Guidelines for sampling microplastics on sandy beaches

Preface

We have all seen pictures of or experienced beaches and coastlines that are littered with plastic pollution. I worked with a team of young people for several hours cleaning one small stretch of beach in the Bahamas – we ended up with 65 large rubbish bags full of plastic. Yet, even if we had picked up every piece of large plastic, the beach would have still have had a huge amount of plastic in and among the grains of sand. This is what is called microplastic – small pieces of plastic either made that way or broken down from larger pieces. Although it often goes unnoticed, one quick look through the sand and you will see that all is not well.

Lifestyles need to change in order to tackle the problem of microplastic pollution. We need to shift away from single use plastic and make sure that plastic is designed for recycling. This is an issue of justice – the plastic we throw away is unlikely to impact our health and wellbeing, but will impact someone else's and often those less able to avoid pollution such as the poor. It is also a spiritual issue – A Rocha is a Christian organization and we seek to love God and our neighbour as Jesus commanded. Polluting the world with plastic in a way that hurts the ocean and others is not loving God or our neighbour.

We also need information! What are the different types of microplastic? How many are there out there? Where are they? These seem like simple questions, but for most places we lack basic information on the amount and types of microplastics on our beaches. Jo Calcutt and Aline Nussbaumer have researched and tested methods which can be used to collect data that will assist in determining global patterns of microplastic pollution but are also explained in sufficient detail and simple enough that ordinary citizens can complete the work. This is called citizen science.

A Rocha is excited that you have this guide in your hand. We hope that you will use it to explore the world of microplastics and use the information you find to help us understand more about the extent of microplastic pollution. Most importantly, we hope you will take this information and use it to educate others and advocate for change. Happy adventures in studying microplastics and in changing the world for the better!

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A Rocha

A Rocha is a family of Christian conservation organizations, committed to working with both people and nature. Through 20 national organizations on six continents we deliver conservation and hope – people and places transformed through practical action and the love of Christ.

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1. Introduction

Microplastics are plastic fragments smaller than 5 mm in size that are now present as a pollutant in the marine environment – in beach sediment, on the sea floor and floating on the sea surface. Primary microplastics are plastics that are released into the marine environment in their 'micro' size either because they have been manufactured that way (such as microbeads used in cosmetics, air-blasting media used for cleaning machinery and boats, and plastic pellets known as 'nurdles' that are the raw material for plastic products) or resulting from abrasion during manufacturing or product use (such as microfibres released from clothes during washing). Secondary microplastics are plastic fragments formed when larger plastic items are broken down in the marine environment by abrasion or UV radiation.

These guidelines provide community groups with a method of determining the type and abundance of microplastic pollution on sandy beaches. Gathering data on microplastic pollution can help to inform the management of coastal habitats as well as informing local, national and global advocacy for reduced plastic pollution in the marine environment. By inviting the public to participate in this protocol, it can become a tool to help raise awareness and thus encourage behavioural change that reduces practices which cause microplastic input into the marine environment.

The protocol is based on the recommendations given in the Guidance on Monitoring of Marine Litter in European Seas produced in 2013 by the Technical Subgroup on Marine Litter of the European Commission's Marine Strategy Framework Directive (MSFD). The protocol is compatable with these European monitoring standards so the data collected will be comparable. We have added practical suggestions and detail which will make the protocol accessible to community groups.

The guidelines cover how to select a survey site; the protocol for collecting sand for analysis at the survey site; and how to extract, identify and classify the microplastics present in the sand sample, which can be done at a later date at another location. Lastly, we provide information on how to analyze and best utilize the data you have collected.

2. Scope and purpose of sampling

Before selecting a study site(s) you should define the scope and purpose of your microplastic sampling project. The scope of the project is defined, for our purposes, as how wide an area you want to survey and over how much time. This will determine how many beaches you survey and how many times you survey them. Do you want to investigate the level of microplastic pollution on a single sandy beach or on all the beaches in a town/area or on a representative number of beaches covering a wider coastal region?

If you are looking at a particular coastal area or region, it is recommended to start with a pilot study to test the accessibility and feasibility of surveying possible sites (see section 3). The study sites to represent the region should then be selected randomly within the feasible study sites. There is no recommendation in the MSFD guidelines on the number of sites you should select to represent a particular region, but you will need enough replication in order to account for the variability in the region. For example, a region with high diversity of topography, human activity and currents will need more study sites to represent it than a region with little diversity.

You will need to consider whether you want to undertake a one-off snapshot of the type and abundance of microplastics at your study site(s) or undertake longer-term seasonal or annual monitoring of the microplastic content. Section 4 provides further information on the factors to consider in undertaking ongoing monitoring of microplastics on beaches.

The purpose of your project can be found by answering the question 'Why are we doing this survey?' There may be many reasons for doing your project and you will want to have this firmly in mind before you start. Otherwise, you may find that you have done a lot of work that will not be useful for answering the questions you have.

3. Selecting the survey site

In the above section, we recommended that you define the scope of your activities in terms of the area you want to know about. The size of that area will determine how much you need to sample in order to say something meaningful about that area. For example, if you want to know something about microplastic pollution in a

country, you cannot just go to one beach, nor even just a few. Sampling design is quite a science, but in general, replication is necessary at all levels.

If you want to know about one beach you will need to sample at least two sections (or transects) in case the first one you do is not typical of the whole beach and in order to be able to calculate an average. Two transects should be sufficient for beaches up to 1 km in length.

If you want to know about a wider beach or a larger area, you will need to divide this up into separate survey areas, in each of which you sample at least two transects. That way you can determine the average per survey site and then the average of all the survey sites. For example, if you want to know about microplastic pollution within a marine national park – which has a beach several kilometers long – you will need to sample at several locations (survey sites) along that park as there can be major differences in the way the currents flow and how plastic accumulates in that distance of beach. You can see how this scales up so that in order to say something about microplastic pollution in a country, there need to be many sampling locations, with replication of survey sites, transects, and quadrats (sampling squares) within transects. This is all in order to make sure that what we are finding is representative of the area that we defined in our scope.

Having determined how many survey sites you need, the following criteria should be used to decide which beaches or sections within a wider beach you are going to use as your survey sites:

- The beach should be at least 100m in length.
- There should be a low to moderate slope (15–45°). If possible avoid shallow tidal areas that are wide at low tide.
- There should be clear access to the sea so that microplastic deposition is not affected by man-made structures such as breakwaters or jetties.
- The beach should be accessible safely by the sampling team and, if periodic rather than one-off sampling is to be undertaken, accessible throughout the year.
- The sediment should be suitable for sampling (for example, the sediment particles should be smaller than 1mm and the sediment should not contain a large amount of pebbles, shingle, shells etc).

