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Neustonic Plastic in the Los Angeles River

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Abstract

The characterization of neustonic plastic found in the Los Angeles River was completed in this study. 3 water samples were collected from the river on April 30, 2011 in Long Beach, CA using a 0.5 mm manta trawl. The plastic was separated from organic material, divided into 3 class sizes (0.5 mm, 1.4 mm, and 2.44 mm), and identified and sized under a microscope. Plastic was found in all three samples and categorized into seven categories. Paper, plastic, and styrofoam were present in all three samples. Styrofoam contributed the greatest percentage of the plastic found among the samples. Plastic film had the largest mean size.

Introduction

The Los Angeles River is a 51-mile river that begins in Canoga Park and empties at its mouth in San Pedro Bay at the Port of Long Beach (Gould, 2011). In the early 20^{th} century when Los Angeles was rapidly growing, the river became a sewer for the city's expanding industrial district (Davis, 1996). The river was also prone to heavy flooding during the wet season. In 1938, the US Army Corp. of Engineers began plans to dig out and pave the river. During that time, much of the river became encased in cement and transformed into a drainage ditch. Today, the majority of the river remains a cement flood channel and is the world's longest paved waterway (Segal, 2011).

The river currently runs through 13 municipal jurisdictions, which includes 16 cities (Higginbotham, 2010). One of these cities is Los Angeles, America's second most populated city. The river is heavily polluted by three main sources: discharge from three water reclamation plants, outflow from river tributaries into the river, and storm drain outfalls. Water reclamation plants contribute the highest concentration and greatest mass emissions of nutrient pollution to the river, while the tributaries and storm drain outfalls contribute the highest concentration and greatest mass emissions of bacteria (Ackerman et al., 2000). Debris ranging from shopping carts to single use trash bags can also be found in the river. In addition to acts of littering and abandonment of waste materials, rainwater washes trash from urban areas into the 127 storm drains that empty into the river after a storm (Higginbotham, 2010).

Synthetic polymers, commonly known as plastics, have become one of the most common and persistent pollutants found in marine environments. Plastic now composes 60-80% of marine litter and can be as high as 90-95% in some areas (Moore, 2008). Plastic is a lightweight and durable material. While this makes it a useful material, incorrectly disposed of plastics are detrimental to marine environments (Moore, 2009). Most plastics break down slowly through a combination of photodegradation, oxidation and mechanical abrasion. Most plastics also take longer to degrade in water than on land because of the reduced UV exposure and lower temperatures found in marine environments (Andrady, 2003). Even plastics labeled as biodegradable are not a sufficient long-term solution because they are only partly compromised of biodegradable materials, leaving behind microscopic plastic fragments (Klemchuk, 1990).

Marine plastic debris is generally divided into two categories: macro-debris (> 5 mm) and micro-debris (< 5 mm) (Moore, 2008). Micro-debris occurs from either fragmentation of larger debris or resin pellets and powders (Moore, 2008). Neustonic plastic refers to the small plastic fragments (mainly micro-debris) that accumulate in the top water column of open water (Moore, 2002). Although there have been studies conducted on other types of pollutants on the coastal waters of LA and its surrounding areas, none have been conducted on the neustonic plastic found in the LA River. This study identifies the types of neustonic plastic found in the downstream part of the LA River in Long Beach, CA.

Materials and Methods

Due to copyright purposes, this image removed. Image was taken from maps.google.com of W Wardlow Rd, Long Beach, Los Angeles, California 90807.

Figure 1. Samples were collected at the intersection of the Los Angeles River and Wardlow Road in Long Beach, CA. Image from Google Maps.

Samples of neustonic plastic were collected at three different sites in the LA River along Wardlow Road in Long Beach, CA on April 30, 2011 as part of the Friends of LA River Clean-up Day (**Figure 1**). Samples were collected using a 0.46 m by 0.25 m manta trawl (a net typically used to collect plankton). Water flow had a speed of 0.5861 m/s. The net remained submerged in the river until the sample collector deemed the net "full." For sample 1 and 3, the sample collection took 2 minutes; sample 2, 10 minutes. Samples were stored in glass containers and frozen until ready for processing.

