A Benthic Macroinvertebrate Survey of Little Hell Gate Salt Marsh

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Purpose

Located in between New York's East and Harlem Rivers (figure 1), Randall's Island provides an example of ecological restoration and management in an urban area. The recently-restored Little Hell Gate Salt Marsh sits on the western shore of the island enclosed by the Harlem River. Its urban location presents a fascinating case study of a recovering ecosystem that faces the issues associated with an urban environment. As is the case with Little Hell Gate Salt Marsh, destruction of even a portion of a natural area due to urban development leads to shifts in natural processes as well as disappearances of native species, creating the challenge of reestablishing species diversity (Ingram 2008). With a damaged habitat, it is difficult for native species to recolonize the marsh.

Randall's Island is particularly susceptible to a number of threats stemming from its position within the New York Harbor system, one of the most active vessel routes in the world. Because New York Harbor receives heavy international shipping traffic, the area is prone to invasive species that often travel in the ballast water of large vessels. Oil from these vessels may also pollute the harbor. Furthermore, New York's outdated sewage treatment system often pollutes its waterways after heavy rainfalls that lead to a combined sewage overflow. High fecal coliform levels due to this faulty system can be dangerous for a number of species. Managing the marsh restoration, or any natural area located in an urban environment, therefore presents ongoing challenges.

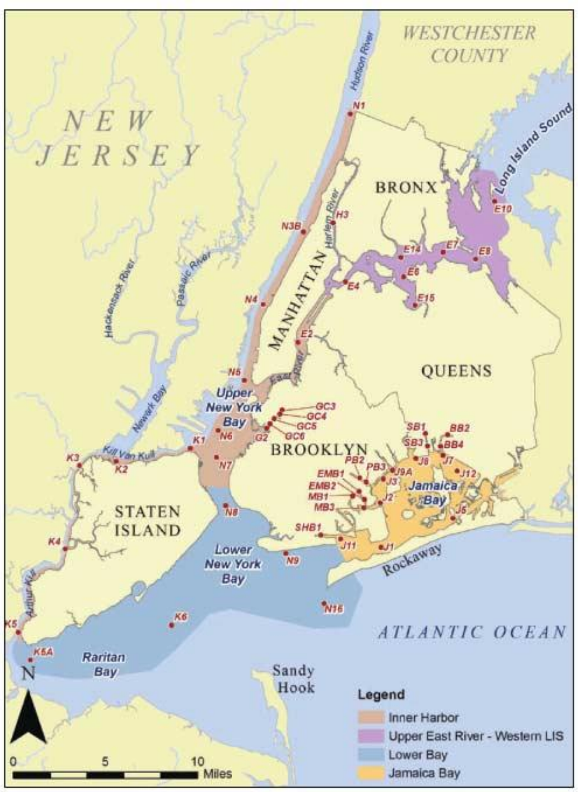

Figure 1. Map of New York Harbor. Randall's Island is located east of Manhattan, west of Queens, and south of the Bronx (image: New York City Department of Environmental Protection).

Looking at the diversity (and abundance of certain indicator species) of the benthic invertebrate community in Little Hell Gate Salt Marsh will aid in providing information regarding the extent of the marsh community's health. By examining the species present, as well as their abundances, we can create a baseline upon which to compare in the future. As this study progresses, we hope to gain a greater understanding of how the species present influence the marsh's overall health. Identifying any invasive species in the area will also prove important as we work to protect the recently-restored salt marsh.

The overall makeup of the salt marsh community can assist in determining the area's health; however, the presence or absence of species performing necessary functions within the ecosystem is particularly beneficial in understanding the status of the marsh. It is imperative to consider the ecosystem functions performed by the observed organisms. Thus, we are ultimately looking to see how many of the necessary ecosystem functions are performed by the present species to better analyze the progress of maintaining the salt marsh restoration. In Short et al.'s 2000 study of success criteria in salt marshes, a wide range of ecosystem functions important to both a salt marsh and human society are listed as indicators of marsh health after restoration. Of these listed functions, five are relevant to the benthic invertebrate community. As shown in table 1, these functions are primary production, sediment filtration and trapping, epibenthic and benthic production, nutrient and contaminant filtration, and nutrient regeneration and recycling. With most of New York Harbor's shoreline made up of hardened, vertical seawalls, Little Hell Gate Salt Marsh remains one of the few natural areas. As such, it is important to focus on preserving this ecosystem and, in turn, maintain the myriad services it provides.

