Final Report
Cruise: RS152510-SVIC

Cruise name/number:	F2025-008 - RS152510-SVIC

Authorizations:

Coastal State	Authorization Document Number	National Participant(s)
Norway	2024/047401-012/DEFNON/414	NA
Denmark (Greenland)	JTHAV File No. 25/05808	NA
Iceland	UTN25010949	NA

Scientist in charge of reporting:

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Brief description of scientific objective:

The primary objectives of our research are to:

-Investigate microplastic and anthropogenic microfiber in the air and surface waters throughout our voyage on the *NG Resolution* with National Geographic-Lindblad Expeditions, including the surface waters/air along the expedition cruise track.

-Engage onboard guests and field staff as citizen scientists to complete the sampling, taking action to understand the problems our ocean faces and, in turn, be inspired to be part of the solutions.

-Further refine CSI for the Ocean's methods and equipment. This program was inspired by and uses forensic science methodology to utilize affordable equipment and accessible techniques so people of all ages can engage in meaningful and robust science that provides data that supports solutions to the problem of microplastic and anthropogenic microfiber pollution. Locations where these methods have been tested and deployed to date include the Hudson River in New York State, the Hawaiian Archipelago, Faroe Islands-Greenland, Arctic Svalbard, fjords of Norway, Falkland Islands, South Georgia and Antarctica. Using the same methods along the expedition route of the NG Resolution (Norway, Greenland and Iceland) will provide valuable information for this growing global database.

-Share the data from our sampling openly, making it accessible to community members, fellow scientists, and all stakeholders interested in microplastic and anthropogenic microfiber pollution.

-Use the data from this expedition and beyond to underpin the development and deployment of solutions to microplastic and particularly microfiber pollution. Our global dataset, as it grows, will have the power to build the will and momentum for solutions that range from inspiring innovation in textile design and manufacturing (alternative materials such as outerwear made from algae, for example) to supporting regulation and policies to installing proper filters on laundry machines - both washers and dryers - to educating consumers on clothing care habits that reduce microfiber production and extend the life of their clothing. These are solutions that will benefit all of the coastal states we visit and beyond.

Brief evaluation of the expedition:

Thanks to permitting assistance from the DoS Marine Science Research office and incredible support from the teams at National Geographic Society - Lindblad Expeditions, as well as the guests and crew onboard the *NG Resolution*, all of the scientific and outreach objectives were met.

Ultimately, 51 total samples were taken; three one-liter samples and one air pump sample from 17 locations over the expedition route. The samples were filtered and transferred to slides onboard the *NG Resolution*. Full slide analysis was conducted at Northumbria University and the data were analyzed by our team in Vermont.

Guests onboard the *NG Resolution* enthusiastically assisted with the water collection. Some helped with filtering and all participated in presentations, workshops and discussions led by PI, Rachael Miller. The final report (below) is currently free and publicly available as an interactive StoryMap at: bit.ly/CSIfortheOceanArctic2025

To date, Rachael has given one several live talks and webinars to discuss the results of this as well as other National Geographic - Lindblad Expeditions voyages on which the same science was conducted and more are planned.

The data from this expedition will be added to the growing global dataset as well as used as part of messaging campaigns, presentations and future publications all with the goal to use what we are learning by conducting this science and translating that data into actions that protect our precious planet and one, big, shared ocean.

We would like to say a second thank you to the teams at the Marine Science Research office as well as the officers and personnel at all of the embassies and offices who assisted us in obtaining the proper permits for this work. We appreciate your time and attention. If you have any questions, would like a copy of the data or would like to discuss anything including opportunities for Rachael to present, teach or meet with other people doing related work in any of the countries in which we visited (or beyond), please do not hesitate to contact her at: rachael@rozaliaproject.org or +1 802-578-6120.

A note about the following report:

This report is designed to be read online, ideally on a computer (rather than a small device) as it is interactive. For reporting and record-keeping purposes, it has been made into this static PDF. We highly recommend, however, that you read the report here: bit.ly/CSIfortheOceanArctic2025

If you prefer to read this PDF, please note that in order to make the report fit within the file size limits for submission through the RATS portal, the resolution has been significantly reduced. To read this PDF version in full resolution, please go to:

https://drive.google.com/drive/folders/1fYleL0GVTiK90Y4-as8sDuhIzozhTJPx?usp=sharing

CSI for the Ocean: Svalbard, East Greenland and Iceland 2025

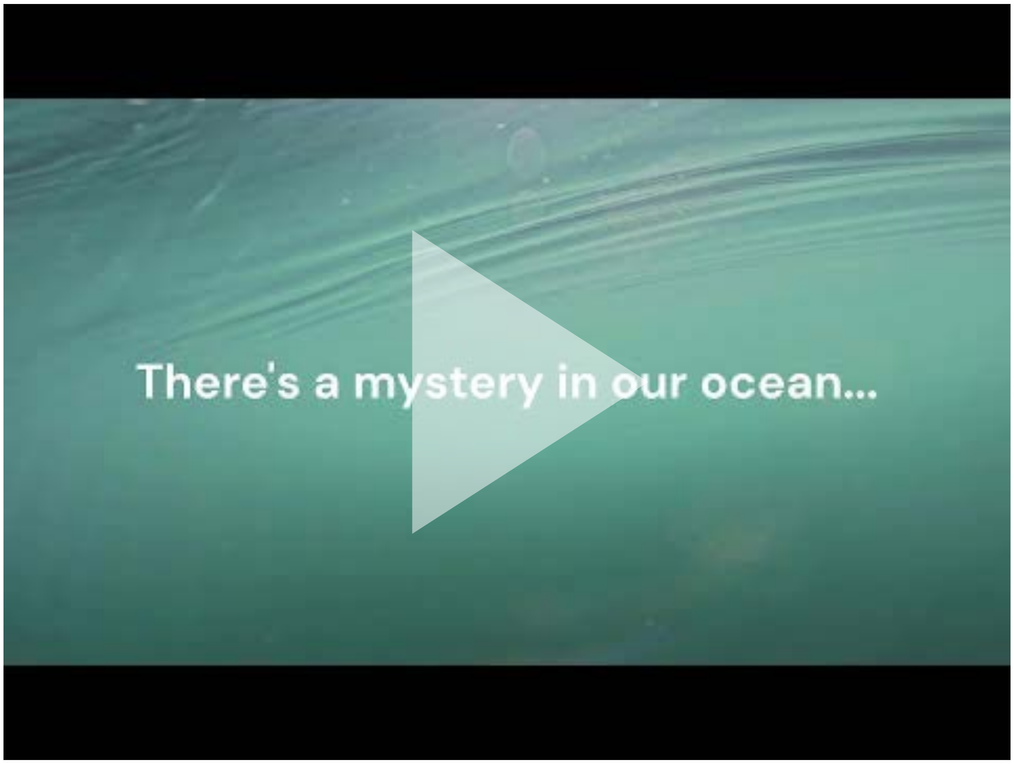
Mapping Microplastics in Air and Water Around the World Using Forensic Techniques: Svalbard, Greenland and Iceland

Rachael Z Miller

November 7, 2025

News about huge garbage patches in the middle of oceans made many people aware of marine plastic pollution. Lately, microplastics have been in headlines. But, how global is the microplastic crisis? Our team is sailing to the ends of the Earth to learn how far microplastics have spread.

