Abundance of plastic debris on the beach and above sea turtle nests on Playa Norte, Costa Rica.

Colofon

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Study: Applied Biology

Organization: Canadian Organization for Tropical Education and Rainforest Conservation (COTERC)

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Barra Del Collorade Wildlife Refuge
Pococí, Limón, Costa Rica

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Cover: Research transect on Playa Norte, Costa Rica (2015)

Photo by Josephine Aussage.

Preface

Many people have contributed to this research in various ways, it is impossible to name everybody individually, but I would like to take this opportunity to thank everybody who spend hours picking debris from the beach in the hot sun or the heavy thunder storms and counting every piece of plastic while under attack of dozens of mosquitoes. In particular I would like to thank Molly McCargar for her patience, advise and help with thinking, correcting and writing. Charlotte Arias for providing a great learning, working and living environment. In addition I would like to thank everybody linked to COTERC and Cano Palma for providing us with the opportunity to work and live in a unique place like the Costa Rican jungle. It has been a great experience and I loved every second of it.

Abstract

Since the start of the mass production of artificial plastics the amount produces has increase significantly. Plastic plays such a big part in present that it plays a vital role in everything from packaging, storage, transport or production. As a result of this mass production a large portion of plastic has ended up in the environment and has resulted in a large 'plastic soup' in the ocean. Anthropogenic marine debris can found in sizes ranging from over a metre to microscopic size. Micro plastics can be manufactured as such (primary) or break down larger pieces of plastic due to physical and chemical processes (secondary). All ranges of marine debris are known to cause harm to marine life either due ingestion, entanglement or by leaking additives into the environment. Micro plastics are easily ingested and are able to build up in the food chain. This research focuses on the plastic abundance found on the beach at Playa Norte in Limon Costa Rica. A transect was set up of 100 by 50 metres on which from march until june every 28 days all the mega and macro plastic was collected, and 50 random samples were taken to analyse the meso and micro plastic abundance. In March 19253 m^3, April 15403 m^3, May 13333 m^3 and June 11477 m^3 on average of micro plastics were found. Meso plastics were 3253 m^3 in March, 2464 m^3 April, 1963 m^3 May and 2165 m^3 in june. For both groups no significant difference was found. This is in line with the expectations, since there was no complete beach cleans of both micro and meso debris and thus no decrease in micro and meso plastic was to be expected. The abundance of macro and mega debris was respectively 119, 59, 82 and 57 marco m^3 and 0.075, 0.009, 0.041 and 0.007 mega m^3 for respectively March, April, May and June. The highest abundance of both micro and meso plastics were found in the range 16-20 meters from the tide line. For both groups a clear decrease is noticed, except for May where an increase in both macro and mega debris was found, which might have been the result of stormy weather with more wash-up of debris as a result. For all groups the highest abundance was found ranging from 16 to 20 meters away from the tide which did show a significant difference compared to the other ranges. Each month the highest concentration of debris consisted of micro plastics followed by respectively meso, macro and mega debris. This is an expected result since bigger pieces of debris tend to reduce in size, in addition to the primarily produced micro plastics which end up in the ocean and wash up ashore.

Table of contents

1. Introduction.

Ever since the discovery of 100 % synthetic plastics in the early 1900's and the start of the mass production of new forms of plastics after the Second World War, the production of these synthetic plastics has increased year by year (Cole et al., 2011). Plastic plays a vital role in virtually every product we buy today, either in production, packaging, storage or transport. (Gesamp, 2015). It is almost certain that the role plastics plays in our society will only increase in the future, and may help us battle some of the world's biggest problems, world food shortage, and an even distribution of water and foods. (European Commission, 2011; Gesamp, 2015). Plastics can also create ideal packaging materials, as they often have low production cost, durability and are lightweight. However, these characteristics can also have negative effects, as they are prone to short-term use, and are easily discarded of and replaced. The durable nature of plastics combined with the their increased production, has generated a worldwide environmental plastic waste problem (Cole et al., 2011; European Commission, 2011). An ever-increasing amount of plastics in many forms are entering the world's ecosystems, affecting plants and animals, including humans (Cheshire et al., 2009).

Anthropogenic marine debris can easily be found in any part of the marine environment, an estimated minimum of 5.25 trillion particles with a combined weight of 268,940 tons is present in the oceans (Eriksen et al., 2014). It may find its way into the environment in ways that can be classified as either land-based or sea-based sources (Cheshire et al., 2009; Nelms et al., 2015). Land-based sources include littering, illegal dumping or improper disposal of waste, and may enter the ocean via harbours, rivers, sewers and storm drains. Sea-based sources quite often include abandoned, lost or otherwise discarded fishing gear, (Macfadyen et al., 2009). Due to the small size of micro plastics, it can be quite difficult, and depending on the type of research conducted, sometimes unnecessary to determine the origin of the waste. Categorisation is instead based on the kind of research being conducted (Lippiatt et al., 2013). Classifications can be based upon size, polymer type, pre or post-consumer purpose and government policy. In marine research specifically, plastic waste is categorised as Mega, Macro, Meso, or Micro plastic (European Commission, 2011; Lippiatt et al., 2013).

Plastic debris in particular is a great threat to marine ecosystems, as plastic debris tends to reduce in size as a result of physical and chemical processes, such as waves and ultraviolet light (European Commission, 2011; Lee et al., 2013). Even the biggest pieces may end up floating in the ocean as micro-plastics, created by breakdown from bigger pieces of plastic. These are called secondary micro-plastics, since they are not manufactured as such, but are created by the forces mentioned above. Plastic particles that are specifically created in microscopic sizes are defined as primary micro-plastics (European Commission, 2011; Cole et al., 2011).

Plastic debris can affect sea turtles at all life stages. Debris washed up on the beach could prevent female sea turtles from reaching the nesting beaches, or could trap hatchlings in the nest.
Smaller debris is known to mix with the sand and have been found in the sand at a depth of 2 meters (Turra et al., 2014). It has been proven that plastic changes the physical properties of the sand, such as temperature, porosity and permeability (Cole et al., 2011). These properties can greatly influence development of eggs and hatchlings, as temperature is known to influence both the sex ratio of sea turtle hatchlings, and length of incubation period (Witt et al., 2009; Nelms et al., 2015; Carson et al., 2011). The presence of micro-plastics could also potentially lead to contamination from additives (Carson et al., 2011; Nelms et al., 2015). Additionally, their apparent inability to distinguish between natural food sources and anthropogenic marine debris has resulted in ingestion in all sea turtle species at all life stages (Nelms et al., 2015).

To study the abundance and rate of accumulation of plastic debris on a sea turtle nesting beach, we will adopt the National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program (MDP), which is a standardised methodology used to conduct debris research. Using this method, debris research conducted worldwide can be compared with one another (Lippiatt et al., 2013). Using this methodology, the rate of plastic debris accumulation, distribution of plastic debris moving away from the high-tide line, and compare accumulation rates and abundance of mega, macro, meso and micro plastics will be investigated.

Expected is that there won't be a significant difference between the months for micro and meso plastics, since there won't be a complete beach clean-up for these classifications, for macro and mega plastic there will be a complete clean-up of the transact, thus a decrease over time is to be expected for these classifications.

2. Methods.

2.1 Study area.

This research has taken place at Playa Norte located in Pococi, Limon on the Caribbean coast in the north east of Costa Rica. On this beach a 100m by 50m transect was established according to the NOAA MDP guidelines (Lippiat et al., 2013, figure 2.2). The transect is based at the river mouth of Laguna Tortuguero.

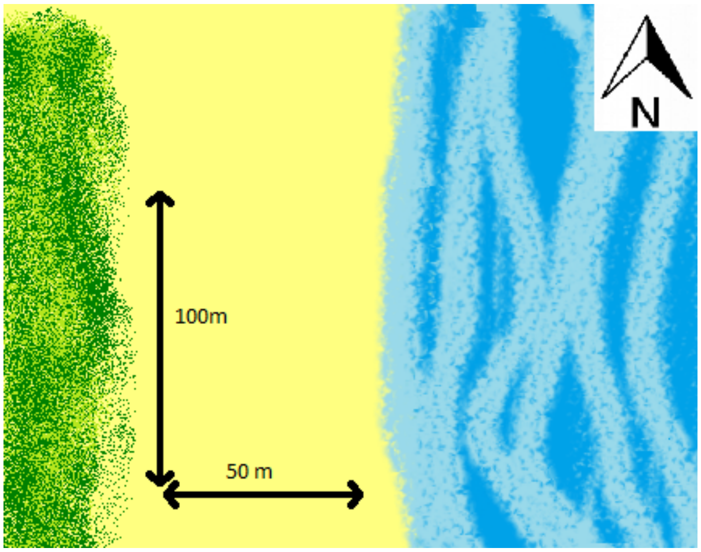

Figure 2.2: Research transect on Playa Norte

2.2 Mega and macro debris.

Every twenty-eight days the whole transect was cleared of all visible anthropogenic marine debris larger than 2.5 centimetres, as per NOAA specifications. NOAA Marine Debris Program classifies marine debris according to size shown in figure 2.1. This size classification was used throughout the whole study.

