Photographs: Aimee Cleary

Citizenship-building via Marine Debris Surveys

Empowering urban teens to become environmental stewards through socio-ecological mapping and data collection

By **Aimee Cleary**

WHEN A FELLOW TEACHER and I took a boat cruise along the coast of Kuwait, we noted the sad state of the Arabian Gulf. Amid the food wrappers, cigarette butts, and plastic bags, we saw dead fish floating on their sides; an indicator that not all was right within the ecosystem below. A walk along the beach treated us to views of food waste, plastic bottles, and even more plastic bags littered across the sandy shoreline. Driving away from the beach, we discussed the need to invigorate the public to address the litter issue, and realized that as educators of locals, we had a role to play.

A country's most valuable asset is its youth. When passionate about local concerns, they can provide the impetus for positive change and become environmental stewards. Unfortunately, like many schools, our curriculum uses a global approach to environmental education. We teach about global warming, rising sea levels, and disappearing rainforests, but the learning is rarely applied to the socio-ecological issues in our own backyards. We decided to address the local issue of marine debris with our grades 9-12 Sustainability Club students. The resultant project was a collaboration between our club and a local conservation group. The following outlines the steps we took in using socio-ecological mapping as a tool for student engagement, and how it can be used by anyone wanting to study marine debris.

Assessing Prior Knowledge

Asking students a variety of questions about a topic, and giving them the chance to explain their thinking, allows educators to gauge the level of their students' comprehension. By doing this before starting a project, teachers can gain insight into students' prior knowledge and misconceptions, thus they can devise strategies for authentic engagement.[1] A range of prompts can be used to initiate this style of questioning, such as storytelling, small group discussions of personal experiences, or related visual imagery such as photographs. To introduce the issue of marine debris in the community, we presented students with photos taken of local beach debris. They were then asked about the types of garbage in the photos and whether they noticed any patterns in the locations of the debris. This type of questioning not only serves to inform the teacher, but also engages students in deep conversations about the subject matter and peaks their interest in learning more.

Upon completing the initial questioning phase introduce the idea of conducting a research project on the marine debris in your area, with the goal of contributing to a solution for the community. Introducing a project of this scale to students can intimidate those who have a difficult time seeing themselves capable of leadership.[2] Address the issue of their skills head on. Give them credit for being experts on their communities and explain that they will learn all the scientific skills needed for their research.[3] Together, begin to build a plan for how the problem can be "attacked." Creating a solution to a problem requires knowing the cause, this is where students' expertise as community members enters the picture. We asked our students for their thoughts on what was generating beach debris in this area. Their list of possible causes included the common practice of families picnicking on the beach, a negative public attitude towards the role of individuals in supporting the community, lack of awareness on how litter affects the local ecosystem, and a lack of transparency and enforcement of littering laws.

Increasing Student Ownership

Understanding possible causes of an issue is only the first step in the process. The next step requires using that information to decide on a course of action. Many teens feel powerless to solve sustainability problems. A good place to begin the empowerment process is to obtain pertinent information on an issue via internet searches, interviews with local experts, email requests to universities, newspaper articles, etc. The more student-driven the research, the better chance of student buy-in.

Our students suggested that we contact a local conservation group to understand how the issue of marine debris was being handled at that time. We learned from them that there had been discussions about beach litter amongst local groups, but no studies had yet been conducted to pinpoint causes.[4] The discussion revealed that the accumulation of so much beach debris might be attributed to inadequate trash collection policies. Students had noticed that beaches tended to have trash bins close to parking lots, which were emptied at irregular intervals, but none were on the actual beach. This observation was echoed by our partner group.[5]

Finding out this background information, while making tangible community connections, made a noticeable difference in students' attitudes towards our work. Using community connections and gaining more insight into what other community members see can be a great way to add further context to the general issue you wish to explore. Finding out what others are interested in understanding, and what the community needs, can help the group decide on a specific question to investigate. Our conversation regarding trash collection policies inspired our specific inquiry topic; to pinpoint or eliminate trash bin placement as a factor for litter on beaches. It was at this point, we introduced students to the data collection method of socio-ecological mapping.

