The distribution, concentration and composition of microplastics in beach sediments and coastal waters of Jersey, C.I.

Adam Dallas-Chapman

Background

Microplastics are an emerging but ubiquitous environmental contaminant. Defined to have a size range of <5mm (Arthur et al. 2009) microplastics account for 92% of all plastic waste within the ocean (Eriksen et al. 2014). Within the environment, microplastics can exist in two forms (Frere et al. 2016):

1. Primary Microplastic - those manufactured to be under 5mm
2. Secondary - those broken down to 5mm within the environment

Secondary microplastics are thought to be the most abundant within the marine environment with the majority of microplastic debris found in the ocean considered to originate from land-based sources. The global pollution of the marine environment by microplastic contamination is linked to several environmental threats including species death (through ingestion, toxicity and starvation), and the spread of invasive species and disease (both for natural species and humanity itself).

Aims & Objectives

This study aimed to determine the concentration, distribution and composition of microplastics in the marine environment of Jersey, Channel Islands. In detail, ten sample sites (Figure 1) were chosen across Jersey's four main coastlines. At each sample site, three distinct experiments were carried out: a beach sand sediment survey, a coastal water survey and a beach litter assessment survey. Data collected from each of the three experiments was then analysed individually and in association with one another to determine the five objectives:

1. Does microplastic concentration, composition and distribution differ across the ten beach sites chosen?
2. Does microplastic concentration composition and distribution differ across areas of beach reached by high tide, intermediate tide and low tide?
3. Does microplastic concentration, composition and distribution differ across the ten coastal water sites chosen?
4. Is the concentration, composition and distribution of microplastics found within the ten beach sits correlated with the microplastic concentration, composition and distribution found across the corresponding coastal water sites.

5. Is the amount of litter found on Jersey's beaches correlated with the concentration, distribution and composition of microplastics in both Jersey's beaches and coastal waters?

