MICROPLASTICS IN SEABED SEDIMENTS FROM THE IRISH SEA CATCHMENT

Science aboard the Asguard Armada Voyage. July 2022

Leanne Hughes
Lean1@bgs.ac.uk

Foreword

This report summarises the science related activities undertaken on TS Pelican of London for the Scientist in Residence program with Seas Your Future. The voyage took place between the 18th and 27th July 2022. The voyage covered a total distance of 520 nm with most of these under sail. The aim of the science project was twofold. Firstly, to trial out the ships new sediment grabber to understand the variability of seabed sediments within the catchment of the Irish Sea. Secondly to engage young voyage crew (age 13-17) in earth science related activities and understand how their thoughts and opinions of the human impact on the environment evolves throughout the voyage. Sediment samples collected during the voyage were also logged and submitted to the British Geological Survey offshore grab sample database.

Acknowledgements

Data contained in this report were recorded during a collaborative voyage involving young people from Sail Training Ireland and volunteers on TS Pelican. The main contribution to the project was made by Seas Your Future who made available a berth on the vessel for a scientist and purchased the science equipment used onboard. Thanks also to the officers and crew of TS Pelican for their professionalism, flexibility and welcome onboard.

Contents

Foreword 1
Acknowledgements 1
Summary 3
Introduction 4
Method 6
Data and observations 7
Conclusion 8
References 9
Appendix 1 – Ships Personnel 11
Appendix 2 - Grab samples 11
Appendix 3 – Instructions for Ekman grabber deployment 12

Summary

The aims of the Scientist in Residence programme are to integrate scientific research into the day-to-day activities of a sail training vessel. The Scientist in Residence undertakes a project onboard, which may relate to data collection, or a personal project. They involve the young people who are interested in science and talk about what they are doing for their project. The Asguard Armada voyage was due to traverse the Irish sea and visit several inshore anchorages shallow enough to obtain sediment grab samples. The voyage collected grab samples from 4 locations and the young people systematically screened the samples for microplastics. The program also tested the deployment of the Ekman sediment grab being the first 'in-voyage' test for the recently acquired equipment and so providing a 'proof of concept' for the project.

Introduction

The objectives of the voyage onboard TS Pelican were to test the capability of the Ekman sediment grabber and to contribute offshore data to organisations (namely the British Geological Survey) who will make it available to institutes, universities, environmental consultancies, industry, and governments. Samples can also help with “ground truthing” current geological map data. Due to the constraints of the grabber system no samples were collected in water deeper than 25m.

Figure 1 Route and sample locations. CC BY 4.0

The voyage took place around the southern edges of the Irish Sea basin (**Figure 1**) which comprises of a southward sloping shelf with a broad coastal depth of <50 m and a central deeper channel area approcimaetly 120 m deep. The seabed geomorphology was influenced by the Irish Sea Ice Stream during the Last Glacial Maximum (LGM), around 25-23 ka BP (Chiverrell et al 2013). The ice channelled meltwater through deeper parts of the basin incising deeper into the substrate. The areas adjacent to the coastal regions are relatively shallow and some exhibit topography indicative of former lower sea levels post LGM (Edwards & Craven 2017). Shallow coastal areas mostly comprise of sandy beach type sands and gravel deposits often derived from the local bedrock units. Sediments collected during the voyage derived from a swathe of different geological units with the majority from Paleozoic Devonian and Carboniferous terrains (**Figure 2**).

