Plastic Waste

Final project for Information Visualization and Presentation (I247)
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Project Goals

The world's first fully synthetic plastic was invented in 1907 and was widely applied to various products in our daily life. This invention not only brought the convenience to our lifestyle but also caused a serious environmental problem during the past decades. The mismanagement of the plastic waste caused the irreversible crisis in the global scale. Plastic pollution is the result of plastic waste accumulating and adversely affecting the environment and ecosystems around it. The world's oceans are being hit the worst by this problem.

Our goal for hosting this website is to provide ***easy-to-digest information about the plastic waste, educate the global citizens of this serious problem, and advocate people to take action*** on protecting our earth in both governmental and individual levels.

To be more specific, we visualize the information about the production of the plastic, the problem of the plastic pollution in the global and the USA levels, the mismanagement of plastic around the world, where the plastic end up, the plastic bags banned policy and the suggested actions that the individuals could take.

Related Work

We drew from three different types of sources in our project. First, we explored publications in the news, scientific journals, and from nonprofit or government agencies to gather data and collect insights into the problem of plastic pollution. Second, we took guidance in methods for visualization and for usability testing from relevant HCI literature. Finally, we surveyed a range of existing websites and infographics in order to understand previous approaches to discussing this topic and to identify where we could make new contributions.

For the first category of sources, we drew on data and reports from Plastics Europe, a trade organization representing plastics manufacturers and recyclers [1], for information on plastic production, waste and microplastics. We also began our research by looking at articles from the San Francisco Chronicle [2], Forbes [3], and the Huffington Post [4], each of which make use of photos to highlight to severity of plastic pollution in the oceans. Visualizations from these sources are displayed below, with details after each image.

While marine litter consists of all kinds of materials, plastics are by item count and material volume the major material fraction today found as litter in Europe (e.g. on beaches, the sea surface or the sea floor). Most data is available for beaches, as can be seen in the OSPAR intermediate assessment of 2017. This assessment describes the abundance and composition of beach litter in the OSPAR Maritime Area across 76 beaches in 2014 - 2015.

The abundance of marine litter in the OSPAR Maritime Area provides information on the magnitude of litter pollution in adjacent waters and coastal areas, indicating spatial differences in litter pollution. The litter on a given beach may be generated locally at sea or on land, or may arrive from distant sources, transported by rivers or ocean currents.

Beach litter composition gives an indication of the scale and magnitude of the problem, as well as the level of threat to the environment.[3]

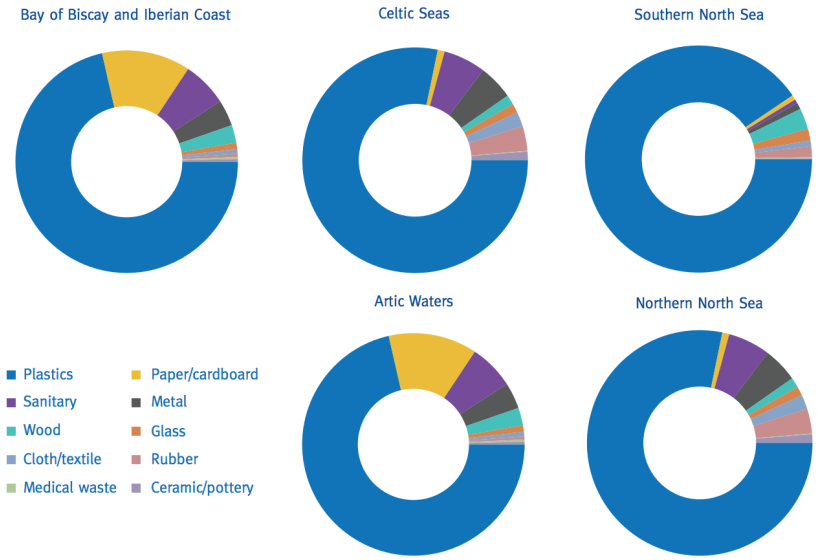
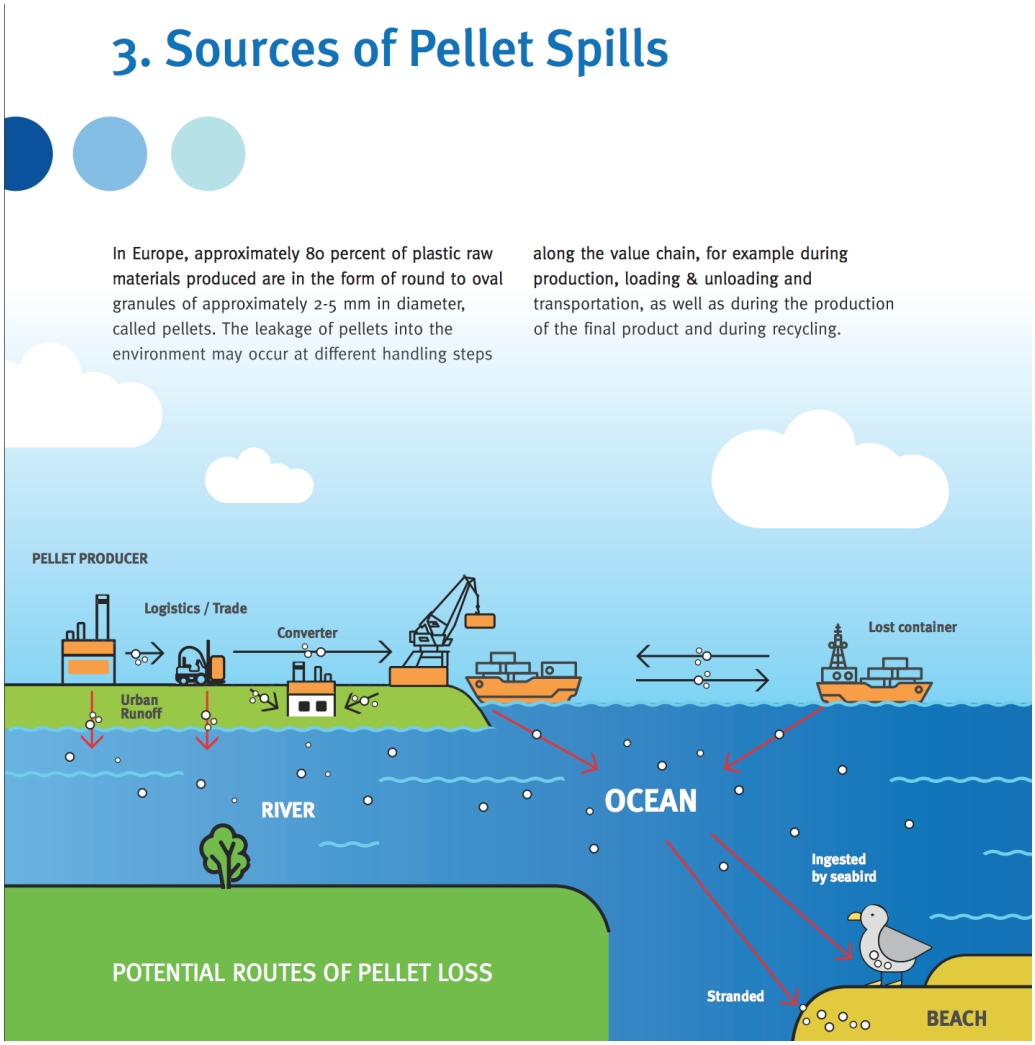


Figure 1. Composition of marine litter according to material / use categories for the period 2014-2015 in the OSPAR Maritime Area

Source: PlasticsEurope Operation Cleansweep Report 2017

In this report, PlasticsEurope highlights the locations of plastic pellets in different marine environments. They also compare amounts between different materials at different locations using a series of side-by-side charts, encoding materials by color.



Source: PlasticsEurope Operation Cleansweep Report 2017

In this same report, PlasticsEurope uses an infographic to show sources of pellet spills. They make the point that pellets may be lost during different stages of transportation and handling, ultimately ending up in the ocean.

Great Pacific Garbage Patch is now nearly 4 times the size of California

By Peter Fimrite | March 22, 2018 | Updated: March 26, 2018 1:40pm

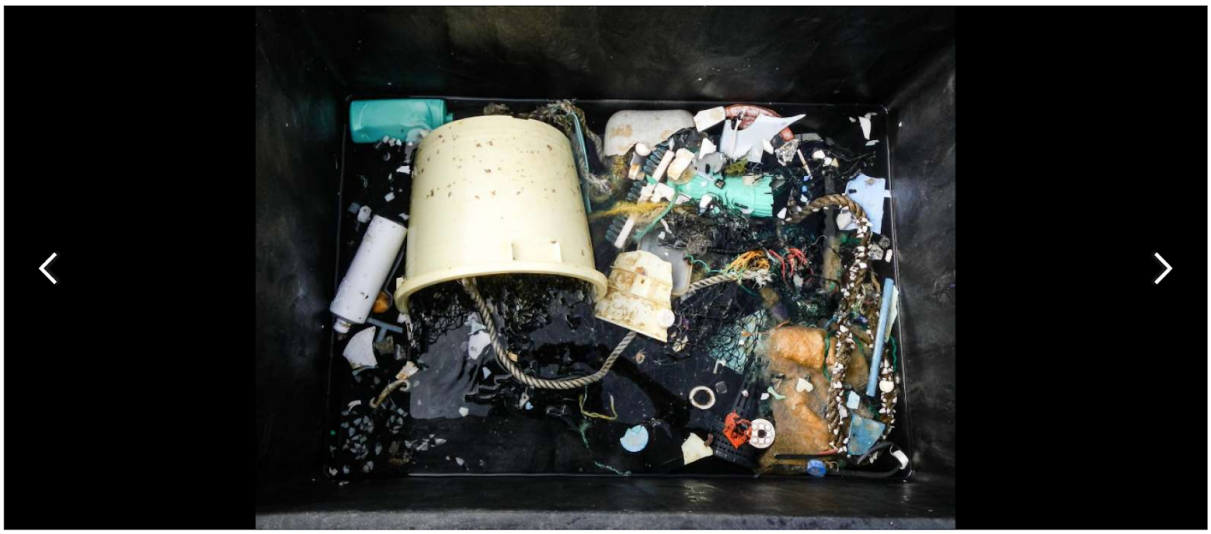


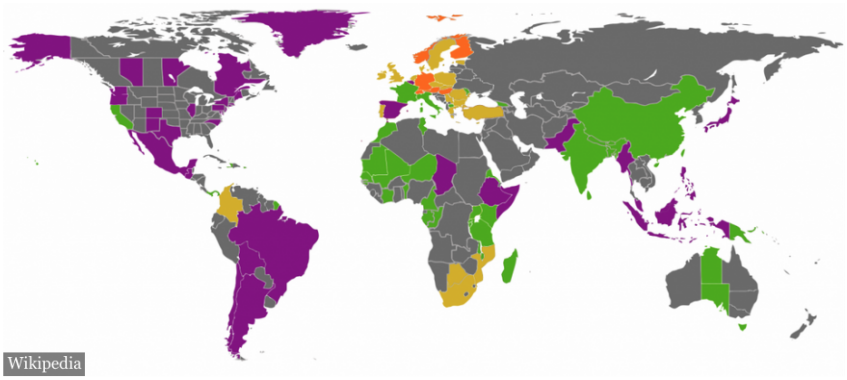
Photo: Ocean Cleanup, TNS

IMAGE 1 OF 5
Debris snagged during an ocean sampling operation. (Ocean Cleanup)

Source: San Francisco Chronicle

This SF Chronicle article displays a number of photos of waste in the ocean found in different contexts. They rely primarily on a slideshow with a variety of pictures to highlight the severity of the problem.

A Greenpeace Philippines representation of a dead whale from ingestion of plastic. The [+]



Countries that are phasing out single-use plastic bags

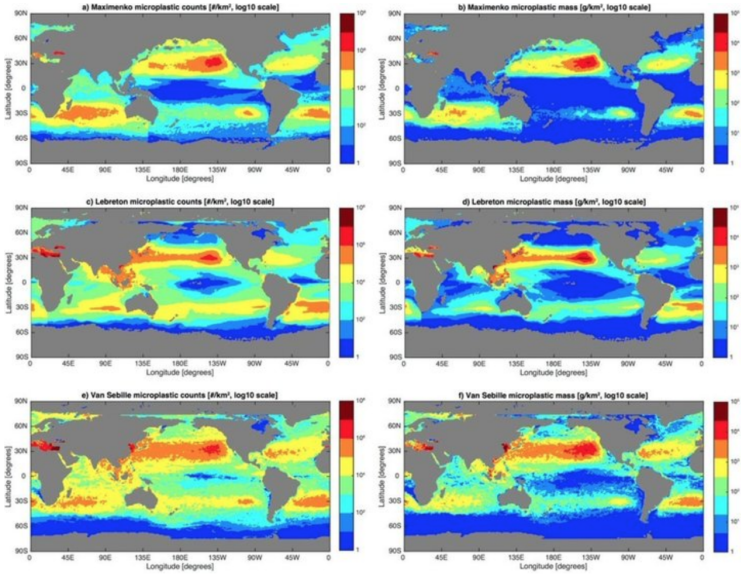
Source: Forbes

This article from Forbes reports on whales that died from malnutrition due to ingesting too much plastic. By displaying shocking photos of suffering animals, it draws our attention to look at the visualizations that follow, which highlight countries that have enacted bans on plastic bags using a chloropleth map.

There's Rage-Inducing New Data On The Amount Of Plastic In The Ocean

Scientists: Up to 37 times more floating microplastics than previously estimated.

Kara Lavender Law and Erik van Sebille The Conversation



VAN SEBILLE ET AL (2015)

Maps of three model solutions for the amount of microplastics floating in the global ocean as particle counts (left column) and as mass (right column). Red colors indicate the highest concentrations, while blue colors are the lowest.

Source: Huffington Post

This article from the Huffington post uses a similar strategy to the Forbes article in showing several pictures of plastic waste in the ocean, and following up with a visualization. In this case they use a heatmap to show models of how microplastics are moving through the oceans.

