

Final Abstract

Final Report Approved on October 2, 2026

M.L. 2023 Project Abstract

For the Period Ending June 30, 2026

Project Title: Sinking and Suspended Microplastic Particles in Lake Superior

Project Manager: ELIZABETH MINOR

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Funding Source:

Fiscal Year:

Legal Citation: M.L. 2023, Chp. 60, Art. 2, Sec. 2, Subd. 04e

Appropriation Amount: \$412,000

Amount Spent: \$411,865

Amount Remaining: \$135

Sound bite of Project Outcomes and Results

Microplastics are removed from lake water by being caught up in sinking particles when the lake is stratified and undergoing its "growing season." Microplastic carbon is a measurable amount of total particulate organic carbon sinking flux in lake waters and likely to be incorporated into sediments for the foreseeable future.

Summary of Project and Outcomes

In this study, suspended particles (>50 µm) from surface, mid-depth and deep waters and sinking particles from deep water (100 m depth) were collected in Lake Superior, which experiences full water column mixing in spring and fall and density (temperature-driven) stratification in summer and winter. The suspended particles were collected by in-situ pumping during each ice-free season (spring, summer, and fall). Sinking particles were collected year-round over 14-to-21-day time periods using a sediment trap. Initial study of surface sediment microplastic concentrations was also attempted but was unsuccessful as the plastic core liners in the sediment sampling device contributed significant plastics to samples and blanks. Microplastic concentrations and characteristics in pump and trap samples were determined by microFTIR analysis. Trends in microplastic-particle polymer composition, density, size, and morphology were investigated relative to particle depth and lake season. Lake stratification state (mixed vs stratified) appeared to be the

main driver of microplastic concentration in the water column. During the stratified season relative to the mixed season, suspended microplastic particles were much lower in concentration across all depths. Conversely, microplastic flux into the sediment traps was higher in the stratified periods. Sinking fractions contained a somewhat higher diversity of denser polymers and a greater proportion of larger particles. However, both light and dense polymers were found throughout the water column and in the sediment trap samples. The seasonal differences and the mixture of polymers present in the samples suggest that vertical transport is not governed by plastic particle density alone. Other processes such as aggregation, fecal pellet incorporation or formation of biofilms likely play pivotal roles in vertical distribution. Microplastics contributed up to 1.5% of the organic carbon flux in sediment trap samples and are thus a quantitatively measurable component of the lake's carbon cycle.

Project Results Use and Dissemination

Methods were shared through the Great Lakes Microplastics Summit (October 23, 2025). Results were presented at departmental seminars at Lakehead University, Thunder Bay, Canada (February 2026) and the Department of Chemistry and Biochemistry, University of Minnesota Duluth (February 2026). Results were also shared in a Freshwater Folks Meeting presentation (May 6, 2026), Science on Deck talks (June 2024, June 2025), Freshwater Discovery Day activities (July 2024), and a presentation to the Duluth, MN Rotary Club (March 2025). One Master's thesis has been completed. Data is archived at the Data Repository for the University of Minnesota.



Environment and Natural Resources Trust Fund

M.L. 2023 Approved Final Report

General Information

Date: October 5, 2026

ID Number: 2023-074

Staff Lead: Tiffany Schaufler

Project Title: Sinking and Suspended Microplastic Particles in Lake Superior

Project Budget: \$412,000

Project Manager Information

Name: ELIZABETH MINOR

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Web Address: <https://scse.d.umn.edu/large-lakes-observatory>

Project Reporting

Final Report Approved: October 2, 2026

Reporting Status: Project Completed

Date of Last Action: October 2, 2026

Project Completion: June 30, 2026

Legal Information

Legal Citation: M.L. 2023, Chp. 60, Art. 2, Sec. 2, Subd. 04e

Appropriation Language: \$412,000 the first year is to the Board of Regents of the University of Minnesota for the Large Lakes Observatory in Duluth to investigate the abundance, characteristics, and fate of microplastic particles in Lake Superior to inform remediation strategies and analyses of environmental impacts. Of this amount, \$189,000 is from the Great Lakes protection account and \$223,000 is from the trust fund. These appropriations may also be used to educate the public about the research conducted with this appropriation.

Appropriation End Date: June 30, 2026

Narrative

Project Summary: Microplastics suspended in and sinking within Lake Superior waters will be compared to help determine source and fate. The flux of microplastics from water to sediment will be determined.