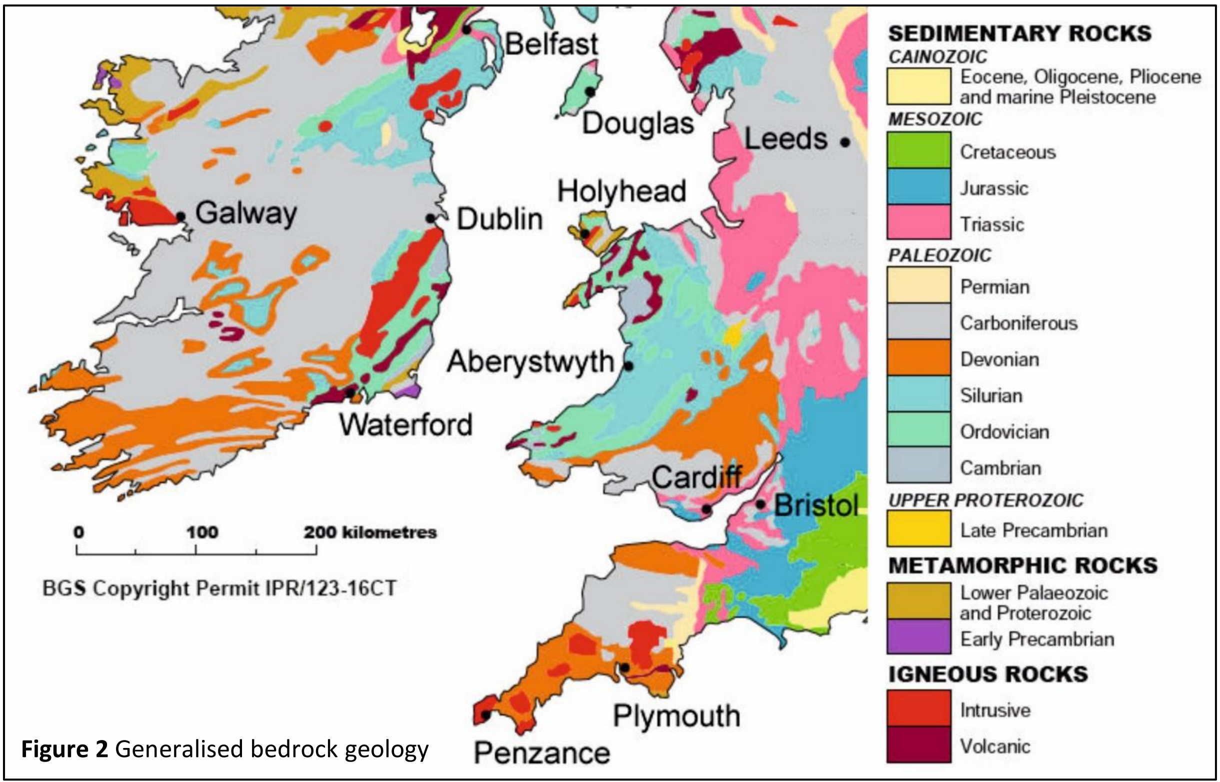

Figure 2 Generalised bedrock geology

Sediment was collected from anchorages and shallow bays around the coast of Wales and Ireland then examined under a microscope for evidence of microplastics. The prevalence of microplastics in the environment has become a topic of increasing interest, demonstrated by the rise in google searches (**Figure 3**) for the term (the peak is the publication of Leslie *at al* 2022 paper on microplastic plastic in blood).

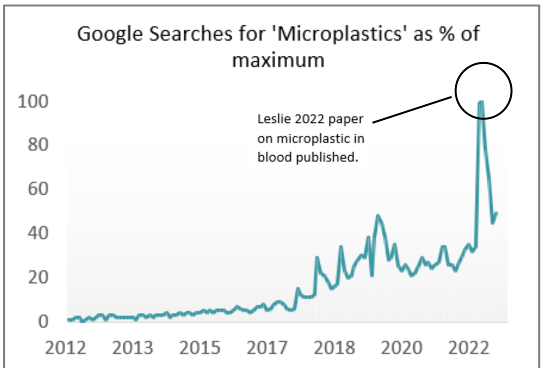

Figure 3 Google trends searches for microplastics

As well as in human organs, such as the placenta (Ragusa *et al* 2021), plastics have been found across many species (Rowley *et al* 2020, Amelia *et al* 2021) as well as in the deep ocean (Pohl *et al* 2020), Antarctica (Caruso *et al* 2022) and the Tibetan plateau (Jiang *et al* 2019). The presence of *macro*plastics in the marine environment is readily understood with emotive images of wildlife caught in nets and the colossal floating oceanic garbage gyres the size of islands sticking in the mind's eye. Even though, only 1% of marine plastic is found at the surface (Kane *et al* 2020). Media attention to marine plastic pollution is increasing (Keller & Wyles 2021), but little focus is placed on consumer responsibility. A recent study estimated human consumption of plastic to be around 5 grammes a week which is about the weight of a credit card (Senathirajah *et al* 2021). Microplastics are harder to illustrate, but recent research suggests they may still have a significant impact on the health of the biosphere. Zooplankton reproduce less successfully in the presence of microplastics (Botterell *et al* 2019), Pacific crabs live shorter lifespans (Horn *et al* 2019), mice develop gut inflammation and suffer lower sperm counts (Boqing *et al* 2020 & Jin *et al* 2021). It is unclear if these consequences are as a result of the chemicals the microplastics themselves are made from or the chemicals which concentrate on 'biofilms' (**Figure 4**) surrounding the outside of many microplastic particles (Amelia *et al* 2021). Given the quantity which humans ingest alongside the fact many of the molecules which accrete on plastic particles are known Endocrine disrupters (Paul-Pont *et al* 2018), an understanding of the distribution, quantity and rate of increase in microplastics is useful.