Function	Value
Primary production	Support of food webs, fisheries, and wildlife
Sediment filtration and trapping	Counter sea level rise, improve water quality, and support of fisheries
Epibenthic and benthic production	Support of food webs, fisheries, and wildlife
Nutrient and contaminant filtration	Improve water quality and support of fisheries
Nutrient regeneration and recycling	Support of primary production and fisheries

Table 1. Five of the ecosystem functions and their value to the both salt marsh and human society as indicated in Short et al.'s 2000 study. These selected functions were chosen because of their relevance to benthic invertebrate species.

While it is, of course, important to record all organisms observed, the species we are looking for, in particular, are: barnacles, blue mussels, ribbed mussels, slipper shells, sea squirts, grass shrimp, mud crabs, blue crabs, oyster drills, clam/sand worms, mud tube worms, polychaetes, sponges, bryozoans, flat worms, anemones, and amphipods. These are the native species we hope to find in the area, but we may also observe some invasive species in the marsh. The Asian shore crab and European green crab are two invasive crabs that we are looking to identify during this monitoring process in order to assess the extent of a potential problem that they may present in the salt marsh ecosystem. Because of their establishment in the nearby Long Island Sound in addition to previous sightings on Randall's Island, we must consider these invasive crabs in the survey to understand the extent of their presence in the area and, in turn, the threat they may pose to Little Hell Gate Salt Marsh.

Materials

1. Four 42" x 42" drop nets
2. One collection basin
3. One measuring wheel
4. One plankton net
5. One 1 meter quadrat
6. One standard 1L Nalgene water bottle for sediment collection
7. Three sieve towers (#60, #10, and #5)
8. One spray bottle
9. Necessary field guides and/or camera to identify species
10. Chest waders
11. Data sheets printed onto rain-on paper and a pencil for recording

Procedure

Four sites are surveyed at the Little Hell Gate Salt Marsh area (figure 2). Along the westernmost shore facing the Harlem River, three spots are surveyed. Each of the three surveying locations in this area are equidistantly spaced out to avoid overlap. The first site is 102 south of the northernmost point of the coastal area. All sites are 102 feet apart walking along the coast. One additional site is surveyed within the inner mud-flat area of the marsh, located just behind Little Hell Gate Bridge.

At each survey site, three methods are utilized to collect data. First, a 42" x 42" drop net is laid down at the site during low or medium-low tide. To ensure that the net does not stand out too much as a foreign object, some sediment is laid atop it to "camouflage" the net. Additionally, a few sizeable rocks are placed on the edges of the net to keep it in place. The net sits overnight so that organisms may have time to colonize it. To avoid bias, the drop nets are tossed within the general vicinity of the site. The following day, the nets are picked up at low tide to observe what organisms are present. The contents of the drop net are placed into a collection basin and then a visual inspection is performed. All observations are recorded.

After picking up the drop net, three passes with the plankton net are performed in order to collect any present free floating organisms. After each pass, the contents of the net are placed in the collection basin and carefully checked for any organisms. Then, all observations are recorded. If necessary, samples are stored in a vessel for future identification under a microscope.

Similar to the manner in which the drop nets were placed, a one meter quadrat is dropped at random in the site area. The sediment is collected at one of the four corners of the quadrat using a standard 1L Nalgene bottle. Three sieve towers are stacked in order from top to bottom (#60, #10, and #5) and then the acquired sediment is dumped from the bottle into the first sieve for inspection. A spray bottle is utilized to break up the mud while combing through the sample (do the same for the other sieves). What is seen at each level is recorded, including below #5.

These steps are repeated for each site. It is important to note that drop nets are set at each site the day before surveying.