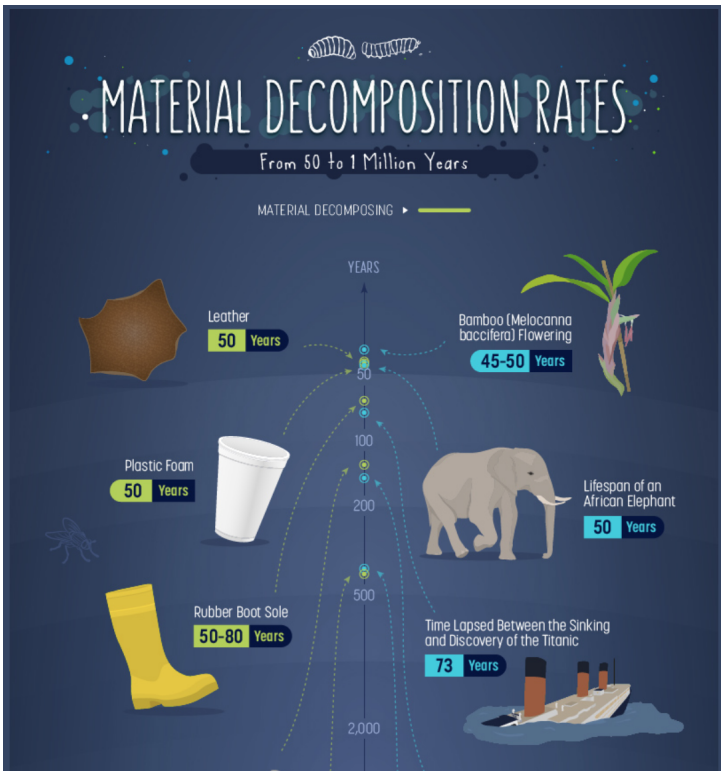
For our second category of sources, in deciding which data to use and which visualizations to employ, we drew on theory from Tufte in aiming to maximize our data to ink ratio and to minimize the Lie Factor in our visualizations [5]. We were informed by Few [6] in designing with human visual perception in mind, and by Cairo [7] in designing infographics aimed to convey a clear and cohesive story. In usability testing, we asked users for feedback in an attempt to choose the most effective presentation for our data [8].

Lastly, we surveyed existing visualizations, websites, and infographics, the most relevant of which we include and discuss in more detail below:

The first existing visualization we looked at comes from oceanconservancy.org: https://oceanconservancy.org/trash-free-seas/plastics-in-the-ocean/).

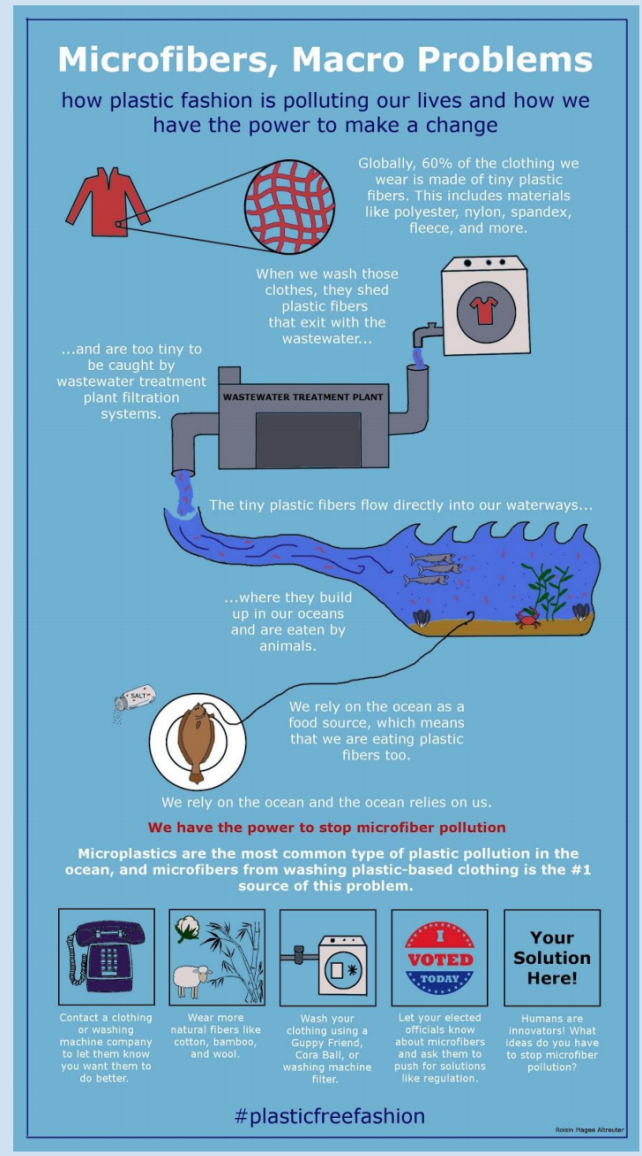
This advocacy site displays an infographic highlighting the presence of plastic bags and bottles in the ocean, at the same time showing a few statistics on plastic waste. The use of icons in conjunction with the numbers is attention-grabbing, but we felt that it could have done more to tell the story of where plastic comes from and where it goes. In our infographic, we also use icons for plastic bottles and bags, but we found in our first round of user testing that the graphic was more understandable and more effective when organized around the visual metaphor of plastic flowing down a river and into the ocean.

A second visualization we looked at comes from saveonenergy.com: https://www.saveonenergy.com/material-decomposition/



This visualization uses a number of examples along a timeline to try to give a sense of how long it takes for different materials to decay. While the technique is effective for understanding just how long it takes for some materials such as glass to decay, this site does not provide additional context that would help understand the causes and scale of the problem. It does not answer questions about how much plastic waste is being created, where the plastic ends up, and what options for controlling the problem have been put into place.

Finally, we looked at an infographic from 5gyres.org. https://static1.squarespace.com/static/5522e85be4b0b65a7c78ac96/t/5a66456cc83025f49135fbc2/1516651904354/Microfibers%2C+Macro+problems.pdf:



This infographic has a clear and consistent narrative flow in explaining microplastics. Microplastics, however, are only a small part of the broader plastics picture, so we don't get the high level perspective here.

In our project, we aimed to combine low level details of the type in these infographics with charts that display trends and large scale statistics. While infographics are effective introductions to the issues, they do not typically do a great job of conveying other types of information, such as trends over time and variations across different regions of the world. We found very few uses of bar charts and line charts online and in news, and while reports for agencies like the EPA do sometimes include these traditional graphs [14], they tend to be buried in very long reports that summarize data in tables.

Description of Visualization

Our first visualization is an infographic showing the journey of trash from production to disposal. We highlight the significance of everyday items and ordinary individuals using icons for bags, bottles, and people. We introduce numbers regarding how much plastic is created and thrown away, which we will then dig into further in later visualizations. We also organize our graphic around a river flowing into the ocean to make visually salient the fact that much of the plastic we discard ultimately ends up in the ocean.

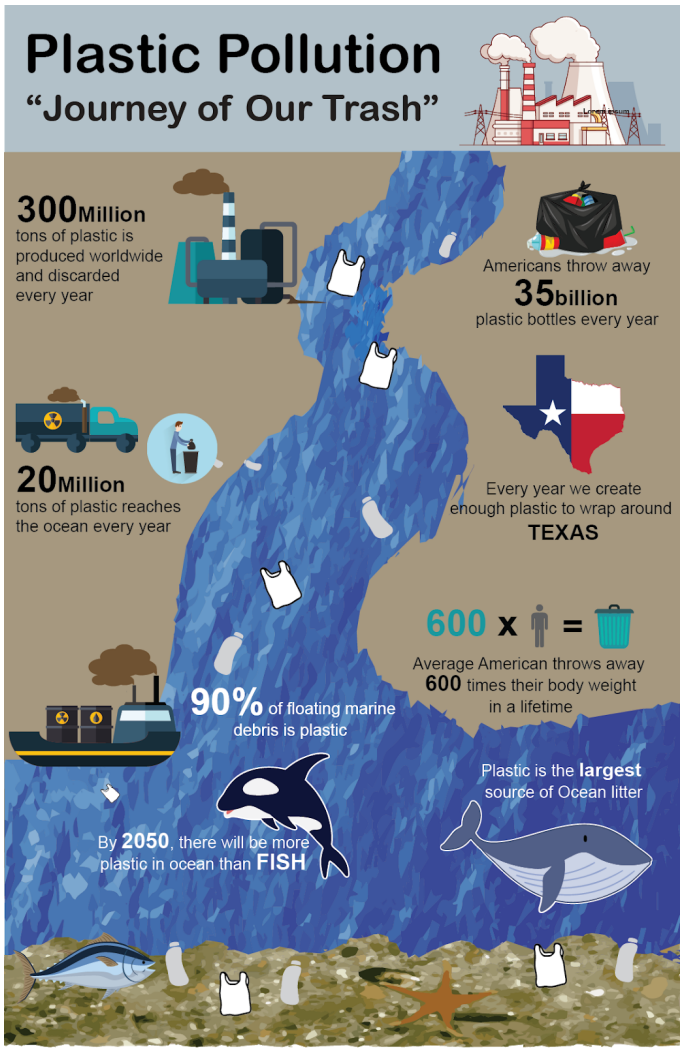


Figure 1: Infographic

After providing the reader with a brief understanding of what plastic pollution is, we wanted to reinforce that the reliance on plastic has been continuously growing and that global plastic production has continued to rise. We, therefore, chose a line graph to highlight this increasing trend. We initially plotted this line graph using d3. The line graph went to join data points by a click on the button. We however found that our had to hover at each point to see the

production in each year. We hence decided to replace in with a line graph with labeled data points and re-created it in Tableau.

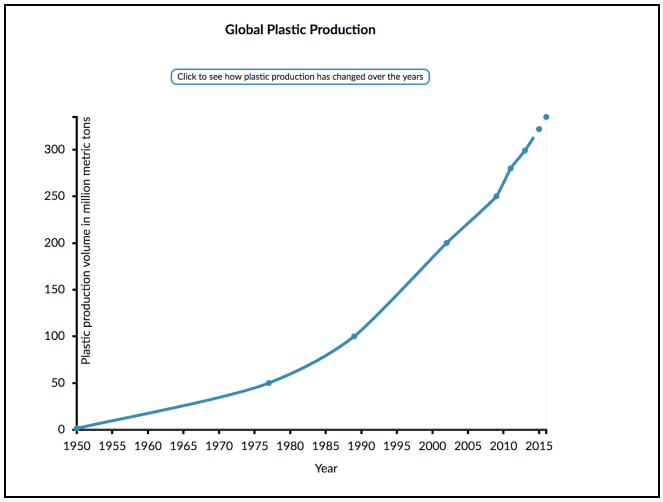


Figure 2: Trend of Global Plastic production (Initial Design without labels for data points)

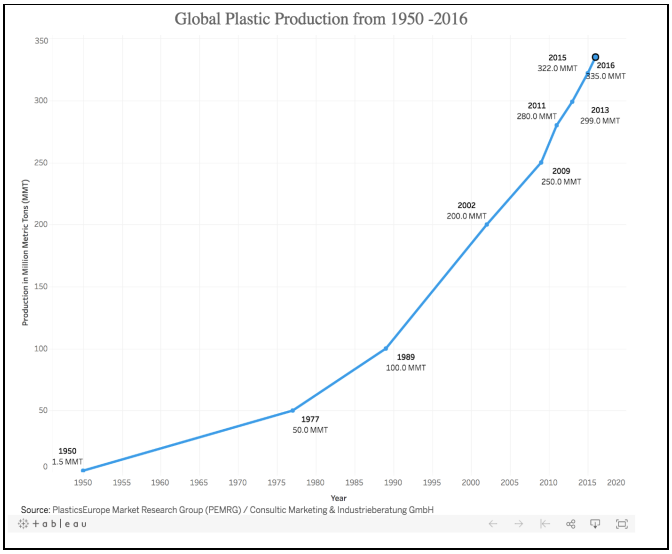


Figure 3: Trend of Global Plastic production (Final Design with labels for data points)

Note, the trend of global plastic production - the production has shown a continuous growth for more than 50 years, and the graph becomes steeper after 1977. Plastics production ramped up from 1.5 Million metric tons in 1950 to ~322 Million metric tons.

Source: The data for the graph was obtained from PlasticsEurope Market Research Group (PEMRG) / Consultic Marketing & Industrieberatung GmbH

Next, we wanted to build upon the non-biodegradable nature of plastic and hence chose to provide our users a comparison of estimated time taken for decomposition of commonly discarded items. The bar graph (Figure 4 - made in Tableau) offers a comparison of the estimated time for decay of newspapers with items containing plastic related compounds such as styrofoam cup, plastic bottles, plastic bag etc.

Through this bar graph, we wanted to bring the attention of our user to the harm even a single plastic bottle can cause by remaining in the environment for as many as 450 years. The labels were mentioned on the bar graph to offer an easy observation for our readers.

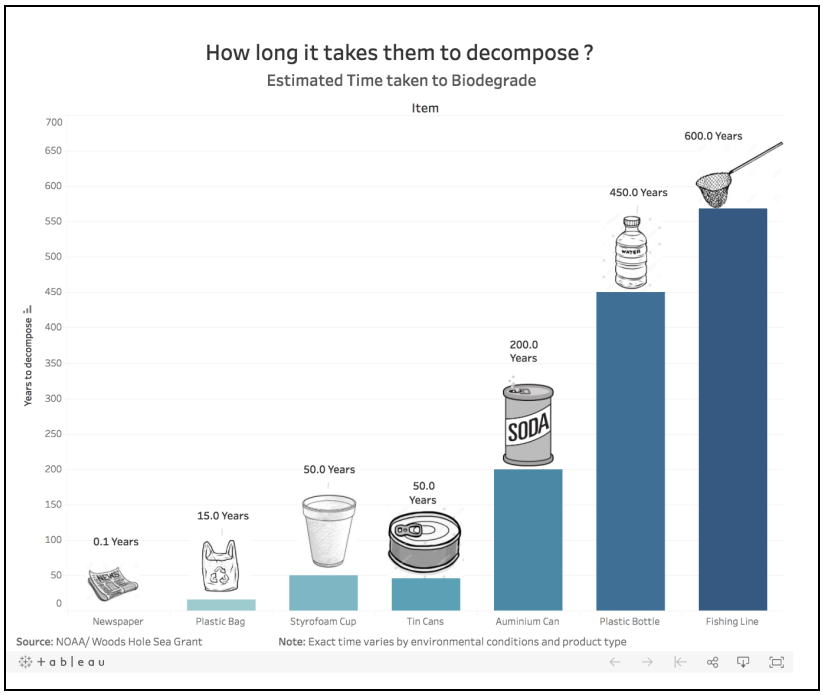


Figure 4 : Estimated time to Biodegrade

The visualization above (Figure 4) shows that the a plastic bottle takes ~ 450 years to decompose compared to a newspaper which takes only 0.1 years (~ 5 weeks) to decompose.

Source: The data for the graph was obtained from U.S. National Park Service; Mote Marine Lab, Sarasota, FL (decomposition times); National Oceanic and Atmospheric Administration Marine Debris Program.

PART- 4 : Which Countries contribute most Plastic Pollution?

