Plastic Beach

A Citizen Science Protocol for Microplastic Pollution

April 2019
TABLE OF CONTENTS

INTRODUCTION: WHAT ARE MICROPLASTICS? ................................................................. 3
1. WHAT YOU NEED TO GET STARTED ............................................................................ 4
2. INSTALLING MARINE DEBRIS TRACKER ON YOUR SMARTPHONE ..................... 5
3. SETTING UP THE MDT APP FOR MICROPLASTIC SAMPLING .............................. 6
4. ENTERING INFORMATION INTO THE MDT APP .................................................. 7
5. SETTING UP YOUR SAMPLING AREA ...................................................................... 7
6. COLLECTING YOUR SAMPLES .................................................................................. 9
7. ANALYZING YOUR SAMPLE ..................................................................................... 11

Figure 8: Visual Guide for Identifying Microplastics .................................................... 14
8. ENTERING MICROPLASTIC INFORMATION INTO THE APP .................................. 16
9. SUBMITTING & ACCESSING INFORMATION USING THE APP .............................. 16
10. FREQUENTLY ASKED QUESTIONS ......................................................................... 18
11. GLOSSARY .............................................................................................................. 19
APPENDIX A: DATA SHEET FOR RECORDING MICROPLASTIC COUNTS ............... 20

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This Plastic Beach protocol is designed to be used by citizen scientists to collect data on microplastic pollution in sandy beaches and shorelines. Using this protocol, volunteers can collect important data that can be used to characterize current levels of microplastics pollution and look for global and regional trends.

INTRODUCTION: WHAT ARE MICROPLASTICS?

Microplastics are, in general, small plastic pieces that are less than 5 mm in size. Plastic fibers smaller than 5 mm in width but larger than 5 mm in length are also considered microplastics. Research tells us that microplastics are found in freshwater rivers and lakes, and in all of the world’s oceans. This protocol helps you find microplastics at your local beaches.

There are two types of microplastics:
- Primary microplastics, which are intentionally produced (for example, plastic microbeads, which are used in some cosmetic products such as face scrubs).
- Secondary microplastics, which result from the breakup of larger plastic items during use or after disposal (for example, plastic microfibers, which originate from synthetic fabrics such as polyester).

This protocol focuses on microplastics 1-5 mm in size because these particles are relatively easy to find and can be identified with the naked eye or using a magnifying glass. Microplastics smaller than 1 mm in size (such as microbeads) are more difficult to find, and more sophisticated technology is required to conclusively identify them.

This Plastic Beach protocol focuses on collecting and identifying microplastics on the sandy beaches or shorelines of oceans and bays, lakes, and rivers. The protocol relies on the use of the Marine Debris Tracker app for smartphones or tablets to record and submit data, although hard copy data sheets are also provided for those who prefer not to use the app or wish to back up their data on paper (see Appendix A for these data sheets; use one data sheet per quadrat and see below for more information on quadrats).
1. WHAT YOU NEED TO GET STARTED

Supplies for collecting your sample:
- 1-Millimeter sieve*
- Cup, scoop, or flat dustpan
- 4-Meter rope or string tied to form a quadrat (1 x 1-meter square)
- Wooden stakes
- 100-Meter tape measure
- 5-Gallon bucket (2)
- Mobile device (smartphone or tablet) with the Marine Debris Tracker app, or data sheets
- Bags, jars or other sealable containers, one for each quadrat you sample
- String or additional tape measure to lay out transects
- Marker and labels for containers

* See the FAQs on page 18 for more information about sieves.

Supplies for analyzing your sample:
- Ruler
- Magnifying glass
- Forceps or tweezers
- Small brush (paint brush or hand brush)
- Mobile device with Marine Debris Tracker app
- Size grid (Figure 6)
- Visual identification guide (Figure 8)

Other materials that may be useful if multiple volunteers will be sampling:
- Digital camera (if smartphones are not being used)
- Additional 4-meter string quadrats
- Additional wooden stakes
- Additional sieves
- Additional buckets
- Additional cups or scoops
2. INSTALLING MARINE DEBRIS TRACKER ON YOUR SMARTPHONE

About the Marine Debris Tracker App

Marine Debris Tracker (MDT) is a joint effort of the NOAA Marine Debris Program and the Southeast Atlantic Marine Debris Initiative (SEA-MDI) of the University of Georgia College of Engineering. MDT contains different “lists” (apps within the app) for tracking different types of information, from International Coastal Cleanup litter counts to derelict vessels.

