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Marine Debris Field Report: Cape Town, South Africa

Earthwatch marine debris surveys, October 2017

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Acknowledgments

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Thanks to Andreas Haas for her great work organising the logistics and operations in the field.

In particular, we thank our volunteers on the ground in South Africa: Iain Crockett, Ben Jenner-Leuthart, Nicole DuBois, Alex Resquin Silingovschi, Luana Meirelles, Dorothea Kleffel, Mark Morgan, Ajay Kumar, Nur Alfi Lailah Ashar, Gerald Rebitzer, Megan Pray, Natalya Kamenkova, Brooke Higgenbotham, Jennifer Lopez, Dominique Besseux, and Manfred Smith.

Foreword

Plastic volume in the ocean is increasing rapidly, affecting wildlife, economies and potentially human health. Recent modelling suggests approximately 8.4 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). There has been very little data collected to empirically document the existence of these extensive plumes and validate the model estimates.

We are developing a world-first empirical baseline estimate of mismanaged waste entering the marine environment around major urban centres. The data collected will clarify the magnitude of this pollution to the public, to industry and to policy makers. We are aiming to conduct this research in countries all over the world. CSIRO has joined with Earthwatch and Amcor to help achieve this goal.

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1 Introduction

In October 2017 Earthwatch and CSIRO took 16 Amcor employees from all over the world to Cape Town, South Africa. The purpose of this expedition was to estimate the plume of debris coming from the Cape Town region. We did this by acquiring a baseline measurement of marine debris along a 350km stretch of coastline of South Africa between St Helena Bay and Franskraal, and measuring what debris may be moved into the marine environment by wind and water from the land and riverways. To do this we conducted three different types of surveys: Coastal, Inland and River surveys.

1.1 Site Selection and Study Area

We selected a region roughly 350km long and 50km wide along the Cape Peninsula to conduct this study. Our target study area includes 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.

Over a two week period, we successfully completed debris surveys at a total of 65 sites (Figure 1.2).

1.1.1 Coastal sites

Coastal sites were selected between St Helena Bay to the north and Franskraal to the south of Cape Town at roughly 25km intervals along the coastline. Some sites were unable to be surveyed due to access constraints, and where this occurred the survey site was moved to the nearest accessible location.

1.1.2 Inland sites

In selecting our inland survey sites, we placed a 5km grid over the study region and selected the centre of each 5x5km cell (Figure 1.1). We then used a geographic information system (GIS) to extract the variables describing conditions at each of these points. The extracted variables included: population, land use, and distance to the nearest road, distance to the coast, distance to the nearest river and distance to the nearest railway station along with some socio-economic variables such as the numbers of people who are employed/unemployed and the number who had finished school.

1.1.3 River sites

We were interested in surveying only those waterways that drained to the coastal margin within the coastal survey region. River sites were selected on rivers draining to the coast and that were within 2km of an inland site, for ease of access and to limit the time spent driving time between survey sites.

