Pilot study of micro-plastics in the Maribyrnong and Yarra Rivers and Port Phillip Bay

Report by Port Phillip EcoCentre, July 2014

Funded by the Victorian Government Cleaner Yarra & Bay Litter Hotspots program

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Introduction

As a component of the 'Clean Bay Coalition' project funded through the State Government's 'Cleaner Yarra and Port Phillip Bay Litter Hotspots' program, Port Phillip EcoCentre collaborated with Yarra Riverkeeper to conduct manta-net trawls to measure micro-plastics in the Yarra and Maribyrnong Rivers. Also, EcoCentre volunteers were deployed to conduct weekly audits for plastic pre-production pellets (nurdles) on local beaches.

Using a manta-net (0.33 mm mesh) towed by the Yarra Riverkeeper motor launch, 8 trawls were conducted in each river between December 2013 and May 2014.

The purpose of the study was to:

- measure levels of micro-plastics entering Port Phillip Bay from either river;
- document common streams of micro-plastic pollution including 'nurdles', polystyrene beads and fragments of assorted user plastics;
- compare the pollution loads from both catchments to inform local strategies to address local sources of micro-plastics pollution.

The original project plan included trawls to measure micro-plastics in Hobsons Bay. However, when the YRK boat proved to be inadequate in rough conditions in the Bay this component of the project was altered to focus on regular (weekly) beach 'nurdle' surveys. These surveys were conducted primarily by volunteers and school groups and proved to be an effective educative tool in addition to capturing consistent data.

Executive summary

8 X '30 minute' micro-plastics trawls were conducted in the Yarra and Maribyrnong between December 2013 and May 2014.

Due to timing of the trawls not coinciding with rainfall or storm surge events the analysis of trawl samples represents background levels of micro-plastics in both Rivers.

The total number of trawl sampled plastics recorded in the Yarra (268) and the Maribyrnong (229) equates to 586,920 per year and 497,388 respectively.

As the width of the rivers is at least 166 times wider than the net, the actual total volume of plastics in both rivers would be significantly greater than the sample collected by the trawl.

The source of extraordinarily high levels of micro-plastics (more than all other samples combined) recorded in a '3 minute' Yarra sample on 15/5/14 warrants further investigation.

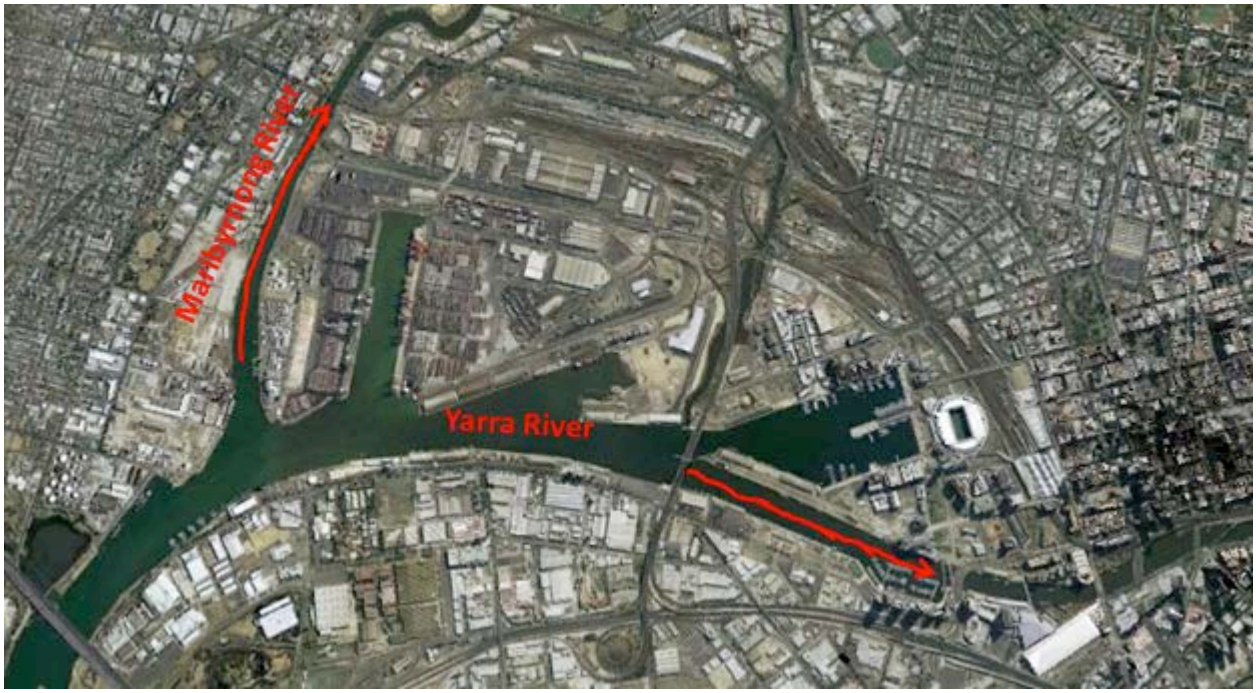
River trawls

Study method

Trawls were conducted with a manta-net of the same specifications as used by 5 Gyres Institute to measure micro-plastics in international studies. The net has a 0.33 mm mesh size. The ‘mouth of the net is 600mm X 200mm.

