Beach Litter Sampling Frequency is Critical for Accurate Results

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The frequency of sampling intervals for the estimation of the amount of litter washing on to beaches is a critical factor. It is time intensive and thus expensive to do high frequency sampling. Hence it is important to establish a frequency that is time and budget manageable yet still can be used to obtain a sufficient accuracy of results. In this study, an analysis of various sampling intervals is compared against the actual values to show how much variation can be found for different sampling periods.

The washing ashore of plastic rubbish is highly erratic. A strong onshore wind one day could cause waves to drag in 10,000-15,000 pieces in 24 hours. The next day with the wind changed, could bring just a few hundred pieces washing ashore. Infrequent sampling could miss these spikes.

Other factors affecting data sampling accuracy. The issue is further complicated for urban beaches for two reasons: Firstly, many local councils regularly sweep beaches with cleaning machines that skim the dry sand to remove most of the non-sand items. If such cleaning has occurred prior to the survey, then the survey results will grossly underestimate the litter. Secondly, people often walk for exercise or walking their dog in the morning and many of these people casually pick up some litter when they see it. This would then also contribute to an under-estimation of true quantitative litter data. The survey described in this paper was done early in the morning to avoid the above two factors. On any beach a strong wind hours before a survey can blow lighter items away off the beach (out of the survey zone) and cause low counts on a survey performed during or just after such a weather event.

Seasonal factors can be large as well. Spring has the fast growth of seaweed and seagrass, and also unstable weather with storms. During a storm some of this is ripped out and carried along by the surface currents. This weed in the water acts like a net and it captures and drags floating plastic along with it. When the direction is on shore, the weed can bring in a very high amount of plastic.

Background

In March 2016, two BeachPatrol Australia (BP) volunteers in the suburb of Port Melbourne in Melbourne, started surveying the plastic that washed ashore every day on a specific beach. They selected two fixed lengths along that beach to survey to get an average for that beach. Their original goals were twofold. They wanted to identify the top or most common item types that were washing out of the bay. This would support any potential upcoming legislation on plastic items. The second goal was to use the data and develop a model that would allow the extrapolation of how many plastic pieces were washing out of the whole bay perimeter every year. This would essentially show how many items of plastic were washing into the bay each year.

For the first two years of the survey, sampling was performed every day of the year. This turned out to be a time intensive exercise, many days taking multiple hours. Some days over 5 hours each for the two people. It was not sustainable. To consider continuing the survey for further years, it forced the volunteers to recess how often they could perform the surveys and still get a reasonably accurate of the count of plastic washing ashore. Using their previous years data from sampling every day they were able to compare that data to if they had sampled that beach a) just once a week

or b) sampling 2 times a week, or c) sampling every 3rd day and d) sampling every 4th day. They then extrapolated for the full week though out the year The results of these different scenarios were compared with the actual full years data to show what the error percentage could be if that level of reducing sampling had have been used.

During this analysis and due to the highly variable amounts of plastic that could wash ashore on any one day, it became clear that it made difference depending on which day of the week the reduced sampling counts were made. For example, for sampling 2 times a week, if Monday and Thursday were selected as the days, of if Tuesday and Friday were selected as the days, the extrapolated annual results would be 25% from each other.

Actual Base Line Data

The actual data collected for the first year is shown in Appendix 1, Table A1

Figure 1 is a graph of the distribution of the of the collection count through out the year with seasons shown.

