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Annotated Bibliography of Voyageurs National Park Interior Lakes Documents and Datasets

Natural Resource Report NPS/VOYA/NRR—2020/2209

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ON THE COVER
Peary Lake.
NPS photo/T. Gostomski

Annotated Bibliography of Voyageurs National Park Interior Lakes Documents and Datasets

Natural Resource Report NPS/VOYA/NRR—2020/2209

Jaime F. LeDuc and Ryan P. Maki

National Park Service
Voyageurs National Park
360 Hwy 11 East
International Falls, Minnesota 56649

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Contents

Page

Introduction and Summary 1

Organization of this Bibliography 1

Section 1. Topics 3

Beavers 3

Contaminants 3

Fish 7

General 17

Invertebrates 18

Paleolimnology 19

Plankton 22

Water Quality 24

Section 2. Entries by Lake. 29

Agnes 29

Beast 29

Beaver (a.k.a., Jorgens) 29

Brown 29

Cayou 30

Cruiser 30

Ek (*see also Jorgen Lake, Leif Lake*) 31

Fishmouth 32

Jorgen (*see also Ek Lake*) 32

Jorgens (*formerly known as Beaver Lake*) 32

Leif (*see also Ek Lake*) 32

Little Johnson 32

Little Shoepack 32

Little Trout 33

Contents (continued)

Page

Locator....34

Loiten....35

Lucille....35

McDevitt....35

Mukooda....35

Net....36

O'Leary....36

Oslo....36

Peary....37

Quarterline....37

Quill....37

Ryan....38

Shoepack....38

Tooth....40

Unnamed....40

War Club....41

Weir....41

Wiyapka....41

Section 3. Entries by Author....43

Introduction and Summary

Voyageurs National Park (Voyageurs) in northern Minnesota offers its visitors an opportunity to experience the northwoods lake country that was once part of the historic water route traveled by the French-Canadian fur traders, who contributed significantly to the opening of the northwestern United States. Voyageurs was established in 1975 under Public Law 91-661 to preserve "the outstanding scenery, geological conditions, and waterway system which constituted a part of the historic route of the Voyageurs." As a unit of the National Park Service, park management is committed to conserving the natural resources for the enjoyment of future generations (1916 NPS Organic Act).

Voyageurs National Park encompasses part or all of four larger lakes and twenty-six smaller lakes commonly denoted as "interior lakes." A substantial amount of interior lake research and monitoring has been carried out, including investigations of fish populations and species assemblages, water quality, mercury contamination, paleolimnology, phytoplankton, zooplankton, benthic invertebrates, vegetation, and furbearers. The objective of this annotated bibliography is to consolidate existing information, to improve access to the information, and to support informed and science-based interior lake management.

Organization of this Bibliography

The first section lists entries by topic. Within a topic, entries are listed alphabetically by author's last name. Documents not identifying an author are listed as "No Author". Entries with the same author(s) are listed from oldest to most recent. Topical entries include a summary of the document.

The second and third sections can be used as a cross-reference for Section 1. Section 2 lists all entries by lake. Section 3 lists all entries by author name.

Section 1. Topics

Beavers

Host, G., and P. Meysembourg. 2010. Historic and recent landscape changes in relation to beaver activity in Voyageurs National Park, Minnesota, USA. Final report to National Park Service Great Lakes Inventory and Monitoring Network and Voyageurs National Park. Available at: https://irma.nps.gov/DataStore/DownloadFile/426953.

> The authors assessed changes in wetland type and area using recent (1997–2005) aerial photography and related changes to beaver population data recorded in aerial surveys during a period of potential beaver population decline.

Windels, S. 2010. A history of beaver activity in the Shoepack Lake area, Voyageurs National Park, 1984–2010.

> This report summarizes the history of beaver in the Shoepack Lake area. One aspect of its importance is that the beaver dam at the outlet of Shoepack affects the amount of available habitat for the genetically distinct population of native muskellunge in Shoepack Lake.

Windels, S. 2017. Beavers as engineers of wildlife habitat. Pages 239–268 *in* C. A. Johnston. Beavers: Boreal Ecosystem Engineers. Springer International Publishing AG, Switzerland.

> The author summarizes the many types of wildlife that utilize habitats created or influenced by beavers, including reptiles and amphibians. The areas around the interior lakes of Voyageurs are included. The author concludes that beavers are a keystone species with a major influence on a wide variety of vertebrates.

Contaminants

Engstrom, D. R., S. J. Balogh, and E. B. Swain. 2007. History of mercury inputs to Minnesota lakes: Influences of watershed disturbance and localized atmospheric deposition. Limnology and Oceanography 52(6):2467–2483.

> The history of mercury (Hg) inputs to 55 Minnesota lakes was reconstructed from lead-210 dated sediment cores to determine if erosion of soils from agriculture and urbanization contributes a significant loading of Hg to lakes, and whether lakes near Hg-emitting facilities receive appreciable local atmospheric deposition. Little Trout, Locator, Loiten, Shoepack, and Tooth lakes from Voyageurs were included in this study. Modern (1994–1997) Hg accumulation and Hg flux ratios (modern-to-preindustrial) increase significantly with the percentage of watershed area under urban or agricultural land use. Both past and modern Hg accumulation rates are strongly correlated with the flux of total aluminum, a tracer for soil erosion. Modern Hg accumulation rates are substantially higher in the Minneapolis-St. Paul metropolitan area and in agriculturally dominated south-central Minnesota than in the forested northeastern part of the state. This is largely because of erosional inputs of soil-bound Hg from disturbed catchments. Modern Hg loading from direct atmospheric deposition

is also greater in the metropolitan region than in the rural areas of south-central or northeastern Minnesota. However, some of the excess loading to urban lakes may also be a legacy of formerly high Hg deposition to urban watersheds. A decline in local Hg emissions from peak levels in the 1970s coupled with reduced erosional inputs has cut Hg loading to many metro-area lakes by more than half.

Engstrom, D. R., K. Thommes, S. J. Balogh, E. B. Swain, and H. A. Post. 1999. Trends in atmospheric mercury deposition across Minnesota: Evidence from dated sediment cores from 50 Minnesota lakes. Legislative Commission on Minnesota Resources, St. Paul, Minnesota.

The objective of this study was to reconstruct the history of mercury inputs to 50 Minnesota lakes using sediment cores to determine 1) if lakes near mercury-emitting facilities receive significant local atmospheric deposition, 2) if erosion of soils from agriculture and urbanization contributes greater loading of mercury to lakes, and 3) if human activities have also altered the rate at which these higher mercury loads are now being methylated. Five of the lakes in this study are in VNP: Little Trout, Locator, Loiten, Shoepack, and Tooth. The results indicate that mercury deposition has declined in VNP by 15%–20% since the mid-1970s, but not at all in other parts of northeastern Minnesota or in the west central part of the state. The localized decline implies a reduction in nearby mercury emissions sources. If local mercury emissions are responsible for declining mercury deposition in VNP, the most likely source contributing to this trend is the paper mill (Boise Cascade).

Goldstein, R. M., M. E. Brigham, L. Steuwe, and M. A. Menheer. 2003. Mercury data from small lakes in Voyageurs National Park, northern Minnesota, 2000–02. U.S. Geological Survey, Open File Report 03-480. Available at: https://pubs.usgs.gov/of/2003/ofr03-480/.

In this report the U.S. Geological Survey shares results from mercury data collection in 20 inland lakes at Voyageurs. The report includes several tables showing surface-water, hypolimnion, nutrient water chemistry, major-ion water chemistry, quality assurance results of blanks, and spatial-variation sampling data from selected lakes during the open water seasons of 2000–2002.

Knights, B. C., J. G. Wiener, M. B. Sandheinrich, J. D. Jeremiason, L. W. Kallemeyn, K. R. Rolfhus, and M. E. Brigham. 2005. Ecosystem factors influencing bioaccumulation of mercury from atmospheric deposition in interior lakes of the Voyageurs National Park, Minnesota. National Park Service, Midwest Region. Project Final Report, NRPP Project Number: 02-01.

Factors influencing physiochemical and trophic variables and concentrations of mercury in yellow perch (*Perca flavescens*) and northern pike (*Esox lucius*) were examined. The authors infer that nearly all of the mercury in fish in the park’s ecosystem results from deposition derived primarily from anthropogenic sources. The authors conclude that mercury inputs have caused substantial contamination of predator fish in the park. They consider the park to be a mercury-sensitive landscape. The authors give options for reducing methylmercury contamination and exposure.

Knights, B. C., J. G. Wiener, J. D. Jeremiason, K. R. Rolfhus, L. W. Kallemeyn, M. B. Sandheinrich. 2003. Role of trophic structure and ecosystem factors in determining methylmercury contamination of northern pike in interior lakes of the Voyageurs National Park. Annual Report. NRPP-USGS Research: FY2003. For Midwest Region of the National Park Service.

In this annual report, the authors summarized research on mercury and stable isotope ratios (carbon and nitrogen) in northern pike and selected prey species. They also assessed the influence of trophic structure on mercury concentration in northern pike by investigating diets and growth of northern pike. The authors stated that the study would be coordinated with ongoing investigations exploring the influence of lake watershed variables on mercury concentrations in yellow perch in park lakes. They wrote that the information could be used to develop criteria for identifying lakes where mercury may bioaccumulate to high levels in game fish and fish-eating wildlife. The report contains a table showing total mercury concentrations, nitrogen stable isotope ratios, and diet information for northern pike and age-1 yellow perch from 16 interior lakes between 2000–2003.

Rolfhus, K. R., B. D. Hall, B. A. Monson, M. J. Paterson, and J. D. Jeremiason. 2011. Assessment of mercury bioaccumulation within the pelagic food web of lakes in the western Great Lakes region. Ecotoxicology 20(7):1520–1529.

In this paper, Voyageurs National Park was one of ten study sites from the western Great Lakes region evaluated to examine (1) the similarity of methylmercury (MeHg) trophic efficiency within the pelagic food web, and (2) assess regional-scale variability. Fourteen Voyageurs interior lakes were included in this study. The samples collected were analyzed for MeHg in water, seston, and bulk zooplankton, and for mercury (Hg) in prey fish and northern pike. The findings indicate that a dissimilar assortment of aquatic systems spanning a multi-state region and several years of collection have similar pelagic food web MeHg bioaccumulation traits. The authors conclude that the similarity suggests that the aqueous supply of MeHg is largely controlling bioaccumulation in pelagic food webs, while local, lake-specific variability can result from an array of trophic (biological) factors.

Sorensen, J. A., G. E. Glass, K. W. Schmidt, J. K. Huber, and G. R. Rapp. 1990. Airborne mercury deposition and watershed characteristics in relation to mercury concentrations in water, sediments, plankton, and fish of eighty northern Minnesota lakes. Environmental Science & Technology 24(11):1716–1727.