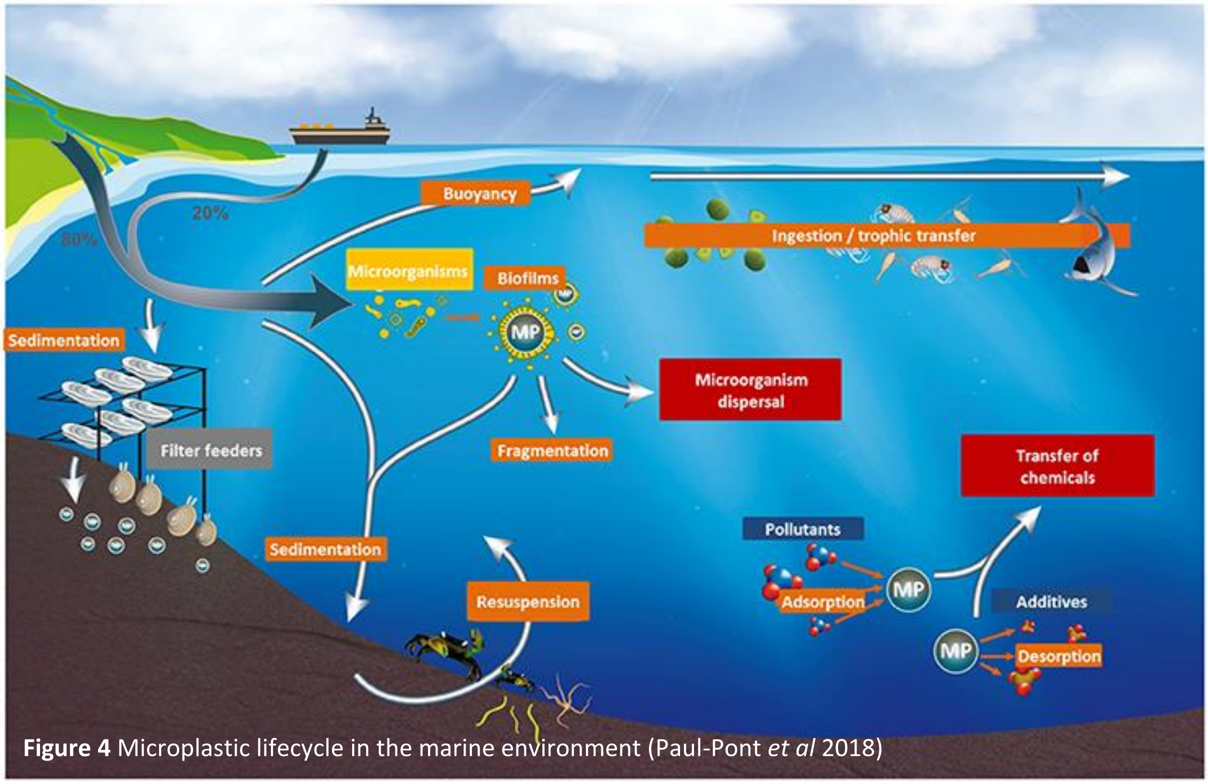

Figure 4 Microplastic lifecycle in the marine environment (Paul-Pont *et al* 2018)

The presence of plastic in the global environment has been used as a key indicator of a new geological era named the 'Anthropocene' (Zalasiewicz *et al* 2016) due to the 'virtually ubiquitous' presence of microplastic particles in both the marine and terrestrial environment. Of the trillions of tonnes of plastic estimated to have entered our oceans, 99.8 percent has sunk below the top hundred meters (Koelmans *et al* 2017) with 10,000 times more microplastics on the seafloor than in contaminated surface waters (Woodall *et al* 2014). This geological cycle of microplastics in sediment is however less publicly understood than the equivalent in the water column. The collaborative element of undertaking a project with seas your future presented the opportunity to raise awareness of seabed microplastic among the young people onboard.

Method

Figure 5 Sediment in a collection tube prior to drying

Any time the vessel was at anchor or stationery in shallow waters (potential depth determined by the location plotted on the relevant chart) the sediment grabber was deployed from the welldeck of the ship. Appendix 3 details the primary deployment method used to obtain sediment samples. Six deployments were attempted, 1 was unsuccessful with 3 partial recoveries. The WGS84 degrees minutes seconds location was taken from the onboard Raymarine axiom 9 chart plotter and the time from an internet connected mobile phone. Depths were listed in metres below surface. About 5 ml of the collected sediment was placed in a petri dish to dry. After the sample was dried it was viewed on an ultradiGI-SB7 40x magnification digital stereo microscope. A systematic visual identification and counting method (Horton *et al* 2017 & Syakti *et* *al* 2017) was used by the students onboard to identify microplastic fibres in the samples. Equipment used in sediment collection was washed out with tap water, so a sample of tap water was also screened via the microscope and no microfibers were found. The blank water samples also acted as evidence we were not artificially contaminating the sample during collection.