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Since 1950, when large-scale plastics production began, plastics have become increasingly important to our everyday lives. They are found in clothing, building materials, food packaging, medical supply packaging, fishing gear, and car parts. Of the plastic produced worldwide since 1950, ~ 59% is now waste present in landfills or the open environment. As plastics are so prevalent and are often long-lived in the environment, they are being spread from areas of input to remote regions by water currents, wind currents, and animal activity. Plastic pieces (many in the microscopic range that can be easily ingested by animals) are often found in natural waters. The health impacts for those animals ingesting microplastics is an active area of research. This project would investigate plastic-particle types, size ranges, and extents of weathering— in particles suspended in the water column (and thus more likely to impact fish and other organisms in open-lake waters) vs those that sink and are thus most likely to end up in the sediments, impacting animals that live on or feed on the sediments. We will estimate the flux of plastic from the water to the sediments and pinpoint the time of year that most of this flux occurs.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

We will measure sinking and suspended plastic particles (>4 mm, >300 µm, >100 µm) in Lake Superior's western gyre by comparing samples from large-volume in situ pumping filtration (suspended particles) at depths from surface water to ~100 m with samples collected in a sediment trap (sinking particles) at 100 m depth. The sediment trap consists of a conical collection surface that deposits sinking particles into a set of rotating tubes, with a new tube put in place every 10 to 20 days. Thus from the sediment trap we not only get physical samples to characterize but a known time frame over which these samples are deposited. We will compare the amount, type, and extent of weathering of microplastics in water column samples with those in the sediment trap to determine predictive factors for the fate of plastic materials in the lake. We will see if there are specific seasons, lake states, or particle types that lead to the sinking and potential burial of plastic particles in sediments. Both suspended and sinking material samples will be analyzed for numbers, shapes (fiber, foam, fragment, etc) and mass of microplastic particles. Microplastic polymers will be identified using specialized equipment (microFTIR or pyGCMS).

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

This project will provide information on the sources and fate of plastic pollution in Lake Superior. Plastic particles have been identified in the lake's surface waters, fish, and beach sands, but we do not yet know what plastics remain in the water and what get buried in sediments. Surprisingly, plastic density appears a poor predictor of particle location in surface waters vs mid-water column vs sediments. This project will provide insights into factors promoting the sinking of microplastics and help us design effective remediation strategies. It will also inform toxicology studies by providing environmentally-relevant particle loadings and size ranges.

Project Location

What is the best scale for describing where your work will take place?

Region(s): NE

What is the best scale to describe the area impacted by your work?

Region(s): NE

When will the work impact occur?

During the Project and In the Future

Activities and Milestones

Activity 1: Determination of sinking and suspended microplastics in Lake Superior

Activity Budget: \$388,270

Activity Description:

Sediment traps have been deployed on cruises funded with non-ENRTF dollars, with installation in August 2021 and recovery/redeployment in August 2022 and August 2023. We request funding to add deployments from August 2023-May 2024, May 2024-October 2024, and October 2024-to May 2025. This will give us two years of sediment trap samples at ~ monthly resolution and 1.6 years at better than monthly resolution at the cost of three sediment trap cruises (May 2024, Oct 2024, and May 2025). On these sediment trap cruises and additional cruises (July 2023, July 2024), we will perform suspended-particle sampling (via McLane pump) at 3 sites within 2 nautical miles of the mooring and at multiple depths (above and below the seasonal thermocline). On the July 2023 and May 2025 cruises we will also collect surface sediments via multicorer from the pumping locations. Sinking-particle samples and sediment samples will be sieved to the same size ranges as the suspended-particle samples. All samples will be oxidized and density separated prior to analysis. The number, size, polymer identification, and extent of weathering of plastic particles will be determined using microFTIR analysis or visual microscopy coupled with pyGCMS (if matrix effects complicate polymer identification using microFTIR).

Activity Milestones:

Description	Approximate Completion Date
Initial testing of sediment trap samples; fine-tuning of microplastic isolation and analysis procedures	February 28, 2024
Preparation and laboratory analysis of the initial suspended-particle and sediment samples	June 30, 2024
Completion of sampling	May 31, 2025
Completion of sample processing and preparation of manuscripts for publication	April 30, 2026

Activity 2: Dissemination of Data to State of MN Partners and the Public

Activity Budget: \$23,730

Activity Description:

We will share our results with the interested public via our lab group websites and via Science on Deck presentations, where the R/V Blue Heron, UMD's research vessel, is open to tours by the general public and hosts presentations on scientific issues. We will also present our results at meetings of the Twin Ports Freshwater Folks, a MN-SeaGrant-hosted gathering of researchers, managers, and community members interested in freshwater issues in northeastern MN and western Wisconsin. Results will be shared with partners at the MPCA and MN Department of Health, who are working on risk assessment of microplastics in Minnesota waters via oral presentations and the sharing of data archive links. All data will be archived along with metadata and a brief project description at the Data Repository for U of MN (DRUM), which provides searchable links to archived data for researchers around the world. We request two half-days of funding for the R/V Blue Heron to cover the travel to/from the Duluth Aquarium and the time for the public tours, funding for outreach materials, and salary for the PI to oversee the outreach, data reporting and data archiving.