Mercury concentrations in precipitation, lake water and sediment, zooplankton, and fish were measured and analyzed together with extensive watershed and lake chemistry data on 80 lake watersheds in the northeastern Minnesota region. Three Voyageurs National Park interior lakes (Ek, Mukooda, and Tooth) were included in this study. The authors concluded that the primary source of mercury was of atmospheric origin and that geologic and point-source contributions were not significant.

Wiener, J. G., R. J. Haro, K. R. Rolfhus, M. B. Sandheinrich, S. W. Bailey, R. M. Northwick, and T. J. Gostomski. 2016. Bioaccumulative contaminants in aquatic food webs in six national park units of the western Great Lakes region: 2008–2012. Natural Resource Report NPS/GLKN/NRR—2016/1302. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2233537.

The results of an intensive assessment of selected bioaccumulative contaminants in aquatic food webs and ecosystems in six national park units within the Great Lakes Inventory and Monitoring Network. The principal objectives of this project were to (1) assess spatial patterns in contamination of aquatic ecosystems and biota in six park units, (2) identify park units and water bodies where bioaccumulative contaminants may pose a risk to organisms—particularly piscivores atop aquatic food webs, and (3) provide data for assessing temporal trends in contamination of fish and aquatic food webs in parks of the Great Lakes Network. The study area includes four inland lakes (Ryan, Peary, Brown, Shoepack) and one large lake (Sand Point) at Voyageurs National Park.

Wiener, J. G., R. J. Haro, K. R. Rolfhus, M. B. Sandheinrich, S. W. Bailey, R. M. Northwick, and T. J. Gostomski. 2013. Bioaccumulation of persistent contaminants in fish and larval dragonflies in six national park units of the western Great Lakes region, 2008–2009. Natural Resource Data Series NPS/GLKN/NRDS—2013/427. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2192699.

Results of an initial assessment completed during 2008 and 2009 of selected bioaccumulative contaminants in aquatic organisms in six national park units within the Great Lakes Inventory and Monitoring Network. The principal objectives of this project were to (1) assess spatial patterns in contamination of aquatic biota in the six park units, (2) identify park units and surface waters where concentrations of bioaccumulative contaminants may pose a risk to organisms atop aquatic food webs, and (3) evaluate temporal trends in contamination of aquatic food webs in parks of the Great Lakes Network. The contaminants analyzed were total mercury, methylmercury, total lead, the insecticide DDT and its metabolites (DDE and DDD), polychlorinated biphenyls (PCBs, 72 congeners), perfluorochemicals (PFCs, nine analytes), and polybrominated diphenyl ethers (PBDEs, nine congeners). The Voyageurs lakes included were Brown, Peary, Ryan, and Sand Point Lake.

Wiener, J. G., B. C. Knights, M. B. Sandheinrich, J. D. Jeremiason, M. E. Brigham, D. R. Engstrom, L. G. Woodruff, W. F. Cannon, and S. J. Balogh. 2006. Mercury in soils, lakes, and fish in Voyageurs National Park (Minnesota): Importance of atmospheric deposition and ecosystem factors. Environmental Science and Technology 40:6261–6268.

This paper summarizes an intensive five-year study of water, soil, invertebrates, and fish in 17 interior lakes of Voyageurs National Park in northern Minnesota. Analyses of soil, bedrock, and sediment cores indicate that atmospheric deposition, primarily from anthropogenic sources, was the dominant source of mercury to the park. Analyses of dated sediment cores from Little Trout, Locator, Loiten, Shoepack, and Tooth lakes showed that most of the mercury accumulated in lake sediments during the 1900s was from anthropogenic sources. Lake pH, SO_4^{2-} concentration, and extent of wetland connectivity were the major factors exerting important controls on mercury bioaccumulation in predatory fish within Voyageurs National Park. Mean concentrations of total mercury in yellow perch varied more than 5-fold across the lakes (182 ng/g [dw] in Mukooda Lake to 942 ng/g [dw] in Ryan Lake). Ryan and Tooth lakes had both the highest concentrations of mercury in yellow perch and the highest concentrations of lake SO_4^{2-} (up to 74 μeq/L) among the studied lakes. Fish mercury concentrations were lowest in the three lakes that had pH >7.0 (Little Trout, Mukooda, and O'Leary).

Woodruff, L. G., M. B. Sandheinrich, M. E. Brigham, and W. F. Cannon. 2009. Impact of wildfire on levels of mercury in forested watershed systems—Voyageurs National Park, Minnesota. U.S. Geological Survey, Scientific Investigations Report 2009–5151. Available at: http://pubs.usgs.gov/sir/2009/5151/.

This report addresses the Section 33 wildfire that burned in the Shoepack Lake watershed in 2004 and the effect it had on mercury levels. The authors conclude that the fire mobilized large quantities of the mercury that had accumulated in forest soil, but the bulk of the mercury did not make its way into either the burned watershed's lake or aquatic food web. The low input of material from the burned landscape into lake waters may be the result of the relatively subdued topography in the watershed.

Fish

Anderson, J., and P. Ferguson. 2012. Assessment of lake trout, *Salvelinus namaycush*, abundance in Little Trout Lake, Minnesota. Voyageurs National Park report, International Falls, Minnesota.

Sixteen gillnet sets were deployed in Little Trout Lake. No lake trout were captured. The authors speculate (based on this and previous sampling efforts) that lake trout may be extirpated from Little Trout Lake and that the additive effects of loss of suitable thermal habitat, interspecific competition with introduced fishes, and overexploitation may be related to their decline.

Broschart, M. R. 2001. 1999 and 2000 volunteer angler report summary—Interior lakes, Voyageurs National Park. Unpublished Voyageurs National Park Resources Management Report.

This report contains the results from surveys that were distributed to visitors who used interior lake park boats and canoes during the summer seasons of 1999 and 2000. A total of 65 and 74 volunteer angler/loon survey forms were returned. Results included size class distributions and comparisons of number of anglers, total angler-hours, and catch rate by species. Canoe and boat use were also calculated.

Burnham-Curtis, M. K., L. W. Kallemeyn, and C. R. Bronte. 1997. Genetic variation among wild lake trout populations: The "wanted" and the "unwanted". Pages 97–102 *in* R. E. Gresswell, P. Dwyer, and R. H. Hamre, editors. Wild Trout VI: Putting the Native Back in Wild Trout. Urbani and Associates, Bozeman, Montana.

In this study, genetic variation within and among self-sustaining lake trout populations from the Great Lakes basin, the Rainy Lake basin (Cruiser, Little Trout, and Mukooda lakes), and Yellowstone Lake was examined. The researchers used RFLP (restriction fragment length polymorphism) analysis and direct sequencing to examine DNA sequence variation among several mitochondrial and nuclear genes, including highly conserved loci and highly variable loci. The lake trout from the three lakes in Voyageurs exhibited low genetic diversity, with the fish from Mukooda and Little Trout lakes having haplotypes similar to the Gillis Lake strain (a small lake located in the Hudson Bay drainage in northeastern Minnesota).

Burri, T. 2000. An angler creel survey of Little Trout and Mukooda lakes, winter 2002. Minnesota Department of Natural Resources, Section of Fisheries Completion Report, F-29-R(P)-21, Study 4, Job 613. St. Paul, Minnesota.

Estimated fishing pressure was 97 angler-hours (0.4 per acre) on Little Trout Lake and 1,588 angler-hours (2.1 per acre) on Mukooda Lake. Lake trout were the most commonly harvested species. An estimated nine lake trout were harvested on Little Trout and 115 on Mukooda. The average size of lake trout caught in Little Trout and Mukooda was much greater than the average size caught in many other lakes in Minnesota. Survey took place from 12 January to 15 March 2002.

Doeringsfeld, M. R. 1996. Niche relationships and morphology of coexisting northern redbelly (*Phoxinus eos*) and finescale (*P. neogaeus*) dace with their hybrids. Thesis. University of North Dakota, Grand Forks, North Dakota.

This study took place in the Lost Ponds and East Shoepack drainages on the Kabetogama Peninsula. The author examined the patterns of morphological variation and habitat utilization within and among populations of finscale dace, northern redbelly dace, and three hybrid biotypes of a single *Phoxinus eos-geogaeus* gynogenetic clone inhabiting the beaver ponds in Voyageurs.

Elder, J. F., and I. J. Schlosser. 1995. Extreme clonal uniformity of *Phoxinus eos/neogaeus* gynogens (Pisces: Cyprinidae) among variable habitats in northern Minnesota beaver ponds. Proceedings National Academy Science USA 92:5001–5005.

Gynogens were sampled from three habitats in each of four different pond types in a single drainage in Voyageurs. The extreme lack of clonal diversity in these gynogens across a range of habitat types does not fit the general pattern of high clonal diversity found within populations of other vertebrate parthenogens.

Ernst, D. 1969–1972. Lake survey summaries for the interior lakes.

Data collected by Dennis Ernst, Fisheries biologist for the Minnesota DNR. Includes fish surveys and some stocking records, fish management recommendations, water quality data, general watershed description, water levels, wildlife and plant surveys, recreational use and more. There is uncertainty about the dates.

Fields, R. D., M. D. G. DesJardins, J. M. Hudson, T. W. Kassler, J. B. Ludden, J. V. Tranquilli, C. A. Toline, and D. P. Philipp. 1997. Genetic analysis of fish species in the upper Midwest. Final Report to the Minnesota and Wisconsin Departments of Natural Resources. Illinois Natural History Survey, Center for Aquatic Ecology, Champaign, Illinois.

The objectives of this study were to: 1) assess the usefulness of three molecular techniques for detecting genetic variation among selected fish species in the upper Midwest; 2) identify a set of variable genetic characters that have the potential to delineate population structure on this regional scale; 3) conduct such a population genetic survey for selected fish species across the Mississippi River, Great Lakes, and Hudson Bay drainage basins; and 4) use these genetic data cooperatively with Minnesota DNR and Wisconsin DNR biologists to develop a regional management strategy based on conservation genetic principles. According to Larry Kallemeyn, Musky, Yellow Perch, and Johnny Darter from Shoepack were included in this analysis (personal correspondence). It is unclear if fish from other interior lakes were used. The report contains several maps showing the genetic groupings of different fish species in Minnesota and gives management recommendations.

Frohnauer, N. K., C. L. Pierce, and L. W. Kallemeyn. 2007a. Population dynamics and angler exploitation of the unique muskellunge population in Shoepack Lake, Voyageurs National Park, Minnesota. North American Journal of Fisheries Management 27:63–76.

This is one of two papers published from a two-year Muskellunge study that took place in Shoepack Lake. The study revealed that the Shoepack Lake Muskellunge exhibited slower growth rates and lower condition, but much higher densities and angler-catch per unit effort than other Muskellunge populations. It was also found that although their growth was slower than other strains in different lakes, the Shoepack-strain Muskellunge grew faster and attained greater ultimate lengths in other lakes than they do in Shoepack Lake. The authors concluded that this is due to a combination of genetic and environmental factors. The results of the study help define the unique nature of the Shoepack Lake Muskellunge and provide a suitable foundation for simulation modeling to assess long-term viability.

