomass and density of brown trout in the Middle Branch River appear to be directly related to changes in thermal characteristics of the river. Wehrly et al. (1998) evaluated the patterns of fish distribution related to thermal habitat conditions in lower-Michigan streams. His evaluations indicated thermal habitat conditions in the Middle Branch River for coldwater fish communities were good upstream of Marion Impoundment but marginal downstream of the impoundment. Brown trout biomass and density upstream and downstream of Marion impoundment were within ranges expected for water temperatures measured at those locations (Figure 8, data from Troy Zorn, Michigan Department of Natural Resources, personal communication).

Changes in the fish community composition are also related to changes in thermal characteristics of the river. Zorn et al. (1998) found relationships between fish distribution patterns, stream size, and hydrology in Michigan streams. These analyses led to development of a model relating fish densities and habitat suitability based on July mean water temperature, catchment area, and low–flow yield (Troy Zorn, Michigan Department of Natural Resources, personal communication). Habitat suitability scores ranged from 0–least suitable habitat to 4–most suitable habitat, and composite scores were determined by averaging the 3 habitat variables. Composite scores for the 6 abundant species of fish collected upstream of Marion Impoundment ranged from 2.3 to 3.3 (Table 3). The model was used to predict habitat suitability under natural conditions for the downstream site, assuming Marion Impoundment was not present. Downstream values for model variables used to make predictions were estimated based on average water temperature and low–flow yield increases per mile of stream from adjacent upstream sites. Predicted scores for the 6 fish species were nearly identical to the site located upstream of Marion Dam, indicating fish community changes should not be significant between these sites. A change in the fish community was apparent downstream of Marion Impoundment. The three relatively abundant fish found at the downstream site were burbot, white sucker, and mottled sculpin. Composite scores for white sucker were higher than the upstream site, and lower for mottled sculpin. Habitat suitability for burbot, white sucker, mottled sculpin, brown trout, and brook trout were directly related to the July mean temperature variable, with scores changing by a factor of 2 to 3 (Figure 9). The catchment and low–flow yield scores were unchanged across sites for all of these species.

Coldwater habitat could be restored in approximately 16 miles of the lower river by removing the detrimental water quality effects of Marion Dam and Impoundment. Currently, base-flow discharge in the lower river is adequate to support trout but elevated water temperatures result in marginal conditions. Removing the dam would provide cooler water to the lower river and observed groundwater inputs would help maintain cool water temperatures in downstream reaches. Removing the dam would also alleviate other potential detrimental effects such as, fragmentation-blockage of fish and invertebrate movements, dissolved oxygen declines, interruption in sediment transport, and losses of productive high gradient stream sections (O'Neal 1997).

Coldwater streams are a limited resource in Lower Michigan, where approximately 25% of stream segments are classified coldwater (Seelbach et al. 1997). Coldwater systems in Michigan are at risk due to extensive human development in watersheds. Development generally degrades water quality conditions and destabilizes the hydrology in these streams. Coldwater streams typically support higher densities of game fish than warmwater systems, and serve as spawning grounds and nursery areas for Great Lakes fish (O'Neal 1997). They are an important recreational fishery resource in Michigan. Streams with characteristics typical of the Middle Branch River have average angler-day/mi values of 831/year, with an estimated economic value of $22,437/mile/year (Michigan DNR creel census records; dollar values based on an estimated angler-day value of $27 from the U. S. Department of the Interior, 2001).

The Muskegon River Watershed Assessment and Plan provide many options for management and improvement of the mainstem and tributaries. Two of the most important issues that must be addressed are the effects of dams, and protection and restoration of system hydrology. A healthy watershed cannot be restored or maintained without appropriate management in these two areas. Water quality conditions (especially water temperature) and hydrology are affected by Marion Dam, and both of these critical habitat features can be improved on the Middle Branch River by removing Marion Dam, or separating Marion Impoundment from the river.

Restoring habitat conditions in the lower portion of the Middle Branch River will contribute, and is essential, to overall protection and restoration of the Muskegon River Watershed. Human development and resulting habitat changes have been occurring throughout the watershed for over 150 years. Restoration and protection efforts will require a long-term approach and must be pursued in all sub-watersheds. The Middle Branch River is one of the larger tributaries of this system. The stream has some of the most productive moderate-gradient reaches for fisheries in the watershed, and especially in the upper portion of the watershed. It is located in a region of high groundwater velocities, and where most of Michigan's high quality coldwater streams are located.

The Middle Branch River coldwater fisheries can be improved, the river can provide seasonal refuge for fish in the mainstem, and can provide good quality spawning and rearing habitat for Great Lakes fish once fish passage is opened to this river segment.