After mentioning that the global production of plastic has continued to climb since 1950, we now wanted to help our user understand that majority of the plastic waste is contributed by only a few

countries in Asia. We provided our readers a map of the world which highlights the mismanaged plastic waste produced by Top 20 countries (causing the most ocean pollution) to achieve this goal.

The visualization is made with the aim to *catch the attention of user towards China, which is the major contributor to mismanaged plastic waste* (and countries which are the major contributors of mismanaged plastic waste). We made a design choice to show only 20 countries in the visualization because we did not want to overload our user with a lot of information. Our aim was to help the reader to focus on only the countries that contribute the most. We believe highlighting all countries in the visualization would not have achieved the same effect. We tested for alternate designs during the prototyping phase and found that the users preferred the design that showed data from only a few countries.

As, can be seen in the visualization (Figure - 5), majority of this waste comes from just six countries: China, Indonesia, Philippines, Vietnam , Srilanka and Thailand. The graph also mentions the economic status of the countries (Based upon 2010 Gross National Income). United States is the only high income country which is in the list of Top 20 countries with highest mismanaged plastic waste. Most of the countries in the list belong to lower middle income or upper middle income economic status. Color was used to show these categories (economic classification).

Source: The data for the graph was obtained from the study *Plastic waste inputs from land into the ocean by* Jambeck, J.R., Andrady, A., Geyer, R., Narayan, R., Perryman, M., Siegler, T., Wilcox, C., Lavender Law, K. , (2015). Plastic waste inputs from land into the ocean, *Science,* 347, p. 768-771.

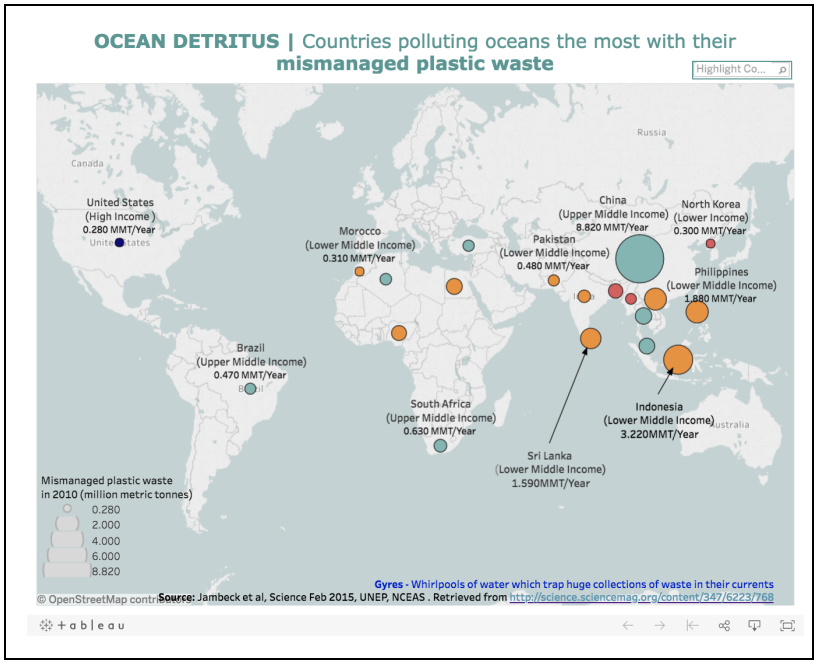


Figure 5 : Countries polluting the oceans most with mismanaged plastic waste

Next, We proceed to zoom-in the plastic problem and dive deeper to indicate the problem at a more granular level.

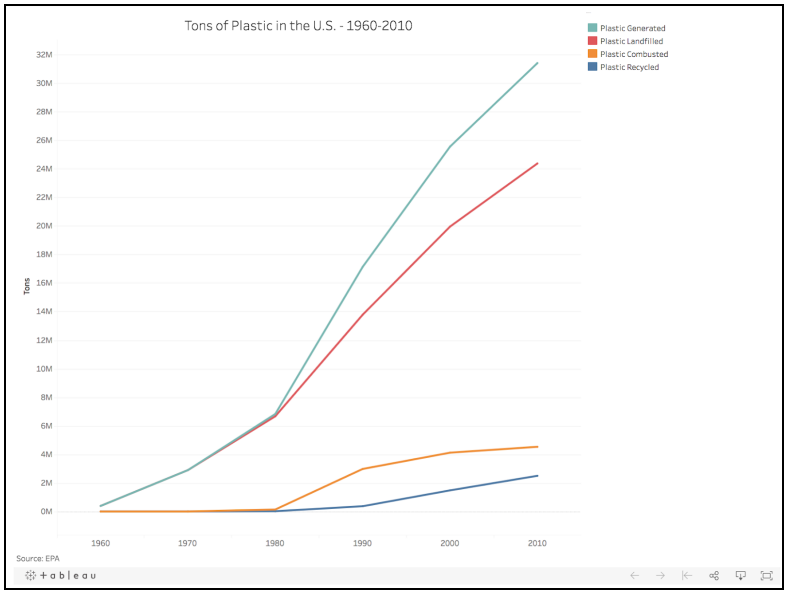


Figure 6: United States and Plastic Waste

For this view, we dive into the data on plastic production and disposal in the United States.. Since large-scale plastic production only began in the U.S. after 1950, we can view the whole history nicely in a single chart. We chose to use a line chart (Figure 6)in order to highlight the increasing trends, using different colors to differentiate between categories. We can see clearly that although recycling is on the rise, the amount of plastic being produced and disposed of in landfills in growing at a much faster rate. Although we have seen in the previous chart that the other countries such as China are managing their waste worse than the U.S., the amount of plastic going to landfills as opposed to being recycled in the United States is still very large.

Source: The data for the graph was obtained from United States Environmental Protection Agency (EPA).

PART- 5 : What is Mismanaged Waste?

This section is designed to help our readers understand what mismanaged plastic waste is and to *introduce the concept of gyres*. The section has a visualization that shows the position of 5 gyres in the world map. The text in the project provides an explanation to the concept of gyres.

The visualization (*Figure* 7) also mentions the percentage of mismanaged plastic waste the top 20 countries produce. The visualization uses the *size of the squares to depict this quantitative information* and *color to highlight the economics classification*.

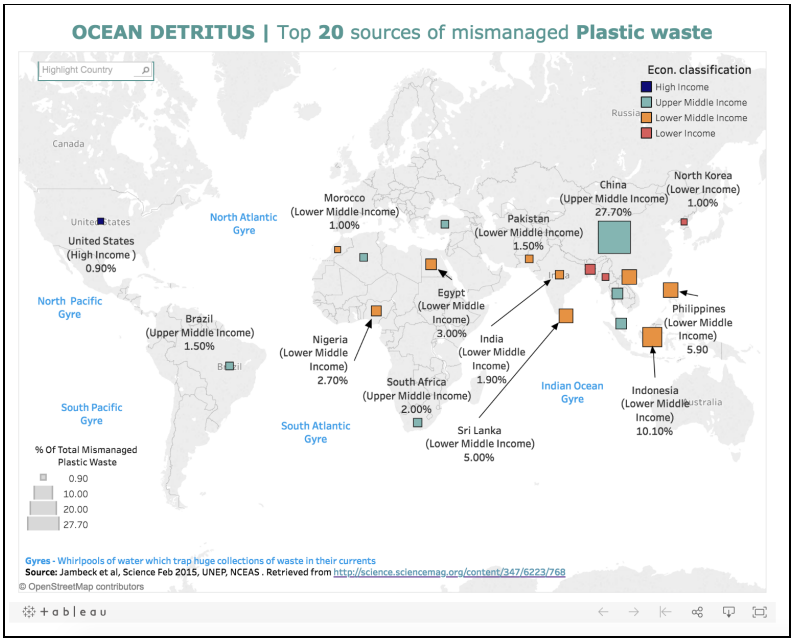


Figure 7: Top 20 sources of mismanaged plastic waste

Source: The data for the graph was obtained from the study *Plastic waste inputs from land into the ocean by* Jambeck, J.R., Andrady, A., Geyer, R., Narayan, R., Perryman, M., Siegler, T., Wilcox, C., Lavender Law, K. , (2015). Plastic waste inputs from land into the ocean, *Science,* 347, p. 768-771.

PART- 6: What Happens to Plastic in the Sea?

After describing about gyres in the previous section, we wanted to help our user understand what happens to plastic that enters the sea. We chose to u*se a Sankey diagram for depicting the flow from one set of values to another.* The visualization highlights the estimated amount of different plastic sources found in the sea, where these plastics are found and the consequences of this for the natural environment.

We used an interactive Sankey diagram (Figure 8; made in Highcharts) to put visual emphasis on the major transfers or flows. The user can click on the respective sources and see their flow from one node to another. The main takeaways from the graph for our readers were that most of the waste sinks to the bottom of the Ocean and that a major portion of waste is ingested by Marine species or entangles them. This visualization provides greater clarity to the infographic presented to the reader in Part-2 "The Problem of Plastics". We chose to provide the user with definitions of Ingestion and Entanglement in the final prototype as few participants were not familiar with the terms.

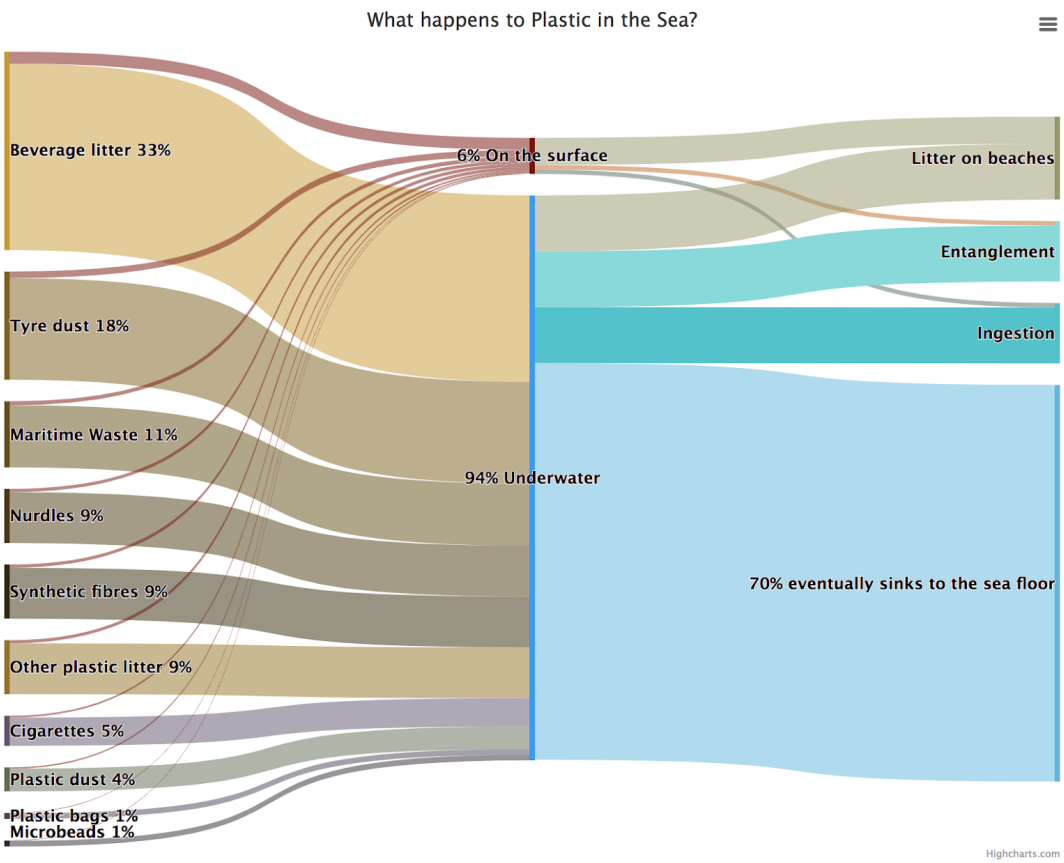


Figure 8: What happens to Plastic in the Sea

Source: The data for the graph was obtained from the website of Green Alliance. Green Alliance is a charity and independent think tank focused on achieving ambitious leadership for the environment.

The section "What Happens to Plastic in the Sea?" has another visualization *(Figure* 9)that provides the reader with Plastic Marine Debris Projections. This visualization aims to incite an urgency to take action amongst our readers, we chose to show three scenarios 1) If some waste management infrastructure improvements are made and the plastic waste production declines 2) if no waste management infrastructure improvements are made 3) If we do worse in waste management infrastructure than the present. The projections are estimated by assuming conversion rates of mismanaged plastic waste to marine debris at a rate of 15%, 25%, and 40% respectively. The main idea behind showing projections in this visualization is to bring user attention to the gravity of the situation. The animation was employed to capture user's attention to the projections. D3js was used to animate this visualization.

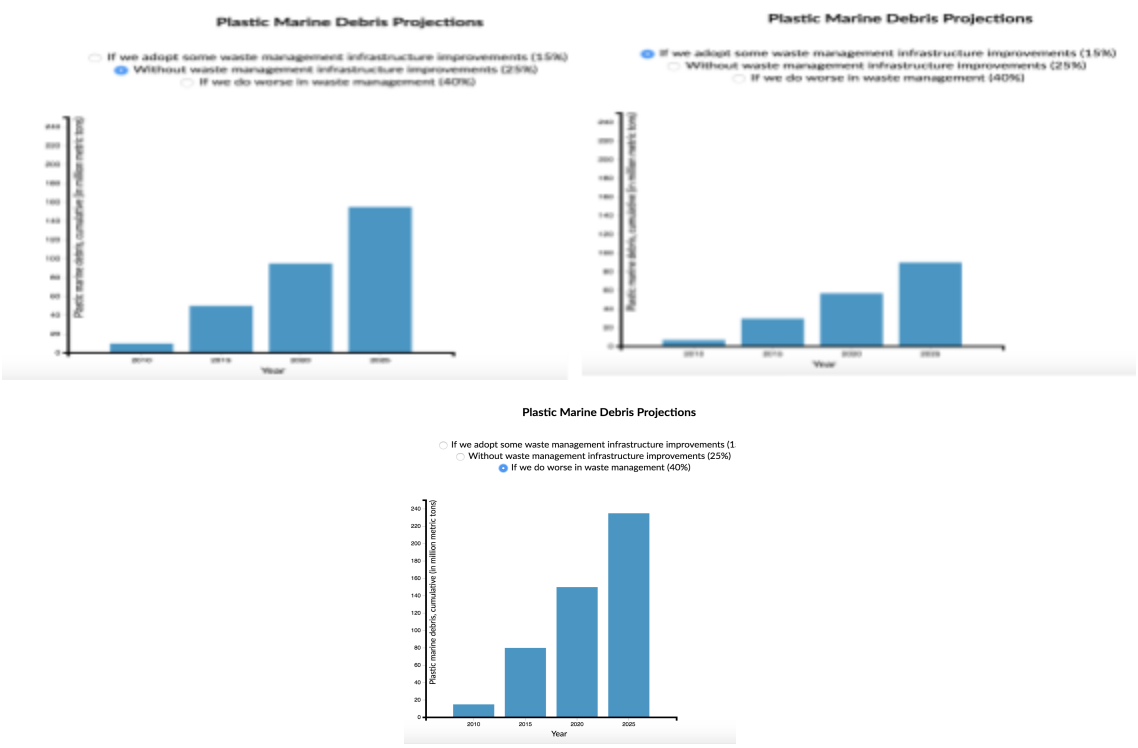


Figure 9: Plastic Marine Debris Projections

Source: The data for the graph was obtained from the study *Plastic waste inputs from land into the ocean by* Jambeck, J.R., Andrady, A., Geyer, R., Narayan, R., Perryman, M., Siegler, T., Wilcox, C., Lavender Law, K. , (2015). Plastic waste inputs from land into the ocean, *Science,* 347, p. 768-771.