Frohnauer, N. K., C. L. Pierce, and L. W. Kallemeyn. 2007b. Simulated effects of recruitment variability, exploitation, and reduced habitat area on the muskellunge population in Shoepack Lake, Voyageurs National Park, Minnesota. North American Journal of Fisheries Management 27:77–88.

This is one of two papers published by these researchers on a two-year study that took place on the genetically unique strain of Muskellunge in Shoepack Lake. They use intensive sampling, mark–recapture, and angler survey data to simulate the effects of recruitment variability, exploitation, and reduced habitat on the Shoepack Lake Muskellunge population. Based on their findings the authors address two threats—reduction in habitat area (construction of an outlet dam by beavers) and fishing mortality—and suggest management actions such as no-kill, barbless hook, and limited entry to help preserve the long-term viability of the population.

Fox, J. E. 2005. Interior lakes volunteer angler survey summary, Voyageurs National Park 2003–2004. Natural Resource Report Series, Voyageurs National Park, International Falls, Minnesota.

Summarizes the results recorded on volunteer angler/loon survey forms distributed to park visitors who used park boats and canoes on the interior lakes during the summer seasons of 2003–2004. One hundred and eight forms were returned. The site locations were Cruiser, Ek, Jorgens, Little Shoepack, Shoepack, and the Chain of Lakes (Loiten, Quill, War Club, and Locator).

Gorman, O., L. W. Kallemeyn, and R. P. Maki. 2014. Biogeographic patterns of inland lake fish communities at Isle Royale, Voyageurs, and Sleeping Bear Dunes national park units. Natural Resource Technical Report NPS/GLKN/NRTR—2014/893. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2211844.

The composition of fish communities in the lakes of Isle Royale National Park, Sleeping Bear Dunes National Lakeshore, and the interior lakes of Voyageurs National Park were examined in this study. The authors evaluated the roles of historical biogeography, local habitat factors, and human impacts in structuring modern fish communities, and evaluated the potential impact of global climate change on the communities. Fish communities of Isle Royale were characterized by mix of coldwater, coolwater, and tolerant species, whereas Voyageurs lake communities contained fewer coldwater species and more tolerant species. Fish communities of Sleeping Bear Dunes were characterized by an absence of coldwater species and a mix of coolwater, tolerant, and warmwater species. Within each region, the authors identified "heritage" communities as those closest to their early Holocene composition, and proposed that they were valuable for conservation.

Hanson, D., B. Strand, D. Post, W. LeGrande, and S. Fillbach. 1983. Muskellunge electrophoresis study. Muskie 17:9–13.

Muskies from Shoepack Lake were included in this analysis because they are considered "slow growers." The Wisconsin and Minnesota Departments of Natural Resources asked authors to look for genetic differences between groups of Muskellunge in Wisconsin and Minnesota. They found that the populations studied were genetically distinct and concluded that if populations can be shown to be different genetically, then growth rate differences may also be due to genetic differences.

Hennig, J., K. Peterson, and L. Miller. 2010. Ancestry of lake trout in stocked lakes of Voyageurs National Park. Undergraduate Research Opportunity Program. University of Minnesota.

Researchers assessed the ancestry of lake trout in Mukooda, Little Trout, and Cruiser Lakes. Voyageurs was thought to have had natural self-sustaining populations of lake trout in these lakes. Dating to the 1940s, the MNDNR stocked these lakes with strains likely from Lake Superior. Starting in 1988, the lakes were solely stocked with a strain from inland Gillis Lake (marked with fin clips for later recognition). Later sampling uncovered unmarked fish. The researchers used microsatellite DNR markers and found few unclipped lake trout were Gillis strain. There was little evidence of natural reproduction by the Gillis strain. Some lakes may have remnant native populations.

Jennings, G., and R. Philipps. 2015. Preventing the establishment of a population of introduced smallmouth bass in Ek Lake—2015. Voyageurs National Park, International Falls, Minnesota.

This report summarizes work done in Ek Lake in 2015 to prevent smallmouth bass from establishing a population. The work included angling, seining, trap netting, and nest searching/destroying. A total of four smallmouth bass were caught and removed over three years.

Kallemeyn, L. W. 1990. Recreational use and fishing pressure on the interior lakes of Voyageurs National Park, 1989. Aquatic Research Report, Voyageurs National Park, International Falls, Minnesota.

Summarizes the results from an interior lake survey conducted in 1989. The survey included the use of routine ranger patrols, information gathered at visitor centers on the use of park-owned boats, and an angler report card. The lakes in the survey were Ryan, Peary, Oslo, Brown, Agnes, Ek, Quarterline, Jorgens, Beast, Net, O'Leary, Little Trout, and Mukooda.

Kallemeyn, L. W. 2006. Control of non-native smallmouth bass in Beast Lake in Voyageurs National Park (poster).

Smallmouth bass have been well established in Voyageurs' large lakes for many years. Their presence in Beast Lake was suspected to be hampering the park's attempt to restore native northern pike (*Esox lucius*). The pike were eradicated in 1961 when the lake was treated with the biocide toxaphene. In 2002, an attempt was made to control smallmouth bass in Beast Lake through physical removal and disruption of nests and eggs. Removal of bass was done primarily by angling because trap nets and minnow traps were not effective. Length, weight, and sex were determined for the bass, and stomachs, scales, and fin rays were collected for food habits and age and growth analyses. Forty spawning nests were visually located and disrupted. Observations of young-of-the-year bass in late summer indicated that some reproduction occurred during this period. Despite this, it appeared that removal of fish and disruption of spawning activities was feasible and could be an effective method for limiting the abundance of smallmouth bass.

Kallemeyn, L. W., and D. Warner. 1995. Potential for reintroduction of northern pike to Beast Lake, Voyageurs National Park. National Biological Service Report, International Falls Biological Station, International Falls, Minnesota.

This paper addresses the potential for reintroduction of native northern pike to Beast Lake. The authors conclude that the aquatic community of Beast Lake appears to have recovered from the toxaphene treatment it received in 1961. They find that the lake's fish, plankton, and crayfish communities are similar to the park's other interior lakes that support northern pike populations. Based on those findings, they conclude that Beast Lake's food web appears capable of once again supporting a pike population.

LeDuc, J. L., and C. Kissane. 2015. Preventing the establishment of a population of introduced smallmouth bass in Ek Lake—2014.

This report summarizes the work done in Ek Lake (2012–2014) to assess whether or not smallmouth bass were abundant and to determine if any young-of-the-year (YOY) bass were present in the lake, indicating the fish were reproducing.

In 2012, smallmouth bass were caught by an angler in Ek Lake, where the species has not historically been detected. That August, VOYA staff subsequently caught two adult smallmouth bass (<250 mm) by angling. In 2013, a total of two adult smallmouth bass were taken via angling, and a total of four nests were found and destroyed by stirring up the site with paddles. NPS staff seined and set minnow traps but did not catch any bass. In 2014, two smallmouth bass were caught in a seine on 11 August. One bass measured 17.5 cm and the other measured 7.5 cm. The smaller of the two was a YOY fish. It had likely hatched from a nest in Ek, indicating the presence of breeding bass. On one occasion, VOYA staff reported spotting multiple juvenile smallmouth bass in a seine haul, but the attempt to bring the haul to shore failed when the net became snagged on a large fallen tree.

Mero, S. W., L. Miller, and J. A. Younk. 2013. Moose Lake (31-0722) muskellunge population and genetic manipulation study (2008 to 2012). Minnesota Department of Natural Resources Section of Fisheries Completion Report. St. Paul, Minnesota.

All muskie stockings in Moose Lake from 1965 through 1983 were Shoepack-strain fish or progeny developed from Shoepack-strain brood stock lakes. The primary objective of this study was to remove fish with Shoepack-strain ancestry from the Moose Lake population to improve muskellunge size structure.

Miller, L. M., S. W. Mero, and J. A. Younk. 2009. The genetic legacy of stocking muskellunge in a northern Minnesota lake. Transactions of the American Fisheries Society 138(3):602–615.

The authors hypothesized that an effect of Shoepack-strain ancestry on fish size was contributing to the absence of large muskies in Moose Lake. They reported that genetic markers identified four unique genetic groupings that included the known Shoepack and Leech muskellunge, and the presumed original Moose Lake and stocked Wisconsin muskies.

Miller, L. M., S. W. Mero, and J. A. Younk. 2012. The impact of stocking on the current ancestry in twenty native and introduced muskellunge populations in Minnesota. Transactions of the American Fisheries Society 141(5):1411–1423.

Using 13 microsatellite DNA markers, the authors determined the ancestry of muskie in ten supplemented native populations and ten introduced populations. The authors were primarily interested in the prevalence of ancestry from the slow-growing Shoepack-strain, but found that the potential effects of Shoepack-strain ancestry on fish size were limited in most of the study lakes because of its low persistence.

Miller, L. M., M. C. Ward, and D. W. Schultz. 2015. Using genetic markers as individual tags: A case study of a mark–recapture estimate of adult muskellunge population size. North American Journal of Fisheries Management 35(2):210–215.

Microsatellite DNA analysis was used on samples from two north-central Minnesota lakes to estimate adult population size using mark-recapture techniques. One of the lakes had been stocked with Shoepack Lake-strain muskie fingerlings annually from 1971 to 1979. The results demonstrate the usefulness of genetic markers in place of traditional tagging methods for fish.

Minnesota DNR. Fish stocking record cards (copies with notes).

Copies of Minnesota DNR fish stocking records on interior lakes listed in alphabetical order followed by the range of years that stocking took place in parentheses: Agnes (1949–1966), Beast (1964–1997), Brown (1965), Cruiser (1948–1988), Ek (Leif) (1949–1966), Jorgen (Ek) (1953–1966), Jorgens (Beaver) (1942–1950), Little Trout (1965–2006), Locator (1932–1965), Loiten (1950–1965), Mukooda (1942–2010), O'Leary (1942–1971), Oslo (1950–1965), Peary (1950–1965), War Club (1965).

Minnesota DNR. MNDNR interior lake management plans.

Lakes are listed in alphabetical order followed by the year of completion: Beast (2003, 2014), Brown (2006), Cruiser (1997, 2007, 2016), Ek (2008), Fishmouth (2011), Jorgens (2007), Little Johnson (2012), Little Shoepack (2001), Little Trout (2011), Locator (2012), Loiten (2003, 2016), Mukooda (2009, 2014), Net (2008), O'Leary (2003), Oslo (2012), Peary (2005), Quill (2004, 2016), Ryan (2006), Shoepack (2001), Tooth (2010), War Club (2012).

Minnesota DNR. MNDNR fisheries investigations.

