The Sources of Macroplastic Waste in Freshwater Ecosystems

Abigail Chapman

Abstract—This research paper was concerning the concentrations of different source of macroplastic waste in Lake Lewisville in the Colony, Texas. Plastic waste has been accumulating in great amounts in both freshwater and marine ecosystems over the last several decades. The presence of plastic waste inside these ecosystems can cause harm to organisms in the area, by causing entrapment, stranglings, and many digestive and reproductive issues if the animals digest smaller pieces of plastic. Plastic stands out from other forms of waste, because its durability that makes it such a useful material in the industrial world also causes it to persist for long periods of time in terrestrial or water environments when it is deposited in these areas. This means that the plastic particles can stay in the environment for much longer periods than other materials can without breaking down. In order to reduce the amount to waste going into oceans and lakes around the world, it is crucial to understand the different sources of plastic waste that are ending up in the bodies of water, and which ones are having the greatest impact. Therefore, this research study attempted to gain more knowledge on which sources of macroplastic waste were the most highly concentrated, in both quantity and mass. Macroplastics are plastics that are over 5mm in size, and were chosen for this study for feasibility purposes, as microplastics (plastics under 5mm in size) are very difficult to see and locate. This research was conducted using a case study of Lake Lewisville in The Colony, Texas, in which plastic was collected, massed and categorized by what its purpose was when it was in use by humans. The specific data collection took place along the shoreline of Hidden Cove of Lake Lewisville. A grid sampling method was used in order to make the data collection a random sample, and the collection occurred along the shoreline, because it was impossible to collect plastics along the bottom of the lake. The results showed that plastic bags were the most highly concentrated source of waste, in quantity, while plastic bottles were the most highly concentrated source, in mass. This study can benefit the scholarly community, because it brings more light to freshwater ecosystems, while most sources in the field focus on marine ecosystems. Also, a study has never been conducted on Lake Lewisville, specifically, and there is also very limited available information concerning the relative concentrations of different sources of plastic waste.

Index Terms— environment, freshwater ecosystems, Lake Lewisville, macroplastics, marine plastics, plastic waste, Texas,

1 Introduction

Plastics in History

Plastic is a very durable, lightweight material made from fossil fuels and found in many consumer products. In the middle of the twentieth century, the use of plastics increased for various products, such as packaging, water bottles, and plastic bags, for its inexpensive production costs [13]. Since the explosion of the plastic industry during that time period, plastics have started to accumulate in both marine and freshwater ecosystems across the globe, in very high quantities [1]. In fact, a recent study estimated that there are approximately 5 trillion pieces of plastic in the ocean, which weigh 250,000 tons altogether [4]. This number continues to grow exponentially as humans continue to be increasingly reliant on using plastics in their everyday lives. The durability of plastic, which makes it such a good material for many consumer products, consequentially makes it very persistent in the environment, meaning that it does not degrade for a long period of time, allowing the concentration of various plastics to build up even more [12].

Plastic waste has built up so quickly in water ecosystems because of how abundantly it is currently being produced. In 2012, approximately 280 million tons of plastic were produced for many different products that we use in our everyday lives, such as plastic bags and disposable water bottles. [10]. One of the main reasons that it accumulates at such a high rate in bodies of water is that much of the plastic currently used in our society is littered or disposed of improperly, causing it to become debris that slowly gets carried into bodies of water. Of the 280 million tons produced in 2012, only half of it was recycled, meaning that a large portion of it still persists in the environment today [10].

Characteristics of Plastics

Two categories can be used to classify plastic, based on size. Microplastics are the smallest, being less than 5 millimeters in size, and are usually pieces of larger plastic pieces that have broken down over time. The second group is macroplastics, which are over 5 millimeters in length. This study will focus on macroplastic plastic pieces, and their effect on freshwater bodies [3].

