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Minnesota Fisheries Information Needs: 2023 Update

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Introduction

In 2017, the Minnesota Department of Natural Resources (MN DNR) Fisheries Research Unit (FRU) developed a fisheries information needs list to guide fisheries research project development in Minnesota. The list was created by first inquiring with MN DNR Section of Fisheries staff statewide regarding what research and information needs are limiting effective and sustainable fisheries management in Minnesota. That inquiry generated more than 250 questions and ideas for research projects submitted to the FRU leadership (manager and three supervisors). The questions and ideas were collated into a Microsoft Excel workbook. They were added to individual worksheets based on the source (e.g., region, species technical teams). Each idea was then assigned a species, a topic, a relative timeframe (e.g., short, medium, long), project scale (e.g., statewide, regional, local), and a qualitative determination of management implications. Research ideas were then summarized by species and topic. The FRU leadership identified approximately 25 questions as most important, but because some questions lacked necessary clarity and some overlapped, related ideas and questions were grouped into 6 related topics (Habitat Program, Surveys and Long-Term Monitoring, Stock Assessment, Regulations, Culture and Stocking, and Emerging Issues). The final information needs list was presented in a document titled, “Building Effective and Sustainable Fisheries Management in Minnesota: Information Needs” and was disseminated to the Section. Since then, the needs document has been used by FRU scientists to develop research projects, and has been shared with external partners (e.g., the University of Minnesota, the Science Museum of Minnesota) to help inform them of the information gaps Minnesota DNR Section of Fisheries views as priority.

Progress Toward Meeting Fisheries Information Needs

For internal projects, researchers consulted with the FRU supervisory team to identify candidate topics. Then they engaged managers to define the key issues and formulate an answerable question that would inform fisheries management decision-making. Integration with the Sentinel Lakes and other long-term monitoring programs was considered with new projects. Dozens of projects have been or are currently being conducted that address one or more of the fisheries information needs (Table 1). They include projects initiated by FRU researchers, other Section of Fisheries’ staff, and external collaborators. Publications resulting from completed projects are cited in the references section. In some cases, citations are provided for grants or proposals associated with projects that are in progress. Where no citation is provided, we have included links to more information about the project, principal investigator, or DNR collaborator.

Table 1. Fisheries information need category, specific information need, and research projects associated with each. Some projects are listed multiple times since they address multiple information needs. The table does not include projects that may have been conducted on these information needs prior to 2017.

Category	Information Need	Projects
Habitat	Develop management guidelines for integrating fish habitat conservation with WRAPs and One Watershed One Plans.	Completed: Associations between biotic integrity and sport fish populations in upper Midwest, USA rivers, with emphasis on Smallmouth Bass (Dieterman et al. 2019. Environmental Management 63:732-746)
Habitat	Economic benefits of healthy habitat, aquatic vegetation and fisheries resources. Full accounting of natural resource benefits of undeveloped shoreline (watershed and water quality protection, wildlife, recreation, aesthetic, etc.) Would be beneficial for Land Asset Mgmt., Trust Lands Mgmt., Environmental Review, project justification.	Completed: The influence of angler values, involvement, catch orientation, satisfaction, agency trust, and demographics on support for habitat protection and restoration versus stocking in publicly managed waters (Schroeder et al. 2018. Environmental Management 62:665-677)
Habitat	Determine critical habitat value of emergent vegetation and sensitivity to loss from shoreline development.	Completed: Nearshore habitat and fish assemblages along a gradient of shoreline development (Dustin and Vondracek. 2017. North American Journal of Fisheries Management 37:432-444) In progress: Assessing relationships between fisheries and aquatic vegetation to improve lake habitat management (Feiner and Rantala. 2022. Midwest Glacial Lakes Fish Habitat Partnership Lake Partnership Grant)
Habitat	Develop a framework to evaluate the effectiveness of stream habitat restoration projects that include measurable and realistic goals.	In progress: Evaluation of coldwater stream projects (Dieterman and Hoxmeier, DJ Study 672, 4/1/2020 – 3/31/2028)

