Assessment of MDNR Fisheries Division research for Rivers, Streams, and Floodplain Wetlands

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Historical approaches used and research areas covered

Historically the bulk of Michigan Department of Natural Resources Fisheries Division (FD) research on inland waters was conducted by researchers stationed at Ann Arbor, Lewiston, and Marquette. The current state of knowledge and technology influenced the type of research that was conducted. Prior to widespread use of computers and GIS (roughly 1990), Fisheries Division's research on rivers can be generally be characterized as follows. Research focused almost entirely on game fishes (especially inland trout), often on waters near these offices, with the bulk of work being conducted by FD Research Section personnel (Table 1). Much research fell under the "Population dynamics for key stocks" and "Evaluation of sport and commercial harvest regulations" research areas, with the following topics often being addressed: basic description of stocks and population parameters (e.g., abundance, growth, survival), effects of habitat change (e.g., sedimentation, eutrophication, sediment removal), and evaluation of regulations. Studies often used a before after control impact (BACI) approach to design and analysis.

Starting around 1990, widespread computer use brought unheard of analytical capability, and this increased efficiency in part enabled FD to dramatically increase the scope and analytic depth of its research (Table 1). The ease with which data could be summarized freed up researchers to synthesize data from across the state and conduct complex analyses. Researchers were no longer limited to focusing on one or a few species and a handful of localities. Studies incorporating data from hundreds of sites throughout the state and covering all fish species were initiated (e.g., Michigan Rivers Inventory), resulting in development of data, models, and results with state-wide applicability. Much progress has been made in several research areas particularly, Sampling, GIS development, Fish distribution, Habitat relationships, and Ecosystems. Studies involved process modeling of key habitat parameters (flow, temperature, channel characteristics), models and decision tools for describing and predicting species distribution and abundance patterns, updated distribution maps, and relationships between key habitat parameters and fish abundance. These studies led to stream classification efforts such as the Michigan VSEC, which provides the GIS sampling platform for FD's Stream Status and Trends Program (SSTP) and other statewide analysis efforts. Still, several local-based BACI-type studies were undertaken, addressing issues such as interactions between Great Lakes and resident salmonids, effects of dams and dam removal, evaluation of regulations, and returns of hatchery fish. Alternate sources of research funding became available during this period, and establishment of the Partnership for Ecosystem Research and Management (PERM) and other collaborations, led to much more work being accomplished through universities. As a result, we see more work being done, more synthesis, more collaboration, more detailed process modeling, more prediction of the biological potential of habitat, etc. Many studies during this period represented truly regional or statewide collaborative operations with data being collected and analyzed by FD (research and/or management) and university personnel.

Focus of current research

During the last decade FD's research in this theme has focused on several major areas (Table 1). Sampling, GIS, Distribution, Habitat Relationships, Ecosystems research areas are major areas of current research primarily due to research studies based upon around the SSTP, MRI, VSEC, and Michigan Fish Atlas projects. Additional GIS development has occurred through the externally-funded 1:24,000 NHD and EPA-STAR projects. Other studies have focused on trout population dynamics, trout interactions with Great Lakes salmonids, water withdrawal effects on trout, trout strain evaluations, and distributional surveys for lake sturgeon. A list of FD research rivers and streams projects active in FY2006 occurs in Table 2.

Research needs

Fisheries Division- Surveys of FD documents (i.e., river assessments, Areas of Emphasis), river research biologists, basin teams, Ecoteam and Strategic Program Committee representatives, and results of the 2003 Research Section meeting (Appendices A and B) highlight several common high priority research areas (Table 1). 1) Ecosystems and Habitat Relationships were key areas, particularly in regards to issues such as habitat degradation and channel management (e.g., bank stabilization, BMP's, sediment management, habitat improvement and its evaluation, dams). Suggested topics of interest in regards to habitat degradation of stream ecosystems included the following:

- effects of dams and potential for restoration;
- effects of dams on temperature and dissolved oxygen;
- potential effects of fish passage on birds and mammals;
- ranking of most damaging of dams in watersheds;
- survey sediment inputs in watersheds;
- bedload dynamics;
- decision tools related to bedload/sand management;
- identifying barrier culverts;
- surveying beaver effects;
- surveying point and non-point sources
- non-point source influences on water quality (e.g. salt brines);
- effects of bank erosion in impoundments on habitat;
- strategies to reduce nutrient inputs
- evaluate buffer strip recommendations;
- evaluate bank stabilization methods;
- evaluate stream habitat improvements

Because the desire is to develop understanding and guidelines for a range of stream types, tying findings (data, model outputs, decision tools, etc.) of future research to existing GIS databases is key so that results can be put into the context of river valley or channel type. 2) Continued development of relationships between species distribution, abundance, and habitat are important, as well as tools (classifications) for assessing habitat potential of river segments for recruitment of migratory fishes (e.g., walleye, lake sturgeon, salmonids). 3) Describing spatial patterns and temporal dynamics of important fishes and development of decision tools based upon SSTP data are priorities.

Related entities- Other sources were examined to identify high priority areas for river research, namely Great Lakes Fishery Commission lake technical committees and the DNR's Comprehensive Wildlife Conservation Strategy. The two most commonly identified priority research areas for rivers as identified by Great Lakes Fisheries Commission Technical committees for Lakes Erie, Huron, Michigan, and Superior involve tributary influences on the

Great Lakes and tributary classification schemes being used for Great Lakes tributaries. There are several aspects to the tributary influences on the Great Lakes area. Interest is in the past, present, and future potential of rivers for producing key native and introduced fishes (e.g., walleye, lake sturgeon, salmonids) as well as sea lamprey, and whether availability of tributary spawning habitat constrains native fish recovery and achievement of Fish Community Objectives. Increased understanding of nutrient, energy, and sediment contributions from tributaries was also mentioned as being of interest. Primary interests in regards to tributary classification, involve development of standardized methods for classifying tributaries and ground-truthing (validation) of existing classes (e.g., Michigan valley segment classes).

Many potential research areas were mentioned in the DNR's Comprehensive Wildlife Conservation Strategy (CWCS) document (Table 1). However, the most commonly expressed areas for future research centered on Habitat relationships and Ecosystems areas, particularly as they related to habitat protection, mitigation, and degradation issues. Many specific items were included in these:

- develop and test fish passage techniques;
- develop BMP's to reverse fragmentation;
- determine effects of agricultural runoff on aquifer features;
- develop and test hydrologic BMP's for dams;
- examine imperviousness in watersheds;
- assess effects of municipal sewage and residential septic systems;
- explore alternatives to current drainage practices;
- assess ecological functionality of natural channel designs;
- develop and test BMP's for riparian areas and road-stream crossings;
- stormwater effects on riparian areas;
- modify dams to minimize adverse effects;
- evaluate erosion prevention measures;
- effects of groundwater withdrawal;
- increase understanding of the function of bogs and fens, remediation and water recharge;
- develop guidelines for wetland buffer zones and connectivity needs;
- assess importance of unregulated wetlands;
- clarify importance of riparian zones;
- monitor streamflows for change;
- identify type and extent of streamflow alterations;

Research gaps and top priorities

Comparison of research priorities identified by FD, GLFC technical committees, and CWCS show fairly clear gaps in our knowledge of rivers, streams, and associated floodplains. Two major areas exist where many agree more work is needed. The first area is "***Stream channel management: diagnosis tools, management techniques, and evaluation of existing protection and management schemes"***. Work is needed in cold, cool, and warm streams. Topic areas may include:

- Sediment- bedload movement (natural vs. unnatural rates), treatment options/recommendations, expected results

- Increasing our understanding of geomorphic processes and their influence on stream beds and banks
- Quantifying rates of change in channels for different types of Michigan streams
- Determining when and where human intervention in geomorphic processes (e.g., sand traps, bank stabilization, etc.) is needed
- Influence of riparian and floodplain conditions, watershed conditions, and stream hydrology on channels
- BMP's (buffer strips, etc) evaluation and recommendations
- Habitat improvement treatment recommendations
- Broad-scale evaluation of habitat improvement/protection activities such as bank stabilization, whole tree addition, fish structure addition on habitat and biota
- Integration of study findings to pertinent river geomorphic classes linked to Michigan stream types via GIS (e.g., tied to river segments)

