Benthic foraminifera assemblage responses to sewage outflow in the Hudson River Estuary at Piedmont, NY

Senior Thesis

Presented to the Department of Earth Science and Geography

Vassar College

James Grosjean

May 2022

ABSTRACT

We present assemblage data on the genera of benthic foraminifera living around Piermont Pier in Piermont, NY in the Hudson River as well as their responses to environmental gradients at the site. These assemblages were based on 5 core samples taken from around the pier, which lies perpendicular to the Hudson River Estuary, allowing for variable influence of estuarine tidal systems. Coupled with these cores were measurements taken of water temperature and salinity. Of particular focus to our work was the effect of a sewage outflow pipe on the southern edge of the pier whose discharges enter the water along that side. Along the southern edge of the pier, foraminifera populations are both smaller in magnitude and less biodiverse, with a majority of individuals picked along that side belonging to the agglutinated genus ammobaculites. This contrasts heavily with equivalent samples from the north edge of the pier, whose populations were far larger and more diverse on a genus scale. Future research into the magnitude and extent of contamination and contents from the sewage outflow will shed more light on their influence on the benthic ecosystems of the pier.

1. Introduction

Robust methods to observe and gauge the health of an ecosystem are increasingly important in the face of growing environmental deterioration as a result of a changing climate. As a corollary, methods that are comparatively cheap, easily reproducible, and responsive to change are especially valuable in these aims. In aquatic environments, some clades of microfauna are well-suited to study in this lens given their wide geographic distribution and high abundance in ecosystems.

Foraminifera, a group of unicellular, shell-making protists, are abundant in the waterways of the Earth either as planktic groups, benthic groups, or both dependent on locale. Because of their abundance both in the present and going into deep time, their assemblages and other information like geochemical signatures in their shells provide opportunities to follow evolutions of climate and ecological health by proxy (Chatelet, 2003). Their presence (or absence) and what they record speak to the state of the lives they led in past versions of their environment. While many live in oceanic environments, populations also exist in saline water in estuaries. The brackish potions of the lower Hudson River Estuary are known to support populations of benthic foraminifera species belonging to genera such as Trochammina, Ammobaculites, etc (Weiss et al. 1978).

The Hudson River stretches from the Adirondacks to the ocean in New York Harbor. All along its path it is a major ecological force, collecting the water of vast tributaries on their ways to the ocean. At its southernmost zone, the river flows in both directions due to tidal influence, creating brackish estuarine ecosystems (Strayer 2012). It is within these brackish sections that one finds the benthic foraminiferal population of the Hudson River. Yet, despite the importance of the Hudson River ecosystem and the size of the human populations living on its banks, these foraminiferal populations remain understudied; the largest and most recent study conducted on their broad assemblage patterns was conducted in 1976 (Weiss et al, 1976).

While many other estuarine environments have seen studies conducted on their foraminifera populations, analogous studies have not been recently conducted on the populations of the Hudson River Estuary. Much has changed in the past 50 years with regards to the Hudson River and its ecology as nearby human settlements mediate their relationship to the estuary. According to US census data, the Mid-Hudson valley has grown in population at a faster rate than western and central New York state while New York City has experienced significant growth as well (US Census 2022). Thus, there is a growing need to build upon previous studies and renew attention on these populations and the information they can convey about their environments. In this study, we hope to begin further work into these populations, to bring their level of study closer to that of their peers in other localities (Orabi et al. 2017, Roni et al. 2017, Cearreta et al. 2000).

In this study we investigate the assemblage distributions of these benthic foraminifera in their manifestations around the Piermont Pier in Piermont, NY. This pier represents a broad gradient of environments, including those directly influenced by human activity in the form of a sewage discharge pipe at the base of the pier. This pipe as well as this section of the river tie into the Sparkill Creek watershed which has on its bounds two water treatment plants according to the state of New York's records on water treatment plants (NY State 2022). We have focused in this study especially on evaluating the potential effect of this pipe on the immediate population of foraminifera. One of the environmental factors visible in the foraminiferal record is in their responses to pollution, a factor which weighs heavily on their assemblages (Alve, 1995). Based on previous research, one would expect varied responses based on the influx of different types of pollutants. Should there be an influx of predominantly organic material, one would expect zoned responses in the benthos with an abiotic zone surrounded by a hypertrophic abundant zone. Metallic pollutants in converse would see a sharp decline in both population counts and genus diversity (Alve 1995).

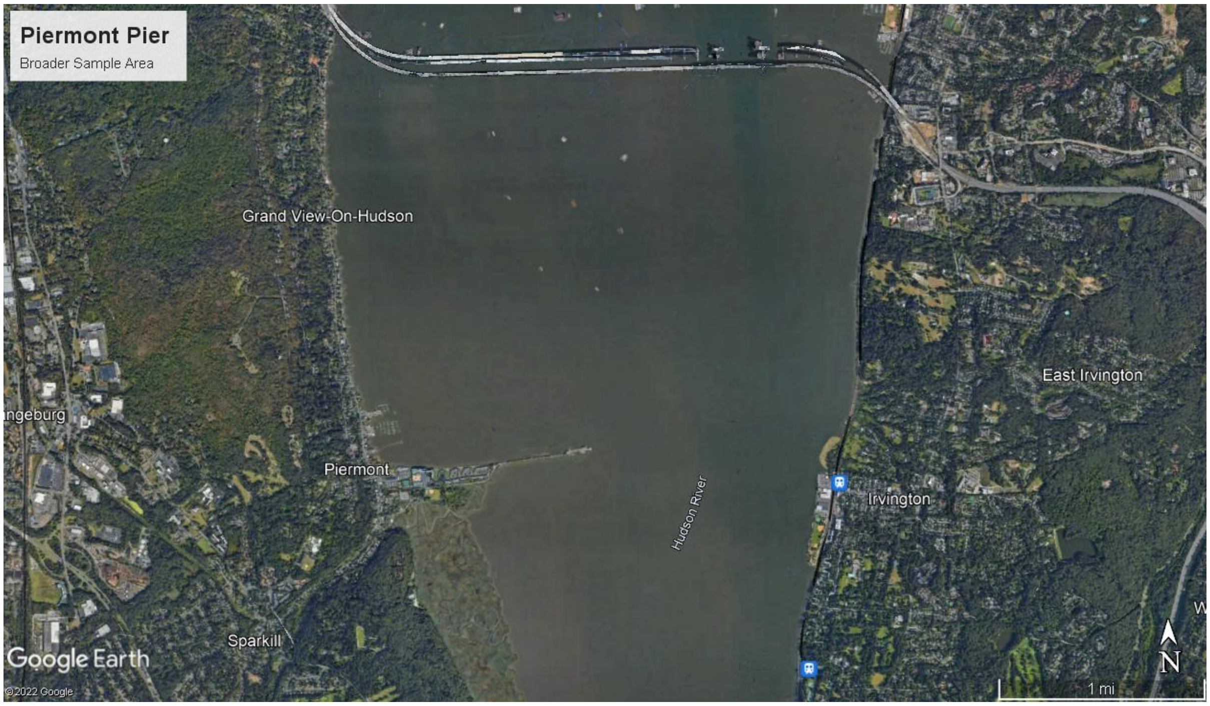


Figure 1: Map of the Piermont Pier and the surrounding area.

