

Marine Debris Field Report: Cape Town, South Africa

Earthwatch marine debris surveys, October 2017

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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).

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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 4cm² 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 3cm² 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

Date	Tra	ansect	No of	ITEMS LIST			rage	Subsampled? Y		
	ITEMS	ID	Fragment	Whole		ITEMS Cont.		Frag	Whole	
	Pipe/PVC	H1				String/rope/strap	C1			
	Beverage bottle <1 L	H2				Clothing/towel	C2			
	Other bottle	H3		1	et l	Wipes/cloths	C3			
ų.	Bottle cap/lid	H4			10	Insulation/stuffing	C4			
ast	Food container	H5			1	Unknown/other	C5			
d p	Utensil/plate/bowl	H6		1	⊢	Wood/timber	T1			
Har	Bucket/Crate	H7			1	Utensil/food stick	T2			-
	Lighter	H8			- Per	Bottle cork	Т3			+
	Lollinon stick/earbud	H9			- 1	Pallet	T4			
	Unknown (athes hard	H10			1	Hoknown (other	TS			-
	Diastic has	\$1		l	⊢	Cigarette /butt	P1	<u> </u>		
	Plastic bag	52			-	Cigarette/butt	82			
stic	Food wrapper/label	56			-	Paper/cardboard	P2	l		
Pla	Sneeting	55 64			-	Magazine/newspaper	P.4			
oft	Cup/iid Straw	55			1	Box	PS	-		-
51	Unknown/othersoft	56			er -	Food container/herr	P6	-		-
	Onknown/other soft	BD1		l	- Se	Food container/box	P7	<u> </u>		+
2 10	String/rope/ribbon	BP2			-	Pood wrapper/bag	PR	<u> </u>		
trap	Packing strap	RP3		l	-	Beverage container	PO	l		
2 3	Cable ties	BP4			-	Cups Distant/houds	P10	<u> </u>		
	Unknown/other strap	61		ļ	-	Plates/ bowls	011			
	Net	ra.		L	⊢	Unknown/other	21	<u> </u>		
	Fishing line	F2		ļ	-	Battery	21			
Bu	Fishing Lures	13		L		Brick/cement	22			
itshi	Buoys/floats	F4		L		Carpet	Z3			
	Glow stick	F5		L	8	Ceramic	Z4			
	Fishhook/sinker	F6		L	8	E Waste	Z5			
	Unknown/other	F7			e	Furniture	Z6			
	Pipe	M1			l ≷	Small appliances	Z7			
	Wire	M2			12	White goods	Z8			
	Aerosol	M3				Large car parts	Z9			
-	Beverage can	M4			1	Large boat parts	Z10			
	Food can/tin	M5			1	Bag/box dom. waste	Z11			
Meta	Lid/cap	M6				Nurdles	Z12			
4	Food wrapper	M7					01			
	Aluminium foil	M8					02			
	Bucket/drum	M9		Jer 1		03				
	Unknown/other hard	M10			8		04			
	Unknown/other soft	M11					05			
	Beverage bottle	G1			1		06			
55	Jar	G2				Size class (and sub-sar	mpling	interval	s)	
Gla	Light globe/tube	G3		1	1	Interval start (m)	Dist.	on tran	ID	Size class
	Unknown/other glass	G4			1	1 0-				
	Thong/shoe	R1			1	2				
Rubber	Tyre	R2			1	3			-	1
	Balloon	R3			1	4				-
	Rubber band	R4			1	5				
	Unknown/other	R5			1	6			<u> </u>	
_	Food container	D1		<u> </u>	1	7			-	
E	Cup/plates/bowls	D2		<u> </u>	1	8				+
Foal	Polystyrene	D4			1	9				
L.		05			-1	10 (-	+

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