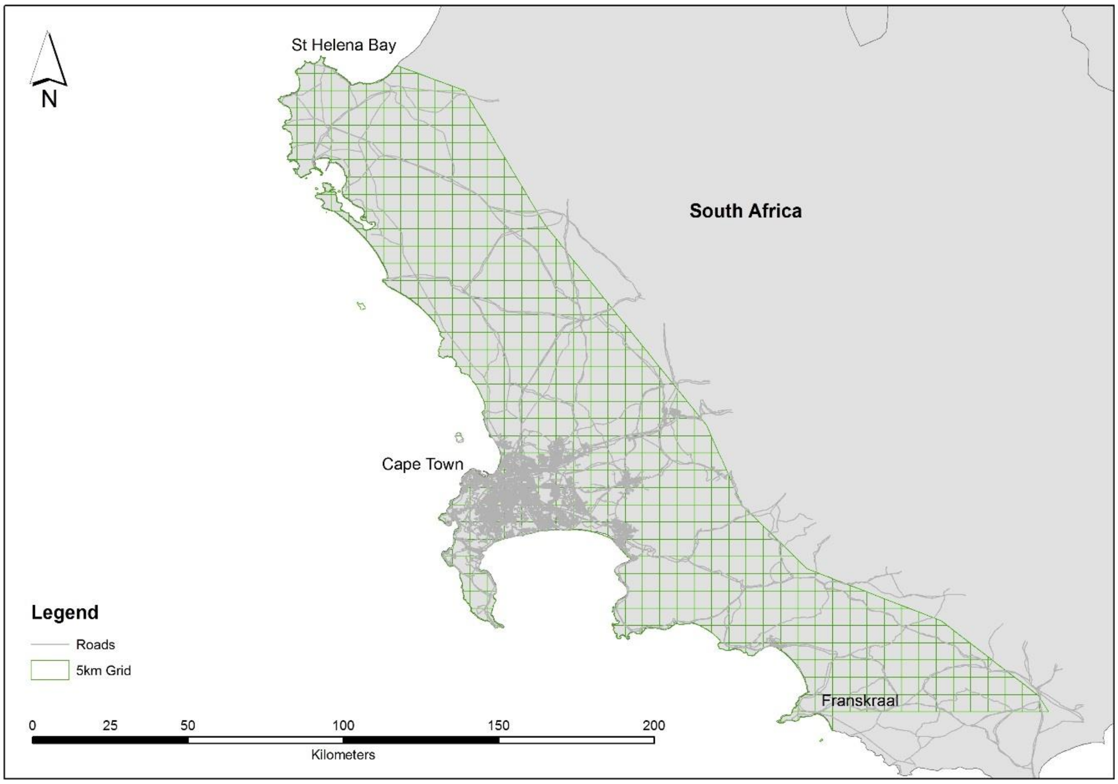

Figure 1.1 Target study area for coastal, riverine and inland debris surveys, along the Cape Peninsula, South Africa, showing the 5km grid used to select the locations for inland debris surveys.