The study uses a line chart (See Figure 10) to describe these projections, we felt adding animation can help catch the attention of user better to the rising plastic productions.

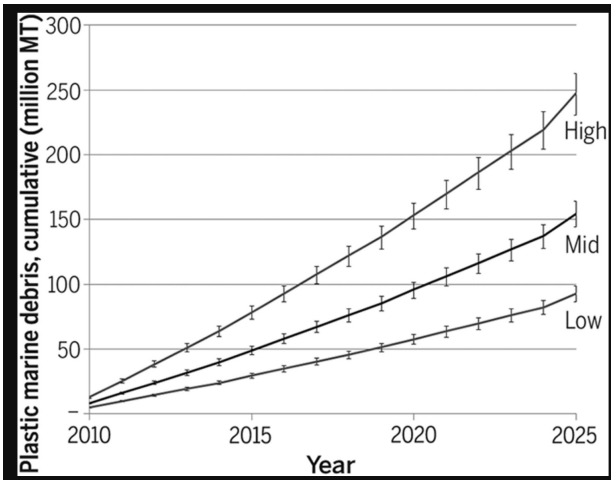


Figure 10: Plastic Marine Debris Projections - as shown in the research article by Jambeck et, 2015

PART- 7: Plastic bags usage bans around the world

After understanding the problem of the plastic waste, we want to exam any existed action took, especially the governmental level. One of the interesting research we found is that one trillion plastic bags are used, equating to 2 million per minute, every year. Moreover, the plastic bag banned policies are various in the different countries around the world, according to the Earth Policy Institute.

We use the maps charts (*Figure 11)* to demonstrate this global information on the plastic bag policy. Also, since the policies were aware, introduced, or re-introduced in the different year, we decided to adopt the year of the awareness of the plastic bag problems in order to simplify and clarify the dataset. Therefore, we provide the timeline options for the user to cruising the policies around the different year in different countries. According to the visualization, one fun fact was that Italy is the first country in the world started to discuss the problem of plastic bag banned policy.

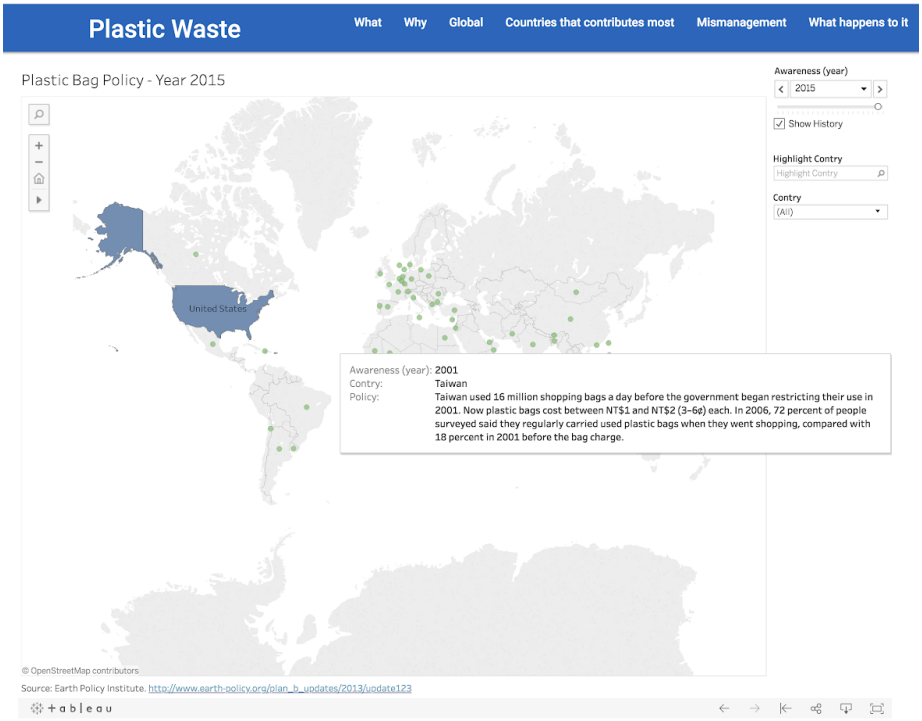


Figure 11: Plastic Bag Policy around the world

Source: Earth Policy Institute. (Link)

PART- 8: Solving the problem

We design the grids format with 9 cards in order to provide simple instructions on solving the plastic problem at the individual level. In the center card, we emphasize our goal where eight actions to reduce the plastic footprint. In the rest of the cards, we use the small image to visualize the concept, the title to highlight the single action, and the content for the more details.

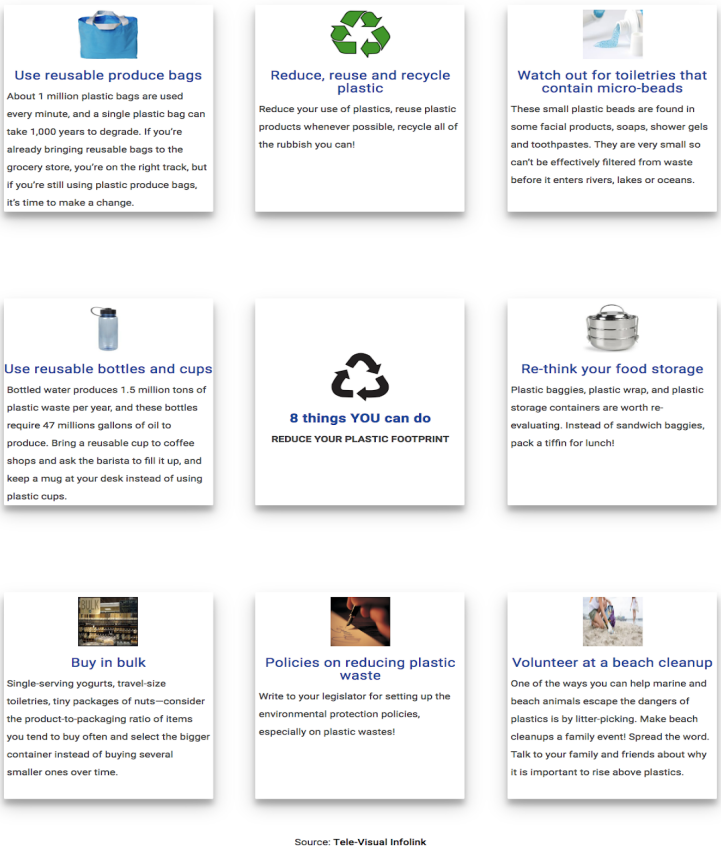


Figure 12: 8 things that the individual could do to reduce the plastic footprint

Source: Tele-Visual Infolink (Link)

PART- 9: Advocate!

An image is a powerful tool for getting attention from the audience. We choose this full width "refuse plastic" picture to finalize our website to raise the awareness of the plastic waste problem and hopefully advocate people to reduce the usage of plastic.

Figure 13: Let's refuse plastic

Data Source and Description

There are several datasets we used to accomplish our goals in the project.

One of the most used data set by us was from the study ***Plastic waste inputs from land into the ocean*** *by* Jambeck, J.R., Andrady, A., Geyer, R., Narayan, R., Perryman, M., Siegler, T., Wilcox, C., Lavender Law, K. , (2015). Plastic waste inputs from land into the ocean, *Science,* 347, p. 768-771. The study collected dataset from 192 Countries regarding waste generation rate per person, Total waste generation rate, % Inadequately managed waste, mismanaged plastic waste, % littered waste , economic categories etc. The original dataset had 15 columns and 192 rows. The study sourced data from World Bank estimates and U.s National Litter Study.

For our project's purpose, we used the data for only the top 20 countries ranked by mass of mismanaged plastic waste (in units of millions of metric tons per year) and focused only these three variables in the dataset:

1) Plastic waste (In million metric tons)
2) % of Mismanaged Plastic Waste
3) Economic classification

We created our own datasheet from this original dataset (See Figure 14). The following table describes the specific variables -

Name of Variable	Description o
Plastic waste	Total mismanaged plastic waste is calculated for populations within 50 km of the coast
% of Mismanaged Plastic Waste	Mismanaged plastic waste is the sum of inadequately managed plastic waste plus 2% littering.
Economic classification	Economic classification based on (World Bank definitions based on 2010 Gross National Income). Classified as ; High income; Upper middle income; Lower middle income; Low income

Apart from the above variables, we also used another dataset (the data on projections) from the same study. The data set had estimated mass of mismanaged plastic waste (millions of metric tons) input to the ocean by populations living within 50 km of a coast in 192 countries, this data was plotted as a cumulative sum from 2010 to 2025. Three estimates were used in the graph (high,

40%; mid, 25%; low, 15%). Estimates reflected assumed conversion rates of mismanaged plastic waste to marine debris.

Rank	Country	Waste Generation Rate [kg/ppd]	% of Waste that Is Plastic	% Mismanaged Waste	Plastic Waste [MMT/yr]	% Mismanaged Plastic Waste	Marine Debris [MMT/yr]
1	**China**	1.10	11	76	8.82	27.7	1.32–3.53
2	**Indonesia**	0.52	11	83	3.22	10.1	0.48–1.29
3	**Philippines**	0.5	15	83	1.88	5.9	0.28–0.75
4	**Vietnam**	0.79	13	88	1.83	5.8	0.28–0.73
5	**Sri Lanka**	5.1	7	84	1.59	5.0	0.24–0.64
6	**Thailand**	1.2	12	75	1.03	3.2	0.15–0.41
7	**Egypt**	1.37	13	69	0.97	3.0	0.15–0.39
8	**Malaysia**	1.52	13	57	0.94	2.9	0.14–0.37
9	**Nigeria**	0.79	13	83	0.85	2.7	0.13–0.34
10	**Bangladesh**	0.43	8	89	0.79	2.5	0.12–0.31
11	**South Africa**	2.0	12	56	0.63	2.0	0.09–0.25
12	**India**	0.34	3	87	0.60	1.9	0.09–0.24
13	**Algeria**	1.2	12	60	0.52	1.6	0.08–0.21
14	**Turkey**	1.77	12	18	0.49	1.5	0.07–0.19
15	**Pakistan**	0.79	13	88	0.48	1.5	0.07–0.19
16	**Brazil**	1.03	16	11	0.47	1.5	0.07–0.19
17	**Burma**	0.44	17	89	0.46	1.4	0.07–0.18
18*	**Morocco**	1.46	5	68	0.31	1.0	0.05–0.12
19	**North Korea**	0.6	9	90	0.30	1.0	0.05–0.12
20	**United States**	2.58	13	2	0.28	0.9	0.04–0.11

Table: (Jambeck, J. R., et al. "Plastic Waste Inputs from Land into the Ocean." Science, vol. 347, no. 6223, 13 Feb. 2015, pp. 768–771., doi:10.1126/science.1260352). Waste estimates for 2010 for the top 20 countries ranked by mass of mismanaged plastic waste (in units of millions of metric tons per year). Interpretation of characters in the table: Mismanaged waste is the sum of inadequately managed waste plus 2% littering. Total mismanaged plastic waste is calculated for populations within 50 km of the coast in the 192 countries considered. ppd, person per day; MMT, million metric tons. If considered collectively, coastal European Union countries (23 total) would rank eighteenth on the list.

Figure 14 : Dataset used in the study (Jambeck et al, 2015)

We also used other sources. Other main sources were different type of data obtained from government, NGOs and other websites that work on environmental issues.

The following table lists other websites and description of the data we used in our visualizations:

Website Title with Link	Description of Dataset	Variables Used from Dataset
Industrieberatung GmbH & International Organization for Standardization (Link)	The above statistic depicts the global plastic production and demand from 1950 to 2015.	World Plastics Production (1950 – 2015)
PlasticsEurope Market Research Group (PEMRG) / Consultic Marketing (Link)	The above site mentions the global plastic production from 1950 to 2016.	World Plastics Production
New Hampshire dept. Of environmental sciences (Link) U.S. National Park Service; Mote Marine Lab, Sarasota, FL (decomposition times); (Link) & National Oceanic and Atmospheric Administration Marine Debris Program. (Link)	All 3 sources provided estimated time to Biodegrade for common trash items	Estimated time to biodegrade
Green Alliance (Link)	They have infographic that shows where marine plastic waste comes from, and what happens to it when it ends up in our seas	Used the information to develop an interactive sankey diagram.
Environmental Protection Agency (Link)	This EPA report provides data on U.S. plastic production and disposal since 1960.	Plastics Generated, Plastics Recycle, Plastics Combusted, Plastics Landfilled
Earth Policy Institute. (Link)	They provides the data about policies adopted by countries around the world to reduce plastic bag usage.	Country name, Continent, Policy, Year of awareness.

Tools Used

A) Website Building (HTML, CSS, and JavaScript)

The final visual presentation is a website hosted on the github pages. Also, we used **Github** to develop our code online and collaborate asynchronously. Meanwhile, We use HTML for building structure, CSS for styling, and JavaScript for the interactive components. Moreover, we adopt the **Material Design** by Google as a foundation of our website and customize our website with further configurations.

B) Tableau

Map Visualizations:

We used tableau for a number of reasons and visualizations. First we used for an exploratory data analysis (EDA) of 192 countries data set (Shown below, Figure 15)

Figure 15: EDA - Mismanaged Plastic Waste (Jambeck et al, 2015)

Second, we plotted the data from only the Top 20 countries (causing the most ocean pollution) on a map in Tableau. The map visualization created showed both the quantity of plastic waste generated and % of Mismanaged Plastic Waste by these countries. This was embedded in our webpage later. (See below).