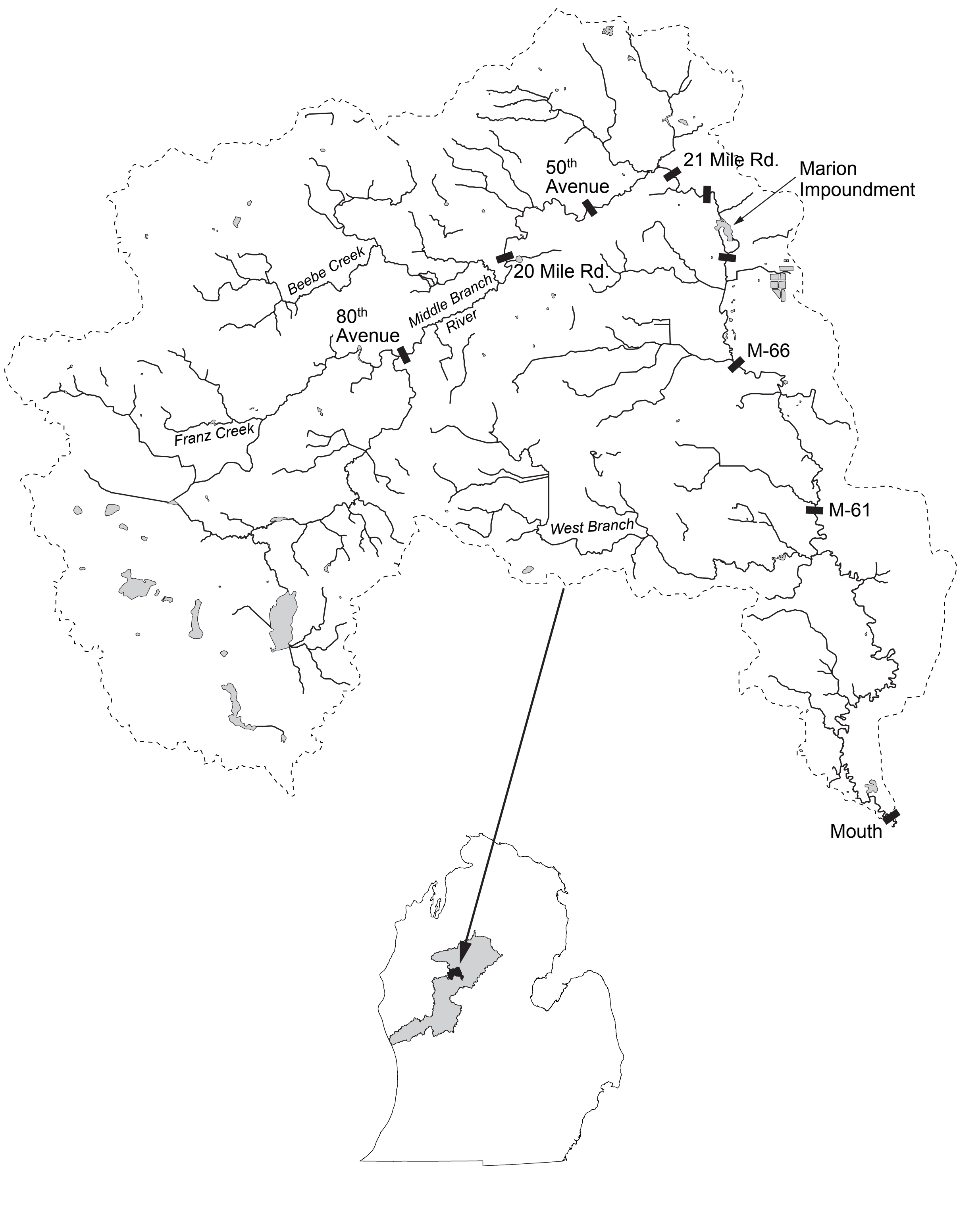

Figure 1.–The Middle Branch River watershed and sampling locations.