Activity Milestones:

Description	Approximate Completion Date
Posting project information (including pictures of sampling) on a webpage for the general public	May 31, 2025
Sharing with interested public through Science on Deck	May 31, 2026
Sharing with colleagues at MDH, MPCA, the Fond du Lac Environmental Program and UMN	June 30, 2026
Archiving data in DRUM, a publicly available data repository	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Josef Werne	University of Pittsburgh	co-PI via subaward (helping with sediment trap sampling, sample analyses and data interpretation)	Yes
Nancy Schuldt	Water Projects Coordinator, Fond du Lac Environmental Program	interested in the data collected	No
Steve Besser	Statewide Fishing Organization Representative on the Minnesota Clean Water Council	interested in data collected, may assist in sample collection	No
Michael Jacob	Large Lakes Observatory	budgeting and administrative assistance	No
Melissa Maurer-Jones	UMD	coPI	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.

Our results will be presented at regional or international scientific meetings, such as those held by the Association for the Sciences of Limnology and Oceanography or the American Water Works Association. We will also present our results at meetings of the Twin Ports Freshwater Folks, a MN-SeaGrant-hosted gathering of researchers, managers, and community members interested in freshwater issues in northeastern MN and western Wisconsin. Through this and other mechanisms, our results will be shared with colleagues at the MPCA, the DNR, and the Minnesota Department of Health who have demonstrated interest in the plastic levels in Minnesota waters. Publication of our results in peer-reviewed journals such as Science of the Total Environment, Environmental Science and Technology, or Limnology and Oceanography will allow them to inform research and management on a national to international basis.

The data collected in this project will be archived at the Data Repository for the University of Minnesota (DRUM). The DRUM repository is open-access and provides searchable doi links for data sets.

To share our results with Minnesotans and to help reduce microplastics pollution in Minnesota waters we will give Science on Deck presentations, where the R/V Blue Heron, UMD's research vessel, is parked by the Great Lakes Aquarium (Duluth, MN) for tours by the general public and the hosting of presentations on scientific issues. We will also maintain a website that is focused on sharing project details with the general public.

The Environment and Natural Resources Trust Fund will be acknowledged on project publications, presentations at meetings, electronic media, and other communications using the trust fund logo or attribution language per the ENRTF Acknowledgment Guidelines.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

We will share our published data with the interested public through our existing laboratory websites.

Seminars/webinars will be used to provide preliminary results to various stakeholders as data becomes available. We will archive the data in a publically available data repository and publish our results in peer-reviewed papers. The data will also be shared with our colleagues at the MPCA and the MN Dept of Health so that they can inform toxicology and risk assessment studies.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Quantifying Microplastics in Minnesota's Inland Lakes	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04d	\$200,000

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount	\$ Amount Spent	\$ Amount Remaining
Personnel										
PI		Will oversee the sampling, analyses, reporting, and data archiving			27%	0.12		\$19,141	-	-
Co-I		Will assist in sampling and analyses, and will oversee the polymer identification and weathering measurements			27%	0.18		\$26,900	-	-
Technician		Will be responsible for packing for sampling cruises and will perform and teach microplastic isolation and identification protocols.			24%	0.48		\$39,999	-	-
Summer PhD Grad Student		Will assist in sampling and will perform microplastic isolation approaches and microscopy,			19.1%	0.36		\$25,739	-	-
Undergrad Researcher		Will assist in analysis of field samples with guidance from the technician. Will prepare the reagents used in microplastics isolation work.			0%	1.23		\$26,568	-	-
							Sub Total	\$138,347	\$138,294	\$53
Contracts and Services										
University of Pittsburgh	Subaward	Co-I Joe Werne from University of Pittsburgh is an expert in sampling sinking sediments for nutrient and carbon flux analyses. His experience with these sampling protocols will enable collection of microplastics flux samples. He will perform total carbon and total sediment mass analyses for placing microplastics amounts in context.		X		0.36		\$60,177	\$60,177	-
UMD-LLO analytical services	Internal services or fees (uncommon)	Lab analyses to identify polymer type in microplastics analysis				0		\$290	\$290	-