Data and observations

Microplastics were observed in all of the samples collected with blue, red and white fibres observed in the samples (**Figure 6**).

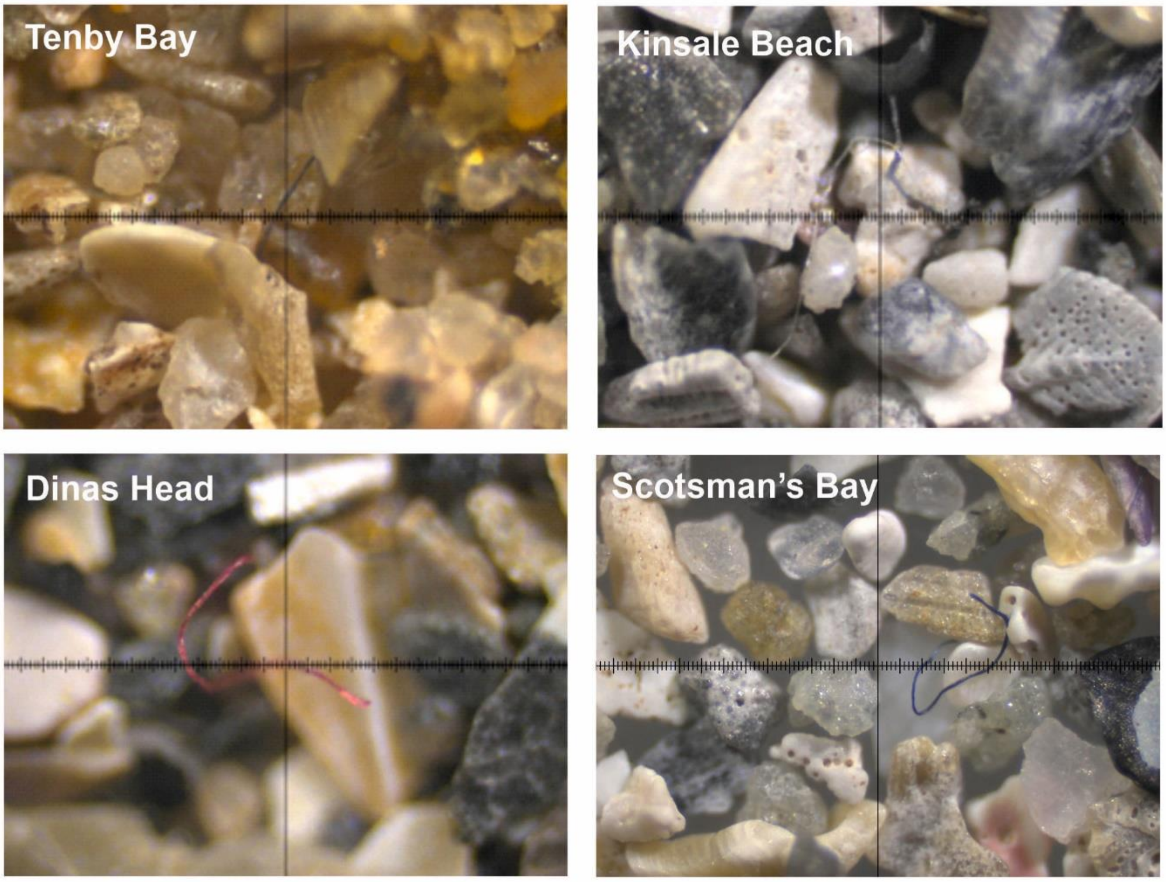

Figure 6 Samples of sediment containing microplastic from the four sampling locations, field of view is 2mm across.

The highest concentration of microfibres was found near Dublin in Scotsman's Bay with 5 microfibers in the sample, second highest was 4 fibres in Tenby Bay followed by Dinas Head and Kinsale Beach with in 3 each. Plankton samples were also collected from the water in Bristol Harbour and from mid-way across the Celtic sea. Microplastic fibres were also observed in these samples (**Figure 7**).

Figure 7 Microplastic fibres visible in water samples from Bristol Harbour and the Celtic Sea

Other items of interest seen in the sediment include Bryozoan parts, Foraminifera shells and Echinoderm spines (**Figure 8**).