We conducted a field sampling campaign to evaluate especially whether or not the influx of sewage contributed to zoned population changes as a result of organic matter influx. Collecting five sediment cores from throughout the pier, we took samples to process and pick for forams in order to analyze each locations distribution of genera and the number of individuals at each location.

2. Methods

Piermont Pier was selected as the sampling site within the brackish section of the Hudson River Estuary due to its ease in accessing a variety of environmental conditions which affect foraminifera populations. 5 coring sites were selected with the rationale of covering a breadth of slight environmental changes in their proximity to the shoreline and a balance of North-facing and South-facing samples, as South-facing samples have a higher salinity overall due to the influence of the Atlantic Ocean. Sampling was conducted on September 26, 2021.

Figure 2: Sample map of Piermont Pier with the location of the sewage outflow marked.

In the field, specific coring sites were selected based on the texture of the sediment. Muddier sections were collected while sandier and gravelly sections were avoided so as to maximize the potential yield of foraminifers in each core. Each coring site's coordinates were collected by GPS and their distances from the pier were taken with a tape measure going from the road on the pier to the coring site. Cores were collected on foot by a push corer. Cores were taken as deeply as was possible in their native sediments. Core PP5 was selected also to be proximal to the sewage outflow in the SW area of the sampling site.

While in the field, each coring site was also accompanied by a salinity and temperature reading which were supplemented by additional readings over a several hour period to account for the tidal cycle observed while in the field.

Once collected, the cores were sectioned off into centimeters which were further divided into two halves (Schönfeld et al, 2012). The first of these halves were placed into plastic jars with a Rose Bengal and ethanol staining solution while the second set of halves were reserved for tests by other labs. The Rose Bengal solution was prepared in advance and brough to the field. The Rose Bengal-stained sections were shaken and left to sit for 2 weeks in order to allow the staining process to complete (Schönfeld et al, 2012). These steps were conducted in the field, operating out of Columbia University's Lamon-Doherty Earth Observatory Hudson River Field Station on the pier.

Back in the lab, the stained samples were washed with deionized water through a sieve tower of sizes 10, 60, and 230 to yield 3 collected size fractions (>2mm, 2-.25mm, and <.63mm) (Schönfeld et al, 2012). These size fractions allow for the potential foraminifers to be cleanly separated into the smallest size fraction for further processing. These washed size fractions were left overnight in a roughly 50° C oven to remove excess water from the washing process. All size fractions from the first 5cm of each core were then labeled and catalogued in individual vials. On remaining the remaining sediment, samples were processed through XRF to obtain elemental signatures of the sediments from each core.

Next, the >.63mm size fractions were run through a splitter and picked for foraminifers. The number of splits was recorded and varied on a sample-by-sample basis based on the concentration in a given sample (Schönfeld et al, 2012). Any foraminifera present were sorted out and counted on a genus level in order to find the character of the assemblages in each.

3. Results

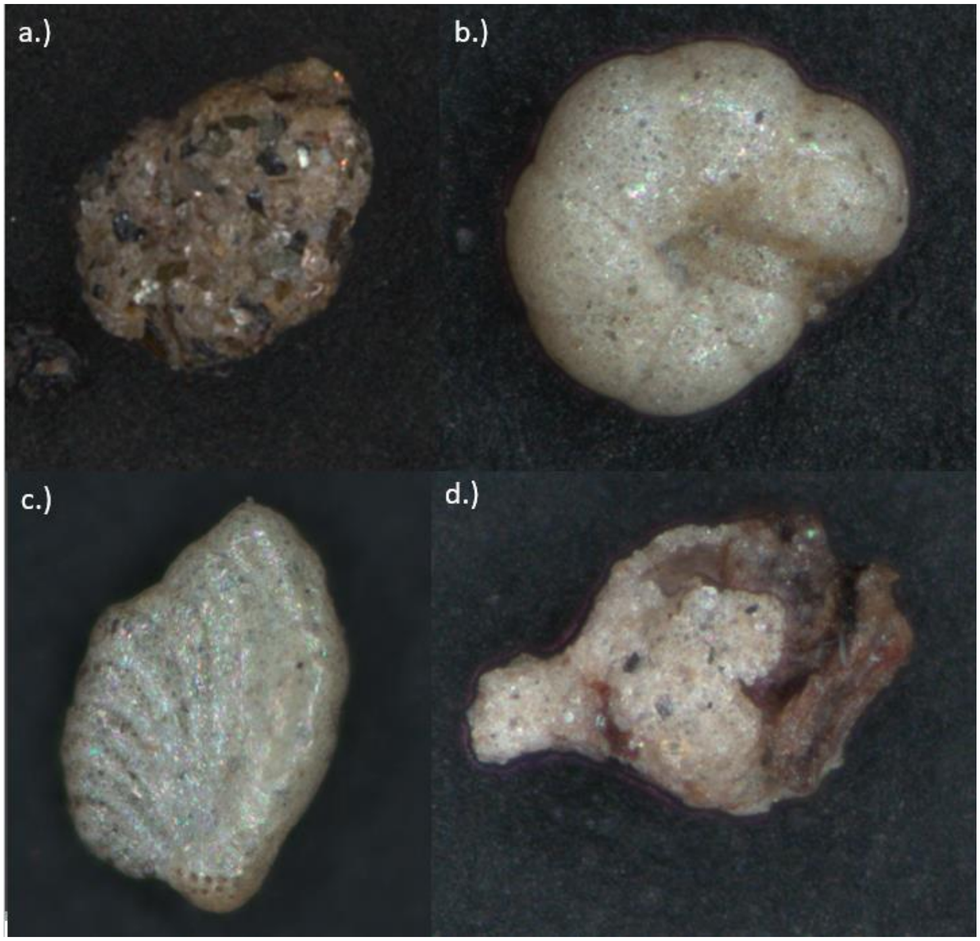
3.1 Conductivity

Probe measurements taken of the water surrounding the pier found that the southern facing side, the seaward direction, had water which was more saline than the northern facing side based on the conductivity.