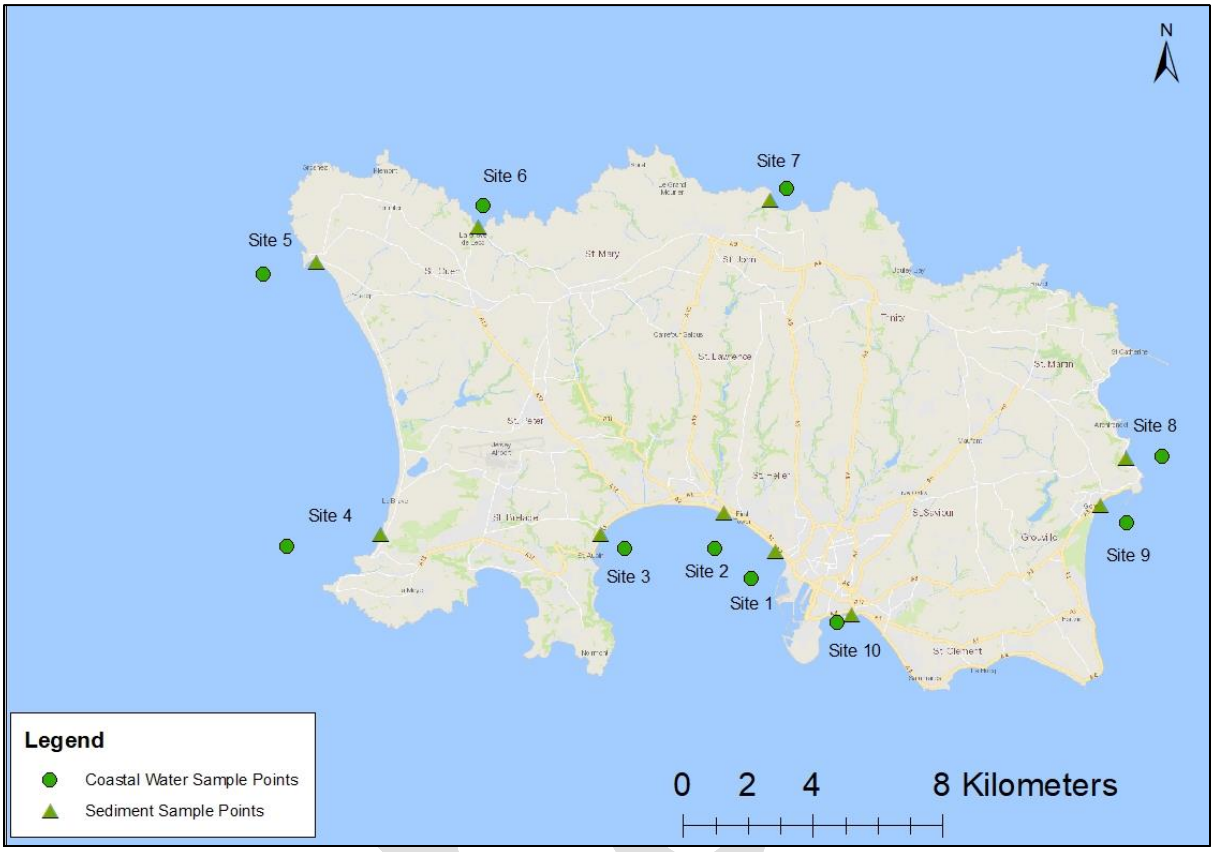

Figure 1. Geographical location of sample sites (including both coastal water sample sites and sand sediment sample sites) visited as part of this study.

Methodology

Sample Collection

Sampling the sand sediment at each location was carried out using a citizen science methodology provided by Besley et al. (2016). This methodology was chosen because of its simplistic and easily repeatable nature. Besley et al. (2016) provide a standard operational procedure for sampling and extracting microplastics from beach sample. Lots et al. (2017) have already used such a methodology in a European-wide sand sediment microplastic investigation. Therefore, the use of such a methodology in this study will also allow results of this study to be easily compared to the rest of Europe. Sand sediment samples were collected across May 2018.

All coastal water samples were taken in one day (02/07/2018) as part of a routine States of Jersey Fisheries patrol that took place around the Island. The coastal water sampling methodology was an adapted from a similar study undertaken in Brest, France (Frere et al. 2016) for sample collection. In line with Frere et al. (2016) a plankton net was trailed behind the research vessel (travelling at an average speed of three knots) for a total of 2 minutes where it was held within the top 20cm of water. After removal from the water, the cap of the plankton net was removed and thoroughly rinsed with demineralised water to collect any debris found into a nearby sample bottle. Between sample sites the plankton net was thoroughly rinsed with sea water (without the cap being attached) to avoid contamination between sites.

Microplastic Extraction & Visual Identification

All samples were transferred back to a laboratory belonging to the States of Jersey Environment department where microplastic extraction was undertaken using a standardized, density separation method provided by Besley et al. (2017). Sediment samples were dried for 24 hours before 50g of sediment were mixed with 200 ml of fully saturated, filtered salt solution (358.9 g of NaCl in 1 L of demineralized water, water density of 9043 kg/m3 at 20 °C). The salt solution/sediment sample mixture was then stirred at 660 rpm for two minutes before being allowed to settle for 6 hours. Approximately 75-100 ml of the supernatant was then pipetted out of the mixture and was filtered through 125 mm Millipore filter paper. The filter paper was then transferred to glass petri dishes where it was allowed to dry at room temperature overnight.

After individual filter papers had been left to dry overnight, each filter paper was examined under a stereo dissecting microscope at up to 40 x magnification. Microplastics were counted systematically by dividing up each filter paper into four quarters with the top marked. For each microplastic counted; the colour and shape (fibre, fragment particle or film) was noted. Visual identification of microplastics followed guidelines provided by Hidalgo-Ruz et al. (2012) and was based upon visual guidelines (Figure 2) and three important microplastic characteristics:

1. There should be no cells or organic structures visible
2. Fibres should be equally thick throughout their length
3. Colour should be clear and uniform throughout