Biotic and non-biotic pieces that were large enough to see without a microscope were first removed from the samples. Samples were then treated with a 25% w/w Instant Ocean solution to separate plastic from biotic debris by density (Fries, 2011). Plastics floated to the top while the remaining biotic sediment stayed on the bottom layer. The plastic was removed from the top layer of the Instant Ocean solution using a turkey baster and a pipette. The plastic was then sorted by size class using a column of 0.5 mm, 1.4 mm, and 2.44 mm Tyler sieves. The plastics were collected separately from each sieve and left to air dry. The plastics found in each size class were identified and categorized and sized (length and width) under a dissection microscope with a magnification of 10X. The plastics was categorized as blue plastic, green string, paper (plastic coated paper), plastic film, styrofoam, white plastic, and white string.

Results

There was plastic present in all three samples. Seven types of plastic were identified among the three samples: blue plastic, green string, paper, plastic film, styrofoam, white plastic, or white string. The number of plastic particles found/m^3 of water that passed through the manta trawl was calculated for each sample. The amount of water that passed through the trawl was calculated by multiplying the area of the trawl by the water flow speed. Sample 1 had the highest number of plastic/m^3 of water that passed the net (3.46 pieces/m^3) and sample 3 had the lowest (1.6 pieces/m^3) (**Figure 2**).

Paper, plastic, and styrofoam was present in all three samples. White plastic and white string was found in samples 1 and 2. Blue plastic and one piece of green string were found only in sample 2 (**Figure 3**). On average among the three samples, styrofoam comprised the greatest percentage of total plastic found. Plastic film, blue plastic, and paper also contributed greater than 10% of the total plastic found among the three samples (**Figure 4**).

Among the three samples, plastic film had the largest mean area (mean area =55.75 mm, s.d. = 321.37, n = 50). Paper also had a large mean area (19.37 mm, s.d. = 38.82, n =10) (**Figure 5**). While styrofoam (mean area = 9.90, s.d. = 21.87, n = 41) and blue plastic (mean area = 9.83, s.d. = 11.39, n = 37) had lower mean areas than plastic film and paper, these plastics had a large distribution of sizes, including some of the largest and smallest pieces of plastic found among all the plastics (styrofoam, **Figure 10**; blue plastic, **Figure 6**).

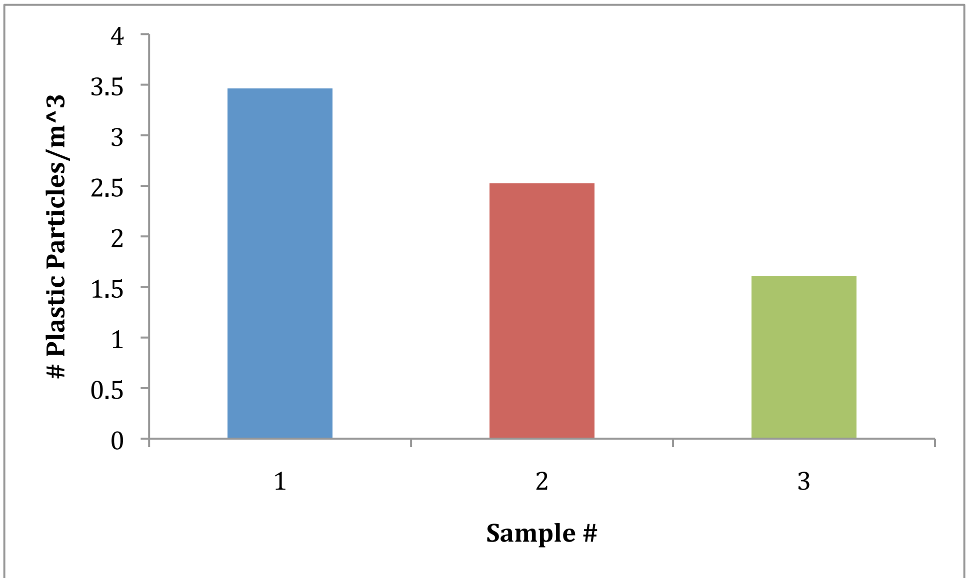

Figure 2. # Plastic Particles collected/m^3 of water that passed through the 0.5 mm manta trawl in the LA River collected on April 30, 2011.