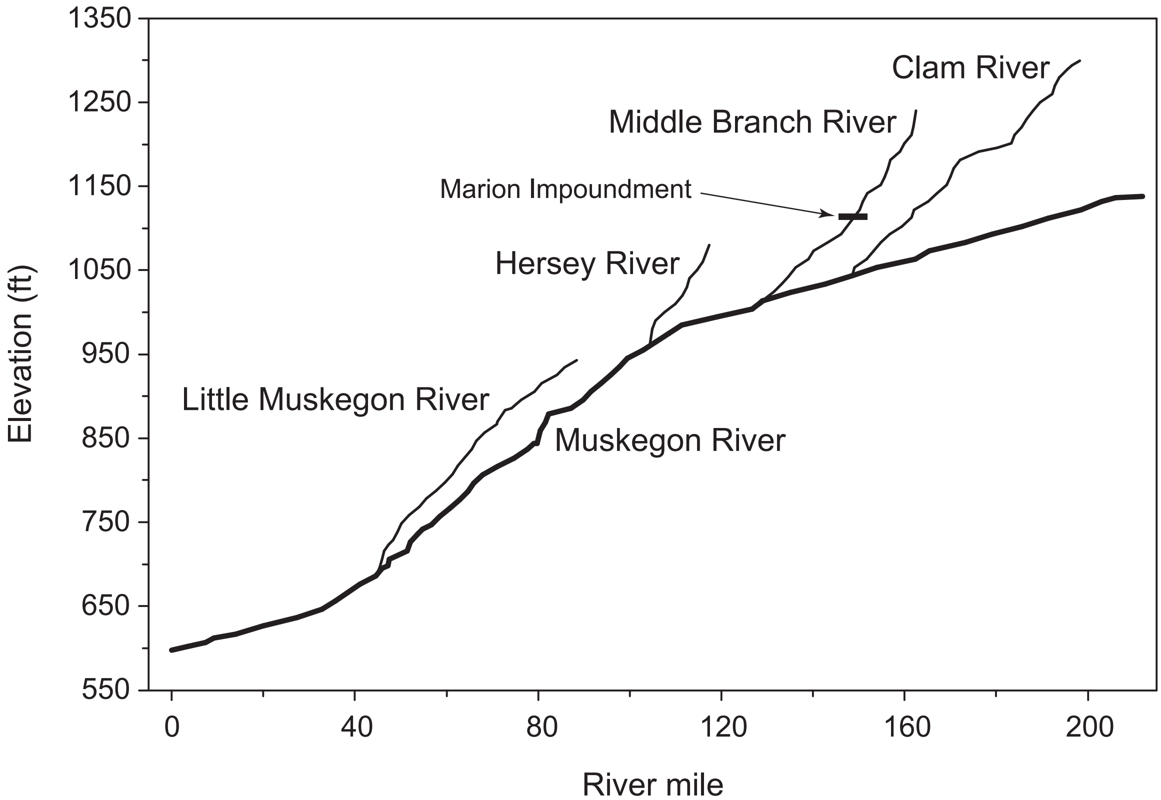

Figure 2.–Gradient profile of the Muskegon River and principal tributaries.

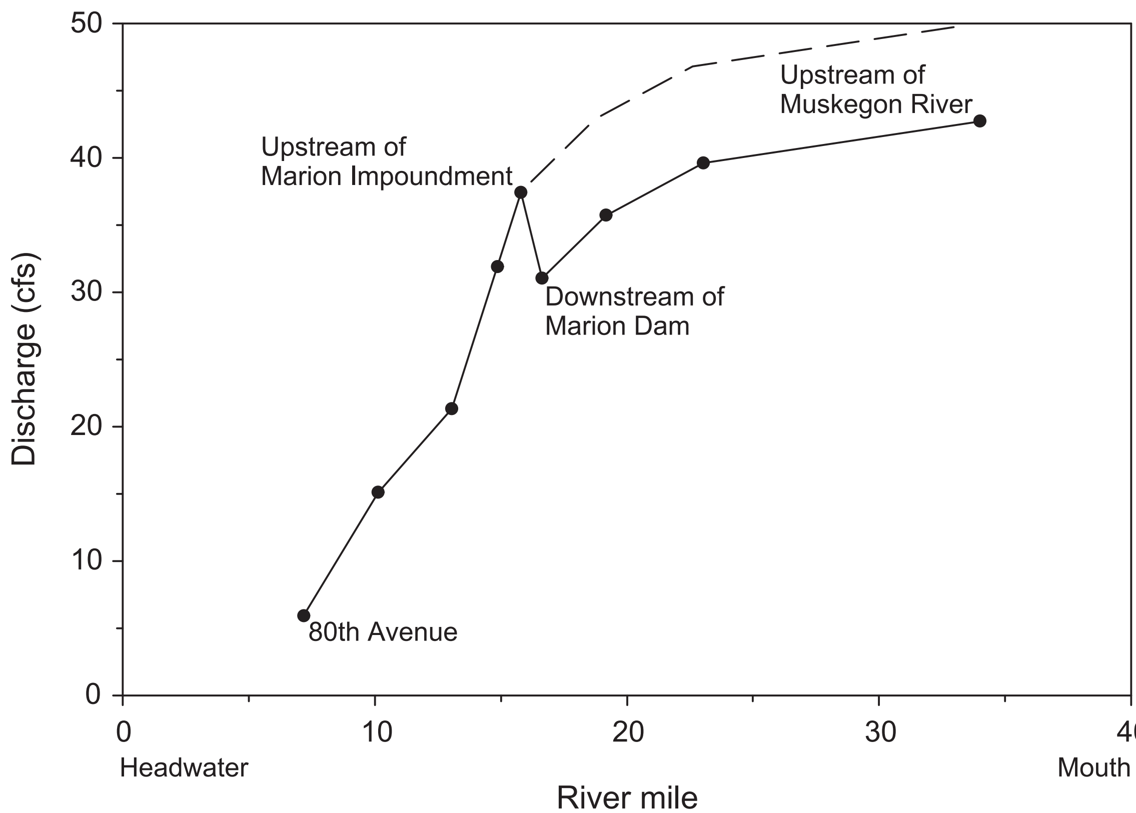

Figure 3.–Middle Branch River water discharge measurements collected on July 26, 2001. Potential discharge without Marion Dam is shown with dashed line.