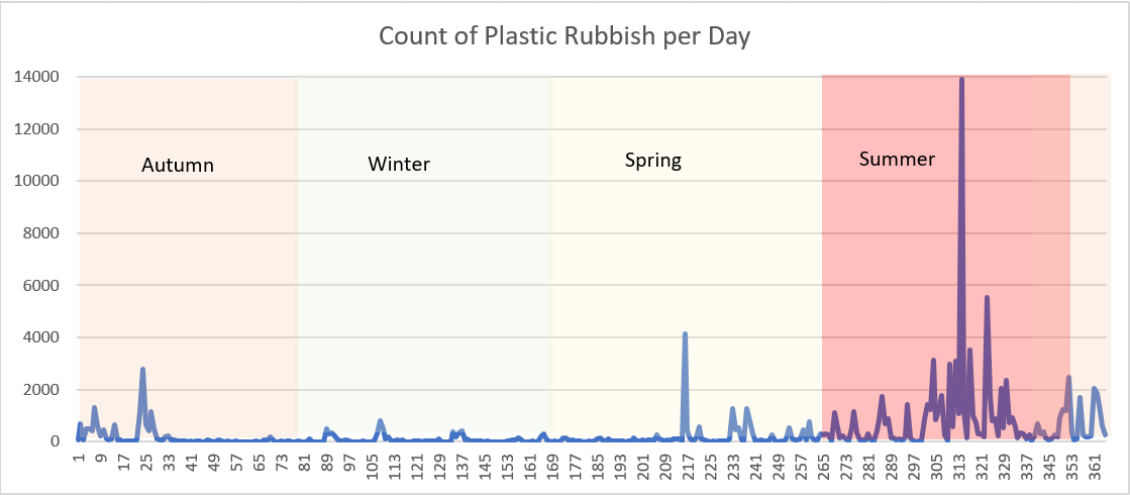

Figure 1 Plastic Count per Day

The first point that can be clearly see for Figure 1 is that sampling beach litter once a year will be very inaccurate. Even sampling once per season would be very inaccurate.

IF we look at sampling just once per week, which would be 52 sampling times per a year, which is a high number based on what is typically reported in other surveys, we get this spread of errors. Table 1 shows the error that would have been incurred from sampling just once a week and picking each of the 7 days to take the sample. For example if we sampled on the 1st day of every week, or the 2nd day of each week and so on.

Sample Day	Percent error that would have been incurred.
1	35%
2	17%
3	14%
4	9%
5	-6%
6	-9%

7	-60%
Average of the above	22%

Table 1 Error variation of Sampling once per week and depending on which day per week the sampling was performed.

From Table 1, a wide variation is errors are seen depending on which of the 7 days the once per week sampling was performed. IF sampling on the 5th day of the week the error would only have been 6%. But if sampling on the 7th day it would have been 60%. This is due to the very spikey nature of the number of bits on the beach on any one day.

IF we look at Sampling 2 times per week, (3 and 4 days apart) (104 samples per year) we get the data as shown in Table 2.

Sample Days	Percent error that would have been incurred.
1, 4	22%
2, 5	5%
3, 6	2%
4, 7	25%
5, 1	14%
6, 3	4%
7, 4	23%
Average of the above	14%

Table 2 Error variation of sampling twice per week and depending on which 2 days per week the sampling was performed.

Table 2 show significant reduction in the average error compared to the once per week sampling, 22% vs 22%. Plus the big error from Table 1 have been reduce to a maximum error of 25% compared to 60%.

If we look at sampling 3 times per weekdays on days 1,4,6, then 2,5,7 etc (156 samples per year) , we get the results as shown in Table 3.

Sample Days	Percent error that would have been incurred.
1, 4. 6	14%
2, 5, 7	6%
3, 6, 1	17%
4, 7, 2	12%
5, 1, 3	16%
6, 2, 4	13%
7, 3, 5	11%
Average of the above	13%

Table 3 Error variation of sampling three times per week and depending on which 3 days per week the sampling was performed.

Table 3 shows a similar average error of 13% to the twice per week sampling of 14%. The maximum error that could have been incurred is 17% compared to 25% of Table 2. Oddly the minimum error from table 3 is 6% compared to only 2% from the twice per week sampling in Table 2, which would be attributed to the very spikey nature of the data daily.

Summary

From the above analysis, it can be seen that for a beach, the sampling rate has to be high to cover the high variability of the daily occurrence of litter washing in on from the water. Sampling once per week (52 times a year) is quite inaccurate. Sampling 2 times a week (104 times a year) provides a significant accuracy improvement. Then sampling 3 times a week (156 times a year) provides a slightly better accuracy on average and less error spread depending on which day the sampling is performed. To get estimates of the amount of plastic pollution on beaches therefore is a trade off between the cost to perform detailed sampling and the sampling frequency. The minimum however should be sampling multiple times per week.