The Marine Debris Tracker (MDT) app allows you to log information about your microplastics sample and upload it to the Marine Debris Tracker website where you can access it later. The app also lets you use other functions of your smartphone, such as GPS and camera, as part of your sampling trip.

Cell service and the MDT app

Before you set out on your sampling trip, install the MDT app and set it up for microplastics sampling (see instructions below). You will need to enable locational services on your mobile device to get GPS data for your site.

You should also select 4 random numbers before your trip as part of the sample site selection process, in case you have no cell service at the sampling site. See Section 5 for instructions.

Once the app is set up on your phone, you can enter and save data on your device without cell service, but you cannot upload it to the website.

For more information, visit http://www.marinedebris.engr.uga.edu/.

To install the app on your smartphone:

A. Go to the Google Play Store (Android) or the Apple App Store (iOS)
B. Search for and select “Marine Debris Tracker”
C. Click “Install” and accept permissions. The app will need to access your camera and other phone functions.
3. SETTING UP THE MDT APP FOR MICROPLASTIC SAMPLING

A. Open the MDT app, and tap “Change List.”
B. Scroll down until you find “5 Gyres Plastic Beach Microplastics Protocol” as shown in Figure 2 and tap this list.

![Figure 2: Scroll down and select the “5 Gyres Plastic Beach Microplastics Protocol” list.]

C. Once you have selected your list, tap “Start.” The screen shown in Figure 3 will appear. Each of the sections (“Site Data,” “Plastic,” and “Other Items”) can be expanded or collapsed by tapping on the arrowheads (▼ to expand; ▲ to collapse). Access the previous screen by tapping the black arrow in the upper left corner of the screen. Location information will appear in the area labeled “GPS information.” Note that location services must be enabled on your mobile device.

![Figure 3. Start screen]
4. ENTERING INFORMATION INTO THE MDT APP

All of the information you collect during your microplastics sampling trip is entered into the MDT app in the same way.

The app gives you two options to enter information:

- as numbers, using the +/- buttons (to record such things as number of microplastics collected or quadrat number), or
- as text, using the “DESC” button to type information into a text box (for example, to record the name of your program, sampling site, volunteers’ names, or any other general information).

Tap the black-and-white camera icon to take photographs of your sampled microplastics as well as of anything else you think is of value, such as your location, or your volunteers. Using your phone’s camera through the app means that the photo will be tagged to a specific location.

Once you have entered information into the app, make sure to tap “LOG” to save it and to tag it to a particular GPS location. Each time you tap “LOG,” the number of “View and Submit Items” at the top of the screen will go up by one (Figure 4). Further details on how to upload your information are in Section 9 below.

The “Start Path Log” button may be used if you want a GPS record of the path you walked for an activity such as cleaning up plastic trash on the beach.

5. SETTING UP YOUR SAMPLING AREA

Identify a sandy beach or shoreline you want to sample for microplastics. At ocean or estuarine/bay beaches, your sampling area will be between the line of the last high tide (also called the high water line or wrack line, where seaweed and other organic debris are deposited by the tide) and the back of the beach where the sand ends at a seawall or path, or where vegetation grows, as shown in Figure 5. At freshwater beaches, your sampling area will be from the water’s edge to where the sand ends and vegetation grows or there are paths, walls, etc.
To set up your sampling area, place the 100-meter measuring tape mid-beach and parallel to the water as shown in the diagram, and measure off 100 meters. Assign one end of the line as 0 and the other end as 100.

If your beach or shoreline is not at least 100 meters long, measure as far as you can, note this distance in the app or on your data card, and use this number in the random number generator as noted below.

Once this distance is measured, you will set up four transects at random intervals along the line, using a random number generator (see below). A transect is a line perpendicular to the 100-meter line along which three 1-meter square areas (quadrats) will be selected and sampled (Figure 5). In this case, the transect can be laid out with string or another measuring tape (or, especially if the water line and the back beach are close together, you may be able to simply establish the transect visually).