Category	Information Need	Projects
Habitat	Develop a robust long-term monitoring program for streams that will provide critical information on the effects of climate change, invasive species, and land use changes on stream habitats and fish populations.	Completed: Use of long-term (40+ year) trend data to evaluate management actions on brown trout, *Salmo trutta*, populations in groundwater-fed streams (Dieterman et al. 2020. Fisheries Management and Ecology 27:551-566) In progress: Streams Long Term Monitoring (MNDNR 2017. Long term monitoring in the driftless region of Minnesota)
Habitat	Determine which invasive species (including plants and animals) most affect fish populations and at what life stage.	Completed: Decrease in young-of-the-year Yellow Perch growth rates following *Bythotrephes longimanus* invasion (Staples et al. 2017. Biological Invasions 19:2197-2205) Completed: Walleye growth declines following zebra mussel and *Bythotrephes sp.* invasion (Hansen et al. 2020. Biological Invasions 22:1481-1495) Completed: Walleye and yellow perch used pelagic resources in Minnesota, USA lakes regardless of invasion by spiny water fleas or zebra mussels (Bethke et al. in preparation. Aquatic Ecology) In progress: Didymo invasion of nearshore Lake Superior and tributaries (Heathcote et al. (Rantala), 2021. Minnesota Sea Grant) In progress: Didymo Danger Zone (Burge et al. (Rantala), MNDNR Coastal Program, 2022-2023) In progress: Rocksnot Threatens Superior's North Shore (Edlund et al. (Rantala), MNDNR Coastal Program, 2021-2022) In progress: Interactions between rusty crayfish invasion and yellow perch population dynamics in North-Central Minnesota lakes (Fink, K. (Herwig), Bemidji State University, M.S. Thesis Project 2022-2024) In progress: Streams Long Term Monitoring (MNDNR 2017. Long term monitoring in the driftless region of Minnesota)

Category	Information Need	Projects
Habitat	Evaluate the role that zebra mussels play in altering food webs in lakes after invasion and the effect on fish production and carrying capacity.	Completed: Stable isotopes indicate zebra mussels (*Dreissena polymorpha*) increase dependence of lake food webs on littoral energy sources (McEachran et al. 2019. Freshwater Biology 64:183-196) Completed: Impacts of zebra mussels (*Dreissena polymorpha*) on isotopic niche size and niche overlap among fish species in a mesotrophic lake (Morrison et al. 2021. Biological Invasions https://doi.org/10.1007/s10530-021-02553-0) In progress: Evaluating secondary production on Mille Lacs (Rantala et al. non-DJ research project) In progress: Assessing impacts of Zebra Mussels on the Ten Mile Lake food web and response of Lake Whitefish and Cisco populations. (Herwig and French, non-DJ research project)
Surveys and Long-Term Monitoring	Standardized and quantified methods for estimation of age, growth, sex, and maturity. *- continued on next page*	Completed: Accurate estimates of age at maturity from the growth trajectories of fishes and other ectotherms (Honsey et al. 2017 Ecological Applications 27:182-192) Completed: Evaluation of age estimates made with scales, dorsal spines, and whole otoliths as surrogates for ages estimated with halved otoliths of Smallmouth Bass and Largemouth Bass in Minnesota (McInerny et al. 2017. Investigational Report 567) Completed: A survey of Minnesota Department of Natural Resources area fisheries staff on methodology and use of fish age estimates (McInerny et al. 2017. Special Publication 184) Completed: Age and growth manual (Hoxmeier et al. 2018) Completed: Potential effects of age, population, and latitude on precision of scale and otolith age estimates of White Crappie in Minnesota (McInerny et al. 2019, Journal of Fish and Wildlife Management 10:544-550) Completed: Influence of age, population, total length, sex, and sample month on precision and bias of scale and whole otolith age estimates of Black Crappie in Minnesota (McInerny et al 2020 Investigational Report 573)