- Ideally the beach should not be subject to beach cleaning activities. Where beach cleaning does take place, you should find out when this is done and schedule the sampling to be undertaken after high tide but before the beach cleaning takes place.

4. Timing of sampling

If you are intending to undertake periodic monitoring of the microplastic content on your study beach, your sampling should be done at regular intervals so that the accummulation periods are of approximately the same length.

The MSFD guidelines recommend that sampling is done seasonally, four times a year as follows:

- **Winter** – mid December to mid January
- **Spring** – April
- **Summer** – mid June to mid July
- **Autumn** – mid September to mid October

Ideally the sampling of all transects at a study site – and all study sites being surveyed in a particular region – should be undertaken within the shortest period of time possible. This will reduce the variation between transects or sites caused by, for example, changes in sea or weather conditions. We would recommend, if possible, undertaking all sampling within a two week period at each seasonal monitoring point. On beaches which have a high tidal range, sampling should be undertaken about one hour after high tide.

You may also notice a difference in the characteristics of the sand at certain times of the day, for example the sand may be drier or more disturbed by human activity in the afternoon than in the morning. So on beaches where it is very hot in the middle of the day or with high human activity it is advised to sample in the morning. Where possible schedule your sampling so that it occurs at a similar time of day at your sites so that you reduce variation between your samples caused by these other factors.

5. Health and safety on the beach

As there are natural hazards on a beach, it is always important to undertake a risk assessment of your sampling activity as part of your preparation before going to the beach.

There are a number of health and safety considerations that need to be taken into account when undertaking fieldwork on the beach. In particular:

- When selecting your survey site, ensure that the site is easily accessible by the sampling team and throughout the year if periodic sampling is to be undertaken
- You should be aware of the tide times and patterns on the beach where you are working and undertake your sampling after high tide
- It is good fieldwork practice for there to be at least two people on the sampling team, particularly when sampling is being undertaken on remote beaches
- Take care when lifting buckets of sand or water as they can be heavy – do not overfill them beyond your capacity to lift
- Avoid working in the midday sun
- Take plenty of water with you
- If it is hot make sure you have adequate protection from the sun (sunscreen, sunglasses, sunhat, long-sleeved clothes to cover up, sun-shade/ umbrella/tent)
- If it is cold make sure you have adequate layers of clothing and waterproofs
- Take towels/change of clothes in case you get very wet
- Always take a first aid kit with you

6. Selecting the transects

Once a study site is selected and you are fully prepared for your sampling, the particular sections to be surveyed within that site can be identified. Two sections – or transects – should be used for each study site. The transects should be 100m in length on beaches that have a light or moderate amount of plastic pollution or 50m in length on beaches that have a heavier amount of plastic pollution. The transects

should be placed along the high tide line (or strandline), positioned at least 50m apart, and placed in parts of the beach that are representative of the whole site (in terms of beach material, topography, extent of pollution/organic matter etc).

From your starting point, the 100m transect can be measured using a measuring or surveyor's tape. If you have a 100m tape and placing the tape will not interfere with the activities of other beach users, you can mark out the entire transect. If you have a smaller tape (for example 30m) you can measure the transect in sections (marking out the position of the first quadrat and then measuring from this point to the position of the second quadrat).

Permanent reference points should be used to identify the start and end points of each transect. If possible you should record the GPS co-ordinates of the start and end points. Where this is not possible, aligning the transect with permanent landmarks in the landscape can be used to identify the start and end points. It is important to know the position of your transects so that, if you are undertaking periodic monitoring on a beach, you can return to the same transect position (as near as possible) for each monitoring survey.

7. Positioning the quadrats

It is recommended that five replicate samples of sand are collected from each transect. This should be done by collecting sand from five 50x50cm quadrats (sampling squares) that are positioned randomly along the 100m transect (see Figure 1).

To determine the random numbers to position the quadrats you can use a random number generator on a calculator to generate five numbers between 1 and 100. Another alternative is to use a random number generator on a computer to generate the random numbers before going to the field. If the numbers generated are 64, 02, 24, 54 and 91, your quadrats should be placed at 2m, 24m, 54m, 64m and 91m along the transect.

The MSFD guidelines recommend that the quadrats should be placed at least 5m apart from each other. So if two of your random positions are closer than this, generate an additional random number so that your quadrats are positioned at least 5m apart.

Figure 1: A quadrat on a 100m transect running along a broad strandline

8. Collection method

This collection method works best if there are three or four people on the sampling team. In our experience it takes about 30 minutes to one hour to collect and sieve the sand from one quadrat. The length of time will depend on the number of people on your sampling team and the amount of other material (such as pebbles, shells and organic matter) mixed in with the sand as this will increase the time it takes to sieve the sand. So it may take you approximately half a day to complete one transect containing five quadrats.

A checklist of the equipment you will need is provided in Appendix 1. Where possible all items used should be made of metal or glass rather than plastic to avoid contamination. It is also a good idea to keep your sampling equipment in a storage box or on a cotton towel on the beach so that the items do not get covered in sand.

8.1 Preparing filtered seawater

You will need to prepare some filtered seawater to use to wash the sand through the sieves. As there may be microplastic particles floating in the seawater, these particles have to be filtered out so that they do not contaminate your sand sample.

Firstly collect sea water in buckets. Pour the seawater through a 100–300µm plastic mesh into a clean bucket or other container (see Figure 2). After filtering the water, if possible cover the bucket containing the clean seawater so that it does not become contaminated with airborne plastic fibres (even if it is not windy, small fibres can still be present in the air).

Figure 2: Filtering the seawater through a 100µm mesh

You can use various designs for your water filter to suit the equipment you have available (see Figure 3). For example, you can (1) tie or glue the mesh on to the end of a plastic tube, (2) fix the mesh to a square rigid frame that you can place over the top of the bucket, or (3) cut a circle of mesh and bind elastic or tie string around the edge so that it fits over the top of the bucket like a shower cap.

Figure 3: Different types of mesh water filters

Whichever model you use, it is important to know which is the 'clean' and 'dirty' side of your filter so that you are always pouring the seawater into the filter from the same direction and collecting any contaminating microplastics on the dirty side of the filter.

If there are enough people on the sampling team, one person can be preparing the filtered water so that there is a constant supply of this while the other members of the team are sieving the sand.