Figure 5: Setting up sampling sites along a 100-meter line on a marine/estuarine beach. Note that on a freshwater beach (along a lake or river), the middle beach is between the water’s edge and the back beach. This is where you would set up your 100-meter line; quadrats 1, 4, 7, and 10 would be at the water’s edge.
To set up the four transects, you will need to identify four random numbers that will be the points where the transects cross the 100-meter line. To do this, use a random number generator, which can be found online using your smartphone. Go to www.random.org and enter a minimum value of 1 and a maximum value of 100. Click “Generate” four times and write the four numbers down. These numbers are where you should mark the positions of your four transects along your 100-meter distance.

Use string or a measuring tape to lay a perpendicular transect across the transect point, from the high water line to the back beach. Place three of the 1 x 1-meter quadrats along the transect (refer to Figure 5). One quadrat should be at the wrack line (last high tide or high water line), one at the middle beach, and one at the back beach (next to vegetation, seawall or path). Do the same for the other three transects so that you have four transects within your 100-meter distance as shown in Figure 5. You may wish to draw a quick diagram of your sampling area with your quadrats labeled, for future reference.

Note: If you are sampling a freshwater beach, one quadrat should be placed just above the water’s edge, one at mid beach, and one at the back beach where vegetation or man made structures begin.

If your beach is less than 100 meters long, enter the length of your beach as the maximum value in the random number generator.

6. COLLECTING YOUR SAMPLES

As a quadrat is set up, you can start collecting your samples. In each quadrat, remove any big pieces of natural debris and litter, like seaweed, wood and trash. Brush them off with your supplied brush (or rinse with water) into your 1-mm sieve so that you collect any microplastics that might be attached.

If the debris is difficult to brush off (such as large clumps of seaweed), try submerging it in a bucket of water and gently agitating it to release any material that is stuck. Once the debris is clean, pour the water through your 1-mm sieve to collect the particles. Be sure not to do this near the quadrat.

Most of your sample will consist of sand, either dry or wet. Sieve your sand carefully and in small batches to avoid losing any microplastics over the edge.
How should I decide how many quadrats to sample?

The number of quadrats you sample depends on the purpose of your sampling trip and how many volunteers are present. *Always be sure to indicate how many quadrats you sampled in the MDT app or on your field data sheets. This is valuable information for potential data users.*

**Beach characterization:** To best characterize the level of microplastics pollution in a 100-meter section of beach, 12 quadrats should be selected along 4 transects, as noted in Figure 5. This allows potential data users to compare your section of beach to others, or to establish a baseline of information for future trend analysis. Since sampling 12 quadrats is time consuming, this is best done with 6 or more volunteers. To save time, you may wish to save microplastics samples in labeled jars or other containers for analysis later in a lab or office.

If you cannot sample 12 quadrats because of time or volunteer labor limitations, sample along 2 or 3 complete transects (6 or 9 quadrats) if possible. Multiple quadrats selected randomly following the procedures in this protocol allow for better characterization of microplastics pollution.

**Education:** If your sampling trip is educational in nature with only one or two volunteers, you may wish to select a quadrat at random to sample.

If four or more volunteers are present, one transect with three quadrats from the high tide line to the back beach (such as quadrats 1-3 in Figure 5) will provide volunteers with opportunities to engage in sampling and learn about the types and abundance of microplastics that might be present. One transect, however, does not fully characterize the 100-meter section of beach.

A. To Sieve Dry Sand:
   a. Evenly scrape the surface of the sand within the quadrat using a metal cup or flat dustpan to a depth of *about an inch* (2.5 cm). Deposit some of the sand you have scraped from the quadrat into your 5-gallon bucket until it is half filled with sand. Do your best to keep a consistent depth as you are scraping the sand.
   b. Scoop the sand back out of the bucket and pour it through the 1-mm sieve. Tap the sieve gently or use a brush to gently move the material through the sieve. Do this away from the quadrat.
   c. Once the first half-bucket of sand has been sieved, continue scraping sand from within the quadrat and placing it in the bucket. You may need to fill the bucket 1-2 more times. If you have enough people, one person can scrape the quadrat while another filters sand.