Plastic can have several detrimental effects on the water ecosystems that it enters. First, animals can become entrapped in the large plastics that enter the water, causing them to be injured or killed [12]. Additionally, animals can ingest the plastic, which can lead to digestive issues, malnutrition and starvation, reproductive failure, chemical leaching, and more [3]. The ingestion of plastics by animals can also have a negative effect on human health, as the consumption of seafoods can allow for the plastic toxins to enter the human digestive system, as well [11]. Aside from the implications that plastic waste can have on the animals in an ecosystem, plastic also serves as visual pollution to the beautiful waters in both the lakes and oceans, and can disrupt various recreational activities, including boating and water sports. Macroplastic waste can even disrupt non-recreational marine navigation [9].

Reduction Efforts

Over the last few decades, there has been a growing

awareness of plastic waste in water ecosystems, and several steps have been taken to combat it. For example, the Marine Debris Prevention and Production Act was put forth by the US Congress to decrease the entrance of plastic into the ocean. In the act, Federal agencies were instructed to complete mapping, identification, impact assessment, prevention, and removal efforts for plastic waste in the ocean to gain more information about the problem [9]. However, much more research has been completed concerning ocean plastic waste, while freshwater ecosystems have very limited information on them, which represents a major research gap in the field.

The first significant study on freshwater plastic waste was conducted in 2014 by Maciej Zbyszewski and Patricia L. Corcoran on Lake Huron and the distribution of plastic in it, as well as the degradation of the plastics in the lake [14]. Due to the lack of research of plastic sources in freshwater ecosystems, this study will look to examine how various sources are concentrated in Lake Lewisville in The Colony, TX, in comparison to both each other and the other non-plastic waste found along the shoreline of the lake.

This Study

This research will be conducted using a case study of Lake Lewisville in The Colony, Texas, in which plastic will be collected, massed and categorized by what its purpose was when it was in use by humans. The specific data collection will take place along the shoreline of Hidden Cove of Lake Lewisville. This is because the relative concentration of plastic in bodies of water can be estimated through data on its shoreline, and collecting in the deep waters of the lake can be extremely difficult, and therefore, unfeasible. Then, the concentration of plastic bags will be compared to the other sources of plastic, by mass and number. The mentor utilized for this research was Mr. Platt, who is currently an AP Environmental Science teacher at Reedy High School in Frisco, Texas. Mr. Platt was decided upon as the mentor for this study, because he is very knowledgeable and passionate about the topic and was very helpful in giving guidance when necessary.

The data collected in this study will give the community a better understanding of where the plastic waste is coming from, which will, in turn, make the prevention of it entering the water more feasible. This is because by knowing what the sources of plastic waste in fresh bodies of water are, individuals can more effectively refrain from the activities that cause them to end up in freshwater ecosystems, especially Lake Lewisville. The data collected in this lab can also better help the scholarly community in the field to have a better idea of what anthropogenic activities are causing the biggest disturbance to freshwater lakes, in terms of plastic waste.

2 Methodology

One important aspect of relieving the effect that macroplastic waste has on both oceans and lakes is identifying what specific sources are primarily concentrated in these bodies of water. By identifying these sources according to end use (such as plastic bottles, plastic bags, packaging plastics, and household or industrial plastics), the population in the community will better understand what products that they use are accumulating in bodies of water, and as a result, they will have the ability to take more preventative, specific actions to keep it from occurring. It can also benefit the scholarly community in the field, as it will detail the specific sources of anthropogenic, or human caused, plastic waste that are causing the phenomenon of accumulating waste in bodies of water. This is a topic of research that has not been focused on, especially in freshwater bodies of water, and thus, represents a gap in research in the field of plastic waste in water ecosystems.

Therefore, this study will be addressing the question: To what extent are various sources of macroplastic waste concentrated in Lake Lewisville in The Colony, Texas, in comparison to both each other and non-plastic waste? Macroplastics are pieces of plastic that are over 5 millimeters in length, and they were decided upon for this study, because they were more feasible to collect, as collecting microplastics, or plastics under 5 millimeters in length, require special equipment to collect and see. It was hypothesized that the category of plastic bags would be the most highly concentrated plastic waste, in numbers, due to the common use of them for many consumer purposes throughout the community, especially for recreational use around Lake Lewisville.