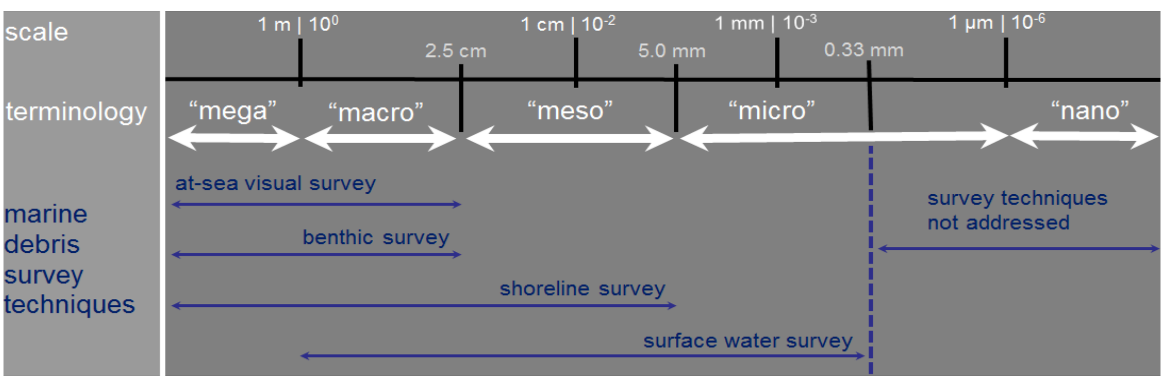

Figure 2.1 Visualisation of the size ranges that are used by each type of survey

The plastic was collected and taken off site for sorting and counting, which was done according to the list of categories shown in appendix 1. Mega debris (over 30cm) was processed on location, where type, dimension and status (stranded, sunken, buried) was recorded.

To compare results from micro and meso plastic the amount of macro and mega plastics found on the beach are converted to m^3, with the following formula.

$$c = \frac{n}{(a \; X \; h)}$$

c = concentration of debris particles per m^3
n = number of debris particles found in sample
a = area sampled (5000 m^2)
h = depth of sample (0.03m for micro and meso, 0.025m for macro, and 0.3m for mega)

The depth of sample for micro and meso plastics is derived from the NOAA marine debris project guidelines (see section 2.3). For both macro and mega samples, depth is defined as the maximum depth a fragment could occupy while still being visible to the collector. As macro items are defined as anything larger than 0.025m, and mega as anything larger than 0.3m, any macro or mega items deeper than 0.025m and 0.3m, respectively, wouldn't have been observed or removed by the collector. Thus, these depths are theoretically the deepest that collected items of these classifications could've been found at. These concentrations were calculated in order to ensure comparability between classifications.

2.3 Meso and micro plastic sampling.

After macro and mega debris was cleared, the transect was divided into 5000 separate $1m^2$ quadrants. Every twenty-eight days 50 random quadrants was sampled, using the random number selector command in Microsoft Excel: randbetween(1,5000). Each chosen quadrant was divided into 16 even squares of 25cm by 25 cm, these squares were chosen in consecutive order from 1 to 16. The top 3 centimetres of $1/16^{th}$ of the quadrant was collected and sieved with a 1mm mesh size sieve, and collected in a container. The meso, and micro plastic caught by the sieve was counted by hand. If necessary a hot needle test was performed to determine micro-plastic from sand or organic material. To do this, a needle was heated and introduced to a suspected micro plastic particle. If it reacted to the heat, by either deformation or melting, it was classified as a micro plastic (De Witte et al., 2014). The quantity of micro and meso plastic particles present were calculated per square meter with the same formula as for macro and mega plastics (see section 2.2). The transect was divided into 10 groups ranging from 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 meter from the tide line, in order to look at stratification of micro and meso plastics moving away from the high tide line.

2.6 Statistical analysis.

A one-way ANOVA was used to determine whether there was a significant difference between the months for micro and meso plastic debris, and whether meso and micro plastic concentrations significantly differed as distance from the high tide line increased. This was tested between 10 different groups, starting at 5 meters from the high tide line, and increasing in intervals of five meters. All tests were conducted using a 95% confidence interval and an alpha value of 0.05, with IBM SPSS version 20.

3. Results.

In this chapter the summaries of the results in statistical form, tables or graphs are presented. For the complete data sets, please see the appendix.

Figure 3.1 shows the results of the ANOVA test for micro plastic per month. With a significance value of 0.396 (compared to an alpha value of 0.05), there is no significant difference in amount of micro plastic per m^3 per month. Figure 3.2 displays the boxplot of the same data set. Figure 3.3 shows the results of the same test for meso plastic per month, which also showed an insignificant amount of variation by month (a significance value of 0.316 compared to an alpha value of 0.05). Figure 3.4 shows the boxplot of the same data set. The raw data sets for each classification per month are given in appendix two and the full SPSS data sheets are shown in appendix three.

3.1 Micro & meso plastic M^3 per month.

ANOVA

Micro m3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1668441600	3	556147200.1	.995	.396
Within Groups	1.095E+11	196	558893075.7		
Total	1.112E+11	199			

Figure 3.1Results Anova test micro plastic per month

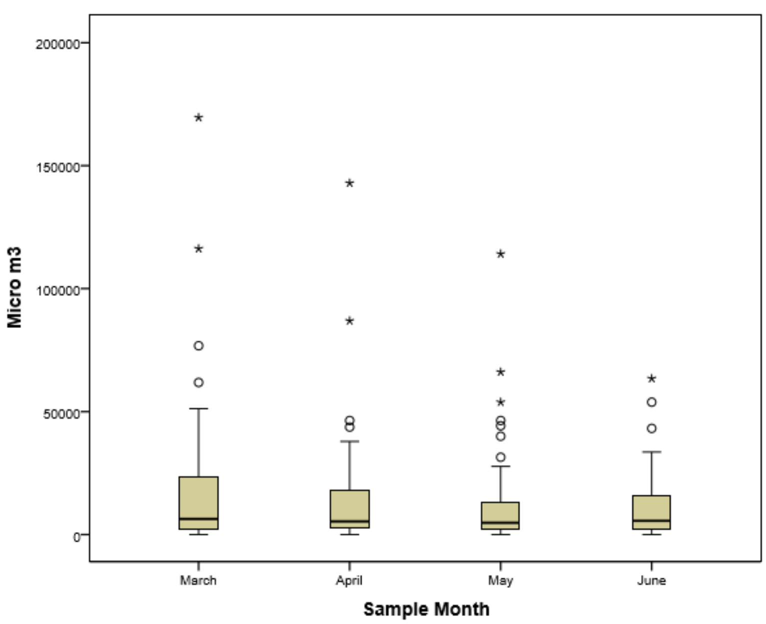

Figure 3.2 Boxplot micro plastic in m^3 per month

ANOVA

meso m3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	48177777.79	3	16059259.26	1.186	.316
Within Groups	2654998755	196	13545912.02		
Total	2703176533	199			

Figure 3.3 Results Anova test meso plastic per month

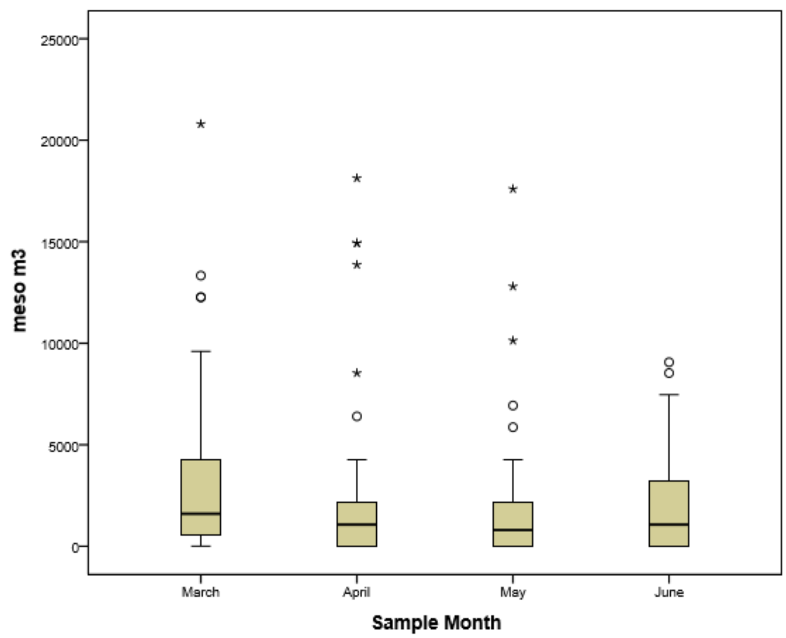

Figure 3.4 Boxplot meso plastic per month

3.2 Macro and mega plastic M^3 per month.

Table 3.1 Results for macro and mega per month

	Macro raw	Macro m^3	Mega raw	Mega m^3
March	14817	118.54	112	0.0747
April	7395	59.16	14	0.0093
May	10307	82.46	61	0.0407
June	7221	57.77	10	0.0067

Table 3.1 shows the raw data for macro and mega debris found on site each month, and the concentration per m^3. Figure 3.3 presents the amount of macro plastic per m^3, while figure 3.4 shows the same for mega plastics.