The second major research area is "***The interface and interrelationships between lotic and lentic systems"***. This area includes both inland lake and Great Lake systems and systems affected and unaffected by dams. Topic areas here may include:

- Movement between and use of lake, river, estuary, and floodplain habitats by all lifestages of fish
- Influence of spatial arrangement, connectivity, size, and other attributes of rivers and lakes on physical and ecological processes (e.g., sediment and LWD transport; temperature, water quality, and nutrient conditions; fish recruitment and population dynamics)
- Biological interactions between lake and river fishes (e.g., Great Lakes fish, ANS in the Great Lakes, and resident river fishes)
- Influence of dams on all of the above
- Use of passage activities to mitigate physical and ecological effects of fragmentation, including potential effects of ANS introduction

At the September 2005 Research Section meeting, our group was tasked to identify three top research areas for future work. Our group decided that high priority future research areas should: 1) have state-wide impact on management; 2) meet basic knowledge gaps; 3) be feasible for FD involvement; 4) fulfill needs identified internally and externally.

In addition to identifying the above two areas, the group identified "***Development of decision support tools based upon Status and Trends Program data and other statewide databases***" as the third top area for future research. These tools tie into and build upon existing GIS databases, studies, and programs such as river valley classification studies, river modeling studies (e.g., EPA-STAR and Aquatic GAP), broad-based assessments (e.g., sediment trap evaluation study (Study 702), and FD's Stream Status and Trends Program and the Fish Collection System. Tools developed could address various physical or biological issues relating to rivers, streams, and floodplain wetlands. Useful tools may include:

- Species-based habitat suitability models
- Valley-segment based, data analysis tools for use with data from individual fish and habitat surveys (e.g., Status and Trends Program random surveys)
- Models for guiding appropriate placement of sediment traps

- GIS-based delivery of population trend data from Status and Trends Program fixed (index) sites
- Relationships between land use (and land use changes) and biotic integrity metrics for stream fish communities
- Risk assessment models that predict the likely path of ANS colonization of inland waters and potential for establishment of significant ANS populations based on key river habitat parameters (e.g., temperature, gradient, size, etc.)

Broad approaches to addressing gaps

Continued refinement of GIS-based statewide data layers and tying research findings to them are key to success of existing and future research. Ability to link research findings (e.g., habitat improvement or protection evaluations results) to attributes of stream data layers will enable findings to more effectively be extrapolated to the rivers statewide. The accuracy and precision of extrapolation of research findings via statewide river classifications will likewise increase as the quality of statewide data layers and stream classifications improves. Continued development and monitoring of Streams Status and Trends sampling program is also key, because in addition to their designated use, these high quality, standardized data will likely provide the fisheries database for future development of most statewide fisheries tools, such as those for predicting fish distribution and abundance, biotic integrity of fish assemblages, etc.

Our theme group identified several broad approaches were identified to help FD to more effectively address the research gaps identified above. These included:

- Using the existing Stream Team or an augmented version of it to steer multi-agency efforts. Their tasks may include identifying specific topics where the research payoff will be greatest, review and synthesis of literature pertinent to Michigan landscapes, or conducting audits to examine past successes (or failures) and achievement of goals for previous habitat projects
- Tying research findings to classifications and GIS-based (and remotely-sensed) attributes of rivers to build a geographically broad information base
- Developing an “early warning system” (email group?) for field activities to facilitate planning and coordination of evaluation work
- Focusing on processes, modeling, and prediction along habitat gradients using a comparative approach. Study results should allow for prediction of piece-meal effects of habitat degradation.
- Collaborating internally and externally. Some examples pertaining to ANS include: 1) working with others to develop and effective detection and data capture strategy for ANS in inland waters (and enhance FD expertise in this area); 2) assessing field techniques and measures for controlling ANS range expansion; 3) using existing data and sampling programs to develop studies to assess ANS effects on river biota.
- Combining resources (e.g., funds, equipment)
- Obtaining training on “tools”
- Outsourcing collection of data, for example, by making it a requirement for receiving FD support or permission for stream habitat work
- Employing more mechanistic and experimental approaches, and less correlation analyses