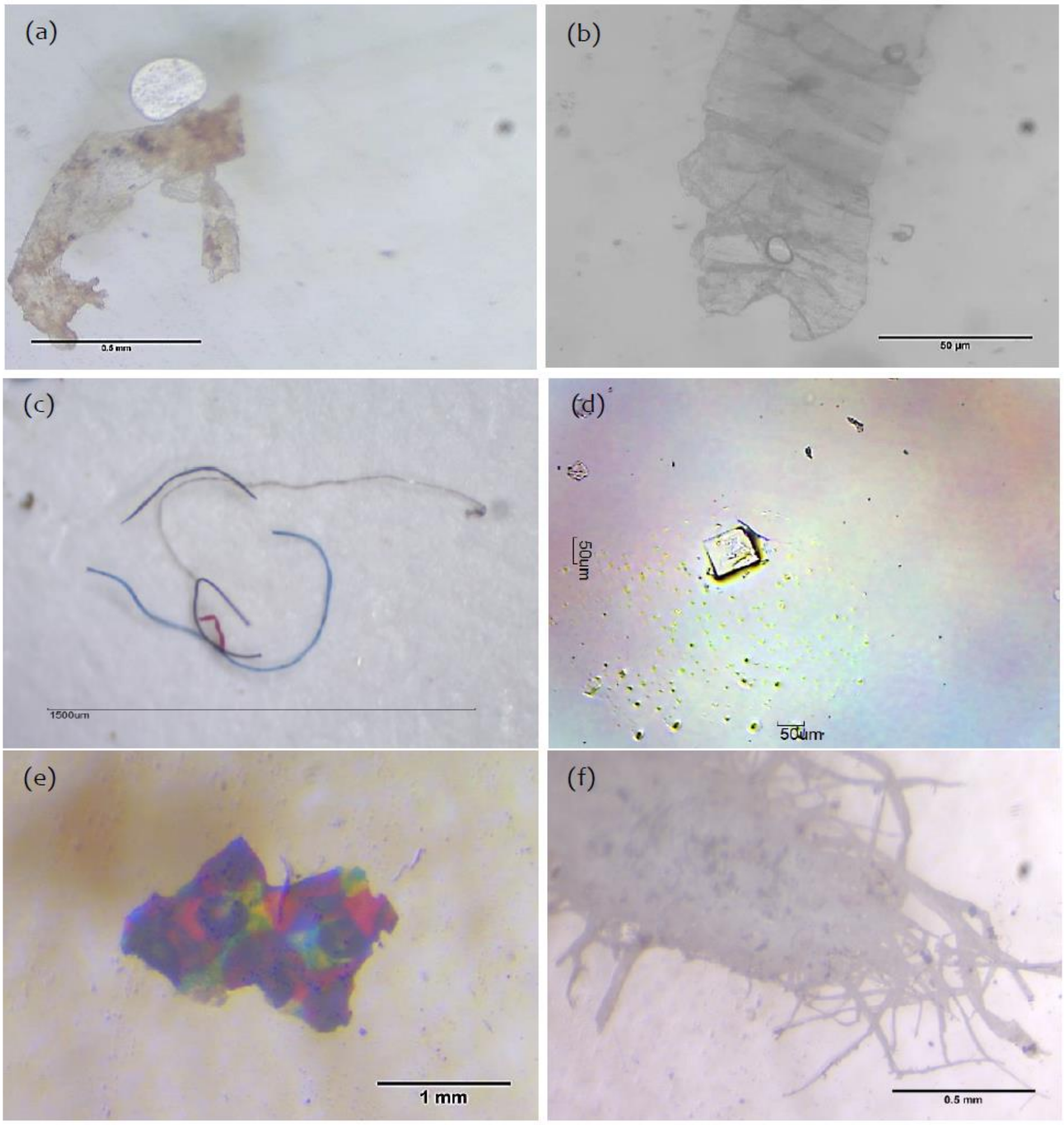

Figure 2. Microplastic identification guidelines (Hansen 2012) (a) & (b) translucent fragments, (c) fibrous, (d) angular fragments, (e) multicoloured fragments and (f) translucent fibres.