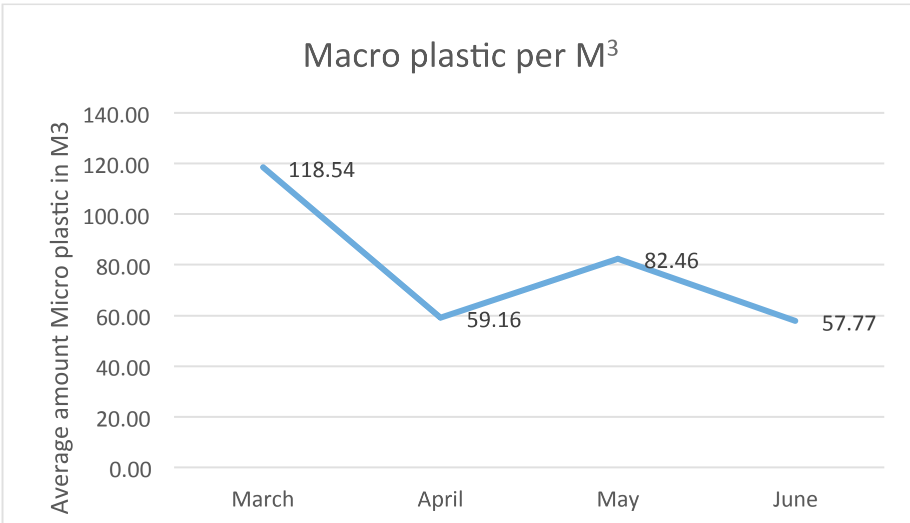

Figure 3.3 Amount of macro plastic per m^3 per month

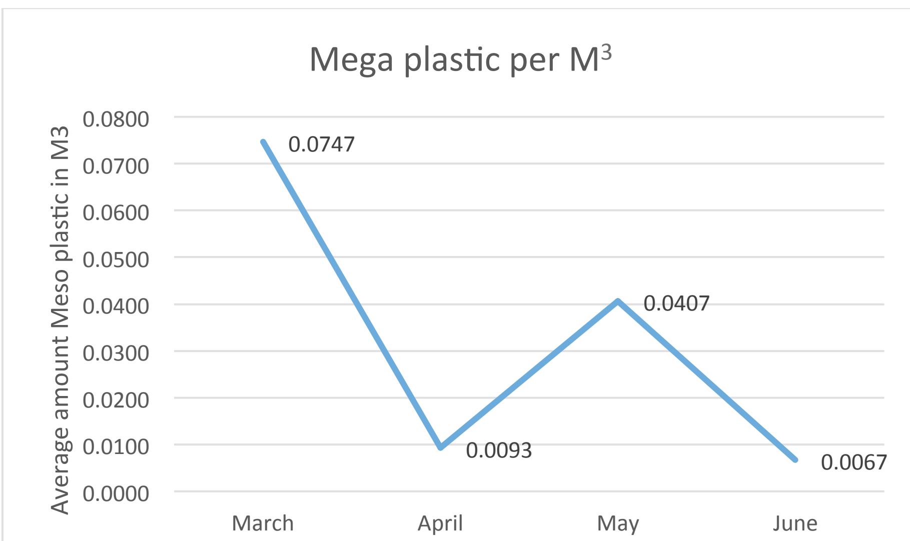

Figure 3.4 Amount of Macro plastic per m^3 per month

3.3 Micro, meso, macro and mega debris per month.

In table 3.2 the results from all the classifications are shown. For both micro and meso debris the average from the 50 monthly samples are shown. Macro and mega debris represent the amount from the monthly beach cleans. All results are shown as concentrations per m^3.

Table 3.2 Results micro, meso, macro and mega debris per m^3

Month	Micro m^3	Meso m^3	Macro m^3	Mega m^3
March	19253.3	3253.3	118.54	0.075
April	15402.7	2464.0	59.16	0.009
May	13333.3	1962.7	82.46	0.041
June	11477.3	2165.3	57.77	0.007

3.5 Micro and meso plastic per range.

Figure 3.5 and figure 3.6 show the amount of plastic per m^3 ranging away from the tide and the related boxplot for the micro plastic data set. Figure 3.7 and 3.8 show the amount of plastic per m^3 ranging away from the tide and the related boxplot for the meso plastic data set. These results are an average of each month together. The complete data set for the average micro plastic is given in appendix four, the complete data set for average meso plastic is given in appendix 5.

