

Initial Investigation into Microplastic Pollution in Lake McDonald, Glacier National Park



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Introduction

Plastic waste contamination, and more specifically microplastic waste (plastic fragments <5mm), has received increasing attention in recent years as public awareness of the issue has grown. Large scale plastic pollution assessment of the world's oceans has raised awareness among the public. The Great Pacific Garbage Patch (GPGP), the largest of these ocean accumulation zones and located between Hawaii and California, is estimated to cover about 1.6 million km² and contain about 800 tons of plastic (<https://theoceancleanup.com>). Having been studied for decades, the GPGP is a well-publicized example of the scale of the plastic pollution problem. Although marine environments have received much of the attention of researchers on this issue (e.g. Rochman et al. 2016), much of the plastic enters the oceans through the world's freshwater rivers (Lebreton et al. 2017). Larger plastic pieces break down over time in response to sunlight, wave action, and other mechanisms into small and smaller pieces where they can be ingested by/or impact the organisms living in a given environment. Plastics also break down in dry environments due to sunlight, heat, and abrasion and these smaller plastic pieces can be transported by wind and weather where they enter protected areas such as national parks (Brahney et al. 2020). A study of microplastics in Yellowstone Lake in Yellowstone National Park determined that microplastics have entered the aquatic foodweb (Driscoll et al. 2021). Concerns that Glacier National Park's Lake McDonald, an icon of high-water quality and perhaps the most photographed feature of the park, could be similarly contaminated with microplastics prompted a pilot study to determine 1) if microplastics exist in the lake and 2) the relative scale of the contamination if it exists. With funding from the Glacier National Park Conservancy and in partnership with Flathead Valley Community College, in 2021 the park conducted the initial investigation.

Methods

We overlaid a 1 km grid over a Google Earth image of Lake McDonald and numbered each intersecting point that fell on the lake surface (Figure 1). We used these points as our sampling frame. From these, we used a random number generator to select approximately 10 sites to sample each day. Our target sample size was 40-50 sites, but the amount of sampling that could occur each day was dependent on a number of factors including weather.

We used a 64 micron plankton net on a 20m rope to collect samples. Our sampling method involved recording the coordinates of each given point, dropping the net to the depth of 20 meters and retrieving it slowly allowing the net to capture plankton, debris and microplastics in the 1.41 m³ of water sampled during each vertical tow (Figures 2 and 3). We remained careful not to create a pressure wave at the net entrance during the retrieval process that could interfere with sample collection.

Most of the water was decanted off and the remaining samples were poured into a 45 ml vial. Each sample was stored separately. At the office, each sample was poured through a white coffee filter and allowed to dry overnight on a shelf in an area of low use (to reduce the likelihood of contamination). Suspected microplastics were defined as particles <5mm in diameter or length (Driscoll et al. 2021) that appeared as colored threads or particles under the microscope. We used a 10X dissecting scope to sort through the samples and identify suspected microplastics (Figure 4). When a suspected microplastic was encountered, we use the "hot needle test" (Marine and Environmental Research Institute) to determine if the particle in question was likely plastic. Plastic reacts to a hot needle by curling and melting under the scope.