The sites were selected on the basis of being close to the lower reaches of each river and therefore indicative of the total pollution load of each respective catchment.

The Maribyrnong trawls commenced at the ‘Water Canon’ jetty extending from the west bank of Coode Island, 300m upstream from the Yarra. The Yarra trawls commenced at Bolte Bridge, 2.5 km upstream of the Maribyrnong mouth. The below satellite image shows the locations of the trawl transects.



In each river all trawls commenced at the same place, traveling upstream for 30 minutes, with the boat motor operated at a constant 1,000 RPM to maintain an appropriate speed to effectively operate the net (photo 1). The length of each trawl varied slightly due to the state of the tide and prevailing wind conditions at the time, e.g. the shortest Maribyrnong trawl was conducted against a rapidly ebbing tide with the boat traveling into a strong northerly wind.

As river boating involves changing course to safely navigate around other watercraft that may be encountered, the course of the trawls in each river was not rigidly defined. The key objectives were to maintain progress into the current at the same speed for 30 minutes.

Photo 1: Yarra Riverkeeper Ian Penrose trawling. Note that the manta-net remains outside of the wake of the boat, so the samples are not disturbed by water movements.

The only departure from the trawl method outlined above was when the net was deployed for 3 minutes in the Yarra adjacent to the ANZ landing on 15/5/14. This deployment was essentially for filming purposes and not intended as part of the study. However, due to the high volume of material collected the sample was analysed like all other samples.

Sample analysis method

Trawl samples were analysed by separating litter items from the organic matter with the naked eye, using tweezers. Litter items were then sorted by litter type and the diameter measured with a ruler where applicable.

In this report, the term ‘plastic pieces’ is used to describe items of hard plastic, which are parts of larger plastic user items (e.g. plastic bins, toys, bottles, pens, etc.). As per internationally accepted guidelines, plastic pieces smaller than 5 mm in diameter are referred to as micro-plastics (Thompson *et al.*, 2004).

Trawl results

Litter distribution per sample

Figure 1. Shows the comparative distribution of litter between the Yarra and Maribyrnong samples. Numbers of litter items and their composition in the samples vary considerably within the same day of sampling.

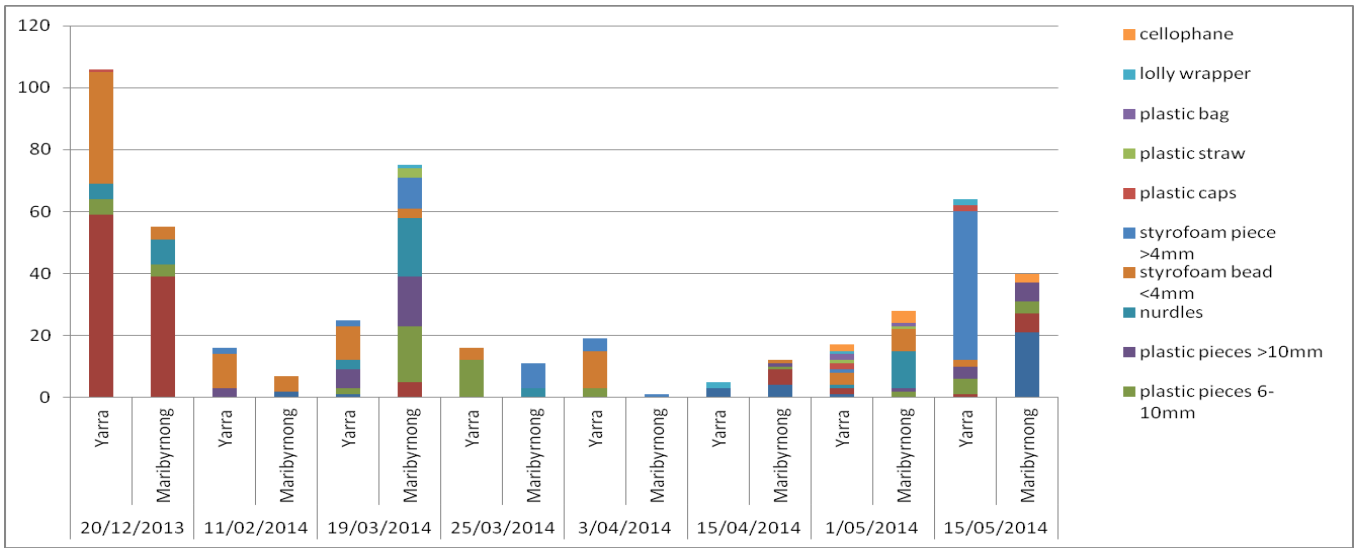


Photo 2. showing the net deployed to the side of the boat

Photos 3 & 4. Boom mounted across front of the boat anchored to railing on the opposite side.