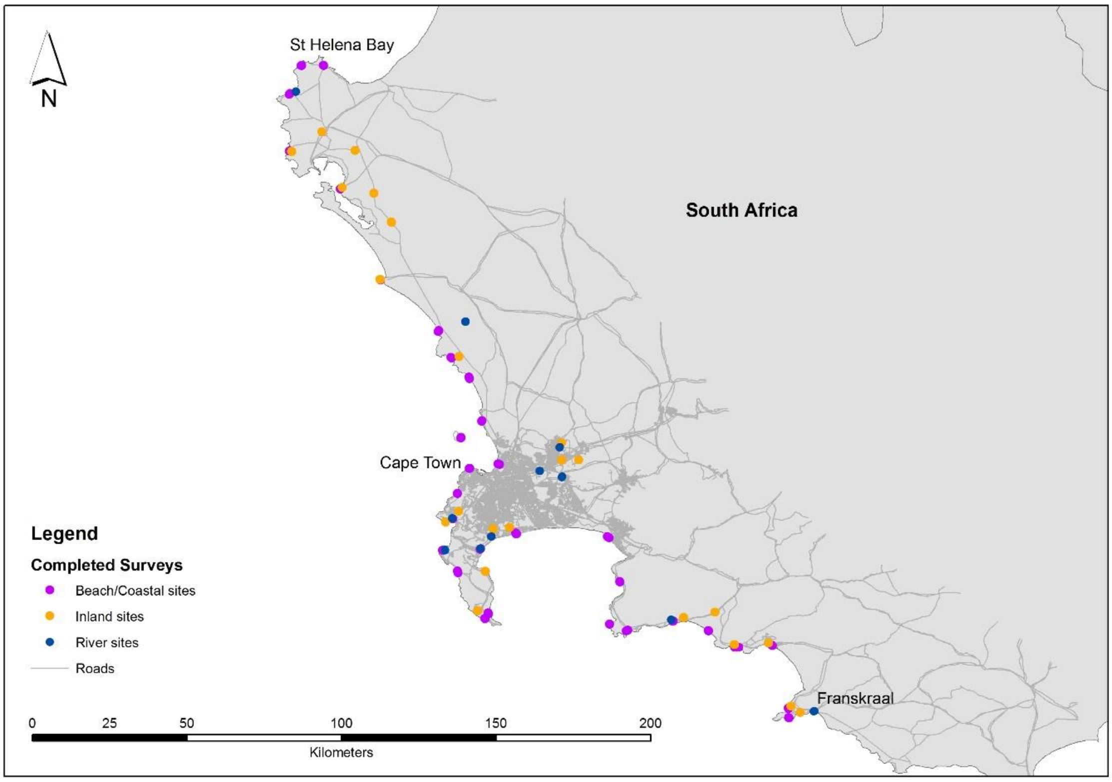

Figure 1.2 Location of completed surveys along the Cape Peninsula, South Africa

2 Methods

Debris was measured in at each site using a fixed area search, frequently known as a transect. Transect lengths varied depending on site characteristics such as the width of beach (distance from the waterline to the backshore vegetation) and river bank height.

Once a site was chosen, a **Site Information** sheet was completed before any surveys took place. This information sheet collected information about the site's aspect, accessibility, apparent cleanliness, number of people present, as well as weather conditions, time of day, and details of the survey recorder. An example is show in Figure 2.1.

Transects were then laid out and split into intervals of 10. Two people walked the transect whilst a third person recorded every item found. Each recorded item was placed into a debris category, and a size class was taken on the first item found in each interval. An example of our **Items List** showing all debris categories is shown on page 19. Three to six transects were completed at each site. For an in-depth methodology on all survey types please refer to the CSIRO Marine Debris Survey Handbook (link in References).

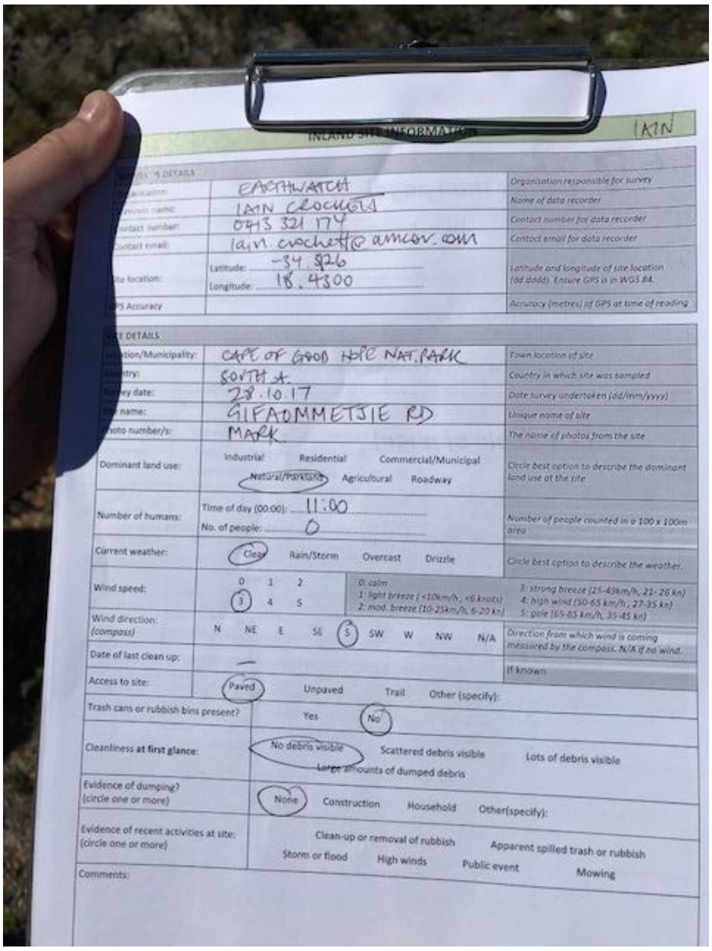

Figure 2.1 Site Information sheet used to collect data for every survey location.

