Australia's National Science Agency

Global Plastic Leakage Baseline Data Summary Report, Cape Town, South Africa

Report for fieldwork conducted October 2017

CSIRO Marine Debris Team* in conjunction with Earthwatch Australia and Amcor

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Citation

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Foreword

Plastic volume in the ocean is increasing rapidly, affecting wildlife, economies and potentially human health. Recent model projections suggest that somewhere between four and twelve million tons of plastic flow into the world's oceans each year, with much of this waste coming from urban centres (Jambeck et al. 2015). However, to date there has been very little data collected to empirically document the existence and extent of these plumes and to validate the model estimates.

Through this collaborative field-based project, CSIRO is developing the first global, empirical baseline estimate of mismanaged waste entering the coastal and marine environments near major urban centres in countries around the world. The project aims to identify links between land-based waste management and pollution entering the marine environment. The data collected is helping to clarify the magnitude of this pollution to the public, to industry and to policy makers. Learnings from the project can serve as a basis for decision making, and to support social pressure for investment in infrastructure and regulation for improved waste management. We hope the results can also be applied to engage with industry, the retail sector, government and consumers alike regarding best-practices. We also aim to improve waste management and increase the value of plastic to reduce poverty and create alternative livelihoods that are socially, culturally, economically, and environmentally appropriate and sustainable.

We are carrying out this research in countries all over the world, and thus far have surveyed major metropolitan centres in numerous countries in the Asia Pacific region, as well as South America and Africa. In South Africa, CSIRO and Earthwatch Australia joined together to help achieve this goal, with the support of Amcor staff.

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Acknowledgments

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1 Introduction

Increasingly considered a tragedy of the commons of the 21st century (Vince and Hardesty 2016), plastic pollution is a wicked problem (Landon-Lane 2018; McIntyre 2020). Trash knows no geopolitical borders, moving with people, rivers, through the landscape and ultimately, if not managed properly, it can be lost into the global ocean. We know that mismanaged waste results in negative social, economic and ecological outcomes. There is substantial value in collecting data to help improve our understanding of the sources and drivers of why, when, where, and how waste is lost to the environment. Furthermore, knowing how waste moves through the environment, the impact our waste has on people, communities, wildlife and economies, and how we can implement policies to result in better outcomes can arm us with the knowledge to make better decisions. Collected properly and consistently, data affords us a metric, a tangible means of measuring change through time and space. This is fundamentally important to understand how effective new actions, activities and legislative measures are in terms of reducing waste entering the environment.

In late 2016, CSIRO was successful in securing funds to embark on a world first project which aims to quantify how much waste is leaking to the environment, where it is entering the environment, and to identify interventions that may be successful in stemming the flow of plastic pollution from land to the sea. The primary objective of the project is to use field sampling and mathematical modelling to document the distribution of plastic in the ocean, on the coast and in the nearshore environment generated by major urban centres and surrounding areas that have been identified as having significant waste mis-management losses into the coastal/marine environment. We initially targeted 6-8 major metropolitan areas in different countries around the world, with a focus in South East Asia. We were focusing on this part of the world because it has been identified as a region of high waste losses to the environment (Jambeck et al. 2015). Furthermore, recent work has suggested that many of the world's major polluting rivers are located in Asia (Lebreton et al. 2017). Rivers are increasingly recognized as critical conduits to plastic waste entering the oceans (Wagner et al. 2019), further highlighting the need for research such as this where empirical data is used to ground-truth predictions and inform model-based estimates of waste in the environment. However, this does not mean that we want to overlook other critical countries and regions of the world where mismanaged waste is also a significant issue. In fact, with the growing population numbers and change in accepting waste from overseas across countries in Asia, ensuring representation from countries across Africa and the Americas is critical.

Understanding the transport of plastics from land into coastal and marine systems is critical for modelling the distribution and trends of plastic in the ocean, estimating its impact on regional economies near sources, and clarifying the magnitude of this pollution to the public, to industry, and to policy-makers. With a robust, comparable baseline of information, we not only are poised to evaluate policy effectiveness and change through on-ground activities at local, national and international scales, but we are starting to see these changes happen.

A further objective of the global plastics leakage project is to increase the capacity and skillset for on-ground partners in multiple countries, helping to build the breadth and depth of skills to monitor coastal and ocean health beyond the life of this project. The more people are armed with knowledge and skills across jurisdictions, the better equipped individuals, communities and governments will be to make the decisions needed to ensure the best outcomes possible to ensure growth, health, wealth and well-being and ensure sustainability and a reduction in waste leaking to the environment.

We hope that the results from this work will serve as an international baseline against which progress can be gauged through time and space. Ideally, governments from all levels, from local or municipal to state and national will be able to use the information from this work to inform or underpin policies and decisions that will ultimately lead to a reduction in waste entering the environment. We also hope that the results can provide opportunities to engage with industry regarding best-practices and product identification for major brands which are frequently lost into the environment.

1.1 A Partnership in Action

In November 2017, CSIRO, Earthwatch Australia and 16 Amcor employees to quantify the amount of debris coming from land in the metropolitan and surrounding regional areas of Cape Town, South Africa, and arriving at the coast. The Cape Town region was selected in collaboration with our partners because it represented an urban region of significance within the country and is the largest city (by population) within the country. Furthermore, we identified the region as an area that could be sampled within a reasonable time frame (~ 2 weeks) with the Amcor team. Additionally, the region or watershed also has a river system which could transport debris to the sea, and hence was deemed appropriate in the context of the overall global project. Our ultimate goal was to develop a baseline measurement of debris along an approximately 350 km stretch of coastline and the surrounding riverine and inland areas of Cape Town. To this aim, we conducted field surveys that included coastal, inland, and river-side surveys following a statistically robust and user-friendly sampling methodology. With a few days of training, the crew was ready to tackle the challenge of sampling.

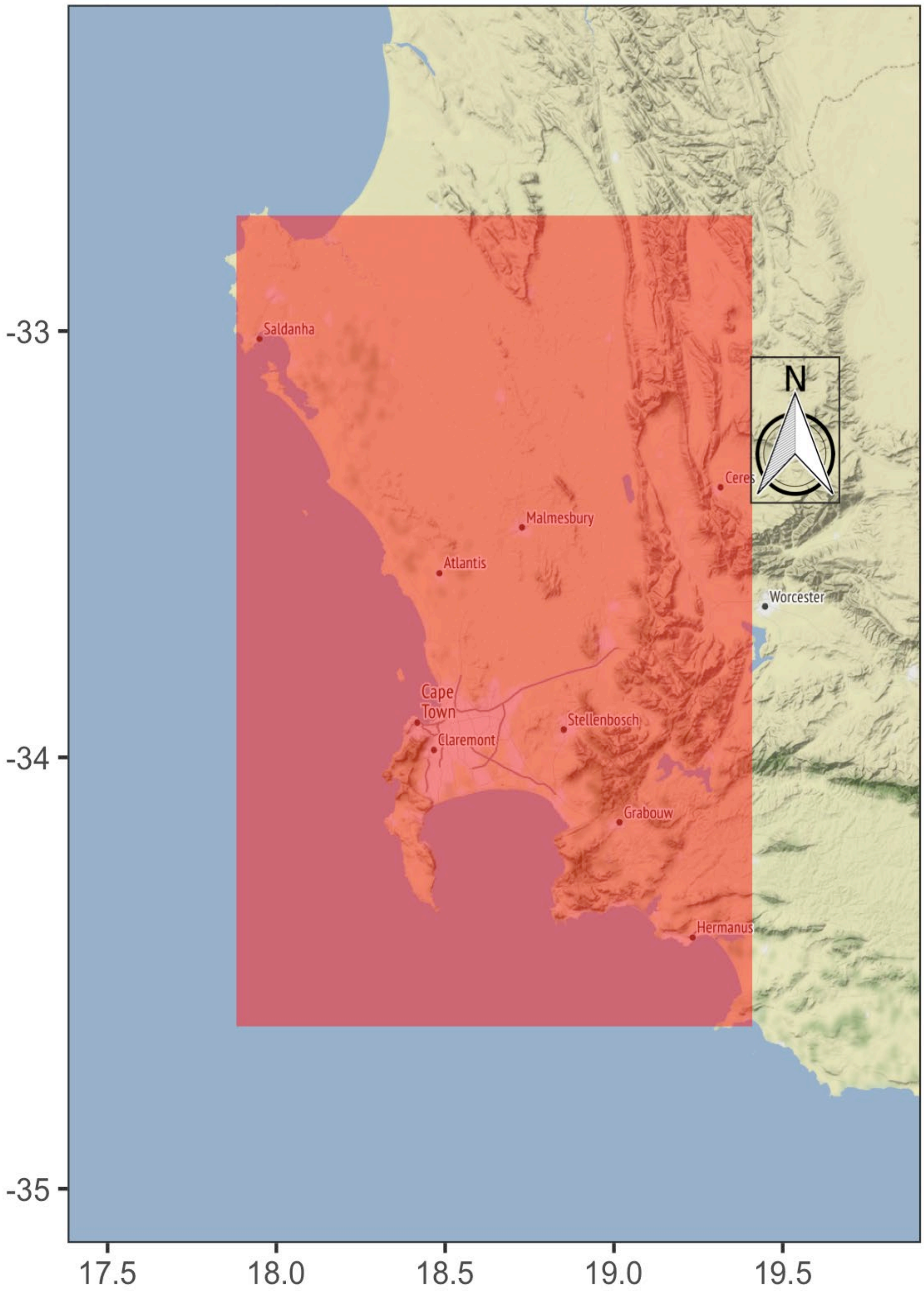

Figure 1. Location of study area.

1.2 Site Selection and Study Area

Our target area included the metropolitan and regional areas surrounding Cape Town. We selected a region roughly 350 km long and 50 km wide, extending from St. Helena Bay to Frankskraal. The survey area included the metropolis of Cape Town, which is located approximately central to the study area. The study area was constricted to the north east by inaccessible terrain.