Table 1. Frequency of research needs identified by River Assessments (RA), research biologists (ResBio), FD's Areas of Emphasis (FD- AoE), the 2003 Research Section meeting (2003ResM), Ecoteams and Strategic Planning Committee representatives (ET's and SPC's), the Lake Michigan Basin Team (LMBT), Great Lakes Fishery Commission (GLFC) lake technical committees, and the Comprehensive Wildlife Conservation Strategy (CWCS). Most frequently mentioned areas are highlighted. Sample size refers to the number of documents, people or Great Lakes responding. Recent historical coverage of research area by Fish Division is shown.

		Sample size:	10	4		-	3	1	4	1
Research Areas (within Theme)		**History**	**RA Tally**	**ResBio- Sum**	**FD- AoE**	**2003ResM**	**ET's & SPC's Sum**	**LMBT**	**GLFC tally**	**#CWCS items**
Sampling										
biota	Development and evaluations of std methods for sampling fish, other biota	2000+ (SSTP)		0.7		x	0	x		3
Habitat	Devel and eval of std methods for sampling habitats (multi-discipline, -scale)	2000+ (SSTP)		0.7		x	0		2	2
anglers	Devel and eval of std methods for sampling anglers, commercial fishers, citizens	?		0			0			
GIS Development										
maps	Compilation and development of std base maps	1990+ (MRI, VSEC, NHD)	1	0			2	x		3
dbases	Compilation and development of statewide georeferenced databases	1990+ (MRI, VSEC, NHD)	1	0		x	1	x	1	3
tools	Development of query tools, decision tools	2000+ (MRI, VSEC, NHD, SSTP)		2.7		x	1	x	1	3
Fish Distribution- fish and habitat inventories		1990+ (MRI, VSEC, NHD)	10	0.5			0		3	3
Fish Population Dynamics for key stocks										
	Genetic stock ID	2000+	1	0.5		x	0			
Temporal datasets, development of std age-structured statistical models		2000+ (Au Sable)	1	0.7		x	0		1	
Recruitment mechanisms		2000+ (OTC, LSturg)	1	2.7		x	0		2	
	Parental details (genetics as a tool)	2000+ (Trout, LSturg)		0.5			0		1	
Mortality mechanisms										
	Early life history	1990+ (Wae, Trout, LSturg)		0.7		x	0			
	Predation losses	1970s (AuSable), otherwise few	1	0.5			0			
	Disease monitoring and dynamics	?		0			0			2
	Harvest monitoring and dynamics (*see other area)	1990+ (Inland Creel), 1960-80s (Au Sable)		0.7			0			
introduced vs. native fish/mussel interactions			3							1?
Growth mechanisms		1960+ (Scattered, mostly trout)								
	Diets			0.5			0			
	Physiology			0.5			0			
Fishery Dynamics, statewide and for key fisheries										
	Spatial patterns	1990+ (MRI)	7	2.7	x	x	0			
	Temporal dynamics	1990+ (AuSable, SSTP)		2.7	x		0			
	Social, behavioral, economic mechanisms		3	0.5		x	0			
Habitat relationships										
biota-habit	Influences on distribution and dynamics	1990+ (MRI, VSEC)	7	3		x	2		3	2
classify	Habitat classifications	1990+ (MRI, VSEC)	3	1		x	0	x		
degradatio	Habitat degradation	1980+ (Sand, Dams- locally-based)	10	3	x	x	1			6
Ecosystems										
processse	Understanding key physical processes	1990+ (MRI)	8	3		x	1	x	2	6
classify	Ecosystem classifications	1960+ (FD Class), 1990+ (VSEC, NHD)	1	0			0			3
biota dist/a	Distribution and abundance of other biota	1990+ (MRI non-game fish)	4	3			1		1	1
trophic	Trophic structure and dynamics	1960+ (Scattered, mostly trout)		0			0			
degradatio	Environmental degradation	1980+ (Sand, Dams- locally-based)	8	3	x	x	2		2	7
Evaluation of sport and commercial harvest regulations										
tools	Development of model-based decision tools			2.7			0			
eval regs	Evaluation of effects of applied regulations	1980+ (Trout, SMB)		2	x	x	1			
attitudes	Survey user attitudes	1970-90 (Trout)		0.5			0			1
Evaluation of hatchery practices										
	In-hatchery processes			0			0			
	Temporal datasets, mortality of stocked fish	1980+ (Salmonids)		0			0			
	Mortality mechanisms			0.85			0			