8.2 Collecting the sand

Tent pegs or other markers should be used to mark the random positions along the transect at which the sand samples are to be collected. The 50x50cm quadrat should be placed at the appropriate position on the transect, with the edge of the quadrat aligned with the marker so that the sampling square begins at that marker position (see Figure 4).

Figure 4: Collecting the sand sample

The MSFD guidelines recommend that sand should be collected to a depth of 5cm. This depth can be measured using a metal ruler. The sand can be collected using a metal trowel or spoon (again avoid using plastic items). The sand should be put into a clean bucket.

To avoid contamination of the sample by fibres released from the clothing of the sampling team, where possible the person doing the sand collection should place themselves downwind of the sampling square.

Here are some other problems you may encounter in collecting your sand samples and some suggested solutions:

- If it is a windy day and the sand is dry, we recommend erecting a windbreak that prevents sand blowing along the beach and into the quadrat while you are collecting the sample. To help with digging the dry sand, you could also try pouring filtered seawater gently over the sample area before digging.

- If the sand is very disturbed by human activity or undulating because of wave action, measure the 5cm depth from what appears to be the level surface, not the peaks or troughs in the sand.
- To help you dig consistently to 5cm across the quadrat it can be helpful to dig a 5cm deep trowel-width trench along two sides of the quadrat first (forming an L shape) and then dig down across the rest of the quadrat to this level.
- If the sand contains larger items such as pebbles, shells, wood or seaweed, we recommend you place these items in the sieve and wash them with filtered seawater so that any microplastics attached to them are washed into the sieve and not discarded. We have found that filaments in particular can become entwined around other objects such as wood or seaweed. Inspect the surface of these larger items after washing (with the aid of a magnifying glass if you have one) before discarding to ensure that all microplastics have been washed off.
- Where there is a tidal range, schedule your sampling one hour after high tide so that the rising tide will not enter your quadrats. If there is little tidal range, ensure that the positioning of your quadrats is as near to the strandline as possible but far enough from the edge of the water to prevent the water entering the quadrats.
- You may find your sampling gets interrupted by other beach users who are interested to know what you are doing. So give yourself sufficient time to undertake the sampling and allow for unexpected events or interruptions. Working on the beach provides a good opportunity to raise awareness of the problem of microplastic pollution and to encourage beach users to take an interest in the health of their beach. On busy beaches it is helpful to have enough people on the sampling team so that some members can explain what you are doing to other beach users and answer questions while other members of the team continue with the sampling activity. A Rocha has produced a factsheet (www.arocha.org/microplastics-factsheet) about microplastics that you can download and laminate and use on the beach when talking to the public about what you are doing.
- Remember to record in your survey site questionnaire anything that you observe or that occurs during your sample collection that might affect the microplastic content of your samples.

Collecting the sand using the quadrat approach will enable you to calculate the number of microplastic items present per quadrat or per 0.25m^2 (0.5x0.5m, the area of the quadrat). You can also calculate the volume of the sand collected from the quadrat. This will enable you to calculate the number of microplastic items present per litre of sand. You can calculate the volume if you know the volume of your bucket or collection container or by decanting the sand into another clean bucket using a measuring jug.

It is possible to weigh the sand so that you can calculate the number of microplastic items present per kg of sand. However, for your results to be consistent you need to weigh the sand when it is dry rather than wet as your sand samples may contain differing amounts of water which will affect their weight. To calculate the dry weight you will need to remove your sand samples from the beach and dry the sand before weighing it.

8.3 Sieving the sand

The sand collected should be sieved to collect all items in the sand that are between 1 and 5mm in size. This is done by placing a sieve with a 5mm mesh on top of a sieve with a 1mm mesh (see Figure 5).

Using the trowel or spoon, place the sand into the 5mm sieve and wash the sand through the sieve using the filtered seawater. All items larger than 5mm will remain in the top sieve (and can be discarded periodically having been well washed with filtered seawater and inspected for any microplastics, particularly fibres or films, that may have stuck to them). Items between 1 and 5mm will pass through the 5mm sieve but remain on top of the 1mm sieve. Items smaller than 1mm, including all the sand, will pass through the 1mm sieve and can be discarded.

We have used metal laboratory test sieves, but it is possible to construct a more basic sieve using plastic mesh of the appropriate size fixed to a wooden frame. For an example, see the sieve being used in a citizen science project being run with schoolchildren in Chile (described in Eastman *et al* (2014) in the Further Reading). If you want to speed up the sieving process you can use two sets of sieves.

If you are sampling on a beach with a large tidal range where the strandline is some distance from the water's edge, you may want to carry your sand sample nearer to

the water's edge and do the sieving there as this will reduce the distance you have to carry the seawater.

Figure 5: Sieving the sand through 5 and 1mm sieves – items between 1 and 5mm in size will accumulate on the surface of the bottom 1mm sieve

8.4 Collecting items between 1 and 5mm in size

Either when all of the sand has been sieved – or when there are a lot of items on top of the 1mm sieve which makes washing the sand through the sieve very slow – use a metal spoon to transfer the items from the sieve into a glass jar for storage and transport (see Figure 6).

The jar should be labelled with the study site, date, transect number and quadrat number so that when you come to separate out the microplastics at a later date you will know exactly where they have come from.

Section 12 describes how to separate out the microplastics from your sample of 1 to 5mm sized items. This can be done away from the survey site and at a later date.

However, if there is a lot of organic matter in your sample, we would recommend that you extract the microplastics with a few days of collecting your sample as otherwise the organic matter will rot and your sample will start to smell.

Figure 6: Collecting all the 1 to 5mm sized items from the surface of the 1mm sieve for subsequent separation of the microplastics from the other items

9. Precautions to minimize contamination of your samples

Whilst on the beach, adopting the following measures will help to minimize contamination of your sample by microplastics that have not come from the sand you have collected:

- Avoid the use of plastic and use metal buckets/trowels/spoons and glass storage jars. These should be clean and kept in storage bags before use.
- Keep all buckets and jars covered with lids or aluminium foil to prevent microplastic fibres blowing into the containers.

- Keep all your sampling equipment as sand-free as possible by placing it in a box or on a towel when not in use.
- The sampling team should wear garments made of natural fibres rather than synthetic clothing such as fleeces which easily shed synthetic fibres.
- The person collecting the sand should be positioned downwind of the quadrat.
- Avoid transferring your samples between containers more than you need to as every time your sample is transferred from one container to another there is the risk of contamination from external microplastics.