Survey locations were vetted prior to the team's arrival in South Africa, so they could be assessed for suitability and any alterations needed could be made prior to arrival to conduct fieldwork. Sites were selected based on a suite of criteria and were intended to sample across the range of a variety of covariates, including population density, land use type, road and transportation networks. We aimed to strike a balance between sites that were representative across the watershed region we were surveying and ensuring travel times between sites were not so long as to make field work impractical. While all of the sites were selected in advance, occasionally chosen site locations could not be accessed in the field. This could be due to a range of reasons, including that the points fell on private land or were unsafe to access. In these instances, surveyors chose the nearest location that was accessible to and in a similar environment as the originally designated site.

During the first several days, participants and trainers worked together to ensure all participants received consistent, intensive training on how to collect, record, report, and make decisions regarding debris items, site selection characteristics, and other key factors required for consistency in data collection for the different survey methods (coastal, inland, and river). Following the training period, we divided into a number of teams to carry out fieldwork safely and securely over the chosen study region. The group successfully completed surveys at a total of 65 sites (Figure 2).

1.2.1 Coastal sites

Coastal sites are defined as those sites that occur directly up to the ocean's edge. They could encompass any of a number of substrates and were not limited to sandy beaches. Coastal sites were selected between St. Helena Bay to the north of Capetown to Franskraal in the south, at approximately 25 km intervals along the coastline. We selected this interval because this provided us with an adequate or appropriate number of sites to be representative of the coastline as a whole and was enough samples to provide the statistical robustness required for analysis purposes.

1.2.2 Inland sites

To select inland survey sites, we placed a 5 km grid over the study region and selected the centre of each 5 km x 5 km cell. We then used globally available Geographic Information System (GIS) spatial layers to quantify several factors that have been shown in our previous work to be associated with the amount of debris or litter observed (covariates). Covariates included the local population density, land use type, distance to the nearest road, distance to the coast, distance to the nearest river and distance to the nearest railway station. We also used proxies for socio-economic status, including night lights within 1 km radius of the site. Additionally, we included a measurement of the total monetary value of the built environment (both rural and urban), calculated by the United Nations as part of a global exposure dataset aimed at on disaster risk management (GAR15) (UNDDR, 2015). We carried out a stratified random sampling design to select sites that covered, as much as possible, the full spectrum of these important covariates.

1.2.3 River sites

We used a global GIS data layer of rivers (https://hydrosheds.org/), and subset the layer to select sites along the river features, starting at the coast. From this set of points, for ease of access, we selected sites that were less than 2 km from the road and close to inland sites.

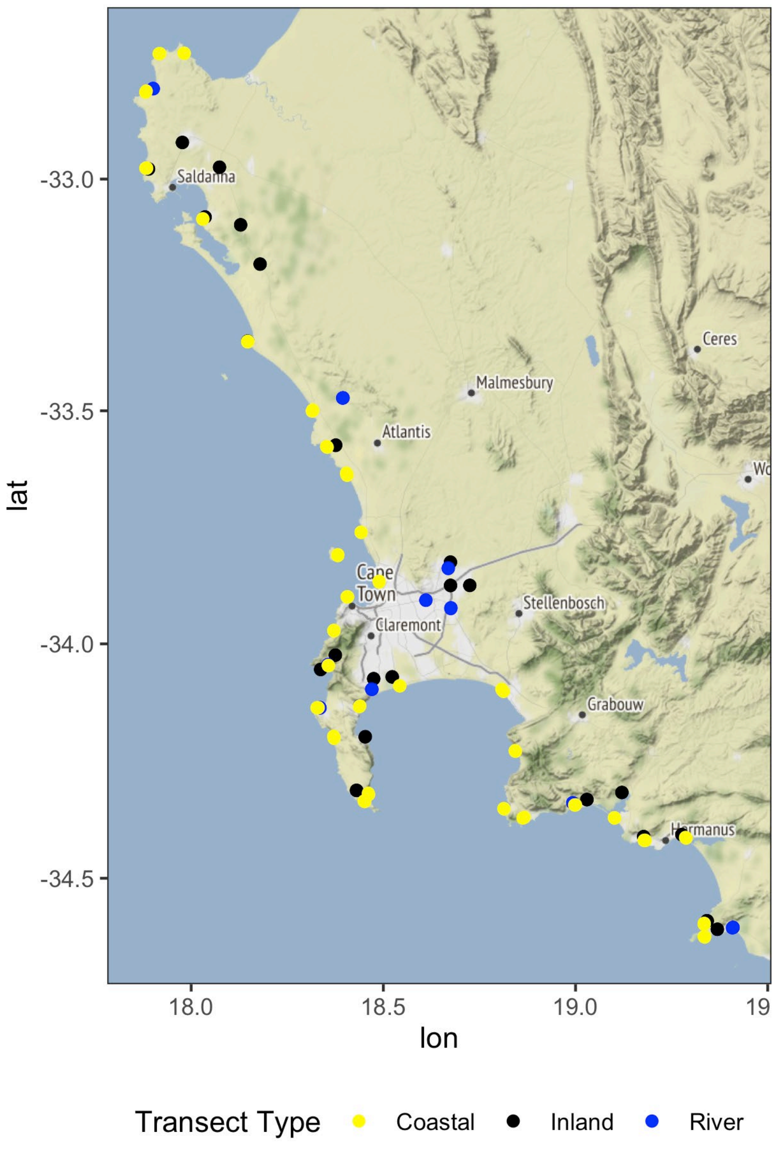

Figure 2. Location of completed surveys along the selected region of coastal South Africa. The yellow points are coastal sites, the black points are inland sites, the blue points are river sites.

2 Methods

The initial few days the team was together were spent explaining the goals of the project and training participants in the survey methods. All participants learned to search, record data, and lay out transects for river, inland and coastal surveys. Furthermore, participants were provided an electronic copy of CSIRO’s survey methods handbook for reference, and a hard copy of the handbook was available for each vehicle transporting participants.

Debris was measured at each land-based site type (river, coastal and inland) using a consistent survey method. Once a site was chosen, a **Site Information Sheet** was completed before any surveys took place (Figure 3). Information was recorded about the site’s aspect, accessibility, apparent cleanliness, and number of people present, as well as weather conditions, time of day, and details of the survey recorder.

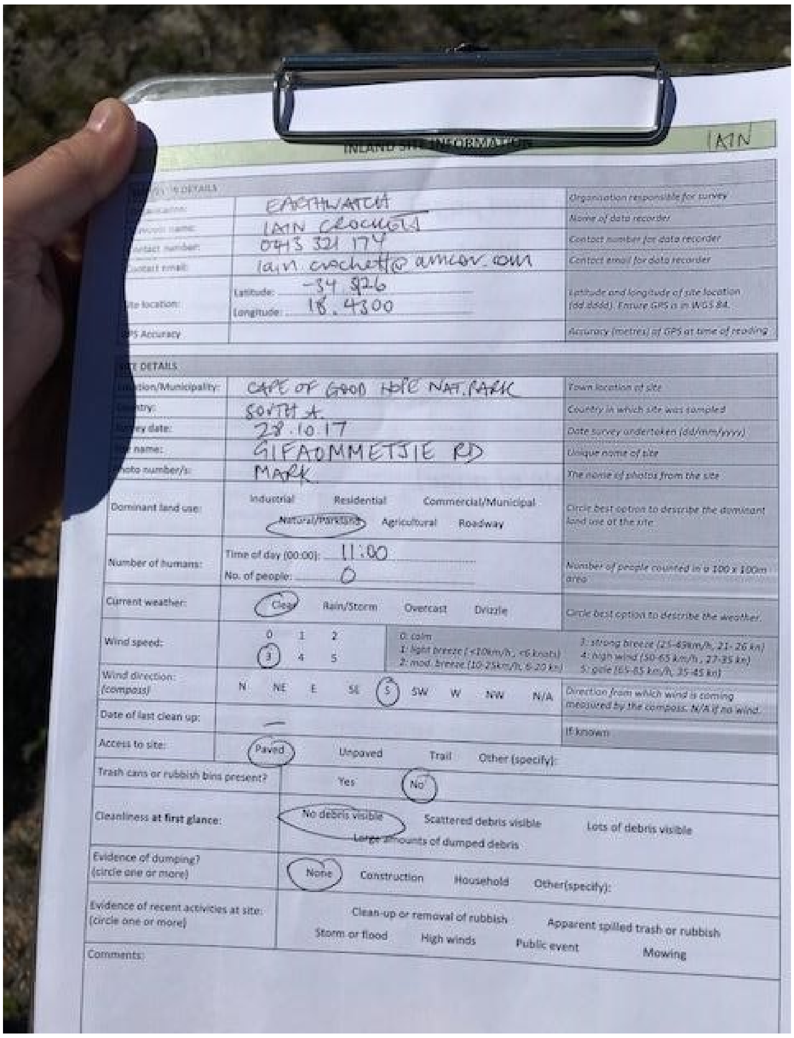

Figure 3. Site Information sheet used to collect data for every survey location.

At each site, a minimum of three and a maximum of six transects were carried out. For river and coastal surveys, transect lengths varied depending on site characteristics such as the width of the shoreline (distance from the waterline to the backshore vegetation) and riverbank height. There was no fixed length for these two survey types, the length of the transect was dependent upon the local environment, and each transect was 2 m wide. For inland surveys, survey dimensions were fixed at either 12.5 m long x 2 m wide, or 25 m long x 1 m wide.

Transects were laid out with a metre tape. For coastal and river transects, the transect always began at the water's edge and ran perpendicular until reaching two meters into the backshore vegetation. For inland transects, the starting point was that which was closest to the GPS location identifying the site. The transect was also divided into ten equal distance intervals that encompassed the full length of the transect. For example, an 18 m long transect would have ten 1.8 m intervals or segments. Typically, two people walked the transect (each surveying a 1 m wide swath) while a third person recorded the debris category for every item found, and whether it was a whole item or a fragment. This information allows us to understand whether the items are likely to have been recently littered or are slightly older and more degraded. Observers were each provided with a string that was one meter wide to ensure only items within the survey width were recorded. This prevents errors that can occur if observers include items that may fall just outside the one meter wide transect zone.