Comparison of litter items collected

Figure 2. Shows the total number of litter items collected from both rivers, distributed over all samples.

The most caught litter item in the Yarra is styrofoam, either in loose beads or larger pieces, followed by micro-plastics (which consist of the categories 'plastic pieces 2mm – 5mm' and 'plastic pieces <2mm' combined).

The most prevalent litter items in the Maribyrnong are plastic pieces in general, followed by nurdles. Micro-plastics make up most of the numbers of litter items in the Maribyrnong.

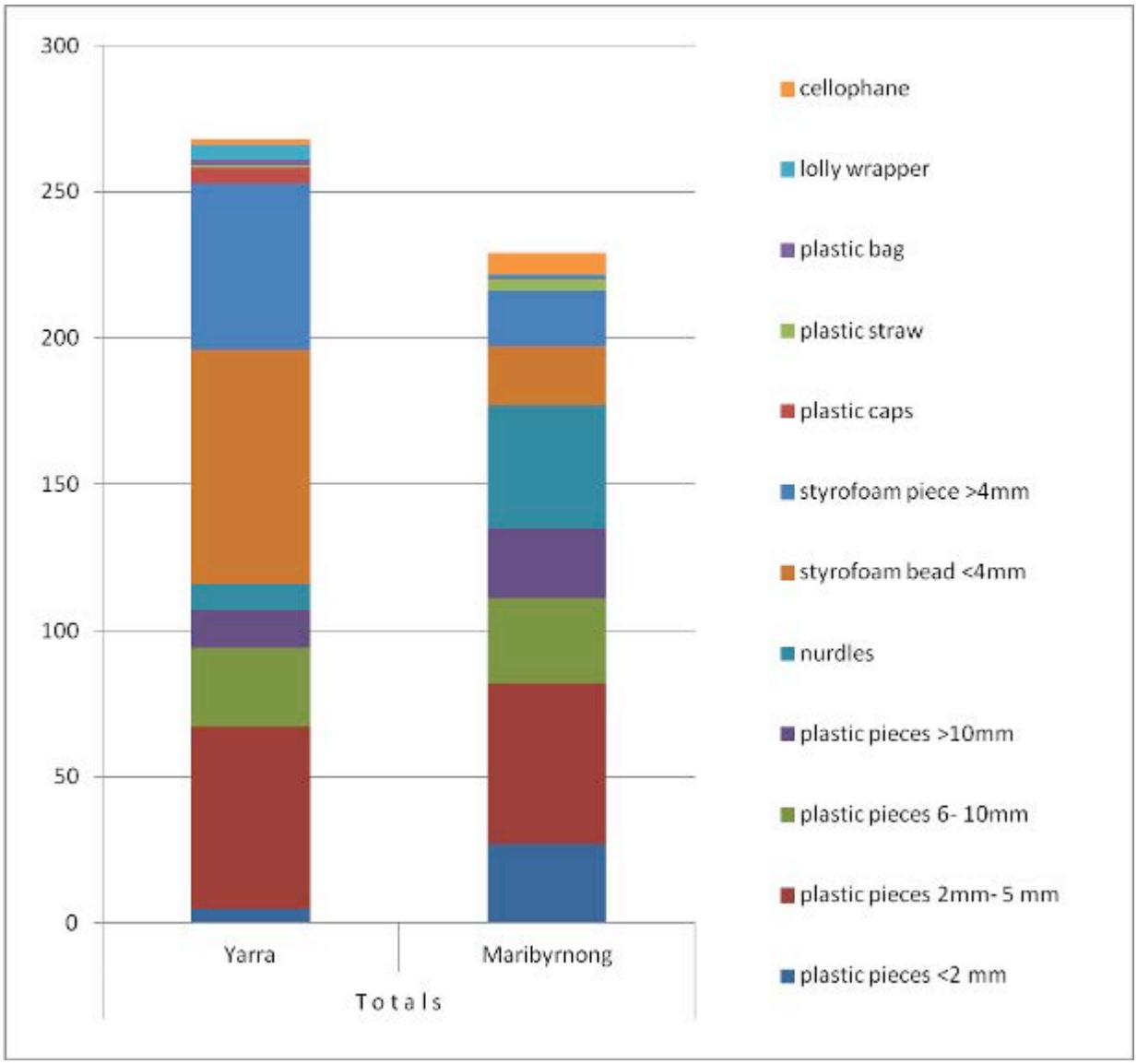


Figure 3. The Yarra and Maribyrnong litter comparison below shows the Yarra contains more styrofoam than the Maribyrnong. However, the Maribyrnong contains more plastic pieces, micro-plastics and nurdles than the Yarra.