							Sub Total	\$60,467	\$60,467	-
Equipment, Tools, and Supplies										
	Tools and Supplies	Lab supplies (need to order these for each year of the project, and a small inflation increase is included in years 2 and 3): 4 boxes anodisc filters (\$3510), 72 petri dishes (\$1026), 2 cases hydrogen peroxide (\$935), 500g ferrous chloride, tetrahydrate (\$501), 1 kg NaCl (\$76), 6 boxes of disposable nitrile gloves (\$300), 6 boxes of kimwipes (\$67), 144 glass sample jars (\$1477), 2 pairs forceps (\$28)	The hydrogen peroxide, ferrous chloride, tetrahydrate, and the sodium chloride are reagents used to remove sample matrix and to isolate the microplastics for analyses. After treatment the reagent solutions plus microplastics are filtered onto anodisc filters, which are made of aluminum oxide and thus are transparent to our microFTIR characterization technique. Gloves, kimwipes, and forceps help in clean sample handling and the samples are stored in the glass jars before processing and petri dishes after filtering.					\$28,604	\$28,522	\$82
							Sub Total	\$28,604	\$28,522	\$82
Capital Equipment										
							Sub Total	-	-	-
Acquisitions and Stewardship										
							Sub Total	-	-	-
Travel In Minnesota										
							Sub Total	-	-	-
Travel Outside Minnesota										
							Sub Total	-	-	-

Printing and Publication										
	Printing	Outreach duplicating/copying	Printing costs for materials shared in science on deck outreach					\$177	\$177	-
							Sub Total	\$177	\$177	-
Other Expenses										
		Blue Heron ship time	Blue Heron Ship time totaling \$32,600 in 2023 for 3 days for sediment trap deployment, and Science on Deck; totaling \$119,730 for 9.5 days in 2024 for sediment trap deployment/recovery, water column in situ pumping and Science on Deck. Increase in 24-hour day rate in 2025 so 3 days for collecting CTD data, water samples, ponar grabs, multi-core samples, and McLane in-situ pump deployments cost was \$60,929; \$32,072 was covered by LCCMR and \$28,854 subsidized by LLO ICR. Note that the research cruises are for this ENRTF project only but that the Science on Deck outreach component will be shared with other area researchers.					\$184,405	\$184,405	-
							Sub Total	\$184,405	\$184,405	-
							Grand Total	\$412,000	\$411,865	\$135

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - University of Pittsburgh	Subaward	Co-I Joe Werne from University of Pittsburgh is an expert in sampling sinking sediments for nutrient and carbon flux analyses. His experience with these sampling protocols will enable collection of microplastics flux samples. He will perform total carbon and total sediment mass analyses for placing microplastics amounts in context.	Werne has over 10 years of experience in sediment trap deployment and organic carbon analyses in deeper-water sites in large lakes and oceans. This expertise is not currently available in Minnesota due to retirements and relocations among that community of researchers. He will be training us in these approaches, thus enhancing the capabilities of Minnesota researchers in the future. Note also that the first deployments of the trap (the ones on non-ENRTF-funded cruises) are provided by his research group at no cost to this project and he is sharing the resulting samples with us.

Non ENRTF Funds

Category	Specific Source	Use	Status	\$ Amount	\$ Amount Spent	\$ Amount Remaining
State						
			State Sub Total	-	-	-
Non-State						
In-Kind	University of Minnesota	Unrecovered indirect costs at 55% of 1st \$25k for U-Pitt sub, 26% of ship time and 55% of the remaining MTDC project	Secured	\$158,137	\$151,140	\$6,997
In-Kind	University of Pittsburg - Joe Werne	6 days of Blue Heron time at \$10,400/day plus 26% F&A	Secured	\$78,624	\$78,624	-
			Non State Sub Total	\$236,761	\$229,764	\$6,997
			Funds Total	\$236,761	\$229,764	\$6,997

Attachments

Required Attachments

Visual Component

File: [a6ac49f1-4af.pdf](#)

Alternate Text for Visual Component

Visual showing the plan for sampling and analyzing sinking and suspended microplastic particles in Lake Superior and sharing this data with those who could use it. The figure also includes pictures of microplastics found in the lake by the PI's research group....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Transmittal letter from UMD SPA	231e7cd1-b73.docx
Background Check Certification Form	9b84d64d-5a6.pdf
Research addendum for Minor et al	940be0be-350.docx
Press release for June 2024 Science on Deck	fb3219cf-23c.pdf
Rotary presentation (spring 2025)	7c60f1d7-e81.pdf
IMOG extended abstract	29f84fa4-69f.pdf
Advertisement for Minor's Freshwater Folks Talk	e4c2ce25-5e9.pdf
Minor pictures and summary	6dc7d812-9f3.pptx
Distribution and Compositional Variability of Plastic Polymers Throughout the Water Column of Lake Superior	9579304f-401.pdf

Media Links

Title	Link
Liz Minor LaB at LLO	https://lizminorlab.weebly.com

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

There has been a shift in personnel allocation to match the requested budget, with the shifts reflected in technician vs PI time on the project. The supply budget no longer includes adjustments for inflation; some supplies (e.g., sample storage containers) from the first year will be re-used to minimize budget change effects on sample throughput.