Each item observed was recorded in a debris category (See Appendix A). The size class was also recorded for the first item found in each distance interval (and if no item occurs in that distance interval a 0 or dash (-) was recorded). The purpose of recording this size information is to gain an indication of the sizes of items across the each transect. We are striking the balance between time required and important information to collect. We acknowledge it would be too time consuming and labour intensive to record the size of every single item (particularly since we can sometimes report hundreds or even thousands of items on an individual transect).

For an in-depth methodology on all survey types please refer to the CSIRO handbook which can be found here (Schuyler et al. 2018).

2.1 Analysis

To design effective interventions and prevent mismanaged waste from entering the sea, it is important to understand what is driving the distribution of debris. Based on previous work, we investigated several different factors that could influence debris distribution. At each survey site, we collected information on the local conditions, including the number of visible humans, the slope of the land, the height of the vegetation, the percent of the transect that was bare ground, and the substrate colour (see Schuyler et al. 2018 for example data sheets).

We also integrated information from globally available GIS layers, including the local population density, land use type, distance to the nearest road, distance to the coast, distance to the nearest river and distance to the nearest railway station. We also used proxies for socio-economic status, including night lights within 1 km radius of the site. Additionally, we included a measurement of the total monetary value of the built environment (both rural and urban), calculated by the United Nations as part of a global exposure dataset aimed at disaster risk management (UNDDR, 2015). We put these covariates into a statistical model, designed to determine which factors are most strongly correlated with debris amounts in the survey sites. We used the R program mgcv and MuMin packages (Wood, 2011; R Core Team, 2018; Bartoń, 2018) to find the model with the lowest AIC value, which explains the most amount of the variability in the data. More than one model was within two AIC points of the best model, which means they are essentially equivalent models. In order to incorporate information from all relevant models, we used model averaging to get the best-fit model.

For coastal analyses, we used an offset of lineal metres for the model, to reflect that the measure of interest was the amount of debris along the lineal coast, while for inland analyses, we used the offset of the area of each transect. We examined residuals of the models to look for indications of non-linear patterns in explanatory variables. We ran comparative models using some variables as categorical, or continuous smoothed variables to identify better fit. To be able to directly compare the covariates and determine which best predicts the observed debris amounts, we calculated the effect size. Terms with a positive effect size have a positive correlation with the amount of debris, while terms with a negative effect size are negatively correlated with the amount of debris. In other words, the higher the value of the covariate, the lower the amount of debris. The higher the absolute value of the effect size, whether positive or negative, the more that particular covariate explains the variability in the debris found (Figure 13 and Figure 16).

3 Results and Discussion

A total of 7365 debris items were detected and recorded across the 65 sites surveyed.

The ten most abundant fragment debris items included glass and hard plastic, as well as brick/cement, cigarette butts and food wrappers (Figure 4). The most common fragment item was unknown/other glass with 35.4% of all fragment items found, followed by unknown/other hard plastic at 17.9%.

The ten most abundant whole debris items found across all the surveys included lids or caps, lollipop sticks, cigarette butts, straws and food wrappers (Figure 5). The most common whole item was bottle cap/lid, with 16.8% of all whole items found, followed by lollipop stick/earbud at 11.8%.

In terms of debris density, inland surveys had the highest debris density with 2.05 items found per m^2 (Figure 6). Overall, inland debris density was 4 times that observed at coastal sites, and 3.4 times that observed at river sites.

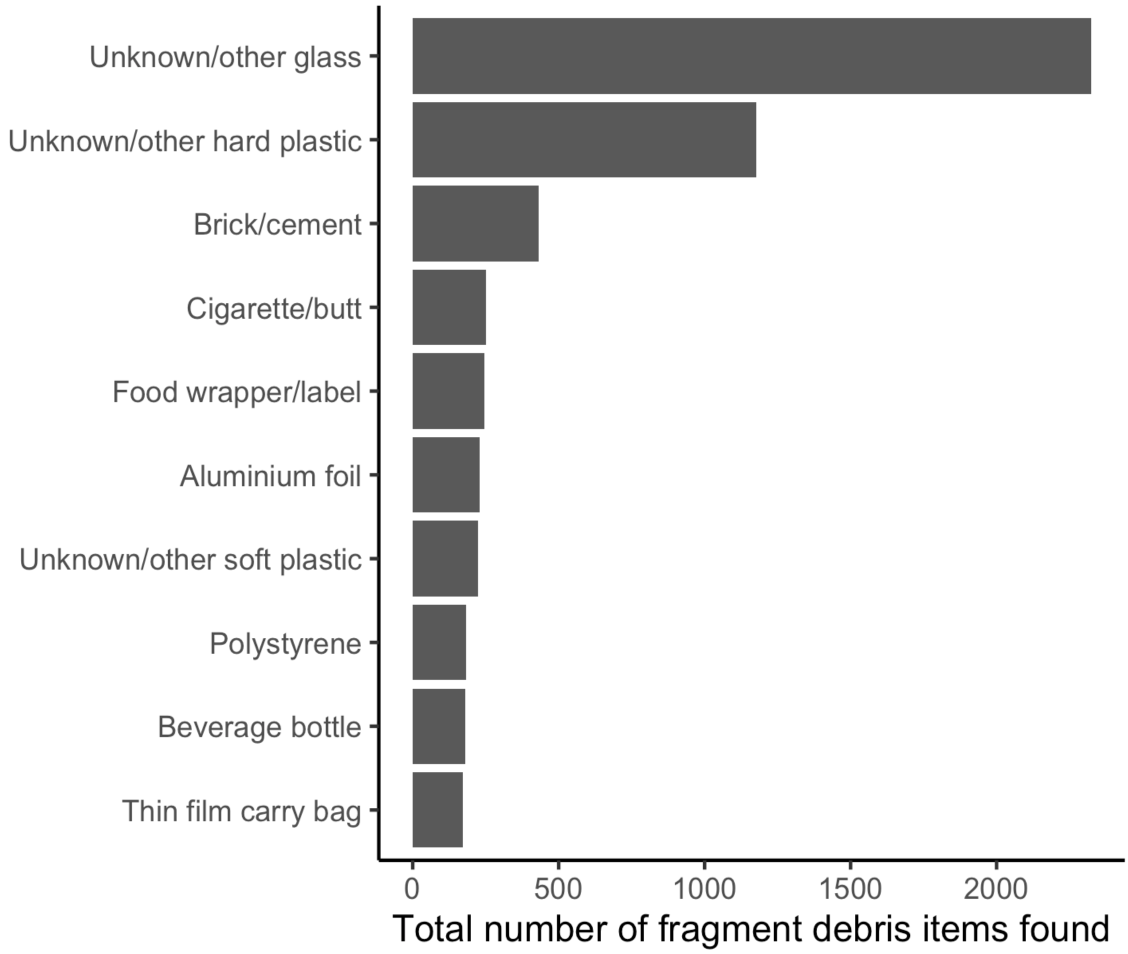

Figure 4. The ten most abundant debris items (fragments) found across the coastal, inland, and river surveys combined.

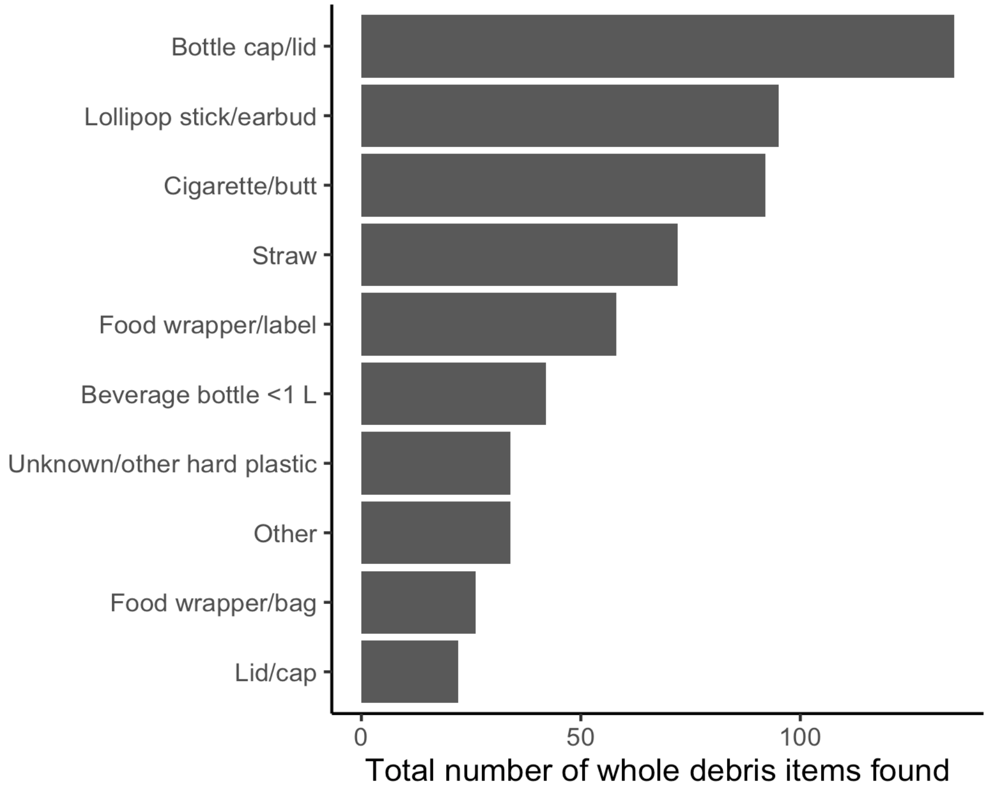

Figure 5. The ten most abundant debris items (whole) found across the coastal, inland, and river surveys combined.