National Geographic Explorer/Visiting Scientist Rachael Miller, along with enthusiastic guests, field staff, and crew on board the *National Geographic Resolution*, collected samples from the air and surface waters along a breathtaking Svalbard, Greenland and Iceland expedition track in order to investigate the presence (or absence) of microplastic and man-made microfiber pollution.



What are microplastics and microfibers you ask? Learn more by watching this short video.

Why this is important

Our goal is to better understand microplastic and man-made microfiber pollution - where it is and what the "it" precisely is so that it can be prevented. A growing body of evidence indicates that microplastics, microfibers in particular, pose a real threat to creatures throughout the marine food web. These particles are present in the air, water, sediment and soil and their tiny size (less than 5mm in all

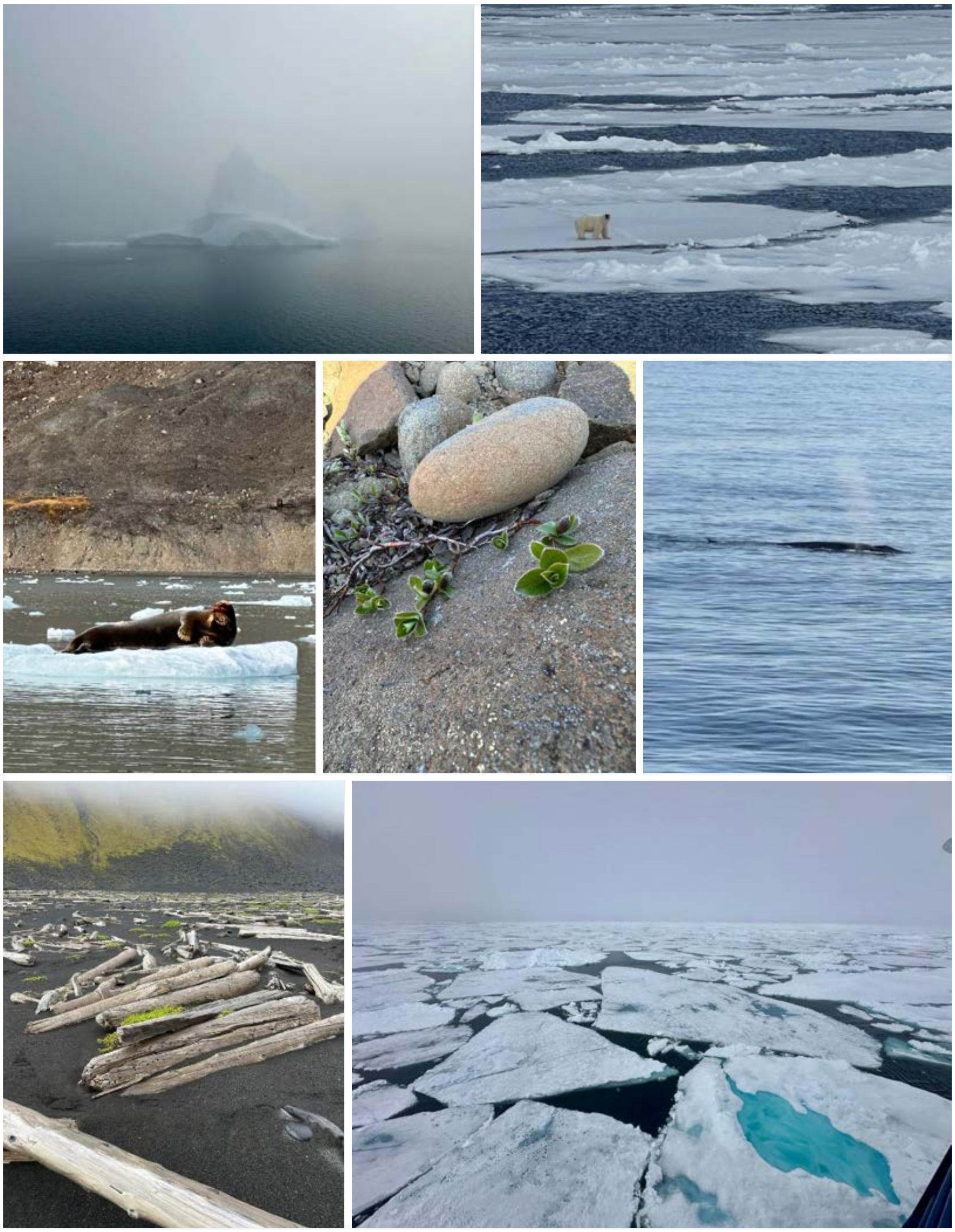
A synthetic fiber found on this expedition.

dimensions) makes them easy to ingest and inhale for creatures of all sizes.

Examples of documented impacts on marine life:

- Inflammation
- Food dilution (e.g. little plankton bellies filled with textile fibers instead of food)
- Behavior changes
- Mortality

Further research shows the presence of microplastics throughout the human body (including hearts, lungs, guts, blood, testicles and brains) via ingestion and inhalation, with studies published this year indicating associations between the presence of microplastics and severe illness.



Bearded seal photo by Pelin Asfuroglu. All other photographs by Rachael Z. Miller.

Examples of health impacts on humans:

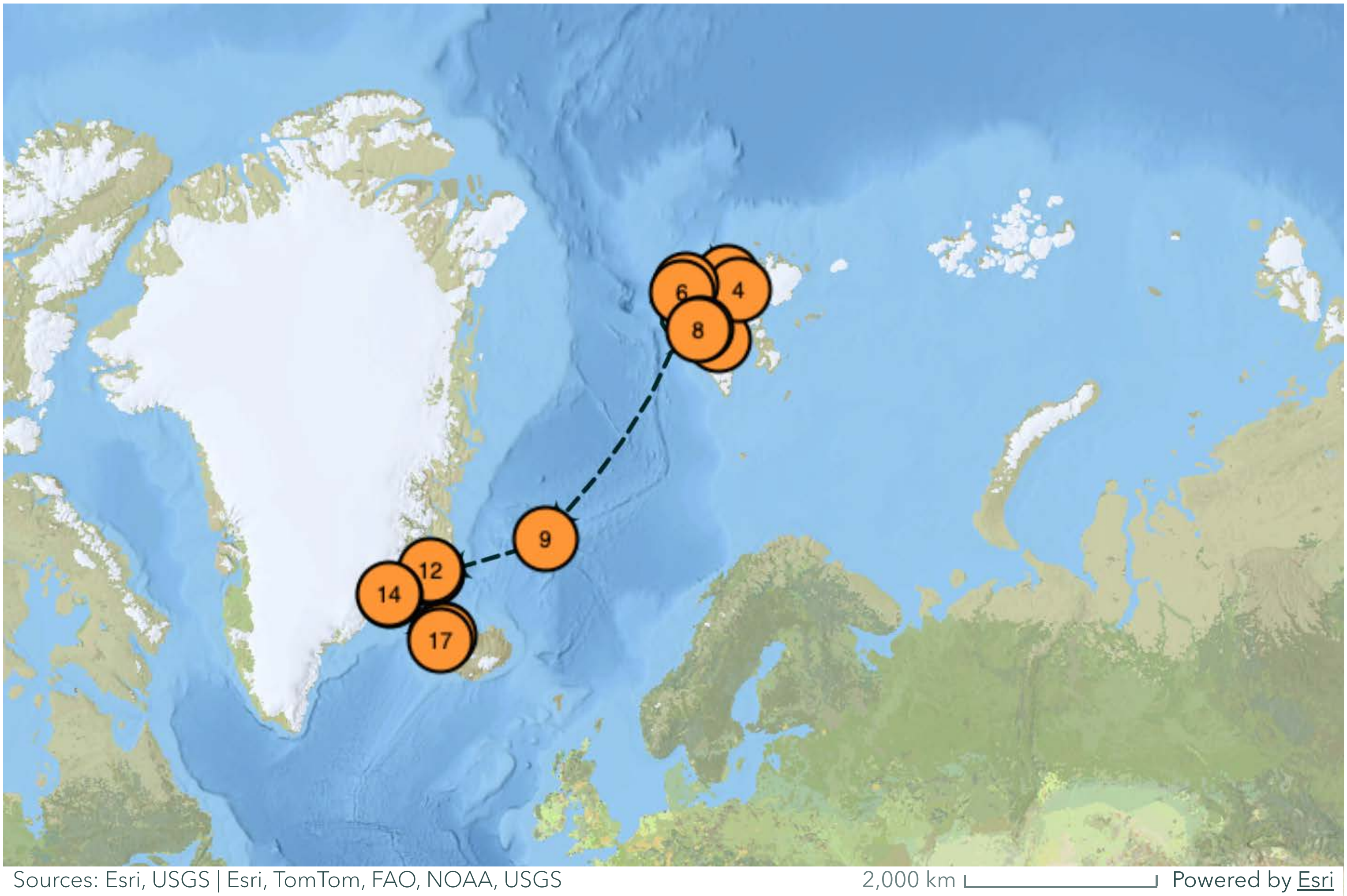
- A disrupted gut microbiome/digestive issues were correlated with microplastics in the human digestive tract (*Pinto-Rodrigues, Science News March 23, 2023*, *Nissen et al. Environment International, 2024*)

- Microplastics in testis indicated a potential of reduced fertility (*Hu et al. Toxicological Sciences, 2024*)
- Microplastics in arterial plaque increased chance of stroke or heart attack (*R. Marfella et al. New England Journal of Medicine, 2024*)

Resting walruses of Svalbard.

Add to this growing body of knowledge the fact that everyone who wears and launders clothing is inadvertently involved in this pollution and the result is a rapidly growing urgency to address microplastic and microfiber pollution. Our expedition data, in populated as well as remote parts of the planet, are already pointing to actionable information while indicating solutions and opportunities for innovation. But to be most effective, we need to learn more. Join us as we share the experiences and results from the high-arctic Svalbard archipelago to, the barren shores of east Greenland to the subarctic fjords of Iceland!

Note: We recommend using a tablet, laptop or desktop monitor for the best viewing experience.



Methods

To measure the presence of microplastics and microfibers we collected 66 samples in total; three one-liter water samples and 1 air pump sample from 17 locations* from latitude 79.9° N in Svalbard, to the eastern coast of Greenland, and the northwestern coast of Iceland (expedition track).

The samples were filtered and transferred to glass slides using Easylift Tape while onboard the ship. The slides were analyzed at Northumbria University using a polarizing light microscope. **Scroll right for more details.**

*One of the three 1-litre water samples was spilled at location 4 and an air sample was not collected at location 1 due to ship operational constraints.

Note: Hover your cursor over the orange dots for additional details about each sample location. You can zoom in and click to drag and explore our sampling locations.

Sample Collection

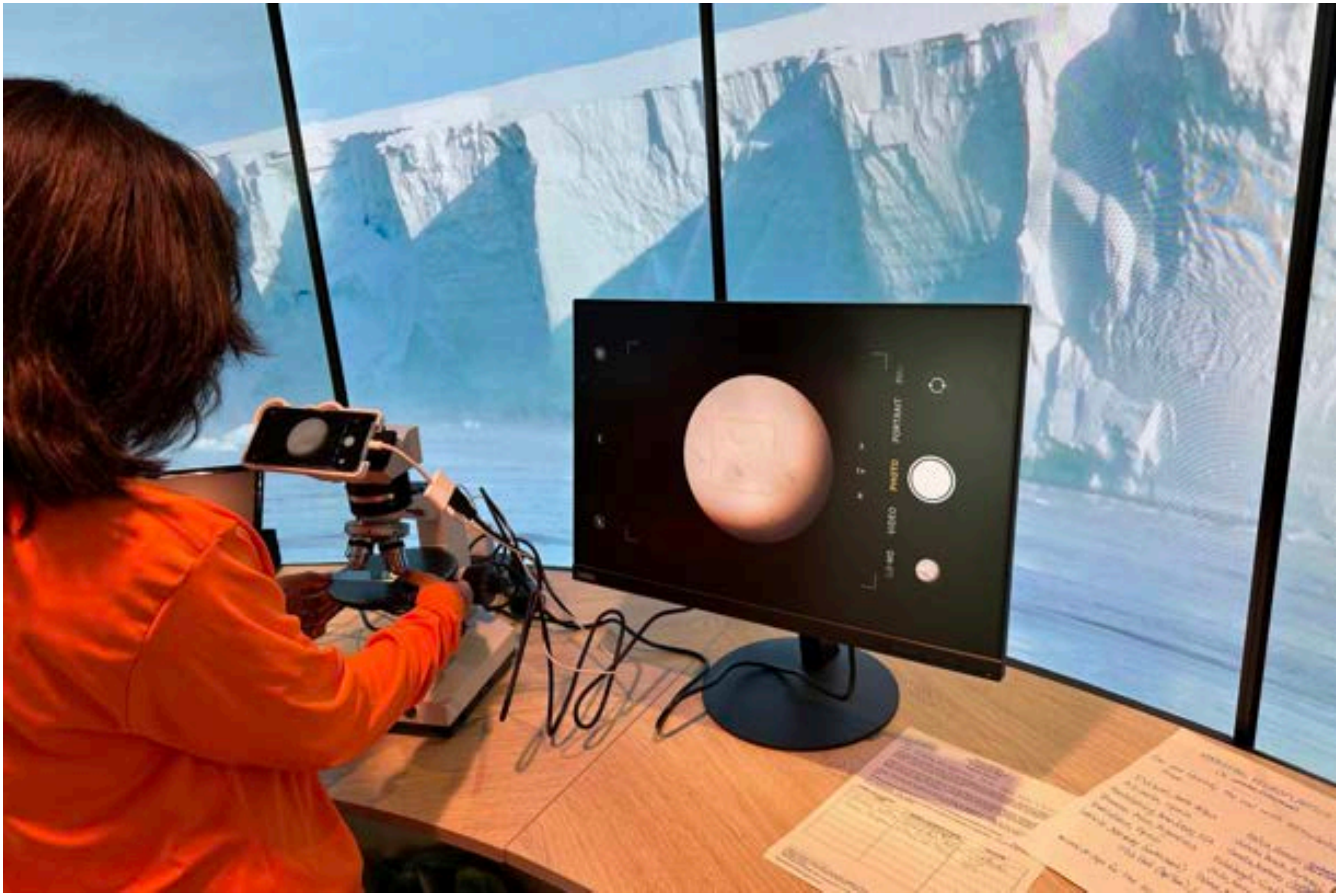
The surface water samples were collected using a metal bucket, decanted into silicone sample bags. All equipment was triple-rinsed in the sea water to remove any contaminant particles before securing the real sample.