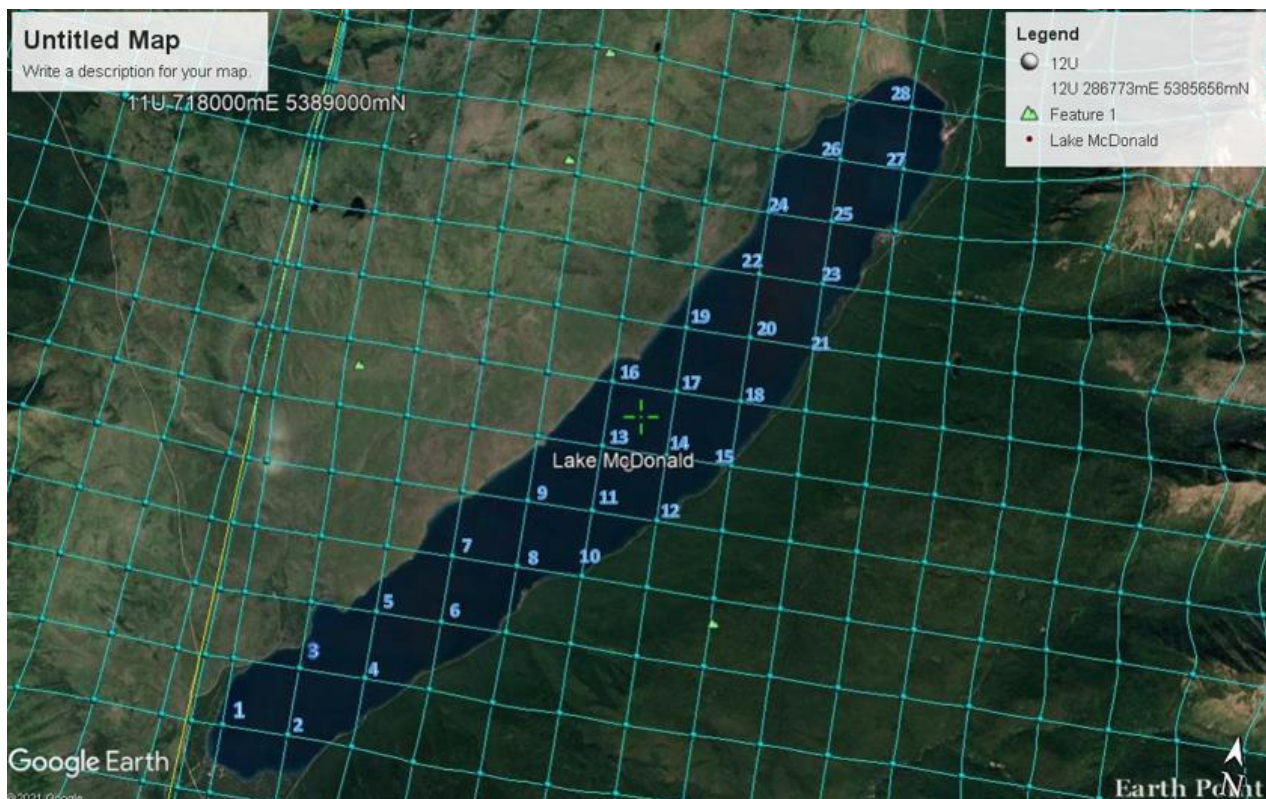


Figure 1. 1km grid map of Lake McDonald used to select random sites for microplastics sampling.



Figure 2. Deploying the plankton net and recording sample coordinates.



Figure 3. Retrieving the plankton net and decanting off much of the water to concentrate the sample.



Figure 4. Sorting through each dried sample looking for microplastics.

Results and Discussion

Surface water temperatures ranged from 20-22.5°C. We estimated Lake McDonald's volume in cubic meters at approximately 1.537 billion m³ by using the formula to calculate the volume of a reservoir (surface area in acres x maximum depth in feet x 0.4). We conducted 41 vertical hauls, each of which sampled 1.41 cubic meters of water for a total of 57.8 m³. This is a very small fraction of the lakes volume, but we did find evidence of microplastic pollution. A total of 11 suspected microplastics were found in nine different sites throughout the lake (sites: 5,8,12,16, 20,23,25 and 27) (Table 1). Most appeared to be very small pieces of black or red fibrous materials along with what appeared to be a fragment of monofilament fishing line. Although we did employ a random sampling approach to allow for characterization of the lake as a whole, our conclusions remain limited by small sample sizes and the narrow range of the water column we sampled (top 20m of the lake).

An important factor in determining our success in documenting microplastic pollution is how long these materials would remain suspended in the upper water column. It's likely larger, heavier plastic particles settle out more quickly and sampling deeper areas of the lake and sampling the lake bottom itself would be informative and allow for a more complete characterization of the issue. Also, more targeted sampling around high-human use areas such as the developed areas and along the Going to the Sun Road could help the park better identify potential sources of microplastics.

The ecological implications of our sampling are less clear. Questions remain as to whether these particles continue to break down into ever smaller and smaller, inert particles concentrated on the lake bottom, how much exits the lake into the larger Flathead River system, and do they end up in the ecological food-chain causing adverse impacts to the ecosystem or harm to individuals? These questions were beyond the scope of our initial investigation and would require significant investment of resources to attempt to understand. However, other authors have documented microplastics entering freshwater food-webs. Driscoll et al. (2021) documented microplastics in three of Yellowstone Lake's trophic levels: in the stomachs of amphipods, Yellowstone cutthroat trout, and lake trout. That said, the question of quantification of ecological impacts in freshwater systems remains an area open to investigation. Rochman et al. (2016) conducted a comprehensive review of the literature on marine debris (including plastics) impacts to ocean systems for perceived versus demonstrated impacts and concluded that most studies did document some "impact" at certain levels (e.g. suborganismal, organismal/individual) but little at the ecological level. Much of the literature involved investigations into plastic debris. They noted the quantity and quality of ecological investigations needs to improve before clear conclusions on the ecological impacts of marine debris on ocean ecosystems can be more clearly understood. Based on our cursory review of the literature, the same holds true for freshwater systems. However, Rochman et al. (2016) did conclude that there is enough evidence of adverse impacts from plastic debris in the marine environment to warrant decision makers to take action to reduce inputs. It's reasonable to conclude the same for freshwater environments and that we should be doing all we can to dispose of plastics properly and keep them out of the natural environment.