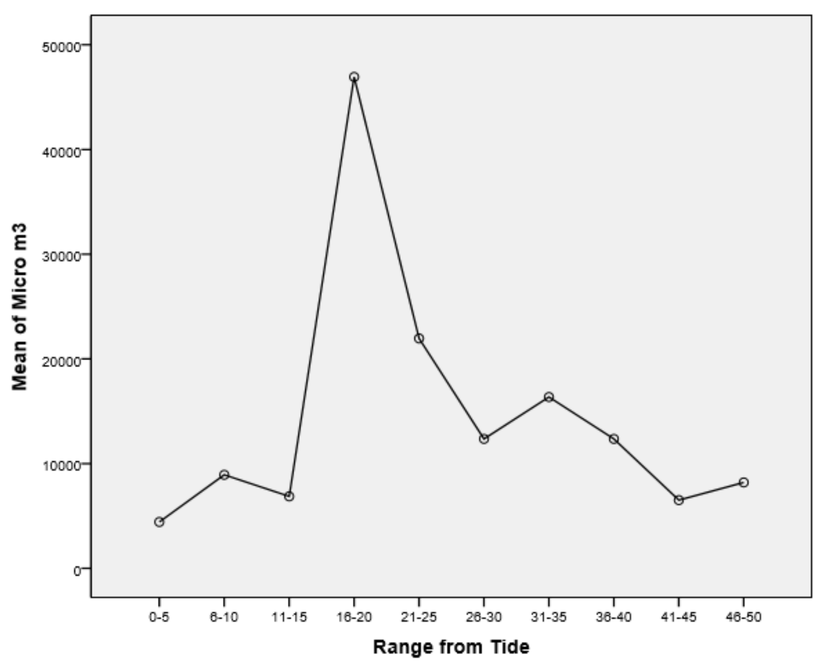

Figure 3.5 Micro plastic amount m^3 per range from tide

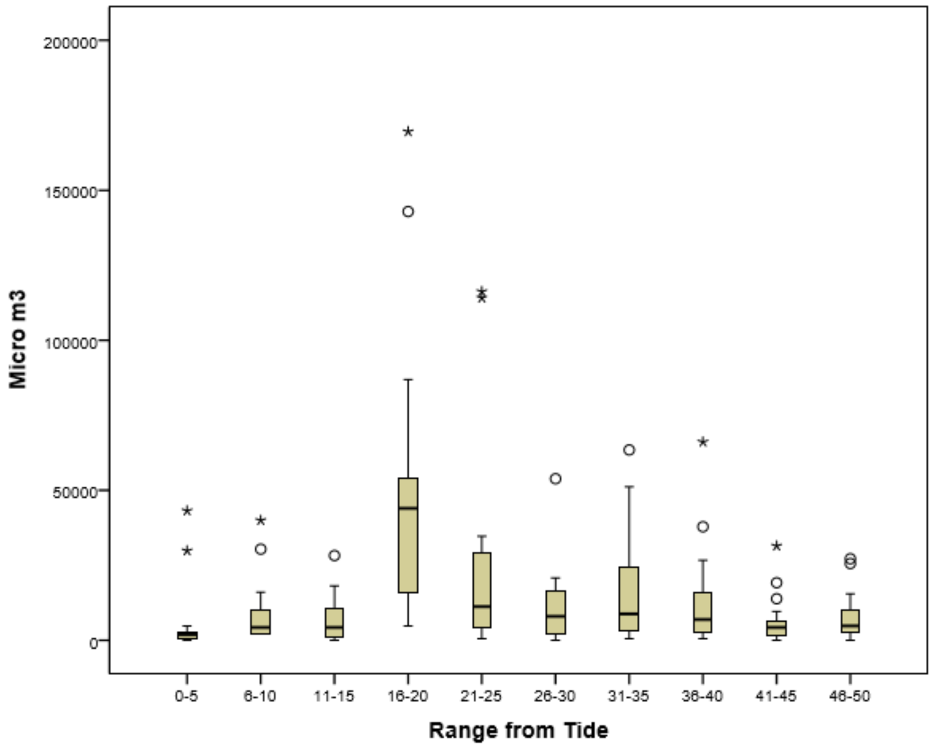

Figure 3.6 Boxplot micro plastic per range from tide

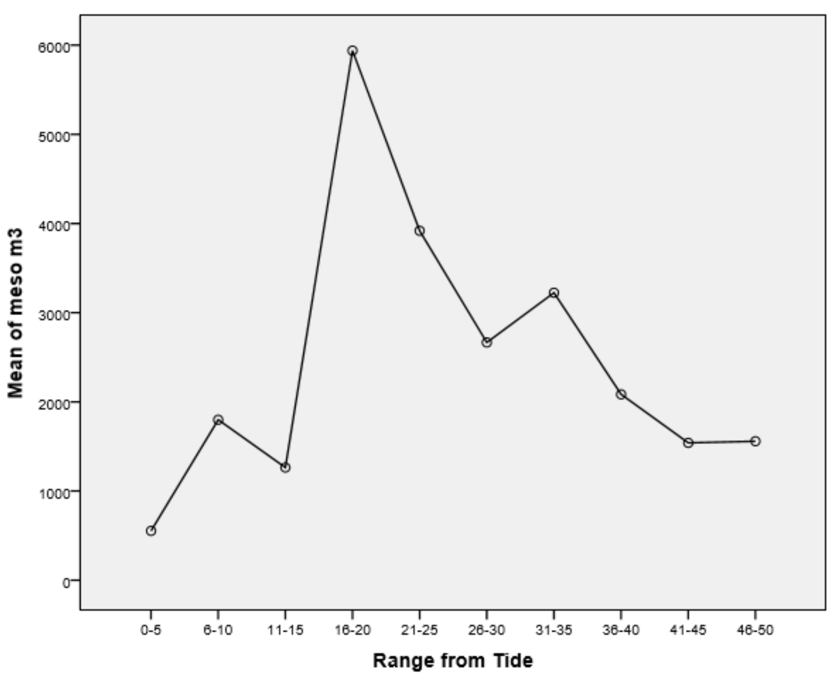

Figure 3.7 Meso plastic amount m^3 per range from tide

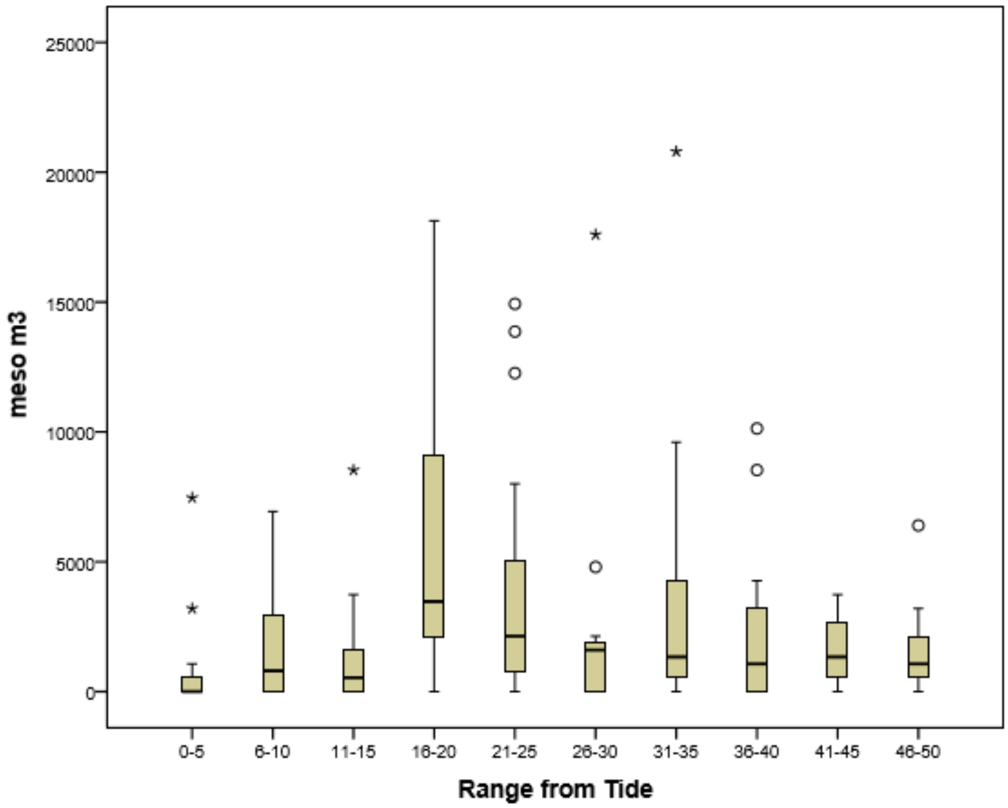

Figure 3.8 Boxplot meso plastic moving away from the tide

The results of the ANOVA tests used to compare micro and meso plastics at 10 different distances from the high tide line are represented in table 3.3, both per month, and over the whole study period. Micro plastic shows a significant difference (significance value <0.05) between distances from high tide in March and April, as well across the total study period. Meso plastic also shows a significant difference in concentrations moving away from the high tide line in March, April, as well as in May and over the total study period.

Table 3.3 Significance Anova for micro and meso plastic per month and in total

Micro		Meso	
Month	significance	Month	significance
March	0.001	March	0.007
April	0.045	April	0.001
May	0.162	May	0.001
June	0.200	June	0.385
Total	0.000	Total	0.000

4. Discussion & Conclusion.

While taking, processing and counting samples it became clear that sieving, handling, transporting and processing the samples put a lot of force on them. Through visual inspection every sample contained pieces that could have been picked up as one whole piece but broke down during one of the processing steps. However, without 100% certainty this was the case, these have been counted as individuals and thus potentially biased abundance counts. To minimize this in future studies, greater care could be taken to reduce external forces while processing/transporting particles.

During April, May and June the micro and meso samples were taking during rain showers, which resulted in wet sand samples that were impossible to sieve. To solve this problem the samples were rinsed trough the sieve using water and the dried before counting. In addition, originally the samples were put in a salt water bath to separate the micro plastic from the sand but while processing the sample of March, it was noticed the salt bath didn't separate more micro plastics from the sand samples and all micro plastics were caught by the sieve. For that reason this step was removed from the process for April, May and June and only the material removed from sieving the sample was used. This could potentially mean that almost no low density micro plastics, smaller than 1 mm were present in the samples and that a portion of high density micro plastics have not been count. A future study could use salts that have a higher specific density and is able to separate both high and low density micro plastics. (Claessens et al., 2013)

Statistical analyses of the results from the micro and meso samples show that there is no significant difference for both classifications across each month. Micro plastics show a significance of 0.396 (>0.05), and meso plastics a significance of 0.316 (>0.05). This is in line with the expectations, since there was no complete beach cleans of both micro and meso debris and thus no decrease in micro and meso plastic was to be expected.

A decrease in both macro and mega debris has been shown, apart from a slight increase in May. Macro debris went from 118.5 per m^3 in March to 59.2 per m^3 in April to 82.5 per m^3 in May and 57.8 per m^3 in June. Mega debris saw a similar decrease with an increase in May. In March there was 0.075 per m^3 mega debris found, 0.009 per m^3 in April, 0.041 per m^3 in May and 0.007 per m^3 in June. A decrease in macro and mega debris was expected since every 28 days the transect was completely cleared from visible macro and mega debris. Since the transect is positioned close to the river mouth of Laguna Tortuguero, on which several settlements are located on the river banks, one could theorise that a significant portion of the debris found on Playa Norte originates from the river, as rivers are a known source of land-based debris. (Macfadyen et al., 2009) Partly in remote areas like Tortugero, Costa Rica, waste disposal is a big problem and locals are known to burn trash or discard in the ocean or river. (Meletis, Z., 2007) Storms could cause an increase in land-based erosion and higher run-off from rivers, which could result in an increase in anthropogenic debris originating.

(Gesamp, 1987) The increase in May could be attributed to the stormy weather with higher tides several days prior to the clean-up, which could have washed up a greater amount of debris onto the beach (Carswell et al., 2011)

Each month the highest concentration of debris consisted of micro plastics followed by respectively meso, macro and mega debris. This is an expected result since bigger pieces of debris tend to reduce in size, in addition to the primarily produced micro plastics which end up in the ocean and wash up ashore. (European Commission, 2011; Lee et al., 2013) to these causes one would expect the least amount of the bigger mega debris, a greater abundance of macro debris, followed by an even greater abundance of meso and eventually the highest abundance for micro plastics (Cole et al., 2011). This research has indicated this is indeed the situation on this particular beach.

On average the highest concentrations of both micro and meso plastics have been found in the range 16-20 meters away from the tide. This would suggest the most recent high tide line found on this beach is located 16 to 20 meters from the tide, considering the highest abundance of micro and meso plastic should be found at the highest most recent tide. For both micro and meso the lowest abundance is found from 0 to 5 meter from the tide, which is understandable, for this is the range with the highest wave action.

5. Recommendations.

A significant part of the marine debris found on Playa Norte could be contributed to the river mouth of Laguna Tortuguero since many settlements are located on the riverside. To be able to give an estimate of how much debris found on Playa Norte is actually a result of the river, a future study could place a second transect further from the river mouth and compare the results from both transects.

Future studies focussing on the abundance moving away from the tide could instead of taking 50 random samples from the whole transect choose to take a set number of samples of each separate range, to create a reliable comparison between the ranges. Although several old tide lines were visible throughout the transect as sharp lines of biological and anthropological debris, the results from this study are dependent on the randomly chosen samples. In future studies these different old tide lines could be compared to determine where the actual highest abundance is found.

A problem in remote areas like the Limon region in Costa Rica, where infrastructure is often minimal, but residents or tourism high, is waste disposal. As a result many locals and even hotels resort to burying or burning solid waste, including plastic waste. Many initiatives are helping to educate locals to the effects of anthropogenic waste in the environment and waste disposal services have started to provide an alternative to burning or burying. But without organised help from governments it will remain a battle to educate the public and minimalize the amount of waste that find its way into the environment.

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7. Appendix.

Appendix 1: Classification macro debris.

ITEM
PLASTIC (HARD/FOAMED/FILM)
Food Wrappers
Bottles
Jugs or containers
Pull cap
Pen cap
Jugs or containers cap
Cigars butt
Cigarettes
Disposable cigarette lighters
6-pack rings
Bags
Plastic rope / small net piece
Buoys & floats
Fishing lures & line
Cups (including polystyrene / foamed plastic)
Plastic utensils
Straws
lollipop stick
Balloons
Personal care products
Needle/syringe
Electric cable
Tape
Label
Diaper
Toys
Cloth handles
Cloth pins
Foamed Plastic/Sponges
Plastics fragments
Other :
METAL
Aluminium/tin cans
Aerosol cans
Metal fragments
Others (aluminium) :
GLASS
Beverage bottles

Jars
Glass fragments
Other :
RUBBER
Flip-Flop
Gloves
Tires
Rubber fragments
Other :
PROCESSED LUMBER
Cardboard cartons
Paper and cardboard
Paper bags
Lumber/building material
Other (paint brush)
CLOTH / FRABRIC
Clothing & Shoes
Gloves (non rubber)
Towels / Rags
Rope / Net pieces (non nylon)
Other
OTHER / UNCLASSIFICABLE
Silicone
concrete
dry wall
Wax candle
Leather

Appendix 2: raw data micro and meso plastics.