Figure 3: Conductivity readings per coring site.

3.2 Foraminiferal Genera

Across the cores, six main genera were identified in *trochammina, ammoastuta, ammobaculites, milaminna, arcellacea*, and *haplophragmoides*. Their number and distribution varied by core. Each core was picked, its members counted, and then recorded.


a.)
b.)
c.)
d.)

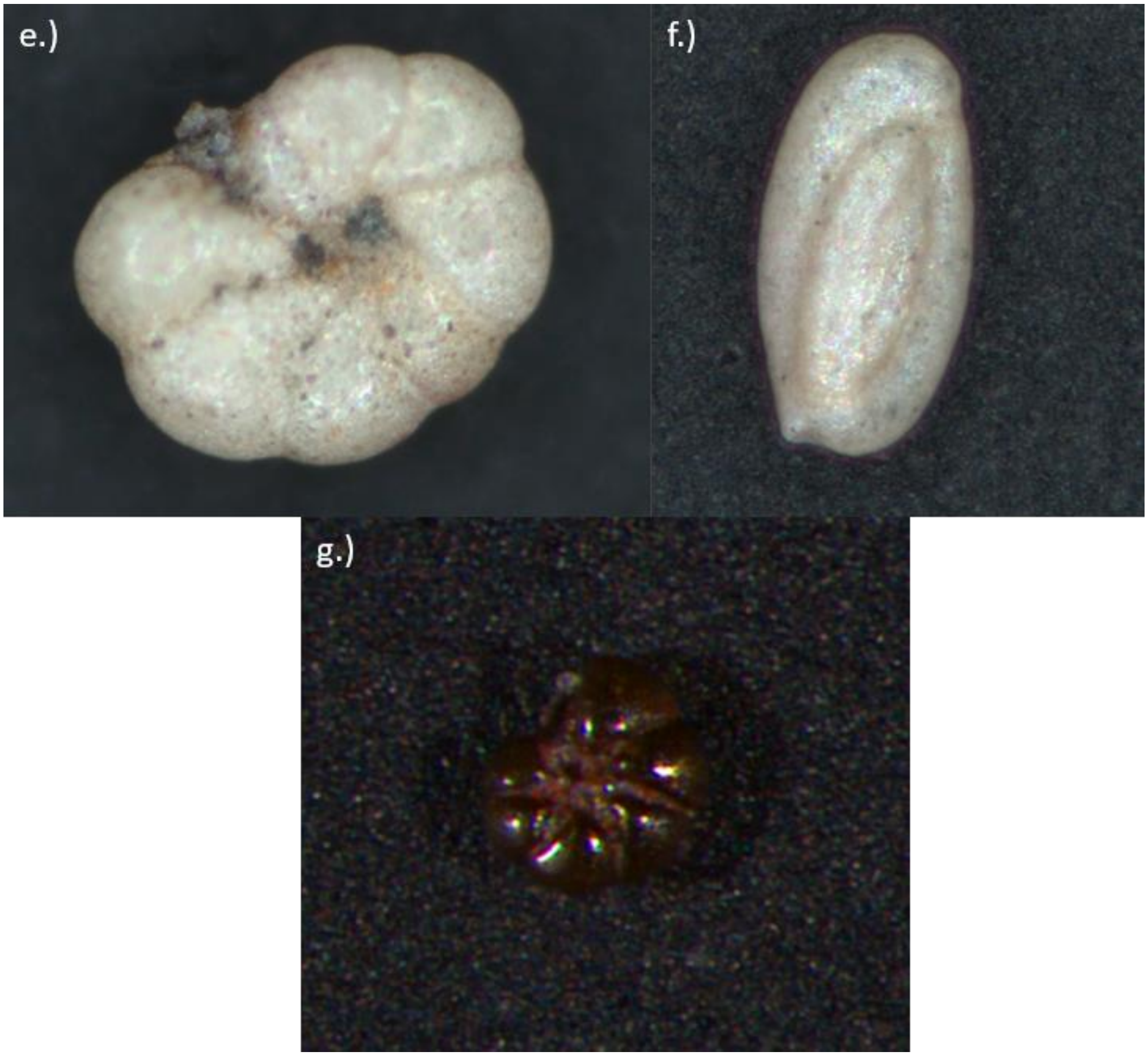


Figure 4: Foraminifera genera found in the Piermont cores. a.) ammobaculites b.) trochammina c.) ammoastuta d.) arcellacea e.) haplophragmoides f.) milaminna g.) organic lining of a foram, lacking its shell.