The air pump was affixed at the bow on the Bridge deck of the ship (deck 7) and left to pump 10L/min for between 107 and 210 minutes.

Sample Processing

The water samples were filtered in the Science Hub on deck 8 of the *NG Resolution*. A tape lift was executed on all water and air samples in order to fix them to glass slides for preservation and analysis.

For both water and air samples, the volume filtered was recorded and the results are reported using the units: anthropogenic (manmade) microparticles per liter (AMPs/L).



Analysis

Analysis was done using a polarizing light microscope to collect morphological data as well as obtain material IDs on fibers. While some slides were analyzed onboard to give us an idea of what was in the samples, all of the samples were sent to Northumbria University for full analysis. PhD candidate Naomi Richardson performed the analysis that included recording six morphological details, including material ID, of all particles of interest on the slides.

Reducing Contamination

One of the biggest concerns with microplastic science, especially when anthropogenic microfibers are included in the investigation, is contamination. In order to control contamination, several actions were taken including triple rinsing the sample bag, noting clothing worn by samplers, and minimizing exposure to the air during processing. Air controls were taken in the Science Hub each day samples were exposed during filtration and tape lifting.

Furthermore, samples were taken of items that could contribute to potential contamination, such as expedition jackets, orange shirts worn during processing, and carpets. If there was a match between a particle of interest on the sample slide and either a known textile from the ship or a fiber from an air blank, that particle was considered contamination and not pollution.

Results

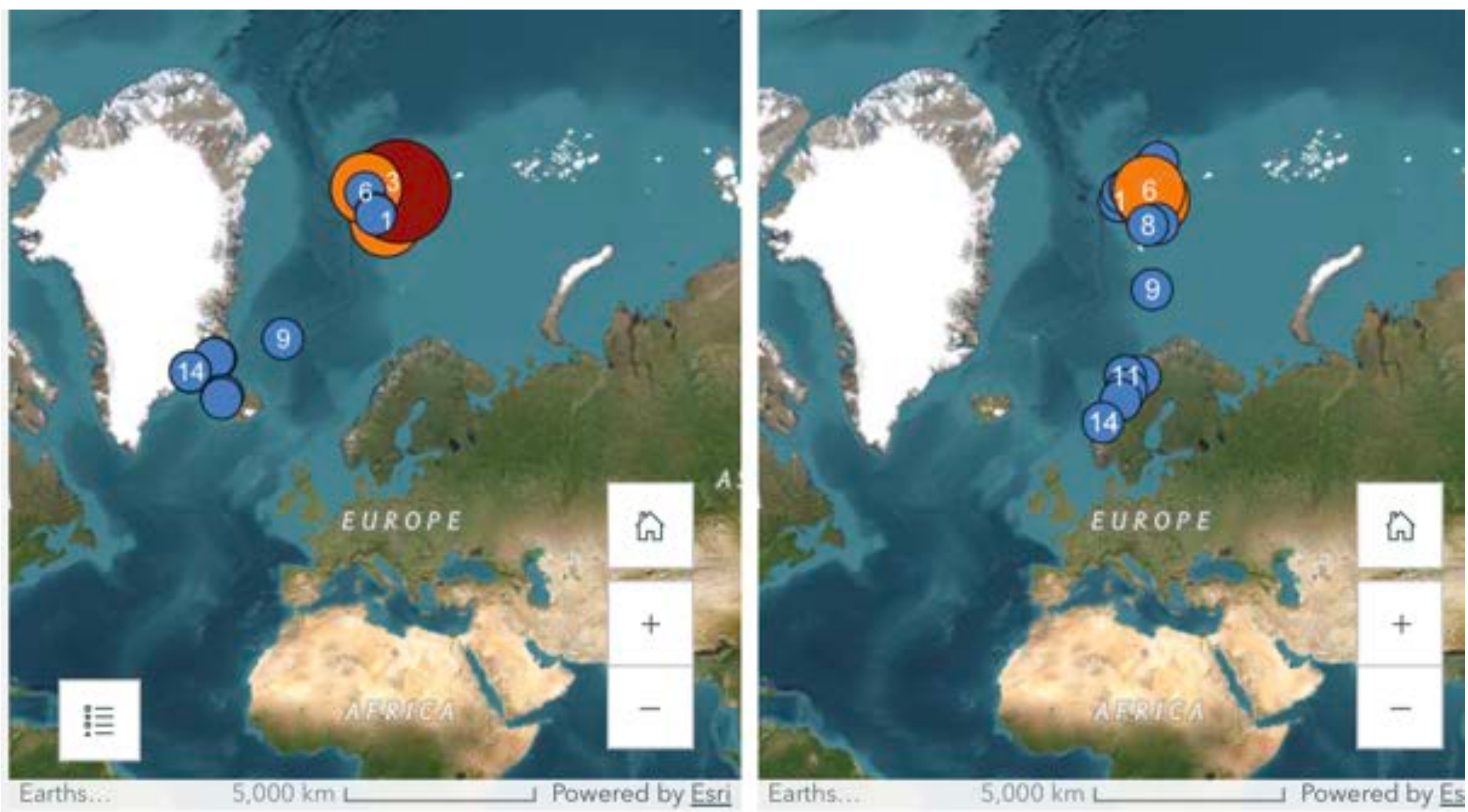
Hotspots: water and air

For our primary analysis, we looked at distribution with an eye toward finding microparticle hotspots (by using z-scores[1]). This indicates whether a region has evenly distributed microparticle pollution and helps us zero in on areas for future study.

There was one primary hotspot in the water, location 4 (Alkefjellet), and two secondary hotspots, also in Svalbard. In the air, there were three secondary hotspots (one in Svalbard and two in Iceland) and no primary hotspots.

Note: Click and drag the white centerline left or right to compare the water (left) and air (right) hotspots.

[1]Z-scores are related to the difference between a location’s concentration and how many standard deviations it is from the mean. If two or more, it is a primary and if 1-1.9, then it is considered a secondary hotspot.