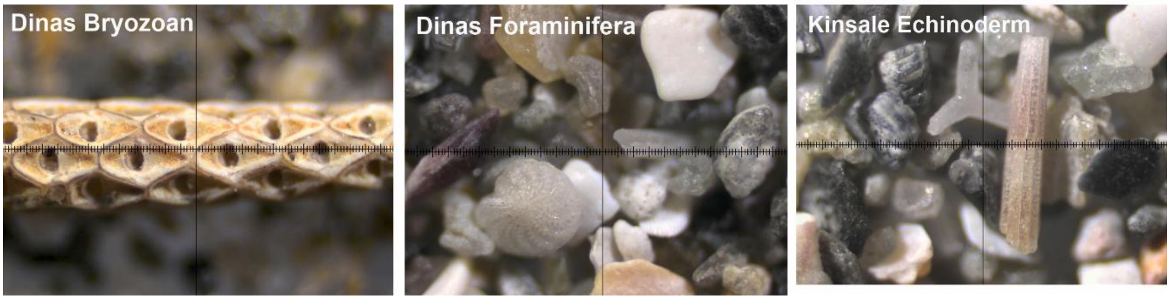

Figure 8 Other items contained in the sediment samples.

Conclusion

The presence of microplastics in every sample aligns with existing research into the topic and agrees with Zalasiewicz *et al* (2016) paper stating the 'virtually ubiquitous' presence of microplastic particles in the marine and terrestrial environment. The distribution of microplastic fibres did seem to correlate with the more populous regions of the coast but it is not a wide enough sample to conclude this definitively. This would suggest that the higher population concentrations and therefore higher presence of plastics in the environment, may generate floating plastic fragments which settle to the bottom of the sea.

References

Amelia, TSM, Khalik, WMAWM, Ong, MC, Shao, YT, Pan, HJ, Bhubalan, K, (2021) Marine microplastics as vectors of major ocean pollutants and its hazards to the marine ecosystem and humans, *Progress in Earth and Planetary Science,* 8, 12.

Botterell, Z.L.R., Beaumont, N, Dorrington, T, Steinke, M, Thompson, R.C., Lindeque, P.K., (2019) Bioavailability and effects of microplastics on marine zooplankton: A review. *Environmental Pollution*, 245, 98-110

Caruso, G, Bergami, E, Singh, N, Corsi, I, (2022) Plastic occurrence, sources, and impacts in Antarctic environment and biota, *Water Biology and Security,* 1, 100034.

Chiverrell, R.C., Thrasher, I., Thomas, G.S.P., Lang, A., Scourse, J.D., Van Landeghem, K.J.J., Mccarroll, D., Clark, C., Ó Cofaigh, C., Evans, D.J.A., Ballantyne, C.K., (2013) Bayesian modelling the retreat of the Irish Sea Ice Stream. *Journal of Quaternary Science*, 28, 200-209.

Edwards, R, Craven, K (2017) Relative Sea-Level Change Around the Irish Coast, Advances in Irish Quaternary Studies.181–215

Horn, D.A., Granek, E.F., Steele, C.L., (2019) Effects of environmentally relevant concentrations of microplastic fibers on Pacific mole crab (Emerita analoga) mortality and reproduction, *Limnology and Oceanography Letters*, 10137.

Horton, A.A., Svendsen, C, Williams, R.J., Spurgeon, D.J., Lahive, E, (2017) Large microplastic particles in sediments of tributaries of the River Thames, UK – Abundance, sources and methods for effective quantification, *Marine Pollution Bulletin*, 114 218–226

Jin, H, Ma, T, Sha, X, Liu, Z, Zhou, Y, Meng, X, Chen, Y, Han, X, Ding, J, (2021) Polystyrene microplastics induced male reproductive toxicity in mice, *Journal of Hazardous Materials*, 401, 123430.

Jiang, C., Yin, L., Li, Z.,Wen, X., Luo, X., Hu, S., Yang, H., Long, Y., Deng, B., Huang, L., Liu, Y., (2019). Microplastic pollution in the rivers of the Tibet Plateau. Environmental Pollution, 249, 91–98.

Kane, I, Clare, M.A., Miramontes, E, Wogelius, R, Rothwell, J.J., Garreau, P, Pohl, F, (2020) Seafloor microplastic hotspots controlled by deep-sea circulation, *Science* 368, 6495, 1140-1145.

Keller, A, Wyles, K, (2021) Straws, seals, and supermarkets: Topics in the newspaper coverage of marine plastic pollution, Marine Pollution Bulletin, 166, 112211.