29/03/2016		March			
Range from tide	Sample	**Micro**	Micro m3	**Meso**	Meso m3
1	181	2	1066.667	0	0
	274	2	1066.667	0	0
	403	3	1600	0	0
	464	7	3733.333	0	0
2	605	4	2133.333	3	1600
	634	57	30400	12	6400
	656	4	2133.333	1	533.3333
	876	10	5333.333	0	0
	1009	9	4800	2	1066.667
	1031	12	6400	9	4800
3	1145	17	9066.667	4	2133.333
	1159	10	5333.333	2	1066.667
	1186	1	533.3333	0	0
	1221	18	9600	5	2666.667
	1323	16	8533.333	6	3200
	1456	8	4266.667	1	533.3333
	1457	4	2133.333	2	1066.667
4	1703	44	23466.67	8	4266.667
	1762	116	61866.67	16	8533.333
	1801	144	76800	7	3733.333
	1838	94	50133.33	23	12266.67
	2032	91	48533.33	11	5866.667
	2053	318	169600	25	13333.33
5	2104	2	1066.667	0	0
	2113	13	6933.333	3	1600
	2124	53	28266.67	12	6400
	2236	21	11200	3	1600
	2396	12	6400	23	12266.67
	2436	218	116266.7	15	8000
	2536	65	34666.67	7	3733.333
6	2615	5	2666.667	0	0
	2797	1	533.3333	3	1600
	2826	3	1600	0	0
	2844	28	14933.33	0	0
7	3195	96	51200	39	20800
	3229	19	10133.33	8	4266.667
	3320	46	24533.33	5	2666.667

	3411	44	23466.67	4	2133.333
	3481	5	2666.667	2	1066.667
	3514	62	33066.67	8	4266.667
	3560	38	20266.67	18	9600
8	3820	7	3733.333	2	1066.667
	3933	9	4800	1	533.3333
	4084	6	3200	1	533.3333
9	4188	10	5333.333	7	3733.333
	4295	2	1066.667	0	0
	4510	0	0	2	1066.667
10	4654	29	15466.67	2	1066.667
	4731	19	10133.33	1	533.3333
	4893	1	533.3333	2	1066.667
	Average		19253.33		3253.333

26/04/2016		April			
Range from tide	Sample	**Micro**	Micro m3	**Meso**	Meso m3
1	156	5	2666.667	1	533.3333
	197	2	1066.667	0	0
	318	4	2133.333	0	0
	524	8	4266.667	1	533.3333
	580	2	1066.667	0	0
2	607	4	2133.333	0	0
	920	6	3200	1	533.3333
	985	30	16000	8	4266.667
3	1121	33	17600	2	1066.667
	1198	1	533.3333	0	0
	1216	24	12800	1	533.3333
	1265	16	8533.333	1	533.3333
	1444	8	4266.667	1	533.3333
	1477	34	18133.33	2	1066.667
4	1669	82	43733.33	6	3200
	1725	45	24000	6	3200
	1726	23	12266.67	2	1066.667
	1749	9	4800	0	0
	1760	10	5333.333	1	533.3333
	1814	87	46400	6	3200
	1817	64	34133.33	4	2133.333
	1819	15	8000	2	1066.667
	1907	163	86933.33	28	14933.33

	2073	268	142933.3	34	18133.33
5	2121	57	30400	28	14933.33
	2280	64	34133.33	26	13866.67
6	2805	0	0	0	0
	2875	4	2133.333	0	0
	3036	15	8000	3	1600
7	3235	1	533.3333	2	1066.667
	3278	3	1600	1	533.3333
	3343	49	26133.33	12	6400
	3410	8	4266.667	0	0
	3468	7	3733.333	1	533.3333
	3513	14	7466.667	2	1066.667
	3529	1	533.3333	0	0
8	3610	1	533.3333	2	1066.667
	3728	32	17066.67	6	3200
	3783	29	15466.67	4	2133.333
	3886	71	37866.67	16	8533.333
	3948	3	1600	0	0
	4027	5	2666.667	0	0
9	4255	6	3200	3	1600
	4282	10	5333.333	2	1066.667
	4322	8	4266.667	4	2133.333
	4413	8	4266.667	1	533.3333
	4455	36	19200	4	2133.333
10	4670	13	6933.333	1	533.3333
	4850	5	2666.667	0	0
	4961	51	27200	6	3200
	Average		15402.67		2464

24/05/2016		May			
Range from tide	Sample	**Micro**	Micro m3	**Meso**	Meso m3
1	31	3	1600	0	0
	34	1	533.3333	0	0
	189	1	533.3333	0	0
	210	6	3200	1	533.3333
	283	9	4800	0	0
	340	0	0	1	533.3333
	448	4	2133.333	0	0
	571	5	2666.667	2	1066.667
2	751	7	3733.333	1	533.3333

	898	75	40000	13	6933.333
	925	4	2133.333	0	0
	1074	4	2133.333	0	0
3	1118	6	3200	0	0
	1148	1	533.3333	0	0
	1186	1	533.3333	0	0
	1191	1	533.3333	1	533.3333
	1194	5	2666.667	3	1600
	1206	25	13333.33	0	0
	1287	0	0	0	0
	1326	21	11200	3	1600
	1482	3	1600	0	0
4	1649	83	44266.67	24	12800
	1974	87	46400	11	5866.667
	2036	34	18133.33	6	3200
5	2204	2	1066.667	0	0
	2347	7	3733.333	3	1600
	2422	214	114133.3	2	1066.667
	2463	24	12800	5	2666.667
	2546	9	4800	4	2133.333
	2553	9	4800	1	533.3333
	2563	21	11200	2	1066.667
6	2662	25	13333.33	3	1600
	2746	101	53866.67	33	17600
7	3218	46	24533.33	0	0
	3260	10	5333.333	6	3200
	3347	52	27733.33	3	1600
	3352	12	6400	2	1066.667
	3383	5	2666.667	0	0
8	3651	124	66133.33	19	10133.33
	3668	1	533.3333	0	0
	3718	50	26666.67	8	4266.667
	3916	26	13866.67	5	2666.667
	4048	16	8533.333	3	1600
9	4189	59	31466.67	7	3733.333
	4361	10	5333.333	1	533.3333
	4386	18	9600	3	1600
10	4673	8	4266.667	3	1600
	4848	9	4800	1	533.3333
	4935	6	3200	4	2133.333
	4954	0	0	0	0
	Average		13333.33		1962.667

21/06/2016 June

Range from tide	Sample	Micro	micro m3	Meso	Meso m3
1	3	0	0	0	0
	96	81	43200	6	3200
	101	0	0	0	0
	153	4	2133.333	1	533.3333
	158	56	29866.67	14	7466.667
	247	1	533.3333	0	0
	316	0	0	0	0
	420	5	2666.667	0	0
	483	5	2666.667	0	0
2	717	16	8533.333	2	1066.667
	819	21	11200	0	0
	874	5	2666.667	2	1066.667
3	1186	1	533.3333	1	533.3333
	1320	53	28266.67	7	3733.333
	1324	7	3733.333	4	2133.333
	1331	28	14933.33	16	8533.333
	1577	6	3200	2	1066.667
4	1753	30	16000	6	3200
	1773	101	53866.67	17	9066.667
	1918	28	14933.33	2	1066.667
5	2128	3	1600	1	533.3333
	2269	28	14933.33	8	4266.667
	2346	1	533.3333	1	533.3333
	2437	7	3733.333	0	0
	2442	63	33600	10	5333.333
	2515	24	12800	9	4800
	2561	30	16000	6	3200
6	2681	39	20800	4	2133.333
	2892	34	18133.33	9	4800
7	3145	32	17066.67	6	3200
	3505	119	63466.67	14	7466.667
	3568	6	3200	0	0
8	3722	3	1600	0	0
	3811	38	20266.67	8	4266.667
	3840	4	2133.333	0	0
	3874	12	6400	7	3733.333
	4015	14	7466.667	1	533.3333
	4055	30	16000	1	533.3333
	4059	21	11200	2	1066.667
	4078	8	4266.667	0	0

9	4135	1	533.3333	1	533.3333
	4198	26	13866.67	5	2666.667
	4242	6	3200	5	2666.667
	4256	1	533.3333	0	0
	4327	3	1600	2	1066.667
	4472	4	2133.333	0	0
	4589	12	6400	5	2666.667
10	4729	9	4800	6	3200
	4737	2	1066.667	0	0
	4840	48	25600	12	6400
	Average		11477.33		2165.333

Appendix 3: SPSS data sheets micro and meso plastics.

Oneway Micro

Notes

Output Created		20-JUL-2016 15:00:04
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Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax		ONEWAY micro BY Month /STATISTICS DESCRIPTIVES HOMOGENEITY BROWNFORSYTHE WELCH /MISSING ANALYSIS /POSTHOC=TUKEY ALPHA(0.05).
Resources	Processor Time	00:00:00.00
	Elapsed Time	00:00:00.02

[DataSet0]

Descriptives

Micro m3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
March	50	19253.33	31458.502	4448.904	10312.93	28193.74
April	50	15402.67	24552.880	3472.302	8424.82	22380.52
May	50	13333.33	21171.632	2994.121	7316.42	19350.24
June	50	11477.33	13958.977	1974.097	7510.24	15444.43
Total	200	14866.67	23640.044	1671.604	11570.34	18163.00

Descriptives

Micro m3

	Minimum	Maximum
March	0	169600
April	0	142933
May	0	114133
June	0	63467
Total	0	169600

Test of Homogeneity of Variances

Micro m3

Levene Statistic	df1	df2	Sig.
2.612	3	196	.053

ANOVA

Micro m3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1668441600	3	556147200.1	.995	.396
Within Groups	1.095E+11	196	558893075.7		
Total	1.112E+11	199			

Robust Tests of Equality of Means

Micro m3

	Statistic[a]	df1	df2	Sig.
Welch	.991	3	104.316	.400
Brown-Forsythe	.995	3	154.829	.397

a. Asymptotically F distributed.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Micro m3
Tukey HSD

(I) Sample Month	(J) Sample Month	Mean Difference (I-J)	Std. Error	Sig.	95% ... Lower Bound
March	April	3850.667	4728.184	.848	-8401.04
	May	5920.000	4728.184	.595	-6331.71
	June	7776.000	4728.184	.356	-4475.71
April	March	-3850.667	4728.184	.848	-16102.37
	May	2069.333	4728.184	.972	-10182.37
	June	3925.333	4728.184	.840	-8326.37
May	March	-5920.000	4728.184	.595	-18171.71
	April	-2069.333	4728.184	.972	-14321.04
	June	1856.000	4728.184	.979	-10395.71
June	March	-7776.000	4728.184	.356	-20027.71
	April	-3925.333	4728.184	.840	-16177.04
	May	-1856.000	4728.184	.979	-14107.71

Multiple Comparisons

Dependent Variable: Micro m3
Tukey HSD

(I) Sample Month	(J) Sample Month	95% ... Upper Bound
March	April	16102.37
	May	18171.71
	June	20027.71
April	March	8401.04
	May	14321.04
	June	16177.04
May	March	6331.71
	April	10182.37
	June	14107.71
June	March	4475.71
	April	8326.37
	May	10395.71

Homogeneous Subsets

Micro m3

Tukey HSD[a]

Sample Month	N	Subset for alpha = 0.05 1

June	50	11477.33
May	50	13333.33
April	50	15402.67
March	50	19253.33
Sig.		.356

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 50.000.