Results

In total, 141 samples were analysed as part of this surveys. Of these, 111 were analysed as part of the sand sediment survey whilst 30 were analysed as part of a coastal water survey. Across both surveys, 2968 microplastics were identified (2626 in the sediment survey & 342 in the coastal water survey). The majority of microplastics identified were found to be fibrous (69.54%) in nature, followed next by irregular fragmented particles (15.77% translucent, 10.85% multicoloured) and then angular fragments (2.43%). Spherical microplastics (suggested to be microbeads or sewage treatment items) were found at only five sites (four in the sediment survey, one in the coastal water survey) and represented only 1.42% of all microplastics found.

Average microplastic abundance was 464.64 ± 36.2 MPs/kg D.W for the sediment survey and 11.40 ± 1.66 MPs/100ml for the coastal water survey respectively. Areas of the south and east coasts showing the highest microplastic abundance followed by areas of St. Ouen's bay and Gorey. Figure 3 shows the rank of sample sites based upon the microplastic abundance in more detail it includes results from both the sand sediment and coastal water surveys.

Across the entire island, microplastic abundance was found to be insignificantly different across the four tidal areas studied (areas of high tide, areas of low tide, and two areas of intermediate tide). However, mean coastal water microplastic abundance was found to be significantly correlated with mean sand sediment microplastic abundance at both the entire beach level and for each of the four defined beach zones (Figure 4).

Mean litter abundance was found to be extremely low for all the ten sample sites studied with only site 10 (Harve De Pas) showing elevated levels. Across the ten sample sites, mean litter abundance was found to show no significant correlation with sand sediment of coastal water microplastic abundance.