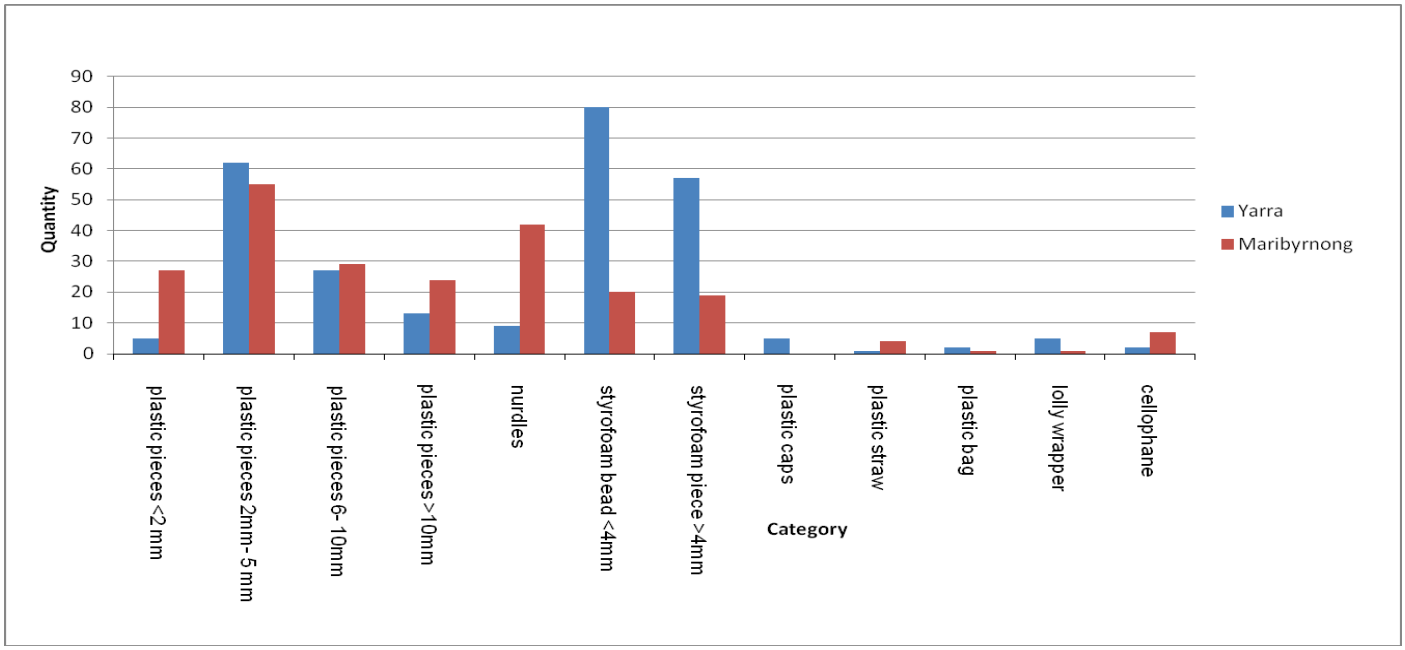
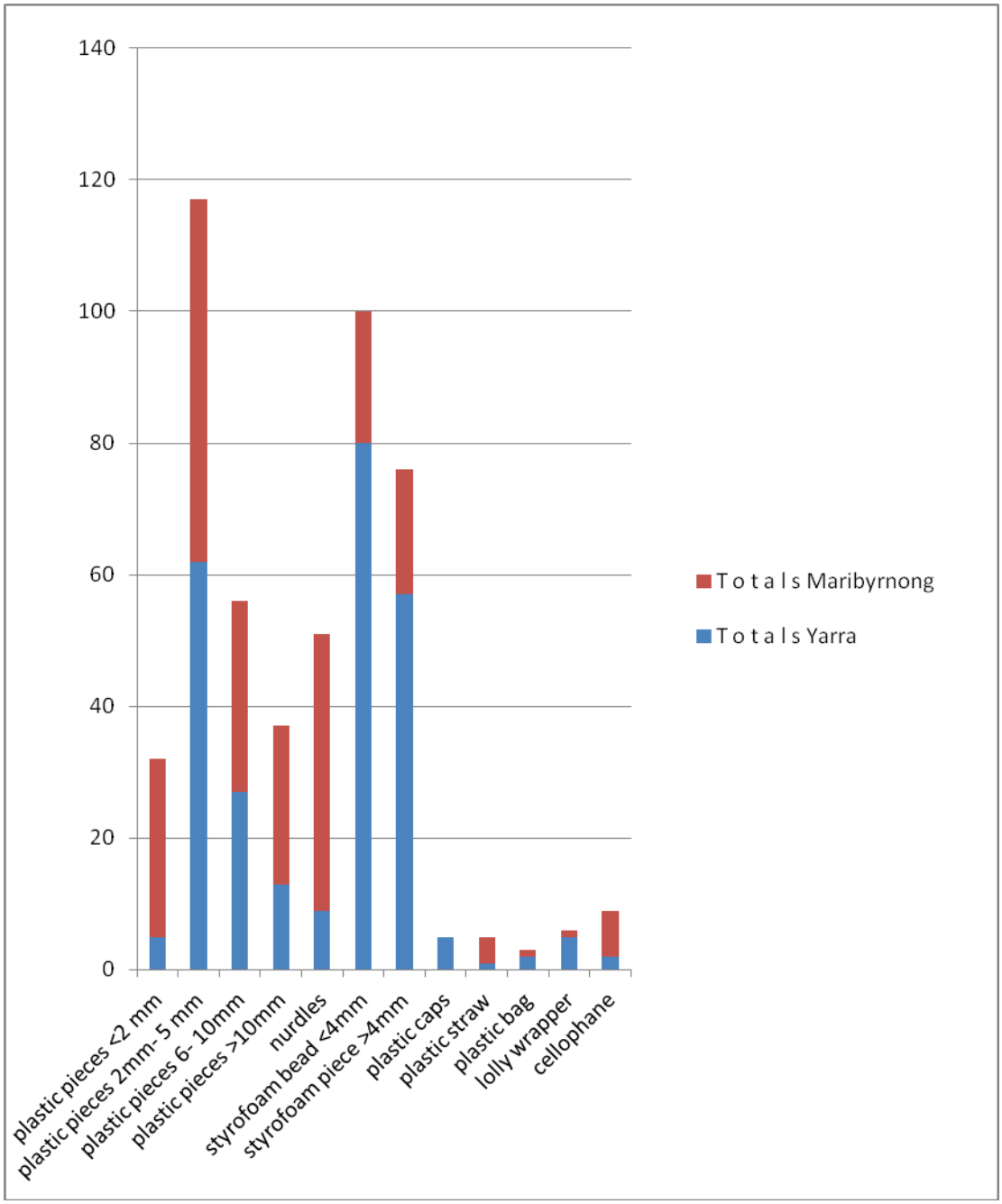