Category	Information Need	Projects
Surveys and Long-Term Monitoring	*- continued* Standardized and quantified methods for estimation of age, growth, sex, and maturity.	In progress: Assessing Yellow Perch populations with experimental sampling gears. (Bethke and Holbrook, DJ Study 654, 4/1/2019 – 3/31/2022) In progress: Status assessment of Longnose Gar, Shortnose Gar, Paddlefish, and River Redhorse (Oliver et al. 2022 – 2024) In progress: Evaluation of Mississippi River Flathead Catfish demography and regulations (Oliver and Rude, MNDNR Miss. River Catfish Monitoring, 2022 – 2023)
Surveys and Long-Term Monitoring	What is the relationship between population size and survey catch rates? Standard methods to estimate N.	Completed: An Assessment Model for a Standard Gill Net Incorporating Direct and Indirect Selectivity Applied to Walleye (Radomski et al. 2019 North American Journal of Fisheries Management 40:105-124) In progress: Evaluation of alternative mark-recapture models and study designs for a Muskellunge population (Shroyer and Hodgins in preparation. North American Journal of Fisheries Management) In progress: Use of Alternative Open and Closed Population Models to Evaluate Assumptions of Largemouth Bass Population Estimates (Shroyer in preparation North American Journal of Fisheries Management) In progress: Fundamentals of mark-recapture study design and analysis for fish populations (Shroyer in preparation MNDNR internal publication)
Surveys and Long-Term Monitoring	How do we measure YCS better or earlier? Use to identify drivers of YCS, including stocking. Is Fall electrofishing a reliable predictor?	Completed: Compilation and Assessment of Historical Minnesota Late-Summer and Fall Walleye Electrofishing Data (Shroyer et al. 2019. Investigational Report 565) Completed: Longitudinal analyses of catch-at-age data for reconstructing year-class strength, with an application to Lake Trout (Salvelinus namaycush) in the main basin of Lake Huron (He, et al. (Staples). 2023. Canadian Journal of Fisheries and Aquatic Sciences 80:183-194)

Category	Information Need	Projects
Surveys and Long-Term Monitoring	Develop standard methods for forage and pelagic fish assessments.	Completed: Seasonal variability in standard assessment techniques. (Carlson and Holbrook. 2018. Project R-26-R-47, Final Report) Completed: Evaluation of four larval fish sampling methods in a large Midwestern River (Lederman et al. 2020. Prairie Naturalist 52:21-30) Completed: Assessing Minnesota's changing Yellow Perch populations using length-based metrics. (Holbrook, et al 2021. North American Journal of Fisheries Management 42:642-658) In progress: MNDNR standardized hydroacoustic data collection and analysis protocol for inland pelagic fish populations. (Holbrook, ongoing non-DJ project) In progress: MNDNR standardized hydroacoustic data analysis protocol for Lake Superior. (Holbrook, ongoing non-DJ project) In progress: Assessing Yellow Perch populations with experimental sampling gears. (Bethke and Holbrook, DJ Study 654, 4/1/2019 – 3/31/2022) In progress: Comparison of quantitative methods for estimating whole-lake Cisco abundance. (Holbrook et al., pilot project, 2022-2024)
Surveys and Long-Term Monitoring	Determine best gear and sampling times for estimating relative abundance and size structure of bluegill.	No known projects currently (work completed prior to 2017; see Reed et al. in review. The history and role of research in managing Minnesota's fisheries resources. Minnesota Department of Natural Resources, Section of Fisheries, Investigational Report. St. Paul.)
Surveys and Long-Term Monitoring	Develop alternative 'creel' survey methods (counters, drones, other); or estimates of Z or F.	Completed: Muskellunge population assessment in two North-central Minnesota lakes aided by angler participation (Ward et al. 2017 AFS Symposium) Completed: Use of motion-activated and time-lapse cameras to monitor angler use of stream trout lakes. (Minnesota DNR Stream Trout Lakes Committee. 2019) In progress: Direct comparison of boat access-based autonomous cameras and roving creel surveys for estimating fishing effort: implications for use in creel surveys with non-uniform probability sampling (Reed, In preparation).

Category	Information Need	Projects
Stock Assessment	Develop and test multiple hypotheses about causes of the statewide yellow perch decline; Regional similarities?	Completed: Assessing Minnesota's changing Yellow Perch populations using length-based metrics. (Holbrook et al. 2021. North American Journal of Fisheries Management 42:642-658) In progress: Assessing Yellow Perch populations with experimental sampling gears. (Bethke and Holbrook, DJ Study 654, 4/1/2019 – 3/31/2022)
Stock Assessment	What mechanisms drive walleye year class strength and how do we quantify them?	Completed: Drivers of walleye recruitment in Minnesota's large lakes. (Honsey et al 2020. Canadian Journal of Fisheries and Aquatic Sciences 77:1921-1933) Completed: Synthesizing Professional Opinion and Published Science to Build a Conceptual Model of Walleye Recruitment. (Krabbenhoft, et al, In press. Fisheries). In Progress: Lagging responses, increasing extremes, and stocking exacerbate phenological mismatches for walleye in north-temperate lakes (Barta et al. In preparation)
Stock Assessment	How much do MUE and NOP alter food webs--effects of stocking / restoring large piscivores? Cannibalism effects? With and without Cisco. MUE recruitment	Completed: Mille Lacs Lake Bioenergetics (Ahrenstorff and Holbrook 2016. Investigational Report 576) In progress: Niche overlap and diets of Muskellunge and other piscivores in MN lakes (Herwig, et al. DJ Study 681, 4/1/2019 – 3/31/2024) In progress: Comparing consumption by Muskellunge, Northern Pike, and Walleye populations (Ahrenstorff and Herwig. DJ Study 661, 4/1/2020 – 3/31/2023)
Stock Assessment	What drives cisco abundance, size structure, and dynamics between lakes?	Completed: Oxythermal habitat as a primary driver of ecological niche and genetic diversity in cisco (Grow et al. 2021 Canadian Journal of Fisheries and Aquatic Sciences https://doi.org/10.1139/cjfas-2021-0059) Completed: Was historical Cisco Coregonus artedi yield consistent with contemporary recruitment and abundance in Lake Superior? (Rook et al. 2021. Fisheries Management and Ecology 28:195-210) In progress: Sentinel Lakes Program In progress: Assessing environmental cues and their overall influence on the growth of inland cisco populations. (Hafs lab, Bemidji State University)