Case Study and Random Grid Method

To answer the research question, a case study was conducted on Lake Lewisville in The Colony, Texas, in which the concentrations of different sources of plastic along the shoreline were determined. A case study was utilized in order to collect more detailed data concerning one particular lake in the community. One research study that inspired the use of a case study as the methodology for this research was the aforementioned analysis of the plastic concentration of Lake Huron, which was conducted by Maciej Zbyszewski and Patricia L. Corcoran, professors at the University of Western Ontario. The study is documented in the academic journal, "Distribution and Degradation of Fresh Water Plastic Particles along the Beaches of Lake Huron, Canada." This research focused specifically on one body of water, Lake Huron, and was able to go into detail on it, which was very beneficial, because it helped to get specific data to that lake, which would better help the community around it [14]. This successful study made it clear that a case study would be the most effective in collecting the data needed to answer the research question.

The samples for this study were waste within the region selected, both non-plastic and plastic. It was decided upon that non-plastic and plastic waste would be collected, so that they could be compared following the data sampling procedure. This comparison was necessary in order to quantify how significant the issue of plastic waste, specifically, is in Lake Lewisville. Collecting plastics from the sampled region and separating them by source helped to clarify which sources are the most common in the area, and in turn answered the research question at hand.

First, it was decided that Hidden Cove in Lake Lewisville will be the area of the shoreline that research is conducted on, due to its public access allowing the research to be feasible. The shoreline was the specific area that the research was conducted on, for a great volume of the plastic in bodies of water washes up onto the shore, so the relative concentra-

tion of different sources can be identified by collecting samples along the shoreline. Several studies in the field, such as Zbyszewski and Corcoran's case study of Lake Huron, also conducted their data collection along the shoreline of the body of water they were researching [14]. Similarly, the 5 Gears Institute also sampled for plastics along the shore of the open ocean, which helped them to gather data about microplastics, or pieces of plastic that are smaller than 5 centimeters in length [11]. These two studies inspired the use of the shoreline as the data collection area in this research project.

After this was decided, Google Earth, which uses GPS to create an accurate map all regions of the Earth, was used to obtain a detailed map of the shoreline. Next, the measuring tool of Google Earth was used to create a rectangular area that would be used for data collection. The area of the rectangular area is 2000 meters squared, or .2 hectares, and the dimensions of the rectangle were 20 meters by 100 meters, making the entire perimeter 240 meters. The exact latitude and longitude points that represent each corner of the rectangular area are 33°07'44''N, 96°56'01''W (top left), 33°07',43''N, 96°56'01''W (bottom left), 33°07'45''N, 96°55'58''W (top right), and 33°07'45''N, 96°55'58''W (bottom left).

The map of the data collection area at Hidden Cove in Lake Lewisville is depicted below. It is important to note that at the time of the data collection, the water level had risen to the point that the grid began at the bottom, at its highest point, due to heavy rainfall in the region during the time that the research was collected, which is why it appears as if the grid is far away from the shoreline in the image [5].

Therefore, the area in which plastic was collected from was on the dry land beginning from the water line of the lake.

Development of a Data Collection Grid

After deciding upon the area that would be used to collect data, it was important to make a grid of the area, only sampling from certain, random grid boxes of the total area. The grid sampling method was decided upon by guidance from Mr. Platt, the mentor for this research project. Using this method of grid sampling makes the data more of a random sample, because only random sections of the total area are examined, making the final data more accurate and free of bias. The gridding method of data collection is commonly used for environmental surveying, so it was a viable option for collection in this research process. The random grid sampling method was discussed in a study conducted by Feng Chen, David E. Kissel, Larry T. West, Doug Rickman, and Wayne Adkins, all of whom are research scientists, professors, and engineers, at the University of Georgia in Athens, as well as J.C. Luvall, who is a research scientist at the Global Hydrology and Climate Center for NASA in Huntsville, Alabama, which helped me to better understand the method [2].