Lake surveys consist of periodic monitoring of fish populations, water chemistry, and fish habitat. Lake survey data is used to track fish population trends, evaluate the effectiveness of management actions such as stocking, and establish realistic management goals for a given lake.

Lakes are listed in alphabetical order followed by the years the lakes were surveyed in parentheses. Agnes (1971, 1979, 1999), Beast (1970, 1978, 2001, 2002, 2012), Brown (1971, 1983, 2004), Cruiser (1970, 1983, 1995, 2005, 2015), Ek (1972, 1979, 1996, 2006, 2016), Fishmouth (1971, 2009), Jorgens (1971, 2005), Little Shoepack (1970, 1983, 1999), Little Trout (1869, 1973, 1976, 1983, 1991, 1994, 1999, 2004, 2009, 2014), Locator (1970, 1983, 2000, 2010), Loiten (1970, 2001, 2015), Lucille (1971), McDevitt (1973), Mukooda (1969, 1983, 1987, 1991, 1994, 1997, 2002, 2007, 2012), Net (1973, 2006), O'Leary (1972, 1979, 2001, 2016), Oslo (1971, 1983, 2010), Peary (1971, 1983, 2003), Quarterline (1971, 2007),

Quill (1970, 1983, 1992, 1993, 2002, 2015), Ryan (1973, 2004), Shoepack (1970, 1983, 1999), Tooth (1973, 2008), War Club (1970, 1983, 2000, 2010), Weir (1983), Wiyapka (1973).

No Author. No Date. Evaluation of restoration of northern pike to Beast Lake, Voyageurs National Park. Proposal for funding (VOYA-N-006.1).

Although this is a proposal to evaluate the restoration of northern pike in Beast Lake, it also provides history of fish stocking and unauthorized fish introductions. It covers the introduction of rainbow trout into Beast and O'Leary lakes in 1964 after the lakes were treated with toxaphene by the Minnesota DNR. The author also covers the unauthorized introductions of smallmouth bass and walleye that were revealed during a post-stocking survey in 1995.

Radomski, P. 1990. Loiten Lake largemouth bass population evaluation using angling and a recreational survey of the Locator chain-of-lakes. Minnesota Department of Natural Resources report.

Returns of the Volunteer Angler Report cards suggested that the largemouth bass population in Loiten Lake could easily be over-exploited. Although angling parties were releasing their catch, reported catch rates indicated that a few anglers could catch a significant portion of the largemouth bass population in a short amount of time. Author recommended imposing a catch-and-release fishing regulation.

Savino, J. F., L. W. Kallemeyn, and M. J. Kostich. 1999. Native northern pike and non-indigenous largemouth bass competition and feeding under low light conditions. Final report to Voyageurs National Park under NBS Agreement No. 84088-1491-MH03. Great Lakes Science Center, Ann Arbor, Michigan.

The main research question in this study was whether the native northern pike or non-native largemouth bass has an advantage when they compete for food under the low light intensities caused by the stained water in the chain-of-lakes. The main finding was that northern pike captured more prey than largemouth bass when both predators were present, even though both predators observed and captured prey at low light intensities. The number of prey captures did not change with light intensity; instead, prey captures seemed to be related to differences in predator biomass.

Schlosser, I. J., and L. W. Kallemeyn. 2000. Spatial variation in fish assemblages across a beaver-influenced successional landscape. Ecology 81(5):1371–1382.

The authors examine the influence of both local successional processes associated with beaver activity and regional geomorphic boundaries on spatial variation in fish assemblages along the Kabetogama Peninsula in the park. They determine that fish abundance was highest in closed environments, primarily upland ponds, whereas species richness was highest in collapsed ponds and streams. They conclude that the entire mosaic of successional habitats

associated with beaver activity needs to be preserved in order to assure the presence of productive and diverse fish assemblages.

Schlosser, I. J., and L. W. Kallemeyn. 2017. Fish assemblages in a beaver-influenced successional landscape. Pages 223–238 *in* C. A. Johnston. Beavers: Boreal Ecosystem Engineers. Springer International Publishing AG, Switzerland.

This study examined the influence of both local successional processes associated with beaver activity and regional geomorphic boundaries on spatial variation of fish assemblages along the Kabetogama Peninsula. The authors present a hierarchical conceptual model suggesting how geomorphic boundaries and beaver pond succession interact to influence fish assemblage attributes. The presence of a productive and diverse fish assemblage in headwater streams requires the entire spatial and temporal mosaic of successional habitats associated with beaver activity. The regional geomorphic context in which the mosaic occurs strongly influences the ultimate impact of the local successional mosaic on fishes.

Schlosser, I. J., M. R. Doeringsfeld, J. Elder, and L. F. Arzayus. 1998. Niche relationships of clonal and sexual fish in a heterogeneous landscape. Ecology 79:953–968.

The authors examined the spatial, physiological, and morphological niche relationships in a *Phoxinus eos-neogaeus* gynogenetic complex of cyprinid fish in five drainages influenced by beaver along the Kabetogama Peninsula. The temporal and spatial unpredictability of environmental conditions has apparently resulted in selection for a physiologically flexible, "general purpose" clonal genotype, which occupies a broad ecological niche and may make establishment of additional clones in the same ecosystem difficult.

Schmidt, K. 2016. Confounding ciscos. American Currents 41(1):7–15.

This article is a summary of work on cisco morphs in Minnesota lakes. The question of whether or not ciscos are multiple species remains unanswered. The article has a table listing cisco collection localities and identification. The following Voyageurs National Park lakes are in the table: Little Vermilion, Crane, Mukooda, Sand Point, Little Trout, Namakan, Kabetogama, Locator, and Rainy. The Voyageurs lakes contain cisco, dwarf, tullibee, and nipigon morphs. Ciscoes may be multiple species or may be a single species that has adapted to fill open niches. In his discussion, Schmidt talks about how some ecologists push for using an ecosystem approach of management, which focuses on maintaining niches in lakes with sympatric, distinct morphological types and not individual species.

Schmidt, K. 2010. Cisco sampling at Voyageurs National Park.

Border Lakes Fish Survey targeting ciscos. Konrad Schmidt led the sampling effort in Mukooda, Little Trout, Agnes, and Locator lakes during the summer of 2010. The fish were captured using gill nets that were set overnight. Weather and site observations were recorded on datasheets, and temperature and dissolved oxygen profiles were taken. Tissue tags were recorded, and photographs were taken on all cisco captured.

Schupp, D. H. 1992. An ecological classification of Minnesota lakes with associated fish communities. Minnesota Department of Natural Resources Investigational Report 417. St. Paul, Minnesota. Available at: https://files.dnr.state.mn.us/publications/fisheries/investigational_reports/417.pdf.

This report was intended to provide a method for ecologically classifying lakes into types so that fishery managers can quickly separate problems from natural biological variation.

Soupir, C. A., M. L. Brown, and L. W. Kallemeyn. 2000. Trophic ecology of largemouth bass and northern pike in allopatric and sympatric assemblages in northern boreal lakes. Canadian Journal of Zoology 78:1759–1766.

This report is a summary of the seasonal food habits of allopatric and sympatric assemblages of largemouth bass and northern pike in six of the interior lakes: Loiten and Quill lakes, which contained allopatric largemouth bass populations; Brown and Oslo lakes, which contained allopatric northern pike populations; and Locator, War Club, and Jorgens lakes, which contained sympatric assemblages. Results suggested that northern pike in the interior lakes of VNP consumed a wide variety of food items that ranged from aquatic insects to fishes; however, the diet of largemouth bass in VNP lakes was more diverse than the diet of northern pike. Fishes (mainly yellow perch, *Perca flavescens*) comprised greater than 60% of the northern pike diet during all seasons in both allopatric and sympatric assemblages. Aquatic insects (primarily Odonata and Hemiptera) were important in the diets of largemouth bass in all communities.

Turnquist, K. N., W. A. Larson, J. M. Farrell, P. A. Hanchin, K. L. Kapuscinski, L. M. Miler, K. T. Scribner, C. C. Wilson, and B. L. Sloss. 2017. Genetic structure of muskellunge in the Great Lakes region and the effects of supplementation on genetic integrity of wild populations. Journal of Great Lakes Research 43(6):1141–1152.

The goal of this study was to investigate contemporary population structure and genetic diversity in forty-two populations of muskie sampled across the Great Lakes region. Muskies from Shoepack Lake displayed high levels of northern lineage ancestry indicating that if any historical stocking of Great Lakes muskellunge has occurred, it has not significantly affected that population.

U.S. Geological Survey. No Date. Control of exotic smallmouth bass in Beast Lake in Voyageurs National Park. (A USGS funding proposal submitted to the Biological Resource Management Projects Species and Population Status fund source.)

This is a proposal to control the exotic smallmouth bass that were illegally introduced into Beast Lake in the early 1990s. It contains a summary of exotic fish stocking, unauthorized introductions, and the northern pike restoration plan for Beast Lake. The authors argue that the removal of smallmouth bass should facilitate the restoration of the northern pike, as well as provide an assessment of the feasibility of removing them from other invaded lakes. It states that there was a noticeable decline in the abundance of minnows and crayfish in Beast Lake since the introduction of bass and pike.

Ward, M. C., L. M. Miller, D. W. Schultz, C. A. Pedersen, and C. S. Anderson. 2017. Muskellunge population assessment in two north-central Minnesota lakes aided by angler participation. American Fisheries Society Symposium 85:95–117.

This study was a population assessment of muskie in two north-central Minnesota lakes. It involved an evaluation of angler data when assessing various population metrics, including the residual effects of historical stocking efforts, as Shoepack Lake-strain muskie fingerlings were introduced into the native population during the 1970s.

Younk, J. A., and R. F. Strand. 1992. Performance evaluation of four muskellunge *Esox masquinongy* strains in two Minnesota lakes. Minnesota Department of Natural Resources Investigational Report 418. Minnesota Department of Natural Resources, Division of Fish and Wildlife, St. Paul, Minnesota. Available at: https://files.dnr.state.mn.us/publications/fisheries/investigational_reports/418.pdf.

In this study, the performance of four muskie strains (Shoepack, Mississippi, Court Oreilles, and Minocqua) were evaluated in two Minnesota study lakes. The authors found that the Shoepack-strain matured earlier and at a smaller size, and that its mortality rates were the highest. The Shoepack and Wisconsin strains had a more robust shape, and the Minocqua and Shoepack-strains had the lowest ultimate growth rates.

General

Kallemeyn, L. W. 1990. Recreational use and fishing pressure on the interior lakes of Voyageurs National Park, 1989. Aquatic Research Report, Voyageurs National Park, International Falls, Minnesota.

This report contains the results from a use and fishing pressure survey conducted in 1989 on the interior lakes using routine ranger patrols, information gathered at visitor centers on the use of park owned boats and canoes, and angler report survey cards. The results indicated that use of the interior lakes was extremely low and concluded that the voluntary angler report cards provided a biased picture of angling success due to the reluctance of unsuccessful anglers to return cards.