Earths… 5,000 km Powered by Esri Earths… 5,000 km Powered by Esri

Riding the Surface Water Current Conveyer-belt

The 2025 surface water hotspot results (left of the slider) are incredibly consistent with the 2023 Svalbard and Norway expedition results (right of the slider). Click and drag the centerline to compare the data.

This continues to support the hypothesis that the Norwegian Coastal Current carries debris from the Atlantic Ocean, past Iceland and the United Kingdom, and deposits them in greater abundance in Svalbard.

Air pollution low along the whole expedition track!

Five locations had zero airborne pollution and even the secondary hotspots had only 2 fibers found at each location. This shows that across all the locations in this expedition, the presence of AMPs was very low and not believed to be a significant source of deposition of pollution into the water.

Potential Sources

To consider sources, we assigned every man-made particle to a numbered category based on multiple features (such as type, color, width, shape and material). Each category represents a potential source (such as a t-shirt, jacket, carpet, fishing line, etc.).

Multiple, diffuse sources; no point source

The particles we found fell into 68 distinct microparticle categories. There were 11 categories with more than one anthropogenic microparticle and 57 categories with only one.

The ratio of categories to total AMPs for the air was 0.93. This indicates that we did not experience a single or point source situation but rather multiple, diffuse sources. This is a similar ratio to what we have seen in previous Arctic and Southern Ocean expeditions.

The ratio of categories to total AMPs for the water samples was 0.74, which is between what we have seen in locations with more population, such as the Hudson River (pending review) and the extremely remote expeditions like in the Southern Ocean. This could be a reflection of the mixed populations sampled in this expedition from near zero human presence in Svalbard and Greenland to the relatively higher population in Iceland.

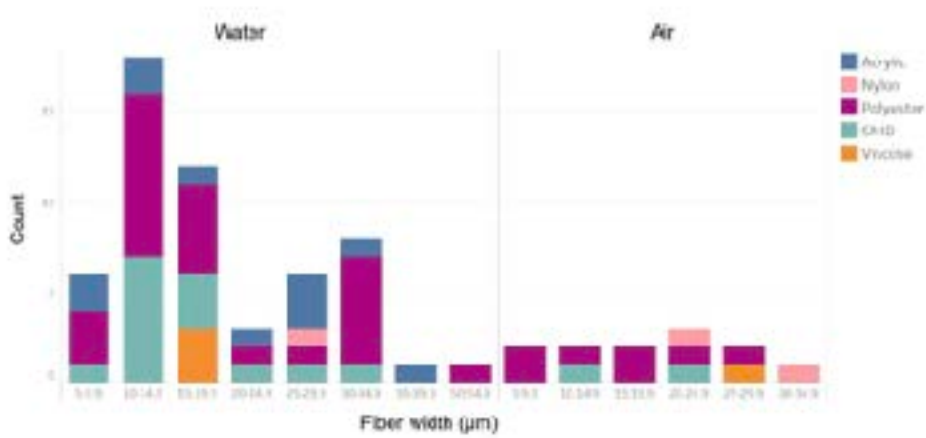
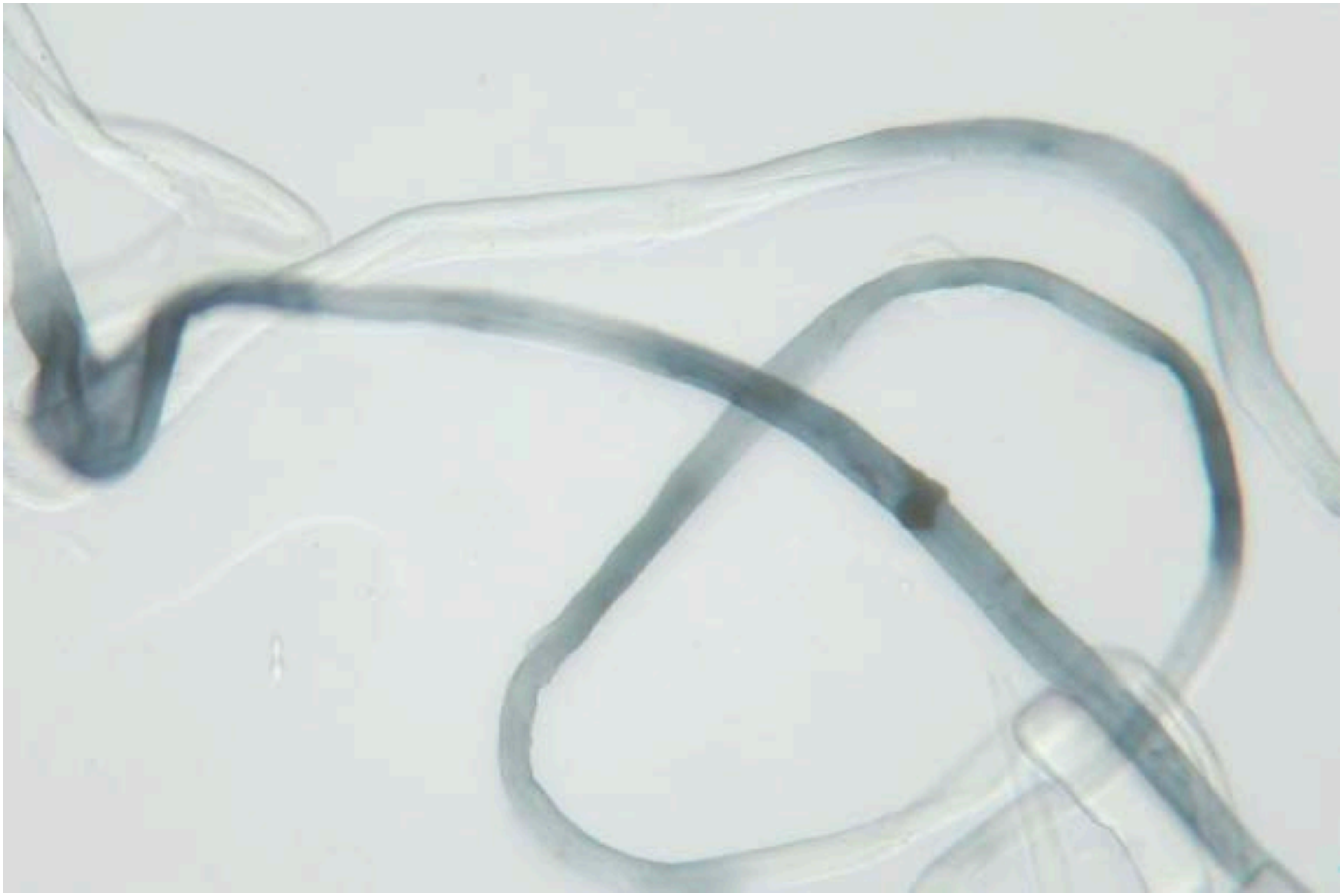


Figure 1: Fiber width and material identification (ID) in air and water.