Figure 4. Comparative abundance of plastics categories (below) shows that overall, micro-plastics and styrofoam make up most of the plastic waste spilled into Port Phillip Bay from both rivers.



River trawls discussion

Whilst there have been some international studies involving manta-net surveys of rivers (NOAA, 2009), there appears to be no published data of Australian studies. It should be noted that the 600mm width of the net captures a very thin sample of the rivers, both being at least 100m wide in the sections in which the trawls were conducted. In addition, a 30 minute trawl presents a limited 'window' over a 24 hour period, let alone over the 2 weeks period (generally) between each trawl.

Local variables identified during the course of the study that could skew data include:

- Trawls coinciding with emptying of the Parks Victoria floating litter traps (potentially releasing micro-plastics back into the water column during grab bucket transfer of litter from the floating traps to the disposal barge)
- High volumes of micro-plastics that have been perched on stream banks above mean high tide are released to the stream by unusually high tides generated by storm surges
- Rainfall events occurring several days prior to trawls flushing most pollutants out of the rivers before the trawl being conducted.

None of the trawls were conducted during or immediately after a high rainfall or storm surge event (when most micro-plastics would be in transit to the Bay). However, despite this, the pilot study did successfully trial the trawl methods and identified common pollutants in both rivers. Accordingly, the findings of the '30 minute' trawls represent 'background levels' of micro-plastics and provide a benchmark to enable comparison with future studies.

The total number of plastics (268) recorded in the Yarra trawls (excluding the 3 minute trawl of 15/5/14) equates to 586,920 plastics per year.

The total number of plastics (229) recorded in the Maribyrnong trawls equates to 497,388 plastics per year.

In considering the figures stated above it should be noted that:

- the current study provides results for less than 6 months of the year and therefore seasonal variations are not reflected; and
- the width of the rivers is at least 166 times wider than the net, so the actual total volume of plastics in both rivers would be significantly greater than the sample collected by the trawl.

In the absence of a detailed study of tidal movements, localised currents and prevailing winds it is not possible to extrapolate the overall 'background' levels of plastics borne on each river.

