

**YEAR 3 ANNUAL REPORT: HUDSON RIVER PARK TRUST'S TRIBECA HABITAT ENHANCEMENT  
MONITORING PROGRAM**

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**Department of the Army Permit Application File Number NAN-2020-00703- ESW  
by the Hudson River Park Trust for Installation Various Oyster Structures in the Hudson River Between  
Piers 26 and 34 in the Hudson River State Park, Borough of  
Manhattan, New York County, City of New York, New York**

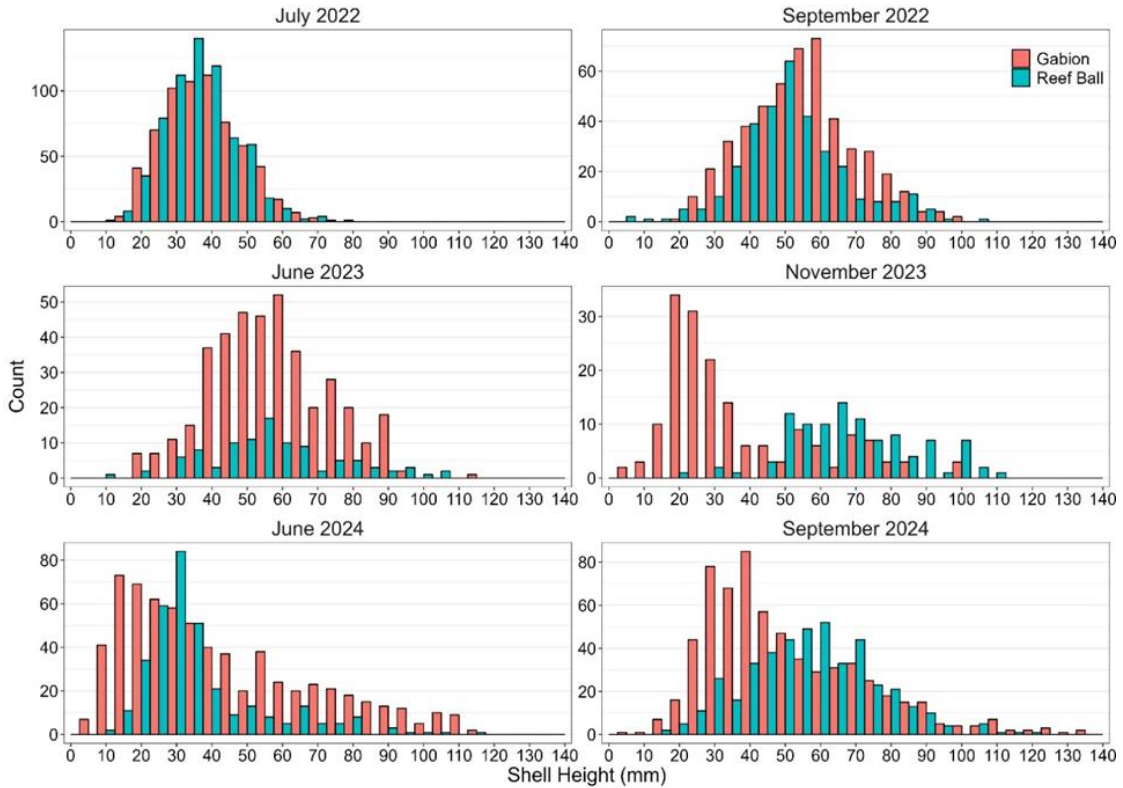
## EXECUTIVE SUMMARY

In the summer of 2021, Hudson River Park Trust installed over 200 habitat enhancement structures between Piers 26 and 34 in the Hudson River. An additional 48 habitat enhancement structures were deployed in August 2023 as part of Phase 2 of this project. The structures deployed included biohuts, textured concrete pile encasements, pile wraps, reef balls, and gabions. The purpose of this effort was to increase the oyster population in the Lower Hudson River Estuary and provide habitat for benthic, epibenthic, and mobile organisms. In accordance with the permit conditions issued for the project, three monitoring areas must be assessed yearly over five years post-installation: oyster health and performance, estuarine community utilization (including benthic, epibenthic, and mobile organisms), and water and sediment properties. This report presents the findings of Year 3 (i.e., 2024) of the monitoring effort, as well as comparisons to the previous years of sampling.

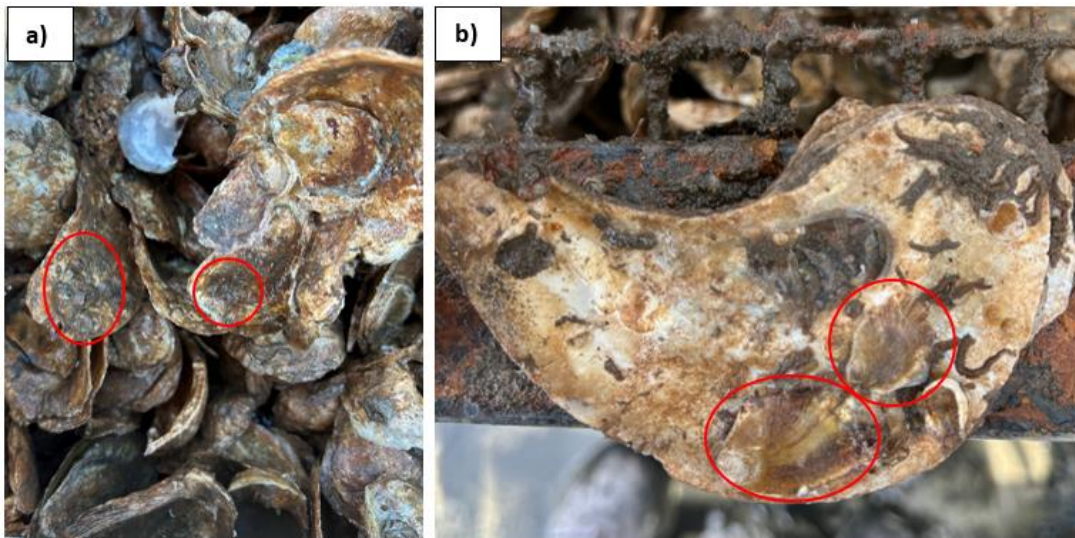
### *Oyster Health and Performance - Growth, Mortality, and Recruitment*