3 Results

3.1 Coastal surveys

A total of 103 transects measuring a total of 3,356m were surveyed in 31 coastal sites. A total of 2,818 items were recorded. This is equivalent to 1.2 pieces of debris being found on every 1m of surveyed beach. **H10F** (unknown hard-plastic fragment) was the most common item found with 834 pieces, almost 30% of the total items recorded. **G4F** (unknown glass fragment) was the second most recorded item with 423 pieces and **S6F** (unknown soft-plastic fragment) had 147 pieces recorded. A size class was estimated for 470 pieces with a size class 4 being the most common found (*size class 4 objects are greater than 3.5cm x 3.5cm but less than 7cm x 7cm. For further information refer to the size class chart in the CSIRO Marine Debris Survey Handbook*).

Sixty-two percent of all items found were 4cm^2 or smaller.

Figure 3.1 Transect method of conducting a coastal debris survey

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 (ie, 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 suggests 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.

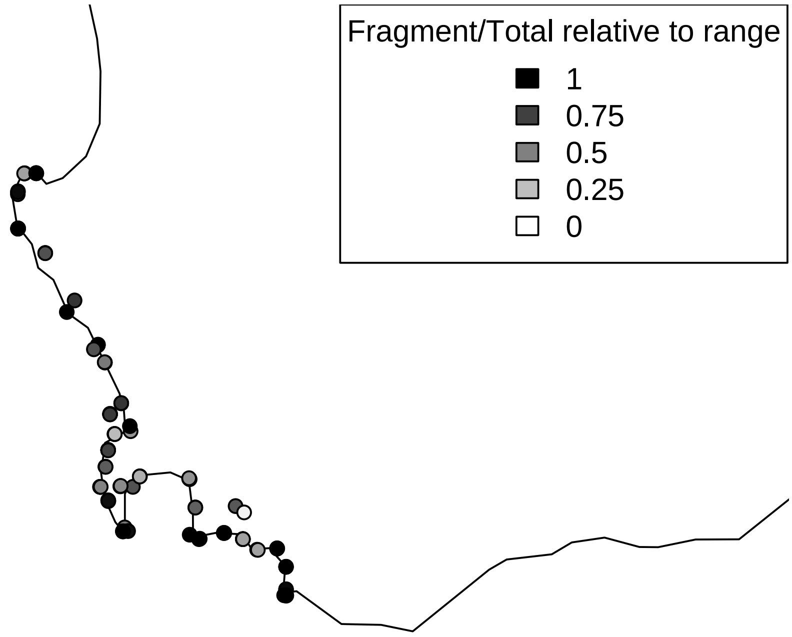

Figure 3.2 Proportion of debris items found as fragments versus whole items

Does aspect of the beach affect the loads we see on beaches?

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 3.3 Bar plot showing the correlation between site aspect and debris load. This is likely due to a mixture of onshore forcing due to winds and/or currents near Capetown, 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 Capetown appear to have mostly urban sourced materials that are likely from the immediate Capetown area, while those near Franskraal appear to have come from ocean sources, and may have originated further away.