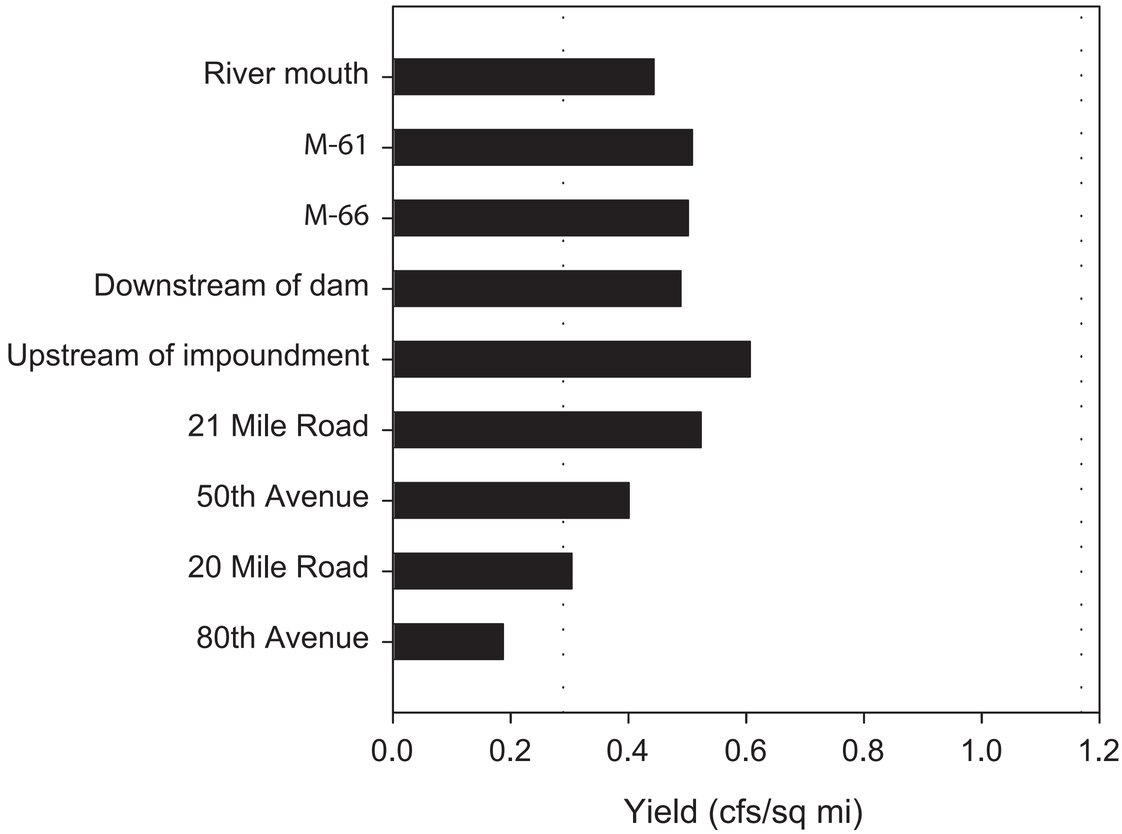

Figure 4.–Middle Branch River water yield values at nine locations (July 26, 2001), compared to 95% exceedence values (dotted lines) for lower Michigan coldwater streams. Coldwater stream limits represent two standard error intervals for coldwater stream summer yields in the Lower Peninsula of Michigan (Paul Seelbach, Michigan Department of Natural Resources, personal communication).