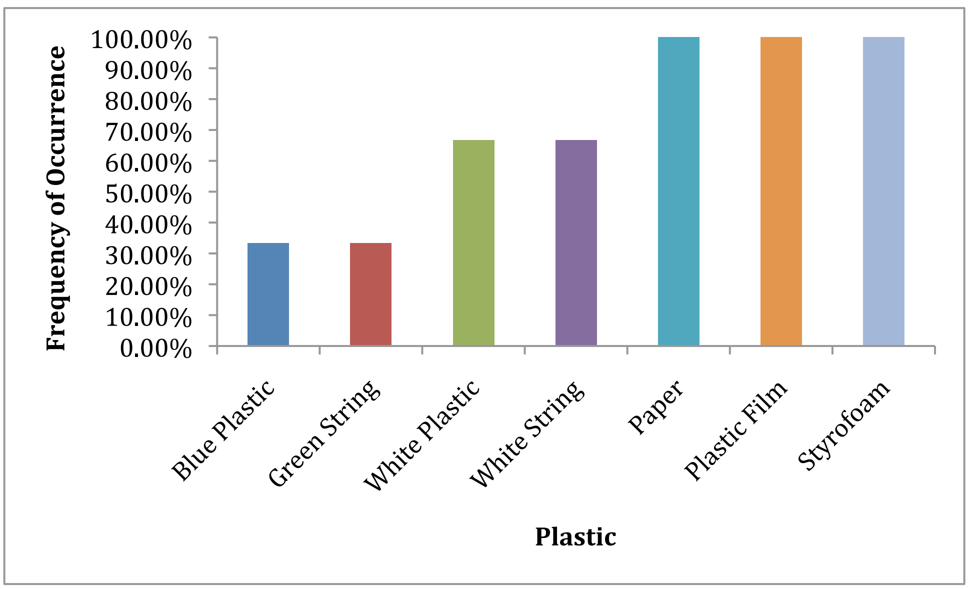

Figure 3. Frequency of occurrence (%) of types of plastics found in the 3 samples collected in the LA River.

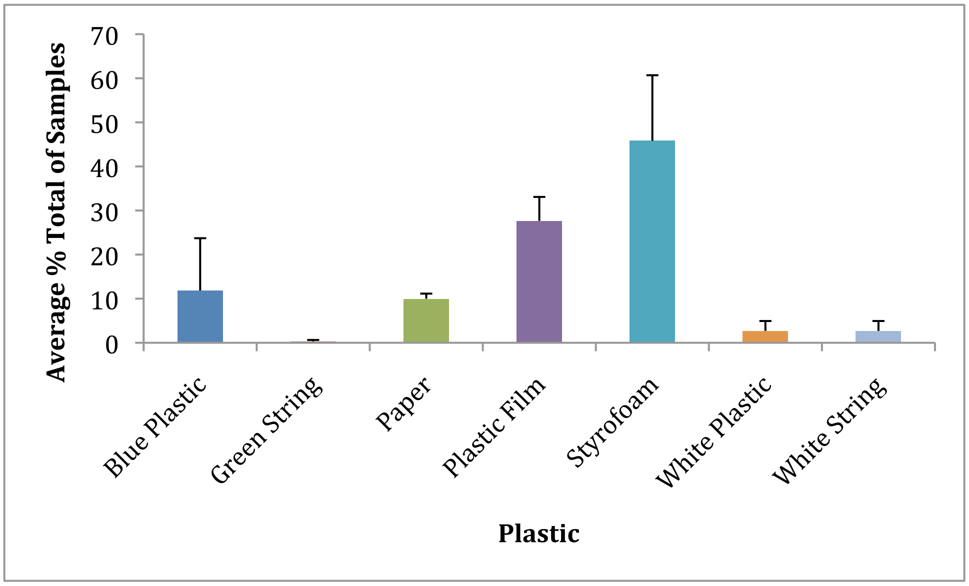

Figure 4. Average % total of type of plastic in sample among the 3 samples collected.