Kallemeyn, L. W., K. L. Holmberg, J. A. Perry, and B. Y. Odde. 2003. Aquatic synthesis for Voyageurs National Park. U.S. Geological Survey, Information and Technology Report 2003-0001. National Technical Information Service, Springfield, Virginia. Available at: https://pubs.usgs.gov/itr/2003/0001/itr20030001.pdf.

The synthesis provides an integrated account of what was known through 2003 about the biological communities and general aquatic ecosystem characteristics of Voyageurs National Park and the area encompassing it. In an effort to help managers better understand the results of research and monitoring efforts within the park, the authors provide comparisons with other areas and identify needs and potential opportunities for filling gaps in the existing knowledge base. They emphasize factors that directly affect the park's water resources, in particular fishing, reservoir operations, invasions and introductions of non-native species, and inputs of persistent contaminants. Results from past monitoring efforts on Locator, Mukooda, Cruiser, Shoepack, and Loiten lakes are addressed, but the authors recognize the sporadic and uneven nature of much of the work that was done on the interior lakes as a whole, and suggest the development of a more intensive long-term monitoring plan that addresses both biotic and abiotic components of these lake systems.

Lafrancois, B. M., and J. Glase. 2005. Aquatic studies in national parks of the upper Great Lakes states: Past efforts and future directions. Water Resources Division Technical Report, NPS/NRWRD/NRTR—2005/334. National Park Service, Denver, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/659907.

To identify aquatic information needs, a synthesis of aquatic studies was conducted for nine parks of the U.S. National Park Service Great Lakes Network. The goal was for the results to be used in developing long-term monitoring strategies.

Invertebrates

Lafrancois, B. M., and R. P. Maki. 2009. Implications of body size, trophic position, species identity, and lake water quality for crayfish mercury burdens in and near Voyageurs National Park (poster). Presented at Ecological Society of America conference.

Based on data collected from 2002 through 2006, the authors investigated: 1) factors influencing mercury burdens in the native crayfish *Orconectes virilis*, 2) potential differences in mercury burdens in *O. virilis* vs. the invasive *O. rusticus*, and 3) the potential for crayfish mercury concentrations to serve as an indicator of mercury burdens in other biota of interest. Few watershed, morphometric, or chemical attributes explained much variation in crayfish total mercury (THg). However, total organic carbon, which likely originated in catchment wetlands, independently explained 78% of the variation in mean crayfish THg. After accounting for between-lake variation in THg, mercury concentration in native *O. virilis* did not differ significantly from that of invasive *O. rusticus*. Crayfish THg explained significant variation in Northern Pike THg across the nine lakes for which data on both species were available (r^2=0.92), suggesting that crayfish may be a useful proxy for mercury burdens in game fish.

LeDuc, J., C. Treat, and M. Bacon. 2009. Crayfish length-weight relationships in lakes within and near Voyageurs National Park. Voyageurs National Park, International Falls, Minnesota.

The main purpose of this study was to assess the relationship between length and weight in native and rusty crayfish populations in lakes within and near Voyageurs National Park. The secondary purpose was to determine if rusty crayfish had invaded any of the interior lakes of the park. The total length versus weight, and carapace length versus weight were similar across all interior lakes sampled despite differences in lake morphology. No rusty crayfish

were found in any of the interior lakes sampled (Brown, Jorgens, Locator, O'Leary, Oslo, Ryan, and Tooth).

Paleolimnology

Davis, M., D. Christine, R. Calcote, K. L. Cole, G. M. Winkler, and R. Flakne. 1999. Holocene climate in the western Great Lakes national parks and lakeshores: Implications for future climate change. Conservation Biology 14(4):968–983.

Holocene climate history was reconstructed for each of the U.S. National Park Service units in the western Great Lakes region in order to evaluate sensitivity to global warming. Annual precipitation, annual temperature, and July and January temperatures were reconstructed by comparing fossil pollen in lake sediment with pollen in surface samples. Samples from Cayou Lake suggest that January temperatures at Voyageurs were higher 8,000 years ago than today, unlike most of the other parks that experienced colder winters. Voyageurs experienced a "prairie period" characterized by falling lake levels, low soil moisture, and pollen evidence of retreating forest on the Great Plains south and west of the park.

Edlund, M. B., J. E. Almendinger, X. Fang, J. M. R. Hobbs, D. D. VanderMeulen, R. L. Key, and D. R. Engstrom. 2017. Effects of climate change on lake thermal structure and biotic response in northern wilderness lakes. Water 9(9):678. Available at: https://www.mdpi.com/2073-4441/9/9/678.

Researchers compared retrospective temperature-depth relationships modeled using MINLAKE2012 with biogeochemical changes recorded in sediment cores. Four lakes in VNP (Cruiser, Ek, Little Trout, and Peary) and four lakes in Isle Royale National Park were studied. Common trends were increased summer epilimnion temperatures and increased frequency and duration of thermoclines in deep lakes. Changes in diatom communities differed between shallow and deep lakes and the parks. Based on changes in benthic and tychoplanktonic communities, shallow lake diatoms respond to temperature, mixing events, pH, and habitat. Changes in deep lakes are evident in the deep chlorophyll layer community of *Cyclotella* and *Discostella* species, mirroring modeled changes in thermocline depth and stability, and in *Asterionella* and *Fragilaria* species, reflecting the indirect effects of in-lake and watershed nutrient cycling and spring mixing.

Edlund, M. B., J. E. Almendinger, D. R. Engstrom, X. Fang, J. Elias, and U. Gafvert. 2014. Modeling the effects of past climate change on lakes in Isle Royale and Voyageurs national parks. Natural Resource Technical Report NPS/GLKN/NRTR—2014/909. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/502551.

To better understand recent changes in wilderness boreal lakes, the authors combined retrospective thermal modeling of temperature-depth relationships in lakes and compared model output with historical biological and physical changes in lakes as interpreted from dated sediment cores. Eight lakes that spanned a range of lake types were studied: Cruiser,

Ek, Little Trout, and Peary lakes in VNP, and Ahmik, Harvey, Richie, and Siskiwit lakes in Isle Royale National Park (ISRO). The most common significant trend was increased summer shallow-water temperatures for all eight lakes. The next significant trend was, for the deep lakes, an increase in the frequency and duration of thermal gradients equaling or exceeding 2°C or 3°C per meter. Surprisingly, there were no significant trends identified among the lakes in timing or duration of ice cover. Subtle shifts in accumulation rates of biogenic silica, a proxy for diatom productivity, hint that some lakes (Cruiser and Ek at VNP, Richie and Harvey at ISRO) may have become more productive in the last few decades.

Edlund, M. B., J. M. Ramstack, and D. R. Engstrom. 2008. Biomonitoring using diatoms and paleolimnology in the western Great Lakes national parks. Annual report (2006–2007) submitted to Great Lakes Inventory and Monitoring Network. St. Croix Watershed Research Station, Science Museum of Minnesota, Marine on St. Croix, Minnesota.

Sediment core analyses combined with repeated sampling of modern sedimented diatom communities and water quality monitoring was used to determine historical biological and water quality change, modern biological change, and potential causes of change. Thirty-three index lakes were selected from the Great Lakes Network parks. The lakes tested in Voyageurs (Ek, Cruiser, and Peary) showed changes in their diatom communities and biogeochemistry in the last 200 years, but in contrast to the other lakes investigated, the changes were not dramatic. The authors speculate that increased sedimentation rates were likely from logging, and that the greatest shift in diatom communities was likely due to the initial Euro-American interests and settlement in the region.

Hobbs, W. O., B. M. Lafrancois, R. Stottlemyer, D. Toczydlowski, D. R. Engstrom, M. B. Edlund, J. E. Almendinger, K. E. Strock, D. VanderMeulen, J. E. Elias, and J. E. Saros. 2016. Nitrogen deposition to lakes in national parks of the western Great Lakes region: Isotopic signatures, watershed retention, and algal shifts. Global Biogeochemical Cycles 30. Available at: doi:10.1002/2015GB005228.

The authors explore the relationships among NADP-measured reactive nitrogen (Nr) deposition, nitrogen stable isotopes (δ15N) in lake sediments, and the response of algal communities in 28 lakes situated in national parks of the western Great Lakes region of the U.S. The interior lakes included in the study from Voyageurs National Park were Cruiser, Ek, Little Trout, Mukooda, and Peary lakes. The authors found that 36% of all study lakes preserve a sediment δ15N record that is statistically correlated with some form of Nr deposition (total dissolved inorganic N, nitrate, or ammonium). Furthermore, they found that measured long-term (since 1982) nitrogen biogeochemistry and inferred critical nitrogen loads suggest that watershed nitrogen retention and climate strongly affect whether sediment δ15N is related to Nr deposition in lake sediment records. Measurements of algal change over the last ca. 150 years suggest that Nr deposition, in-lake nutrient cycling, and watershed inputs are important factors affecting diatom community composition, in addition to direct climatic effects on lake physical limnology. Their findings suggest that bulk sediment δ15N does reflect Nr deposition in some instances. In addition, this paper highlights the interactive effects of Nr deposition and climate variability.

Ramstack, J. M., S. C. Fritz, D. R. Engstrom, and S. A. Heiskary. 2003. The application of a diatom-based transfer function to evaluate regional water-quality trends in Minnesota since 1970. Journal of Paleolimnology 29:79–94.

A diatom-based transfer function was developed to reconstruct water chemistry since 1970 in 55 Minnesota lakes that span three different ecoregions. Shoepack, Little Trout, Locator, Loiten, and Tooth lakes from Voyageurs were included in the analysis of the Northern Lakes and Forests region. The diatom-based reconstructions suggest that change since 1970 has been limited in lakes within the Northern Lakes and Forest region compared to lakes in the Twin Cities metropolitan and agricultural dominated regions where land-use disturbances are greater. This paper supports the idea that modern land-use practices are having substantial impacts on Minnesota lakes.

Ramstack, J. M., S. C. Fritz, and D. R. Engstrom. 2004. Twentieth century water quality trends in Minnesota lakes compared with presettlement variability. Canadian Journal of Fisheries and Aquatic Sciences 61(4): 561–576.

This paper contains the results of a diatom-based transfer function designed to reconstruct water chemistry before European settlement in the same 55 Minnesota lakes addressed in Ramstack et al. (2003). The authors found that human impacts not only changed the relative abundance of individual taxa within an ecoregion, but in some cases have reduced or nearly eliminated some taxa and expanded the range of others. There was little change in the water quality in the forested regions of northeastern Minnesota. The authors conclude that the small changes seen were probably related to variations in climate or catchment soils.

U.S. Geological Survey, Biological Resources Division, Global Change Research Program. 1997. Cayou Lake, Voyageurs National Park. Pages 34–51 *in* Western Great Lakes Biogeographic Area Summary Report. Department of Forest Resources, University of Minnesota, St. Paul, Minnesota.