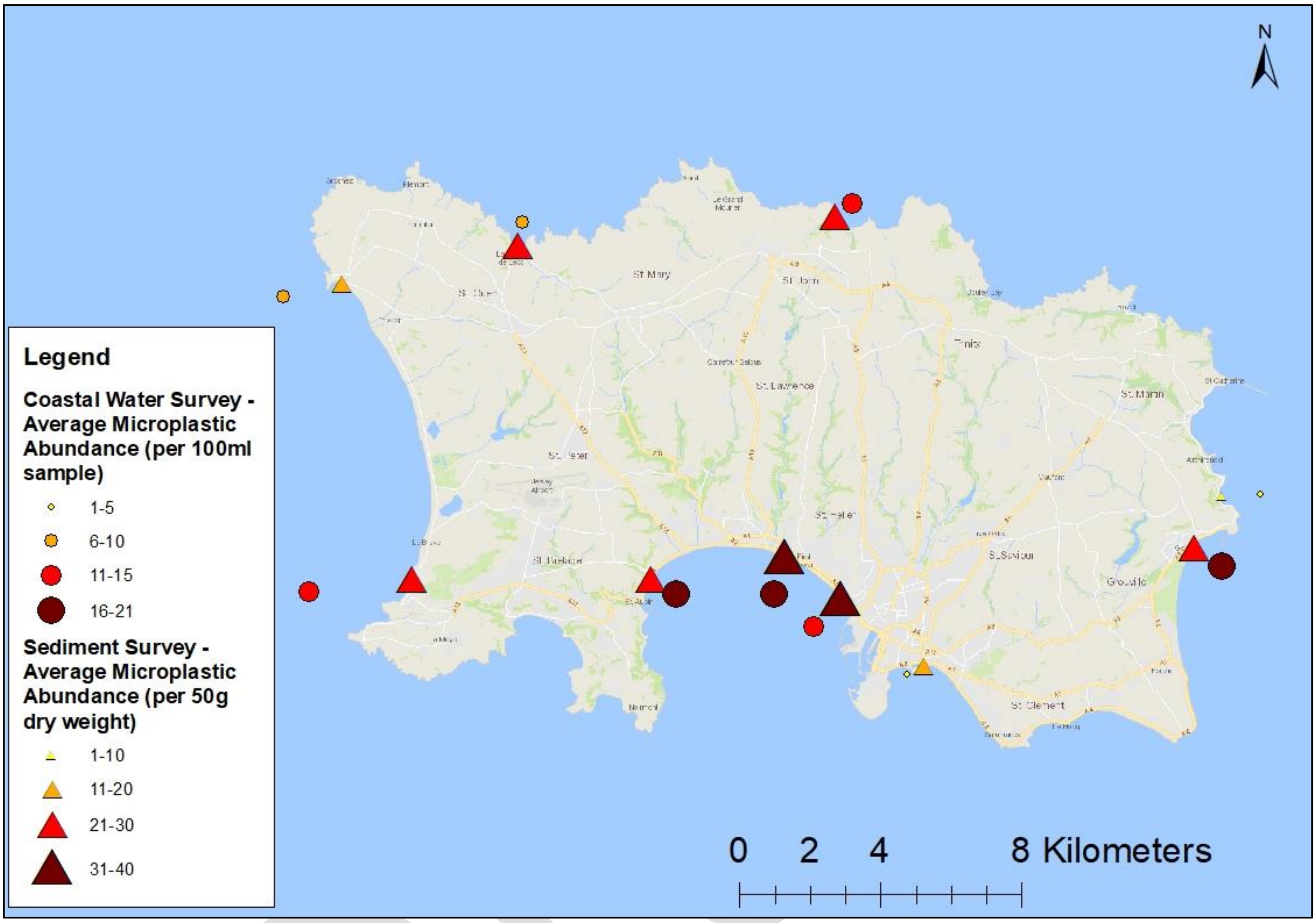

Figure 3. Total results from the two microplastic surveys. Average microplastic abundance is shown at each of the ten sample sites for both the sediment (Δ) and coastal water (O) results.