On Nov 7, the plan was amended further to address requested comments and revisions.

On Jan 23, 2023, the approved research addendum was added and the activity 1 description was edited to add sediment sampling.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

N/A

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A

Work Plan Amendments

Amendment ID	Request Type	Changes made on the following pages	Justification For Amendment Request (word limit 75)	Date Submitted	Approved	Date of LCCMR Action
1	Amendment Request	• Budget • Other • Budget - Personnel • Budget - Professional / Technical Contracts • Budget - Capital, Equipment, Tools, and Supplies • Budget - Printing and Publication • Budget - Other • Budget - Non-ENRTF Funds Contributed • Attachments	We request rebudgeting: 1. Shiptime day rates for 2025 on the RVBH are much higher than originally estimated. 2. We're shifting to covering costs for supplies related to the FTIR analysis as direct charges rather than through invoices via the cost center. 3. These increases can be covered by shifting funds from Lab Analyses, lower outreach costs and reduced paid PI time.	October 2, 2025	Yes	October 2, 2025
2	Amendment Request	• Budget - Personnel • Budget - Other • Budget - Non-ENRTF Funds Contributed	The 2025 shipping season had considerable upheaval in establishing and maintaining day rates. We received approval for a rebudget last year that anticipated, to the best of our ability at the time, what the final rate would be. Ultimately, when the cruise was concluded, the billing was \$3,041 more than anticipated. We request a second budget amendment to reconcile that difference, drawing from funds that remain available beyond what will be needed for personnel.	April 2, 2026	Yes	April 7, 2026

Status Update Reporting

Final Status Update August 14, 2026

Date Submitted: August 17, 2026

Date Approved: September 4, 2026

Overall Update

Field sampling expeditions are done and the sediment trap and pump samples have been analyzed. Seasonality and biological factors play pivotal roles in vertical transport of microplastics. The density of the plastic polymer itself does not play a major role in vertical transport. At all sampled depths, in suspended plastic particles, lower density polymers dominate the composition: polypropylene (PP, 52%), polyamide (PA, 16.5%), and polyethylene (PE, 12.6%). Sinking particles contain PP, polyvinyl chloride (PVC) and PA as the main polymers (all present at roughly 25 to 30% of the total plastics). Approximately 40% of sinking particles are PP and PE, which are less dense than freshwater. Plastic concentration averages (particle number/liter) in suspended particles are 1.4 to 5.4 times higher at all depths in spring when the water column is well mixed relative to summer stratification. In the stratified season more plastic particles per g dry weight are collected in the sediment trap (and thus are sinking) than in the unstratified season. This indicates that biological activities are sweeping plastic particles out of the water column, most likely in particle aggregates and fecal pellets, which sink to the sediments in the summer.

Activity 1

Sampling via sediment traps, pumping, and sediment multicoring is complete. All analyses are complete. We did have a partial failure of the sediment trap on the last deployment, where the sampling cups stopped advancing partway through. However, this gave us the opportunity to collect true field blanks for this process, as the sampling cups were deployed to the lake filled with MilliQ water. We processed these untriggered sampling containers as field and method blanks. Sediment core samples have also been processed and analyzed, though we ran into issues with plastic contributions to the samples from the core liners, as determined from measurement of deep sediment samples (10-15 cm below the sediment water interface) that should have been microplastic free along with the top 5 cm of sediment, which were our plastics samples. Thus, on our last cruise, we also took a sediment sample via ponar (which is all metal) to obtain at least one “clean” sediment sample. All sampling and analyses are complete and an initial draft of a manuscript has been developed for submission to the journal *Limnology and Oceanography*.

(This activity marked as complete as of this status update)

Activity 2

PI Minor participated in the Great Lakes Microplastics Summit, Expert Small Group Discussion on the State of Microplastics Work, on October 23, 2025, sharing aspects of this work and giving suggestions on QA/QC for environmental plastics sampling.

Minor presented a department seminar on this work at Lakehead University, Thunder Bay, ON, Canada on February 6, 2026.

Graduate student Ariyah Thomas gave a departmental seminar in the Department of Chemistry and Biochemistry at the University of Minnesota Duluth sharing preliminary data from this project on February 27, 2026.