Koelmans, A, Kooi, M, Law, L.L., Sebille, E, (2017) All is not lost: deriving a top-down mass budget of plastic at sea, Environmental Research Letters, 12, 11, 114028.

Leslie, H.A., a, Van Velzen, M.J.M., Brandsma, S.H., Vethaak, A.D., Garcia-Vallejo, J.J., Lamoree, M.H., (2022) Discovery and quantification of plastic particle pollution in human blood, *Environment International,* 163, 107199.

Paul-Pont, I, Tallec, K, Gonzalez-Fernandez, C, Lambert, C, Vincent, D, Mazurais, D, Zambonino-Infante, J, Brotons, G, Lagarde, F, Fabioux, C, Soudant, P, Huvet, A, (2018) Constraints and Priorities for Conducting Experimental Exposures of Marine Organisms to Microplastics, *Frontiers in Marine Science*, 5.

Pohl, F., Eggenhuisen, J.T., Kane, I.A., Clare, M.A., (2020) Transport and Burial of Microplastics in Deep-Marine Sediments by Turbidity Currents, *Environmental Science and Technology*, 54, 4180–4189.

Ragusa, A, Svelato, A, Santacroce, C, Catalano, P, Notarstefano, V, Carnevali, O, Papa, F, Rongioletti, M, Baiocco, F, Draghi, S, D'Amore, E, Rinaldo, D, Matta, M, Giorgini, E, (2021) Plasticenta: First evidence of microplastics in human placenta, Environment International, 146, 106274,

Rowley, K.H., Cucknell, A, Smith, B.D., Clark, P.F., Morritt, D, (2020) London's river of plastic: High levels of microplastics in the Thames water column, *Science of the Total Environment*, 740, 140018.

Senathirajah, K, Attwood, S, Bhagwat, G, Carbery, M, Wilson, S, Palanisami, T, (2021) Estimation of the mass of microplastics ingested - A pivotal first step towards human health risk assessment, *Journal of Hazardous Materials*, 404, Part B, 124004.

Syakti, A.d., (2017) Microplastics Monitoring in Marine Environment, *Omni-Akuatika*, 11, (2), 1–6.

Woodhall, L.C. Sanchez-Vidal, A, Canals, M, Paterson, G.L.J., Coppock, R, Sleight, V, Calafat, A, Rogers, A.D., Narayanaswamy, B.E., Thompson, R.C., (2014) The deep sea is a major sink for microplastic debris. *Royal Society Open Science*, 1, 140317.

Zalasiewicz, J, Waters, C.N., Ivar do Sul, J.A., Corcoran, P.L., Barnosky, A.D., Cearreta, A, Edgeworth, M, Gałuszka, A, Jeandel, C, Leinfelder, R, McNeill, J, Steffen, W, Summerhayes, C,Wagreich, M, Williams, M, Wolfe, A.P., Yonan, Y, (2016) The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene, *Anthropocene,* 13, 4-17.

Appendix 1 – Ships Personnel

Master	Axel Schaipp
Mate	Simon Jordan Mate
2nd Mate	David Damkiær
Bosun	Connor Sexton
Bosuns Mate	Theresa Ellensohn
Engineer	Sergej Solopov
Cook	Abbie Davis
Medic	Emma Monk
Scientist	Leanne Hughes
Assistant Scientist	Olivia Yorke-Dunne
Deck Cadet	Connor Hunter
Deck Cadet	Tony Clayton
Deck Cadet	Ben Lewis
Deckhand	Megan Raven
Fore WL	Hannah Blake
Main WL	Eoghan Spillane
Mizzen WL	Ronja Brömme