Although there are a number of species that we are looking for, in particular, any observed organisms are additionally recorded. The European green crab is of particular interest due to its status as an invasive species in the area. Because any present organism maintains the possibility of providing information regarding the health of the salt marsh, nothing observed is overlooked. For this reason, it is important to bring necessary field guides and/or a camera during the surveys. From such careful observations, data is analyzed to gain more information into the community make up and health of the recently restored Little Hell Gate Salt Marsh.

Figure 2. The four benthic macroinvertebrate survey sites located in Little Hell Gate Salt Marsh.

Results

The drop net recovered from site one yielded four different species; three grass shrimp (*Palaemonetes vulgaris*), two blue crabs (*Callinectes sapidus*), one polychaete, and forty one mud snails (*Tritia obsoleta*). The sediment sample from this site contained one polychaete and six *T. obsoleta* (table 2).

The second site's drop net also contained four species; one *C. sapidus*, one mummichog (*Fundulus heteroclitus*), twelve *T. obsoleta*, and one European green crab (*Carcinus maenas*). Four *T. obsoleta* were found in the sediment sample at site two (table 2).

Site three's drop net yielded four different species; twenty three *T. obsoleta*, two soft-shell clams (*Mya arenaria*), one annelid, and one mud/clam worm (*Alitta succinea*). In this site's sediment sample, there were five *T. obsoleta* (table 2).

The final sample site, site four, yielded two species in the drop net; one *C. sapidus* and forty seven *T. obsoleta*. Site four's sediment sample contained one polychaete and three *M. arenaria* (table 2).

The plankton tows performed at sites 1, 2, and 3 did not yield any plankton, however two zooplankton were collected from the tow at site 4 (table 2).

Species	Abundance at site 1	Abundance at site 2	Abundance at site 3	Abundance at site 4	Total abundance
Palaemonetes vulgaris	3				**3**
Callinectes sapidus	2	1		1	**4**
Polychaete	2			1	**3**
Tritia obsoleta	47	16	28	47	**138**
Carcinus maenas		1			**1**
Mya arenaria			2	3	**5**
Annelid			1		**1**
Alitta succinea			1		**1**
Fundulus heteroclitus		1			**1**
Zooplankton				2	**2**
Total					**159**

Table 2. The abundance of each species observed in the benthic macroinvertebrate survey. Each site is included along with the total abundance.

Discussion/Conclusion

As one might expect, the Little Hell Gate Salt Marsh habitat prefers pollution tolerant species. *P. vulgaris* certainly falls into this category, yet its presence is still crucial for the health of salt marsh habitats. This marsh shrimp serves both as a food source for larger invertebrates as well as a decomposer, breaking down detritus in the water column to then be consumed by similar invertebrate species (Massie 1998). Therefore, *P. vulgaris* fulfills multiple ecosystem functions noted as success criteria by Short et al.; sediment filtration and trapping, epibenthic and benthic production, and nutrient regeneration and recycling (table 3). It is a positive sign to observe three *P. vulgaris* in site one when considering the site's rocky nature (especially in comparison to site four's more grassy habitat). Future monitoring should note their presence or absence in the salt marsh as an important indicator.

C. sapidus is a top predator of the benthic invertebrate community in salt marshes, rendering them a crucial species for the food web. In fact, in the Chesapeake Bay, *C. sapidus* is considered a keystone species (National Oceanic and Atmospheric Administration). In terms of Short et al.'s success criteria, *C. sapidus* performs the function of epibenthic and benthic production, ultimately supporting the overall food web (table 3). As such, it is a positive sign to have found them in three of the four monitoring sites. *C. sapidus* is a fairly environmentally tolerant species, particularly to varying salinities and low dissolved oxygen levels (Virginia Institute of Marine Science 2015). Their presence is, thus, not surprising, but it is still important that we continue to see *C. sapidus* in our monitoring.

While only two were found in the survey, the polychaetes' presence in the salt marsh ecosystem is a good sign, as they serve as food for other benthic invertebrates while also feeding on mud and algae (Jumars et al. 2015). In this way, polychaetes help maintain the salt marsh ecosystem. They perform the functions of sediment filtration and trapping as well as epibenthic and benthic production (table 3). As mud-feeders, their presence is to be expected, yet their importance is not overlooked.