Table 2. MDNR Fisheries Division research projects active in FY2006.

Study #	Study Title; PI (Organization-Location)	$ Source
Sampling		
230684	Resource inventory design; Hayes (MSU-PERM)	G & F
230721	Design, analysis, and implementation of aquatic resource inventory in Michigan; Hayes (MSU-PERM)	SFR (F-81)
230737	Status and trends of fish populations and community structure in Michigan streams; Wills (DNR-Hunt Creek)	SFR (F-81)
GIS Development		
?	Modeling the influence of lake circulation patterns, upwelling events and turbulence on fish recruitment variability in Lake Michigan; Beletsky/Rutherford (UM-Perm—IFR)	GLFT
230711	Compilation and analysis of Lake Erie spatial fisheries data; Rutherford (UM-Perm—IFR)	GLFC
230514	Lake Huron GIS; Zorn (DNR-Hunt Creek)	USFWS
230715	Lake Huron aquatic habitat / GIS; Rutherford (UM-PERM)	EPA
237001	Digital atlas for inland waters; Breck (DNR-IFR)	SWG
None	Development of High-Res NHD; Seelbach (DNR-IFR), *External Consult*	USFS
None	Lake Erie GIS; Haas (DNR-Lake St. Clair)	USFWS (GLFC)
Fish distribution- fish and habitat inventories		
230661	Assessment of lake sturgeon in northern Michigan; Baker (DNR-Marquette)	SFR (F-81)
Fish population dynamics for key stocks		
?	Salmon spawning stock abundance, recruitment and exploitation in the Muskegon River; Mason/Rutherford (UM-PERM—IFR)	GLFT
230654	Evaluate brown trout and steelhead competition in streams; Nuhfer (DNR-Hunt Creek)	SFR (F-80)
230679	Ecological river classification for management of cold water streams; Wehrly (DNR-IFR)	SFR (F-81)
230703	Lakewide assessment of the contribution of natural recruitment to the chinook salmon population of Lake Huron; Johnson (DNR-Alpena)	SFR (F-80)
230732	Factors Affecting Lake Sturgeon Recruitment: A model system for species recovery in Michigan waters of the Great Lakes; Scribner (MSU-PERM)	SFR (F-80)
*230519	Colonization of a brook trout stream by introduced brown trout; Nuhfer (DNR-Hunt Creek)	SFR-(F-80)
*230521	Influence of lotic and nearshore habitats on fish populations in Great Lakes and inland lake ecosystems, with emphasis on walleye; Zorn (DNR-Marquette)	SFR-(F-80)
Fishery dynamics- statewide for key fisheries		
230646	Inland creel survey; Su (DNR-IFR)	SFR (F-81)
230665	Investigate causes of declines of brown trout in Au Sable River; Zorn (DNR-Hunt Creek)	SFR (F-80)
Habitat relationships		
?	Fish recruitment at the interface of the Great Lakes and their watersheds (an addendum to enhance current projects of the Muskegon River initiative); Wiley/Rutherford (UM-Perm—IFR)	GLFT
230647	River history modeling; Hayes (MSU-PERM)	G & F
230662	Inventory and classification of Upper Peninsula rivers and fish communities; Baker (DNR-Marquette)	SFR (F-81)