In this technical report the major results of Cayou Lake core sediment paleoecological analyses are presented. The analysis included: sediment chemistry, stable carbon isotope analyses of sediment charcoal and whole sediment, percent-charcoal analyses and microscopic charcoal counts, pollen, diatoms and Cladocera. A site-specific climate model for the Cayou Lake region was generated using the modern climate at International Falls, to be compared with the data-climate interpretation. Author is unknown. The PI for this was Ken Cole who was stationed at Indiana Dunes.

Winkler, M. G., and P. R. Sandford. 1998a. Environmental changes since deglaciation in Voyageurs National Park: A summary for park personnel. Pages 3–10 *in* E. D. Schneider, editor. Holocene Paleoenvironments in Western Great Lakes Parks. Final report to the National Park Service. Northern Prairie Wildlife Research Center, Missouri Field Station, Columbia, Missouri.

Sediment cores were collected by a piston corer and freezer corer from lakes and bogs in Voyageurs National Park, Apostle Islands National Lakeshore, and Isle Royale National Park and from a lake in northern Wisconsin. In this report, the authors write about the history of Cayou Lake by explaining what was found in its sediments. They explain climate changes since the last glacial maximum—approximately 18,000 years ago—when the Laurentide ice sheet began to recede, and they contrast pre-European settlement conditions with those in modern sediments to document changes due to recent human modification of the landscape.

Winkler, M. G., and P. R. Sandford. 1998b. Western Great Lakes paleoecology study, global climate change initiative. Pages 53–105 *in* E. D. Schneider, editor. Holocene Paleoenvironments in Western Great Lakes Parks. Final report to the National Park Service. Northern Prairie Wildlife Research Center, Missouri Field Station, Columbia, Missouri.

In this final report the authors describe the climate and landscape in Cayou Lake by explaining what was found in its sediments. They conclude that paleoecologic studies provide evidence of late-glacial and Holocene (the last 10,500 years) geomorphic, vegetational, limnologic, and climatic changes. Climate reconstructions were produced using the data produced, and data-climate model comparisons are presented in this report. The authors discuss their results and the direction and trends of vegetational and hydrologic change in the past in the western Great Lakes region in light of predicted global climate change.

Plankton

BSA Environmental Services. 2010a. Final report of phytoplankton analysis: Voyageurs National Park, Minnesota, methods and results. 2010. Prepared for the National Park Service Great Lakes Inventory and Monitoring Network under contract No: R2105090024. BSA Environmental Services, Inc., Beachwood, Ohio.

In 2006, NPS staff sampled zooplankton from 22 of the 26 interior lakes in Voyageurs National Park as part of the first year of NPS Great Lakes Inventory and Monitoring Network water quality monitoring. The phytoplankton samples were analyzed by BSA Environmental Services, Inc., and the methods and raw data are presented in this report. Phytoplankton specimens were identified to the lowest possible taxonomic level.

BSA Environmental Services. 2010b. Final report of phytoplankton microphotograph collection: Voyageurs National Park, Minnesota. 2010. Prepared for the National Park Service Great Lakes Inventory and Monitoring Network under contract No. R2105090024. BSA Environmental Service, Inc., Beachwood, Ohio.

In 2006, NPS staff sampled phytoplankton in 22 of the 26 interior lakes of Voyageurs National Park as part of the first year of NPS Great Lakes Inventory and Monitoring Network water quality monitoring. Phytoplankton specimens were photographed by BSA Environmental Services, Inc., and the microphotographs are presented in this report.

Hargis, J. R. 1978–1979. Ecological analysis of the plankton communities of Voyageurs National Park. Annual report submitted under contract no. CX-6000-8-R-133.

There is some uncertainty about the dates of this report. Library copy appears to contain original photographs of cladoceran and copepod zooplankton from Voyageurs. Ek is included with the large lakes as a reference lake. Physical, chemical, and biological features are noted.

Hargis, J. R. 1981. Ecological analysis of the plankton communities of Voyageurs National Park. Final report to the National Park Service submitted under contract PX-60007-0921. University of Minnesota, Duluth, Minnesota.

Ek, Locator, War Club, Quill, Loiten, Shoepack, Little Shoepack, Jorgens, Quarterline, and Agnes were sampled, along with the four large lakes. Based on various water quality parameters, chlorophyll-*a* concentrations, zooplankton population densities, and zooplankton community structures, the lakes were tentatively grouped into management units. There were apparent consistent differences between Hargis plankton data and VOYA/USGS data. These differences could be due to differences in taxonomic resolution and misidentification. Actual interannual differences in zooplankton data populations may have also been attributed.

Kallemeyn, L. W. 1982–1984. Phytoplankton analysis data, May–August, 1982–1984. U.S. Geological Survey annual report.

Each of the interior lakes was sampled in May and August, 1982 to 1984. Phytoplankton were identified to genera, and the number of individual cells was counted for 12 of the interior lakes collected during 1978–1983. Samples collected in 1984 from the other 14 interior lakes were analyzed at a different laboratory where phytoplankton were identified to species and counts were made of "algal units".

LeDuc, J. L., C. Kissane, and R. P. Maki. 2017. Twenty-six-lake survey for presence or absence of spiny water flea. Voyageurs National Park Resource Management Report—2017. National Park Service, International Falls, Minnesota

Three methods were used to determine presence or likely absence of spiny water flea (SWF) in the 26 Voyageurs National Park interior lakes in this study: zooplankton net tows, Ekman dredge sediment samples, and environmental DNA (eDNA) samples (from both water and lake bottom sediment). One SWF was found in a zooplankton net tow sample from Lucille Lake, indicating that spiny water fleas have likely been introduced into Lucille Lake. Additional sampling is needed to determine if there is an established population of SWF in Lucille Lake. The SWF was not detected in any of the other 25 interior lakes, despite being present in the surrounding large lakes since 2006. This suggests that regulations and Best Management Practices put in place by Voyageurs National Park in 2007 have been effective in preventing SWF from becoming established in at least 25 of the 26 interior lakes for a period of 10 years.

Lafrancois, B. M., R. Maki, and J. Tilmant. 2007. National Park Service data set: Characterize pre-*Bythotrephes* invasion zooplankton communities in interior lakes at Voyageurs National Park.

Zooplankton samples were collected from twelve lakes three times throughout the open water season in 2007. During the middle round of sampling (July), an additional thirteen lakes were sampled once for a total of 25 lakes sampled. Samples were collected with plankton nets having a 10-cm mouth and 80-micron pore-size mesh. Two vertical tows were collected at three randomly chosen points along the longest transect through the lake. The six tows were composited. All zooplankton were identified by Marte Thabes Kitson and Dr. Donn Branstrator at the University of Minnesota-Duluth. Taxonomic identification of zooplankton included *Bythotrephes* presence/absence checks, and identification, enumeration, and length and weight estimates of copepods, cladocerans, and rotifers.

Water Quality

Damstra, R., D. VanderMeulen, and J. Elias. 2014. Monitoring water quality of inland lakes, Great Lakes Network, 2012: Data Summary Report. Natural Resource Data Series NPS/GLKN/NRDS—2014/629. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2208297.

Summarizes the results of water quality monitoring by the Great Lakes Inventory and Monitoring Network (GLKN) in 2012. At Voyageurs, eight index lakes were sampled three times during the open water season. Field measurements included depth profiles of temperature, pH, specific conductance, and dissolved oxygen; water clarity; and water level relative to a benchmark. Water samples were collected once in July for laboratory analyses of total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica, calcium, sodium, magnesium, potassium, sulfate, chloride, dissolved organic carbon, alkalinity, and chlorophyll-*a*. In collaboration with the USGS, mercury sampling was conducted in five lakes: Ek, Shoepack, Brown, Ryan and Peary.

Elias, J. E. 2009. Monitoring water quality of inland lakes, 2008: Annual summary report. National Park Service, Great Lakes Inventory and Monitoring Network Report GLKN/2009/01. Available at: https://irma.nps.gov/DataStore/Reference/Profile/662762.

Summarizes the results of water quality monitoring by the Great Lakes Inventory and Monitoring Network (GLKN) in 2008. At Voyageurs, eight index lakes were sampled three times during the open water season. Field measurements included depth profiles of temperature, pH, specific conductance, and dissolved oxygen; water clarity; and water level relative to a benchmark. Water samples were collected once in July for laboratory analyses of total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica, calcium, sodium, magnesium, potassium, sulfate, chloride, dissolved organic carbon, alkalinity, and chlorophyll-*a*. In collaboration with the USGS, mercury sampling was conducted in five lakes: Ek, Shoepack, Brown, Ryan and Peary.

Elias, J. E., and D. VanderMeulen. 2008. Monitoring water quality of inland lakes, 2007: Annual summary report. National Park Service, Great Lakes Inventory and Monitoring Network Report, GLKN/2008/05. Available at: https://irma.nps.gov/DataStore/Reference/Profile/660550.

Summarizes the results of water quality monitoring by the Great Lakes Inventory and Monitoring Network (GLKN) in 2006 and 2007. At Voyageurs, eight index lakes were sampled three times during the open water season. Field measurements included depth profiles of temperature, pH, specific conductance, and dissolved oxygen; water clarity; and water level relative to a benchmark. Water samples were collected once in July for laboratory analyses of total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica, calcium, sodium, magnesium, potassium, sulfate, chloride, dissolved organic carbon, alkalinity, and chlorophyll-*a*. In collaboration with the USGS, mercury sampling was conducted in five lakes: Ek, Shoepack, Brown, Ryan and Peary. Field parameters were measured on additional lakes in 2007 in conjunction with a project to collect zooplankton samples (see "Plankton" section, Lafrancois et al. 2007). Surface sediment samples were collected from all sampled lakes at Voyageurs in 2006 for analysis of diatom communities.

Elias, J. E., and R. A. Damstra. 2011. Monitoring water quality of inland lakes, Great Lakes Network, 2009 and 2010: Data summary report. Natural Resource Data Series NPS/GLKN/NRDS—2011/163. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2170874.

Summarizes the results of water quality monitoring by the Great Lakes Inventory and Monitoring Network (GLKN) in 2009 and 2010. At Voyageurs, eight index lakes were sampled three times during the open water season. Field measurements included depth profiles of temperature, pH, specific conductance, and dissolved oxygen; water clarity; and water level relative to a benchmark. Water samples were collected once in July for laboratory analyses of total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica, calcium, sodium, magnesium, potassium, sulfate, chloride, dissolved organic carbon, alkalinity, and chlorophyll-*a*. In collaboration with the USGS, mercury sampling was conducted in five lakes: Ek, Shoepack, Brown, Ryan and Peary. In addition, sediment samples were collected from 16 lakes for analysis of change in diatom communities over a five-year period (the first sampling took place 2006).