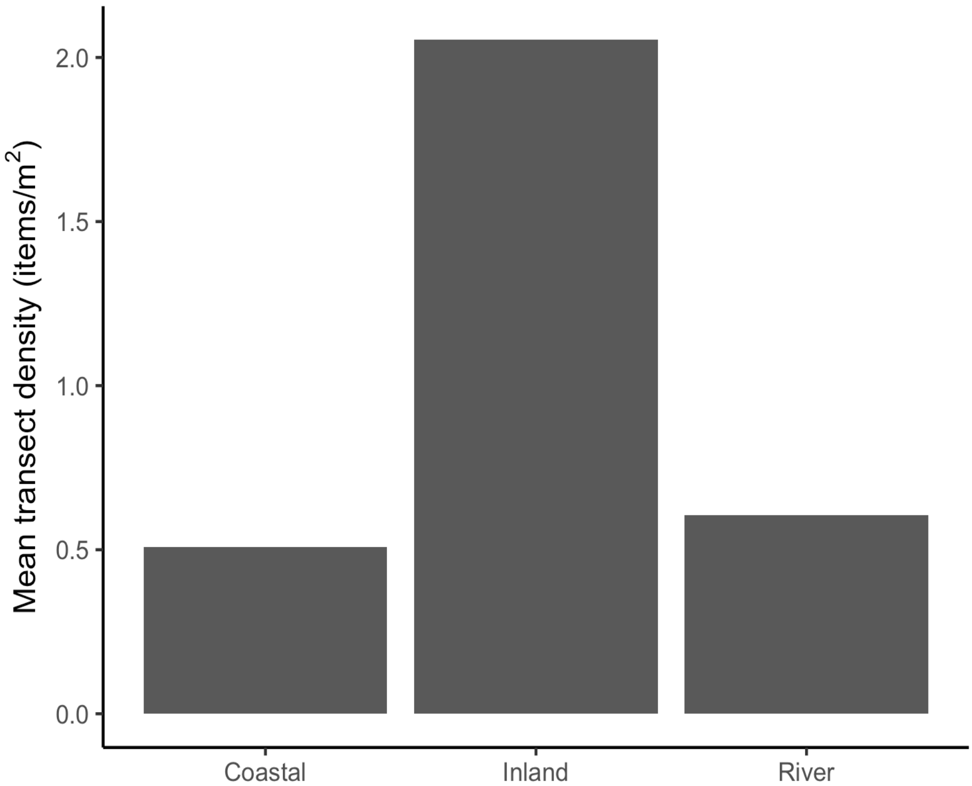

Figure 6. The mean density of debris found on transects for coastal, inland and river surveys.

3.1 Coastal Surveys

A total of 105 transects were completed at 31 coastal sites. Overall, 2847 items were recorded within coastal surveys. On average, across all transects, 13.56 items of debris per lineal metre of coastline were recorded within the Cape Town region.

Unknown/other hard plastic was the most common *fragment* type found with 837 pieces or 35.42% of the total fragment items recorded. Unknown/other glass was the second most recorded item with 447 items recorded and unknown/other soft plastic was the third most common, with 147 pieces recorded.

Bottle cap/lid was the most common *whole* item found with 99 pieces or 20.45% of the total whole items recorded. Lollipop stick/earbud was the second most recorded item with 79 items recorded and straw was the third most common, with 65 pieces recorded.

Figure 7. Coastal debris transect.

A size class was estimated for 369 debris items with size class 4 being the most common found (size class 4 objects are larger than 4 cm x 4 cm, but smaller than 8 cm x 8 cm). For further information refer to the size class chart in the [Marine Debris Survey Handbook] (https://research.csiro.au/marinedebris/resources/). Of all items recorded, 22% were 16cm^2 or smaller.

There was substantial variation in the number of debris items observed across the coastal surveys (in the unit of log number of items per lineal metre) (Figure 8). The highest number of items found on a coastal survey was at site SACC21 located at Hout Bay beach,-34.047, 18.357. Of the 428 items recorded at this site, 128 of them were classified as H10_F: Pipe/PVC whole.

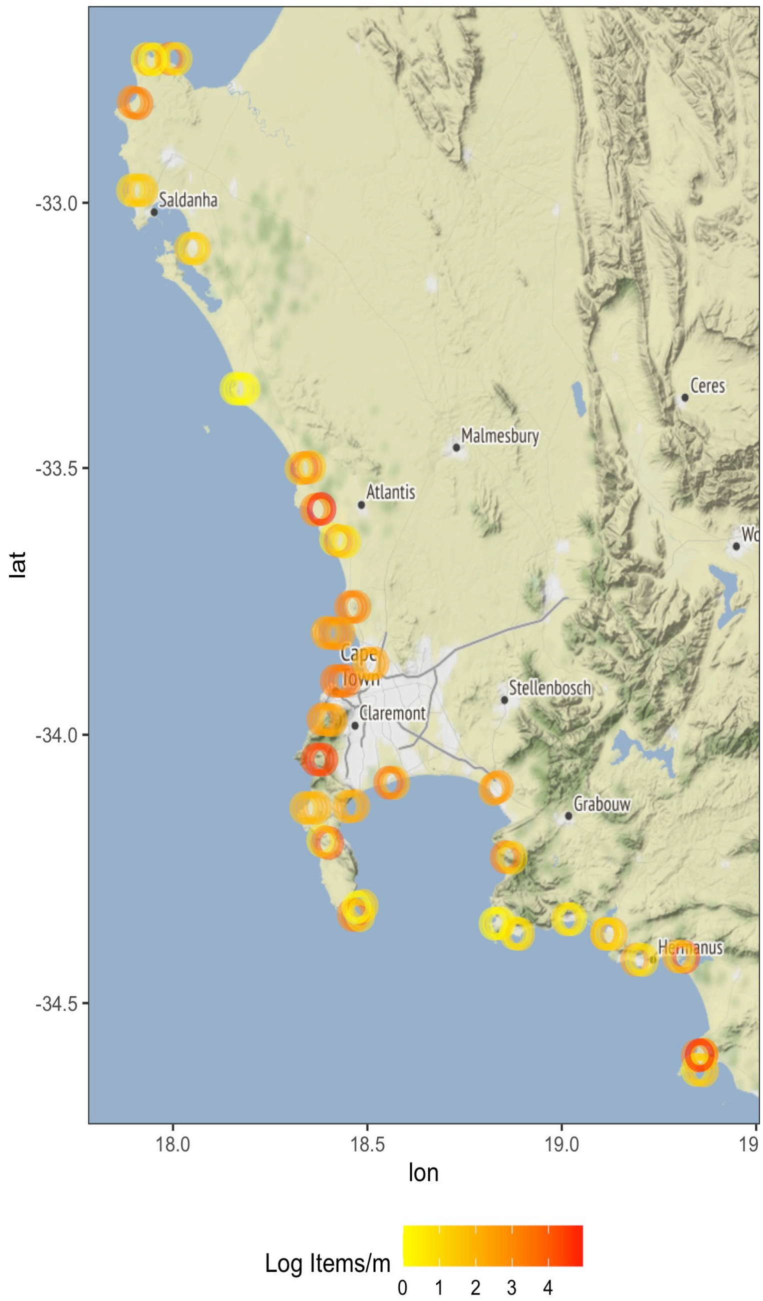

Figure 8. The log number of items per lineal metre for coastal sites near Cape Town, South Africa.

The size of the items found can provide us with useful information. In coastal regions near urban centres we see a lower fragment to whole item ratio (i.e. a higher proportion of whole items), which suggests that the items found on the beach are newer – i.e. they have not been in the environment as long, and thus are more likely to be intact. This also may suggest a larger role for wind transport and direct deposition (people dropping rubbish) in accumulating debris in these areas. This lower fragment ratio also suggests that clean-ups near towns do not fully compensate for local inputs of marine debris, although they undoubtedly reduce the amount of debris, densities are still elevated near urban areas suggesting they serve as debris sources.

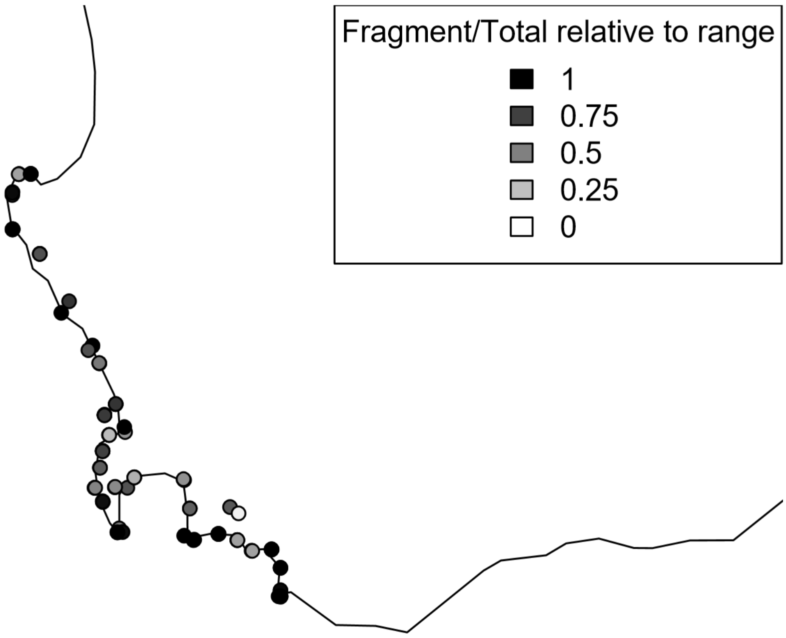

Figure 9. Proportion of debris items found as fragments versus whole items.

3.1.1 Does aspect of the beach affect the debris loads we see at coastal sites?

We are interested in whether the aspect of a coastal survey site has any correlation to the debris loads found at that site. We found that north-facing and north-west facing, and to a lesser extent south-facing sites demonstrate a higher debris load compared to other aspects. The results are shown in Figure 10. This is likely due to a mixture of onshore forcing due to winds and/or currents near Cape Town, where there are several north facing survey sites with high loads, and at south facing sites near Franskraal where there appeared to be high concentrations of debris deposited from the sea. These sites differ in that those near Cape Town appear to have mostly urban sourced materials that are likely from the immediate Cape Town area, while those near Franskraal appear to have come from ocean sources and may have originated further away.