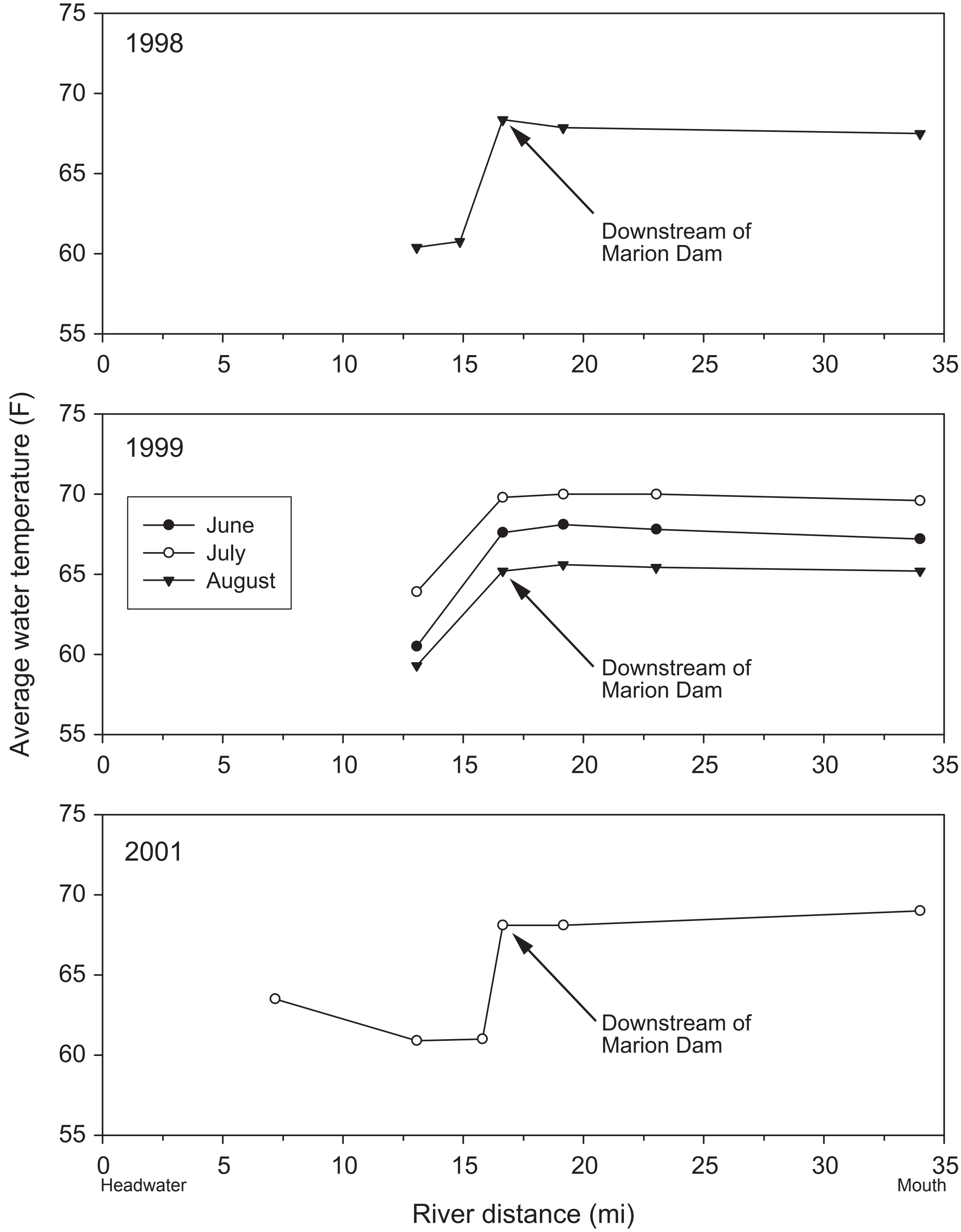

Figure 5.–Average water temperatures on the Middle Branch River during August 1998 (top), June–August 1999 (middle), and July 2001 (bottom).

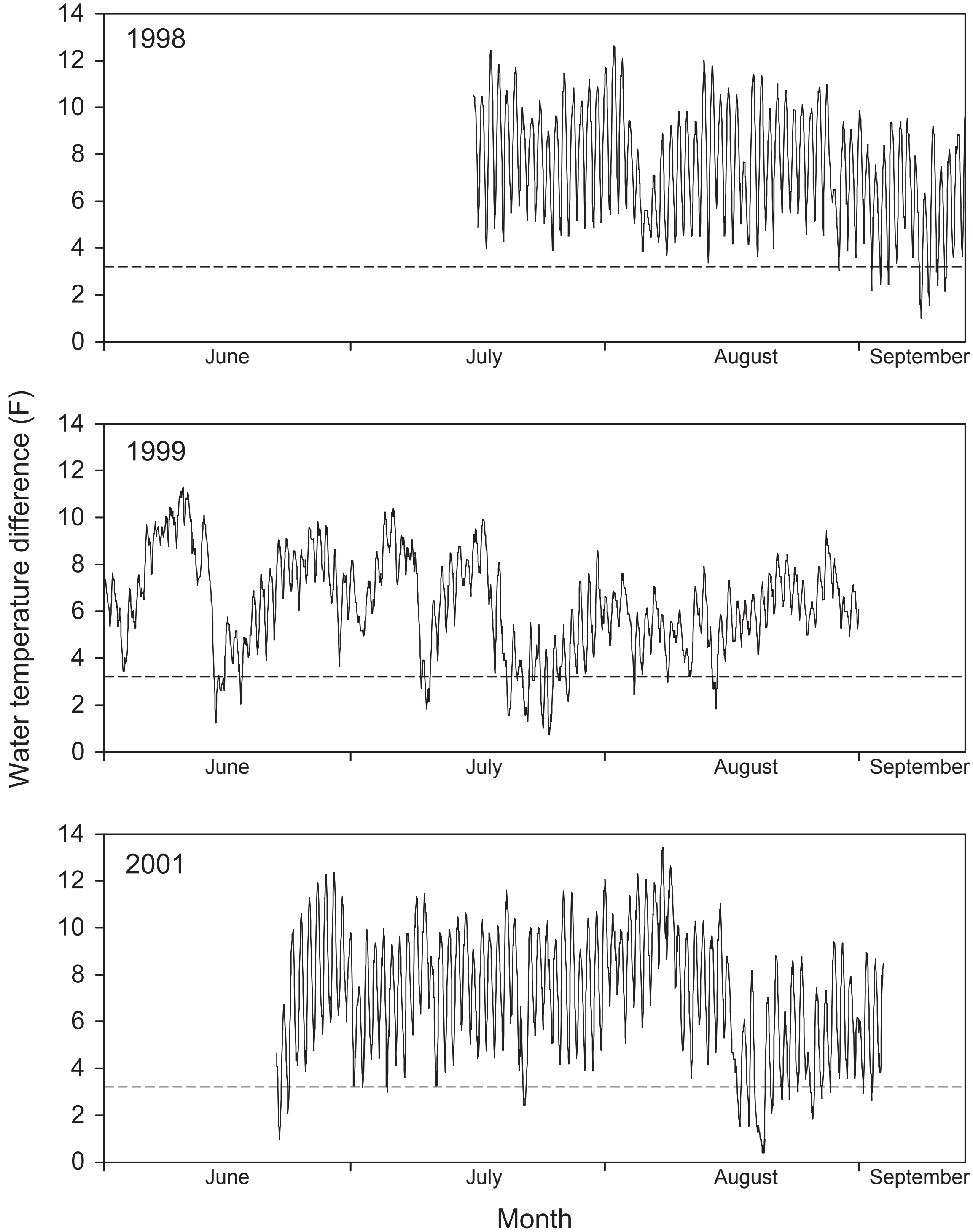

Figure 6.–Water temperature increases from upstream of Marion Impoundment to downstream of Marion Dam, July 16–September 13, 1998 (top), June 1–August 31, 1999 (middle), and June 22–September 3, 2001 (bottom). Horizontal lines represent the maximum temperature increase allowable under Michigan Surface Water Quality Regulations.