PI Minor gave a Freshwater Folks Meeting presentation on this work on May 6, 2026.

PI Minor has provided MPCA hydrologist David Duffey with a copy of the draft manuscript presenting our results. It is available for sharing with state colleagues.

Ariyah Thomas provided metadata and data files to the Data Repository for the U of M (DRUM) on August 8, 2026 and the data will be publically available at <https://hdl.handle.net/11299/166578> once it is approved by the repository staff. *(This activity marked as complete as of this status update)*

Dissemination

Please see activity 2 update. Sharing with the Great Lakes research community in the Great Lakes Microplastics Summit and discussing results local water researchers, managers, and stakeholders at the Freshwater Folks Meeting fulfills the intent to share expertise with managers and stakeholders in the region.

Graduate student Ariyah Thomas defended her master's thesis on this work on July 16, 2027. The thesis has been approved and submitted to the graduate school for publication. The data have been submitted to the Data Repository for the University of Minnesota (DRUM). The thesis is essentially the first draft of a manuscript that we hope to submit to Limnology and Oceanography in early fall 2026.

Status Update Reporting

Status Update April 1, 2026

Date Submitted: April 2, 2026

Date Approved: April 7, 2026

Overall Update

Field sampling expeditions are done and the sediment trap and pump samples have been analyzed. Seasonality and biological factors play pivotal roles in vertical transport of microplastics. The density of the plastic polymer itself does not play a major role in vertical transport. At all sampled depths, in suspended plastic particles, lower density polymers dominate the composition: polypropylene (PP, 52%), polyamide (PA, 16.5%), and polyethylene (PE, 12.6%). Sinking particles contain PP, polyvinyl chloride (PVC) and PA as the main polymers (all present at roughly 25 to 30% of the total plastics). Approximately 40% of sinking particles are PP and PE, which are less dense than freshwater. Plastic concentration averages (particle number/liter) in suspended particles are 1.4 to 5.4 times higher at all depths in spring when the water column is well mixed relative to summer stratification. In the stratified season more plastic particles per g dry weight are collected in the sediment trap (and thus are sinking) than in the unstratified season. This indicates that biological activities are sweeping plastic particles out of the water column, most likely in particle aggregates and fecal pellets, which sink to the sediments in the summer.

Activity 1

Sampling via sediment traps, pumping, and sediment multicoring is complete. All the water column field samples have been processed and analyzed and we are planning to finish all analyses by the end of April. We did have a partial failure of the sediment trap on the last deployment, where the sampling cups stopped advancing partway through. However, this gave us the opportunity to collect true field blanks for this process, as the sampling cups were deployed to the lake filled with MilliQ water. We processed these untriggered sampling containers as field and method blanks. Sediment core samples have also been processed and are being analyzed this month. Due to good weather, we were able to multicore on all of our sampling cruises, thus taking more samples here than originally proposed. We are using the top 5 cm of the cores as samples to look for plastics burial and the 10-15 cm depth as a process blank; sediments at that depth should be too old for plastics inputs as their deposition predates plastic manufacturing by many decades.

Activity 2

Since the last report on October 1, 2025:

PI Minor participated in the Great Lakes Microplastics Summit, Expert Small Group Discussion on the State of Microplastics Work, on October 23, 2025, sharing aspects of this work and giving suggestions on QA/QC for environmental plastics sampling (and addressing Milestone 3 of the project)

Minor presented a department seminar on this work at Lakehead University, Thunder Bay, ON, Canada on February 6, 2026.

Graduate student Ariyah Thomas gave a departmental seminar in the Department of Chemistry and Biochemistry at the University of Minnesota Duluth sharing preliminary data from this project on February 27, 2026.

We are currently collating data in the form requested by DRUM, thus Milestone 4 is still in progress.

Dissemination

Please see activity 2 update.

Status Update Reporting

Status Update October 1, 2025

Date Submitted: September 26, 2025

Date Approved: September 30, 2025

Overall Update

We have performed all of the field sampling expeditions and are processing suspended particle, sinking particle and sediment samples. Preliminary data shows that sinking and suspended microplastics from the open lake are very similar in terms of polymer composition and size distribution. Polypropylene is the most abundant polymer in both sets of samples; polypropylene and polyethylene (which are both less dense than freshwater) contributed a total of roughly half the sinking particles and two-thirds of the suspended particles. These results indicate that polymer type and microplastic particle size are not the main determinants of whether a microplastic sinks or remains suspended in Lake Superior. Most likely other particle processes, such as aggregation with other organic and inorganic particles, packaging in fecal pellets, and formation of biofilms, affect a microplastic's fate in natural lake waters.