Category	Information Need	Projects
Stock Assessment	Have declines in productivity reduced sustainable walleye harvests; how much; where; why?	In progress: Evaluating secondary production on Mille Lacs (Rantala et al. non-DJ research project)
Stock Assessment	What are the effects of invasive species on trophic dynamics in lakes?	Completed: Decrease in young-of-the-year Yellow Perch growth rates following *Bythotrephes longimanus* invasion (Staples et al. 2017. Biological Invasions 19:2197-2205) Completed: Walleye growth declines following zebra mussel and *Bythotrephes* invasion (Hansen et al. 2020. Biological Invasions 22:1481-1495) Completed: Walleye and yellow perch used pelagic resources in Minnesota, USA lakes regardless of invasion by spiny water fleas or zebra mussels (Bethke et al. in preparation. Aquatic Ecology) Completed: Simultaneous invasion decouples zebra mussels and water clarity (Rantala et al. 2022. Communications Biology 5:1405 https://doi.org/10.1038/s42003-022-04355-z). In progress: Assessing impacts of Zebra Mussels on the Ten Mile Lake food web and response of Lake Whitefish and Cisco populations. (Herwig and French, non-DJ research project) In progress: Impacts of AIS on zooplankton productivity in Minnesota lakes (Rantala et al., non-DJ research project) In progress: Aquatic invasive species impacts on walleye populations and mercury concentrations (Hansen Lab, University of Minnesota) In progress: Didymo invasion of nearshore Lake Superior and tributaries (Heathcote et al. (Rantala), MN Sea Grant funded, 2022-2023) In progress: Factors influencing littoral energy use and trophic position of Walleye and Northern Pike in Minnesota lakes. (Thelen, et al. (Herwig) Zimmer Lab, University of St. Thomas)

Category	Information Need	Projects
Stock Assessment	Information on stock status of neglected species: Black Crappie, Lake Whitefish, Paddlefish, Lake Sturgeon, Gizzard Shad, White Bass, Lake Trout. *- continued on next page*	Completed: Historical review and status of Crystal Darter, Bluntnose Darter and Warmouth in Mississippi River navigation pools 3, 4, 5, 5A, 6, 7, 8 and the lower St. Croix, 1990-2017 (DeLain et al. 2018. Final Report for State Wildlife Grant T-5-R-7) Completed: Life history traits and status of a peripheral Redside Dace population in Minnesota (Dieterman et al. 2018. American Midland Naturalist 180:273-289) Completed: Status of peripheral Redside Dace populations in Minnesota, 2017 (Dieterman et al. 2018. Final Report for State Wildlife Grant T-5-R-7) Completed: Guidelines for monitoring Redside Dace in Minnesota (Dieterman et al. 2018. Ecological and Water Resources Division, Minnesota Department of Natural Resources) Completed: Population dynamics of Flathead Catfish in the lower Minnesota River (Shroyer 2018. Investigational Report 564) Completed: Temporal variation in trap net catch per effort in seven Minnesota lakes (McInerny et al. 2020. Investigational Report 566) Completed: Genetic origins and diversity of Lake Sturgeon in the St. Louis River Estuary (Estep et al. 2020 Journal of Great Lakes Research 46:1028-1035) Completed: Influence of age, population, total length, sex, and sample month on precision and bias of scale and whole otolith age estimates of Black Crappie in Minnesota (McInerny et al 2020 Investigational Report 573) Completed: Comparisons between mark-recapture population estimates of Largemouth Bass and Black Crappie made with the same and different capture gears in Minnesota lakes (McInerny and Cross 2021. Investigational Report 575) Completed: An evaluation of standard trap netting as a sampling gear for White Crappie in Minnesota lakes (McInerny and Cross 2021. Investigational Report 672) Completed: Darter (Family: Percidae) abundance in deep-water habitats of the Upper Mississippi River. (Dieterman et al. 2022. Natural Areas Journal 42:139-144)