B. To Sieve Wet Sand:
   a. Fill the 5-gallon bucket a little less than half full with water.
   b. Evenly scrape the surface of the sand within the quadrat using a metal cup or flat dustpan to a depth of *about an inch* (2.5 cm). Deposit some of the sand you have scraped from the quadrat into your bucket partially filled with water. Be
careful not to overflow the bucket, and add the sand in small batches using the scoop to prevent the bucket from getting too heavy.

c. Once enough sand has been added to the bucket, slowly pour water from the bucket through the sieve, or use the scoop to transfer all floating particles into the sieve. Do this away from the quadrat.

d. After pouring the first bucketful of water through the sieve, remove the sand remaining in the bucket and discard it outside the quadrat. Then start again at step (a) and continue filling and emptying the bucket until all of the sand from your quadrat has been sieved.

As you sieve the sand or water, remove any suspected microplastics from the sieve using the tweezers and place them in a labeled, sealed bag, jar or bottle for later analysis. Whether you combine the samples into one or two containers or use one container for each quadrat sample depends on the purpose of your sampling trip (e.g. education versus in-depth characterization). For the latter more intensive purposes, a container for each quadrat is recommended. Be sure to label the containers (see Figure 5 for quadrant numbers). Labels should include the beach name, the date of the sampling trip, the quadrat number(s), and the name of the volunteer(s).

Also note in the app or on your data card if you find other plastic items that are larger than microplastics.

7. ANALYZING YOUR SAMPLE

Once suspected microplastics have been separated from the sand, use the size grid (Figure 6) to determine which of your particles are smaller than 5 mm. You may wish to print the size grid and laminate it for use in the field. If any particles are larger than the individual boxes in the grid, this means they are larger than 5 mm and thus are not microplastics. The exception is plastic lines (fibers), which may be larger than 5 mm in length, but smaller than 5 mm in width. These should be counted as microplastics.

Ideally, you should keep track of larger items as well, for general information. Use the “Other items” section on the app or data sheet.

Microplastics can be grouped into 5 broad categories: fragments, pellets (nurdles), lines (fibers), films, and foams. Each of these groups has a characteristic appearance. Figure 8 is a visual guide to the different types of microplastics.

Particles can be identified as plastic using a few methods:

A. Visual identification using a magnifying glass and the visual guide in Figure 8.
B. A ‘sink test’ to differentiate shells from plastic—shells and shell fragments will sink, while many plastics will float.
C. A 'squish test' to differentiate hard plastics, such as polypropylene or polyethylene, from soft organic matter. Use your tweezers to gently squeeze the particle. Hard natural materials like shell fragments will crack under tweezer pressure, while plastics will generally bend, but not break (some harder plastics will not bend). Foam microplastics will also 'squish,' but not in the same way as organic matter. Foam microplastics can usually also be visually identified.

**NOTE:** Weathered plastics—plastics that have been in the environment for a long time—may not have the same properties as “new” plastics. Weathered plastics may appear faded in color, they may break more easily and may be more difficult to identify. If you are not sure that a particle is plastic, consider it non-plastic.

Count the number of plastics in each category and enter the information into the Marine Debris Tracker app. If you want to record separate information for each quadrat, make sure to note which quadrat(s) you are analyzing using the “DESC” button.
Figure 6: Use this grid to determine if your microplastics are larger than 5 mm—each box is 5 mm x 5 mm.

Figure 7: Use these size guides to measure other plastic pollution

<table>
<thead>
<tr>
<th>Size</th>
<th>Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm</td>
<td><img src="image" alt="5 mm grid" /></td>
</tr>
<tr>
<td>10 mm</td>
<td><img src="image" alt="10 mm grid" /></td>
</tr>
<tr>
<td>20 mm</td>
<td><img src="image" alt="20 mm grid" /></td>
</tr>
<tr>
<td>30 mm</td>
<td><img src="image" alt="30 mm grid" /></td>
</tr>
</tbody>
</table>
**Figure 8: Visual Guide for Identifying Microplastics**