Appendix 1

The actual data from one year's collection. March 16 2016 to Mar 15 2017

Day	Count	Day	Count	Day	Count	Day	Count	Day	Count	Day	Count
1	66	21	16	41	12	61	3	81	8	101	2
2	704	22	80	42	8	62	7	82	7	102	16
3	65	23	1107	43	11	63	8	83	94	103	5
4	510	24	2793	44	30	64	25	84	1	104	4
5	509	25	631	45	8	65	6	85	1	105	3
6	431	26	426	46	2	66	7	86	1	106	10
7	1300	27	1148	47	71	67	48	87	1	107	308
8	607	28	478	48	19	68	12	88	4	108	799
9	211	29	89	49	1	69	180	89	478	109	484
10	441	30	84	50	9	70	80	90	300	110	111
11	91	31	83	51	53	71	4	91	357	111	169
12	85	32	166	52	9	72	5	92	213	112	25
13	111	33	222	53	4	73	13	93	77	113	41
14	630	34	78	54	9	74	4	94	18	114	62
15	51	35	80	55	5	75	9	95	26	115	38
16	81	36	26	56	2	76	11	96	64	116	61
17	7	37	11	57	23	77	6	97	23	117	6
18	20	38	11	58	2	78	3	98	8	118	1
19	15	39	29	59	7	79	10	99	5	119	2
20	13	40	5	60	4	80	1	100	2	120	13

Day	Count	Day	Count	Day	Count	Day	Count	Day	Count	Day	Count
121	29	141	16	161	6	181	2	201	57	221	639
122	15	142	11	162	13	182	42	202	0	222	167
123	2	143	27	163	2	183	0.01	203	87	223	83
124	17	144	10	164	2	184	17	204	65	224	18
125	11	145	3	165	168	185	120	205	23	225	3
126	26	146	9	166	284	186	133	206	284	226	11
127	17	147	4	167	48	187	20	207	128	227	1
128	18	148	7	168	25	188	11	208	52	228	45
129	87	149	5	169	6	189	104	209	42	229	36
130	5	150	8	170	15	190	10	210	61	230	26
131	7	151	8	171	2	191	19	211	30	231	21
132	3	152	2	172	9	192	16	212	102	232	136
133	3	153	9	173	151	193	12	213	88	233	1296
134	383	154	14	174	162	194	11	214	104	234	482
135	192	155	60	175	29	195	8	215	34	235	533
136	356	156	60	176	77	196	45	216	4837	236	89
137	431	157	131	177	43	197	10	217	569	237	33
138	57	158	69	178	38	198	148	218	119	238	1650
139	94	159	5	179	22	199	47	219	12	239	998

140	44	160	4	180	1	200	12	220	156	240	403

Day	Count	Day	Count	Day	Count	Day	Count	Day	Count	Day	Count
241	8	261	538	281	282	301	854	321	334	341	699
242	28	262	65	282	55	302	1466	322	267	342	437
243	54	263	84	283	15	303	1964	323	5518	343	411
244	17	264	428	284	424	304	3229	324	4122	344	148
245	35	265	303	285	841	305	917	325	830	345	77
246	17	266	318	286	1740	306	1426	326	1180	346	101
247	245	267	292	287	668	307	1964	327	450	347	407
248	19	268	25	288	881	308	276	328	2299	348	232
249	5	269	1200	289	155	309	49	329	553	349	919
250	16	270	600	290	162	310	3486	330	2350	350	1357
251	2	271	167	291	52	311	653	331	1022	351	1175
252	109	272	276	292	255	312	3120	332	1149	352	2465
253	530	273	155	293	114	313	1153	333	976	353	343
254	90	274	18	294	212	314	14033	334	254	354	97
255	55	275	539	295	1538	315	1169	335	432	355	130
256	75	276	1538	296	178	316	130	336	297	356	1754
257	110	277	338	297	67	317	3659	337	148	357	268
258	459	278	65	298	19	318	1046	338	264	358	188
259	52	279	71	299	13	319	1004	339	35	359	261
260	992	280	54	300	53	320	406	340	310	360	223

Day	Count
361	2187
362	2292
363	1225
364	705
365	311
Total	**133,628**