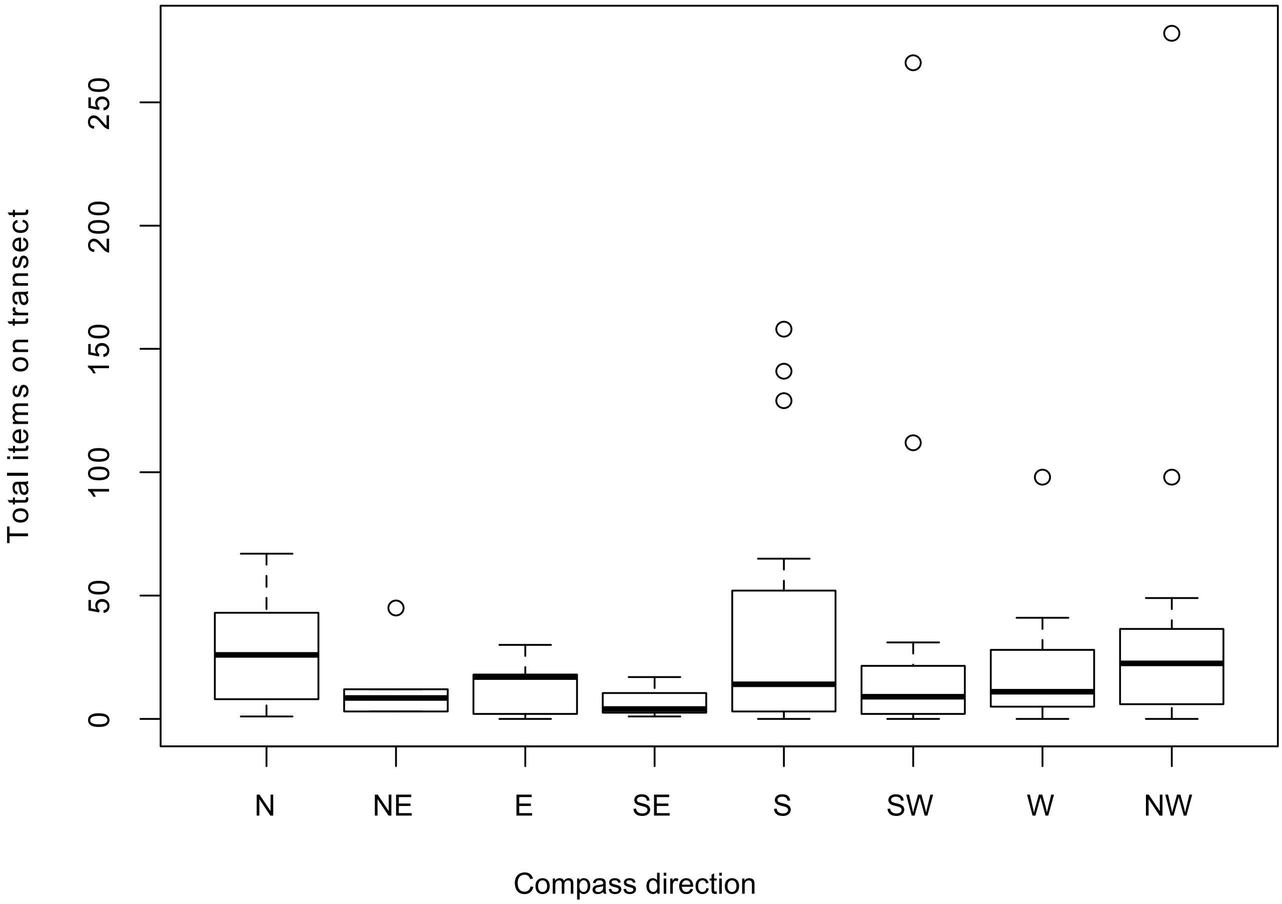

Figure 10. Bar plot showing the correlation between site aspect and debris load.

3.1.2 What influences sampling variation?

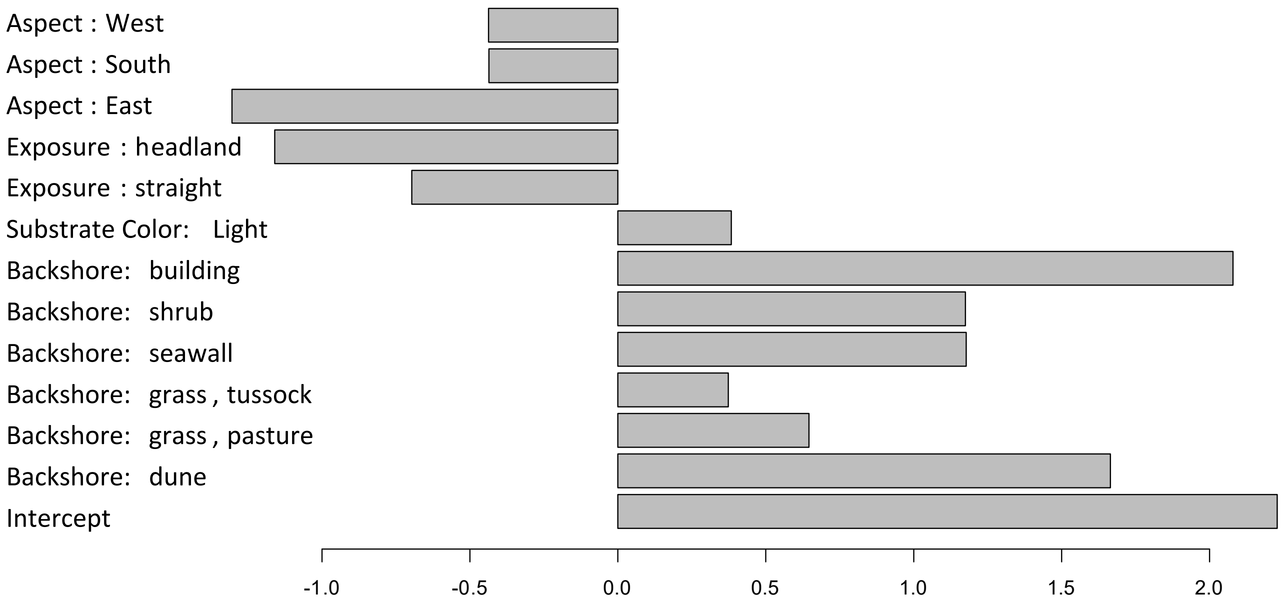

Figure 11. Positive and negative effects of particular covariates in marine debris surveys.

We used a statistical model to investigate the important factors affecting the amount of debris found at survey sites. The analysis for the coastal debris sites has been completed, while the inland and river sites are still in process. We evaluated a wide range of combinations of potential factors, and used a statistical technique to select the best model out of all the possible combinations. The final best model included the aspect of the site (i.e. compass bearing toward the ocean), the shape of the coastline in the immediate area, the colour of the ground surface at the survey site, and the type of vegetation or land use inshore from the survey site. Figure 11 gives a graphical representation of the statistical coefficients for each of these variables. For instance, sites with an easterly aspect had a more negative coefficient than those with a westerly or southerly aspect. This means that the statistical model suggests those sites have lower debris loads, due to that aspect in comparison with other possible values of the variable. Variables with positive coefficients increase the level of debris at a site. The model is based on a linear equation, with an intercept term and various coefficients adding to the slope of the linear relationship. This model can be expanded to include the effects of population size, socio-economic variables, transport infrastructure and other potentially relevant factors. Each of these factors can be tested to determine the best overall set of explanatory variables. One important advantage of this approach is that it captures the marginal contribution of each variable, while including the contributions of all of the other ones at the same time.

3.1.3 What is the pattern within the region?

The statistical model discussed above also included a spatial surface as one of the model components (Figure 11). This surface captures the unexplained variation in the data, due to purely spatial processes like plastic waste blowing from a source to a nearby site that would otherwise be clean, and from variables that were not included in the analysis. For example, the highest density of plastic waste in the spatial surface is in the central Cape Town region. Since we have not included the population in the area around each survey site, the spatial component of the model captures that effect along with other ones. It likely integrates the effect of ocean currents, winds, and other transport processes.

Using this statistical model together with the site characteristics outlined above, we can correct for factors that might bias the count of debris at particular sites. For instance, low gradient beaches in bays tend to have higher debris loads. But, that is a function of the coastal shape and gradient, not of the supply of debris in the environment. Using a statistical model as presented here, we can account for these potential biases and uncover important patterns such as the role of Cape Town in driving debris loads in the region, or the effect of the Kogelberg Nature Reserve in restricting access and inputs, and thus having lower coastal loads (red is high density, green is low density).