*Figure 16:*Visualizations showing top 20 countries with mismanaged plastic waste

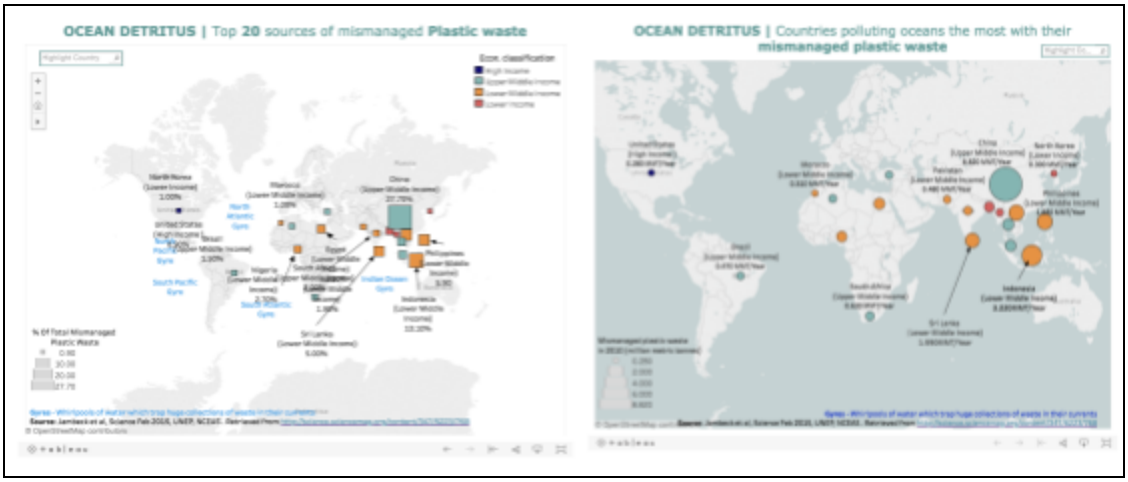


Tableau was a good choice for these visualizations because it has intuitive highlighting and filtering functionalities for our users to help them see a specific country.

We also used Tableau to create a visualization to help our readers understand when a policy was enacted to address the problem of plastic pollution in different countries of the world.

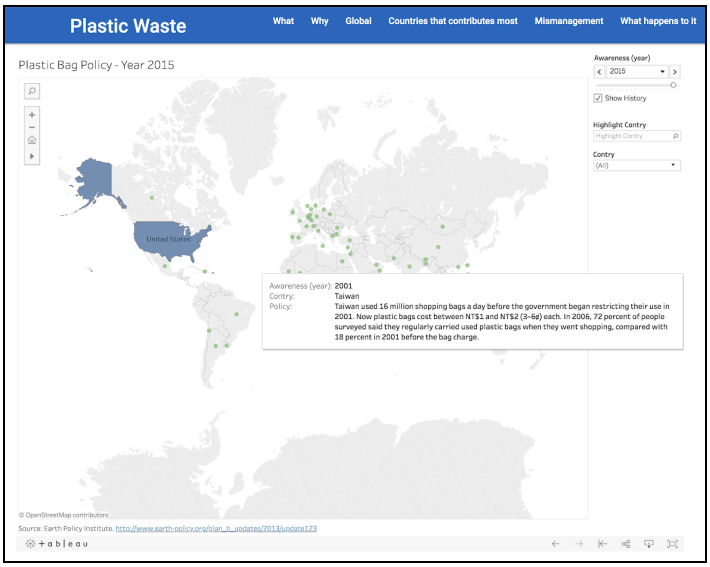


Figure 17: Plastic bag banned policies around the world

Line Graphs:

We used Tableau to create a line graph to show the trend of Global Plastic Production from 1950 -2016, and also a line graph to show U.S. Plastic Production and Disposal over the same time period.

Figure 18: Global Plastic Production

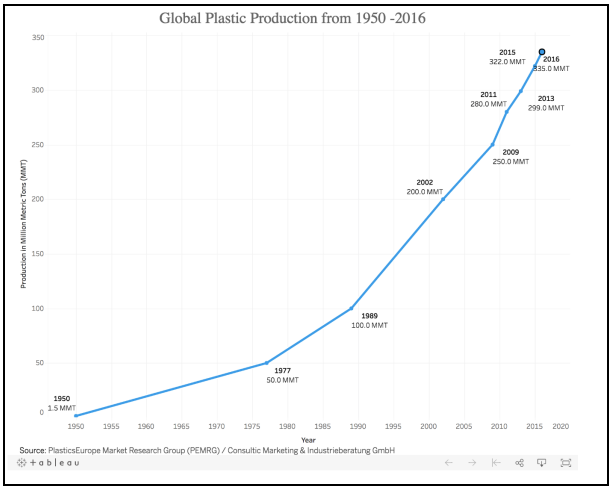
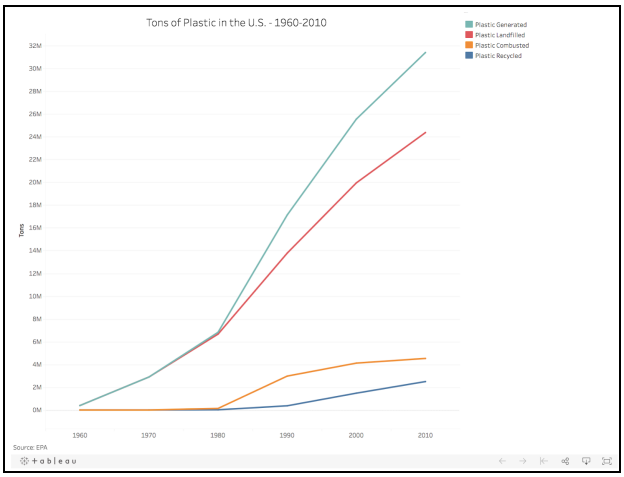


Figure 19: U.S Plastic Production



Bar Graph

We also used Tableau to present a comparison of the estimated time for decay of common garbage items such as newspapers, styrofoam cup, plastic bottles, plastic bag etc.

Figure 20: Estimated time taken by garbage items to decay

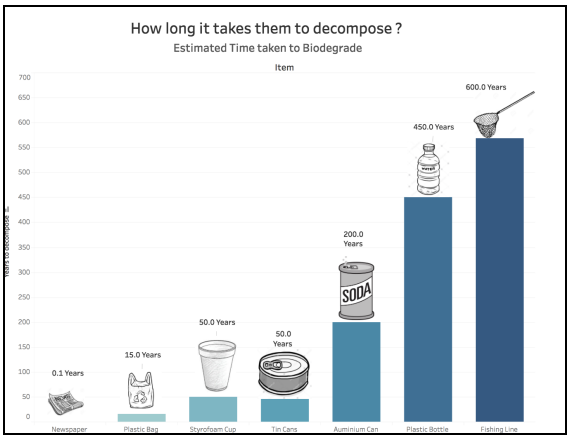


Tableau was a good choice for these visualizations because it has intuitive highlighting functionality which can help the user to interact with these visualizations. Tableau also allows to import images which we wanted for our visualization.

C) Highcharts

Sankey Diagram:

We used Highcharts to draw a sankey diagram (an interactive visualization) to highlight the estimated amount of different plastic sources found in the sea, where these plastics are found and where do they end up? The Sankey diagram consisted of two types of data. The nodes and the Links. We defined the values if links in the Highcharts, and the nodes were generated dynamically.

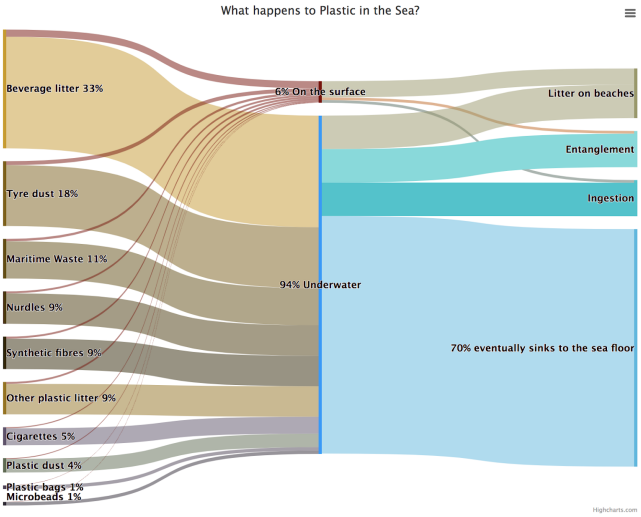


Figure 21: Sankey Diagram

D) Data Driven Documents (D3)

Bar Graph:

We used D3 as a key tool to create a dynamic, interactive bar graph, using animation to show projections of Plastic waste to marine debris. We used D3 js because we wanted to draw our readers attention to the changes (in amount of plastic marine debris) in three different scenarios. Because, the visualization only had a few data point, the data for the chart is included in the html file itself.

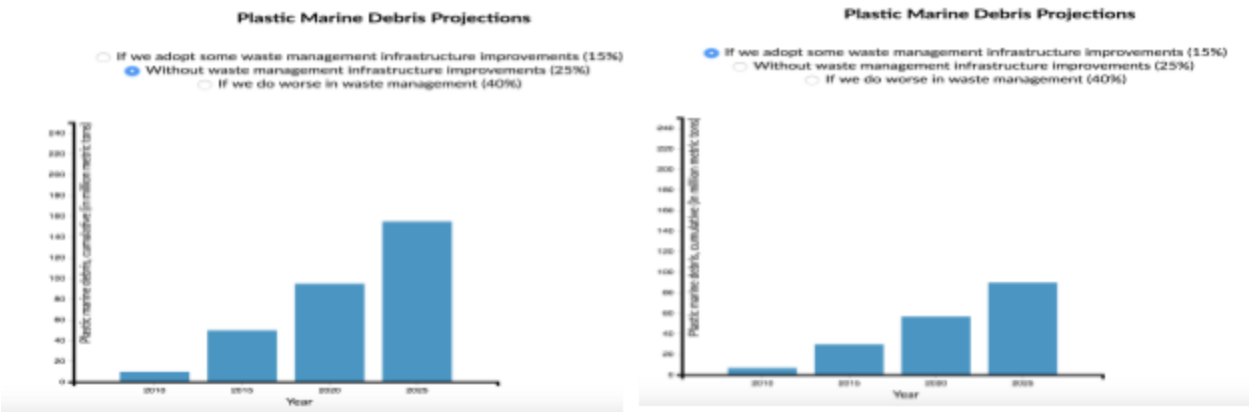


Figure 22: Bar graphs made with D3js

E) Adobe Illustrator

Infographic:

We used Adobe Illustrator to create our infographics. We found that many previous works emphasized infographics when describing the current state of plastic pollution, and we felt that it was important to make this graphic colorful and visually stimulating in addition to conveying a clear narrative.

Usability Testing

Round 1 of User Testing

Site Layout:

Since our final product is a web-based experience, we wanted to get a sense of how the narrative would flow before we began development, so we sketched out the prototype displayed below. This sketch served as the backbone for our final website. Ultimately, after discussions among our team, we decided to switch the infographic to come before the charts displaying the scale of plastic production and disposal, because we felt that this would capture users' attention more quickly.

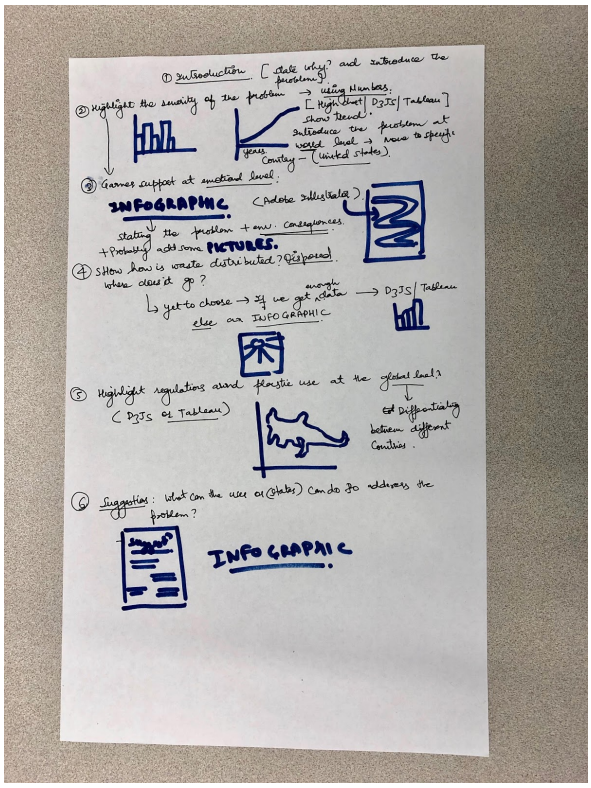


Figure 23: Initial rough layout for our project

Prototyping for respective sections:

In our first phase of usability testing, we sketched ***two potential designs for the infographic displaying the flow of plastics into the ocean***. We asked three potential users for their feedback on the designs, looking for which design they preferred and which was easier to understand. We found that while participants liked both designs (see below), they felt that design 1 was easier and faster to understand. After this testing phase, we created a high fidelity version of design 1 using Adobe Illustrator.