Elias, J. E., and R. A. Damstra. 2012. Monitoring water quality of inland lakes, Great Lakes Network, 2011: Data summary report. Natural Resource Data Series NPS/GLKN/NRDS—2012/363. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2189073.

Summarizes the results of water quality monitoring by the Great Lakes Inventory and Monitoring Network (GLKN) in 2011. At Voyageurs, eight index lakes were sampled three times during the open water season. Field measurements included depth profiles of temperature, pH, specific conductance, and dissolved oxygen; water clarity; and water level relative to a benchmark. Water samples were collected once in July for laboratory analyses of total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica, calcium, sodium, magnesium, potassium, sulfate, chloride, dissolved organic carbon, alkalinity, and chlorophyll-*a*. In collaboration with the USGS, mercury sampling was conducted in five lakes: Ek, Shoepack, Brown, Ryan and Peary. In addition, preliminary results from diatom sampling are included as well as results from mercury sampling. Results from total suspended solids sampling at Ek, Peary, Cruiser, and Little Trout are also included.

Great Lakes Inventory and Monitoring Network. No Date. Inland lake water quality monitoring 2013—present. Reports and resource briefs available at: www.nps.gov/im/glkn/voya.htm.

Inland lake water quality monitoring at the eight index lakes continues. Data are available in NPSTORET. The eight index lakes continue to be monitored three times during the open water season. Field measurements include depth profiles of temperature, pH, specific conductance, and dissolved oxygen; water clarity; and water level relative to a benchmark. Water samples are collected once in July for laboratory analyses of total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica, sulfate, chloride, dissolved organic carbon, alkalinity, and chlorophyll-*a*. In collaboration with the USGS, mercury sampling is conducted in five lakes: Ek, Shoepack, Brown, Ryan, and Peary. Common loon (*Gavia immer*) surveys are also completed during GLKN water quality sampling rounds.

Kallemeyn, L. W. 1981–1984. Unpublished water quality data, 1981–1984.

Each of the interior lakes was sampled monthly generally from early May to late October. The sampling only took place for one season in each lake. There are depth profiles for dissolved oxygen and temperature. There are surface and bottom readings for pH, conductivity and alkalinity. There are also Secchi readings.

Newell, A. D., C. F. Powers, and S. J. Christie. 1987. Analysis of data from long-term monitoring of lakes. EPA/600/4-87/014. U.S. Environmental Protection Agency, Office of Acid Deposition National Surface Water Survey, Washington, D.C.

This research was funded and peer reviewed by the United States Environmental Protection Agency. A total of 121 lakes in four regions of the United States were sampled to monitor trends in low acid neutralizing capacity (ANC) surface waters across a gradient of acidic atmospheric deposition. It provides a guideline for the design of future monitoring programs. Cruiser, Locator, Loiten, and Shoepack were chosen from Voyageurs for this long-term monitoring program and were considered to be susceptible to acidification by acid deposition.

Payne, G. A. 1991. Water quality of lakes and streams in Voyageurs National Park, northern Minnesota, 1977–84. Water Resources Investigations Report 88-4016. U.S. Geological Survey. Available at: https://pubs.er.usgs.gov/publication/wri884016.

This report contains the results of water quality research that was conducted at Voyageurs from March 1977 through August 1984. Along with the results of thorough sampling on the large lakes, it contains the results of reconnaissance sampling of 19 of the park's 26 interior lakes. From 1982 through 1984, each interior lake was sampled twice, once in the spring and once in the fall, in order to determine water chemistry, trophic state, and physical characteristics. This preliminary analysis showed that the interior lakes were sharply stratified and had very low dissolved solids and alkalinity concentrations. Thirteen of the lakes were classified as moderately sensitive to acid precipitation, and two appeared extremely sensitive. About half of the interior lakes had low nutrient concentrations and low algal densities, and five of the lakes had a noticeable reduction in trophic state from May to August.

United States National Park Service. 1995. Baseline water quality data inventory and analysis, Voyageurs National Park. Water Resources Division Technical Report NPS/NRWRD/NRTR—95/44. National Park Service, Ft. Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/13824.

Includes information for 98 monitoring stations, based on data collected from 1967 to 1984. The U.S. Environmental Protection Agency's water quality criteria were used to identify water quality problems in surface waters. Nine parameters were found to have exceeded screening criteria at least once during the study.

Whitman, R. L., M. B. Nevers, L. L. Last, T. G. Horvath, M. L. Goodrich, S. M. Mahoney, and J. A. Nefczyk. No Date. Status and trends of selected inland lakes of the Great Lakes Cluster national parks. Unpublished report to the United States National Park Service Midwest Region, Omaha, Nebraska.

This report was never finalized due to unresolved data quality issues. Use this information with caution. In this study, a baseline lake inventory was established at selected inland lakes in the Great Lakes Cluster Parks. Sampling took place during the open water seasons of 1997–1999. The lakes selected in Voyageurs were Mukooda and Locator. Physical variables included lake profiles for dissolved oxygen, temperature, pH, and specific conductance. Phytoplankton, zooplankton, and benthic macroinvertebrates were sampled once per month. Water chemistry was sampled monthly in the epilimnion, hypolimnion, and littoral zones for chlorides, total hardness, total alkalinity, ammonia, nitrates, total phosphorus, and sulfate. Sediment samples were collected monthly in 1997 for nutrients and once for pesticides, volatiles, and metals. Phytoplankton and zooplankton were collected in the littoral zone in 1997, and benthic macroinvertebrates were collected from the littoral zone throughout the study.

Webster, K. E., and P. L. Brezonik. 1995. Climate confounds detection of chemical trends related to acid deposition in upper Midwest lakes in the USA. Water, Air, and Soil Pollution 85:1575–1580.

The paper presents trends in the acid-base chemistry of 28 low-ANC (acid neutralizing capacity) lakes in the upper Midwest between 1983 and 1994. Cruiser, Loiten, Locator, and Shoepack lakes were selected because they were considered to be susceptible to acidification by acid deposition.

Webster, K. E., P. L. Brezonik, and B. J. Holdhusen. 1993. Temporal trends in low alkalinity lakes of the upper Midwest (1983–1989). Water, Air, and Soil Pollution 67:397–414.

The authors present temporal trends in the chemistry of 28 lakes in the upper Midwest. Cruiser, Locator, Loiten, and Shoepack were chosen from Voyageurs. Temporal trends in SO_4^{2-} were all negative in direction, consistent with a regional decline in SO_2 emissions and atmospheric SO_4^{2-} deposition.

Section 2. Entries by Lake.

Listings under the "Unnamed" category do not mention lake names in the abstract/summary in Section 1. In some cases, the number of VNP lakes is noted, and that information is included in parentheses after the citation below.

Agnes

Hargis (1981)

Kallemeyn (1990)

Minnesota DNR. Fish stocking.

Minnesota DNR. Fisheries investigations.

Schmidt (2010)

Beast

Kallemeyn (1990)

Kallemeyn (2006)

Kallemeyn and Warner (1995)

Minnesota DNR. Fish stocking

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

No Author (No Date)

U.S. Geological Survey (No Date)

Beaver (a.k.a., Jorgens)

Minnesota DNR. Fish stocking.

Brown

Damstra et al. (2014)

Elias (2009)

Elias and Damstra (2011)

Elias and Damstra (2012)

Elias and VanderMeulen (2008)

Great Lakes Inventory and Monitoring Network (No Date)

Kallemeyn (1990)

LeDuc et al. (2009)

Minnesota DNR. Fish stocking.

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Soupir et al. (2000)

Wiener et al. (2013)

Wiener et al. (2016)

Cayou

Davis et al. (1999)

U.S. Geological Survey, Biological Resources Division, Global Change Research Program (1997)

Winkler and Sandford (1998a)

Winkler and Sandford (1998b)

Cruiser

Burnham-Curtis et al. (1997)

Damstra et al. (2014)

Edlund et al. (2008)

Edlund et al. (2014)

Edlund et al. (2017)

Elias (2009)

Elias and Damstra (2011)

Elias and Damstra (2012)

Elias and VanderMeulen (2008)

Fox (2005)

Great Lakes Inventory and Monitoring Network (No Date)

Hennig et al. (2010)

Hobbs et al. (2016)

Kallemeyn et al. (2003)

Minnesota DNR. Fish stocking

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Newell et al. (1987)

Webster and Brezonik (1995)

Webster et al. (1993)

Ek (*see also Jorgen Lake, Leif Lake*)

Damstra et al. (2014)

Edlund et al. (2008)

Edlund et al. (2014)

Edlund et al. (2017)

Elias (2009)

Elias and Damstra (2011)

Elias and Damstra (2012)

Elias and VanderMeulen (2008)

Fox (2005)

Great Lakes Inventory and Monitoring Network (No Date)

Hargis (1978–1979)

Hargis (1981)

Hobbs et al. (2016)

Jennings and Philipps (2015)

Kallemeyn (1990)

LeDuc and Kissane (2015)

Minnesota DNR. Fish stocking

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Sorensen et al. (1990)

Fishmouth

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Jorgen (*see also Ek Lake*)

Minnesota DNR. Fish stocking.

Jorgens (*formerly known as Beaver Lake*)

Fox (2005)

Hargis (1981)

Kallemeyn (1990)

LeDuc et al. (2009)

Minnesota DNR. Fish stocking.

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Soupir et al. (2000)

Leif (*see also Ek Lake*)

Minnesota DNR. Fish stocking.

Little Johnson

Minnesota DNR. Lake management plans.

Little Shoepack

Fox (2005)

Hargis (1981)

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Little Trout

Anderson and Ferguson (2012)

Burnham-Curtis et al. (1997)

Burri (2000)

Damstra et al. (2014)

Edlund et al. (2014)

Edlund et al. (2017)

Elias (2009)

Elias and Damstra (2011)

Elias and Damstra (2012)

Elias and VanderMeulen (2008)

Engstrom et al. (1999)

Engstrom et al. (2007)

Great Lakes Inventory and Monitoring Network (No Date)

Hennig et al. (2010)

Hobbs et al. (2016)

Kallemeyn (1990)

Minnesota DNR. Fish stocking

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Ramstack et al. (2003)

Schmidt (2010)

Schmidt (2016)

Wiener et al. (2006)

Locator

Damstra et al. (2014)

Elias (2009)

Elias and Damstra (2011)

Elias and Damstra (2012)

Elias and VanderMeulen (2008)

Engstrom et al. (1999)

Engstrom et al. (2007)

Fox (2005)

Great Lakes Inventory and Monitoring Network (No Date)

Hargis (1981)

Kallemeyn et al. (2003)

LeDuc et al. (2009)

Minnesota DNR. Fish stocking

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Newell et al. (1987)

Ramstack et al. (2003)

Schmidt (2010)

Schmidt (2016)

Soupir et al. (2000)

Webster and Brezonik (1995)

Webster et al. (1993)

Whitman et al. (No Date)

Wiener et al. (2006)

Loiten

Engstrom et al. (1999)

Engstrom et al. (2007)

Fox (2005)

Hargis (1981)

Kallemeyn et al. (2003)

Minnesota DNR. Fish stocking.