Fiber width indicates Arctic and subarctic fibers are likely from clothing

The width of a human hair is approximately 70 micrometers (μm, a millionth of a meter). As a general rule, fibers from clothing are within the 5-19.9 μm range. Fibers from carpets are usually thicker than 35 μm and fibers from fishing lines are even wider in diameter. Thus, it is most likely that a large majority of the fibers we found in the air and water along this expedition track are fragmented from clothing (Fig. 1). This fiber fragmentation can happen when clothing is worn, washed and/or dried.



Top Observations

Here are the most common and interesting microparticles we found!

Scroll right to check them out...

Polyester

Polyester is one of the most common materials used to make our clothing. From fleeces to leggings to coats, hats and gloves.

25 of the 68 categories (36.8%) of materials found in this expedition were polyester, differentiated by color, cross-sectional shape, delusterant (an additive) and width.

Acrylic

The second-most common material type found this expedition was acrylic and made up 9 categories. Acrylic is commonly used for gloves, scarves, hats, sweaters and other articles of clothing. See those tiny specks in the fiber? That is an additive called delusterant because it "de-lusters" the plastic fiber, or makes it less shiny. Considering that most gloves, hats and scarves are not shiny, it makes sense to find high delusterant in acrylic fibers such as this one.

The relationship between air and water

Of 68 total categories, 4 were found in both air and water; 28% of all air microparticle categories and 7% of water microparticle categories. This is relatively low, further indicating that except for the broad category of clothing, there are no point sources such as factories or manufacturing that are contributing large amounts of plastics into specific locations in the Arctic/sub-Arctic locations we sampled.

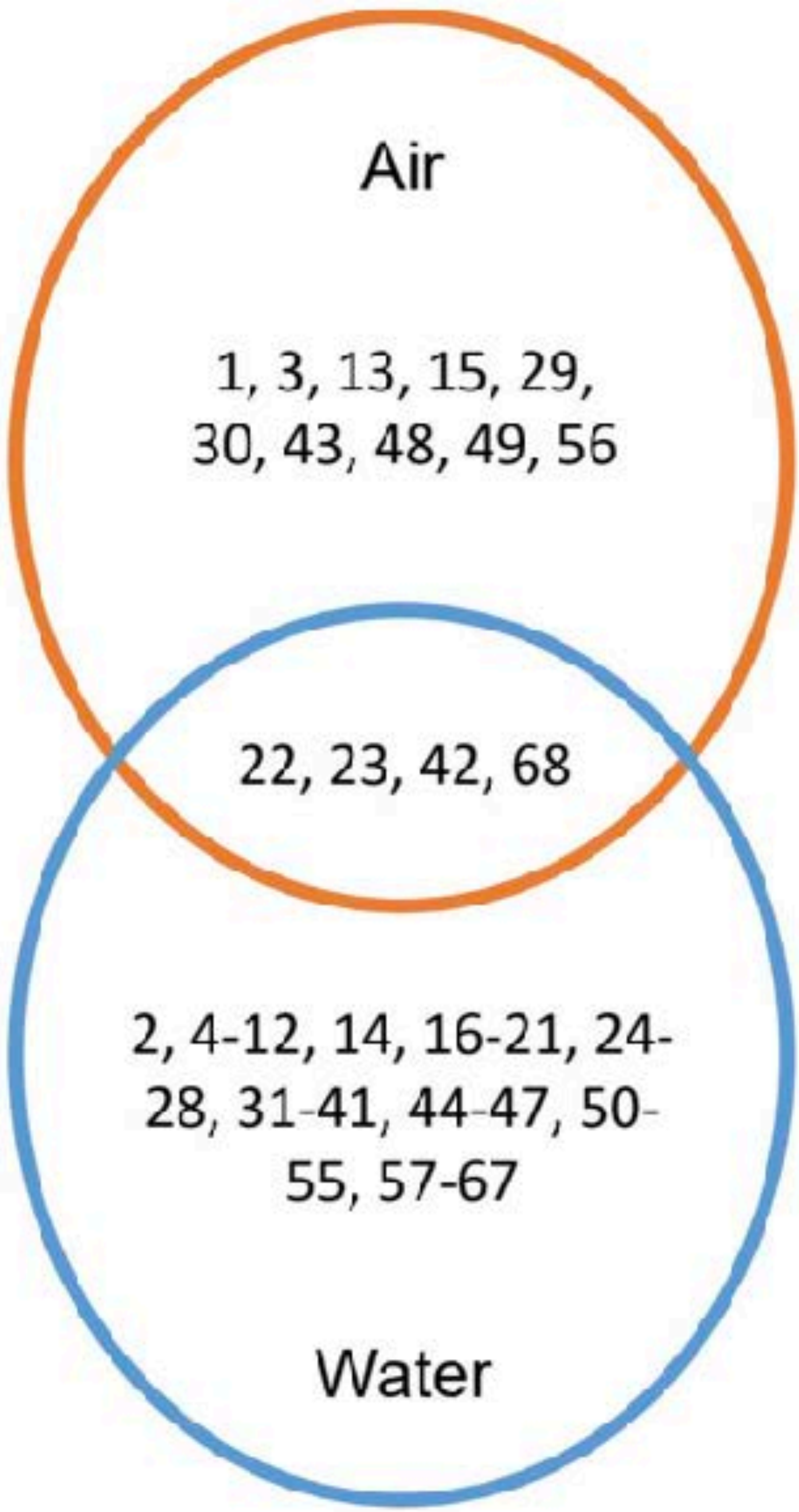
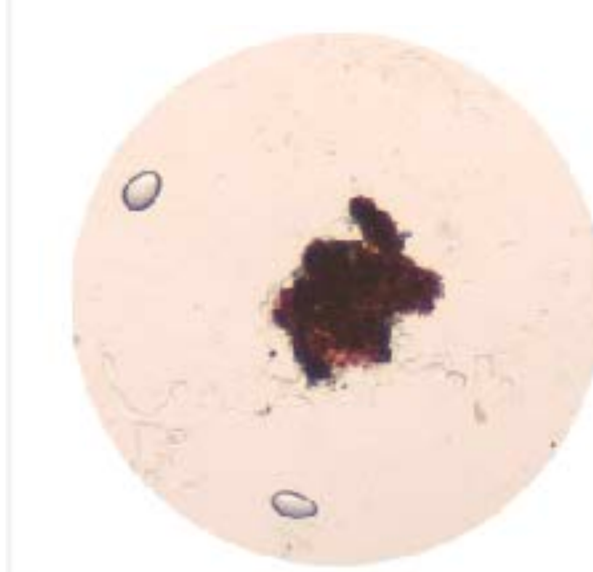


Figure 2: The distribution of fiber categories in water and air samples.

Marine growth-dating



Biofouled and fractured fragment.

Colonization by seaborne microscopic creatures or plants, also called biofouling, is evidence of a particle having been in the environment long enough for this growth to take place. We do not have the ability to estimate the amount of time these fragments have been in the water (yet - that would be an excellent additional study), but this colonization does help us understand that particular particles have been in the water for sometime and/or may have come from far away.