As shown in Appendix 1, analysis of the '3 minute' Yarra trawl revealed significantly higher than the 'background' levels recorded in the '30 minute' Yarra samples. The '3 minute' sample was collected on May 15, just a few minutes after, and upstream of the '30 minute' Yarra sample.

The total micro-plastics in the ‘3 minute’ trawl was more than twice as many as the combined total of the ’30 minute’ Yarra trawls, suggesting that localised influxes of micro-plastics may have occurred. Subsequent consultation with Chris Stevenson (Parks Victoria) who maintains the Parks Victoria floating litter traps confirmed that:

- micro-plastics do escape as trash trapped by the booms is transferred from the water body to the disposal barge; and
- Chris Stevenson has frequently observed localised influxes of micro-plastics (particularly Styrofoam) in the vicinity of the Crown Casino car park.

Photo 5. Floating litter trap on south bank just downstream of Spencer Street.

River trawls conclusions

The results of the trawl samples for both rivers represent 'background' levels of micro-plastics in the upper water column. Longer term studies, designed specifically to coincide trawls with rainfall and storm surge events are required to capture data relating to different environmental conditions.

The '3 minute' Yarra trawl sample of 15/5/14 highlights the fact that samples can vary considerably and that localised causes may be a play. Specific investigations are required to measure the quantity of micro-plastics being released to the river due to:

- existing methods for emptying the Parks Victoria floating boom litter traps; and
- localised release of Styrofoam in the vicinity of the Crown Casino car park.

Nurdles were recorded in trawl samples from both the Yarra and the Maribyrnong; and during the course of the study were also recorded on several occasions in the Merri Creek and Darebin Creek.

Beach 'nurdle' surveys

Nurdles are small plastic pre-production pellets that serve as the base for the manufacturing of plastic products. They typically have a diameter of about 5 mm and come in a variety of colours, of which transparent seems the most common. Because of their small size and light weight they are hard to clean up after a transport spill or spill on the factory floor. Through wind and rain they end up in the drains that come out in the Yarra and Maribyrnong rivers. When they arrive in Port Phillip Bay, wind and wave action deposit most of them on the beach in the high tide line (photo 2). Some may escape from the Bay, particularly with prevailing northerly winds and coinciding ebb tide currents, entering the ocean.

Nurdles pose a serious threat to wildlife as they are frequently mistaken for food (Hutton *et al.*, 2008; Lusher *et al.* 2013) and can kill animals by causing indigestion as well as through starvation (Carey, 2011). In addition to this, they resorb toxic molecules called POP's (Persistent Organic Pollutants), like DDT, PCB, DDE and other pesticides and chemicals, which are then absorbed by the animal's tissues and enter the food chain (Tanaka *et al.,* 2013; Lavers, 2014)

Photo 2: Plastic debris caught in the high tide line on Elwood Beach, with many nurdles among it..

Nurdles Study method

Since August 2013 EcoCentre volunteers collected nurdles from a wide variety of locations around Port Phillip Bay, going out on organised sampling sessions nearly every Thursday and sometimes by themselves as well. Beach nurdle data was also collected by schools during EcoCentre excursions and by groups of corporate volunteers. Sampling sessions usually lasted anywhere between 15 and 60 minutes and nurdles were picked up on-site by hand from the high-tide line or from nurdle 'hotspots'. Hotspots are places outside of the high-tide line, where nurdles have been deposited over prolonged periods of time by the wind, together with other litter. Weather, wind direction, wind speed and any big weather events like storms or high rainfall were recorded for each sampling session.

During this pilot, data collection methods were tested and changed several times. The following methods were trialed:

- Manual collection of nurdles from dedicated creek bank sites (Merri and Darebin Creeks)
- Transect plots along the high-tide line, picking up nurdles manually;
- Manually collecting nurdles from the high-tide line for a set amount of time (photo 3);
- Bulk collection of shoreline detritus (for processing later), where heavy concentrations of nurdles were evident.

Photo 3: Volunteers trial a research method by manually picking up nurdles from the high tide line.

Eventually, a sampling method developed and published by established scientists was trialed and adopted (Hidalgo-Ruz, 2013; EC JRC, 2013). Collectors focus attention on the high tide strand line where 'nurdles' are deposited by the most recent tide are found.

This new sampling method for high-tide lines will be used in the second stage of the research project and allow for statistically sound data analysis of results and long term monitoring of nurdles in the environment. The new method adopted for beach nurdle surveys is as follows:

- Collecting all debris including first 2 centimetres of sand, in 50 cm2 quadrats on the high-tide line. A minimum of 2 samples is taken per session. If necessary, he sampled material is air-dried for a few days to allow for easy sifting and isolation of nurdles. Nurdles are then extracted and counted.