Table 1. Microplastic sample site locations and results for samples collected from Lake McDonald, Glacier National Park in July, 2021.

1	Sample #	UTM X	UTM Y	Site #	length of tow	suspect microplastics pre	coloration of micro plastic
2	072121-1	48' 37.570 N'	113' 52.637 W'	27	20m	3 fibers	black
3	072121-2	48' 37.181 N'	113' 53.276 W'	25	20m	none	NA
4	072121-3	48' 36.449 N'	113' 53.350 W'	23	20m	1 fiber	NA
5	072121-4	48' 35.519 N'	113' 54.808 W'	17	20m	none	NA
6	072121-5	48' 35.486 N'	113' 55.733 W'	16	20m	1 fiber	red
7	072121-6	48' 34.741 N'	113' 55.721 W'	11	20m	none	NA
8	072121-7	48' 33.940 N'	113' 55.617 W'	10	20m	none	NA
9	072121-8	48' 33.796 N'	113' 56.525 W'	8	20m	none	NA
10	072121-9	48' 34.438 N'	113' 56.409 W'	9	20m	none	NA
11	072121-10	48' 33.374 N'	113' 56.823 W'	6	20m	none	NA
12	072121-11	48' 33.348 N'	113' 58.130 W'	5	20 m	none	NA
13	072721-1	48' 33.893 N'	113' 57.090 W'	9	20m	none	NA
14	072721-2	48' 35.547 N'	113' 54.261 W'	20	20m	1 fiber	blue
15	072721-3	48' 36.202 N'	113' 54.801 W'	16	20m	none	NA
16	072721-4	48' 37.766 N'	113' 53.562 W'	26	20m	none	NA
17	072721-5	48' 35.547 N'	113' 54.261 W'	18	20m	none	NA
18	072721-6	48' 37.560 N'	113' 53.795 W'	25	20m	1 fiber	black
19	072821-1	48' 33.815 N'	113' 55.862 W'	10	20m	none	NA
20	072821-2	48' 32.229 N'	113' 58.206 W'	6	20m	none	NA
21	072821-3	48' 34.616 N'	113' 54.619 W'	12	20m	1 fiber	blue
22	072821-4	48' 32.026 N'	113' 58.407 W'	2	20m	none	NA
23	072821-5	48' 35.870 N'	113' 55.200 W'	19	20m	none	NA
24	072821-6	48' 35.436 N'	113' 55.234 W'	17	20m	none	NA
25	072821-7	48' 38.202 N'	113' 52.386 W'	28	20m	none	NA
26	072821-8	48' 34.434 N'	113' 56.681 W'	7	20m	none	NA
27	072821-9	48' 32.635 N'	113' 56.787 W'	3	20m	none	NA
28	072821-10	48' 37.889 N'	113' 52.326 W'	27	20m	1 fiber	black
29	072821-11	48' 34.749 N'	113' 54.595 W'	15	20m	none	NA
30	072821-12	48' 36.678 N'	113' 54.328 W'	22	20m	none	NA
31	072821-13	48' 37.859 N'	113' 53.595 W'	26	20m	none	NA
32	072921-1	48' 33.699 N'	113' 56.356 W'	8	20m	1 micro filament	blue
33	072921-2	48' 35.514 N'	113' 55.152 W'	17	20m	none	NA
34	072921-3	48' 36.202 N'	113' 54.801 W'	19	20m	none	NA
35	072921-4	48' 33.151 N'	113' 58.303 W'	5	20m	1 fiber	black
36	072921-5	48' 37.198 N'	113' 53.023 W'	25	20m	none	NA
37	072921-6	48' 38.028 N'	113' 52.366 W'	28	20m	none	NA
38	072921-7	48' 33.829 N'	113' 57.518 W'	7	20m	none	NA
39	072921-8	48' 34.321 N'	113' 56.790 W'	9	20m	none	NA
40	072921-9	48' 35.445 N'	113' 55.702 W'	16	20m	none	NA
41	072921-10	48' 33.780 N'	113' 56.065 W'	10	20m	none	NA

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