Contamination

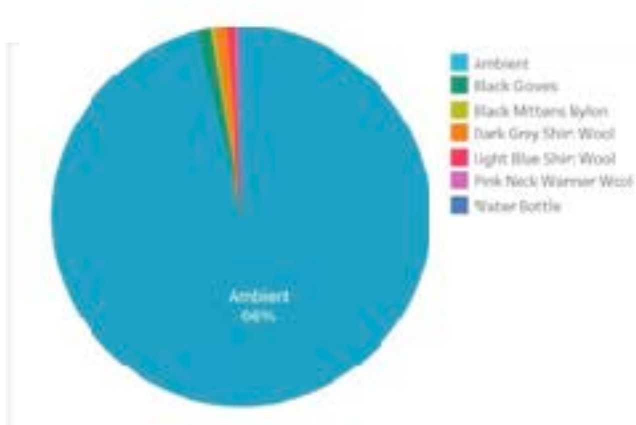


Figure 3: The sources of contamination during sample processing.

92% of all particles of interest, or 1034 total microparticles, were contamination contributed by our team while sampling or in the ambient air where the samples were processed onboard. This percentage may seem high and would be if we were doing our processing in a lab. However, this contamination percentage is consistent with previous expedition on the *NG Resolution* and *NG Endurance*. Considering our public sample processing location intended to encourage curious and lively engagement, it is unsurprising and we were ready. With rigorous attention to detail, we are confident that any fiber with a similar profile as those found in our air blank controls was excluded from being recorded as environmental pollution.

Larger Debris Observations

While the focus of our sampling on this expedition is micropollution, we are also very interested in the state of mesodebris (5mm-2.5cm), macrodebris (2.5cm-1m) and megadebris (larger than 1m) in our areas of study. Overlaying these observations with our sampling data can potentially explain the presence or transport mechanisms of both types of debris.

This is the island of Jan Mayen. It lies between Norway and

Greenland. Interestingly, the currents arriving to this remote islands come from the north (far north Russia). While it has a tremendous amount of debris, it is not the type in which we are concerned - we were told it is primarily driftwood from the forests of Russia!

An unusual find

Among the driftwood was a very small amount of fishing line fibers and fishing gear fragments as well as this - a plastic bough of holly?!

UV degradation in East Greenland

East Greenland was a wild and remote place. There were no overt signs of humans. No structures, other vessels or even trash except for this single bottle on its way to becoming hundreds-thousands of plastic fragments. Rachael was able to extract it from the rocks (all of it) and place it for display in the Science Hub - a clear example of the effect UV degradation has on the production of microplastic fragments.

A beach walk in Iceland...

The most macro debris on this expedition was found on a beach next to the most populated place we visited, Isafjordour, in Iceland. It closely follows what we'd expect - primarily fishing line and net tangled in the rocks and kelp. And even on the coast in Maine, we find a fairly large number of nips (tiny bottles of alcohol).

Opportunity for Future Study

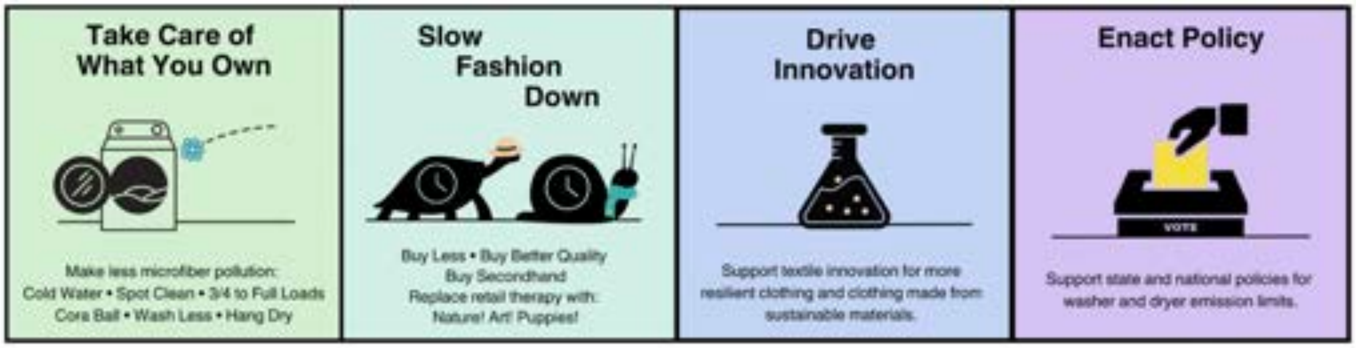
In addition to comparing similar expedition tracks and opposite poles (see our other StoryMaps in the

Sample analysis in the *NG Resolution's* Science Hub with a young volunteer.

Resources section below), investigating microparticle fluctuations that could be influenced by weather, the presence or absence of sea ice, and changes in human activities like fishing effort and tourism would also be impactful follow-up research. Based on the results from this expedition, we'd love to expand our Arctic data to the east around Greenland and toward the Canadian coast as well as continuing to understand the microplastic situation in Svalbard.

Recommendations for Action

Solutions for microplastic and microfiber pollution need to take place long before the debris gets to the walruses, bird colonies, humpbacks, polar bears and belugas of Svalbard and the subarctic. As you just learned, we primarily found microfiber pollution from fiber fragmentation in the arctic and subarctic. In fact, that is what we primarily find worldwide. We can all take action - as individuals, as innovators, as decision-makers and as policy-makers. If the list below seems like a lot, start with one item, incorporate it into your life, and then add another. These small actions will all add up to big impact!



Concerned about microfiber pollution from clothing? Solutions include everything from adapting individual attitudes toward fashion, laundering techniques, using innovations like the Cora Ball, supporting upsteam innovation to national-level action.

Click here for more information about Sustainable Laundry

In combination, these actions can result in the immediate reduction of microfiber pollution while supporting the development of long-term innovative solutions, which will, in turn, protect the spectacular creatures that call these special places home.


Mama and cub polar bears crossing the sea ice.

Conclusion

This is one of the most remote expedition tracks we have sampled in the northern hemisphere. And yet, we found hotspots of microplastic (primarily microfiber) pollution in Svalbard, high above the arctic circle. The fact that this is consistent with the first arctic expedition two years ago is strong evidence that Svalbard and the Arctic Ocean are receiving both macro and micro-pollution from the oceanic currents in the North Atlantic. Think about the Gulf Stream flowing through the Carribean north along the US eastern seaboard, west to the British isles and then north...to end at Svalbard. The connection is relatively direct. Therefore, we are confident that prevention for this pollution must start far away, where the human activity introduces it to the environment in the first place.

This expedition's findings call for action from stakeholders around the globe to make a positive change - from governments and corporations to individuals at home and exploring in nature!