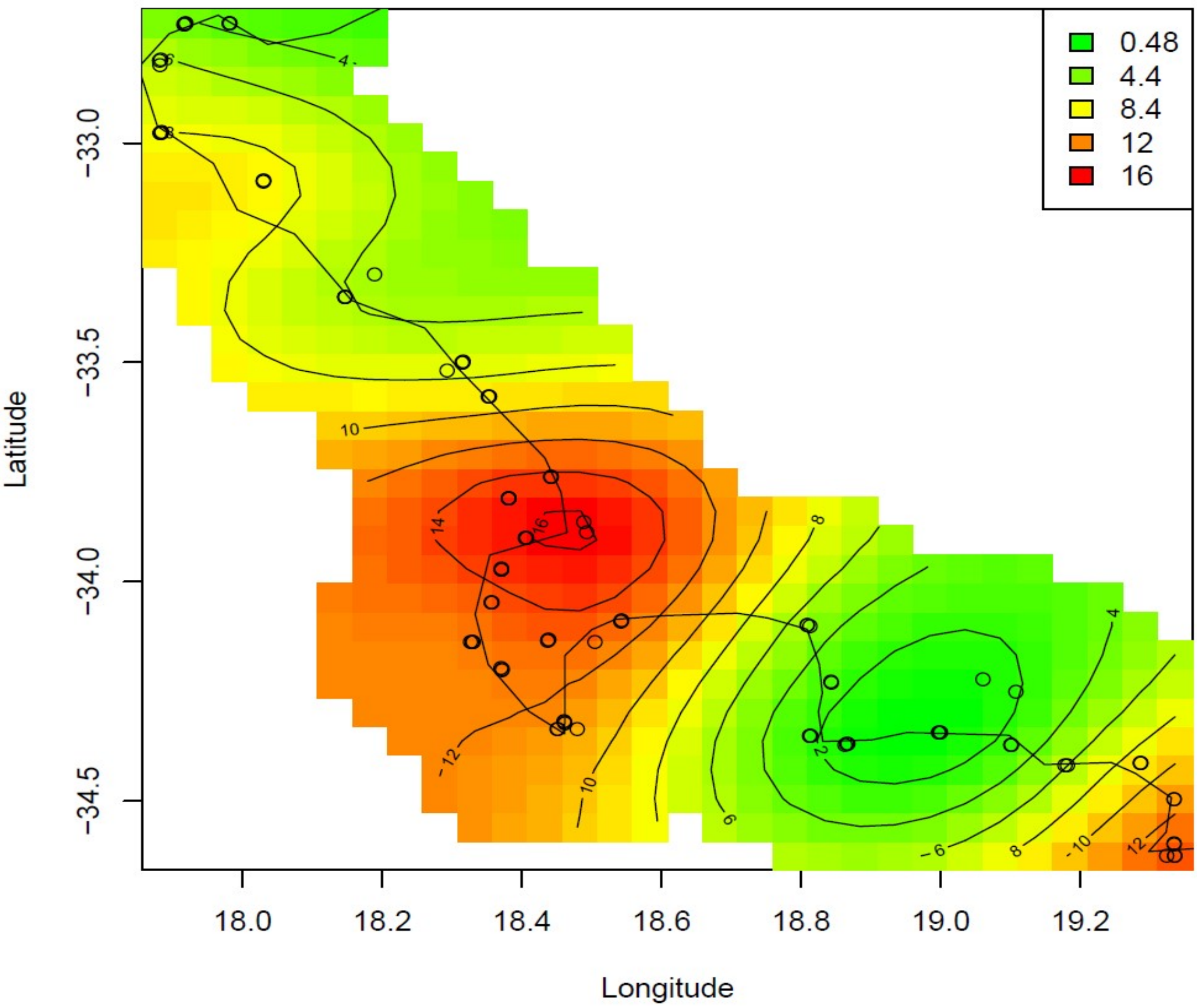

Figure 12. Debris load heat map showing correction for site characteristics.

In South Africa, after running the GAM modelling, six coastal models were functionally equivalent, based on AIC values. These models were averaged to get the best final model. In the best final model, two terms were statistically significant. While the remaining terms were not statistically significant at p = 0.05 level, they did explain some of the variability in the model, and thus were left in the model. The terms with the highest effect size were landuse and the shape of the site, with higher quantities of debris in Villages, Rangelands and Forested areas than in Croplands, and higher amounts of debris in concave shaped sites than straight or convex sites.

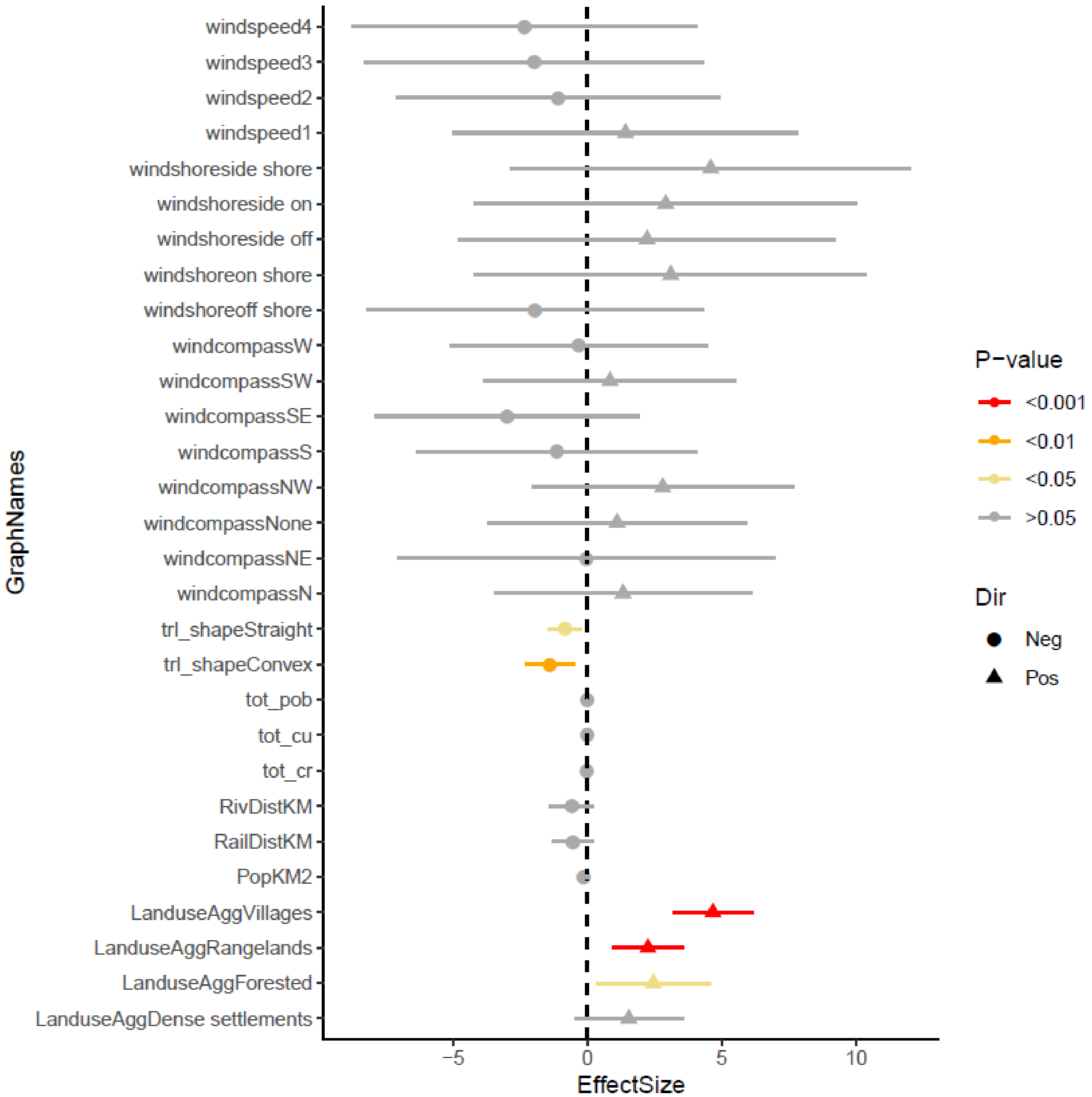

Figure 13. Model average effect size plot for coastal transects. Colour represents the p-value significance level, and the lines are the standard error for each term. Triangles denote a positive coefficient for a given factor, whereas circles denote a negative coefficient. The effect size is calculated as the median value of the factor times its coefficient. Reference variables for categorical variables were a windspeed of 0, no wind for wind relative to the shore, wind compass (direction of the wind) of East, trl_shape (the shape of the shore) is concave, and LandUseAgg (predominant landuse in the area around the site) is Croplands.

3.2 Inland Surveys

The team completed 78 transects at 23 inland sites across a range of site types including roadways, car parks, natural vegetation and agricultural landscapes (Figure 14). A total of 3983 items were recorded on inland transects, equivalent to an average of 2.05 pieces of debris for every square metre of land surveyed.

Unknown/other glass was the most common *fragment* type found with 1849 pieces or 49.33 % of the total fragment items recorded. Brick/cement was the second most recorded item with 370 items recorded and unknown/other hard plastic was the third most common, with 268 pieces recorded.

Cigarette/butt was the most common *whole* item found with 74 pieces or 31.49 % of the total whole items recorded. Food wrapper/label was the second most recorded item with 21 items recorded and bottle cap/lid was the third most common, with 17 pieces recorded.

A size class was estimated for 366 debris items with size class 3 being the most common found (size class 3 objects are larger than 2 cm x 2 cm, but smaller than 4 cm x 4 cm). For further information refer to the size class chart in the Marine Debris Survey Handbook. Of all items recorded, 44% were 16 cm^2 or smaller.

Figure 14. Transect method of debris survey at inland sites, urban (L) and rural (R).

There was substantial heterogeneity in the number of debris items observed across the inland surveys (in the unit of log number of items per square metre) (Figure 15). The highest number of items found on an inland survey was at site SACI02 located at -33.082, 18.036 Lelie St, Langebaan. Of the 1232 items recorded at this site, 887 of them were classified as G4_F: Unknown/other glass fragments.