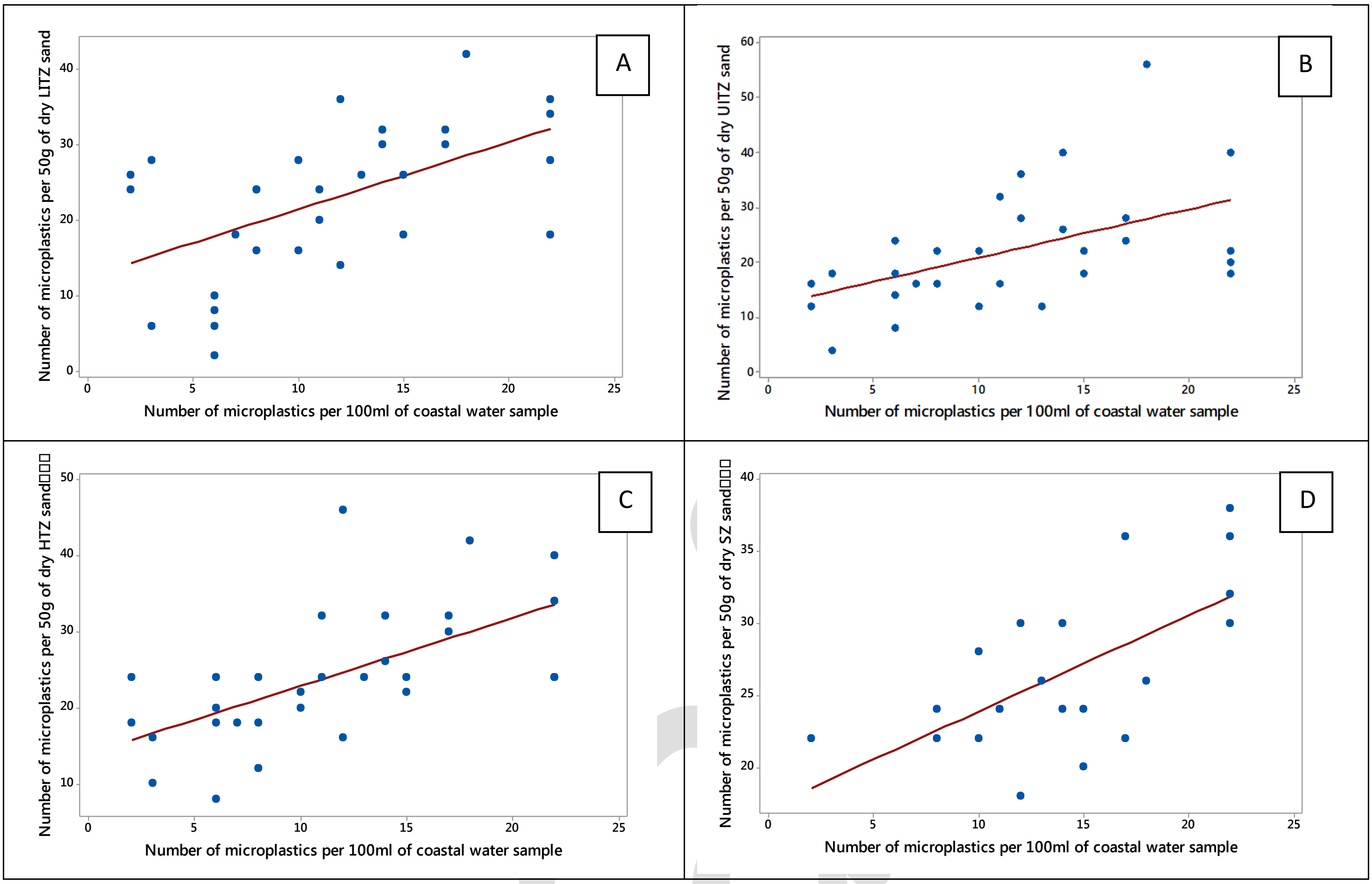

Figure 4. Total island wide microplastics found during the coastal water survey versus the total number of microplastics found at the Lower intertidal zone (A), Upper Intertidal zone (B), High tide zone (C) and Supralittoral zone (D) during the sediment survey.

Discussion

The results of this study have revealed that microplastic contamination is ubiquitous throughout the beach sediments and coastal waters of Jersey, Channel Islands. Microplastic has been found at each of the ten beach sites visited and at every beach zone sampled. Such a result is consistent with the academic literature which suggests worldwide microplastic pollution is ubiquitous within the marine environment (Bowne et al. 2011 & Eriksen et al. 2014). The results of the sediment survey revealed that microplastic number shows little significant variation between areas above and below the high tide line (both at the island and beach site level). However, a slight trend was noticed as the analysis nears the top of the beach (the supralittoral zone) both for the overall analysis and certain microplastic types (angular, fibrous and 'other'). Whilst microplastic contamination has previously found to be ubiquitous across all areas of beach (Besley et al. 2017), more research is required to determine whether the trend towards the supralittoral zone is significant.

Surface water microplastic concentration has previously been reported to correspond with areas of urban development (Frias et al. 2014). The results of this study do suggest a similar result within the sites visited. The spatial variability of microplastics reported within the study may therefore be explained by their location and distance from urban and anthropogenic development. Across both microplastic surveys the highest number of microplastics were reported across sites 1-3 and site 9. All three of these sites are found near urban development including both recreational and commercial harbours. Sites 1-3 are found in a bay that also contains the outfall of the islands main sewage treatment plant which is found 750 m from the seawall (Gross & Murphy 1993). Indeed, coastal water sampling of Site 2 (Bellozanne) occurred directly above the outfall previously discussed. The fact that this site recorded the highest number of microplastics across the entire coastal survey suggests that the islands sewage treatment works plays an important role in microplastic contamination within St. Aubin's Bay. By comparison, sites with little urban development (e.g. Site 8 & Site 5) and those far from sewage outfalls reported low microplastic contamination.

However, urban development may not explain all the results reported. For example, Site 10 (Havre De Pas) reported little amounts of microplastic in both the sand sediment and coastal water surveys despite being near the largest area of urban development on the island (St. Helier town centre). Sites 6 & 7 (Greve De L'ecq & Bonne Nuit) are also found within areas of high beach use (both contain recreational harbours) but recorded intermittent microplastic contamination. On top of this, the results of the litter assessment survey produced as part of this study revealed little correlation between the amount of plastic being recorded across the ten beach sites and the average microplastic concentration at the same sites. This may suggest that microplastic are not linked to urban development (and the breakdown of Jersey-based plastic litter) but are instead originating elsewhere and then being transported to Jersey through tidal movements.