The original rectangular data collection area was separated into sections of 5 meters by 5 meters, making a total of 80 sections in the total region. Each of the grid sections was then labeled with a number, 1 through 80. A random number generator was then used to select 20% of the grid areas, or a total of 16. The way a random number generator functions is that the parameters were set as 1-80, and then the generator randomly selected 16 out of the 80 available numbers. 20% was used as the percentage of the area, because this is the percentage commonly used in the field when completing grid sampling. The number generator application used was random.org, and the numbers selected by the generator were: 5, 8, 11, 15, 18, 22, 23, 39, 40, 42, 65, 66, 72, 74, 76, 80 [5]. These would be the grid sections that data would be collected from. The image of the number generating process is shown below, with each square representing one five by five meter section of the total area. Each number selected is highlighted green.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

Data Collection Process

The next step in this research process was to collect the data at Hidden Cove. The data collection process occurred on December 2nd, 2018. The materials needed going into the data collection were string, flag markers, gloves, a meter stick, and paper bags, as well as a GPS latitude and longitude locator by the name of MotionX-GPS. Prior to arriving at the site, strings were cut to be five meters and 20 meters, exactly, in length by using a meter stick. This string would be used as a measurement tool throughout the data collection.

Upon arrival at Hidden Cove, the corners of the rectangle were identified by first using visual landmarks from the Google Earth image to get the general location of the area, and then by using the GPS tool, MotionX GPS to find the exact latitude longitude marks that were decided upon in the map [7]. These four corners were marked with flags.

Next, grids of data collection were identified by measuring, using the 5 meter-long string from the flagged corners of the total area. With one 5 by 5 meter gridded section at a time, in numerical order, a flag marker was placed at each corner, and string was wrapped around the perimeter. Next, any plastic pieces within the perimeter were picked up using gloves and placed in paper bags based on the site of collection. This process was exactly repeated for each of the 16 gridded areas selected at Hidden Cove.

Directly following the initial data collection, each of the plastic pieces was separated into one of 6 categories, based on end use: plastic bags, plastic bottles, packaging plastics(such as plastic food wrappers and containers), fishing equipment, household plastics. A category was also created

for the non-plastic waste that was collected. The categories were then counted solely based on the number of plastics present in each. Each piece of waste was then put back into the paper bag that it was originally placed into.

Compiling the Data

Four days after the initial collection, on December 6th at 8:15 am, the waste pieces were massed using a scale that measured the plastics in grams. The scale used for this massing was the OHAUS Pioneer Scale, because it is highly accurate and gave readings into the ten-thousandths decimal place. After the pieces were all massed, the sums of each categories' masses were recorded to show the approximate concentration of each of the plastics found during the collection of data. After the masses were totaled, charts were created to represent the concentrations of plastics versus non-plastics, both in mass and number. The same was done for the different sources of macroplastics, as charts were made for both mass and number. Next, pie charts were made for each of these data tables, which included percentages.

After these charts and graphs were developed, the data analysis process began. The data was examined to see how the different sources of plastic waste were concentrated, relative to each other, and the most and least concentrated plastic sources were identified, in both mass and number, and then the macroplastic sources that were between those two were ordered. Next, the amount of plastics relative to non-plastics in mass and number were evaluated. Outliers were then searched for, as well as discrepancies with the original hypothesis. By analyzing the data in this way, trends were discovered, and much more could be seen about the relative concentrations of plastic waste by source, which helped to better understand and answer the research question being examined.