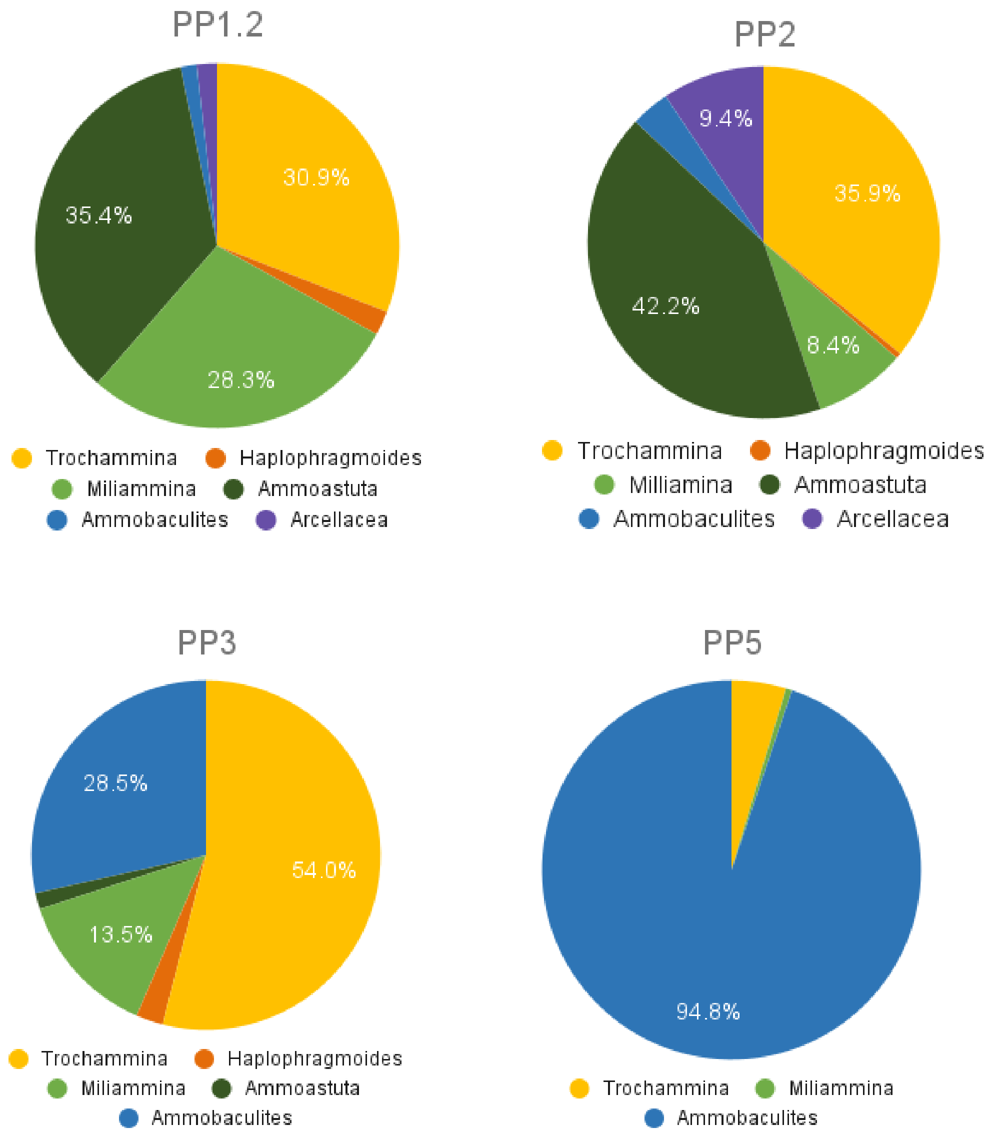


Figure 5: Assemblages by genus for each core in aggregate, combining results downcore into a single holistic result.

In core PP1.2, the dominant genera were *trochammina*, *ammoastuta*, and *milammina*. This was the first of two cores on the northern end of the pier. Picking totals are based on 25% of the total sample.

Figure 6: Genera diversity in each cm of core PP1.2

In core PP2, *ammoastuta* and *trochammina* were the dominant genera of the core's population. This core was the easternmost core of the three collected on the southern side of the pier. This sample differed from the others and was picked for its entire volume per centimeter.

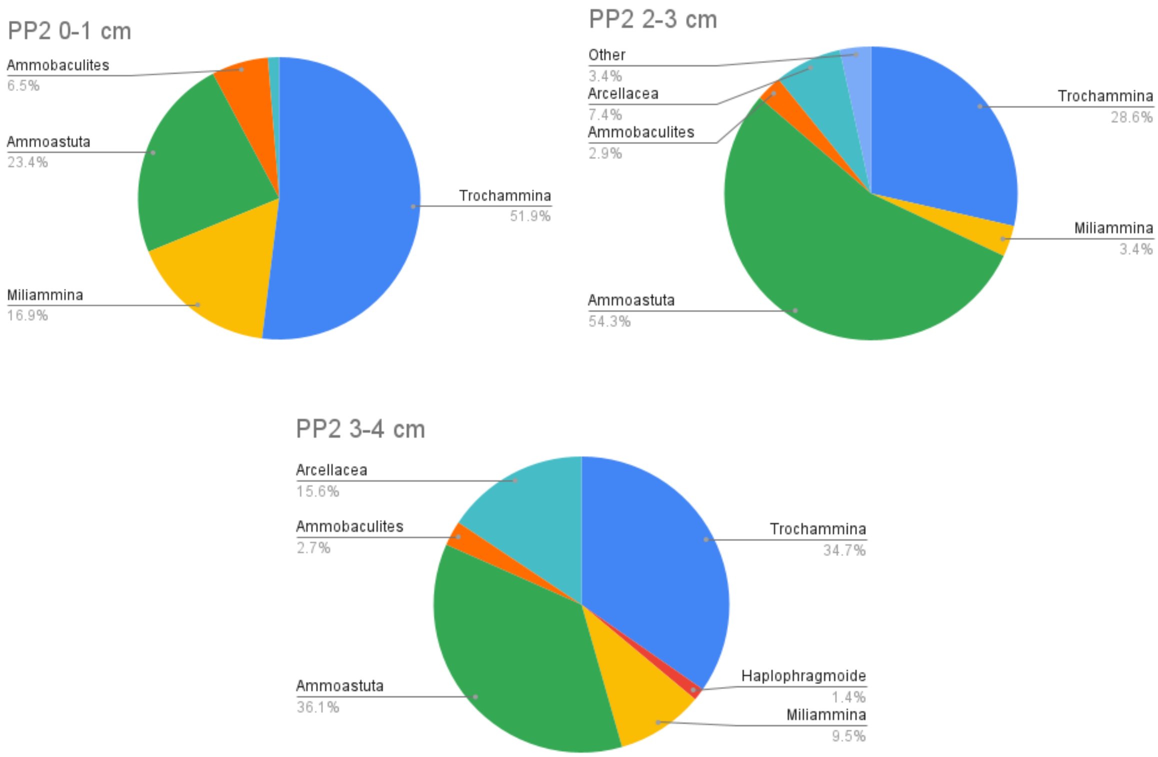


Figure 7: Genera diversity in each cm of core PP2

In core PP3, *ammobaculites*, and *trochammina* were the dominant genera. This was the second of the two north-facing cores, and the one further to the west. This sample was picked based on 25% of total sample size.