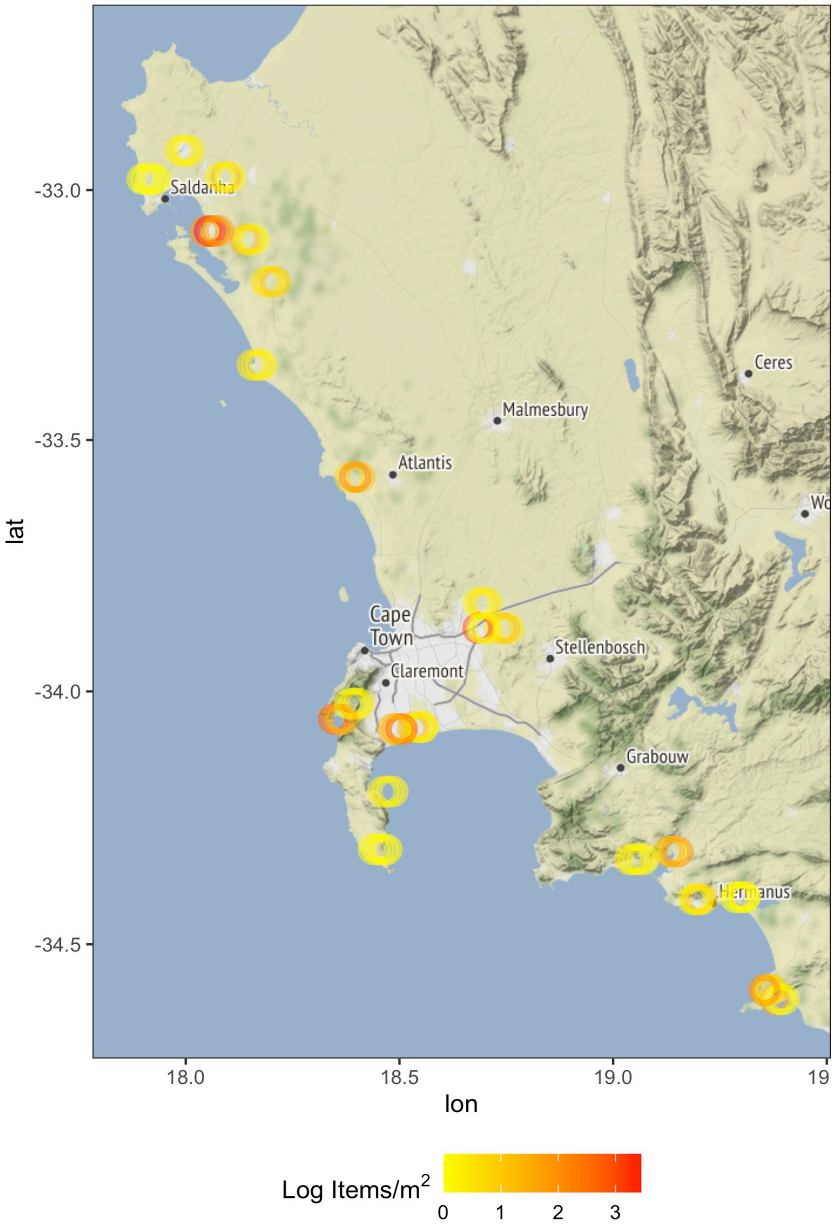

Figure 15. The log number of items per square metre for inland sites in South Africa.

In South Africa, after running the GAM, 18 inland models were equally as good as one another. These models were averaged to get the best final model. In the best final model, substrate colour and number of people visible were statistically significant. While the remaining terms were not statistically significant at a $p = 0.05$ level, they did explain some of the variability in the model, and thus were left in the model. The terms with the highest effect size were substrate colour, distance to river, and distance to rail stations. Light substrates had significantly higher debris than dark, probably due to the differential visibility of debris against different coloured backgrounds. There was more debris closer to rivers and farther from rail stations. Additionally, the brighter the nightlights and more people seen in the area during debris surveys, the higher the amount of debris found.

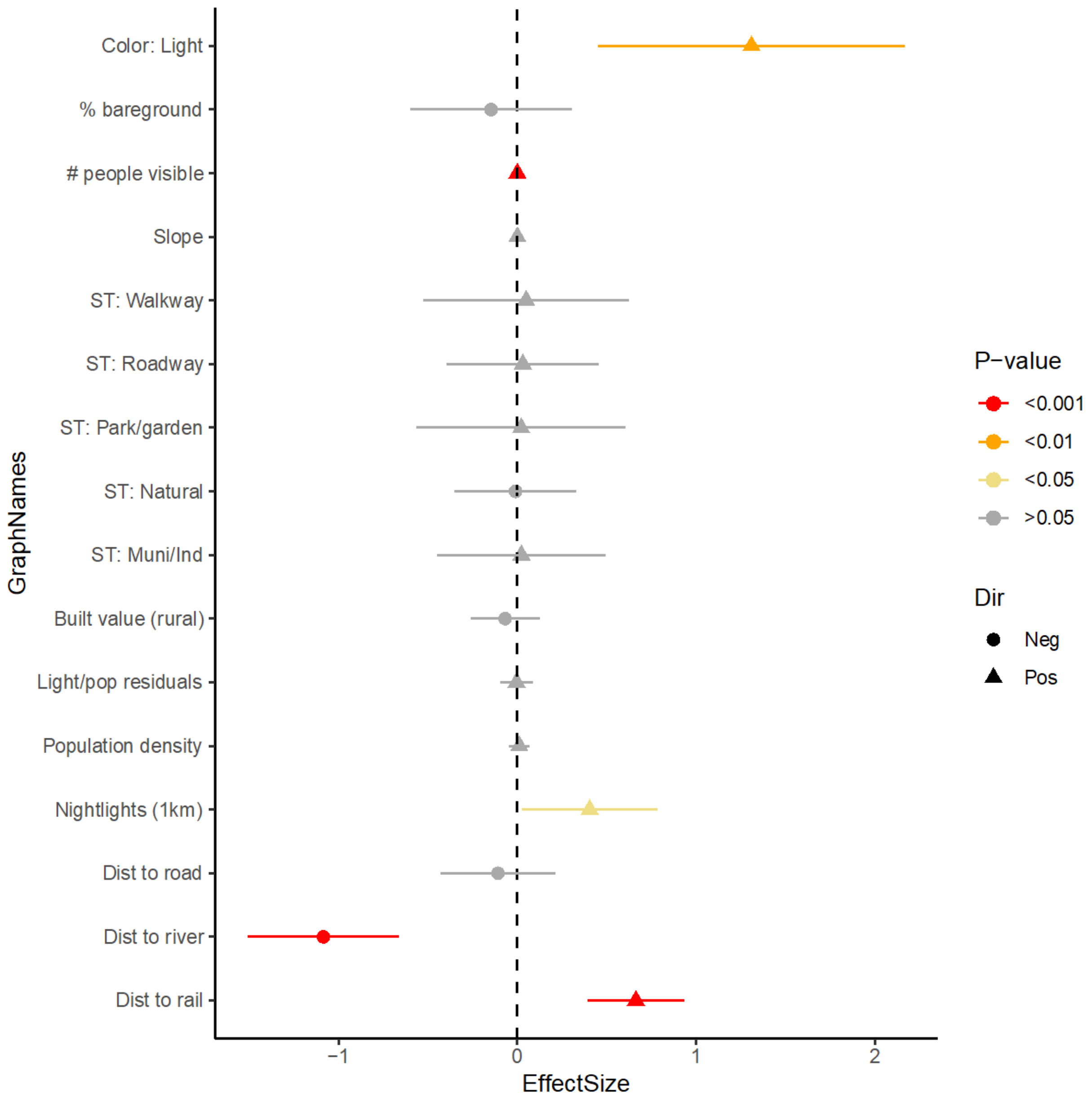

Figure 16. Model average effect size plot for inland transects. Colour represents the p-value significance level, and the lines are the standard error for each term. Triangles denote a positive coefficient for a given factor, whereas circles denote a negative coefficient. The effect size is calculated as the median value of the factor times its coefficient. Reference term for Site Type is Agricultural, and for Colour is Dark.

3.3 River Surveys

A total of 39 river transects were conducted at 11 river sites. A total of 535 items were recorded in river surveys, an equivalent of 25.53 pieces of debris for every lineal metre of riverbank surveyed (on average).

Unknown/other hard plastic was the most common *fragment* type found with 71 pieces or 15.85 % of the total fragment items recorded. Food wrapper/label was the second most recorded item with 49 items recorded and polystyrene was the third most common, with 40 pieces recorded.

Bottle cap/lid was the most common *whole* item found with 19 pieces or 21.84 % of the total whole items recorded. Cigarette/butt was the second most recorded item with 9 items recorded and lollipop stick/earbud was the third most common, with 7 pieces recorded.

A size class was estimated for 103 debris items with size class 3 being the most common found (size class 3 objects are larger than 2 cm x 2 cm, but smaller than 4 cm x 4 cm). For further information refer to the size class chart in the Marine Debris Survey Handbook. Of all items recorded, 23% were less than 16 cm^2.

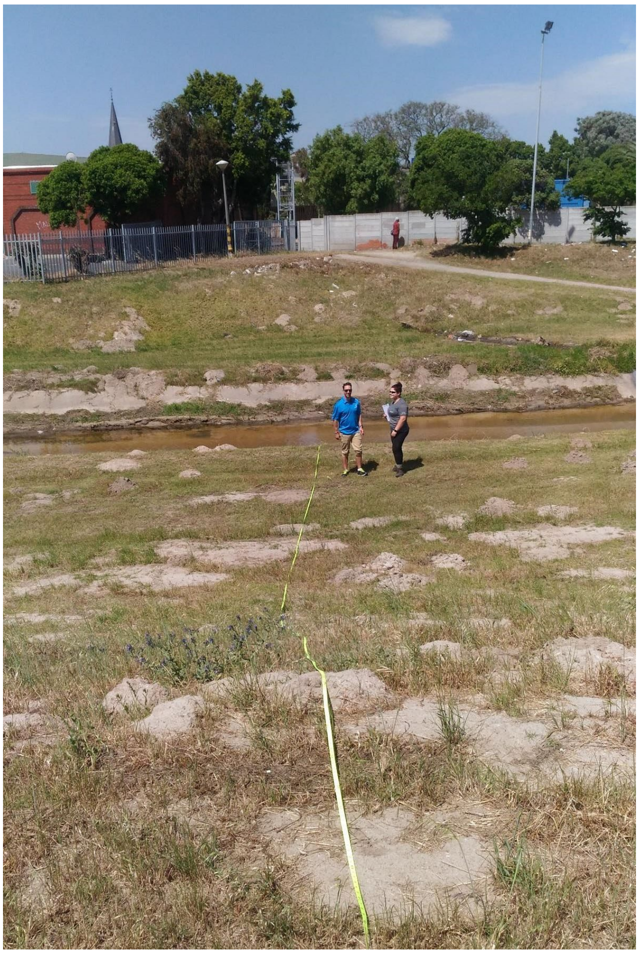

Figure 17. River surveys conducted from the water's edge to the top of the riverbank.

Figure 18 shows the variability in the number of debris items observed across the river surveys (in the unit of log number of items per lineal metre). The highest number of items found on a river survey was at site SACR06 located at -33.925, 18.675 accessed via Gazania St, Brantwood. Of the 116 items recorded at this site, 15 of them were classified as H10_F: Pipe/PVC whole.