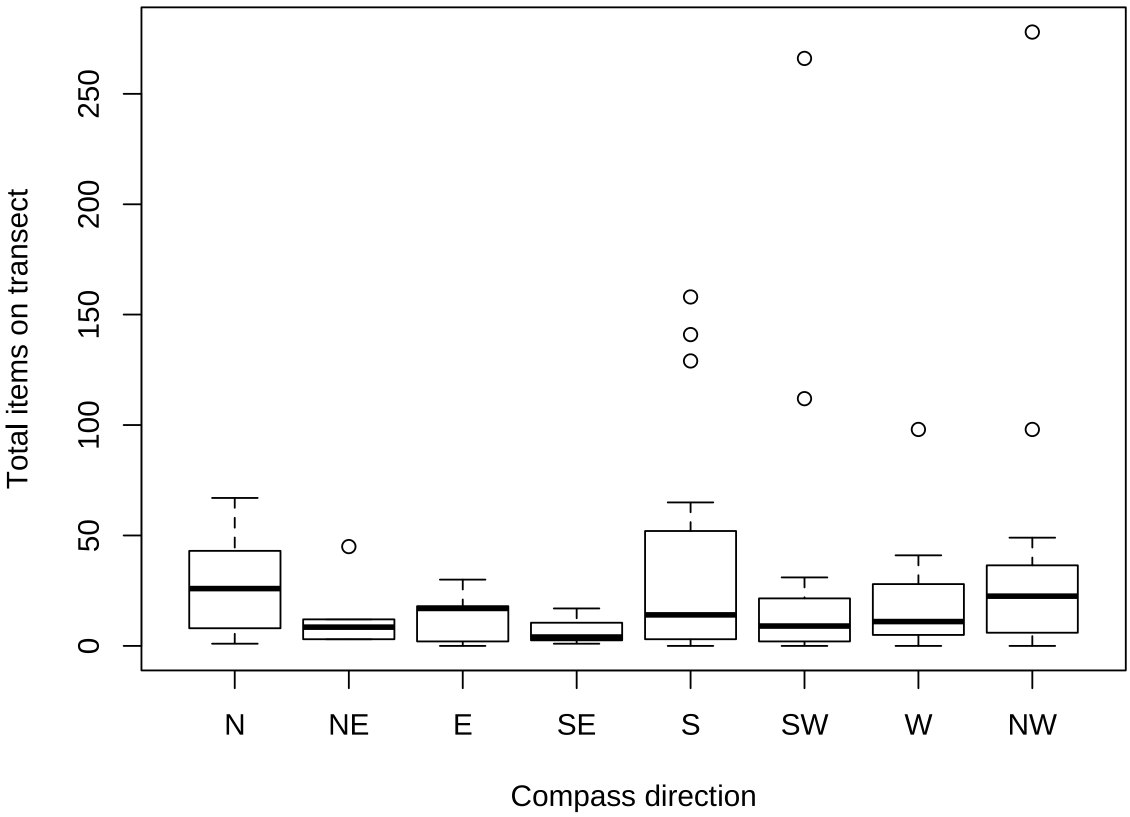

Figure 3.3 Bar plot showing the correlation between site aspect and debris load

What influences sampling variation?

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

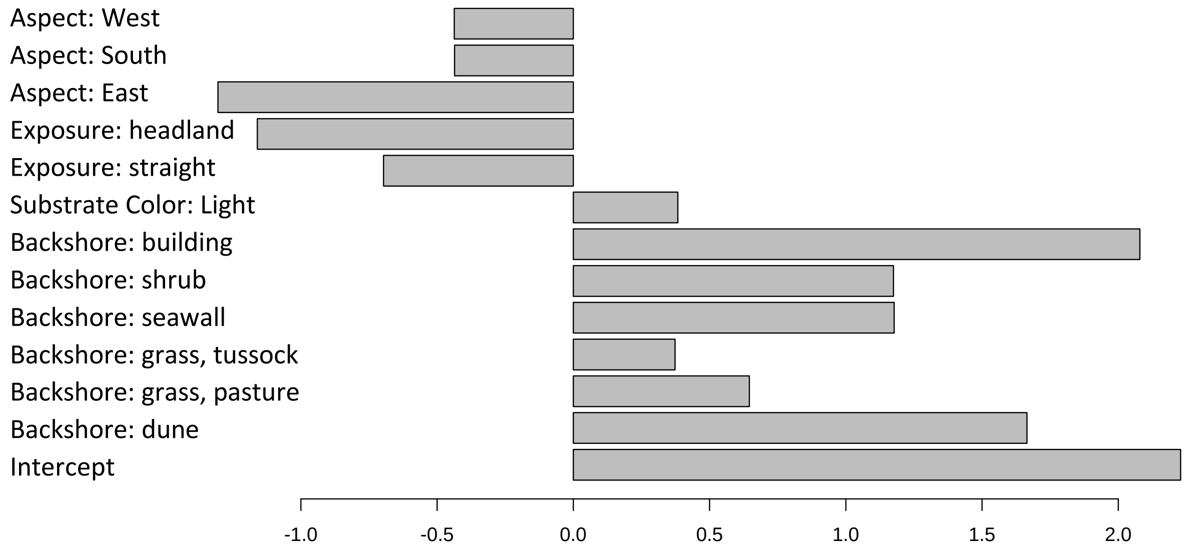

Figure 3.4 Positive and negative effects of particular covariates in marine debris surveys

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 color of the ground surface at the survey site, and the type of vegetation or land use inshore from the survey site. Figure 3.4 gives a graphical representation of the statistical coefficients for each of these variables. For instance, as can be seen from Figure 3.4 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.