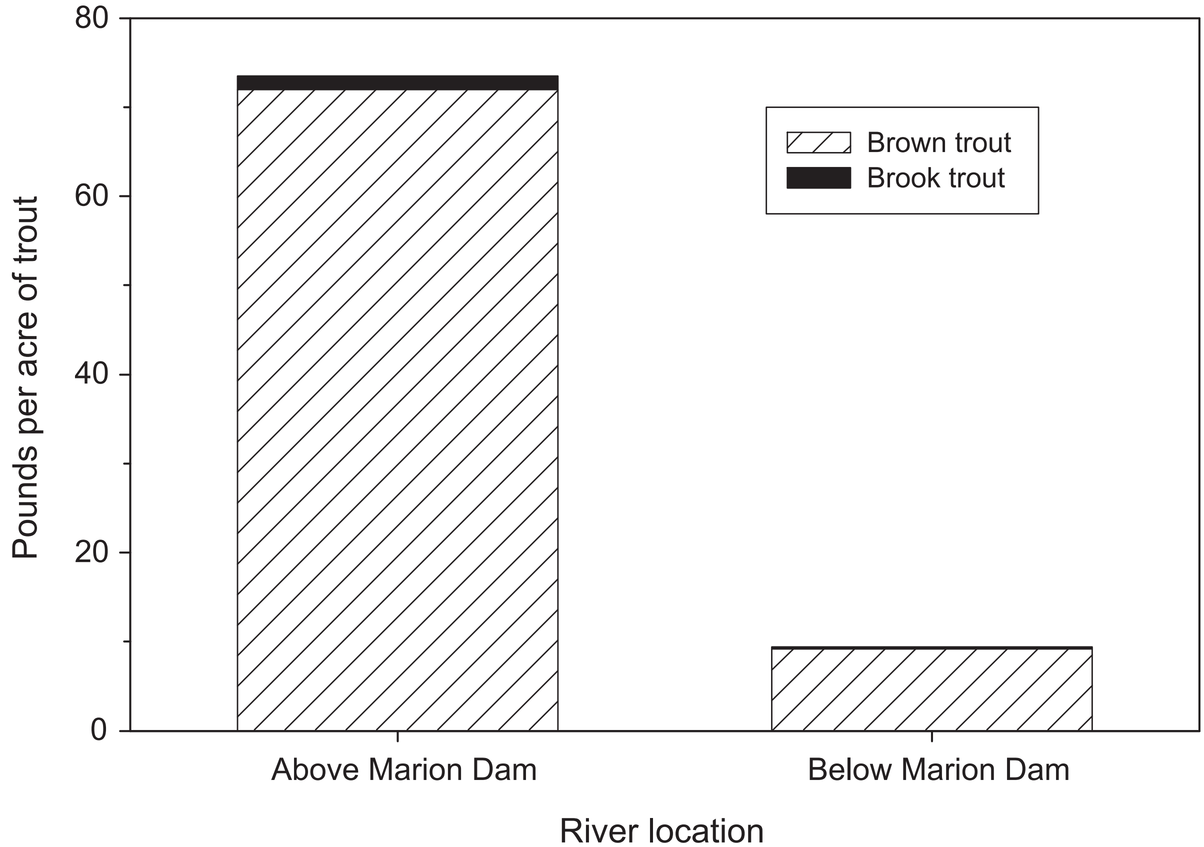

Figure 7.–Biomass of trout collected upstream of Marion Impoundment and downstream of Marion Dam in summer 1998.