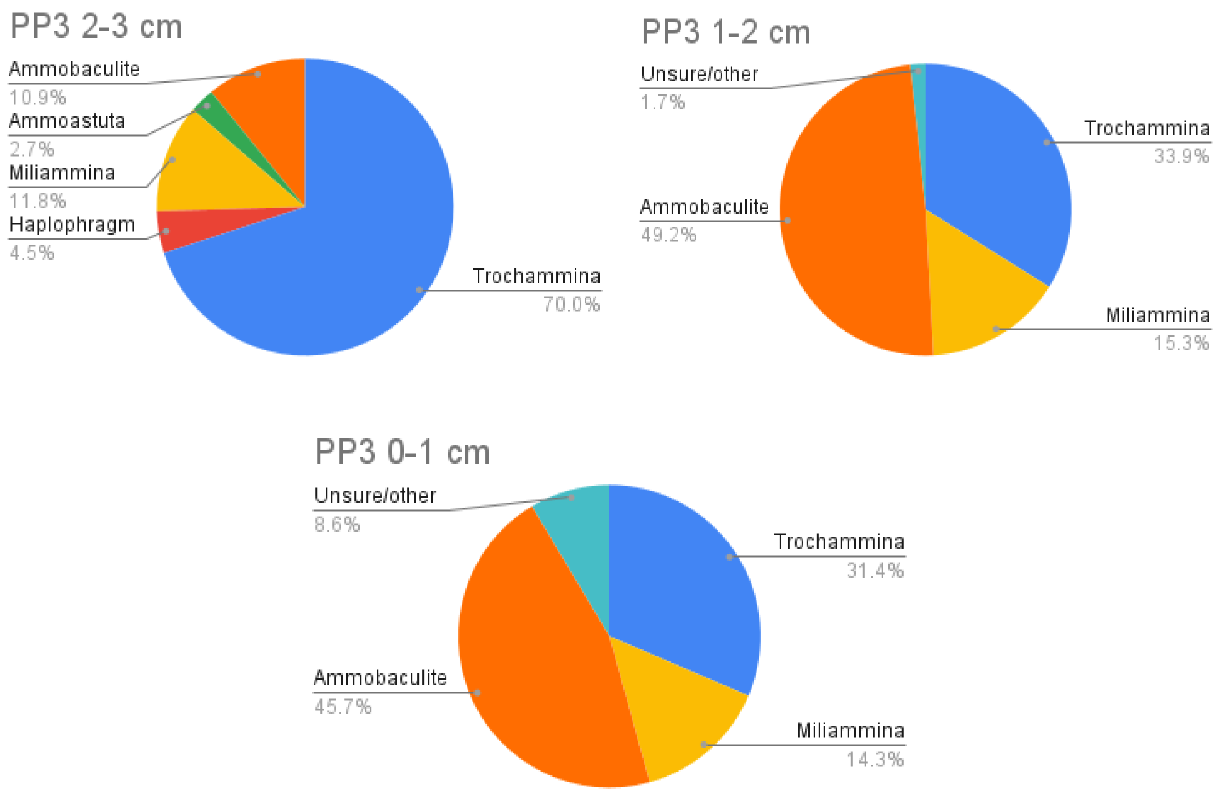


Figure 8: Genera diversity in each cm of core PP3

Core PP4, one of the south-facing cores, had a notably sandier texture compared to the other cores and lacked forams, as well as much or any observable clays, silt, or organic matter.

In core PP5, *ammobaculites* was the dominant genus. The only other individuals in the samples were a single *milaminna*, several *trochammina* and a few organic core liners, templates without shells, belonging to unknown genera. These samples were picked out of 25% of their total volume.

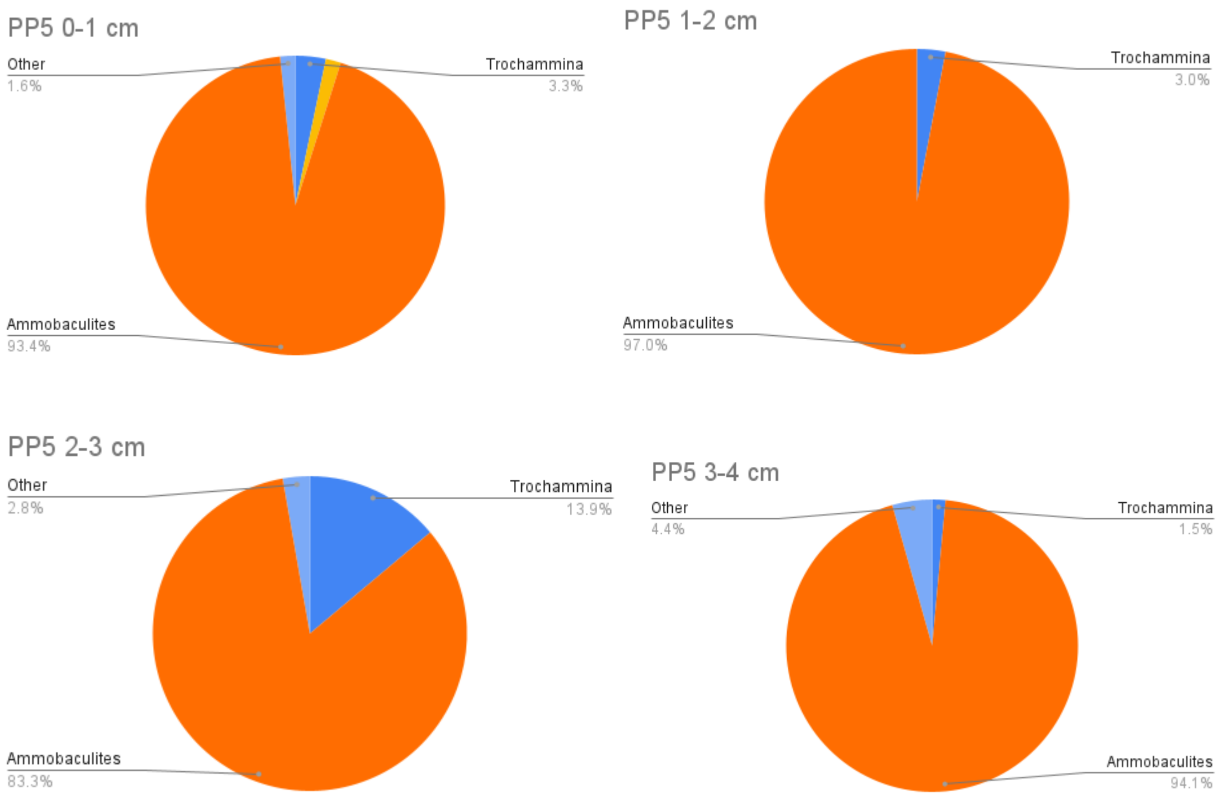


Figure 9: Genera diversity in each cm of core PP5.