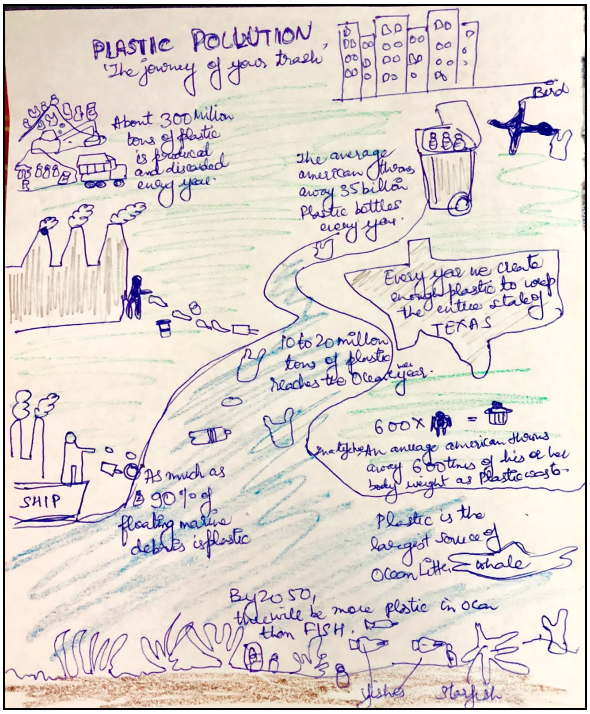


Figure 24: Design 1 for Infographic

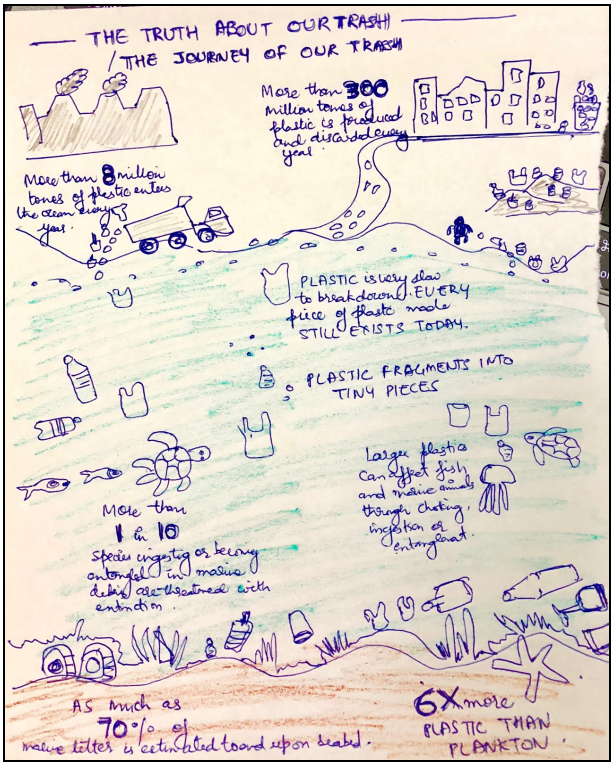


Figure 25: Design 2 for Infographic

We also sketched a design for what would be the ***final section of our website***, which highlights a set of actions that people can take in their everyday lives to combat plastic pollution. We asked participants to look at the designs and to report on any particular actions that might be confusing or complicated. Based on the user feedback, we chose a final set of 8 actions for our final version.

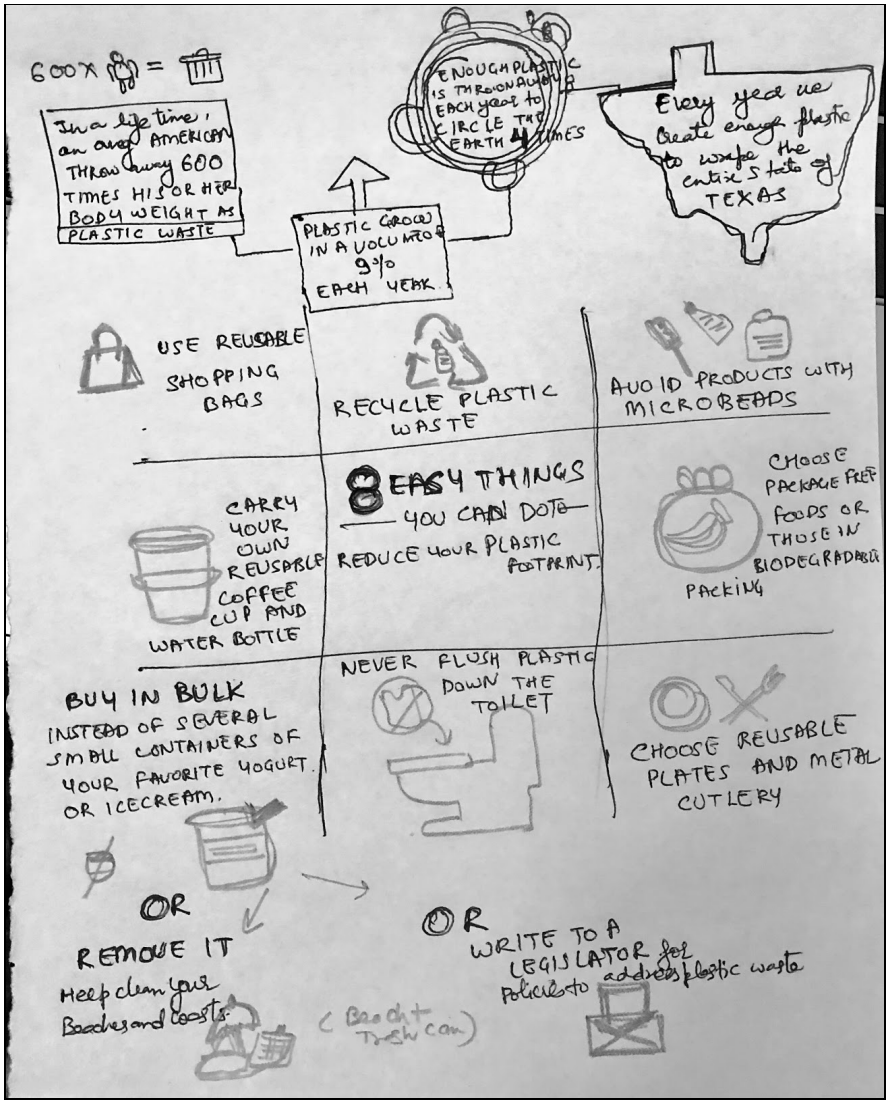


Figure 26: Design for Grid in the last section

We created prototype for the graphs we wanted to make interactive such as the ***Sankey diagram*** and the ***d3.js bar graph*** to test the idea and to see if the concept could be understood by people. We found that people understood the concept and could easily follow the sankey diagram. We also got feedback that adding right colors to sankey (different shades of brown or grey for trash and blue for water) would make it more impactful. We implemented these suggestion in our final prototype.

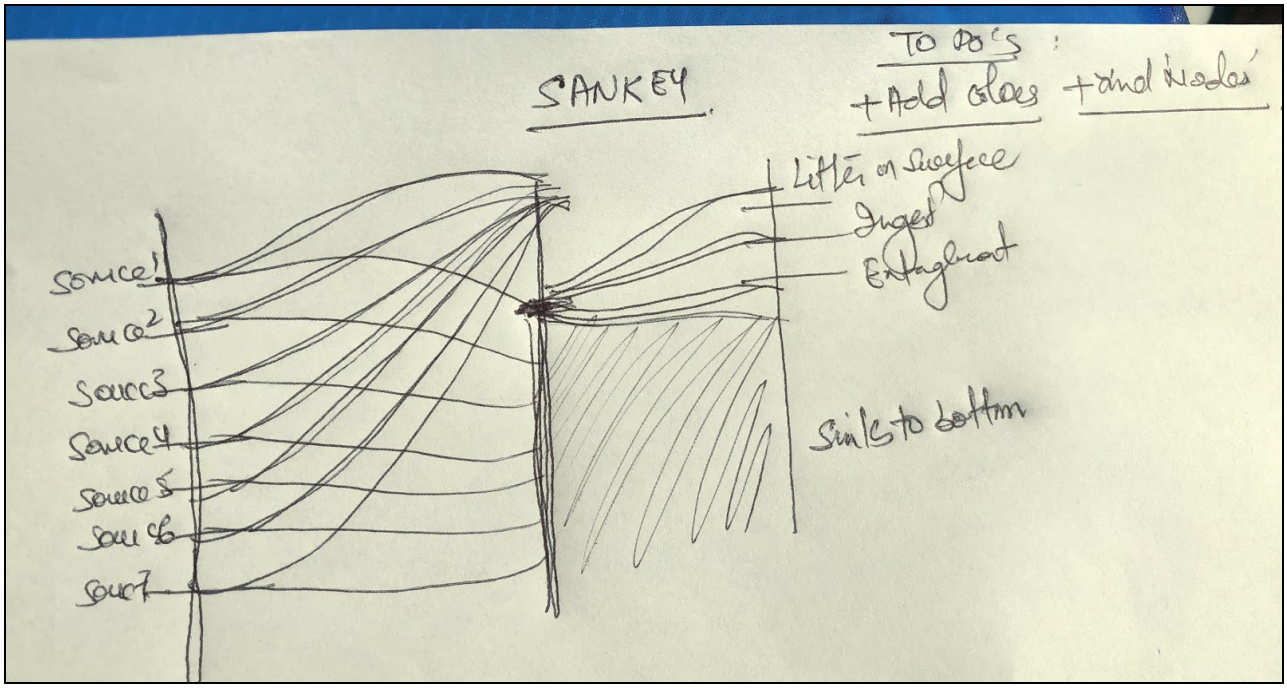


Figure 27: Initial design for the Sankey diagram

Similarly, we created a prototype for the bar charts that we later created using d3js. The interactive component was explained to receive feedback from the respondents.

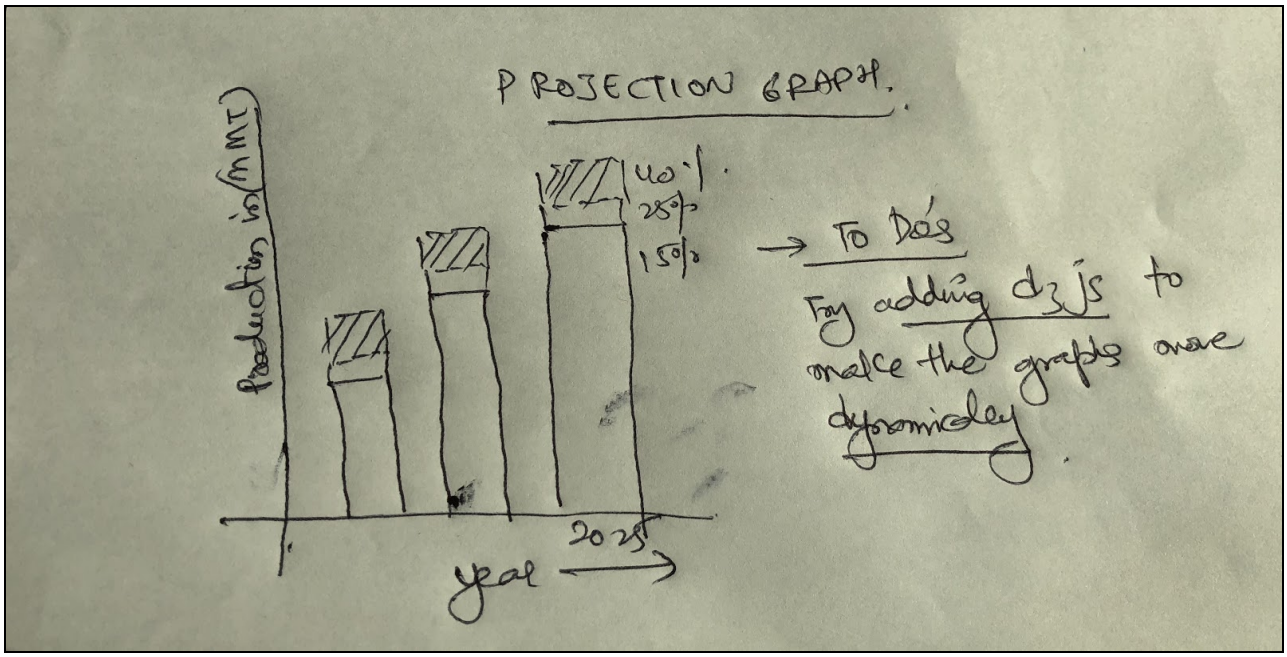


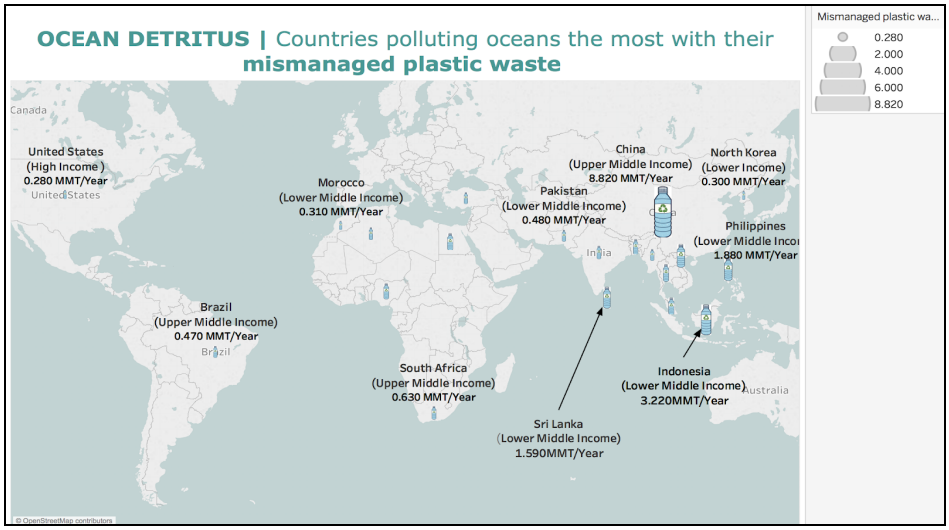
Figure 28: Initial design for bar graph created using d3.js

Feedback from the project showcase

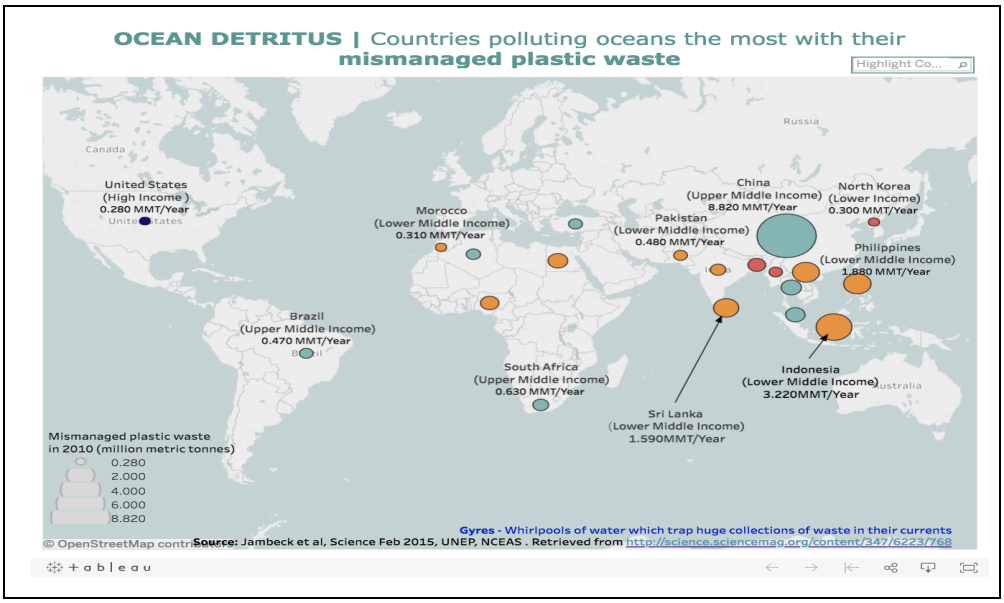
While most of the showcase time was spent in presenting the website to visitors, we received a lot of feedback from the I School community as well as outside visitors, many of them seemed to be really surprised to learn the amount of plastic they produce in a day and data from Top 20 countries with mismanaged waste. They seen to specially like the Sankey diagram, the interactive projection Bar graph and the visualization describing the time of regulation in different countries. We also received specific feedback from Prof. Marti Hearst, and our teaching assistants - Usman Raza and Samuel Meyer on certain charts, which we later *implemented and have included in our final design*.