230683	Classification at Land & Water Interface; Seelbach (DNR-IFR)	ViGIL
231541	Predicting potential production of steelhead based on habitat conditions in the Pine River, Alcona County	G & F
Ecosystems		
?	Ecological footprint of the Muskegon River watershed on Great Lakes Fisheries; Rutherford (UM-Perm—IFR)	UM-OVPR
230511	Assessing the ecological characteristics of forest types for the application of sand dredge spoils; Millenbah (MSU)	G & F
230541	Au Sable Pine River; Hayes (MSU-PERM)	G & F
230656	Stronach dam removal; Hayes (MSU-PERM)	FERC
230680	Patterns in community structure, life histories, and ecological distributions of fishes in Michigan rivers; Zorn (DNR-Marquette)	SFR (F-81)
230702	Effects of sediment traps on Michigan river channels	SFR (F-80)
230736	Response of an aquatic invertebrate community to reduced summer streamflows in a northern Michigan stream; Wills (DNR-Hunt Creek)	SFR (F-80)
230738	Improve and validate river segment identification and classification models for assessing fishery potential and environmental impairment in Michigan; Wang (DNR-IFR)	SFR (F-80)
230999	Development of ecological reference criteria, status assessments, and risk analyses for ecological segments of Michigan rivers; Wang (DNR-IFR)	G & F
231656	Impact of removal of Stronach Dam, Manistee County; Hayes (MSU-PERM)	FERC
None	Riverine Fragmentation; Zorn (DNR-Hunt Creek), *External Consult*	G & F
Evaluation of sport and commercial harvest regulations		
230709	Development of fisheries assessment and harvest allocation methods for inland lakes and streams in Michigan; Clark (IFR-UM)	G & F
Evaluation of hatchery practices		
230487	Evaluate performance of stocked steelhead in Lake Michigan tributaries; Jonas (DNR-Charlevoix)	SFR (F-80)
230735	Evaluation of the field performance of wild and domestic brown trout strains in seven Michigan rivers; Wills (DNR-Hunt Creek)	SFR (F-80)
*230520	Evaluation of Michigan's inland fish stocking program and optimizing allocation of stocking resources by a systems analysis; Su (DNR-IFR)	SFR-(F-8?)

Appendix A. MDNR Fisheries Division 2003 Research Section meeting summary of research needs and ongoing and recently completed studies by research areas for Rivers, streams, and floodplains theme.

Research needs	Recently completed and ongoing studies
Sampling • Refine wadeable stream fish and habitat sampling methods; • Develop and evaluate nonwadeable river fish & habitat sampling methods; • Develop & implement protocols for amphibians, reptiles, mollusks.	• Aquatic resource inventory methods (2 projects); • Development of nonwadeable river habitat assessment methods (SWG) • Inland creel survey.
GIS Development • Statewide stream segment catchment boundary and attributes; • Historical stocking database & predicting distribution of stocked fish; • Test Darcy model to understand groundwater flow & temperature relation.	• Atlas for inland lakes and rivers; • Stream improvement; • 1:24k NHD; • Lake Huron GIS • Lake Erie GIS • Great Lakes GIS • EPA-STAR Project: Development reference criteria, status assessment, and risk analysis for river segments.
Fish Distribution • Evaluate relation between flow and fish distribution, w/ FERC unit; • Explore distribution and abundance of lower trophic level aquatic life (invertebrates and foraging fish); • Develop models for predicting potential fish distribution under given/projected changes in watershed land uses.	• Stream status and trends program; • Evaluate fish community structure and distribution in rivers; • Fish Atlas. • EPA-STAR Project: Development reference criteria, status assessment, and risk analysis for river segments.
Fishery Dynamics, statewide for key species • Develop model to predict statewide fish distribution; • Evaluate winter/summer strains or hatchery/wild steelhead inter breeding; • Overwinter mortality of YOY salmonid species; • Estimate fishing mortality for stream systems.	• Stream status and trends program; • Brown trout & steelhead competition in stream; • Investigate causes of decline of brown trout; • Genetic study on sturgeon & brown trout (2 projects); • Genetic baseline data for all stocked species/strains of MI. • EPA-STAR Project: Development reference criteria, status assessment, and risk analysis for river segments.
Habitat Relationships • Link habitat attributes (e.g. flow, temp,	• Stream status and trends program;