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Newell et al. (1987)

Radomski (1990)

Ramstack et al. (2003)

Soupir et al. (2000)

Webster and Brezonik (1995)

Webster et al. (1993)

Wiener et al. (2006)

Lucille

Minnesota DNR. Fisheries investigations.

McDevitt

Minnesota DNR. Fisheries investigations.

Mukooda

Burnham-Curtis et al. (1997)

Burri (2000)

Hennig et al. (2010)

Hobbs et al. (2016)

Kallemeyn (1990)

Kallemeyn et al. (2003)

Minnesota DNR. Fish stocking.

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Schmidt (2010)

Schmidt (2016)

Sorensen et al. (1990)

Whitman et al. (No Date)

Wiener et al. (2006)

Net

Kallemeyn (1990)

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

O'Leary

Kallemeyn (1990)

LeDuc (2009)

Minnesota DNR. Fish stocking.

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

No Author (No Date)

Wiener et al. (2006)

Oslo

Kallemeyn (1990)

LeDuc et al. (2009)

Minnesota DNR. Fish stocking.

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Soupir et al. (2000)

Peary

Damstra et al. (2014)

Edlund et al. (2008)

Edlund et al. (2014)

Edlund et al. (2017)

Elias (2009)

Elias and Damstra (2011)

Elias and Damstra (2012)

Elias and VanderMeulen (2008)

Great Lakes Inventory and Monitoring Network (No Date)

Hobbs et al. (2016)

Kallemeyn (1990)

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Fish stocking.

Minnesota DNR. Lake management plans.

Wiener et al. (2013)

Wiener et al. (2016)

Quarterline

Hargis (1981)

Kallemeyn (1990)

Minnesota DNR. Fisheries investigations.

Quill

Fox (2005)

Hargis (1981)

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Soupir et al. (2000)

Ryan

Damstra et al. (2014)

Elias (2009)

Elias and Damstra (2011)

Elias and Damstra (2012)

Elias and VanderMeulen (2008)

Great Lakes Inventory and Monitoring Network (No Date)

Kallemeyn (1990)

LeDuc et al. (2009)

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Wiener et al. (2006)

Wiener et al. (2016)

Shoepack

Damstra et al. (2014)

Doeringsfeld (1996)

Elias (2009)

Elias and Damstra (2011)

Elias and Damstra (2012)

Elias and VanderMeulen (2008)

Engstrom et al. (1999)

Engstrom et al. (2007)

Fields et al. (1997)

Fox (2005)

Frohnauer et al. (2007a)

Frohnauer et al. (2007b)

Great Lakes Inventory and Monitoring Network (No Date)

Hanson et al. (1983)

Hargis (1981)

Kallemeyn et al. (2003)

Mero et al. (2013)

Miller et al. (2009)

Miller et al. (2012)

Miller et al. (2015)

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Newell et al. (1987)

Ramstack et al. (2003)

Turnquist et al. (2017)

Ward et al. (2017)

Webster and Brezonik (1995)

Webster et al. (1993)

Wiener et al. (2006)

Wiener et al. (2013)

Wiener et al. (2016)

Windels (2010)

Woodruff et al. (2009)

Younk and Strand (1992)

Tooth

Engstrom et al. (1999)

Engstrom et al. (2007)

LeDuc et al. (2009)

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Ramstack et al. (2003)

Sorensen et al. (1990)

Wiener et al. (2006)

Unnamed

Broschart (2001) (***Interior lakes with park boats and canoes***)

BSA Environmental Services (2010a) (***22 lakes***)

BSA Environmental Services (2010b) (***22 lakes***)

Elder and Schlosser (1995)

Ernst (1969–1972)

Goldstein et al. (2003) (***20 lakes***)

Gorman et al. (2014)

Host and Meysembourg (2010)

Kallemeyn (1981–1984)

Kallemeyn (1982–1984)

Kallemeyn (1990).

Knights et al. (2003) (***16 lakes***)

Knights et al. (2005)

Lafrancois and Glase (2005)

Lafrancois and Maki (2009)

Lafrancois et al. (2007) (***12 lakes***)

LeDuc et al. (2017) (***26 lakes***)

Payne (1991) (***19 lakes***)

Ramstack et al. (2004)

Rolfhus et al. (2011)

Savino et al. (1999)

Schlosser and Kallemeyn (2000)

Schlosser and Kallemeyn (2017)

Schlosser et al. (1998)

Schupp (1992)

United States National Park Service (1995)

Wiener et al. (2006) (***17 lakes***)

Windels (2017)

War Club

Fox (2005)

Hargis (1981)

Minnesota DNR. Fish stocking

Minnesota DNR. Fisheries investigations.

Minnesota DNR. Lake management plans.

Soupir et al. (2000)

Weir

Minnesota DNR. Fisheries investigations.

Wiyapka

Minnesota DNR. Fisheries investigations.

Section 3. Entries by Author

Topical area under which the entry is found is shown in bold and parentheses at the end of the entry.

Anderson, J., and P. Ferguson. 2012. Assessment of lake trout, *Salvelinus namaycush*, abundance in Little Trout Lake, Minnesota. Voyageurs National Park report, International Falls, Minnesota. **(*Fish*)**

Broschart, M. R. 2001. 1999 and 2000 volunteer angler report summary—Interior lakes, Voyageurs National Park. Unpublished Voyageurs National Park Resources Management Report. **(*Fish*)**

BSA Environmental Services. 2010a. Final report of phytoplankton analysis: Voyageurs National Park, Minnesota, methods and results. 2010. Prepared for the National Park Service Great Lakes Inventory and Monitoring Network under contract No: R2105090024. BSA Environmental Services, Inc., Beachwood, Ohio. **(*Plankton*)**

BSA Environmental Services. 2010b. Final report of phytoplankton microphotograph collection: Voyageurs National Park, Minnesota. 2010. Prepared for the National Park Service Great Lakes Inventory and Monitoring Network under contract No. R2105090024. BSA Environmental Service, Inc., Beachwood, Ohio. **(*Plankton*)**

Burnham-Curtis, M. K., L. W. Kallemeyn, and C. R. Bronte. 1997. Genetic variation among wild lake trout populations: The "wanted" and the "unwanted". Pages 97–102 *in* R. E. Gresswell, P. Dwyer, and R. H. Hamre, editors. Wild Trout VI: Putting the Native Back in Wild Trout. Urbani and Associates, Bozeman, Montana. **(*Fish*)**

Burri, T. 2000. An angler creel survey of Little Trout and Mukooda lakes, winter 2002. Minnesota Department of Natural Resources, Section of Fisheries Completion Report, F-29-R(P)-21, Study 4, Job 613. St. Paul, Minnesota. **(*Fish*)**

Damstra, R., D. VanderMeulen, and J. Elias. 2014. Monitoring water quality of inland lakes, Great Lakes Network, 2012: Data Summary Report. Natural Resource Data Series NPS/GLKN/NRDS—2014/629. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2208297. **(*Water Quality*)**

Davis, M., D. Christine, R. Calcote, K. L. Cole, G. M. Winkler, and R. Flakne. 1999. Holocene climate in the western Great Lakes national parks and lakeshores: Implications for future climate change. Conservation Biology 14(4):968–983. **(*Paleolimnology*)**

Doeringsfeld, M. R. 1996. Niche relationships and morphology of coexisting northern redbelly (*Phoxinus eos*) and finescale (*P. neogaeus*) dace with their hybrids. Thesis. University of North Dakota, Grand Forks, North Dakota. **(*Fish*)**

Edlund, M. B., J. E. Almendinger, D. R. Engstrom, X. Fang, J. Elias, and U. Gafvert. 2014. Modeling the effects of past climate change on lakes in Isle Royale and Voyageurs national parks. Natural Resource Technical Report NPS/GLKN/NRTR—2014/909. National Park

Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/502551. (***Paleolimnology***)

Edlund, M. B., J. E. Almendinger, X. Fang, J. M. R. Hobbs, D. D. VanderMeulen, R. L. Key, and D. R. Engstrom. 2017. Effects of climate change on lake thermal structure and biotic response in northern wilderness lakes. Water 9(9):678. Available at: https://www.mdpi.com/2073-4441/9/9/678. (***Paleolimnology***)

Edlund, M. B., J. M. Ramstack, and D. R. Engstrom. 2008. Biomonitoring using diatoms and paleolimnology in the western Great Lakes national parks. Annual report (2006–2007) submitted to Great Lakes Inventory and Monitoring Network. St. Croix Watershed Research Station, Science Museum of Minnesota, Marine on St. Croix, Minnesota. (***Paleolimnology***)

Elder, J. F., and I. J. Schlosser. 1995. Extreme clonal uniformity of *Phoxinus eos/neogaeus* gynogens (Pisces: Cyprinidae) among variable habitats in northern Minnesota beaver ponds. Proceedings National Academy Science USA 92:5001–5005. (***Fish***)

Elias, J. E. 2009. Monitoring water quality of inland lakes, 2008: Annual summary report. National Park Service, Great Lakes Inventory and Monitoring Network Report GLKN/2009/01. Available at: https://irma.nps.gov/DataStore/Reference/Profile/662762. (***Water Quality***)

Elias, J. E., and D. VanderMeulen. 2008. Monitoring water quality of inland lakes, 2007: Annual summary report. National Park Service, Great Lakes Inventory and Monitoring Network Report, GLKN/2008/05. Available at: https://irma.nps.gov/DataStore/Reference/Profile/660550. (***Water Quality***)

Elias, J. E., and R. A. Damstra. 2011. Monitoring water quality of inland lakes, Great Lakes Network, 2009 and 2010: Data summary report. Natural Resource Data Series NPS/GLKN/NRDS—2011/163. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2170874. (***Water Quality***)

Elias, J. E., and R. A. Damstra. 2012. Monitoring water quality of inland lakes, Great Lakes Network, 2011: Data summary report. Natural Resource Data Series NPS/GLKN/NRDS—2012/363. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2189073. (***Water Quality***)

Engstrom, D. R., K. Thommes, S. J. Balogh, E. B. Swain, and H. A. Post. 1999. Trends in atmospheric mercury deposition across Minnesota: Evidence from dated sediment cores from 50 Minnesota lakes. Legislative Commission on Minnesota Resources, St. Paul, Minnesota. (***Contaminants***)

Engstrom, D. R., S. J. Balogh, and E. B. Swain. 2007. History of mercury inputs to Minnesota lakes: Influences of watershed disturbance and localized atmospheric deposition. Limnology and Oceanography 52(6):2467–2483. (***Contaminants***)

Ernst, D. 1969–1972. Lake survey summaries for the interior lakes. (***Fish***)

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Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525