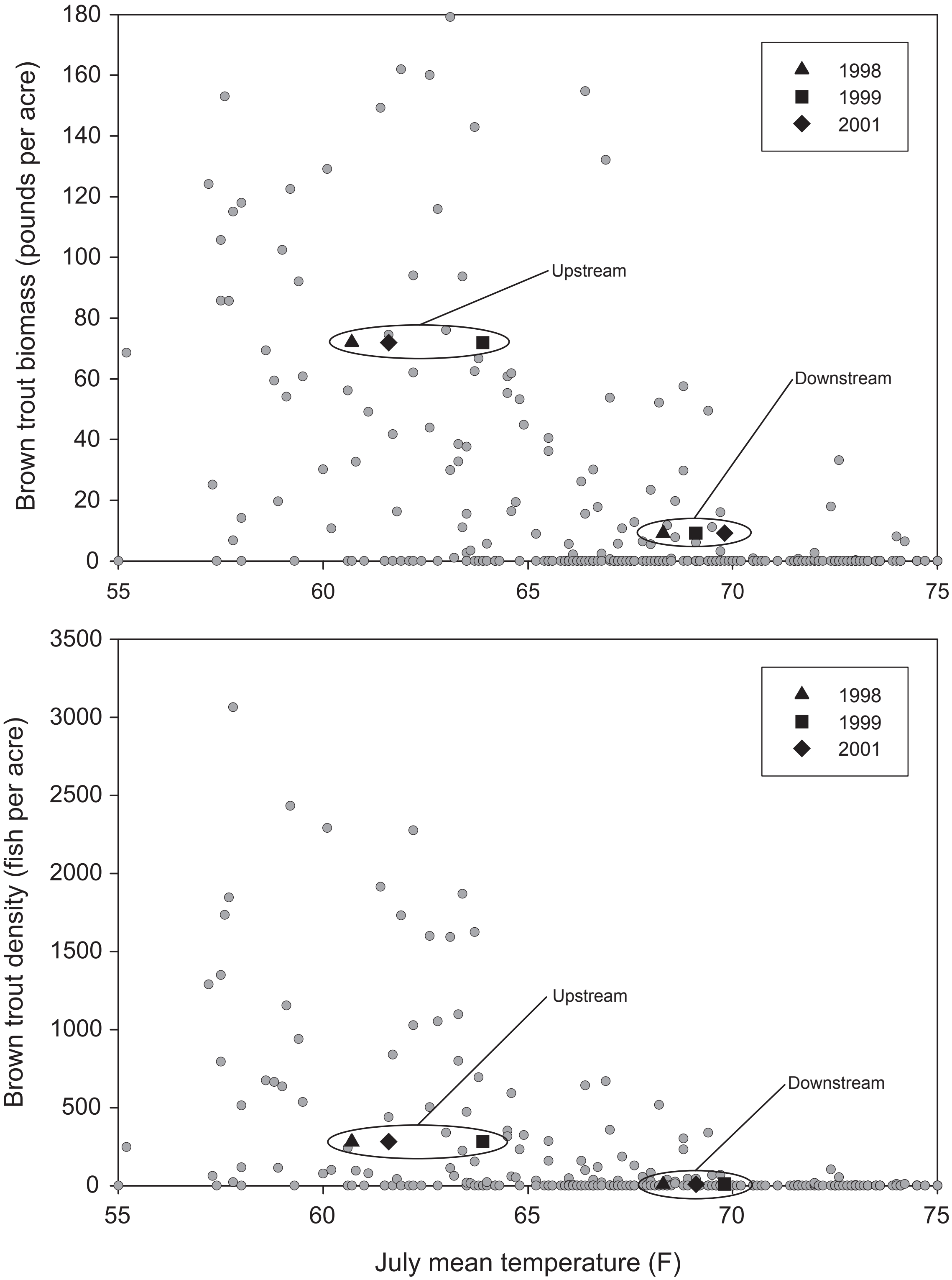

Figure 8.–Water temperature, biomass, and density comparisons for brown trout in the Middle Branch River and other lower Michigan streams. Middle Branch River values are provided for 1998, 1999, and 2001 upstream of Marion Impoundment and downstream of Marion Dam. Base data from Troy Zorn (Michigan Department of Natural Resources, personal communication).