In reality, differing microplastic concentration noted across Jersey is most probably due to a combination of all the theories noted above. The high microplastic concentration within St. Aubin's Bay points towards the waste water outfalls, whilst the intermediate concentrations noticed as well may be a result from a combination of both increased beach use, the geography of the bays themselves (and thus their ability to trap sediment) and the strong tidal currents around the island

Jersey's average sediment microplastic abundance of 464.64 ± 36.2 MPs/Kg D.W was shown to be higher than nearby locations including Guernsey (Hubert 2006), northern France (Lots et al. 2017) and southern England (Thompson et al. (2004) but lower than other areas of Europe. Further research is required to determine the overall source of microplastic within Jersey's marine environment and how this result is influenced and/or influences other nearby areas.

Conclusion

Microplastic pollution is an emerging and complex environmental challenge with associated threats that have been well documented within this report and within the academic literature. This study aimed to establish a base-line survey into the state of microplastic pollution with Jersey's marine environment. Further research is now required to determine the origin of microplastic pollution within Jersey's waters and to determine how the result of this study compare to other similar microplastic pollution studies produced across the world.

References

Arthur, C., Baker, J. and Bamford, H. (2009) 'Proceedings of the International Research Workshop on the Occurrence , Effects , and Fate of Microplastic Marine Debris', *Group*, (January), p. 530.

Besley, A., Vijver, M. G., Behrens, P. and Bosker, T. (2017) 'A standardized method for sampling and extraction methods for quantifying microplastics in beach sand', *MPB*, 114, pp. 77–83. doi: 10.1016/j.marpolbul.2016.08.055.

Browne, M. A., Dissanayake, A., Galloway, T. S., Lowe, D. M. and Thompson, R. C. (2008) 'Ingested Microscopic Plastic Translocates to the Circulatory System of the Mussel, Mytilus edulis', *Environmental Science & Technology*. American Chemical Society, 42(13), pp. 5026–5031. doi: 10.1021/es800249a.

Eriksen, M., Lebreton, L. C. M., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., Galgani, F., Ryan, P. G. and Reisser, J. (2014) 'Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea', *PLoS ONE*. doi: 10.1371/journal.pone.0111913.

Frere, L., Paul-Pont, I., Moreau, J., Soudant, P., Lambert, C., Huvet, A. and Rinnert, E. (2016) 'A semi-automated Raman micro-spectroscopy method for morphological and chemical characterizations of microplastic litter', *Marine Pollution Bulletin*. doi: 10.1016/j.marpolbul.2016.10.051.

Frias, J. P. G. L., Otero, V. and Sobral, P. (2014) 'Evidence of microplastics in samples of zooplankton from Portuguese coastal waters', *Marine Environmental Research*. Elsevier, 95, pp. 89–95. doi: 10.1016/J.MARENVRES.2014.01.001.

Hanson, D. (2012) 'Guide to Microplastic Identification', (December 2000).

Hidalgo-Ruz, V., Gutow, L., Thompson, R. C. and Thiel, M. (2012) 'Microplastics in the marine environment: A review of the methods used for identification and quantification', *Environmental Science and Technology*. doi: 10.1021/es2031505.

Hubert, D. (2006) *The Quantification and Distribution of Microscopic Plastic Fibre Contamination in Beach Sediments on the Island of Guensey, C.I*.

Lots, F. A. E., Behrens, P., Vijver, M. G., Horton, A. A. and Bosker, T. (2017) 'A large-scale investigation of microplastic contamination: Abundance and characteristics of microplastics in European beach sediment', *Marine Pollution Bulletin*. Pergamon, 123(1–2), pp. 219–226. doi: 10.1016/J.MARPOLBUL.2017.08.057.

Thompson, F. L., Iida, T. and Swings, J. (2004) 'Biodiversity of vibrios.', *Microbiology and molecular biology reviews : MMBR*. American Society for Microbiology, 68(3), p. 403–31, table of contents. doi: 10.1128/MMBR.68.3.403-431.2004.