Category	Information Need	Projects
Stock Assessment	*- continued* Information on stock status of neglected species: Black Crappie, Lake Whitefish, Paddlefish, Lake Sturgeon, Gizzard Shad, White Bass, Lake Trout.	Completed: An assessment of Burbot life history in Minnesota with a focus on movement dynamics and spawning vulnerability. (Robinson. 2022. M.S. Thesis Bemidji State University) In progress: Assessing impacts of Zebra Mussels on the Ten Mile Lake food web and response of Lake Whitefish and Cisco populations. (Herwig and French, non-DJ research project) In progress: Evaluating past and potential future reintroduction of sculpin in southeastern Minnesota (Dieterman, et al., non-DJ research project) In progress: Status assessment of Longnose Gar, Shortnose Gar, Paddlefish, and River Redhorse (Oliver et al. 2022 – 2024) In progress: Evaluation of Mississippi River Flathead Catfish demography and regulations (Oliver and Rude, MNDNR Miss. River Catfish Monitoring, 2022 – 2023)
Stock Assessment	What are the effects of stream restorations? Need a framework to evaluate.	Completed: Winter habitat selection by large Brown Trout in streams with and without habitat rehabilitation (Dieterman et al. 2018. North American Journal of Fisheries Management 38:253-266) Completed: Use of long-term (40+ year) trend data to evaluate management actions on brown trout populations in groundwater-fed streams (Dieterman et al. 2020. Fisheries Management and Ecology 27:551-566) In progress: Evaluation of coldwater stream projects (Dieterman and Hoxmeier, DJ Study 672, 4/1/2020 – 3/31/2028)
Regulations	What are the effects of regulation XYZ on size, abundance, creel, community? A more systematic approach to evaluating regulations appears needed. *- continued on next page*	Completed: Visualizing trade-offs between yield and spawners per recruit as an aid to decision making (Schmalz et al. 2016. North American Journal of Fisheries Management 36:1-10). Completed: Evaluation of Mille Lacs walleye harvest policy (Treml 2017. DJ Study 615). Completed: Water clarity and temperature effects on walleye safe harvest: an empirical test of the safe operating space concept (Hansen et al. 2019. Ecosphere 10:1-12).

Category	Information Need	Projects
Regulations	*- continued* What are the effects of regulation XYZ on size, abundance, creel, community? A more systematic approach to evaluating regulations appears needed.	Completed: Use of long-term (40+ year) trend data to evaluate management actions on brown trout populations in groundwater-fed streams (Dieterman et al. 2020. Fisheries Management and Ecology 27:551-566) Completed: Review of Northern Pike Toolbox Regulations Implemented Spring 2003 (Bethke et al. 2021 Special Publication 188) Completed: Estimating Recycling in Catch-and-Release Fisheries (Jones et al. 2022. Fisheries 47: DOI: 10.1002/fsh.10824). In progress: Re-Evaluation of Hooking Mortality (Staples and Jones in preparation). In progress: Status assessment of Longnose Gar, Shortnose Gar, Paddlefish, and River Redhorse (Oliver et al. 2022 – 2024) In progress: Evaluation of Mississippi River Flathead Catfish demography and regulations (Oliver and Rude, MNDNR Miss. River Catfish Monitoring, 2022 – 2023)
Regulations	How effective has the 17-26 inch PSL for walleye been? BMP guidance document needed.	In progress: Evaluation of a 432-660 mm Protected Slot Limit for Walleye in Minnesota Lakes (Staples in preparation).
Regulations	What lake classes/population densities of sunfish and/or crappie are most likely to benefit from a special regulations? Guidance on regulation options, evaluation protocols, etc. would be useful.	In progress: Quality sunfish initiative.
Culture and Stocking	What factors affect the production of walleye fingerlings?	No known projects currently (work completed prior to 2017; see Reed et al. in review. The history and role of research in managing Minnesota's fisheries resources. Minnesota Department of Natural Resources, Section of Fisheries, Investigational Report. St. Paul.)