Two sample sites have been identified as suitable for regular sampling, based on proximity to the EcoCentre and the site not being disturbed by the Council beach-cleaning operations.

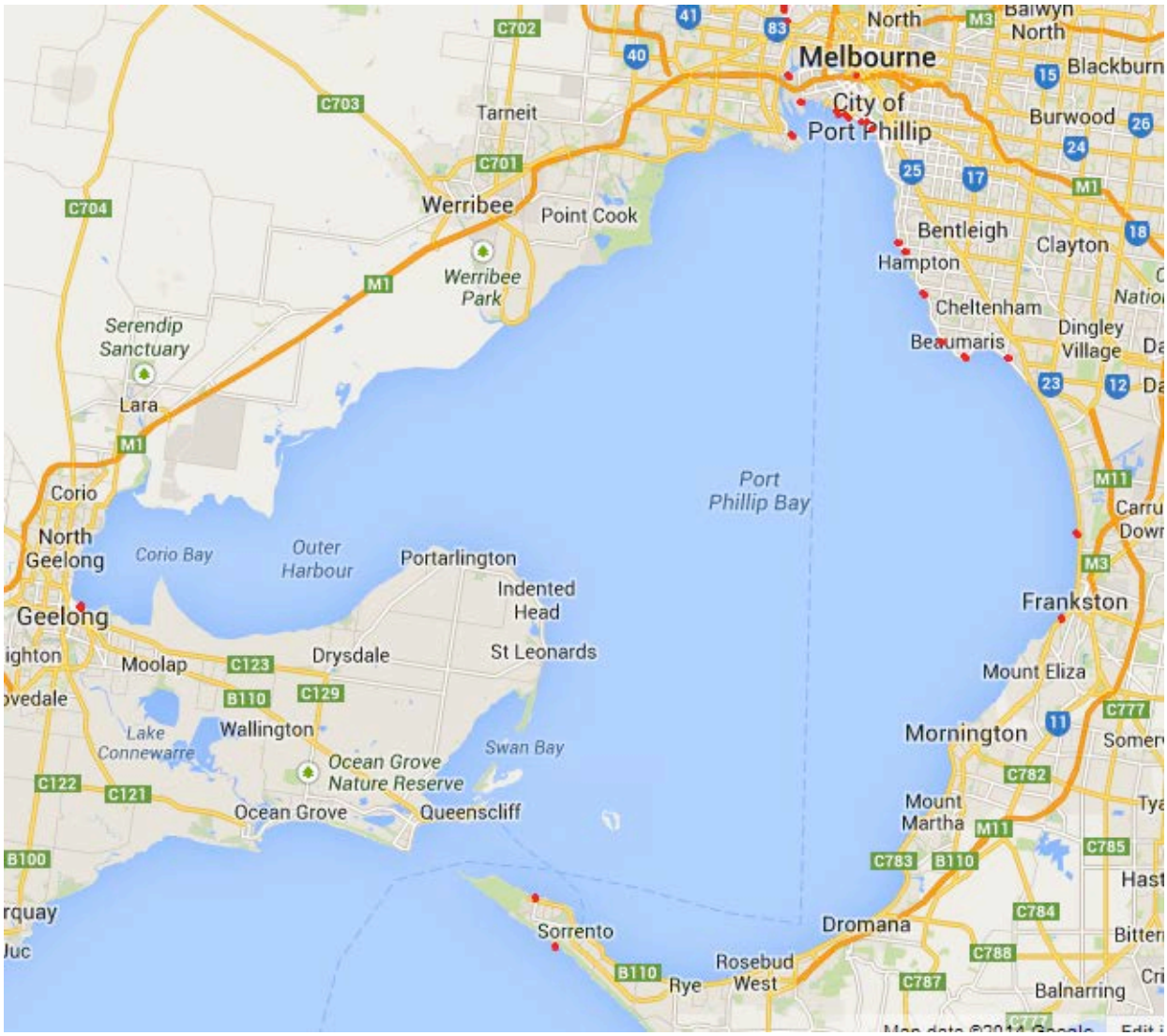
Two sample creek bank sites have been identified as suitable for monitoring nurdles in the Merri and Darebin Creeks.

Nurdles Results

Because of the different methods of data collection used and trialed, quantitative analysis of the dataset is not suitable. However, qualitative analysis of the pilot data shows the following:

1) Close to 40,000 nurdles were collected over a period of 11 months, over 89 sampling sessions.
2) Of the 89 sampling sessions, 9 were conducted on riverbanks or drain outlets. All of these sessions yielded nurdles, sometimes in relatively large quantities.
3) Of the 89 sampling sessions, 18 were conducted in nurdle hotspots. All of these sessions yielded nurdles, sometimes in relatively large quantities.
4) The highest number of nurdles found in one session was 5,045 on St Kilda West Beach.
5) A spike in the number of nurdles could usually be found in the high-tide line some days after an extreme weather event with rain and/or strong winds. No nurdles were found in the high-tide line during periods of prolonged absence of rain.
6) Different methods of data collection were trialled, after which the most suitable one was identified and adopted for use in further research.