What is the pattern of the region?

The statistical model discussed above also included a spatial surface as one of the model components (Figure 3.4). 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).

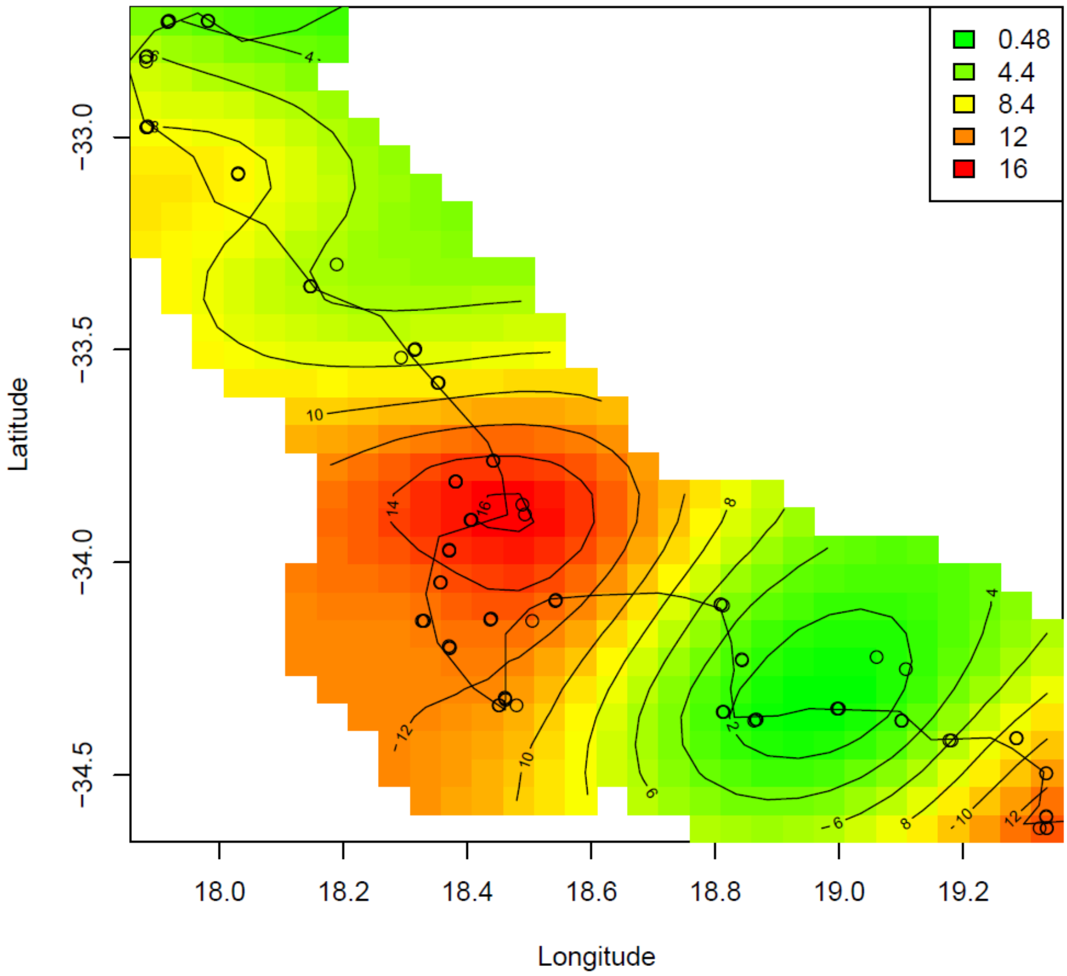

Figure 3.5 Debris load heat map showing correction for site characteristics

3.2 Inland Surveys

Seventy-five transects measuring a total of 1,875m were completed at 23 inland sites. A total of 3,972 items were recorded; equivalent to 2.1 pieces of debris for every 1m of land surveyed. **G4F** (unknown glass fragment) was the most common item found with 1,848 pieces (46.2% of total items found), **Z2F** (brick or cement fragment) was the second most recorded item with 370 pieces and **H10F** (unknown hard-plastic fragment) third with 262 pieces. A size class was estimated for 434 pieces with a size class 3 being the most common found. Size class 3 objects are greater than 2cm x 2cm but less than 3.5cm x 3.5cm.

Sixty-two percent of all items found were $3cm^2$ or smaller.

Figure 3.6 Transect method of debris surveys at an inland (urban) survey site

Figure 3.7 Transect method of debris survey at an inland (rural) survey site

3.3 River Surveys

Due to timing constraints, we were only able to complete 37 river transects measuring a total of 442m. Only 11 river site surveys were conducted.

A total of 524 items were recorded; an equivalent of 1.2 pieces of debris for every metre of river bank surveyed. Again, **H10F** (unknown hard-plastic fragment) was the most common item found with 71 pieces. **S2F** (food wrapper fragment) was the second most recorded item with 49 pieces and **D4F** (polystyrene fragment) had 39 pieces recorded. These top three item classes make up approximately 30% of the total items recorded. A size class was estimated on 131 pieces. Size class 3 and 4 account for just under 50% of items with size class measurements. Size class 3 however was the most common size class recorded.

Figure 3.8 River surveys are conducted from the water's edge to the top of the river bank

Figure 3.9 Example of river survey being conducted from the water's edge to the top of a flat riverbank.

4 Summary