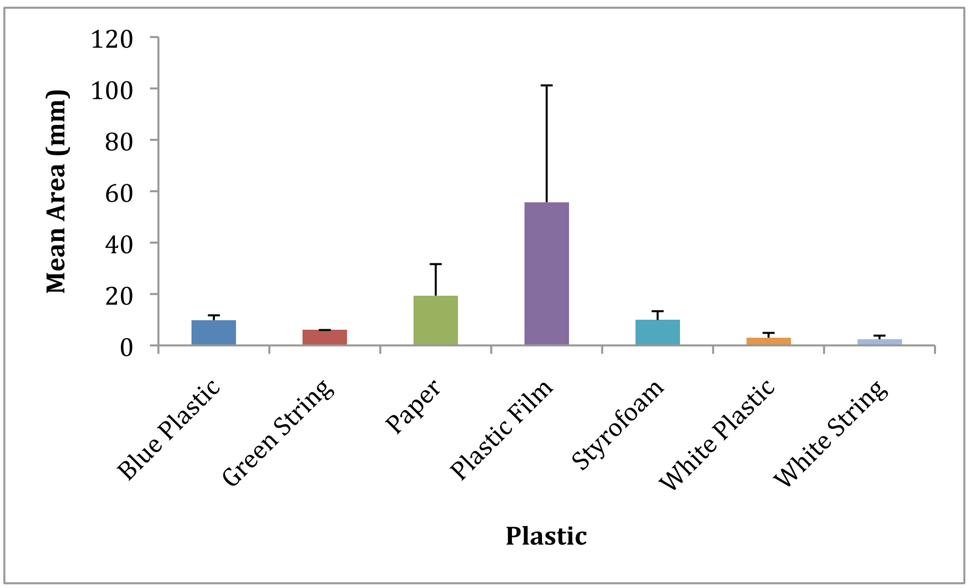

Figure 5. Mean area of plastics (mm) found in all 3 samples.

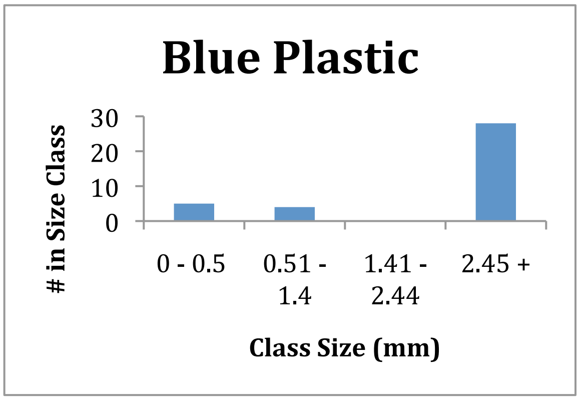

Figure 6. Amount of blue plastic pieces found based on area class size.

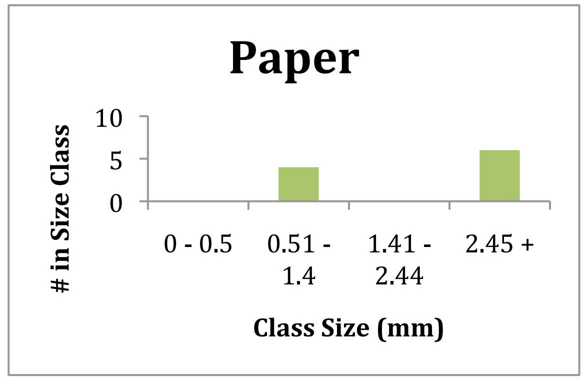

Figure 8. Amount of paper pieces found based on area class size.

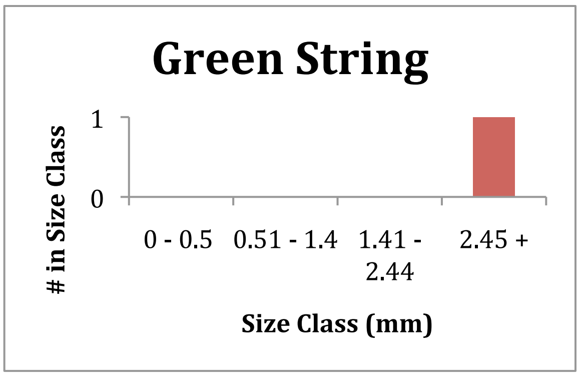

Figure 7. Amount of green string found based on area class size.

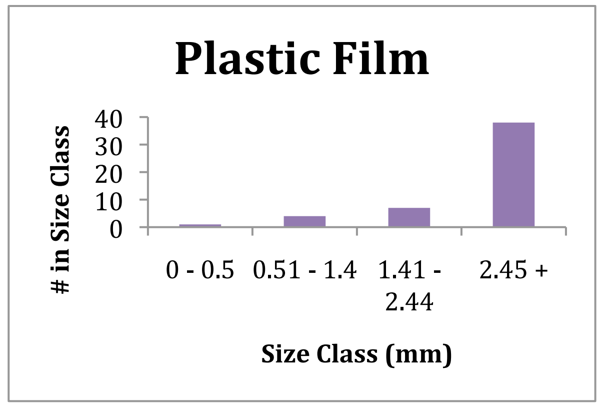

Figure 9. Amount of plastic film pieces found based on area class size.