PP1.2 (Per 2 Splits)	**0-1 cm**	**1-2 cm**	**2-3 cm**	**3-4cm**	**4-5 cm**	**5-6 cm**	**Total (genus)**
Genera							
Trochammina	108	162	170	86	87	103	716
Haplophragmoides	10	23	4	4	4	5	50
Miliammina	93	75	83	117	163	125	656
Ammoastuta	177	184	191	114	114	39	819
Ammobaculites	0	14	3	2	8	6	33
Arcellacea	0	6	9	8	9	10	42
Unknown	0	0	0	0	1	0	1
Total (core)	388	464	460	331	386	288	
PP2 (Whole Sample)	**0-1 cm**	**1-2 cm**	**2-3 cm**	**3-4 cm**	**4-5 cm**	**5-6 cm**	**Total (genus)**
Genera							
Trochammina	40	50	51				141

Haplophragmoides	0	0	2				2
Milliamina	13	6	14				33
Ammoastuta	18	95	53				166
Ammobaculites	5	5	4				14
Arcellacea	1	13	23				37
Other	0	6	0				6
Total	77	175	147				399
PP3 (Per 2 Splits)	**0-1 cm**	**1-2 cm**	**2-3 cm**	**3-4 cm**	**4-5 cm**	**5-6 cm**	**Total (genus)**
Genera							
Trochammina	11	20	77				108
Haplophragmoides	0	0	5				5
Miliammina	5	9	13				27
Ammoastuta	0	0	3				3
Ammobaculites	16	29	12				57
Unsure/other	3	1	0				
Total	35	59	110				
PP5 (Per 2 Splits)	**0-1 cm**	**1-2 cm**	**2-3 cm**	**3-4cm**	**4-5 cm**	**5-6 cm**	**Total (genus)**
Genera							
Trochammina	2	1	5	1			9
Haplophragmoides	0	0	0	0			0
Miliammina	1	0	0	0			1
Ammoastuta	0	0	0	0			0
Ammobaculites	57	32	30	64			183
Arcellacea	0	0	0	0			0
Other	1	0	1	3			
Total	61	33	36	68	0	0	

Figure 10: Picking data from the four cores with populations. Core PP4 was omitted due to a complete absence of forams. These are totaled both by total forams per centimeter and total of each genus per core.

3.3 Foraminiferal Population Totals

In addition to the assortment based on genus, we collected the total populations within each core. Core PP1.2 was, by a significant margin, the most populated of the cores. The cores along the south side of the pier tended to be the cores which were less populated compared to their northern side counterparts.

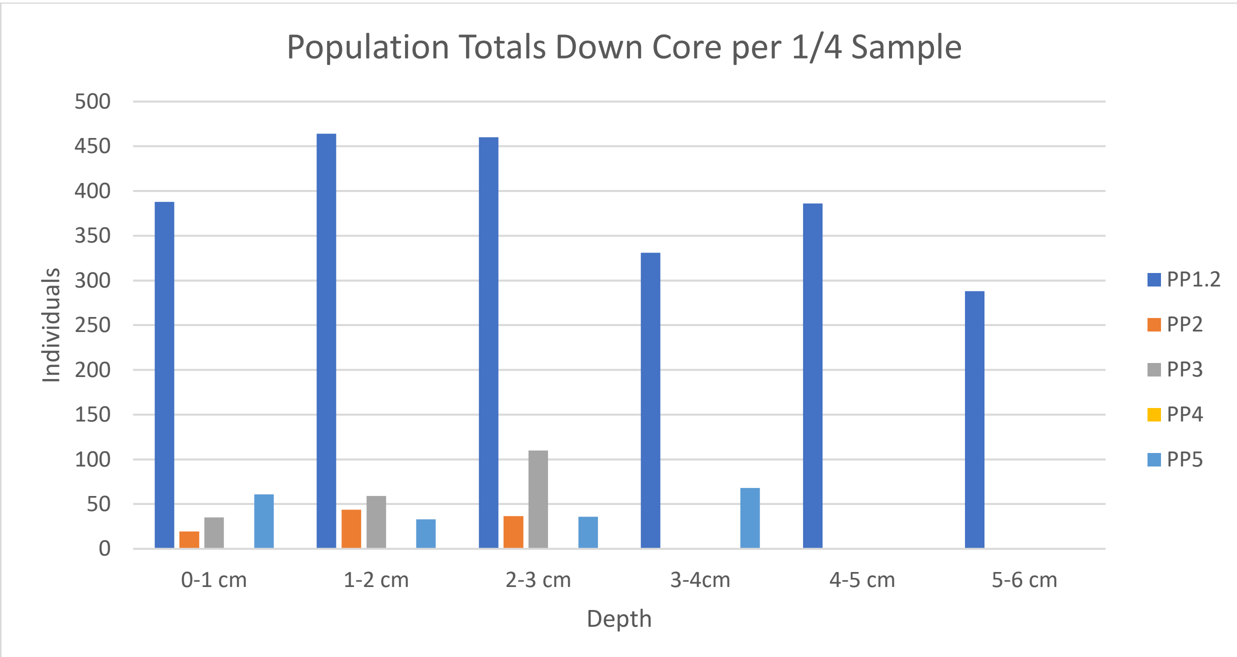


Figure 11: Population totals over each core over each centimeter. Each core was picked for 25% of total sample. PP2 was picked whole sample for each cm. Totals for PP2 were algebraically adjusted to represent an average for 25% of sample.

4. Discussion

Despite their close geographical bounds, each of the five coring sites presents a unique distribution of forams. Distances of only several meters express highly distinct records as conditions change around the pier.

Core PP4 yielded no forams when picked, but for the sake of this assessment, it can be preliminarily disregarded as the result of a grain-size related control instead of a pollution related one. Its abundantly sandy texture is a generally unsuitable environment for benthic foraminifera

(Sadough et al. 2013). This interpretation is tentatively supported by our XRF analysis, which varied for PP4 in several elements including titanium (Appendix 1*)*.

Notably, the population and assemblage data of core PP5, the most directly influenced by sewage influx, demonstrate an area both less diverse on the genera level and less populated overall when compared to the other cores. Only three genera were identified in that core out of the six defined in the site at large, not including the organic linings found, whose genus could not be solidly identified. This was the least diverse sample of all the cores from which forams were collected. The north side of the pier and the edge of the southern end were the areas most diverse and most populated.