10. Recording the characteristics of the survey site and the sampling conditions

Appendix 2 lists the details about your survey site and the sampling you have done that you may want to you record. In particular you should record anything that you notice that you believe may have affected the microplastic content of your samples. These might include weather conditions, sea conditions, beach cleaning activities, human activities on the beach that may have disturbed the sand, together with any obvious local sources of microplastics such as cafes on the beach, fishing or shipping activity, nearby industry, etc. Any larger plastic items that you find on the beach or are being discarded nearby have the potential to break down into smaller fragments. You can also record any other evidence of or possible sources of non-plastic pollution in the locality.

11. After sampling

When you have finished sampling on the beach, make sure that you take all your equipment away with you and that you do not leave any rubbish on the beach.

Wash all your sampling equipment, particularly the metal items, in freshwater and dry them before storage to remove any salt residue and prevent rusting.

12. Separating the microplastics from the other 1 to 5mm items

Sections 3 to 11 of this protocol have described the collection of the sand samples from your survey site. The following sections describe how to separate out the microplastics from the other items of a similar size and classify and record the microplastics. This can be undertaken at a later date and at a different location away from the beach. A checklist of the equipment you will need for this stage of the protocol is given in Appendix 3.

The 1 to 5 mm items that you have sieved from the sand will contain a mixture of material – fragments of rock, shell, glass and organic matter – as well as microplastics. To extract the microplastics from this sample, carefully transfer the contents into a glass serving dish containing filtered seawater or a salt water solution made of one heaped tablespoon of salt dissolved in 1L of tap water (see Figure 7). This gives a salt concentration of approximately 35g/L, the same as the salt concentration of seawater.

Figure 7: The 1 to 5mm items sieved from the sand being mixed with seawater

Most microplastics will float as they are a lighter density than the salt water (see Figure 8).

Figure 8: Microplastics floating on the surface of the seawater

Here are some other tips which will help you identify which items are microplastics:

- the microplastics will be attracted to the sides of the glass dish and so will often be found along the edge where the water meets the glass
- if you put a metal item into the water (such as tweezers or forceps), the microplastics will move towards the metal item
- place the dish over both a white and a black background as darker or lighter microplastics will show up more easily against a contrasting background
- shine a torch or other light source over the surface of the water as this will light up transparent microplastics such as films that can otherwise be difficult to see
- aggitate the material at the bottom of the dish to release any microplastics that are underneath or attached to other items

- if there is any organic matter in the sample such as wood or seaweed the microplastics may be attached to this
- items that appear to have a cellular structure when viewed under the microscope are likely to be organic and not plastic
- items that disintegrate or shatter easily when prodded are unlikely to be plastic
- plastic items will feel smooth when the surface is scraped with a metal tool and have a very different texture to the ridged surface of shells
- refer to a microplastic photo guide to help with identification and, as you become familiar with the types of microplastic present at your study site, you can compile your own photo guide

You can use a magnifying glass to help you with identification. Alternatively, put the items you think may be microplastics into some salt water in a petri or other small dish and view their structure and behaviour under a dissecting microscope (see Figure 9) or a digital microscope.

Figure 9: Viewing potential microplastics under the microscope

As you identify and record the microplastics you have found (see next section), transfer them into a small glass labelled container for storage.

As on the beach, be aware of the potential for contamination of your sample at this stage. Where possible, keep the glass dish and other sample containers covered with lids or aluminium foil when not in use. In addition, be aware of the colour of any potential sources of contaminating microplastics such as any plastic sampling equipment you have used or synthetic clothes worn by the sampling team so that you can identify and remove any contaminating fragments or fibres that have come from these sources.

13. Classifying and recording the microplastics

The MSFD guidelines recommend that counts of the number of microplastic items found are used rather than trying to work out the weight or volume of the microplastics. It is easiest to record the microplastics one by one as you take them out of your sample of 1 to 5mm items.

This is the information we record for each microplastic item:

- transect number
- quadrat number
- type of microplastic (see below)
- size (the dimensions or the diameter for spherical items)
- colour
- photo number (if a photo is taken of the item)
- any additional observations about the item (for example, if it is found in association with other items, colonized by algae, covered in oil or charcoal particles etc)

An example data sheet for recording this information is given in Appendix 4.

We classify the microplastics into the following categories:

- **Filament** – single or multiple twisted/woven fibres, often derived from clothing or fishing nets

- **Film** – thin, flexible pieces of plastic, often transparent in colour, often derived from polythene bags or food packaging
- **Foam** – usually white and spongy, originates from polystyrene packaging or disposable cups
- **Fragment** – hard angular pieces of plastic formed from the degradation of larger plastic items
- **Pellet** – the raw material from which plastic items are made, they have a distinctive cylindrical, disc- or lentil-like shape and are mostly white or transparent (although other colours are found)
- **Other** – examples of other types of plastic can include spherical granules and other small moulded plastic pieces

These are the categories of microplastic that are commonly recorded. However, you can classify your microplastic items in much greater detail (see the Master List of Categories of Litter Items on page 120 of the MSFD guidelines). You may want to define your own categories that reflect the particular types of microplastic that you are finding at your survey site. For example, you can separate out clothing fibres from fishing net fibres as the advocacy and conservation actions required to combat these types of microplastic fibres are very different. In general, we would recommend that you record more rather than fewer types as you can always amalgamate two or more types into a single category in your subsequent analysis.

To help you identify the microplastics you have found we have provided photographs of the different types in the Photo Guide in Appendix 5. We recommend that you take photos of the microplastics you are finding at your survey site so that you can compile your own photo guide which will help with future identification and training new members of the sampling team. You can also photograph any items that you are unsure about so that you can study them again later or consult with others.

Another alternative is to maintain a microplastic sample library, keeping good examples of different types of microplastic in glass sample jars that can be used as a reference for future identification sessions.

It is also useful to record and photograph any other items of interest in your sample that are evidence of other types of pollution at your survey site. Examples of this might include pieces of coal, charcoal, oil, rubber, paraffin/wax, metal etc.

14. Analysis of your microplastic data

Once you have identified all the microplastics present in the samples obtained from your survey site and completed the data sheets, you can enter the data into a spreadsheet. From this you can calculate:

- the average number and proportion of each type, colour and size of microplastic found per quadrat, transect, survey site or wider beach/area
- as you know the dimensions of your quadrat you can also calculate the average number and proportion of different types of microplastic found per m^2
- if during your sampling you have recorded the volume of the sand collected in each quadrat you can also calculate the number and percentage of different types of microplastic found per litre of wet sediment

In analyzing your microplastic data you should relate the analysis back to the purpose of your study. What answers does the data provide to the questions you wanted to address in your study?