A feedback we received from Prof. Marti was that the use of plastic bottles isotypes in the visualization seemed out of proportion. We therefore decided to replace the plastic bottles with circles. We used size of circle to represent the quantitative information and color (in circle) to highlight the different economic categories.

Visualization Before

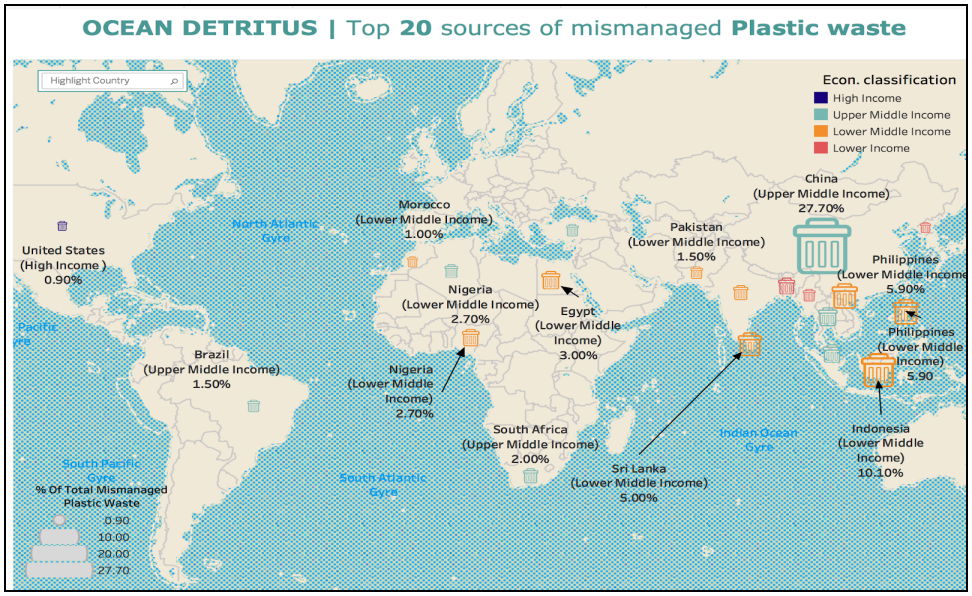


Visualization After Incorporating Feedback

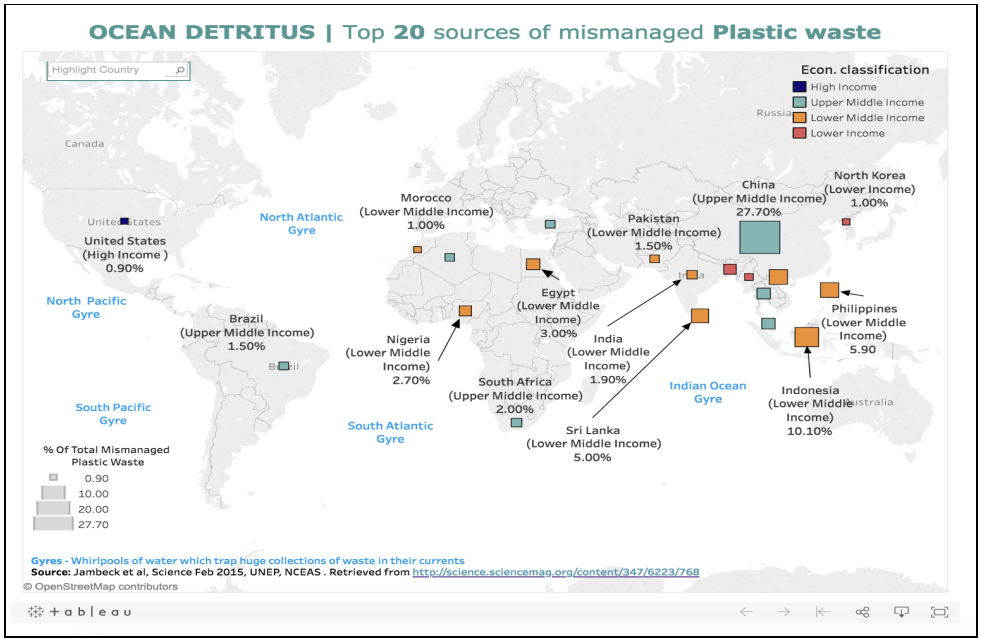


Similarly, we were told that the background image (maps) were too colorful and the trash icons were difficult to understand. We hence changed the background map and replaced the trash isotypes with squares. We used size of square to represent the quantitative information and color to highlight the different economic categories.

Visualization Before



Visualization After Incorporating Feedback



Round 2 of User Testing (for the website created by us)

After the showcase presentation, we were able to further test our project website with **two** more users. Our participants were given the following scenario: “While trying to learn more about Plastic Pollution, you have come across this website on property abandonment.” For user-testing

sessions, first they were asked to explore the website and speak aloud their feelings and thoughts. They were also asked to voice any questions that came to their mind as they explore our project website.

After the first step of exploring website, each participant was asked the following four questions:

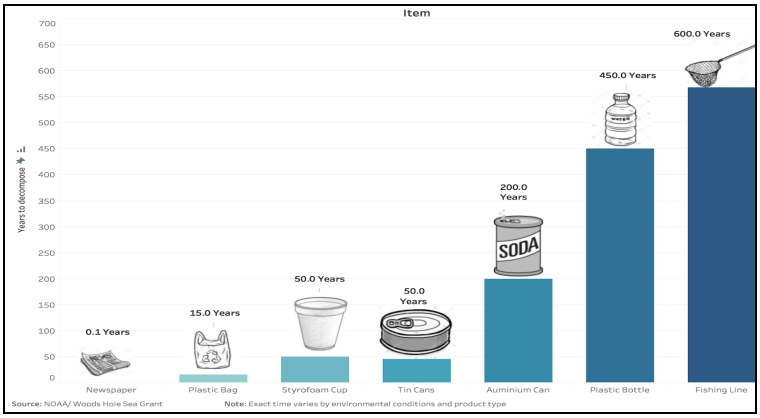
1. Should we use Plastic? If yes, Why? / If No, Why not
2. Describe the trend of Plastic production (Global and U.S)
3. Which countries are polluting the oceans most with their mismanaged Plastic waste?
4. What can you do to reduce Plastic Pollution?

Finally, a general feedback was elicited from each participant. Throughout the user testing process, we made the following observations :

A) Task completion / ability to answer question correctly
B) Errors and reported feedback
C) Overall feedback on the project website

Synopsis of these usability tests

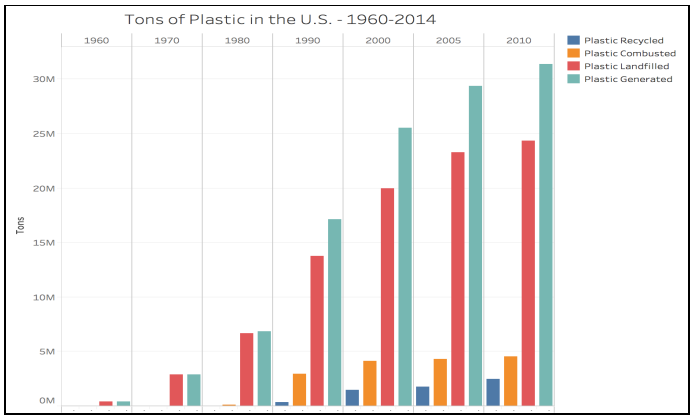
A) *Task completion:* Both respondents were able to correctly answer the 4 questions posed to them or complete the task, although the amount of information retained and the clarity of answers varied. One respondent remembered the graph mentioned the time taken by different items to decompose in the first answer. The second respondent did not mention the graph but hinted that plastic takes a long time to biodegrade and hence should be avoided. Later, we decided to add isotypes (see below) to the bar graph to catch the attention of our readers more. We tested the design and found that both respondent s liked the use of isotypes in the bar charts.



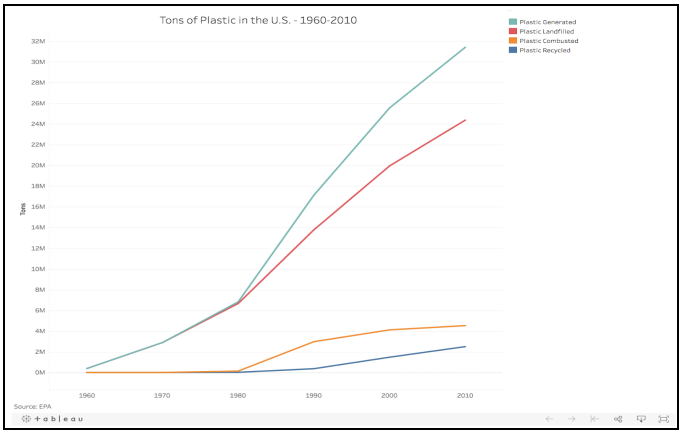
Both respondents correctly identified the trend of global and U.S plastic production. For Q.3, the first respondent could recall a total of 3 countries that contributed most to mismanaged plastic waste in the ocean while the second respondent mentioned China and said the "major polluters were countries in Asia.". For the last task each respondent were able to recall at least 4 ways to reduce plastic pollution at an individual level.

B) *Errors and reported feedback* : One respondent mentioned that it was difficult for him to see all the bars for United states and found that they were difficult to compare(as it was not displayed in proportion to size in the website). We addressed this feedback by replacing the bar graph with line graph (see below) and subsequently testing it with them for feedback. Both users mentioned that it was easier to see the trend using a line graph as compared to bar charts.

Visualization before



Visualization After Incorporating feedback

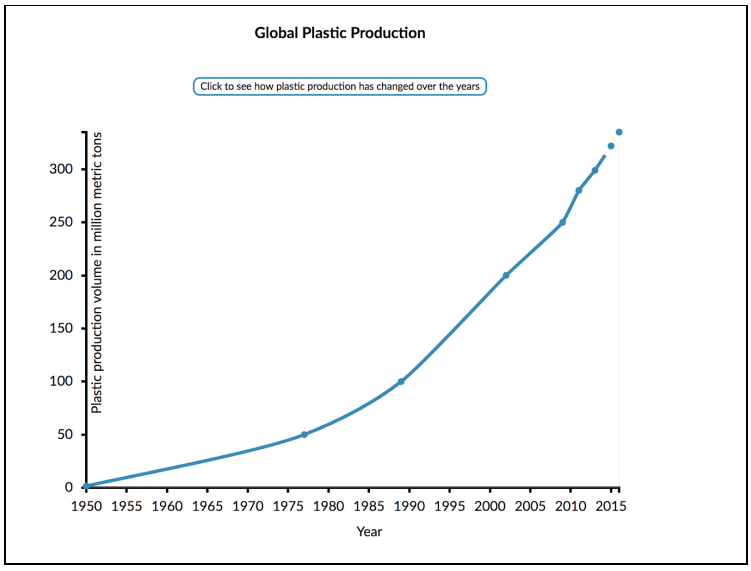


One user pointed that the nav bar looked a little constricted, we fixed the css for the nav bar in the final design.

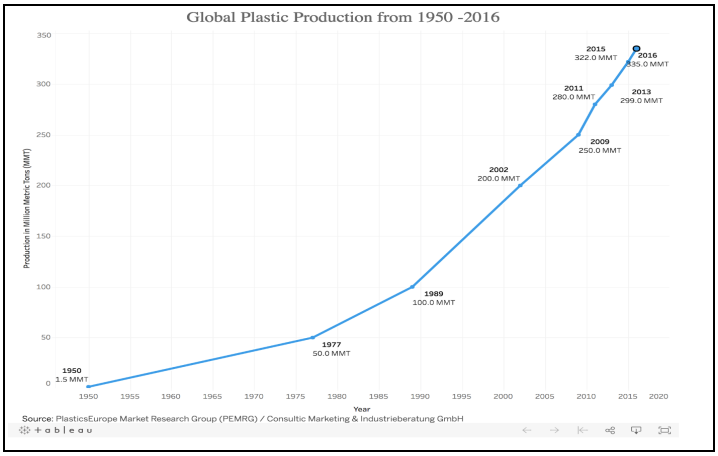
C) ***Overall Feedback and Observation:***

The concepts was clear to both the participants and they both showed concern on the increasing plastic production and rising plastic marine debris. They liked the website not only provided clarifications for the concepts but also provided action points to reduce plastic pollution. A few common confusion we noticed were interpreting the title of Sankey - we modified it from "Where does Plastic go" to "What happens to Plastic you throw in the Sea". Similarly, we also added the *definition for Ingestion and Entanglement f*or helping them to understand the concepts better.We also added labels to each data point in our line graph that showed global plastic production data. We saw our respondent going at each data point to see the values . We, therefore, decided to make it easier by providing data labels for each data point in the visualization.

Visualization before



Visualization After Incorporating Feedback



Lessons Learned

We found the journey of completing this project to be a rich learning experience. Through our visualizations, we gained many interesting insights about Plastic pollution. Some key lessons our team learned in the process were:

- ***Importance of following an Iterative process:*** We performed both major and minor iterations of our visualizations during this time period, both in terms of layout and specific visualizations. We used our own critique, judgment and supplemented these findings with user feedback.

- ***Choosing the right tool*** is extremely important to creating a good visualization: Though we ended up using almost all the tools introduced in this course by the time we completed the final version of our project. We could have achieved the task with fewer tools, but we found it best to use the relevant tool for each segment of the project. Time was a constraint as we had to change a visualization from d3js to tableau due to time constraint.

- ***Audiences and type of data play a huge role*** in shaping the type of visualizations feasible: In our project, we took special precautions to present data in a very easy to understand manner. We used a lot of simple lines and bar graphs to achieve this and paired it with easy to understand dynamic visualizations and infographics.