channel morpho) w/ fish distribution & sport fisheries;
- Evaluate habitat in large coolwater river;
- Develop GIS-based mesohabitat maps;
- Habitat simulations from tailwater release;
- Effect of nutrient transportation by salmon on inland biota;
- Behavioral study relating habitat/stream condition;
- Evaluate effect of stream sand removal on fish and channel morphology;
- Study sand dynamic and distinguish natural sandy bottom from sand sedimentation from degradation in streams .
- Evaluate fish community structure and distribution in rivers;
- Effects of sand bed load on brook trout;
- Development of nonwadeable river habitat assessment methods (SWG)
- Assess ecological characteristics of forest types for application of sand dredge spoils;
- Effect of sediment traps on river channels;
- Predict potential steelhead production based on habitat;
- Evaluation of large woody debris addition in river.

Ecosystems

- River fragmentation;
- Statewide stream classification for random sampling design, identification target streams for restoration, for trout stocking, for permit issuing, and for impairment evaluation;
- Link habitat diversity to fish occurrence and abundance.
- Stream status and trends program;
- Evaluate fish community structure and distribution in rivers;
- Studies on river ecosystems (2 projects);
- Effect of water withdrawal on trout and invertebrate (2 projects);
- Dam removal;
- Inventory and classification of Upper Peninsula river and fish, and of coldwater streams (2 projects);
- EPA-STAR Project: Development reference criteria, status assessment, and risk analysis for river segments.

Evaluate sport/commercial harvest regulations

- Evaluate new coldwater stream regulation;
- Need more effort on inland angler survey, especially emphasizing on social and economic influences on recreational fishing dynamics.
- There have been very extensive evaluation on trout regulation projects through 1990;
- There are a few warmwater sport fish evaluation projects;
- Modeling trout regulation;
- Angler survey;

Evaluation of hatchery practices

- Develop strain with better fitness;
- Evaluate tailwater stocking;
- Identify critical wild stocks available for broodstock development and their potential uses;
- Explore opportunity for development of anadromous brown trout strains.
- Evaluation of field performance of wild and domestic brown trout strains;
- Several studies have done on stocking evaluation; comparison of trout strains, evaluate size at stocking.

Appendix B. High priority research areas for rivers, streams, and floodplain wetlands identified during MDNR Fisheries Division 2003 Research Section. Areas are: relevant to Section research objectives, directly support Division's mission and activities; also statewide scale, extensive management activity involved, needed for both sort- and long-term, urgent, can be used to deal with broad issues, and current knowledge. Non-highlighted areas area being addressed to some degree.

- Status and trend monitoring for wadeable and non wadeable streams/rivers;
- Model major stream/river characteristics (flow, channel, temperature, biota) and validate statewide valley segment classification map for random sampling design, identification of target streams for restoration, for trout stocking, for permit issuing, and for impairment evaluation;
- Study sand dynamic and distinguish natural sandy bottom from sand sedimentation of degradation in streams; evaluate effectiveness of stream sand removal and its effects on fish and channel morphology;
- Evaluate impacts of dam removal on habitat, sediment dynamic, and biota at both upstream and downstream locations;
- Develop or refine sampling methods for fish and habitat for wadeable and nonwadeable streams/rivers; develop GIS-based mesohabitat maping tool;
- Link major habitat attributes (e.g. flow, temperature, channel morphology) with fish distribution and sport fisheries;
- Conduct inland creel survey with social and economic components;
- Conduct individual species ecological research, especially salmonids and other important sport fish species;
- Evaluate new coldwater fishing regulation;
- Conduct genetic research to preserve natural strain, enhance stocking effectiveness, and improve fisheries.