Category	Information Need	Projects
Culture and Stocking	Standardize evaluation of statewide stocking protocols; How often, how many, what size, where? Especially WAE.	Completed: Evaluation of two different stocking rates of small walleye fingerlings in Minnesota lakes (Reed and Staples. 2017. North American Journal of Fisheries Management 37:1243-1248) Completed: A report from the Walleye Technical Committee on the status of fingerling stocking and associated fish populations in lakes with stocking increased in response to recommendations under the Accelerated Walleye Program or Walleye Stocking Operational Plan 2010-2015 (Walleye Technical Committee 2017) Completed: Impacts of walleye fry stocking on year-class strength in lakes with walleye spawn-take operations (Logsdon and Anderson 2018. Investigational Report 569) Completed: Walleye stocking operational plan 2021-25 (Walleye Technical Team) Completed: Compilation and assessment of historical MN late-summer and fall walleye electrofishing data (Shroyer et al. 2019. Investigational Report 565) In progress: Evaluation of walleye natural reproduction in lakes stocked with fry (Walleye Technical Team)
Culture and Stocking	What mechanisms drive walleye year class strength and how do we quantify them?	Completed: Impacts of walleye fry stocking on year-class strength in lakes with walleye spawn-take operations (Logsdon and Anderson 2018 Investigational Report 569)
Culture and Stocking	What are the effects of stocking on native or naturalized populations?	Completed: Natural replacement of invasive brown trout by brook charr in a upper Midwestern United States stream (Hoxmeier and Dieterman 2019. Hydrobiologia 840:309-317) Completed: Reproductive dynamics of a native brook trout population following removal of non-native brown trout from a stream in MN, north-central USA (Miller et al. 2019. Hydrobiologia 840:49-61) Completed: Are MUE affecting fish communities in waters where they have been introduced? A re-examination of MN's stocked MUE waters (Knapp et al. 2020. North American Journal of Fisheries Management 41:229-241) In progress: Evaluating past and potential future reintroduction of sculpin in southeastern Minnesota (Dieterman et al.)

Category	Information Need	Projects
Culture and Stocking	Evaluate genetic effects of stocking, ours and others, and appropriate BMPs and regulations.	Completed: Introgression of hatchery rainbow trout in naturalized steelhead populations of western Lake Superior (Miller et al. 2020. Journal of Great Lakes Research 46:356–365) Completed: The ghosts of propagation past: haplotype information clarifies the relative influence of stocking history and phylogeographic processes on contemporary population structure of walleye (*Sander vitreus*). (Bootsma et al. 2021. Ecological Applications 14: 1124–1144) In progress: Evaluate population genetic structure of Lake Trout (Miller et al.) In progress: Evaluate population genetic structure of Walleye (Miller et al.) In progress: Evaluating past and potential future reintroduction of sculpin in southeastern Minnesota (Dieterman et al.) In progress: Genetic effects of stocking heritage Brook Trout on top of existing feral Brook Trout strains (Miller et al.)
Culture and Stocking	How does strain affect performance of walleye (or Heritage BKT, or LAT) stocked across the state (region)?	In progress: Lower Mississippi Strain Walleye performance and reproduction in southern Minnesota (Logsdon et al. DJ Study 601) In progress: Genetic effects of stocking heritage Brook Trout on top of existing feral Brook Trout strains (Miller et al.).
Culture and Stocking	Develop applications of parentage, individual ID, structure and ancestry analyses for culture, stocking and wild pops. Develop genomics tools for more power. *- continued on next page*	Completed: A GT-seq panel for walleye (Sander vitreus) provides important insights for efficient development and implementation of amplicon panels in non-model organisms. (Bootsma et al. 2020. Molecular Ecology Resources 20:1706–1722) Completed: Introgression of hatchery rainbow trout in naturalized steelhead populations of western Lake Superior (Miller et al. 2020. Journal of Great Lakes Research 46:356–365) Completed: The ghosts of propagation past: haplotype information clarifies the relative influence of stocking history and phylogeographic processes on contemporary population structure of walleye (Sander vitreus). (Bootsma et al. 2021. Ecological Applications 14: 1124–1144)