Links to demos, code and documents

Here is the link to our project website:
https://plasticwaste.github.io/

Here is the link to our github repository, including all the data files used:
https://github.com/plasticwaste/plasticwaste.github.io

Summary of contributions by team members

Task	Anu	Jeffery	Jonathan
Content literature search	1/3	1/3	1/3
Search for data and statistics	1/3	1/3	1/3
Defining exploratory questions	1/3	1/3	1/3
Data cleaning and preparation	1/3	1/3	1/3
Exploratory Data Analysis	1/3	1/3	1/3
Creating charts in Tableau	4/6 2 map charts for Mismanaged plastic waste 1 line graph for global plastic production 1 Bar graph for estimated time for decay	⅙ 1 map chart for policies around the world	⅙ 1 line graph for U.S plastics production
Creating charts in Highcharts	1 Sankey diagram	0	0
Creating visualization in D3	1 Interactive dynamic bar graph	0	0
Creating visualization in Infographic	½	0	½
Descriptive content creation	1/2	1/4	1/4
Developing low fidelity prototypes	1	0	0
Website design (incl. CSS styling)	1/5	4/5	0
User research design and usability testing	¾	0	¼

	Round 1+ Round 2 Usability testing		Round 1 Usability testing
Revision in response to feedback	⅓ Each revised their own parts in response to feedback	⅓ Each revised their own parts in response to feedback	⅓ Each revised their own parts in response to feedback
Thumbnail creation	0	1	0
Final report write up	⅓ Wrote parts completed by her in project + parts on Sources + Feedback from project showcase + Round 2 of user testing	⅓ Wrote parts completed by him in project + Goals	⅓ Wrote parts completed by him in project + parts on Related work + Round 1 of User testing

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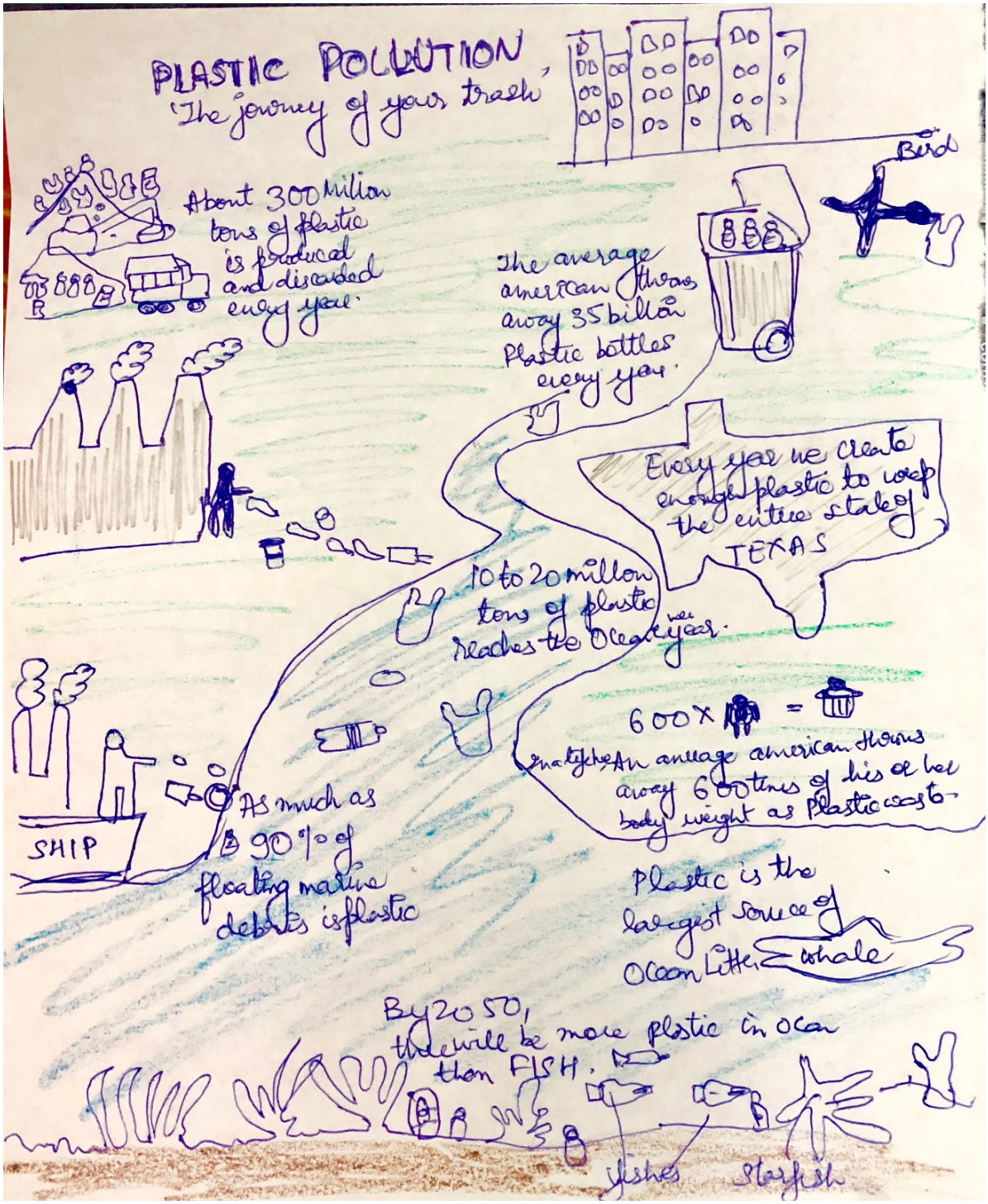
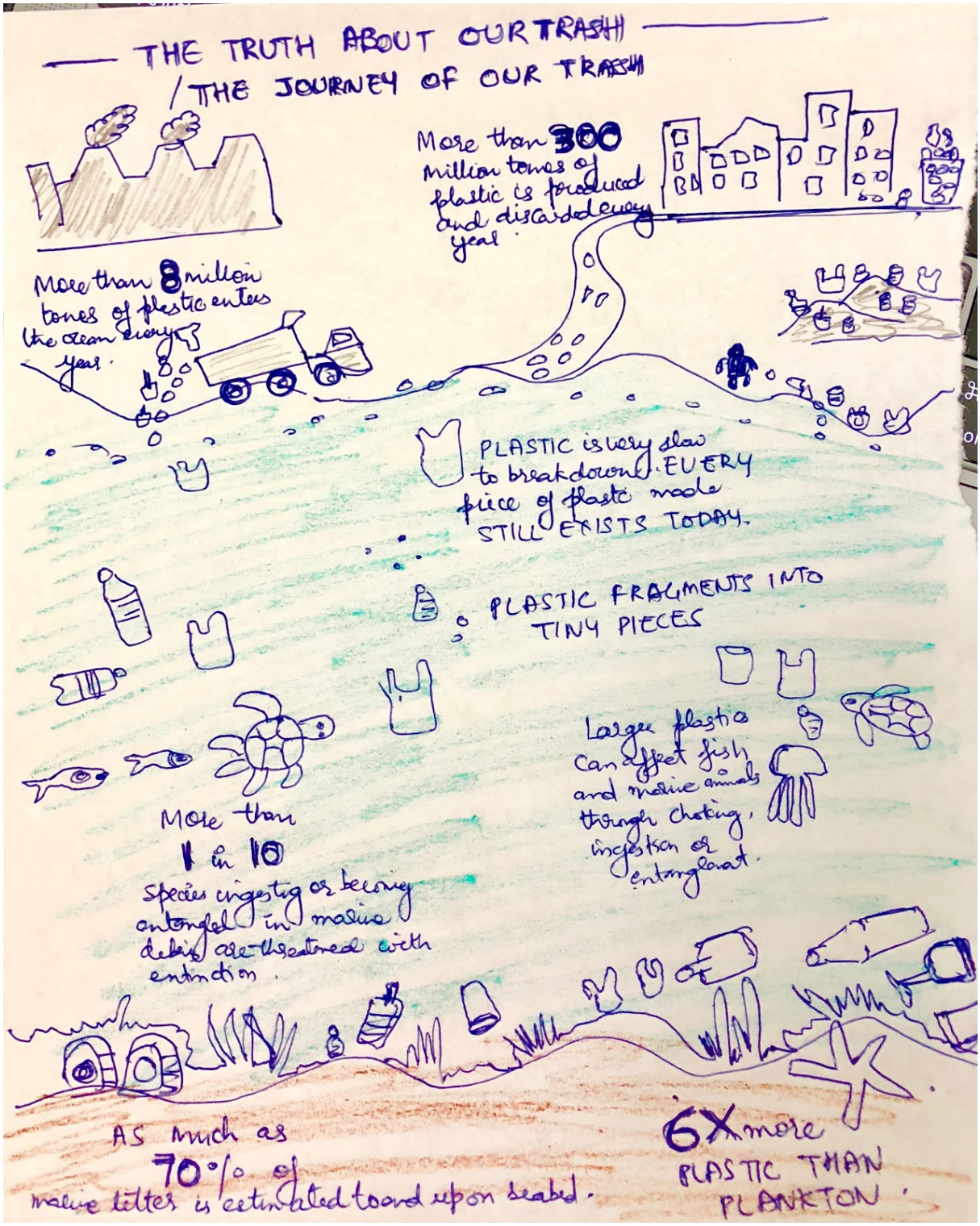
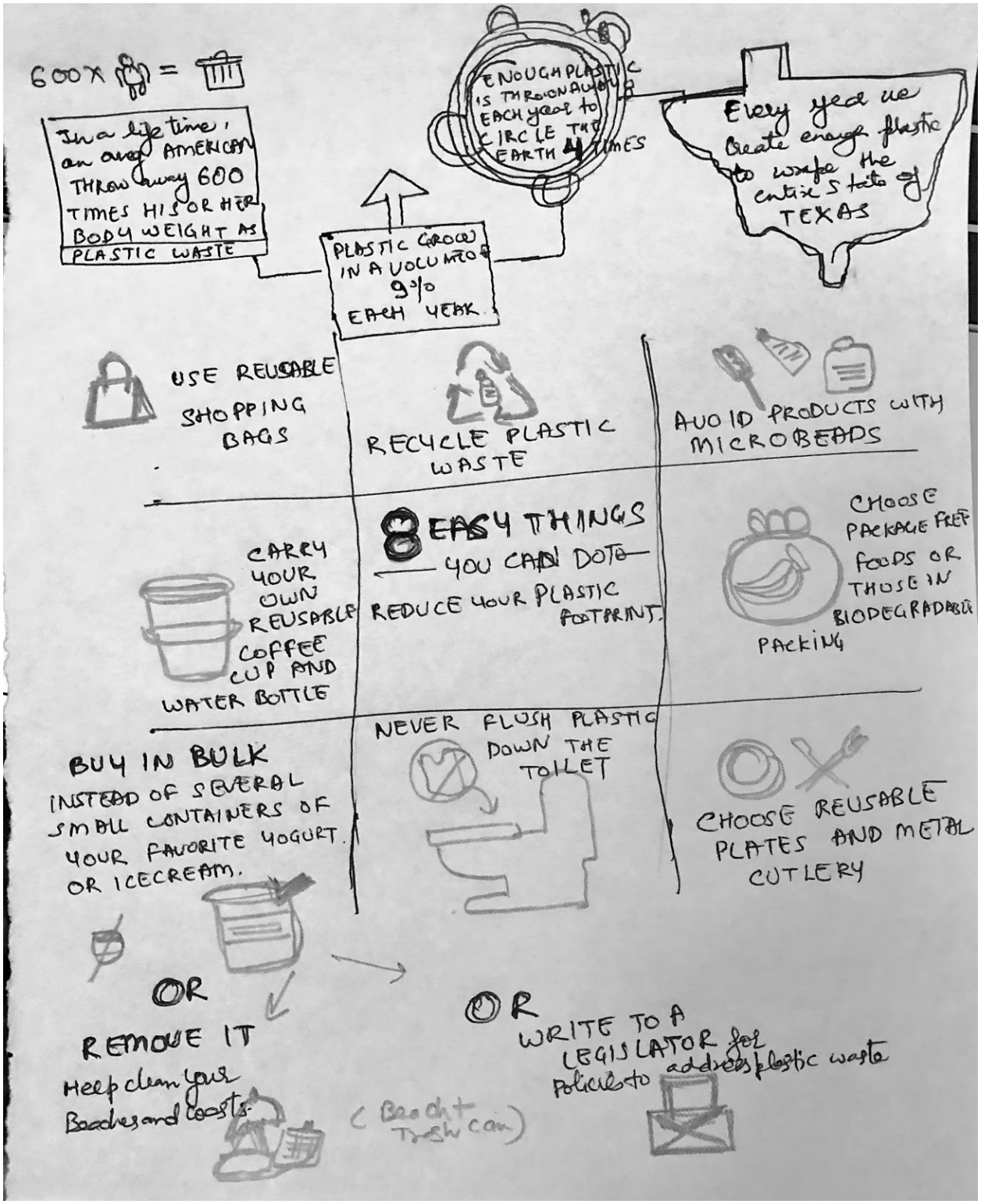
Appendix A - Prototypes of Visualization




THE TRUTH ABOUT OUR TRASH
/THE JOURNEY OF OUR TRASH
More than 300 million tones of plastic is produced and discarded every year
More than 8 million tones of plastic enters the ocean every year.
PLASTIC is very slow to breakdown. EVERY piece of plastic made STILL EXISTS TODAY.
PLASTIC FRAGMENTS INTO TINY PIECES
Larger plastics can affect fish and marine animals through choking, ingestion or entanglement.
More than 1 in 10 species ingesting or becoming entangled in marine debris are threatened with extinction.
AS much as 70% of marine litter is estimated toand upon seabed.
6X more PLASTIC THAN PLANKTON.


600X =
In a lifetime, an avg AMERICAN THROW away 600 TIMES HIS OR HER BODY WEIGHT AS PLASTIC WASTE
ENOUGH PLASTIC IS THROWN AWAY EACH year to CIRCLE THE EARTH 4 TIMES
Every year we create enough plastic to wrap the entire state of TEXAS
PLASTIC GROWS IN A VOLUME BY 9% EACH YEAR
USE REUSABLE SHOPPING BAGS
RECYCLE PLASTIC WASTE
AVOID PRODUCTS WITH MICROBEADS
8 EASY THINGS YOU CAN DO TO REDUCE YOUR PLASTIC FOOTPRINT
CARRY YOUR OWN REUSABLE COFFEE CUP AND WATER BOTTLE
CHOOSE PACKAGE FREE FOODS OR THOSE IN BIODEGRADABLE PACKING
BUY IN BULK
INSTEAD OF SEVERAL SMALL CONTAINERS OF YOUR FAVORITE YOGURT OR ICECREAM.
NEVER FLUSH PLASTIC DOWN THE TOILET
CHOOSE REUSABLE PLATES AND METAL CUTLERY
OR
REMOVE IT
Help clean your Beaches and coasts.
(Recycle Trash can)
OR
WRITE TO A LEGISLATOR for Policies to address plastic waste

Appendix B - Prototypes of Website