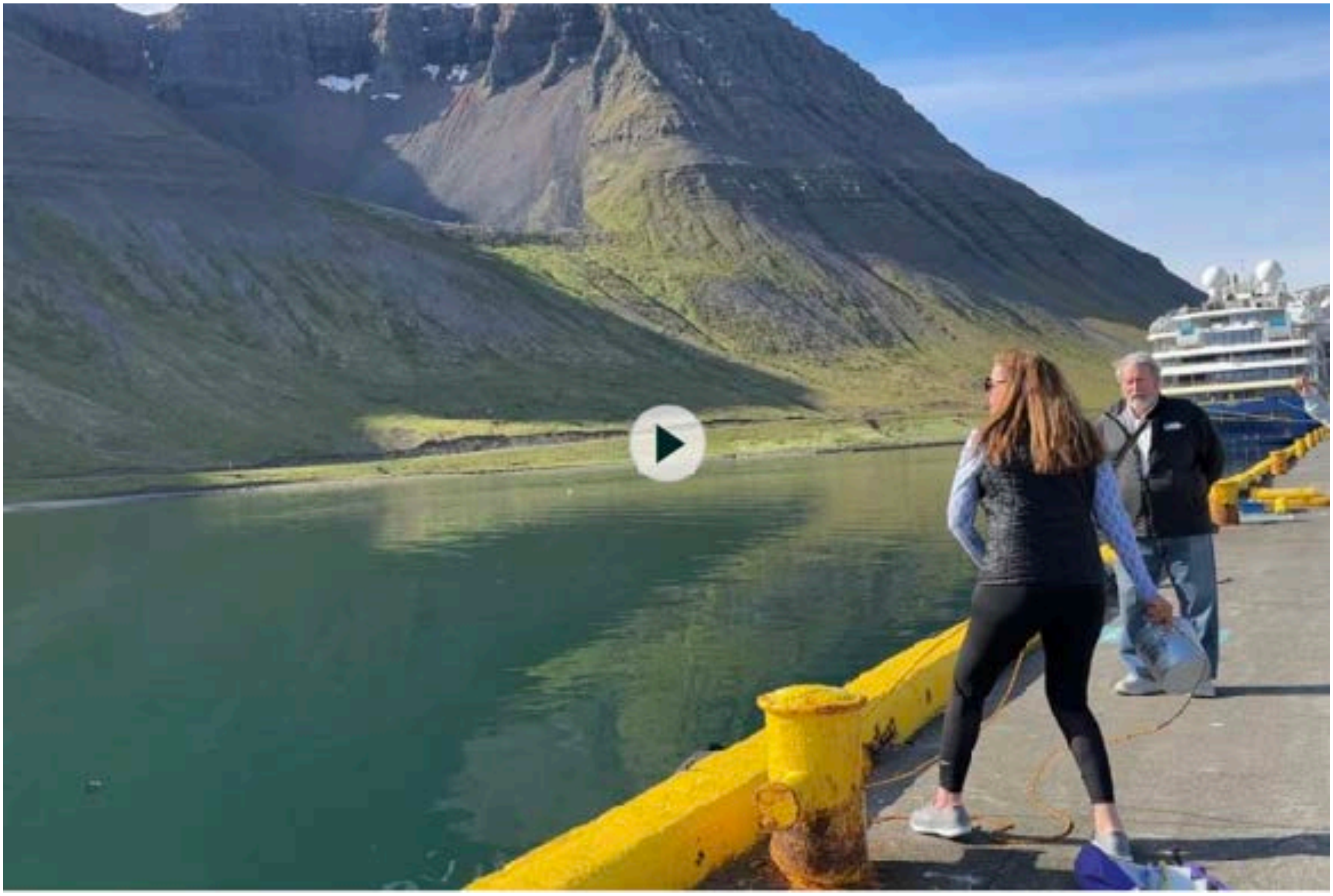
Is microfiber pollution screaming out to you?

Are you a researcher, looking for a meaningful, impactful, and solutions-oriented capstone, thesis, or other project? See our Future Study page for a list of questions whose answers will speed the creation and deployment of solutions!

Acknowledgements

This work was made possible thanks to the incredible partnership and support from National Geographic-Lindblad Expeditions and the National Geographic Society, specifically the LEX-NG Fund.

Thank you to the individuals at National Geographic-Lindblad Expeditions and National Geographic Society who created and are driving this program forward as well as the incredible guests, crew and dazzling field staff on the National Geographic-Lindblad Expeditions ships, the *NG Resolution* in particular.



For this report, we specifically applaud those on the Svalbard, Greenland and Iceland expedition in July 2025. You injected your intellect, enthusiasm, skills and joy into this project and with that in the mix, we are sure to have impact! Microplastic and anthropogenic microfiber pollution may be invisible without a microscope, but all of us together are turning data into knowledge and that knowledge into action and impact - all for a clean ocean.

We’d like to say an ocean-sized thank you to everyone who has donated to the LEX-NG Fund! Your support is creating opportunities for knowledge, innovation and action that has the power to protect this breathtaking planet.

We also would like to acknowledge the team at Rozalia Project for a Clean Ocean. When Rachael founded Rozalia Project in 2009, the goal was to protect the ocean by addressing the problem of marine debris. It is incredible to see the organization grow in the capable and often sandy hands of the Board, Executive Director, staff and volunteers. Without the on-the-water team at Rozalia Project, these NG-LEX expeditions would be difficult and sometimes impossible for Rachael to execute.

We have some spectacular academic and institutional partners, specifically Dr. Kelly Sheridan, Assistant Professor in Forensic Science at Northumbria University and Research Director at The Microfiber Consortium, and Naomi, also at Northumbria University, who completed all of the slide analysis for this expedition.

Lastly, a big shout out to CSI for the Ocean development partner, Professor Claire Gwinnett and her team at Staffordshire University as well as Maija Niemesto and her team at Norrie Point Environmental Center in New York for helping field test the methods we are now using far from the Hudson River.

Resources

Antarctic Peninsula 2024 National Geographic-Lindblad Expedition on the *National Geographic Resolution StoryMap: bit.ly/CSIfortheOceanAntarctica2024*

Arctic and Subarctic 2024 National Geographic-Lindblad Expedition on the *National Geographic Endurance* StoryMap:

bit.ly/CSIfortheOceanSubarctic2024

Arctic 2023 National Geographic-Lindblad Expeditions on the *National Geographic Endurance* StoryMap: bit.ly/CSIfortheOceanArcticNorway2023

Southern Ocean 2023 National Geographic-Lindblad Expeditions on the *National Geographic Endurance* StoryMap: bit.ly/CSIfortheOceanSouthernOcean2023

Hawaii 2022 National Geographic and Ocean Exploration Trust Expedition on the *E/V Nautilus* StoryMap: bit.ly/CSIfortheOceanHawaii2022

Rozalia Project for a Clean Ocean CSI for the Ocean homepage https://www.rozaliaproject.org/csi-for-the-ocean

Rozalia Project for a Clean Ocean Microplastic Lesson Plans for formal and informal educators https://www.rozaliaproject.org/resources

Microfiber Primer for more background information about microfiber pollution https://coraball.com./blogs/ocean-protectors-blog/the-microfiber-pollution-primer

Open Access Data

The data collected on this expedition is available for free public examination and additional analysis. Please contact us at micro@rozaliaproject.org with inquiries.