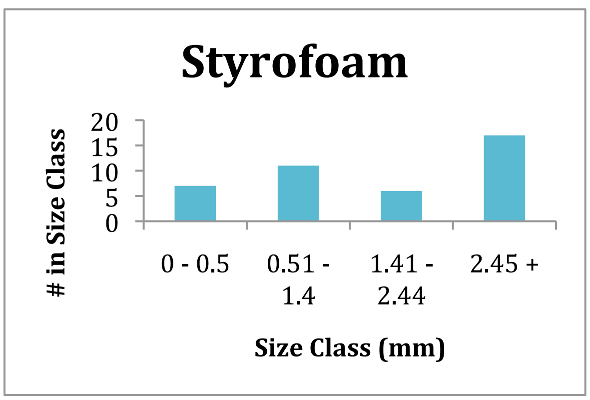

Figure 10. Amount of styrofoam pieces found based on area class size.

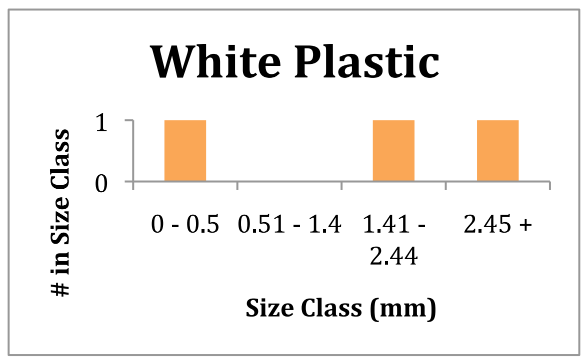

Figure 11. Amount of white plastic pieces found based on area class size.

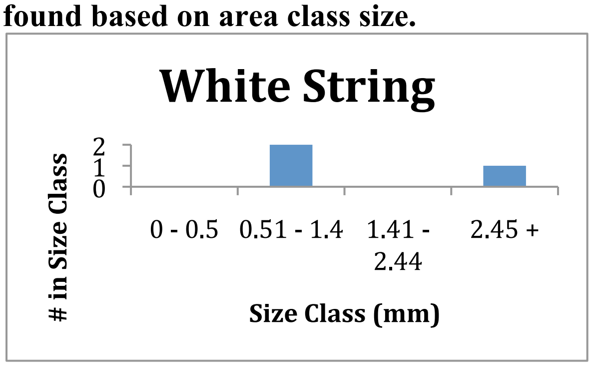

Figure 12. Amount of white string found based on area class size.

Discussion

Plastic was found in high quantities in all three samples. It can be concluded that the plastic in the LA River near Long Beach, CA is ubiquitous. Unfortunately, the small size of the plastic makes it difficult to identify the origin of the plastic. While these plastic fragments are primarily attributable to land-based run-off, the exact location and identity of the larger piece of debris the fragment once was a part of is difficult to determine.

The presence of neustonic plastic in marine environments is extremely detrimental to marine biota (Ryan, 1999). Ingestion of plastic occurs much more often than entanglement and is a much larger problem for neustonic plastic (Ryan 1987; Laist 1997; Robards et al. 1997). Ingestion of plastic can result in impaired movement and feeding, reduced reproductive output, lacerations, ulcers, and death (Laist 1997; Derraik 2002; Gregory 2009). There have been a number of studies on the effect of plastic ingestion on seabirds and planktivorous fish. While there have not been similar studies on freshwater birds and fish, according to Cooper (2011), there are 230 species of birds and at least 6 species of fish that are part of the LA River ecosystem and it is likely that the effect of plastic on these species is similar.

In a study by Boerger et al. (2010) about the ingestion of plastic by planktivorous fish in the North Pacific Central Gyre, 33% of the fish studied had ingested plastic. Moore et al. (2002) found that the average mass of plastic is two and half times greater than the mass of zooplankton in the coastal ocean near Long Beach, CA. It is probable that the fish in the LA River share a similar situation to marine fish of ingesting neustonic plastic by mistaking it for plankton.