The most common species discovered in this survey was *T. obsoleta*. Such is to be expected, as *T. obsoleta* is capable of tolerating even the most degraded habitats and are willing to consume most anything they can. Thus, the plethora of *T. obsoleta* seen in this survey is not surprising. *T. obsoleta* serves mostly as food to other species, contributing to epibenthic and benthic production (table 3). Although not an invertebrate, one *F. heteroclitus* was observed in the survey. *F. heteroclitus* is another example of a pollution tolerant species and, therefore, one that we would expect to see in Little Hell Gate Salt Marsh.

The one *C. maenas* observed at site two was a more concerning discovery. Considered one of the greatest invasive threats along the Atlantic coast, *C. maenas* was first introduced to North America at the end of the twentieth century in New York Harbor. For the most part, this species has migrated north to the Gulf of Maine, but it has still managed to remain prominent in Long Island Sound. While only one individual was observed in the survey, *C. maenas*' presence raises concern for the future. Additionally, *C. maenas* has been found in great numbers on other parts of Randall's Island. *C. maenas* is a highly tolerant species capable of consuming most anything. It is known to often outcompete native crabs for food, rendering the invasive crab a threat to the native *C. sapidus* that inhabits the marsh. It is, therefore, not surprising to find *C. maenas* in Little Hell Gate Salt Marsh. Since its arrival over one hundred years ago in the ballast of shipping vessels, the species has increased in size, especially in areas where it receives little competition. While *C. maenas* feeds on almost anything, it will frequently consume shellfish, such as *M. arenaria*, mussels, and oysters. *C. maenas*' presence in the marsh jeopardizes the area's health, posing the most significant threat to the oysters involved in the Billion Oyster Project (an oyster restoration project in New York Harbor). With all the progress made since the marsh's restoration, it has now become important to maintain this success by managing such an aggressive invasive species. As monitoring continues in the future, it is imperative that we pay specific attention to *C. maenas*' level of abundance in the salt marsh.

It was somewhat unexpected to see *M. arenaria*, as many previously seen in informal observations in the marsh were not alive. Like other bivalves, *M. arenaria* is a filter feeder that takes in water, filters it out, and then releases it back into the water (University of Massachusetts Boston). *M. arenaria* serve the crucial function of nutrient and contaminant filtration (table 3), aiding in reducing pollution in their habitat. As a food source for organisms such as crab species, *M. arenaria* also contributes to epibenthic and benthic production (table 3). Playing such an imperative role renders them a beneficial species to Little Hell Gate Salt Marsh. Because the survey yielded live *M. arenaria*, we see this as a positive sign of the marsh's health since restoration. With *C. maenas* (the species responsible for decimating Maine's massive soft-shell clam industry in recent years) present in the salt marsh, however, *M. arenaria* should be carefully monitored. In the future, it will be informative to look at the abundance of *C. maenas* in comparison to that of *M. arenaria* (as well as other shellfish, such as oysters and mussels) to gain any information into how the invasive species might be impacting the marsh community.

Annelids perform largely similar functions to that of polychaetes, and we can therefore draw the same general conclusions about how their presence in the salt marsh influences the area's health and progress since restoration (table 3). *A. succinea*, also a species of annelid, is consumed by shore birds. The presence of shore birds in a salt marsh serves as a useful indicator of the marsh's health, where more shore birds indicate a healthier marsh. Thus, *A. succinea* can help us better understand the status of the salt marsh through its trophic connections.

As the base of many marine ecosystems, the zooplankton perform the function of epibenthic and benthic production (The MarineBio Conservation Society). Zooplankton often eat detritus, therefore additionally contributing to nutrient regeneration and recycling in the salt marsh (table 3).

Function	Value	Observed species in Little Hell Gate Salt Marsh performing function
Primary production	Support of food webs, fisheries, and wildlife	N/A
Sediment filtration and trapping	Counter sea level rise, improve water quality, and support of fisheries	*P. vulgaris*, polychaete, annelid, *A. succinea*
Epibenthic and benthic production	Support of food webs, fisheries, and wildlife	*P. vulgaris*, *C. sapidus*, polychaete, *T. obsoleta*, *M. arenaria*, annelid, *A. succinea*, zooplankton
Nutrient and contaminant filtration	Improve water quality and support of fisheries	*M. arenaria*
Nutrient regeneration and recycling	Support of primary production and fisheries	*P. vulgaris*, zooplankton

Table 3. Five of the ecosystem functions highlighted in Short et al.'s study and the observed species that perform each function.