The red dots on the map below show the locations of sampling sites around the Bay. Two samples were taken further upstream of the Darebin Creek and the Merri Creek as well.



Nurdles discussion

The combination of prevailing south-westerly winds and clockwise tidal currents make the St Kilda foreshore a likely destination for nurdles entering the Bay from the Yarra. Regular monitoring of sites in this area will provide data that is representative of the frequency of nurdles entering the Bay from the Maribyrnong and Yarra Rivers.

The qualitative results show that there are consistent deposits of nurdles on the beaches of the Bay. Specifically when there has been rain and/or wind a few days prior, nurdles are found in the high-tide line, due to their light weight and high buoyancy in the water. Regularly finding (sometimes high) concentrations of nurdles in rivers, creeks and drain outlets – especially after rain - shows that there is an ongoing influx of nurdles into Port Phillip Bay from the mainland. More sampling of further upstream parts of rivers and drains may provide clues as to where the nurdles originate from.

There is a difference between sampling high-tide lines and nurdle hotspots with regard to methods and data analysis. Nurdles found in hotspots may have been deposited there by storm surges in the distant past; or by winds after having been deposited in the high-tide line. They may be present anywhere between surface level and over a meter deep, depending on how long and how fast the hotspot has been accumulating them in the various weather conditions.As it is impossible to determine how long the nurdles in the hotspots have been there and when they were deposited there by tide and wind, it makes sense to concentrate further research on nurdles in the most recent high-tide line only. This will be a more accurate representation of the current situation in the Bay and possibly show any big influxes that may occur from rivers and drains. The newly adopted sampling method was designed to sample high-tide lines only and will be used accordingly.

Specific studies to monitor the movement of nurdles across the beach from the high-tide line into hotspots are warranted.

Nurdles conclusions

There are large numbers of nurdles in Port Phillip BayThe weekly ‘nurdle’ surveys consistently found nurdles of all colours and sizes on Port Phillip Bay beaches, indicating that the influx of preproduction pellets into the bay is ongoing and not merely the result of a one-off incident.

Once spilled, nurdles are too small to clean up, emphasising the difficulties faced once they are released in the environment. The way to stop the detrimental effects of nurdles on wildlife and the food chain is to prevent any more nurdles from entering the Bay.

Ongoing monitoring will enable the success of any initiatives to reduce nurdles escaping to waterways to be measured. The new monitoring method for beached nurdles outlined in this report has proven to be effective and conclusive and should be continued.

Acknowledgements

Ian Penrose (Yarra Riverkeeper), Andrew Kelly (Yarra Riverkeeper committee member), Chris Stevenson (Parks Victoria), Heidi Taylor (Tangaroa Blue), Fam Charko, Bronnie Walsh, Neil Blake, David Giles (Port Phillip EcoCentre), EcoCentre volunteers.

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Appendix 1. Trawl data

		Totals		20/12/13		11/02/14		19/03/14		25/03/14		3/04/14		15/04/14		1/05/14		15/05/14		3 min Yarra trawl 15/05/14
	Total	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	
plastic pieces <2 mm	32	5	27	0	0	0	2	1	0	0	0	0	0	3	4	1	0	0	21	41
plastic pieces 2mm-5mm	117	62	55	59	39	0	0	0	5	0	0	0	0	0	5	2	0	1	6	60
plastic pieces 6- 10mm	56	27	29	5	4	0	0	2	18	12	0	3	0	0	1	0	2	5	4	41
plastic pieces >10mm	37	13	24	0	0	3	0	6	16	0	0	0	0	0	1	0	1	4	6	28
nurdles	51	9	42	5	8	0	0	3	19	0	3	0	0	0	0	1	12	0	0	30
styrofoam bead <4mm	100	80	20	36	4	11	5	11	3	4	0	12	0	0	1	4	7	2	0	424
styrofoam piece >4mm	76	57	19	0	0	2	0	2	10	0	8	4	1	0	0	1	0	48	0	40
plastic caps	5	5	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	
plastic straw	5	1	4	0	0	0	0	0	3	0	0	0	0	0	0	1	1	0	0	
plastic bag	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	
lolly wrapper	6	5	1	0	0	0	0	0	1	0	0	0	0	2	0	1	0	2	0	1
cellophane	9	2	7	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	3	
Total	497	268	229	106	55	16	7	25	75	16	11	19	1	5	12	17	28	64	40	625