Measuring the abundance of microplastics by type, size and colour can enable you to establish which types of microplastic pollution are most common at your survey site. If you undertake sampling at more than one site you can compare the level of microplastic pollution across your sampling sites and assess the variability in microplastic deposition across a wider beach or area.

There are standard statistical procedures for analyzing statistically this type of data. However, their description is beyond the scope of this manual. If you have not received training in statistics, you can seek out the help of an ecologist who will be able to help you using freely available online computer programmes. Basic graphs of the average number of microplastic types, colours or totals can be plotted by survey site in order to determine any major differences in average microplastic pollution for an area.

Appendix 6 provides some examples of how you can summarize and display the data you have gathered on the types of microplastics you have found.

15. What to do with your microplastic data

Gathering data on the microplastic content of the beaches in your survey area is useful as it provides baseline data on the type and abundance of microplastic pollution in your region. Collecting the data using a protocol that follows the MSFD recommendations will enable your results to be compared with those of other studies based on these European monitoring standards.

This baseline data on microplastic pollution can be used to help:

- compile a picture of the extent of microplastic pollution locally, nationally and globally
- identify coastal habitats that may be affected by microplastic pollution
- identify particular species within those habitats that may be at risk from ingesting microplastics of a particular size/colour or through the food chain
- identify possible local sources of microplastic pollution
- raise awareness among local communities of the problem of microplastic pollution
- inform local advocacy for reduced microplastic input into the marine environment
- prioritize advocacy and awareness-raising activities according to which type of microplastic pollution are most common

What you do with the microplastic data you have gathered will depend upon the purpose of your survey. You may be already undertaking the survey for or in collaboration with a conservation or environmental organization that is interested in your results. However, we would encourage you to think creatively and positively about how you can use and disseminate any information on microplastic pollution that you have discovered. The particular conservation, advocacy and awareness-raising actions that follow on from the data will be influenced by the types of microplastics which you most find on the beach. Please refer to the A Rocha Microplastics Toolbox (www.arocha.org/microplastics-toolbox) for information about organizations collecting data and undertaking advocacy on microplastics.

Please get in contact with us (international@arocha.org) to let us know if you have used this protocol or have any feedback.

Appendix 1: Checklist of equipment for sampling on the beach

Metal buckets (2 for collecting sand, 2–4 for filtering seawater)
Water filters
GPS tracker
Measuring or surveyor's tape (30–100m)
Tent pegs or other markers
Quadrat 50x50cm
Metal trowel
Metal ruler (15 cm)
Metal sieve with 5mm mesh
Metal sieve with 1mm mesh
Tweezers/forceps
Wooden cocktail sticks
Metal tablespoon
Magnifying glass
Glass storage jars with lids
Permanent marker
Labels for glass storage jars
Clipboard
Survey site questionnaire
Cotton towel
Windbreak
Drinking water
Sunscreen
First aid kit
Bag for any rubbish

To explain microplastic sampling work to other beach users:

Laminated microplastics factsheets (or paper copies to hand out to beach users)
Glass jar containing example microplastics
Metal tray to display example microplastics

Appendix 2: Example survey site questionnaire

This example survey site questionnaire gives you some suggestions for the type of information you can collect about your microplastic sampling and your survey site. The questionnaire is based on the Marine Litter Beach Questionnaire from the OSPAR Commission's Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area.

Name of beach:

Details of microplastic sampling

	Transect 1	Transect 2
Date sampling undertaken		
Sampling start time		
Sampling end time		
GPS co-ordinates start 100m		
GPS co-ordinates end 100m		
Position of quadrat 1 from start (m)		
Position of quadrat 2 from start (m)		
Position of quadrat 3 from start (m)		
Position of quadrat 4 from start (m)		
Position of quadrat 5 from start (m)		

Weather conditions:
(for example recent rainfall, wind direction and strength)

Sand conditions:
(for example wet, dry, coarse, fine)

Any factors affecting sampling:
(for example disturbance of sand by human activities/beach cleaning, wind blowing sand, water entering quadrat, seaweed or other organic matter on beach)

Description of beach

Approximate length of beach:

Approximate width of beach (from the strandline to the back of beach):

What is at the back of the beach:
(for example dunes, grass, car park, houses, shops)

When you look from the beach to the sea, what direction is the beach facing:
☐ N ☐ E ☐ S ☐ W

Prevailing currents off the beach: ☐ N ☐ E ☐ S ☐ W

Prevailing winds: ☐ N ☐ E ☐ S ☐ W

Type of beach material and percentage coverage:
(for example sand 80%, pebbles 20%)

Beach topography:
(for example 20% slope)

Are there any objects in the sea (for example pier, harbour wall, breakwater) that influence the currents:

Major beach usage:
(local people, swimming/sunbathing, fishing, surfing, sailing etc)

Type of usage	Months when it occurs

Potential sources of microplastic pollution

What are the nearest population centres to the beach:
(please give name, type, population size and distance from beach)

Is there any development behind the beach: ☐ No ☐ Yes, please describe:

Are there any food/drink outlets on the beach: ☐ No ☐ Yes, please describe:

What is the distance from the beach to the nearest harbour:
Name of harbour:
Type and size of harbour:
Position of harbour in relation to survey area: ☐ N ☐ E ☐ S ☐ W

What is the distance from the beach to the nearest shipping lane:
What type of boats use the shipping lane:
Position of shipping lane in relation to survey area: ☐ N ☐ E ☐ S ☐ W

Are there any industrial areas near the survey area: ☐ No ☐ Yes, please describe:

What is the distance from the survey area to the industrial area:
Position of industrial areas in relation to survey area: ☐ N ☐ E ☐ S ☐ W

What is the distance from the survey area to the nearest river mouth:
Name of river:
Position of river mouth in relation to survey area: ☐ N ☐ E ☐ S ☐ W

Is the beach located near a wastewater discharge: ☐ No ☐ Yes, please describe:

Distance from the survey area to the discharge point:
Position of wastewater discharge in relation to survey area: ☐ N ☐ E ☐ S ☐ W

Other kinds of pollution found on the beach:
(macroplastics, glass, metal)

Beach cleaning activity

How often is the beach cleaned:

All year round: ☐ Daily ☐ Weekly ☐ Monthly ☐ Other: .....