Median microplastic lengths pumped at all depths are roughly the same but the variation in length is lowest for the deepest samples.

Activity 1

Sampling via sediment traps, pumping, and sediment multicoring is complete. We have processed and analyzed the 2022-2023 sediment trap and pump samples and the 2023-2024 sediment trap samples. The remaining trap and pump samples are undergoing oxidation and analyses this fall. We did have a partial failure of the sediment trap on the last deployment, where the sampling cups stopped advancing partway through. However, this gave us the opportunity to collect true field blanks for this process, as the sampling cups were deployed to the lake filled with MilliQ water. We are processing these untriggered sampling containers as field and method blanks. This fall, sediment core samples are also being processed and analyzed. Due to good weather, we were able to multicore on all of our sampling cruises, thus taking more samples here than originally proposed. We are using the top 5 cm of the cores as samples to look for plastics burial and the 10-15 cm depth as a process blank; sediments at that depth should be too old for plastics inputs as their deposition predates plastic manufacturing by many decades.

Activity 2

We presented preliminary results via Science on Deck (June 2024), Freshwater Discovery Day (July 2024) and at the Duluth Rotary Club Meeting in March 2025. Further results were presented at a Science on Deck in June 2025. These all targeted the interested general public. We also presented results to other scientists through an oral presentation and subsequent discussions the International Meeting of Organic Geochemists in September 2025. In addition, PI Minor presented preliminary results from this project in a keynote talk at the Penn State PIERS Student Symposium in April 2024, which targeted STEM students interested in aquatic and environmental science.

The Minor Group webpage (<https://lizminorlab.weebly.com/>) now contains a slideshow showing microplastics sampling techniques used on the cruises funded by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR).

Dissemination

Please see activity 2 update. Minor has not had the opportunity to present to the Freshwater Folks Meeting as her teaching schedule conflicts with their meetings. Hopefully that will not be the case next semester!

Status Update Reporting

Status Update April 1, 2025

Date Submitted: June 10, 2025

Date Approved: June 11, 2025

Overall Update

We have performed all but one of the field sampling expeditions and are processing suspended particle, sinking particle and sediment samples. Preliminary data shows that sinking and suspended microplastics from the open lake are very similar in terms of polymer composition and size distribution. Polypropylene is the most abundant polymer in both sets of samples; polypropylene and polyethylene contributed a total of roughly half the sinking particles and two-thirds of the suspended particles. The size range for the two pools of particles was very similar, with the average length for both pools being 200 μm . The median length for particles in the sinking pool was slightly larger (149 μm) than for the suspended pool (134 μm). These results indicate that polymer type and microplastic particle size are not the main determinants of whether a microplastic sinks or remains suspended in Lake Superior. Most likely other particle processes, such as aggregation with other organic and inorganic particles, packaging in fecal pellets, and formation of biofilms, affect a microplastic's fate in natural lake waters.

Activity 1

Our last cruise on Lake Superior is scheduled for May 6-8, 2025. We are currently oxidizing, density extracting, and analysing the past year's suspended particle (pump samples) on our uFTIR instrument and anticipate being done with these samples by the end of the summer. Preliminary analyses of sediment samples indicates potential contamination from the multicorer used in sampling. We are testing multicorer materials to identify the source for these plastics. We are also planning to collect sediment samples by a metal ponar sampler on the May cruise as an alternative to using the multi-corer.

Activity 2

We presented preliminary results via Science on Deck (June 2024) and Freshwater Discovery Day (July 2024) and hope to present this summer on another Science on Deck or Freshwater Discovery Day opportunity. We also presented preliminary results at the Duluth Rotary Club in March 2025. PI Minor will focus on adding field work photos and preliminary data to the lab website in June 2025. We plan to share preliminary results at the IMOG meeting in September 2025.

Dissemination

Preliminary results were shared with the interested public via Science on Deck (June 2024) and Freshwater Discovery Day (July 2025). We also presented preliminary results with local business and community leaders at the Duluth Rotary Club in March 2025. Results will be presented to scientists and managers in 2 presentations at the IAGLR Annual Conference on Great Lakes Research in Milwaukee, WI in June 2025. The abstracts for these presentations were accepted and are available on the IAGLR Conference website.

Status Update Reporting

Status Update October 1, 2024

Date Submitted: November 19, 2024

Date Approved: November 20, 2024

Overall Update

We have been processing sediment trap, water column, and sediment samples for microplastics. Our first year of seasonal samples from the sediment traps (n= 8) show that there are more plastics settling per unit time in late summer/early fall; but at all times the counts were less than one plastic particle (>50 um in size) per day. The most prevalent plastic (40% of the particles counted across the seasons) was polypropylene.