What remains in core PP5 is a minute population of *trochammina* surrounded by a larger population of exclusively *ammoaculites*, yet the total population remains minute compared especially to core PP1.2. This population pattern is potentially inconsistent with expectations of organically fueled sewage influx. A signature of organic influx would have seen an expansion of these populations. However, point pollution like from sewage generally yields with this signature an abiotic zone surrounded by a ring of hypertrophic population blooms, which fades back to expected generalized population levels (Alve 1995). Discounting Core 4, PP5 remains the best indicator core within the potential sphere of influence of the sewage outflow. Further refinement and expansion on this study would benefit from a higher resolution view of the immediate vicinity of the pipe. From this study we have established the immense diversity of assemblage visible within even a few meters. Operating on these findings, it is reasonable to expect such variation may hold true approaching the pipe. This higher resolution may or may not find a distribution pattern such as the one highlighted by Alve 1995, which could support or refute an organic-laden pollution signature.

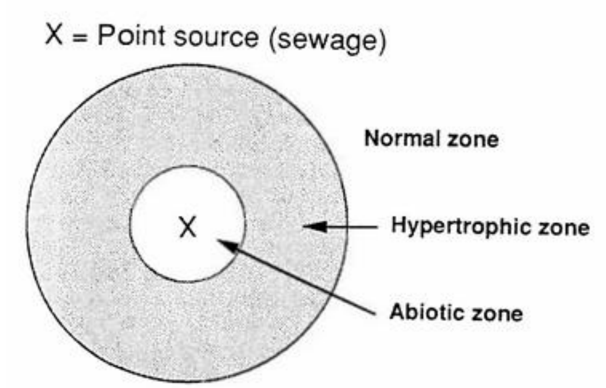


Figure 12: Schematic of trophic population density surrounding a point source of pollution from Alve 1995.

In contrast, these signatures of population may be indicative of a signature of metal pollution. Unlike the population growth one may expect from an organically-laden signature, metallic pollution tends to broadly deplete both the size and diversity of a population (Alve 1995). Based on the comparison between core PP5 and its analogues, its diversity and population size suggest this as a strong option for the influences on the southern end of the pier. This study did not investigate the contents and chemistry of the water of the river around Piermont. Future expansion on this study would benefit from a solid identification of the contents entering the Hudson from the Sparkill Creek watershed. Often pollution sources tend to be mixed or entangled with one another, making it difficult to parse their character purely from their effects.

While not a definitive identification, the results of this study warrant further investigation to confirm a probable metallic pollution signature for that region of the pier.

Additionally, we were unable to find definitive ages for the cores. Information such as the sedimentation rate of the pier and concrete age markers in the sedimentary record may also provide useful information especially in parsing the development of the pier ecosystems through time with the development of human activity in the area.

5. Conclusion

We have found that Piermont Pier has a diverse suite of environmental conditions concentrated in a small geographic range. Of these environmental conditions, we have found that the southern end of the pier, near the outflow of a sewage pipe and of Sparkill Creek, has a decreased population of forams and little biodiversity among them. The dominant genus of the outflow area is *ammobaculites* with only minimal diversity in a few *trochammina*. This signature is contrary to the expectations of an organic matter rich contamination pattern, which would expect to see an increase in foraminiferal population outside of a small abiotic zone surrounding the point outflow of the pipe. Instead, this signature is more consistent with noted foraminiferal responses to pollution from heavy metals, suggesting that metallic pollution may be a prominent component of the outflow from the nearby watershed. It is our hope with this study to begin these investigations and conversations about the health of the Hudson Estuary's benthic populations.

Acknowledgements

I would first like to thank Dr. Laura Haynes for her work in advising this project. Additionally I would like to thank my lab collaborators Kendall Hayes and Will Riley, as well as Dr. Alison Spodek Keimowitz, Dr. Logan Brenner, the staff of Cornell's Lamont-Doherty Earth Observatory, and the Vassar Earth Science Department for all of the work and support they have contributed to make this project possible.

References

Alve, E. "Benthic Foraminiferal Responses to Estuarine Pollution; a Review." *The Journal of Foraminiferal Research*, vol. 25, no. 3, 1995, pp. 190–203., https://doi.org/10.2113/gsjfr.25.3.190.

Armynot du Châtelet, E, et al. "Foraminiferal Proxies for Pollution Monitoring in Moderately Polluted Harbors." *Environmental Pollution*, vol. 127, no. 1, 2004, pp. 27–40., https://doi.org/10.1016/s0269-7491(03)00256-2.

Cearreta, A, et al. "Environmental Transformation of the Bilbao Estuary, N. Spain: Microfaunal and Geochemical Proxies in the Recent Sedimentary Record." *Marine Pollution Bulletin*, vol. 44, no. 6, 2002, pp. 487–503., https://doi.org/10.1016/s0025-326x(01)00261-2.

Cearreta, A., et al. "Recent Anthropogenic Impacts on the Bilbao Estuary, Northern Spain: Geochemical and Microfaunal Evidence." *Estuarine, Coastal and Shelf Science*, vol. 50, no. 4, 2000, pp. 571–592., https://doi.org/10.1006/ecss.1999.0582.

Gildeeva, Olga, et al. "Recent Brackish Water Foraminifera and Ostracoda from Two Estuaries in Ghana, and Their Potential as (Palaeo)Environmental Indicators." *Estuarine, Coastal and Shelf Science*, vol. 256, 2021, p. 107270., https://doi.org/10.1016/j.ecss.2021.107270.

Orabi, O.H., et al. "Benthic Foraminifera for Heavy Metal Pollution Monitoring: A Case Study from Burullus Lagoon of Egypt." *Marine Pollution Bulletin*, vol. 121, no. 1-2, 2017, pp. 411–417., https://doi.org/10.1016/j.marpolbul.2017.06.015.

Ruiz, F., et al. “Correlation between Foraminifera and Sedimentary Environments in Recent Estuaries of Southwestern Spain: Applications to Holocene Reconstructions.” *Quaternary International*, vol. 140-141, 2005, pp. 21–36., https://doi.org/10.1016/j.quaint.2005.05.002.

Sadough, Mina, et al. “Identification and Abundance of Benthic Foraminifera in the Sediments from Fereidoonkenar to Babolsar of Southern Caspian Sea.” *Turkish Journal of Fisheries and Aquatic Sciences* , vol. 13, pp. 79–86., https://doi.org/10.4194/1303-2712-v13_1_10.

Schönfeld, Joachim, et al. “The FOBIMO (Foraminiferal Bio-Monitoring) Initiative—towards a Standardised Protocol for Soft-Bottom Benthic Foraminiferal Monitoring Studies.” *Marine Micropaleontology*, vol. 94-95, 2012, pp. 1–13., https://doi.org/10.1016/j.marmicro.2012.06.001.