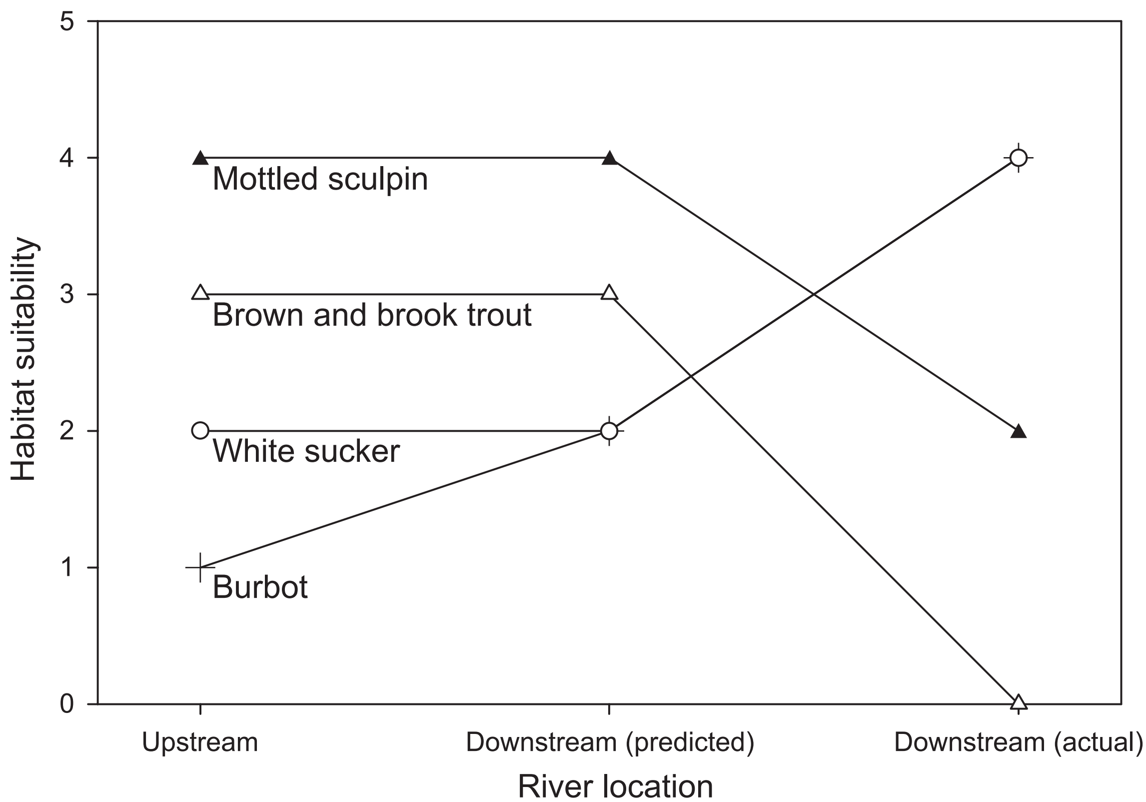

Figure 9.–Habitat suitability estimates for 5 species of fish found in the Middle Branch River. Habitat suitability scores range from 0–least suitable to 4–most suitable (Model was provided by Troy Zorn, Michigan Department of Natural Resources, personal communication). River locations indicate sites upstream and downstream of Marion Impoundment. The model was used to provide scores for actual downstream site conditions and predicted natural conditions assuming no impoundment was present.

Table 1.–Middle Branch River water temperature information upstream of Marion Impoundment and downstream of Marion Dam, 1998, 1999, and 2001. The Michigan Surface Water Quality Standard monthly maximum for this stream is 68 ºF.

Year	Month	Location upstream or downstream of Marion Impoundment	Water temperature			Number of readings	Number of readings >68 ºF	Percentage of readings >68 ºF
			Mean	Minimum	Maximum			
1998	August	Upstream	60.7	53.8	68.1	744	1	0.1
1998	August	Downstream	68.3	61.3	75.2	744	387	52.0
1999	June	Upstream	60.5	52.5	67.5	720	0	0.0
1999	June	Downstream	67.6	55.9	76.7	720	365	50.7
1999	July	Upstream	63.9	55.6	71.6	744	91	12.2
1999	July	Downstream	69.8	60.7	80.2	744	487	65.4
1999	August	Upstream	59.3	52.8	66.6	744	0	0.0
1999	August	Downstream	65.2	59.3	72.7	744	82	11.0
2001	July	Upstream	61.6	52.1	71.1	744	30	4.0
2001	July	Downstream	69.1	56.2	79.8	744	447	60.1
2001	August	Upstream	61.2	55.0	72.3	744	47	6.3
2001	August	Downstream	68.1	57.3	83.1	744	352	47.3

Table 2.–Species of fish found in the Middle Branch River, upstream and downstream of Marion Impoundment in 1998[a]. Species are listed generally in order of increasing water temperature tolerance (Zorn et al. 2002).

Common name	Species	Upstream	Downstream
Brook trout	*Salvelinus fontinalis*	X	
Brown trout	*Salmo trutta*	X	X
Mottled sculpin	*Cottus bairdii*	X	X
Northern redbelly dace	*Phoxinus eos*		X
Western blacknose dace	*Rhinichthys obtusus*	X	X
Creek chub	*Semotilus atromaculatus*	X	X
Longnose dace	*Rhinichthys cataractae*		X
Johnny darter	*Etheostoma nigrum*		X
Central mudminnow	*Umbra limi*	X	X
Golden shiner	*Notemigonus crysoleucas*	X	
White sucker	*Catostomus commersonii*	X	X
Burbot	*Lota lota*		X
Rainbow darter	*Etheostoma caeruleum*		X
Green sunfish	*Lepomis cyanellus*	X	X
Common shiner	*Luxilus cornutus*		X
Bluegill	*Lepomis macrochirus*		X
Rosyface shiner	*Notropis rubellus*		X
Shorthead redhorse	*Moxostoma macrolepidotum*		X
Northern hog sucker	*Hypentelium nigricans*		X

[a] Blackside darter *Percina maculate* and lamprey *Ichthyomyzon* spp. were also found at locations downstream of Marion Impoundment.

Table 3.–Habitat suitability scores for dominant fish species found upstream and downstream of Marion Dam. The composite score is the average of the scores for July mean water temperature, catchment area, and low-flow yield. Scores range from 0 (least suitable) to 4 (most suitable) (Troy Zorn, Michigan Department of Natural Resources, personal communication). Habitat variables used in the model are in **bold** text.

Location Species	Composite score	July mean temperature (°F)	Catchment area (mi2)	Low flow yield (cfs/mi2)
Upstream		**63.9**	**61.6**	**0.61**
Brown trout	3.3	3	3	4
Mottled sculpin	3.3	4	3	3
Blacknose dace	2.7	3	3	2
Brook trout	2.7	3	1	4
White sucker	2.7	2	4	2
Green sunfish	2.3	1	4	2
Downstream (expected [a])		**64.4**	**63.3**	**0.60**
Brown trout	3.3	3	3	4
Mottled sculpin	3.3	4	3	3
Blacknose dace	2.7	3	3	2
Brook trout	2.7	3	1	4
White sucker	2.7	2	4	2
Green sunfish	2.7	2	4	2
Downstream (actual)		**69.8**	**63.3**	**0.49**
Burbot	3.3	4	3	3
White sucker	3.3	4	4	2
Mottled sculpin	2.7	2	3	3

[a] Expected values for temperature and low flow yield were estimated from average increases per mile of stream.

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