Category	Information Need	Projects
Culture and Stocking	*- continued* Develop applications of parentage, individual ID, structure and ancestry analyses for culture, stocking and wild pops. Develop genomics tools for more power.	Completed: Cisco population genetic structure in Minnesota (Miller et al. 2021. Investigational Report 570). Completed: Mechanism of northern pike invasion in the Columbia River Basin (Carim et al. 2022 Management of Biological Invasions 13:168-190 https://doi.org/10.3391/mbi.2022.13.1.10). In progress: Coordinating with USGS/UWSP to develop next-gen sequencing panel of microsatellites for esocids (Miller) In progress: Detecting hatchery fish in Coaster Brook trout populations (Miller et al.) In progress: Assessing effective population size of Knife River Steelhead population (Miller et al.) In progress: Identify Kamloops ancestry (Miller et al.) In progress: Determine ancestry of Muskellunge populations (Miller et al.) In progress: Identify prey species in Muskellunge guts (in support of DJ Study 681) In progress: Evaluate population genetic structure of Lake Trout (Miller et al.) In progress: Catfish population structure (Miller et al.) In progress: Using genomics to delineate stock structure and create a standardized genetic resources for Great Lakes Walleye (Miller et al.) In progress: Lower Mississippi Strain Walleye performance and reproduction in southern Minnesota (Logsdon et al. DJ Study 601)
Culture and Stocking	Does NOP stocking play a key role in southern fisheries; building on known age fish and the recent & future creels.	In progress: Identifying stocked Northern Pike using parentage-tagging (Miller et al.) In progress: Using drawdown followed by northern pike and yellow perch stocking to improve habitat quality in shallow southern Minnesota lakes (Howe et al (Herwig). In preparation).

Category	Information Need	Projects
Emerging Issues	How do zebra mussels impact the biological carrying capacity for gamefish/fish communities?	In progress: Evaluating secondary production on Mille Lacs (Rantala et al. non-DJ research project) In progress: Sentinel Lakes Program In progress: Examining the impacts of zebra mussels on walleye populations (Walleye/Zebra Mussel Workroup)
Emerging Issues	What are the influences of spiny waterfleas, hatch date, season, and zooplankton assemblage on first-year growth of sportfishes in Minnesota's Large and Sentinel Lakes?	Completed: Decrease in young-of-the-year Yellow Perch growth rates following *Bythotrephes longimanus* invasion (Staples et al. 2017. Biological Invasions 19:2197-2205) Completed: Walleye growth declines following zebra mussel and *Bythotrephes* invasion (Hansen et al. 2020. Biological Invasions 22:1481-1495) In progress: The effects of *Bythotrephes* on the native zooplankton community, the interactions between fish and *Bythotrephes*, and energy flow in the food web of an infested lake (UMD, Branstrator Lab)
Emerging Issues	Effects of warming atmospheric temperature and changing water clarity on fish communities; and Thermal-optical habitat as a predictor of WAE abundance. - *continued on next page*	Completed: Disentangling the effects of a century of eutrophication and climate warming on freshwater lake fish assemblages (Jacobson et al. 2017. PLOS One 12 (8):e0182667). Completed: Loss of Coldwater Fish Habitat in Glaciated Lakes of the Midwestern United States after a Century of Land Use and Climate Change (Jacobson et al. 2019. American Fisheries Society Symposium 90:141–157). Completed: Trophic Interactions and Regulators of Abundance of Largemouth Bass in Northeastern Minnesota (Bethke and Schmalz 2020. Investigational Report 568). Completed: Walleye Thermal Optical Habitat Area (TOHA) of selected Minnesota lakes (Read et al. 2021. U.S. Geological Survey data release, https://doi.org/10.5066/P9PPHJE2). Completed: Effects of a Shallow Lake Condition Shift on Habitat, Zooplankton, and Yellow Perch Dynamics (Skolte et al. 2021 North American Journal of Fisheries Management 42:659-667. https://doi.org/10.1002/nafm.10720)