The data collected has provided a comprehensive look at plastics on land, along rivers and at the coastal interface for the region around Cape Town South Africa. CSIRO will use this data in conjunction with statistical models to produce maps that highlight the load of unmanaged plastic waste in the urban and nearby areas, and the volume along the coast. Using this dataset and others collected from around the world we will estimate the amount of plastic from these plumes that is lost to the open ocean or redeposited back to land. Also with a robust, comparable baseline of information, we stand poised to evaluate policy effectiveness and change through on-ground activities at local, national and international scales.

5 Glossary

Site Name: **ITEMS LIST** **Page ____ of ____**

Date: **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	Plastic bag	S1		
	Food wrapper/label	S2		
	Sheeting	S3		
	Cup/lid	S4		
	Straw	S5		
	Unknown/other soft	S6		
Plastic Straps	String/rope/ribbon	BP1		
	Packing strap	BP2		
	Cable ties	BP3		
	Unknown/other strap	BP4		
Fishing	Net	F1		
	Fishing line	F2		
	Fishing Lures	F3		
	Buoys/floats	F4		
	Glow stick	F5		
	Fishhook/sinker	F6		
	Unknown/other	F7		
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		
Foam	Food container	D1		
	Cup/plates/bowls	D2		
	Polystyrene	D4		
	Unknown/other	D5		

	ITEMS Cont.	ID	Fragment	Whole
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		
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		
Miscellaneous	Battery	Z1		
	Brick/cement	Z2		
	Carpet	Z3		
	Ceramic	Z4		
	E Waste	Z5		
	Furniture	Z6		
	Small appliances	Z7		
	White goods	Z8		
	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	Size class
1 0 -			
2			
3			
4			
5			
6			
7			
8			
9			
10 - (end)			

6 References

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Jambeck JR, Geyer R, Wilcox C, Siegler TR, Perryman M, Andrady A, Narayan R, Lavender Law K (2015). Millions of tons of plastic waste end up in our oceans every year. *Science* 13 Feb 2015 : 768-771. DOI: 10.1126/science.1260352.

Schuyler QA, Willis K, Lawson TJ, Mann V and Hardesty BD (2018)/ Handbook of Survey Methodology - Plastics Leakage, version 1.1 (developed for CSIRO Global Plastic Pollution Project). CSIRO Australia. ePublish 182021.

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