Strayer, David L. *The Hudson Primer: The Ecology of an Iconic River*. 1st ed., University of California Press, 2012, http://www.jstor.org/stable/10.1525/j.ctt1pp112. Accessed 17 May 2022.

U.S. Census Bureau Quickfacts: New York. https://www.census.gov/quickfacts/NY.

“Wastewater Treatment Plants.” *State of New York,* https://data.ny.gov/Energy-Environment/Wastewater-Treatment-Plants/2v6p-juki/data.

Weiss, Dennis, et al. “Foraminifera, Diatom and Bivalve Distribution in Recent Sediments of the Hudson Estuary.” *Estuarine and Coastal Marine Science*, vol. 7, no. 4, 1978, pp. 393–400., https://doi.org/10.1016/0302-3524(78)90091-9.

Appendix 1: XRF Results

No.	Start/keV	End/keV	Name	Gross	Net	Backgr.	Spectrum
1	3.524	3.806	Ca_K	1084	609	475	pp 5 0-1
				642	292	351	pp1.2 3-4
				697	306	391	pp1.2 4-5
				713	292	421	pp2 3-4
				671	247	424	pp2 4-5
				746	370	377	pp3 3-4
				743	307	436	pp3 4-5
				988	561	427	pp4 0-1
				803	348	455	pp4 1-2
				828	382	447	pp5 1-2
				810	339	471	pp5 2-3 yellow
				909	495	414	pp5 3-4
2	4.245	4.684	Ti_K	1273	790	482	pp 5 0-1
				1164	804	359	pp1.2 3-4
				1225	824	401	pp1.2 4-5
				1240	860	379	pp2 3-4
				1198	790	407	pp2 4-5
				1166	788	378	pp3 3-4
				1221	759	462	pp3 4-5
				2171	1763	408	pp4 0-1
				1643	1187	456	pp4 1-2
				969	561	408	pp5 1-2
				1039	610	429	pp5 2-3 yellow
				859	475	383	pp5 3-4
3	5.625	6.033	Mn_K	1213	842	371	pp 5 0-1
				650	323	328	pp1.2 3-4
				676	316	361	pp1.2 4-5
				572	272	300	pp2 3-4
				658	349	310	pp2 4-5
				615	272	344	pp3 3-4
				671	316	355	pp3 4-5
				786	488	298	pp4 0-1
				629	344	285	pp4 1-2
				939	634	304	pp5 1-2
				1055	689	366	pp5 2-3 yellow
				1378	1071	308	pp5 3-4
4	6.127	6.754	Fe_K	36378	35772	605	pp 5 0-1
				50151	49609	543	pp1.2 3-4

				53317	52697	619	pp1.2 4-5
				42018	41498	520	pp2 3-4
				42843	42308	535	pp2 4-5
				41663	41106	557	pp3 3-4
				43164	42581	582	pp3 4-5
				35978	35476	502	pp4 0-1
				39043	38529	514	pp4 1-2
				28125	27602	523	pp5 1-2
				32657	32061	595	pp5 2-3 yellow
				32443	31941	502	pp5 3-4
5	7.727	8.26	Cu_K	762	443	320	pp 5 0-1
				1003	664	339	pp1.2 3-4
				1030	648	381	pp1.2 4-5
				829	508	321	pp2 3-4
				822	509	313	pp2 4-5
				948	603	345	pp3 3-4
				745	421	324	pp3 4-5
				923	620	303	pp4 0-1
				1129	763	366	pp4 1-2
				772	432	340	pp5 1-2
				746	446	300	pp5 2-3 yellow
				771	497	274	pp5 3-4
6	8.291	8.887	Zn_K	1437	1022	415	pp 5 0-1
				1662	1192	469	pp1.2 3-4
				1977	1486	491	pp1.2 4-5
				2033	1606	427	pp2 3-4
				2233	1766	467	pp2 4-5
				1461	1002	458	pp3 3-4
				1431	1043	388	pp3 4-5
				1211	823	388	pp4 0-1
				1725	1260	465	pp4 1-2
				1263	870	393	pp5 1-2
				1351	982	369	pp5 2-3 yellow
				1509	1122	387	pp5 3-4
7	10.267	10.863	As_K	1111	207	903	pp 5 0-1
				2053	1250	803	pp1.2 3-4
				2106	1246	860	pp1.2 4-5
				1920	1077	843	pp2 3-4
				1702	783	920	pp2 4-5
				1731	906	825	pp3 3-4
				1339	468	871	pp3 4-5
				1188	341	847	pp4 0-1

				1697	823	874	pp4 1-2
				1104	224	880	pp5 1-2
							pp5 2-3
				1126	196	930	yellow
				1042	256	786	pp5 3-4
8	11.647	12.149	Br_K	2917	1168	1749	pp 5 0-1
				2631	1005	1626	pp1.2 3-4
				2739	1123	1616	pp1.2 4-5
				2395	761	1634	pp2 3-4
				2362	735	1627	pp2 4-5
				2153	568	1585	pp3 3-4
				2108	390	1719	pp3 4-5
				1706	116	1590	pp4 0-1
				1843	273	1570	pp4 1-2
				2057	372	1685	pp5 1-2
							pp5 2-3
				2102	370	1732	yellow
				2083	539	1544	pp5 3-4
9	13.152	13.623	Rb_K	4273	1387	2886	pp 5 0-1
				4132	1513	2619	pp1.2 3-4
				4235	1553	2682	pp1.2 4-5
				4177	1449	2728	pp2 3-4
				4587	1710	2877	pp2 4-5
				4129	1400	2729	pp3 3-4
				3821	980	2841	pp3 4-5
				3513	766	2747	pp4 0-1
				3367	607	2760	pp4 1-2
				4181	1254	2927	pp5 1-2
							pp5 2-3
				4181	1243	2938	yellow
				3484	915	2570	pp5 3-4
10	13.78	14.595	Sr_K	11303	5323	5981	pp 5 0-1
				6782	1564	5218	pp1.2 3-4
				6833	1410	5424	pp1.2 4-5
				7418	1835	5583	pp2 3-4
				7916	1897	6018	pp2 4-5
				7209	1591	5618	pp3 3-4
				7550	1685	5865	pp3 4-5
				7342	1604	5738	pp4 0-1
				7678	1846	5832	pp4 1-2
				8358	2248	6110	pp5 1-2
							pp5 2-3
				8775	2586	6189	yellow
				7523	2232	5291	pp5 3-4