Limitations

There are several limitations within the scope of this research method. First, the entire shoreline of the lake was not sampled, but just one gridded region, due to time and resource restraints. However, the random grid sample helped to combat this issue and make the data more of a random sample. Additionally, the data collection process was completed at a time that the lake levels were fluctuating heavily, due to a high amount of rainfall at the time. This could have had a small effect on the number of plastic and non-plastic pieces that accumulated along the shoreline. Also, the data was collected along the shoreline, and not actually in the water because the amount of resources needed to collect plastic from the deep waters of Lake Lewisville was unfeasible for this research process. However, collection along the shoreline is a widely practiced form of research concerning bodies of water and waste, as stated earlier in the methodologies. Another limitation is that data was only collected within Hidden Cove of Lake Lewisville, and other regions may have different concentrations of plastic. Only one area of the lake was able to be used due to feasibility reasons, with the time constraints of the research project and the many sections of the lake that are privately own and could not be used. Finally, the plastic pieces were located using the human eye, so a few very small pieces that barely exceeded the 5 millimeter line that would cause them to still be classified as a macroplastic may have been missed.

3 Data Collection

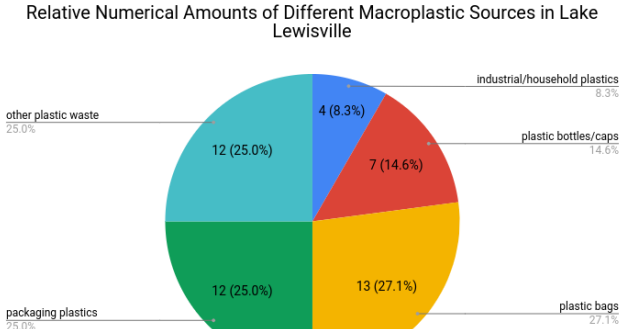
After completing the data collection, it was calculated that a total of 85 pieces of waste was collected during the research process, in the 16 sections designated for collection. These pieces varied in source among the six categories that were predetermined, with some pieces of waste being classified as non-plastic, as well. An image of all of these pieces of waste, after the separation, counting, and massing processes was complete, is shown below.

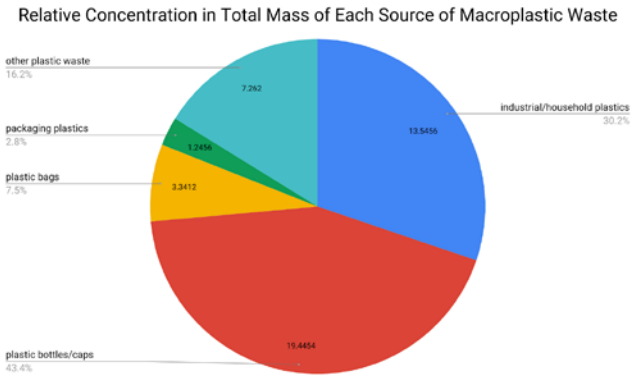
The total amount of each source of plastic waste was calculated, both in number and mass, and the results can be seen in the table below. The pie charts correspond to the data tables shown below, also detailing the percentages of each type of plastic. All of the graphs and tables in this research report were created by the researcher.

Concentrations of Sources of Plastic Waste

Source of Macroplastic	Number Collected	Total Mass (g)
Industrial/Household Plastics	4	13.5456
Plastic Bottles/Caps	7	19.4454
Plastic Bags	13	3.3412
Packaging Plastics	12	1.2456
Fishing Equipment Plastics	0	0
Other Macroplastic Waste	12	7.262

The first two graphs depict the relative amounts of the different sources of plastic waste collected. The first relates to the numerical amount, and the second relates to the total mass.



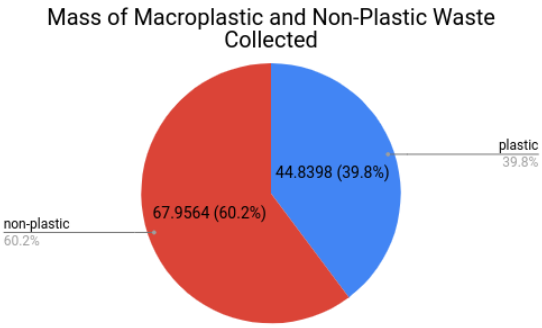


Next, the concentrations of numbers and mass of the total macroplastic waste collected was compared to those of the non-plastic waste collected in the research. The data collected is shown below.