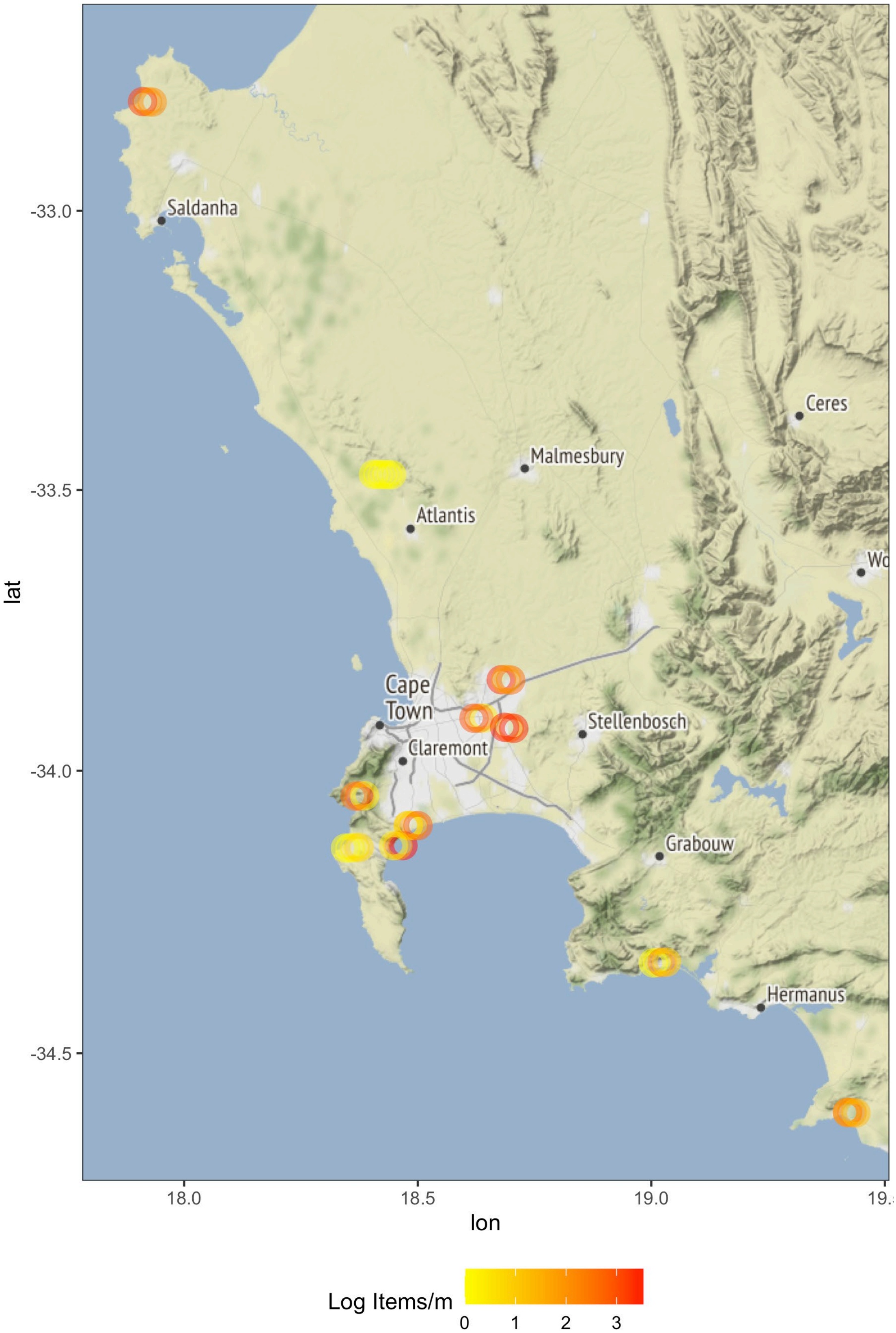

Figure 18. The log number of items per lineal metre for river sites near Cape Town, South Africa.

4 Summary

Surveying the Cape Town region of South Africa was a tremendous undertaking, which required substantial coordination, field effort by a large number of participants and patience and good humour by all. A total of 222 transects (including 105 coastal transects, 78 inland transects, and 39 river transects) were conducted. To our knowledge, the data collected provides the first comprehensive baseline look at plastics and other anthropogenic debris on land, along rivers and at the coastal interface for such a large portion of South Africa. While we acknowledge these data provide a ‘snapshot’ in time, this information can be used as a baseline against which change and seasonal differences in debris deposition and movement can be compared. Such information provides an important first step that can be used to inform policy and decision making. Furthermore, as new policies or practices are implemented, the data can be used to quantify the changes that may come with such policies, practices or awareness-raising campaigns. We also hope to use these data in conjunction with statistical models to produce figures that highlight the litter plume of this particular urban and nearby area.

The data collected here contributes to a world first, statistically robust, global baseline study of how much waste is lost to the coastal and marine environment. By using the same methodology and building capacity for individuals in multiple countries around the world, we are better able to make large scale predictions about not only local, but also national, regional and global debris losses into the environment. Additionally, we can look at differences we identify in types and amounts of debris across coastal, inland and riverine areas between countries to identify the drivers that may be similar or different amongst surveyed regions.

It appears that the amount of debris on the Cape Town coastline is around five times higher than the loads estimated along the Australian (10.2 items/m; Hardesty et al. 2016) and United States (16.5 items/m; Hardesty et al. 2017) coastlines based on previous survey work conducted by the CSIRO team. The total coastal debris load in Cape Town is similar to that of a similar study carried out using the same methods in Mombasa, Kenya, and ten times that in the Seychelles. Generally, the amount of debris around Cape Town coastline is similar to countries around the Indian Ocean but lower than for countries of east and south-east Asia. Using this dataset and others collected from around the world, ultimately we will be able to estimate the amount of waste, most of which is plastic, from these plumes that is lost to the open ocean or redeposited back to land. We are also able to discern regional differences that may occur. For instance, the most common debris item found in Kenya was hard plastics compared to Seychelles which was glass. With a robust, comparable baseline of information gathered in multiple major metropolitan centres around the world, we will have the data in hand to evaluate policy effectiveness and change through on-ground activities at local, national and international scales.

If this estimate is representative of the entire 2,800 km of South African coastline (downloaded from Wikipedia Feb/2021), this would equate to an estimated total debris load of nearly 38 million items along the entire South African coastline. We acknowledge that this is an estimate, given the variability in annual weather patterns, coastal topography, population density, and other factors, but it provides a useful baseline to understand the relative magnitude of the problem, based on the very best available data.

Given our work in Durban, where we found much higher coastal litter counts, we note that an estimate based on Cape Town would be a substantial underestimate of total coastal debris load. This is most likely a reflection not only of local currents and geography, but of local coastal clean-up efforts which are reportedly much, much higher in Cape Town and surrounds than they are in other coastal communities (including Durban).

Understanding the transport of plastics from land into marine systems is critical for modelling the distribution and trends of plastic in the ocean and estimating its impact on regional economies. This project will clarify the magnitude of this pollution to the public, to industry, and to policy-makers.

Appendix A

An example of the debris survey items list showing all debris categories

ITEMS LIST

Site ID Code: **Page _____ of ______**

Date: ☐ **No debris found**   **Transect No. ____ of ____**   **Subsampled? Y N**

	ITEMS	ID	Fragment	Whole
Hard Plastic	Pipe/PVC	H1		
	Beverage bottle <1 L	H2		
	Other bottle	H3		
	Bottle cap/lid	H4		
	Food container	H5		
	Utensil/plate/bowl	H6		
	Bucket/Crate	H7		
	Lighter	H8		
	Lollipop stick/earbud	H9		
	Unknown/other hard	H10		
Soft Plastic	Thin film carry bag	S1		
	Food wrapper/label	S2		
	Sheeting	S3		
	Cup/lid	S4		
	Straw	S5		
	Unknown/other soft	S6		
	Other plastic bag	S7		
Plastic Straps	String/rope/ribbon	BP1		
	Packing strap	BP2		
	Cable ties	BP3		
	Unknown/other strap	BP4		
Metal	Pipe	M1		
	Wire	M2		
	Aerosol	M3		
	Beverage can	M4		
	Food can/tin	M5		
	Lid/cap	M6		
	Food wrapper	M7		
	Aluminium foil	M8		
	Bucket/drum	M9		
	Unknown/other hard	M10		
	Unknown/other soft	M11		
Glass	Beverage bottle	G1		
	Jar	G2		
	Light globe/tube	G3		
	Unknown/other glass	G4		
Rubber	Thong/shoe	R1		
	Tyre	R2		
	Balloon	R3		
	Rubber band	R4		
	Unknown/other	R5		
Cloth	String/rope/strap	C1		
	Clothing/towel	C2		
	Wipes/cloths	C3		
	Insulation/stuffing	C4		
	Unknown/other	C5		
Timber	Wood/timber	T1		
	Utensil/food stick	T2		
	Bottle cork	T3		
	Pallet	T4		
	Unknown/other	T5		

	ITEMS Cont.	ID	Fragment	Whole
Foam	Food container	D1		
	Cup/plates/bowls	D2		
	Polystyrene	D4		
	Unknown/other	D5		
Paper	Cigarette/butt	P1		
	Paper/cardboard	P2		
	Magazine/newspaper	P3		
	Bag	P4		
	Box	P5		
	Food container/box	P6		
	Food wrapper/bag	P7		
	Beverage container	P8		
	Cups	P9		
	Plates/bowls	P10		
	Unknown/other	P11		
Fishing	Net	F1		
	Fishing line	F2		
	Fishing Lures	F3		
	Buoys/floats	F4		
	Glow stick	F5		
	Fishhook/sinker	F6		
	Unknown/other	F7		
Miscellaneous	Battery	Z1		
	Brick/cement	Z2		
	Carpet	Z3		
	Ceramic	Z4		
	E Waste	Z5		
	Furniture	Z6		
	Appliances	Z7		
	Large car parts	Z9		
	Large boat parts	Z10		
	Bag/box dom. waste	Z11		
	Nurdles	Z12		
Other		O1		
		O2		
		O3		
		O4		
		O5		
		O6		

Size class (and sub-sampling intervals)

Interval start (m)	Dist on tran	ID (F/W)	Size class
1 0 -			
2			
3			
4			
5			
6			
7			
8			
9			
10 - (end)			

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