Seasonal, please specify months: .....

☐ Daily ☐ Weekly ☐ Monthly ☐ Other: .....

What method is used: ☐ Manual ☐ Mechanical

Appendix 3: Checklist of equipment for identifying and classifying microplastics

Glass serving dish
Sodium chloride
Black and white paper/card against which to view the sample dish
Torch or other light source
Magnifying glass
Tweezers/forceps
Teasing needles
Wooden cocktail sticks
Glass petri dishes
Dissecting microscope or digital microscope
Ruler
Small glass storage jars
Labels
Permanent marker
Microplastics photo guide
Data sheet
Camera

Appendix 4: Example microplastics data sheet

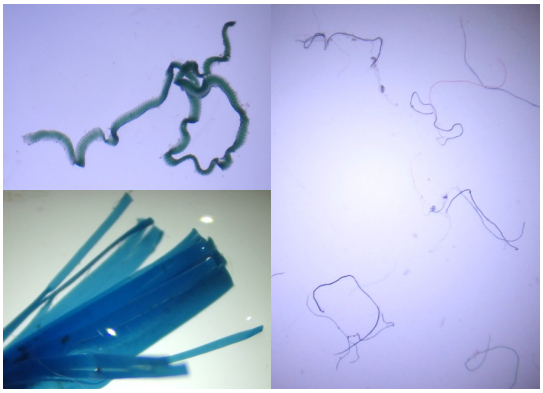
Survey site:
Date:
Transect number: 1

Quadrat	Type	Size (mm)	Colour	Comments
1	Pellet	3	Red	Photo 10152
	Pellet	2.5	Yellow	
	Foam	2	White	Photo 10153, dirty/covered in black
	Fragment	5 x 2	Blue	Photo 10154
	Fragment	4 x 2	White	
	Pellet	4	White	
	Filament	2 x 0.25	Blue	
	Pellet	3.5	White	
	Wax	4 x 3.5	White	For info, photo 10155
	Iron	2.5 x 2.5	Brown	For info, photo 10156
Total MPs	8			
2	Fragment	3	White	
	Fragment	4 x 1	Pink	Photo 10157
	Film	5 x 4	Transparent	Photo 10158, covered in algae
	Filament	4 x 0.5	Green	Photo 10159, fishing net
	Foam	2	White	
	Fragment	2 x 3.5	Blue	
	Foam	3	White	
	Filament	5 x 0.5	Green	Fishing net
	Film	4 x 3.5	Transparent	
	Fragment	2	Yellow	Photo 10160
	Foam	2	White	
	Coal	5 x 2.5	Black	For info
Total MPs	11			

Appendix 5: Microplastics photo guide

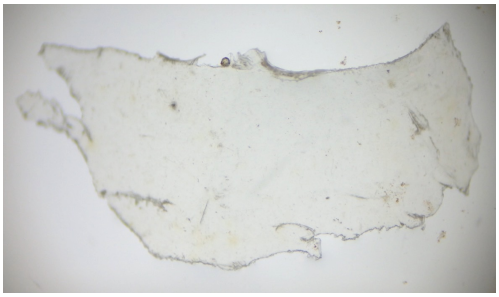
Filaments

Single or multiple fibres



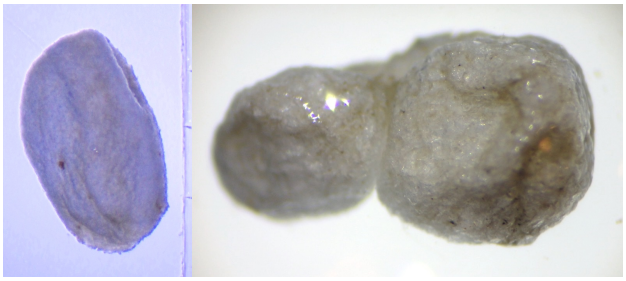
Films

Thin, flexible pieces of plastic
Often transparent



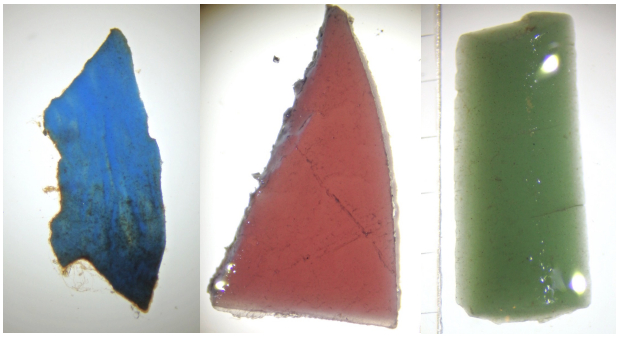
Foam

White and spongy, often spherical
Occur singly or stuck together



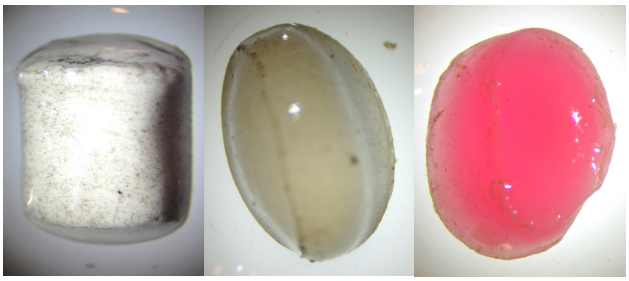
Fragments

Hard, angular pieces of plastic
Formed by breakage of larger plastics



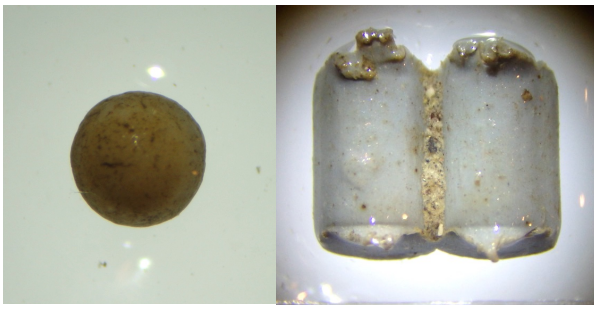
Pellets

Cylindrical, disc- or lentil-shaped
Mostly white or transparent but can also be coloured