Concentrations of Plastic and Nonplastic Waste

Source of Waste	Number of Pieces Collected	Mass in Total (g)
Macroplastic	48	44.8398
Non-Plastic	37	67.9564

The following two graphs relate to the amounts of plastic waste collected versus the amount of non-plastic waste that was collected. The first graph relates to the number collected while the second graph relates to the total mass of the pieces collected.



4 Data Analysis

First, several observations were made during the initial data collection. The first of these observations was that there was generally more waste residing in the gridded areas that were closer to the water. This could possibly be explained by the phenomenon that different types of waste from the water washes up onto the shoreline. Also, a vast majority of the pieces collected were not in their original state, with many being degraded or broken down into smaller pieces. This occurrence was more predominant in the plastic waste pieces than the non-plastic pieces.

Several key details were seen through observing the data of the number and masses of plastic pieces, in comparison to non-plastic pieces. Numerically, about 56.5% of the waste collected was plastic, or about 48 pieces, with the other 43.5% coming from non-plastic sources, or 37 pieces. However, the mass of the non-plastic pieces collected greatly outnumbered the mass of the plastic waste, comprising about 67.9% of the total collected mass, while macroplastic waste only totaled to 44.8398 grams of the total 112.7962 grams collected. This may be because some of the non-plastic pieces were composed of dense materials, such as metal, and also because many of the plastic materials had been broken down over time. This contributes to the idea that plastic breaks down water ecosystems over time, but still remains present and very persistent in the environment.

A lot of new discoveries pertaining to the research questions were illustrated through the number and mass of each category of plastic waste. The most numerous categories, in number, were plastic bags and plastic bottles, with 13 and 12 in each category, respectively. This is most likely due to the recreational activities that take place at Hidden Cove. However, a lot of the pieces collected in these categories appeared to be broken down, and they had a combined total mass of less than 5 grams (4.5868). One potential reason for this could be that these two sources are comprised of less durable plastics, so they are easier to break down over time, which accounts for the large number of pieces but low mass. Plastic bottles and bottle caps, while only being collected 7 times, had a total mass of 19.4454 grams, which made the category the most heavily concentrated source of plastic by mass, as it accounted for almost half of the total mass of the macroplastic waste.

One of the more scarcely found categories, household, and industrial plastics, only appeared four times. This could be due to the fact that household items are not used near or in the water, so there are not many that appear on the shoreline.

However, the household and industrial plastics took up 30.2% of the total plastic waste mass, which is likely because they are comprised of more dense, durable plastics that do not break down easily. It was surprising to find that no fishing equipment was found along the shoreline, which was expected prior to data collection. The surprise was due to the fact that fishing equipment was a very common source of plastic waste in oceans, and was expected to have the same concentration in Lake Lewisville.

Of the plastic pieces that were collected, 12 were not in any of the predetermined categories, and, thus, fell under "other plastics." These waste pieces included balloons, decorations, caution tape, and bandaids, as well as others that are a result of the recreational activities that take place nearby and on the lake.

5 Discussion

Conclusion

Overall, through the research conducted, it can be concluded that macroplastic waste does outnumber the non-plastic waste that is present in the freshwater ecosystem of Lake Lewisville. This can be concluded through the evidence of plastic waste being more highly concentrated than non-plastic waste along the shoreline, numerically. Also, the discovery was made that plastic bags and packaging plastics were the most highly concentrated sources of plastic out of the total collected during the research, numerically, but household plastics and water bottles and caps were the most highly concentrated plastics, in mass. This occurrence can be most likely explained by the high recreational use of these materials throughout the lake, and the fact that plastic bottles and household plastics are much more durable and difficult to degrade than other forms of plastic waste.