Oneway meso

Notes

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	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
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Resources	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.02

[DataSet0]

Descriptives

meso m3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound

March	50	3253.3333	4288.71852	606.51639	2034.4930	4472.1737
April	50	2464.0000	4243.32390	600.09662	1258.0607	3669.9393
May	50	1962.6667	3408.09121	481.97688	994.0979	2931.2355
June	50	2165.3333	2483.87964	351.27363	1459.4226	2871.2441
Total	200	2461.3333	3685.62093	260.61276	1947.4163	2975.2504

Descriptives

meso m3

	Minimum	Maximum
March	.00	20800.00
April	.00	18133.33
May	.00	17600.00
June	.00	9066.67
Total	.00	20800.00

Test of Homogeneity of Variances meso m3

Levene Statistic	df1	df2	Sig.
1.826	3	196	.144

ANOVA

meso m3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	48177777.79	3	16059259.26	1.186	.316
Within Groups	2654998755	196	13545912.02		
Total	2703176533	199			

Robust Tests of Equality of Means meso m3

	Statistic[a]	df1	df2	Sig.
Welch	1.043	3	106.070	.377
Brown-Forsythe	1.186	3	172.183	.317

a. Asymptotically F distributed.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: meso m3
Tukey HSD

(I) Sample Month	(J) Sample Month	Mean Difference (I-J)	Std. Error	Sig.	95% ...
					Lower Bound

March	April	789.33333	736.09543	.707	-1118.0427
	May	1290.66667	736.09543	.299	-616.7093
	June	1088.00000	736.09543	.453	-819.3760
April	March	-789.33333	736.09543	.707	-2696.7093
	May	501.33333	736.09543	.904	-1406.0427
	June	298.66667	736.09543	.977	-1608.7093
May	March	-1290.66667	736.09543	.299	-3198.0427
	April	-501.33333	736.09543	.904	-2408.7093
	June	-202.66667	736.09543	.993	-2110.0427
June	March	-1088.00000	736.09543	.453	-2995.3760
	April	-298.66667	736.09543	.977	-2206.0427
	May	202.66667	736.09543	.993	-1704.7093

Multiple Comparisons

Dependent Variable: meso m3

Tukey HSD

(I) Sample Month	(J) Sample Month	95% ... Upper Bound
March	April	2696.7093
	May	3198.0427
	June	2995.3760
April	March	1118.0427
	May	2408.7093
	June	2206.0427
May	March	616.7093
	April	1406.0427
	June	1704.7093
June	March	819.3760
	April	1608.7093
	May	2110.0427

Homogeneous Subsets

meso m3

Tukey HSD[,a]

Sample Month	N	Subset for alpha = 0.05 1
May	50	1962.6667
June	50	2165.3333
April	50	2464.0000
March	50	3253.3333
Sig.		.299

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 50.000.

Appendix 4: SPSS data sheets average micro plastics range from tide.

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	Split File	
Missing Value Handling	N of Rows in Working Data File	User-defined missing values are treated as missing.
	Definition of Missing	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
	Cases Used	
Syntax		ONEWAY micro BY Range /STATISTICS DESCRIPTIVES HOMOGENEITY BROWNFORSYTHE WELCH /PLOT MEANS /MISSING ANALYSIS /POSTHOC=TUKEY ...
		00:00:00.22
Resources		00:00:00.22
	Processor Time	
	Elapsed Time	