Of all the ecosystem functions represented, epibenthic and benthic production was the best-represented, with eight different species performing this function (table 3). The only observed species left out of this categorization are *C. maenas* (because it is invasive) and *F. heteroclitus* (because it is not an invertebrate). As table 4 shows, 157 individuals observed contributed to epibenthic and benthic production. This is to be expected, as all species ultimately contribute to the ecosystem's trophic web in some way.

P. vulgaris, polychaetes, annelids, and *A. succinea* fulfilled the important role of sediment filtration and trapping (table 3). While the eight individuals performing this function (table 4) is much lower than the abundance of the species contributing to epibenthic and benthic production, it is still a positive discovery. As shown in table 1, sediment filtration and trapping benefits the ecosystem in a number of ways, including improvement of water quality. With improved water quality, a more diverse range of species may inhabit the area. Nutrient and contaminant filtration is also imperative for improving water quality (table 1). Only one species observed in the survey, *M. arenaria*, performed this function (table 3). In the future, we hope to find a greater diversity of species contributing to nutrient contaminant filtration, such as other bivalves.

Two species observed in the survey contribute to nutrient regeneration and recycling: *P. vulgaris* and zooplankton (table 3). It is a positive observation to find more than one species performing this function, as it is ultimately imperative for primary production in a salt marsh ecosystem (table 1). Furthermore, multiple individuals of each species were observed (table 2). With a base of five observed individuals contributing to nutrient regeneration and recycling, we hope to observe an abundance of individuals from a variety of species performing this function in future monitoring.

Just one of these relevant functions from Short et al.'s study was not represented in the survey (table 3). Generally, plant species and phytoplankton perform the function of primary production in a salt marsh. Such a role is absolutely imperative for any ecosystem, though it was not expected to observe any macrobenthic invertebrate primary producers in this survey. Phytoplankton could have been observed, however they are often too small to be seen with the naked eye (in other words, they are microbenthic invertebrates).

Function	**Value**	**Number of individuals performing function**
Primary production	Support of food webs, fisheries, and wildlife	0
Sediment filtration and trapping	Counter sea level rise, improve water quality, and support of fisheries	8
Epibenthic and benthic production	Support of food webs, fisheries, and wildlife	157
Nutrient and contaminant filtration	Improve water quality and support of fisheries	**5**
Nutrient regeneration and recycling	Support of primary production and fisheries	**5**

Table 4. The abundance of species performing each of the five ecosystem functions highlighted in Short et al.'s study.

Looking Ahead

Considering the information gathered through this initial study, it is important to continue benthic macroinvertebrate surveying in Little Hell Gate Salt Marsh in the future. It is evident that these species' presence is absolutely imperative to sustaining the recently-restored marsh. As the area faces constant challenges from its urban location, it is crucial to formally observe the progress of maintaining the marsh since its restoration. In fact, such challenges provoke the need for more frequent monitoring in this area than one might perform in a more isolated setting. This study has shown that a number of important ecosystem functions are, indeed, being performed in the salt marsh, yet there is still the potential for the abundance of such important species to climb. Thus, comparing the abundance of these species observed over time can aid us in analyzing the progression of the ecosystem's health. Looking forward, surveys should be performed at least annually to observe how results change from year to year, and ultimately hypothesize what might cause possible changes. One survey at the beginning of the summer (June or July), and one at the end of the summer (September), will also allow us to see differences within the season. This could help us better understand how populations are influenced by the time of the season.

Furthermore, it would be both fascinating and worthwhile to develop a more quantitative measure of health for the salt marsh. Such could be accomplished by creating a point system for the species. For example, a species performing a number of ecosystem functions or an especially valuable function might be assigned a greater score than another species. Ultimately, with the goal to successfully maintain Little Hell Gate Salt Marsh, it will become important, moving forward, to continually develop the methods utilized to understand the ecosystem's health.

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