Socio-Ecological Mapping

Mapping is a great method for spatially exploring a socio-ecological issue. It allows students to visually explore data they have collected, and to look for patterns and possible keys to the problem at hand. Mapping works well for these types of projects because it can foster problem-solving skills and provide an interdisciplinary immersion into a community issue, beach debris in our case. The process of creating a socio-ecological map involves overlaying collected data on a map of the area being studied.[6] Many different tools can be used to construct the map both manually and digitally. Data points can be drawn onto paper maps, coordinates of locations of interest may be marked via symbols, or photos of actual sites and/or concerns such as marine debris may be superimposed onto a map. For our map, we planned to capture a Google Maps image of our test area, and use Adobe Photoshop to place trash bin and debris information in the appropriate locations.

Whatever the tools used, the ultimate goal is to observe any patterns in collected data to see if there are correlations between a social issue, such as trash collection, and an ecological issue, such as marine debris. Through the visual display of data, students more easily make connections and draw conclusions about possible cause and effect relationships between their studied social and ecological problems.[7] The visual nature of mapping projects means they can be conducted with groups of any size or age, and for any subject of interest.

Using mapping as an inquiry tool also enables interdisciplinary study within an environmental framework. Core curricula outside of Science which may be addressed include:

- Geography and math (students map to scale, measure distances, calculate volumes and areas, and older students can perform statistics on the data such as linear regressions between the amount of trash in a transect and the distance between the transect and trash bins)
- Language and Communication (students interview community members, work in groups to gather and represent data, and communicate results to other community members)

Figure 1: Original map plan created by student researchers and teachers through a brainstorming exercise.

- Technology (students use computers to create maps and research the social and ecological issues being studied)
- Social studies (students may explore the community's history, land use, demographics and resources)

Regardless of the issue you choose to explore, background research on similar issues elsewhere in the world can provide examples of mapping being used successfully with it. Our students examined marine debris research from Chile, which also featured students as field surveyors tackling a similar problem.[8]

In our study, students worked with two teacher-supervisors to collect data on the concentration of debris in different areas of a local beach. A random sampling method of plastic collection from quadrats within transects was decided as the best way to map any possible patterns in debris concentration along the beach. As the goal was to determine what factors were causing beach-goers to leave debris behind, a beach was chosen where the litter would most likely be the result of recreational visitors rather than being deposited along the shore by currents. A brainstorming exercise enabled the group to plan how transects and quadrats would be plotted on site, and how data would be recorded (Figure 1). During the brainstorm, students were given "situations" similar to those that we were focusing on, and asked to figure out how to best collect useable but accurate data. They were then presented with descriptions of potential data collection procedures, and in small groups discussed which ones might work in our situation and how. As students presented their ideas we wrote them down, then looked for similarities in plans, and the teacher noted possible biases or gaps in data. This same brainstorming process can be replicated for any mapping inquiry topic. It allows students to maintain ownership over project design, while simultaneously allowing the teacher/facilitator to present plausible research techniques and fill in knowledge gaps.

Students as Field Researchers

Students need exemplars for sampling methods as well as a lot of practice with them in advance of actual data collection. Prior to your sampling day, hold meetings with students to review the project's goals and possible applications of their research. If mapping marine debris, have students practice finding the mass of debris using hanging balances, using quadrat rope to mark a sampling area, using field-distance measuring tools to mark transects, and how to report and record their mass data after sampling a quadrat. It is important to the success of the project that students feel as confident as possible in their sampling techniques *before* heading out into the field.

Once on site, the focus of supervisors will shift to keeping students organized, occupied and focused. While students will need reinforcement with their skills, allowing them to lead the inquiry and sampling is important for their investment in the project. Ideally supervisors should act as facilitators rather than data collectors.

Sampling occurs in three stages: (i) surveying and marking of the sample area, (ii) creating the quadrats, and (iii) collecting and massing of plastics debris. In our study, after a quick review on using field equipment, one group of students measured the width of the sample area, while another group measured the length. The width of the concrete walking path within the sample area was determined, as this portion was separated from the rest of the beach by a cement barrier and a 1.5-meter (5 feet) difference in height from the sand portion of the beach. All garbage cans for the beach were located on the path along the cement wall, spanning the entire beach, approximately 10 meters apart from each other. Setting the path as transect A, the 6.5-meter width was used for the entire sample area keeping all transects equal in width. From the path, eight transects were marked along the beach to the high tide water line.