Moore (2008) found that 44% of all seabird species are known to ingest plastic, including albatross, fulmars, petrels, and shearwaters that mistake plastic for food **(Figure 12)**. Plastic ingestion reduces the storage volume of the stomach, causing birds to consume less food. The reduced food consumption may limit the birds' ability to lay down fat deposits, thus reducing fitness (Ryan 1988). Of the types of plastics found in the seabirds studied by Ryan (1987), styrofoam and manmade plastics were present **(Figure 13)**. It is concerning that styrofoam and manmade plastics encompasses all the neustonic plastic found in the LA River in this study because the river feeds into the Pacific ocean, where it will most likely have adverse affects on the marine biota.

Figure 13. Storm Petrels at sea. Picture taken by Steve Howell.

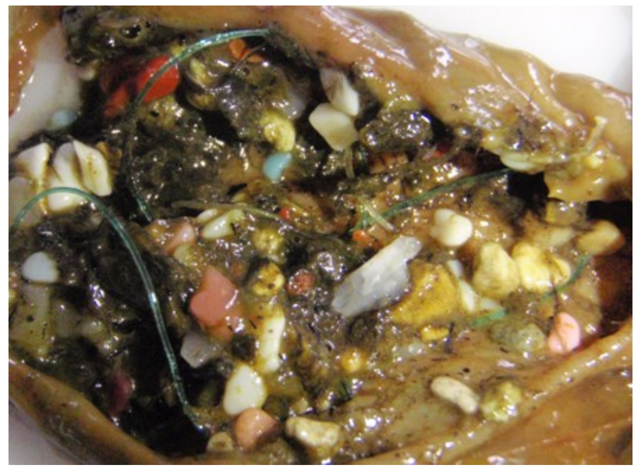

Figure 14. Stomach contents of storm petrel with ingested plastic. Picture taken by Nina Karnovsky

In addition to the physical issue of ingestion, there is a growing concern that plastic has the potential to transfer toxic substances to the food chain (Teuten et al., 2009). Plastic fragments have been shown to contain polychlorinated biphenyls (PCB's), polycyclic aromatic hydrocarbons, petroleum hydrocarbons, organochlorine pesticides (2,20 -bis(p -chlorophenyl)-1,1,1 trichloroethane (DDT), hexachlorinated hexane (HCH)), polybrominated diphenylethers (PBDEs), alkylphenols and BPA. PCBs in particular has been shown to lead to reproductive disorder and death, increase the risk of disease, and alter hormone levels (Ryan et al., 1988; Lee et al., 2001). While some of these contaminants are added during the manufacturing process of plastic, plastic also adsorbs some of these toxins from the surrounding environment (Mato et al., 2001) from human health. Due to the small size of neustonic plastic that can be mistaken for zooplankton, bioaccumulation beginning with lower trophic level species that feed on zooplankton should be considered. In addition to the wildlife that may be affected by this chemical transfer, recreational fishermen catch fish in the LA River and a concern is that these chemicals are then transferred to humans as well.

This is the first study on the neustonic plastic found in the LA River and the samples were only collected in Long Beach, CA. Long Beach is located towards the end of the river before it meets with the Pacific Ocean and most of the storm drains are located upstream of Long Beach. A good study in the future would be to collect and analyze samples from sites that span the entire length of the river to be able to have a better understanding of the characteristics of the neustonic plastic at different points along the river and to quantify the change in size of the plastic as it travels downstream. It would also be beneficial to be able to identify and characterize some of the specific inputs of plastic along the river. Furthermore, plastic collectors could be installed upstream to prevent the larger pieces of plastic from becoming macerated as it makes its journey to the sea as small fragments, which is much more difficult to remove than large pieces. Small pieces of plastic are also harder to process in the lab because it becomes more difficult to separate the fragments from organic debris. Additionally, multiple studies assessing the effect of plastic, and perhaps specifically neustonic plastic, on the wildlife of the LA River would be useful in the future.

Acknowledgements

I would like to thank Professor Nina Karnovsky for her tremendous amount of support and help throughout this entire process. Without her, this project would not have been possible. I would also like to thank Captain Charles Moore and Friends of the LA River for providing me with these samples. Additionally, I would like to thank Professor Char Miller for his support and enthusiasm throughout the semester.

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