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[DataSet1] E:\data 20-7-2016.sav
```

Descriptives

Micro m3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound

0-5	26	4430.77	9728.058	1907.829	501.52	8360.02
6-10	16	8933.33	11099.656	2774.914	3018.74	14847.92
11-15	27	6874.07	7035.668	1354.015	4090.86	9657.29
16-20	22	46933.33	42162.417	8989.058	28239.56	65627.10
21-25	23	21959.42	31549.414	6578.508	8316.43	35602.41
26-30	11	12363.64	15687.288	4729.895	1824.77	22902.50
31-35	22	16363.64	16970.672	3618.159	8839.26	23888.01
36-40	22	12363.64	15310.994	3264.315	5575.12	19152.15
41-45	18	6518.52	7935.016	1870.301	2572.53	10464.51
46-50	13	8205.13	9096.783	2522.994	2708.00	13702.26
Total	200	14866.67	23640.044	1671.604	11570.34	18163.00

Descriptives

Micro m3

	Minimum	Maximum
0-5	0	43200
6-10	2133	40000
11-15	0	28267
16-20	4800 533	169600
21-25	0	116267
26-30	533	53867
31-35	533	63467
36-40	0	66133
41-45	0	31467
46-50	0	27200
Total		169600

Test of Homogeneity of Variances

Micro m3

Levene Statistic	df1	df2	Sig.
6.022	9	190	.000

ANOVA

Micro m3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	30986096544	9	3442899616	8.154	.000
Within Groups	80225387893	190	422238883.6		
Total	1.112E+11	199			

Robust Tests of Equality of Means

Micro m3

	Statistic[a]	df1	df2	Sig.
Welch	3.728	9	68.591	.001
Brown-Forsythe	8.769	9	74.787	.000

a. Asymptotically F distributed.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Micro m3

Tukey HSD

(I) Range from Tide	(J) Range from Tide	Mean Difference (I-J)	Std. Error	Sig.	95% ...
					Lower Bound
0-5	6-10	-4502.564	6529.157	1.000	-25407.08
	11-15	-2443.305	5646.099	1.000	-20520.52
	16-20	-42502.564*	5952.532	.000	-61560.89
	21-25	-17528.651	5882.021	.092	-36361.22
	26-30	-7932.867	7390.894	.987	-31596.42
	31-35	-11932.867	5952.532	.597	-30991.19
	36-40	-7932.867	5952.532	.945	-26991.19
	41-45	-2087.749	6300.609	1.000	-22260.52
	46-50	-3774.359	6979.962	1.000	-26122.22
6-10	0-5	4502.564	6529.157	1.000	-16401.95
	11-15	2059.259	6482.932	1.000	-18697.25
	16-20	-38000.000*	6751.489	.000	-59616.36
	21-25	-13026.087	6689.405	.637	-34443.67
	26-30	-3430.303	8048.309	1.000	-29198.71
	31-35	-7430.303	6751.489	.984	-29046.66
	36-40	-3430.303	6751.489	1.000	-25046.66
	41-45	2414.815	7060.287	1.000	-20190.22
	46-50	728.205	7672.669	1.000	-23837.51
11-15	0-5	2443.305	5646.099	1.000	-15633.91
	6-10	-2059.259	6482.932	1.000	-22815.77
	16-20	-40059.259*	5901.792	.000	-58955.13
	21-25	-15085.346	5830.668	.231	-33753.49

(I) Range from Tide	(J) Range from Tide	95% ... Upper Bound
0-5	6-10	16401.95
	11-15	15633.91
	16-20	-23444.24
	21-25	1303.91
	26-30	15730.68
	31-35	7125.45
	36-40	11125.45
	41-45	18085.02
	46-50	18573.50
6-10	0-5	25407.08
	11-15	22815.77
	16-20	-16383.64
	21-25	8391.50
	26-30	22338.11
	31-35	14186.05
	36-40	18186.05
	41-45	25019.85
	46-50	25293.92
11-15	0-5	20520.52
	6-10	18697.25
	16-20	-21163.39
	21-25	3582.80

(I) Range from Tide	(J) Range from Tide	Mean Difference (I-J)	Std. Error	Sig.	95% ... Lower Bound
16-20	26-30	-5489.562	7350.090	.999	-29022.47
	31-35	-9489.562	5901.792	.843	-28385.43
	36-40	-5489.562	5901.792	.995	-24385.43
	41-45	355.556	6252.695	1.000	-19663.80
	46-50	-1331.054	6936.742	1.000	-23540.54

	0-5	42502.564*	5952.532	.000	23444.24
	6-10	38000.000*	6751.489	.000	16383.64
	11-15	40059.259*	5901.792	.000	21163.39
	21-25	24973.913*	6127.878	.003	5354.18
	26-30	34569.697*	7588.019	.000	10275.01
	31-35	30569.697*	6195.591	.000	10733.17
	36-40	34569.697*	6195.591	.000	14733.17
	41-45	40414.815*	6530.727	.000	19505.28
	46-50	38728.205*	7188.365	.000	15713.10
21-25	0-5	17528.651	5882.021	.092	-1303.91
	6-10	13026.087	6689.405	.637	-8391.50
	11-15	15085.346	5830.668	.231	-3582.80
	16-20	-24973.913*	6127.878	.003	-44593.64
	26-30	9595.784	7532.832	.958	-14522.21
	31-35	5595.784	6127.878	.996	-14023.95
	36-40	9595.784	6127.878	.863	-10023.95
	41-45	15440.902	6466.524	.339	-5263.08
	46-50	13754.292	7130.086	.649	-9074.23
26-30	0-5	7932.867	7390.894	.987	-15730.68
	6-10	3430.303	8048.309	1.000	-22338.11
	11-15	5489.562	7350.090	.999	-18043.35
	16-20	-34569.697*	7588.019	.000	-58864.39
	21-25	-9595.784	7532.832	.958	-33713.78
	31-35	-4000.000	7588.019	1.000	-28294.69
	36-40	.000	7588.019	1.000	-24294.69
	41-45	5845.118	7864.036	.999	-19333.30
	46-50	4158.508	8418.151	1.000	-22794.03
31-35	0-5	11932.867	5952.532	.597	-7125.45
	6-10	7430.303	6751.489	.984	-14186.05
	11-15	9489.562	5901.792	.843	-9406.31
	16-20	-30569.697*	6195.591	.000	-50406.23
	21-25	-5595.784	6127.878	.996	-25215.51
	26-30	4000.000	7588.019	1.000	-20294.69
	36-40	4000.000	6195.591	1.000	-15836.53

		95% ...
(I) Range from Tide	(J) Range from Tide	Upper Bound

(I) Range from Tide	(J) Range from Tide	Mean Difference (I-	Std. Error	Sig.	95% ...
16-20	26-30	18043.35			
	31-35	9406.31			
	36-40	13406.31			
	41-45	20374.91			
	46-50	20878.43			
	0-5	61560.89			
	6-10	59616.36			
	11-15	58955.13			
	21-25	44593.64			
	26-30	58864.39			
	31-35	50406.23			
	36-40	54406.23			
	41-45	61324.35			
	46-50	61743.31			
21-25	0-5	36361.22			
	6-10	34443.67			
	11-15	33753.49			
	16-20	-5354.18			
	26-30	33713.78			
	31-35	25215.51			
	36-40	29215.51			
	41-45	36144.88			
	46-50	36582.81			
26-30	0-5	31596.42			
	6-10	29198.71			
	11-15	29022.47 -			
	16-20	10275.01			
	21-25	14522.21			
	31-35	20294.69			
	36-40	24294.69			
	41-45	31023.54			
	46-50	31111.05			
31-35	0-5	30991.19			
	6-10	29046.66			
	11-15	28385.43 -			
	16-20	10733.17			
	21-25	14023.95			
	26-30	28294.69			
	36-40	23836.53			

					Lower Bound
36-40	41-45	9845.118	6530.727	.888	-11064.42
	46-50	8158.508	7188.365	.980	-14856.60
	0-5	7932.867	5952.532	.945	-11125.45
	6-10	3430.303	6751.489	1.000	-18186.05
	11-15	5489.562	5901.792	.995	-13406.31
	16-20	-34569.697*	6195.591	.000	-54406.23
	21-25	-9595.784	6127.878	.863	-29215.51
	26-30	.000	7588.019	1.000	-24294.69
	31-35	-4000.000	6195.591	1.000	-23836.53
	41-45	5845.118	6530.727	.996	-15064.42
	46-50	4158.508	7188.365	1.000	-18856.60
41-45	0-5	2087.749	6300.609	1.000	-18085.02
	6-10	-2414.815	7060.287	1.000	-25019.85
	11-15	-355.556	6252.695	1.000	-20374.91
	16-20	-40414.815*	6530.727	.000	-61324.35
	21-25	-15440.902	6466.524	.339	-36144.88
	26-30	-5845.118	7864.036	.999	-31023.54
	31-35	-9845.118	6530.727	.888	-30754.66
	36-40	-5845.118	6530.727	.996	-26754.66
	46-50	-1686.610	7479.146	1.000	-25632.72
46-50	0-5	3774.359	6979.962	1.000	-18573.50
	6-10	-728.205	7672.669	1.000	-25293.92
	11-15	1331.054	6936.742	1.000	-20878.43
	16-20	-38728.205*	7188.365	.000	-61743.31
	21-25	-13754.292	7130.086	.649	-36582.81
	26-30	-4158.508	8418.151	1.000	-31111.05
	31-35	-8158.508	7188.365	.980	-31173.62
	36-40	-4158.508	7188.365	1.000	-27173.62
	41-45	1686.610	7479.146	1.000	-22259.50

		95% ...
(I) Range from Tide	(J) Range from Tide	Upper Bound
36-40	41-45	30754.66
	46-50	31173.62

	0-5	26991.19
	6-10	25046.66
	11-15	24385.43 -
	16-20	14733.17
	21-25	10023.95
	26-30	24294.69
	31-35	15836.53
	41-45	26754.66
	46-50	27173.62
41-45	0-5	22260.52
	6-10	20190.22
	11-15	19663.80
	16-20	-19505.28
	21-25	5263.08
	26-30	19333.30
	31-35	11064.42
	36-40	15064.42
	46-50	22259.50
46-50	0-5	26122.22
	6-10	23837.51
	11-15	23540.54
	16-20	-15713.10
	21-25	9074.23
	26-30	22794.03
	31-35	14856.60
	36-40	18856.60
	41-45	25632.72

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

Micro m3

Tukey HSD[a,b]

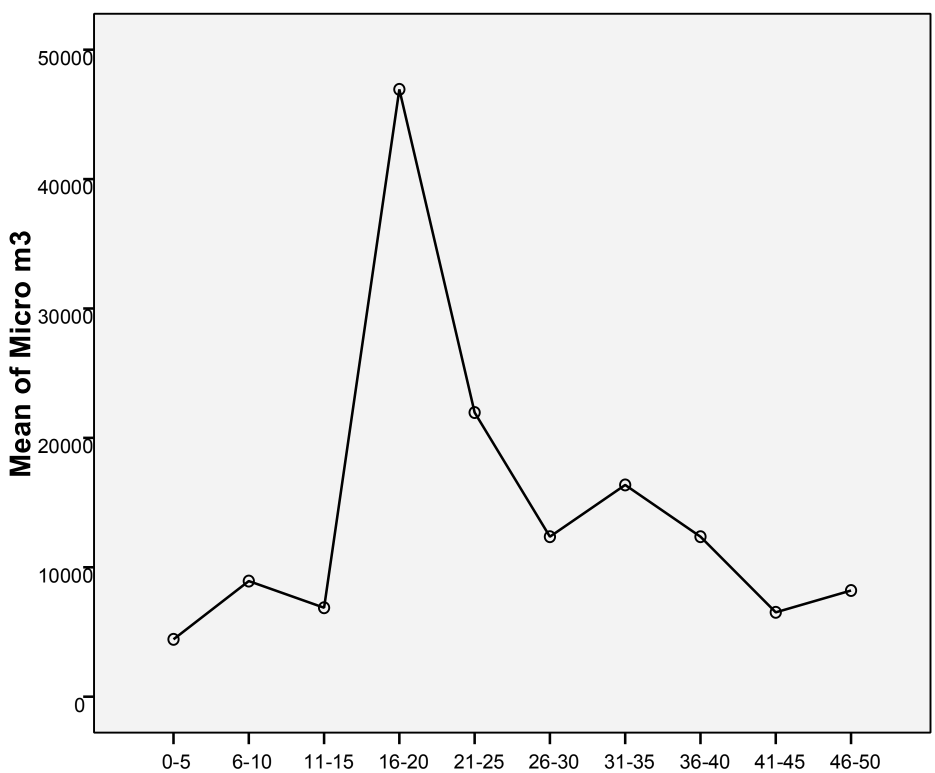
Range from Tide	N	Subset for alpha = 0.05 1	 2
0-5	26	4430.77	
41-45	18	6518.52	
11-15	27	6874.07	
46-50	13	8205.13	
6-10	16	8933.33	
26-30	11	12363.64	
36-40	22	12363.64	
31-35	22	16363.64	
21-25	23	21959.42	
16-20 Sig.	22		
		.228	
			46933.33
			1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 18.476.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Range from Tide



Appendix 5: SPSS data sheets average meso plastics range from tide.

Notes

Output Created		27-JUL-2016 20:25:27
Comments		
Input		E:\data 20-7-2016.sav
		DataSet1
	Data	<none>
	Active Dataset	<none>
	Filter	<none>
	Weight	200
	Split File N of Rows in Working Data File	User-defined missing values are treated as missing.
Missing Value Handling	Definition of Missing	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
	Cases Used	
Syntax		ONEWAY meso BY Range /STATISTICS DESCRIPTIVES HOMOGENEITY BROWNFORSYTHE WELCH /PLOT MEANS /MISSING ANALYSIS /POSTHOC=TUKEY ...
		00:00:00.20
Resources		00:00:00.21
	Processor Time	
	Elapsed Time	