In stage two, a quadrate outline of 3.5-meters by 3.5-meters was created using rope to mark areas for sampling. Within each transect, three quadrats were randomly selected by throwing a small ball. At the edge of the sampling area or current quadrat, a ball was thrown with full force by a student along the length of each transect. Wherever the ball landed became a left corner of the quadrat, then the quadratmeter, (the pre-measured rope used to lay out the quadrat) was used to mark the quadrat into the sand so students could clearly see their sampling area. This was repeated three times in each transect for the creation of 24 quadrats, and recorded (Figure 2).

During stage three, student groups were assigned quadrats where they collected all forms of plastics. Before determining that a quadrat was fully sampled, students called a

Figure 2: The in-field map used for data collection. The top of the map represents the cement pathway and at the bottom is the high tide mark, just before the water. Two students weigh the trash found in one plot.

supervisor over to inspect the area and discuss whether any remaining items needed to be collected. Once their quadrat was clear of plastics students used a spring scale to determine the mass of plastics in grams. These weights were recorded in the field map.

To contribute positively to the community while conducting a marine debris study, after all quadrats are sampled for plastics debris have students do a complete cleanup of any remaining debris along the sampling area. A group debriefing will allow students to note the work that was completed and what trends emerge. Discuss ideas for further studies and changes they would make the next time sampling needs to be done. As a group share the results and examine with students and teachers the observed trends and what they could possibly indicate.

After all data is collected, it's time to construct the final map. To replicate our map style, find an aerial view of the beach (or area you are studying) from Google Earth, and use this as a base for your map. Over this image, use Adobe Photoshop to draw each transect onto the correct location within the sample area. Then calculate the average mass of plastics found within each transect using the masses found in each of its three quadrats, and place this number in a key on the map. Continue improving the map by placing other significant factors, such as trash cans, using symbols and you will have a sleek, visual representation of all your research.

Interpreting Mapping Data

Once the data has been collected, the real problem solving and action begins. In our case the results of this beach mapping study indicate there could be a relationship between the amount of trash found and the location of available trash bins. Students pointed out during their debriefing discussion, that the transects with the greatest average masses of plastics debris, were the farthest away from the trash bins. Alternatively, the area with the lowest average mass of plastics was the transect which included all the trash bins. The excitement in the group of students upon their discovery of these patterns was clear, and the longer the conversation went on, the more momentum they seemed to build. They identified possible reasons for breaks in the general pattern of low to high plastics masses from the cement pathway to the water such as onshore breezes moving trash from its original location.

Creating Active Citizens

After the completion of the beach mapping project, students were eager to participate in further studies, expressing both a desire to learn new sampling methods and enact change within their country regarding marine debris. This positive response gives hope that the younger generation is aware of issues their communities face, and they are prepared to work towards solving these problems. Through the creation of our plastic debris map, my students were able to draw connections between beach debris problems in Kuwait and potential steps towards alleviating the problem. The possible correlation between the amounts of debris mass increasing in locations further from trash bins indicates the need for further research into trash bin locations. Students suggested in their follow-up discussion with our partner group that placing some garbage bins in different areas of the beach and closer to the water could help save ocean life, as perhaps people may be less inclined to leave debris behind in the sand.

Positive momentum within the students continued as they began to see the problem as solvable. They suggested the next step would be to communicate with local ministries in an attempt to increase the presence of garbage bins on public beaches. Another idea presented by students was to engage other local youths and increase awareness of the issue by having school groups create trash bins that are works of art. The concept being that aesthetically pleasing bins backed by the community will be more likely to be placed on local beaches and start positive conversations. A bin creation contest between local schools may garner even further support. This trash bin campaign could also benefit from a coinciding public awareness campaign, including radio and television spots highlighting some of the environmental effects that marine debris, especially plastics, have on local wildlife to help locals make connections between their actions and the health of their country.[9] Students finished this project hopeful their work would lead to a cleaner Kuwait, with its young citizens at the core of the movement.

Effects of Socio-Ecological Mapping

The mapping experience proves to be a valuable and tangible method of having students engage in inquiry out in the community.[10] As demonstrated in our study, students learn new techniques, feel like they are participating in "real" research, and are motivated by a feeling of being able to authentically help their community. Most students conclude this project believing they are valuable members of the community who can help solve local issues. Active members of the community are being formed!

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