Appendix 2 - Grab sample descriptions

Location name	Sample I.D	Date	Time	Type	Lat WGS84 DMS	Long WGS84 DMS	Measured depth (m)	Composition, colour, texture, grain size odour	Remarks
Bristol Harbour	PoL_220717_001	17/07/2022	09:50:00	Grab	51°26'52"N	-002°35'53"W	4.5 m	Wet colour, Brownish black 5 YR 2/1, Dry Olive grey 5 Y 4/1, soft clay with some silt. High organic content, sulphurous odour.	Particles of anthropogenic matter visible such as brick
Swansea bay	N/A	18/07/2022	16:10:00	Grab	51°23'54"N	-003°39'20"W	19.2 m	No recovery due to too much lateral movment in the water and release wire deploying upon contact with the water.	Hopeful till location
Tenby Bay	PoL_220719_002	19/07/2022	10:04:00	Grab	51°39'13"N	-004°40'12"W	21 m	Wet colour, mid orange-brown, dry colour, pale yellowish brown fine to coarse grained sand, some small shelly fragments. Microplastics observed	Poor recovery, 4 microplastic fibres observed
Kinsale Beach	PoL_220722_003	22/07/2022	15:20:00	free dive hand sample	51°41'42"N	-008°30'45"W	2 m	Wet colour, brownish -grey, dry colour pale grey fine to very coarse sand with abundant shell fragments including bivalves and forams. Microplastrics observed	Hand sample from seabed
Dinas Head	PoL_220724_004	24/07/2022	14:55:00	Grab	52°01'55"N	-004°53'19"W	11.9 m	Wet colour dark grey, dry colour, greyish brown clayey silty sand with some gravel. Abundant shell fragments including echinoderm spines, forams and bivalves. Microplastics observed.	Poor recovery, 3 microplastic fibers observed
Scotsmans Bay	PoL_220726_005	25/07/2022	20:36:00	Grab	53°17'70"N	-006°06'58"W	14.8 m	Wet colour, dark grey, dry colour pale grey coarse to very coarse sand with abundant shell fragments including bivalves and forams. Microplastrics observed	Poor recovery, 5 microplastic fibers observed

Appendix 3 – Instructions for Ekman grabber deployment

Equipment – 100m Tape measure with weight, Ekman bottom grabber, Shuttle weight, 30m line on a reel, white plastic sample tray, petri dish, 50ml test tube, grain size card, notebook.

The line on the bottom grabber is long enough to take samples to a depth of 30m, however we have had poor recovery rates at depths greater than 15m so far. The vessel must be stationary either at anchor or along the harbour side in order to attempt sampling. If there is a significant drift whilst at anchor then the grabber will be pulled sideways and will not deploy correctly. It may take a few attempts to see if the location is suitable.

1. **Get permission** from the officer of the watch to deploy the sediment grabber. Tides, current, drift, waves, protected seabed and deck operations might mean it is not safe to use the grabber. In rough weather the grabber may be liable to swing against the vessel which could damage the equipment or the ship. Check the depth and nature of the seabed before deployment to ensure there is an opportunity to take a sample. If it is listed as rock or boulders then the grabber will not be able to collect anything and could get stuck.
2. **Prepare necessary hands.** Two people minimum are needed to operate the grabber, one to lower the box and another to feed out the line on the reel. Gather in the well deck along either the port or starboard rail where it is low enough to see over.
3. **Prepare all equipment.** Thread the white line through the hole in the middle of the grabber handle, tie two figures of eight in this end to ensure the line cannot slip out. Make sure the line is secure. And make sure again! Press the button on the handle (which the line threads through) down to release the inner pin, hook over the eye of the wire attached to the jaw. Now carefully hook the other wire over the outer pin. Both jaws should now be held open. Move the sample tray close to where you are operating so you don't have to carry a potentially sloshing muddy sample across the deck. Put the deployment weight (the thing looks like a shuttle) in a zipped pocket so it will not come out when you lean over. Tie the handle of the tape measure to a fixed point and attach the weight to the end
4. **Take a depth measurement**. Using the weighted tape measure, find the distance from the capping rail to the surface of the water and take a note of the measurement. You will need to remove this number from your overall depth measurement. Now lower the tape measure into the water being careful to keep the metal weight away from the ship's side. As the weight drops through the water, make a note of it's position. Is it going straight down, or is it disappearing aft or below the hull? This might indicate a current or drift that could make sampling difficult. When the weight reaches the seabed you will feel a little slack in the line, lift the weight back up a little and place back down on the seabed. Read off the depth from the capping rail and subtract your first measurement from this. Note down the depth, date, time, location name and the coordinates of the ships location.
5. **Launching the grabber.** Make sure the person holding the reel is ready for you to deploy and has a strong hold of the line. Lower the grabber steadily over the side of

the ship, again being careful not to make contact with the hull. When it reaches the waterline gently lower it as any significant movement can release the jaw secured to the outer pin. Visually check both jaws are still open. Continue to lower until you feel it make contact with the seabed. Standing back from the capping rail remove the shuttle weight from your secure pocket and twist the end to attach it to the line, pointy end down. When it is locked onto the line, hold the line vertically over the grabber and release the weight. You will feel it slide down the line and 'knock' against the release button. Slowly raise the grabber, it will feel much heavier because the flaps on the top will be closed when it is ascending. When it reaches the surface hold it for a moment to let excess water drain out then bring it over the side. Open the jaws into the sample tray and *hopefully* you will have a sample!