<table>
<thead>
<tr>
<th>Film</th>
<th>Foam</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pieces of plastic bags and wrappers</td>
<td>• Pieces of expanded or extruded polystyrene (one example is Styrofoam™ insulation)</td>
</tr>
<tr>
<td>• Usually flexible</td>
<td>• Generally have a softer texture, but may also be brittle</td>
</tr>
<tr>
<td>• Occur in many colors, but white/clear particles are common</td>
<td></td>
</tr>
<tr>
<td>• May become brittle over time due to weathering</td>
<td></td>
</tr>
</tbody>
</table>
| Fragment | • Result from the break up of larger plastic items  
• Represent many types of plastic  
• Generally rigid  
• Occur in many colors and shapes  
• May become brittle over time due to weathering |
| --- | --- |
| Line (Microfibers) | • Plastic fibers from synthetic textiles and synthetic ropes  
• Occur in many colors  
• May fray over time due to weathering  
• May be larger than 5 mm in length, but are smaller than 5 mm in width |
| Pellets (Nurdles) | • Used in the production of plastics  
• Can be made in many colors, but white pellets are common  
• Usually have a round, smooth, manufactured appearance and feel |
8. ENTERING MICROPLASTIC INFORMATION INTO THE APP

The “Plastic” section of the MDT app contains all of the microplastic categories described above. Use the +/- buttons to enter the number of microplastics you identified for each category, including “Other Plastic Items” (if applicable). You can also use the “DESC” button to enter the quadrat number and a text description for your sample (for example, if you found many blue lines/fibers, you can include this information).

The “Other Items” section can be used to enter information on non-plastic litter or items larger than microplastics.

Use the camera icon to take photographs of your microplastics. Group the microplastics together and take a photo of all of them on the Figure 6 grid. This photo will represent your entire sample for that quadrat. Make sure to tap the “LOG” button after you enter the information to save it to the app. The orange number under “View and Submit Items” will go up by the number of microplastics you have entered for each category each time you tap “LOG.” For example, if you enter three fragments into the app, the “View and Submit” field will show “3 Items” once you tap “LOG.”

NOTE: Photographs are not uploaded to the Marine Debris Tracker website. Your photographs will remain on your phone, but will be tagged in your device to the information you upload so that you can match them to your microplastic data later when you access it through the website.

9. SUBMITTING & ACCESSING INFORMATION USING THE APP

After you have entered all information for all quadrats and transects into the app, tap the “View and Submit” button at the top of the screen to view a list of the information you entered into the app. You can view the information as either a list or a map, and you can choose to delete information on this screen if you do not want to upload it.
Once you are happy with the information shown, tap the “Submit” button. You may submit data to the website in a few ways (Figure 11):

A. **Submit it as a MDT user.** To do this, register using an email address, username and password. This allows you to download your microplastic information later;

B. **Submit it anonymously.** Username and password not required; you can still view your information on the MDT website but will not be able to access it specifically; or

C. **Save as a CSV file to back up your information if you are currently offline.** Your information should stay in the app memory until you submit it, whether or not you back it up. However, backing up the information is safer.

You will also have the option here to share your findings through Facebook, Twitter or Google, including a photo, map or image that you submit (Figure 12).

Any information you upload can be viewed publicly on the Marine Debris Tracker website (all data is anonymous unless you choose to share it on social media). To access your information, go the Marine Debris Tracker website and click on “View and Get Data” on the menu banner. You will be taken to a webpage where you can log into your account (if you created one), view a map containing information submitted by users, or search for information by date, keyword or list on the app. You can then download your data as a .csv file that can be opened in Excel.
10. FREQUENTLY ASKED QUESTIONS

• Where can I buy a sieve?
Durable, high-quality stainless steel or brass sieves can be purchased from biological or scientific supply companies. Look for a #18 sieve with a mesh size of 1 mm.

• Can I make my own sieve?
Yes. You can use stainless steel mesh and a wooden or metal frame to make your own sieve. US #18 mesh (Tyler 16 mesh) is equivalent to 1-mm mesh. A 12” x 12” square frame with 1-mm stainless steel mesh securely attached to it (for example, with staples) will work well as a sieve.

• Will I find plastic microbeads in my sample?
No. Microbeads are much smaller in size than 1 mm, so they will not be trapped by your sieve.

• I only have access to a small beach. Can I still collect microplastics?
Yes—all information on microplastics is valuable! Follow the instructions in the protocol for how to measure your beach and set up your transects and sampling quadrats.