Other

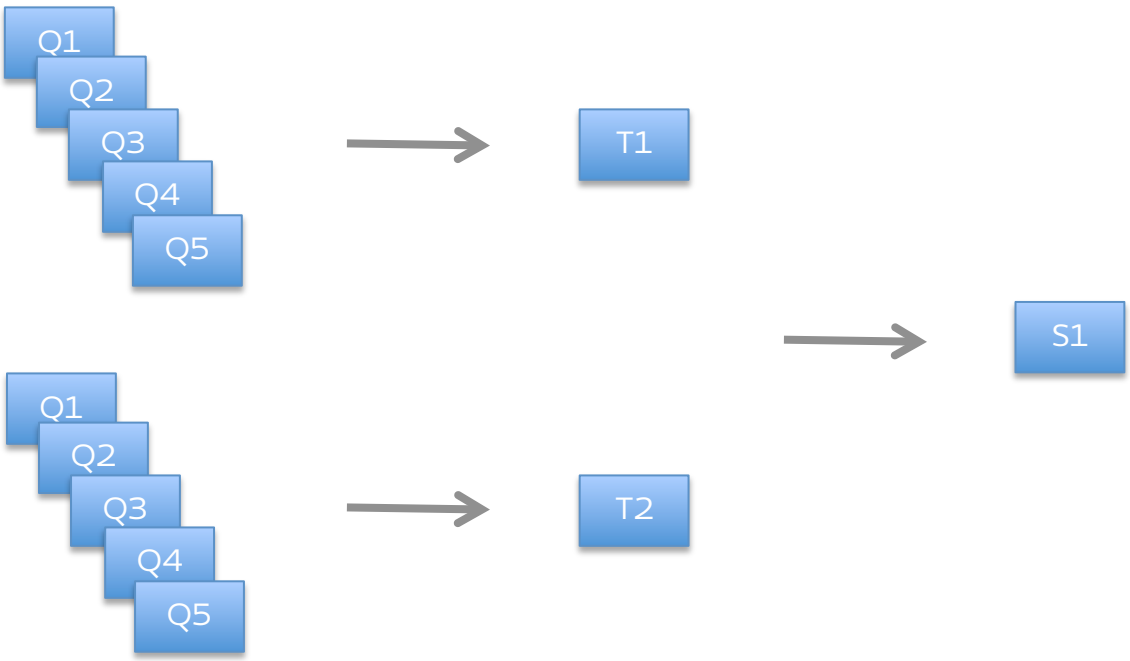
Other pieces can include spherical granules or 'micro' sized plastics manufactured between 1 and 5mm



Appendix 6: Example analysis of microplastics data

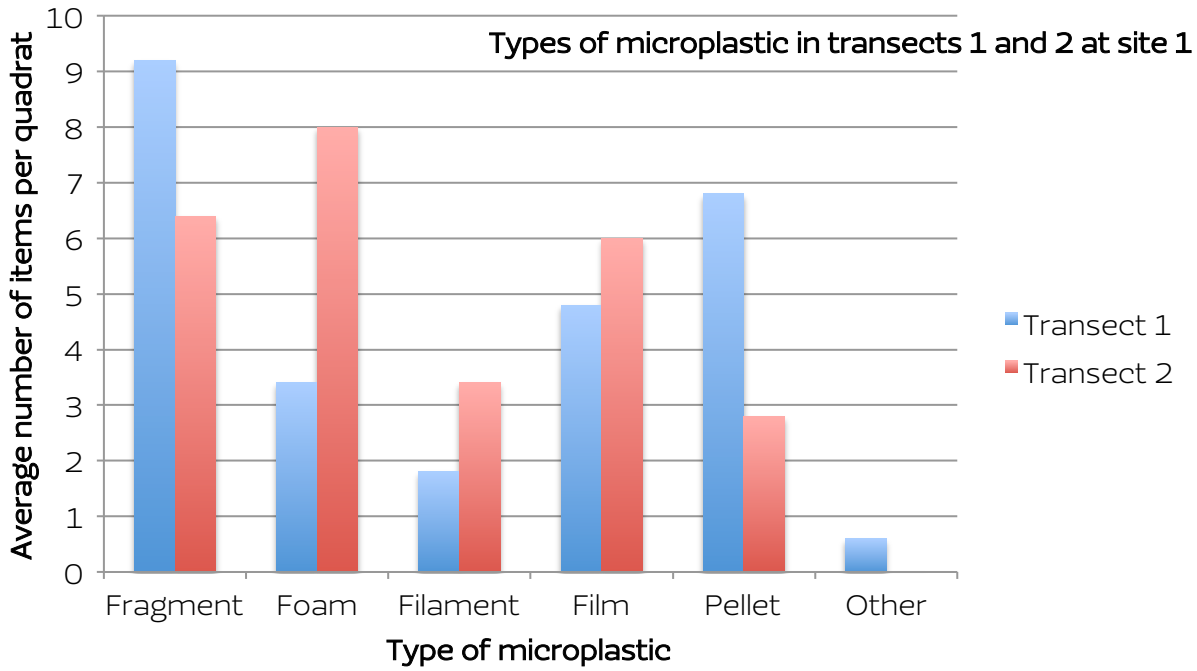
Name of survey site	Site 1									
Transect number	Transect 1					Transect 2				
Quadrat number	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
Number of items/quadrat:										
Fragment	7	10	13	13	3	5	6	4	8	9
Foam	3	2	5	4	3	4	8	10	5	13
Filament	0	2	1	4	2	3	1	4	5	4
Film	5	2	4	6	7	4	6	7	5	8
Pellet	6	3	7	6	12	2	1	5	3	3
Other – granule	0	0	2	1	0	0	0	0	0	0
Total	21	19	32	34	27	18	22	30	26	37

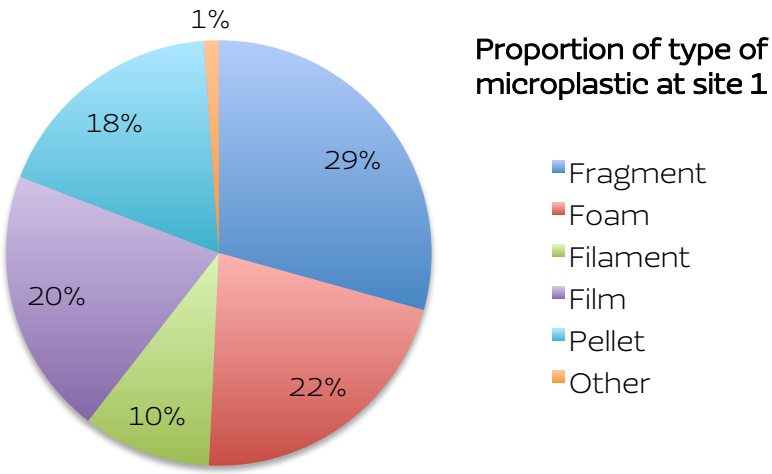
From the number of items of each type of microplastic per quadrat you can calculate the average number and proportion of each type of microplastic for each transect and for the survey site as a whole, as demonstrated in the following diagram:



The average number or proportion of each type of microplastic can be presented in a table, bar chart or pie chart as follows:

Type of microplastic:	Average number per quadrat for:			Proportion for Site 1 (%)
	Transect 1	Transect 2	Site 1	
Fragment	9.2	6.4	7.8	29.3
Foam	3.4	8.0	5.7	21.4
Filament	1.8	3.4	2.6	9.8
Film	4.8	6.0	5.4	20.3
Pellet	6.8	2.8	4.8	18.0
Other – granule	0.6	0.0	0.3	1.1





Appendix 7: Other activities that can be undertaken on the beach alongside microplastic sampling

Nurdle hunt

Plastic pellets are the raw materials from which plastic items are produced. These are frequently washed up on beaches and organizations such as the Scottish environmental charity FIDRA (www.fidra.org.uk) are recording the extent of this type of microplastic pollution on beaches.

You can see how many plastic pellets you can find on your beach in a given period of time (this can be as short as 15 minutes) and then submit your findings to FIDRA's **Great Nurdle Hunt** (www.nurdlehunt.org.uk).

Beach clean-up

Take plastic rubbish bags and gloves with you to the beach so that you can clean up macroplastic debris on your beach at the same time as undertaking your microplastic survey. There is further information about how to do a beach clean up in the A Rocha Microplastics Toolbox – see www.arocha.org/clean-up-guide.

Macroplastic sampling

There are several protocols available to enable you to undertake a survey of the type of macroplastic debris found at your survey sites:

The **OSPAR Commission** (www.ospar.org), which works to protect the marine environment in the North East Atlantic, has produced guidelines for monitoring marine litter on beaches. This can be used to sample macroplastic debris along a 100m stretch of beach. The guidelines can be downloaded from the OSPAR website (www.ospar.org/documents?v=7260). The guidelines contain a useful macroplastic photo guide, survey site questionnaire and marine litter reporting form.

Marine LitterWatch has been set up by the European Environment Agency and enables you to undertake a survey of the macroplastic debris at your survey site and report your findings using a mobile app (available for Android and iOS). Please go to

the Marine LitterWatch website for more information about how to download and use the app (www.eea.europa.eu/themes/coast_sea/marine-litterwatch).

Microplastic pollution awareness-raising activities

If you feel able to, engage local beach-users in discussions about what you are doing on the beach and why. The factsheet available in the Toolbox can be taken to the survey site during sampling to distribute and/or aid discussions with beach users. You can also use the microplastics questionnaire in the Toolbox as a starting point for discussions. Encouraging the public to hold the sieves, look at the samples and see how many microplastics are present in the sand can give them a memorable experience which could influence how they react to the problem of microplastics in the future.

Factsheet: www.arocha.org/microplastics-factsheet

Questionnaire: www.arocha.org/wp-content/uploads/2018/01/microplastics-questionnaire.pdf

The Microplastics Toolbox

Information on other plastic pollution citizen science projects and organizations that arrange clean-up events can be found in the A Rocha Microplastics Toolbox - www.arocha.org/microplastics-toolbox.

Appendix 8: Further reading

Citizen science projects

Eastman L, Hidalgo-Ruz V, Macaya-Caquilpán V, Nuñez P & Thiel M (2014) The potential for young citizen science projects: A case study of Chilean schoolchildren collecting data on marine litter, Journal of Integrated Coastal Zone Management 14: 569-579

Hidalgo-Ruz V & Thiel M (2013) Distribution and abundance of small plastic debris on beaches in the SE Pacific (Chile): A study supported by a citizen science project, Marine Environmental Research 87-88: 12-18

Examples of projects sampling microplastics on sandy beaches

Baztan J, Carrasco A, Chouinard O, Cleaud M, Gabaldon JE, Huck T, Jaffrès L, Jorgensen B, Miguelez A, Palliard C & Vanderlinden J-P (2014) Protected areas in the Atlantic facing the hazards of micro-plastic pollution: First diagnosis of three islands in the Canary Current, Marine Pollution Bulletin 80: 302-311

Besley A, Vijver MG, Behrens P & Bosker T (2017) A standardized method for sampling and extraction methods for quantifying microplastics in beach sand, Marine Pollution Bulletin 114: 77-83

Dekiff JH, Remy D, Klasmeier J & Fries E (2014) Occurrence and spatial distribution of microplastics in sediments from Norderney, Environmental Pollution 186: 248-256

Microplastics in the marine environment

Crawford CB & Quinn B (2017) 'Microplastics, standardisation and spatial distribution' in Crawford CB & Quinn B Microplastic Pollutants, Elsevier, 101-130

Cole M, Lindeque P, Halsband C & Galloway TS (2011) Microplastics as contaminants in the marine environment: A review, Marine Pollution Bulletin 62: 2588-2597

Deudero S & Alomar C (2015) Mediterranean marine biodiversity under threat: Reviewing influence of marine litter on species, Marine Pollution Bulletin 98: 58–68

Ivar do Sul JA & Costa MF (2014) The present and future of microplastic pollution in the marine environment, Environmental Pollution 185: 352–364

Lusher A (2015) 'Microplastics in the marine environment: Distribution, interactions and effects' in Bergmann M *et al* (eds) Marine Anthropogenic Litter, Springer, 245–307

Wright SL, Thompson RC & Galloway TS (2013) The physical impacts of microplastics on marine organisms: A review, Environmental Pollution 178: 483–492

Monitoring marine litter

MSFD (2013) Guidance on Monitoring of Marine Litter in European Seas, Final Report of the Marine Strategy Framework Directive Technical Subgroup on Marine Litter, European Commission Joint Research Centre

OSPAR (2010) Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area, OSPAR Commission

Sampling methods

Hidalgo-Ruz V, Gutow L, Thompson RC & Thiel M (2012) Microplastics in the marine environment: A review of the methods used for identification and quantification, Environmental Science & Technology 46: 3060–3075

A more extensive microplastics bibliography is available in the A Rocha Microplastics Toolbox – see www.arocha.org/wp-content/uploads/2018/01/Microplastics-bibliography.pdf.