6. **Taking a sub-sample.** Using a petri dish, scoop up a portion of the material and cover with a lid, if the sample feels gritty or sandy then it might be worth also taking a washed sample to examine under the microscope. To do this, scoop some of the sample into a test tube and fill with fresh water, shake and pour off any suspended sediment. Repeat until the shaken water is mostly clear. Tip the washed sample into another petri dish. Put the tube and dish in a safe place and rinse all the equipment with fresh water. Leave to dry in the black crate.
7. **Preparing the sample.** Both samples need to dry before you can examine them, so remove the lids and put them somewhere warm and ventilated, you may need to secure them down.
8. **Examining the sediment** Once dry, write a description of the sediment, start with the colour, grain sizes (using the card) and any other visible material (such as organic matter or shells). You could also look at the samples under the microscope for a better view of the material. If you are searching for microplastics it is best to use the unwashed sediment sample and undertake the sampling wearing low-shedding clothing such as oilskins. Don't dry these samples with the lids removed, as this could contaminate the material.
9. **Recording the data** add your data and descriptions to the *'Pelican of London Sample Recording'* spreadsheet. If you are in British Territorial waters and would like to upload your sample to the national offshore grab sample database the fill out the more detailed BGS_sample_submission form and send to Leanne at lean1@bgs.ac.uk
10. **Return the equipment** once all the kit is clean and dry return and secure it in the tough case and put the petri dishes and test tubes back in the relevant box.

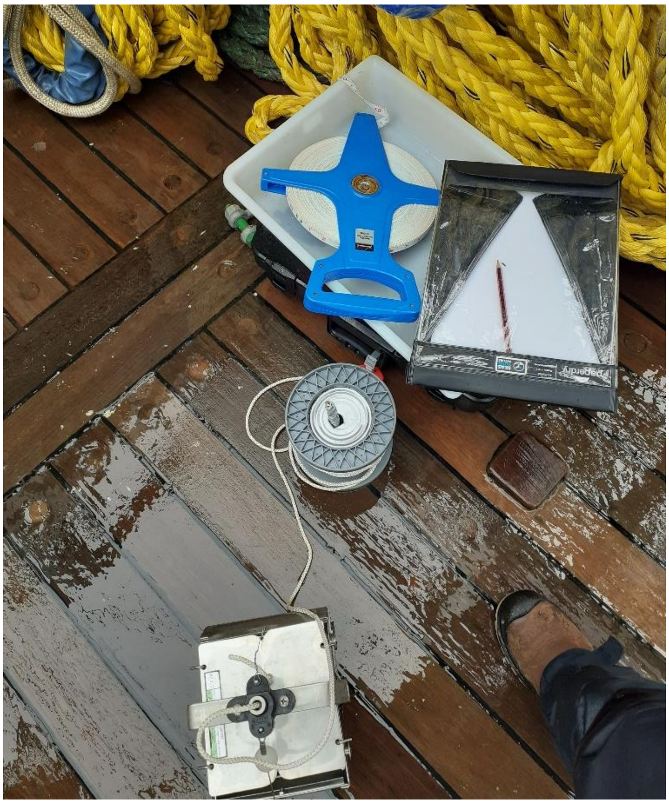

Image 1 Equipment prepared and ready for sampling, shuttle weight is secured in a zipped pocket.

Image 2 Lowering the grabber over the side of the ship

Image 3 Sediment emptied into sample tray and wet colour checked

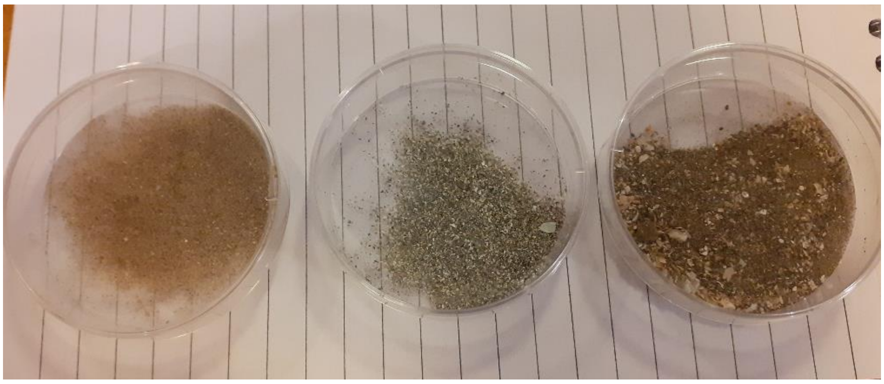

Image 4 dried sediment samples in petri dishes

Image 5 Samples being examined under a microscope.