• I don’t have a lot of time. Can I still collect microplastics?
Yes—all information on microplastics is valuable! Follow the instructions in the protocol for how to measure your beach and set up your transects and sampling quadrats. Sample only as many quadrats as your time allows, taking care to record your location and microplastic information on the data sheets or using the MDT app. Your sampling and analysis skills will improve with time, which means that you can analyze more samples in a shorter time.

• Will the MDT app use my network cellular data to upload my sampling information?
No. The app will only use WiFi to upload information. The information will be held on your phone until you access WiFi.

• Who will be using the data in the Marine Debris Tracker?
As you can see from the number of lists that are included in the app and the amount of data available on the website, Marine Debris Tracker is already being used by many groups and organizations who are interested in tracking plastic pollution. Your microplastics data can be used by you or your organization, or by someone in your area, to understand local microplastic pollution. As more people use the app to collect microplastic data, scientists may use the data collected from larger areas (for example, counties, states, regions or the entire United States) to examine and analyze broader trends in microplastic pollution over space and time.
11. GLOSSARY

**Back beach:** The part of the beach farthest from the water where plants (grasses, shrubs and/or trees) are growing and/or there are seawalls, boardwalks, paths, parking lots, etc.

**Human use of beach:** Classify human use of beach as low if there are usually few or no people who use that beach during the beach season; medium if there are usually scattered individuals or small groups of people who use that beach during the beach season; or high if there are large numbers of people who use that beach during the beach season.

**Microplastics:** Generally, plastic pieces smaller than 5 mm. Plastic lines (fibers) larger than 5 mm in *length*, but smaller than 5 mm in *width*, are also considered microplastics.

**Nurdles:** Small plastic pellets that are the raw material from which many plastic goods are made.

**Quadrat:** A 1-meter x 1-meter square that is used to mark off a sampling location for collecting microplastics.

**Transect:** A line perpendicular to the water line along which the quadrats are placed for microplastics collection (see Figure 5). Random numbers are used to identify where you should establish your transects along the 100-meter (or less) distance.

**Weathering:** A change in the appearance or other characteristics of microplastics due to exposure to the environment. Wind, water, salt and microbial activity can all cause weathering of microplastics. Signs of weathering include changes in color, shape or texture.

**Wrack line:** A visible line of natural (for example, seaweed, drift wood, or shells) or manmade (for example, plastic litter) debris on the beach that is parallel to the water and reflects a recent high tide. The wrack line also indicates the **high water line**.
APPENDIX A: DATA SHEET FOR RECORDING MICROPLASTIC COUNTS
Use one sheet for each quadrat sample

<table>
<thead>
<tr>
<th>Beach Name:</th>
<th>Nearest City or Town:</th>
<th>State/Province/Country:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Human Use of Beach:** (circle one)
- Low
- Medium
- High

<table>
<thead>
<tr>
<th>Organization/Group Name:</th>
<th>Quadrat #: (per Figure 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volunteer Name(s)(optional):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Recent Rain/Storms: (circle one)</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Beach Name:**

**Nearest City or Town:**

**State/Province/Country:**

**Human Use of Beach:** (circle one)

- Low
- Medium
- High

**Organization/Group Name:**

**Volunteer name(s)(optional):**

**Notes:** (include whether a photo of the microplastics was taken)

*Last High Tide or High Water Mark applies to marine/estuarine beaches. For rivers/lakes, this is the Water’s Edge.

**DATA SHEET FOR RECORDING MICROPLASTIC COUNTS**

Use one sheet for each quadrat sampled.
<table>
<thead>
<tr>
<th>Recent Rain/Storms: (circle one):</th>
<th>Beach Type: (circle as many as apply)</th>
<th>Location of Quadrat on Beach: (circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Urban      Rural Remote</td>
<td>Last High Tide*</td>
</tr>
<tr>
<td>No</td>
<td>River      Lake Bay Ocean Island</td>
<td>Middle Beach</td>
</tr>
<tr>
<td></td>
<td>Sampling Date:</td>
<td>Time of Day:</td>
</tr>
<tr>
<td></td>
<td>Number of Fragments</td>
<td>Number of Pellets</td>
</tr>
<tr>
<td>1-5mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;5mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** (include whether a photo of the microplastics was taken)

*Last High Tide or High Water Mark applies to marine/estuarine beaches. For rivers/lakes, this is the Water’s Edge.*