Implications

This study has serious implications on the field of plastic production and waste. First of all, there was a total of 44.8398 grams of plastic collected in the grid areas of the region researched. Since waste was only collected on 20% of the total mapped area of the research, it can be approximated that there were about 225 grams of plastic on the total area, or .112 grams of plastic per square meter of the area. This expanse covered 100 meters of the shoreline, and Lake Lewisville has a lake perimeter of 233 miles, or approximately 374,977.152 meters, long [8]. If the amount of plastic collected in the 100 meter-long expanse is extrapolated to fit the total perimeter of Lake Lewisville, the total amount of plastic would amount to 840,740 grams, or 840.740 kilograms. This amount is a very large mass of plastic to be along the shoreline of the lake, which means that plastic waste is certainly a very significant issue in the body of water. Therefore, the amounts collected in this experiment further solidify the idea that Lake Lewisville is impacted greatly by plastic waste. Additionally, citizens in the area, by realizing that plastic bags and bottles are the most greatly concentrated plastics in the lake, according to the research collected, can now avoid overuse of these materials, or refrain from bringing the sources of plastic in great amounts near the lake. Proper disposal methods can also be created to discard of plastic bags and bottles around Lake Lewisville, now that my research has been conducted, so that these heavily concentrated macroplastics can decrease in their presence around the lake.

The scholarly community can also be positively impacted by this research. There is currently not a lot of information concerning the most concentrated sources of plastic waste in freshwater bodies, or much knowledge on plastic in freshwater, in general. The discoveries that were concluded in this study can better inform that scholarly community of the exact sources that are concentrating in these ecosystems, which helps to better understand the problem.

Now that the most abundant sources of macroplastic waste have been identified within the shoreline of Lake Lewisville, preventative actions can be taken by members of the community in order to lessen the impact human waste is having on the ecosystem. First, due to the high concentration of plastic bottles found, it can be advised that those wishing to use the lake for recreational purposes bring reusable water bottles, as opposed to disposable. More accessible recycling bins can also be placed near the lake to prevent the littering that causes the phenomenon of plastic waste. Also, visitors can use reusable bags instead of the single-use plastic bags that were found in high concentrations along the shoreline. These small changes to the activity around Lake Lewisville would help to target the specific sources of waste that were found frequently in this study.

Future Research

There are several different ways that this research could be furthered to bring more light to the subject of plastic waste in water ecosystems. First, more could be done to determine the location that the plastic pieces are coming from. For example, the is a landfill approximately 9.5 kilometers away from the area researched in this study, and about 2 kilometers away from Lake Lewisville at its closest point to the landfill [5]. This close proximity could account for some of the plastic appearing in the Lake, as low density plastics, such as the packaging plastics and plastic bags collected in this study, could drift from the landfills and build up in the lake. Research done to determine if this phenomenon is occurring would identify a point source of freshwater plastic pollution that could be prevented with the correct precautions, but the research required to test this conclusion was not a feasible option for this study.

Additionally, if more resources were allocated, the concentrations of different sources of plastic on the bed and surface of the Lake could be tested, and this could be compared to the shoreline plastics collected in this study. This would address the limitation of collecting along the shoreline, and would determine how the relative concentrations of sources of shoreline plastics align with plastics within the water. There could also be further research to test if the plastic levels along the shoreline fluctuate in different parts of the lake due to the amount of recreational activities taking place in that region of the freshwater environment. Overall, this study could be extended in several ways to even further benefit both the scholarly community and the community surrounding Lake Lewisville.