We are currently compounding plastic recovery standards as a check on our analytical methods, in particular the isolation of plastics from sediment samples.

In June and August 2024 we did further sampling in Lake Superior. We multicored for sediments and did McLane pumping for suspended particles at one nearshore site close to Duluth (46deg49'N, 91deg57'W, 2m water depth) and at 3 open lake sites triangulating at 1-2 miles around the deployed sediment trap (47deg18.779'N, 89deg48.593'W). At 2 open-lake sites we pumped at 4 depths (2m, 30m, 70m, and 140m in June, 100m in August); the last open-lake site included pumping at 2 depths (30m and 70m in June and 2 and 30 m in August). We also took pump field blanks during each cruise.

Activity 1

We have performed this year's sampling as described in the overall update and are working through the sample processing (oxidations and density extractions) to prepare these samples for microplastics counting on the Bruker Lumos uFTIR. Preliminary sediment trap analyses on the Bruker have showed us that we need to use a larger sample split per monthly sampling "cup" to get sufficient numbers of plastics for reasonable "count statistics" above our processing blanks. We combined the 1/10 splits we initially obtained from our colleagues for each 15-day sample and now know that we need 3/10 splits from the sediment traps going forward. These have been sent to us from the University of Pittsburgh for the trap samples covering the sampling period from August 2023-May 2024 and retrieved from the lake in May 2024. The 15-day samples from May to September 2024 have been collected by our UPitt colleagues, who are currently drying and splitting these samples in preparation for C and N and microplastic analyses.

Activity 2

A presentation with preliminary data from this project was shared with the interested public at a Science on Deck event on June 21, 2024 (see press release in Attachments). The Blue Heron was docked at Pier B and PI Minor gave a half hour talk with a question and answer session afterward. The timing for this Science on Deck event was chosen to coincide with Grandma's Marathon weekend to reach a larger target audience.

Minor also presented data from this project at a post-banquet talk for Freshwater Discovery Day (a UMD-Large Lakes Observatory event) on July 31, 2024.

Dissemination

Please see Activity 2 update.

Status Update Reporting

Status Update April 1, 2024

Date Submitted: March 25, 2024

Date Approved: May 21, 2024

Overall Update

So far in this project we have sampled Lake Superior water by pumping in July and August of 2023 and collected surface sediment in July 2023. Sediment trap water-column samples were removed from the lake in Fall 2023. A sediment separator to assist in density fractionation for the surface sediment samples has been built. We tested it using a known-plastics standard and plastic free sediment to assess recoveries and blanks. Two archived sediment trap samples (from September and November 2022) have been processed and counted by microFTIR. Microplastic particles have been found in both of these samples. The September sample had polyamide, polypropylene, and polystyrene particles. The November one had polypropylene and polyethylene particles. Both sediment trap samples had considerable amounts of clay included in the density fractions that had the plastic particles. Clays make it difficult to see plastic particles and to identify their polymer compositions using microFTIR. We are now adding an additional separation step to our protocols to remove the small clay particles from our recently collected trap samples. We will continue processing samples throughout the spring now that we have fine-tuned our analytical protocols.

Activity 1

We performed suspended particle pumping in July and August 2023 at 3 sites around our mooring and at multiple depths (above and below the seasonal thermocline). We also collected surface sediment samples via multicorer in July 2023. For comparison with these surface sediments, we also collected sediments from 10-15 cm depth within the sediment. These deep sediments should pre-date the development of plastics and thus act as a blank for the multi-corer and our sediment processing laboratory protocols. We built a sediment separator for easier density separation of microplastics from sediment samples and have tested it using sediment spiked with a microplastic standard. We had ~110% recovery for polyethylene beads using the separator as compared to 40% recovery using traditional density separation performed in the original sample jars. We have also processed and counted two sinking particle (sediment trap) samples. Clay, which is difficult to work with, was in the same density fractions as our plastic particles so we have now added an additional processing step to separate smaller clay particles from the microplastics in our samples.

Activity 2

Our first Science on Deck presentation on the Blue Heron is scheduled for June 21, 2024. This is the day before Grandma's Marathon and we anticipate a fair amount of foot traffic from visitors to Duluth in the area where the Blue Heron will be docked. Progress re sediment sample processing has been shared verbally with the MPCA via meetings with hydrologist David Duffey.

Dissemination

Please see the activity 2 report. In addition, Minor will present preliminary results from this project in a keynote talk at the Penn State PIERS Student Symposium in April 2024.