```
[DataSet1] E:\data 20-7-2016.sav
```

Descriptives

meso m3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound

0-5	26	553.85	1556.608	305.276	-74.88	1182.57
6-10	16	1800.00	2384.145	596.036	529.58	3070.42
11-15	27	1264.20	1782.103	342.966	559.22	1969.17
16-20	22	5939.39	5270.218	1123.614	3602.71	8276.08
21-25	23	3918.84	4440.719	925.954	1998.53	5839.15
26-30	11	2666.67	5165.355	1557.413	-803.47	6136.80
31-35	22	3224.24	4725.997	1007.586	1128.85	5319.63
36-40	22	2084.85	2753.674	587.085	863.94	3305.76
41-45	18	1540.74	1211.899	285.647	938.08	2143.40
46-50	13	1558.97	1827.676	506.906	454.52	2663.43
Total	200	2461.33	3685.621	260.613	1947.42	2975.25

Descriptives

meso m3

	Minimum	Maximum
0-5	0	7467
6-10	0	6933
11-15	0	8533
16-20	0	18133
21-25	0	14933
26-30	0	17600
31-35	0	20800
36-40	0	10133
41-45	0	3733
46-50	0	6400
Total	0	20800

Test of Homogeneity of Variances meso m3

Levene Statistic	df1	df2	Sig.
5.845	9	190	.000

ANOVA

meso m3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	497511902.7	9	55279100.30	4.762	.000
Within Groups	2205664630	190	11608761.21		
Total	2703176533	199			

Robust Tests of Equality of Means meso m3

	Statistic[a]	df1	df2	Sig.

Welch	3.843	9	68.574	.001
Brown-Forsythe	4.583	9	90.159	.000

a. Asymptotically F distributed.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: meso m3
Tukey HSD

(I) Range from Tide	(J) Range from Tide	Mean Difference (I-J)	Std. Error	Sig.	95% ...
					Lower Bound
0-5	6-10	-1246.154	1082.607	.978	-4712.36
	11-15	-710.351	936.186	.999	-3707.76
	16-20	-5385.548*	986.996	.000	-8545.63
	21-25	-3364.994*	975.305	.024	-6487.64
	26-30	-2112.821	1225.493	.780	-6036.50
	31-35	-2670.396	986.996	.179	-5830.48
	36-40	-1531.002	986.996	.869	-4691.09
	41-45	-986.895	1044.711	.995	-4331.76
	46-50	-1005.128	1157.356	.997	-4710.65
6-10	0-5	1246.154	1082.607	.978	-2220.05
	11-15	535.802	1074.943	1.000	-2905.86
	16-20	-4139.394*	1119.472	.010	-7723.63
	21-25	-2118.841	1109.178	.662	-5670.12
	26-30	-866.667	1334.500	1.000	-5139.36
	31-35	-1424.242	1119.472	.959	-5008.48
	36-40	-284.848	1119.472	1.000	-3869.08
	41-45	259.259	1170.674	1.000	-3488.91
	46-50	241.026	1272.214	1.000	-3832.24
11-15	0-5	710.351	936.186	.999	-2287.05
	6-10	-535.802	1074.943	1.000	-3977.46
	16-20	-4675.196*	978.583	.000	-7808.34
	21-25	-2654.643	966.790	.163	-5750.03

Multiple Comparisons

Dependent Variable: meso m3
Tukey HSD

(I) Range from Tide	(J) Range from Tide	95% ... Upper Bound
0-5	6-10	2220.05
	11-15	2287.05
	16-20	-2225.46
	21-25	-242.34
	26-30	1810.86
	31-35	489.69
	36-40	1629.08
	41-45	2357.98
	46-50	2700.40
6-10	0-5	4712.36
	11-15	3977.46
	16-20	-555.16
	21-25	1432.43
	26-30	3406.02
	31-35	2159.99
	36-40	3299.39
	41-45	4007.43
	46-50	4314.30
11-15	0-5	3707.76
	6-10	2905.86
	16-20	-1542.05
	21-25	440.74

(I) Range from Tide	(J) Range from Tide	Mean Difference (I-J)	Std. Error	Sig.	95% ... Lower Bound
16-20	26-30	-1402.469	1218.727	.979	-5304.49
	31-35	-1960.045	978.583	.598	-5093.19
	36-40	-820.651	978.583	.998	-3953.80
	41-45	-276.543	1036.767	1.000	-3595.98
	46-50	-294.777	1150.189	1.000	-3977.36

Multiple Comparisons

Dependent Variable: meso m3
Tukey HSD

	0-5	5385.548*	986.996	.000	2225.46
	6-10	4139.394*	1119.472	.010	555.16
	11-15	4675.196*	978.583	.000	1542.05
	21-25	2020.553	1016.071	.608	-1232.62
	26-30	3272.727	1258.178	.224	-755.60
	31-35	2715.152	1027.298	.205	-573.97
	36-40	3854.545*	1027.298	.009	565.43
	41-45	4398.653*	1082.868	.003	931.62
	46-50	4380.420*	1191.911	.011	564.26
21-25	0-5	3364.994*	975.305	.024	242.34
	6-10	2118.841	1109.178	.662	-1432.43
	11-15	2654.643 -	966.790	.163	-440.74
	16-20	2020.553	1016.071	.608	-5273.72
	26-30	1252.174	1249.028	.992	-2746.86
	31-35	694.598	1016.071	1.000	-2558.57
	36-40	1833.992	1016.071	.731	-1419.18
	41-45	2378.100	1072.222	.448	-1054.85
	46-50	2359.866	1182.248	.603	-1425.36
26-30	0-5	2112.821	1225.493	.780	-1810.86
	6-10	866.667	1334.500	1.000	-3406.02
	11-15	1402.469 -	1218.727	.979	-2499.55
	16-20	3272.727	1258.178	.224	-7301.06
	21-25	-1252.174	1249.028	.992	-5251.21
	31-35	-557.576	1258.178	1.000	-4585.91
	36-40	581.818	1258.178	1.000	-3446.51
	41-45	1125.926	1303.945	.997	-3048.94
	46-50	1107.692	1395.824	.999	-3361.34
31-35	0-5	2670.396	986.996	.179	-489.69
	6-10	1424.242	1119.472	.959	-2159.99
	11-15	1960.045	978.583	.598	-1173.10
	16-20	-2715.152	1027.298	.205	-6004.27
	21-25	-694.598	1016.071	1.000	-3947.77
	26-30	557.576	1258.178	1.000	-3470.76
	36-40	1139.394	1027.298	.983	-2149.72

		95% ...
(I) Range from Tide	(J) Range from Tide	Upper Bound

Multiple Comparisons

Dependent Variable: meso m3
Tukey HSD

16-20	26-30	2499.55
	31-35	1173.10
	36-40	2312.50
	41-45	3042.89
	46-50	3387.80
	0-5	
	6-10	8545.63
	11-15	7723.63
	21-25	7808.34
	26-30	5273.72
	31-35	7301.06
	36-40	6004.27
	41-45	7143.66
	46-50	7865.69
		8196.58
21-25	0-5	6487.64
	6-10	5670.12
	11-15	5750.03
	16-20	1232.62
	26-30	5251.21
	31-35	3947.77
	36-40	5087.16
	41-45	5811.05
	46-50	6145.09
26-30	0-5	6036.50
	6-10	5139.36
	11-15	5304.49
	16-20	755.60
	21-25	2746.86
	31-35	3470.76
	36-40	4610.15
	41-45	5300.79
	46-50	5576.72
31-35	0-5	5830.48
	6-10	5008.48
	11-15	5093.19
	16-20	573.97
	21-25	2558.57
	26-30	4585.91
	36-40	4428.51

Multiple Comparisons

Dependent Variable: meso m3
Tukey HSD

(I) Range from Tide	(J) Range from Tide	Mean Difference (I-J)	Std. Error	Sig.	95% ...
					Lower Bound
36-40	41-45	1683.502	1082.868	.868	-1783.53
	46-50	1665.268	1191.911	.927	-2150.89
	0-5	1531.002	986.996	.869	-1629.08
	6-10	284.848	1119.472	1.000	-3299.39
	11-15	820.651	978.583	.998	-2312.50
	16-20	-3854.545*	1027.298	.009	-7143.66
	21-25	-1833.992	1016.071	.731	-5087.16
	26-30	-581.818	1258.178	1.000	-4610.15
	31-35	-1139.394	1027.298	.983	-4428.51
	41-45	544.108	1082.868	1.000	-2922.93
	46-50	525.874	1191.911	1.000	-3290.29
41-45	0-5	986.895 -	1044.711	.995	-2357.98
	6-10	259.259	1170.674	1.000	-4007.43
	11-15	276.543	1036.767	1.000	-3042.89
	16-20	-4398.653*	1082.868	.003	-7865.69
	21-25	-2378.100	1072.222	.448	-5811.05
	26-30	-1125.926	1303.945	.997	-5300.79
	31-35	-1683.502	1082.868	.868	-5150.54
	36-40	-544.108	1082.868	1.000	-4011.14
	46-50	-18.234	1240.126	1.000	-3988.77
46-50	0-5	1005.128	1157.356	.997	-2700.40
	6-10	-241.026	1272.214	1.000	-4314.30
	11-15	294.777	1150.189	1.000	-3387.80
	16-20	-4380.420*	1191.911	.011	-8196.58
	21-25	-2359.866	1182.248	.603	-6145.09
	26-30	-1107.692	1395.824	.999	-5576.72
	31-35	-1665.268	1191.911	.927	-5481.43
	36-40	-525.874	1191.911	1.000	-4342.04
	41-45	18.234	1240.126	1.000	-3952.30

(I) Range from Tide	(J) Range from Tide	95% ...
		Upper Bound
36-40	41-45	5150.54
	46-50	5481.43

Multiple Comparisons

Dependent Variable: meso m3
Tukey HSD

	0-5	4691.09
	6-10	3869.08
	11-15	3953.80
	16-20	-565.43
	21-25	1419.18
	26-30	3446.51
	31-35	2149.72
	41-45	4011.14
	46-50	4342.04
41-45	0-5	4331.76
	6-10	3488.91
	11-15	3595.98
	16-20	-931.62
	21-25	1054.85
	26-30	3048.94
	31-35	1783.53
	36-40	2922.93
	46-50	3952.30
46-50	0-5	4710.65
	6-10	3832.24
	11-15	3977.36
	16-20	-564.26
	21-25	1425.36
	26-30	3361.34
	31-35	2150.89
	36-40	3290.29
	41-45	3988.77

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

Multiple Comparisons

Dependent Variable: meso m3
Tukey HSD

meso m3

Tukey HSD[a,b]

Range from Tide	N	Subset for alpha = 0.05	
		1	2
0-5	26	553.85	
11-15	27	1264.20	
41-45	18	1540.74	
46-50	13	1558.97	
6-10	16	1800.00	
36-40	22	2084.85	
26-30	11	2666.67	
31-35	22	3224.24	
21-25	23	3918.84	2666.67
16-20 Sig.	22		3224.24
		.087	3918.84
			5939.39
			.107

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 18.476.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.