References

[1] Andrady, A., Geyer, R., Jambeck, J. R., Law, K. L., Narayan, R., Perryman, M., Siegler, T. R., Wilcox, C. (2015). Plastic Waste Inputs from Land into the Ocean. Science. Retrieved from http://science.sciencemag.org/content/347/6223/768.full

[2] Chen, F., Kissel, D. E., West, L. T., Rickman, D., Luvall, J. C., & Adkins, W. (2005). Mapping Surface Soil Organic Carbon for Crop Fields With Remote Sensing. Journal of Soil and Water Conservation, 60(1), 51+. Retrieved from http://link.galegroup.com/apps/doc/A129565383/AONE?u=j043905010&sid=AONE&xid=26213d7e

[3] de Vere, A. J., Lilley, M. K., & Frick, E. E. (2018). Anthropogenic Impacts on the Welfare of Wild Marine Mammals. Aquatic Mammals, 44(2), 150+. Retrieved from

http://link.galegroup.com/apps/doc/A539388449/AONE?u=j043905010&sid=AONE&xid=a99905b4

[4] Eriksen, M., Lebreton, L. C. M., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., Reisser, J., Galgani, F., Ryan P. G., (2014). Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea. PLoS ONE, 9(12). Retrieved from http://link.galegroup.com/apps/doc/A418633814/AONE?u=j043905010&sid=AONE&xid=6c2dd31f

[5] Lewisville Lake. Google Earth. Retrieved from https://earth.google.com/web/@33.1555419,-96.94932554,163.91532192a,6771.4020336d,35y,-0h,0t,0r/data=ClQaUhJKCiUweDg2NGMzNmE1OGY2MGU1OGQ6MHg4NDA0ZjFjZTNjZThkNDJlGfLpsS0DjkBAIWG572IrPljAKg9MZXdpc3ZpbGxlIExha2UYASABKAI

[6] Haahr, M. (1998). RANDOM.ORG - True Random Number Service. Random.org. Retrieved from https://www.random.org/

[7] Khan, P. (2005). MotionX GPS. Fullpower Labs. Retrieved from https://gps.motionx.com/

[8] Lewisville Lake (2019). Visit Lewisville Texas. Retrieved from https://www.visitlewisville.com/where-to-play/lake-and-outdoors/lewisville-lake

[9] Marine Debris Research Prevention and Reduction Act. (2006). In B. W. Lerner & K. L. Lerner (Eds.), Environmental Issues: Essential Primary Sources (pp. 343-347). Detroit: Gale. Retrieved from http://link.galegroup.com/apps/doc/CX3456400130/GPS?u=j043905010&sid=GPS&xid=aac8e7e1

[10] Rochman, C. M., & Browne, M. A. (2013). Classify Plastic Waste as Hazardous: Policies for Managing Plastic Debris are Outdated and Threaten the Health of People and Wildlife. Nature, 494(7436), 169+. Retrieved from http://link.galegroup.com/apps/doc/A319614611/SCIC?u=j043905010&sid=SCIC&xid=fdfd89d1

[11] Seltenrich, N. (2015). New Link in the Food Chain? Marine Plastic Pollution and Seafood Safety: Investigators are Researching Whether Consumption of Plastic Debris by Marine Organisms Translates into Toxic Exposures for People who Eat Seafood. Environmental Health Perspectives, 123(2), A34. Retrieved from http://link.galegroup.com/apps/doc/A402483517/AONE?u=j043905010&sid=AONE&xid=7be5bfc6

[12] Sigler, M. (2014). The Effects of Plastic Pollution on Aquatic Wildlife: Current Situations and Future Solutions. Water, Air, & Soil Pollution, 225(11). Retrieved from http://link.galegroup.com/apps/doc/A395461861/AONE?u=j043905010&sid=AONE&xid=edbe667a

[13] Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W. G., Russell, A. E. (2004). Lost at sea: Where is all the Plastic? Science, 304(5672), 838. Retrieved from http://link.galegroup.com/apps/doc/A117257427/OVIC?u=j043905010&sid=OVIC&xid=c1dc5837

[14] Zbyszewski, M., & Corcoran, P. L. (2011). Distribution and Degradation of Fresh Water Plastic Particles Along the Beaches of Lake Huron, Canada. Water, Air, & Soil Pollution, 220(1-4), 365+. Retrieved from http://link.galegroup.com/apps/doc/A359853308/AONE?u=j043905010&sid=AONE&xid=40ea8060