Category	Information Need	Projects
Emerging Issues	*- continued* Effects of warming atmospheric temperature and changing water clarity on fish communities; and Thermal-optical habitat as a predictor of WAE abundance.	In progress: Quantifying multi-state drivers of hypoliminetic oxygen to inform management of Cisco habitat (Knoll et al., Midwest Glacial Lakes Partnership funded) In progress: Quantifying the impacts of climate change on fish growth and production to enable sustainable management of diverse inland fisheries (Hansen et al., Northeast Climate Adaptation Science Center funded). In progress: Walleye fisheries bright spots in a changing climate (Embke et al, Climate Adaptation Science Centers funded). In progress: Supply-and-demand dynamics associated with using stocking to maintain walleye fisheries in the face of climate change (University of Wisconsin – Stevens Point, Isermann lab) In progress: Evaluating secondary production on Mille Lacs (Rantala et al. non-DJ research project)
Emerging Issues	Quantify food webs across lakes with different fish communities, habitats and invasive species. Isotope analysis of historical samples. *- continued on next page*	Completed: Mille Lacs bioenergetics (Ahrenstorff and Holbrook 2016, Investigational Report 576) Completed: Stable isotopes indicate zebra mussels (*Dreissena polymorpha*) increase dependence of lake food webs on littoral energy sources (McEachran et al. 2019. Freshwater Biology 64: 183-196) Completed: Stable isotope patterns in lake food webs reflect productivity gradients (Zimmer et al. 2020. Ecosphere, https://doi.org/10.1002/ecs2.3244) Completed: Using stable isotope data to quantify niche overlap and diets of Muskellunge, Northern Pike and Walleye in a deep Minnesota lake (Herwig et al. 2021. Ecology of Freshwater Fish, https://doi.org/10.1111/eff.12608) Completed: Impacts of zebra mussels (Dreissena polymorpha) on isotopic niche size and niche overlap among fish species in a mesotrophic lake (Morrison et al. 2021. Biological Invasions https://doi.org/10.1007/s10530-021-02553-0) Completed: Trophic complexity of small fish in nearshore food webs (Wellard Kelly et al. 2021. Hydrobiologia 848:2505–2521)

Category	Information Need	Projects
Emerging Issues	*- continued* Quantify food webs across lakes with different fish communities, habitats and invasive species. Isotope analysis of historical samples.	Completed: Exploring watershed effects on nutrient concentrations in shallow lakes through stable isotope analysis (Langer et al. 2022 Science of the Total Environment DOI: 0.1016/j.scitotenv.2022.153742) In progress: Niche overlap and diets of Muskellunge and other piscivores in MN lakes (Herwig, et al. DJ Study 681, 4/1/2019 – 3/31/2024) In progress: Assessing impacts of ZM on the Ten Mile Lake food web and response of Lake Whitefish and Cisco populations (Herwig and French, non-DJ research project) In progress: Patterns of trophic position, littoral carbon use and habitat coupling in fish communities in MN lakes. (Kangas and Zimmer (Herwig), University of St. Thomas) In progress: Understanding drivers of isotopic niche overlap and trophic redundancy in fish communities in MN lakes. (Gallagher and Zimmer (Herwig), University of St. Thomas)

Updating Fisheries Information Needs

The FRU is committed to ensuring that fisheries information needs are periodically reviewed and updated. To update the fisheries information needs the FRU will rely on Section staff to not only develop research questions and needs, but also to assist in summarizing and prioritizing the needs. The Section's technical teams (e.g., Walleye Technical Team, Habitat Team) will be asked to review the 2017 information needs list and discuss and develop any new research ideas. Technical team members will be responsible for gathering input from Section staff they represent. Teams should identify any needs that are no longer relevant, add new information needs, and prioritize the needs. The team will pass along to the FRU supervisory team a short list of well-defined top priority needs using a standard new project idea form located on the FRU Intranet page (Appendix 1). Priority information needs should include a clearly defined problem or issue, and an initial evaluation of whether the question can be answered with existing data. A recommendation regarding how the Team believes the problem can be addressed should also be included (e.g., University project, Study 4, FRU research project). The FRU supervisory team will collate the prioritized lists from the Technical Teams and make it available for review by the Fisheries Management Team. The list will also be shared with the Division Leadership Team.

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APPENDIX 1 – New Project Idea Form

DEPARTMENT OF NATURAL RESOURCES

Fisheries Research Unit suggestion form

Please use this form to suggest potential priority research projects. These suggestions will be reviewed by the FRU Supervisory Team and the FMT to determine the best course of action.

Name		**Team/Office**	
Project scale		**Timeline**	
	Area/Regional/Statewide		How long to complete project?

Please answer the following questions

1. Succinctly describe your study idea, including a brief description of the study design if applicable.
2. What are the management implications for doing this study?
3. What are the specific questions/objectives? Are there hypotheses are you interested in testing?
4. Do you have an analysis approach in mind (e.g., based on previous studies or literature)? Would this require new data collection or could existing data be used?
5. Is there any previous literature (state reports, journal articles) that would familiarize us with this project idea?