In Year 3, oyster health and performance sampling occurred June 25-26, and September 9-10, 2024. The June 2024 sampling represented approximately three years of population development on the Phase 1 structures and approximately 10 months of population development on the Phase 2 structures. The September 2024 sampling represented approximately three and a half years of oyster population development on the Phase 1 deployed enhancement structures and 13 months of population development for the Phase 2 deployments. Key results from the June and September sampling events are as follows:

- When Phase 1 and Phase 2 data were considered together, mean densities were substantially greater and mean oyster sizes were substantially smaller on the Phase 2 gabions and reef balls. When considering only the Phase 1 structures, mean densities of live oysters were significantly higher on the gabions and mean oyster sizes were similar across the two structure types.
- When Phase 1 and Phase 2 data from the September 2024 sampling event were combined, mean densities were significantly greater on the gabions, though mean oyster sizes were comparable across both structure types.
- A notable increase in live oyster spat was observed in Year 3 as compared to previous years. Live oyster percent coverage did not vary significantly between the June and September sampling periods, with live oysters, consisting of both adults and spat, covering from 5% up to 65% of quadrats on reef balls during both sampling events.
- Considering all three years of data, oyster populations on reef balls steadily decreased over the first three years, while live oyster density on gabions has remained relatively stable after an initial decrease in Year 1. However, the overall trend indicates a decline in live oyster percent coverage as the enhancement structure population ages. The overall trend from Year 1 to Year 3 showed an increase in the mean size of oysters on both structure types, with significantly larger oysters on the reef balls compared to the gabions. Percent coverage of live oysters did not differ significantly across Years 1 through 3.



**Figure 1.** Size-frequency plots for combined (all clusters) data by structure type for all four sampling dates. November 2023, June 2024 and September 2024 gabion data includes monitoring data from Phase 2 clusters 13 and 14 which were set with oysters prior to deployment in summer 2023. Note: the y-axis is not standardized across all plots to maximize clarity of the size frequency trends.



**Figure 2.** a) Newly recruited spat on shells in gabions in June 2024; b) Spat recruited to a bare shell in gabion cage in Sept 2024. The shell also has encrusting organisms present. Spat are circled in red.

- Although overall densities are relatively low compared to recent data from the same types of structure deployed in the Tappan Zee area of the Hudson River, this is not unexpected, as there are naturally reproducing oyster beds in that area. However, monitoring at the Tappan Zee also showed considerable variation in oyster densities across its three study sites and three types of enhancement structures. Furthermore, the observed growth rates in the Tappan Zee studies are comparable to those seen at the Tribeca Habitat Enhancement area

**Table 1.** Summary data (all clusters) for all monitoring periods 2022 – 2024 by structure type. Values reported as mean + standard error.

Monitoring Period	Structure Type	Oyster Density (# / 0.05 m <sup>2</sup> )	Oyster Density (# / 0.10 m <sup>2</sup> )	Shell Height (mm)
July 2022	Gabions	20.0 + 1.8	40.1 + 3.5	38.1 + 0.4
	Reef Balls	18.9 + 5.0	37.7 + 4.8	36.3 + 0.4
September 2022	Gabions	13.4 + 1.9	26.9 + 3.8	55.4 + 0.7
	Reef Balls	8.9 + 2.8	17.8 + 5.6	51.5 + 0.8
June 2023	Gabions	11.1 + 1.4	22.1 + 2.9	57.0 + 0.8
	Reef Balls	3.3 + 2.8	6.6 + 3.6	57.1 + 1.9
November 2023	Gabions	10.8 + 2.8	21.5 + 5.6	36.7 + 1.6
	Reef Balls	3.1 + 1.7	6.3 + 3.4	68.4 + 1.8
June 2024	Gabions	13.7 + 2.4	27.3 + 4.8	42.1 + 1.0
	Reef Balls	7.2 + 3.7	14.4 + 7.3	36.3 + 0.9
September 2024	Gabions	13.0 + 2.8	26.0 + 4.4	50.1 + 0.9
	Reef Balls	0.9 + 0.5	1.9 + 1.0	57.2 + 0.9

Oyster Health and Performance – Reproduction and Disease

Year 3 marks the first year of assessing oyster gonad and tissue condition, as well as disease incidence, as outlined in the monitoring plan. On June 25, 2024, a total of 30 oysters were randomly selected from multiple gabions and shipped to the Marine Animal Disease Laboratory at Stony Brook University for processing. These oysters were analyzed for Dermo disease diagnostics, histopathology, and condition index. Key results are as follows:

- *Perkinsus marinus* (Dermo) was detected at very low prevalence and extremely low intensities and is not of concern at these levels. MSX (*Haplosporidium nelson*) was observed in 28.6% of the analyzed oysters, including some heavily infected oysters that are likely associated with mortalities. Ciliate infections were incidental and observed at low levels.
- The average condition index of the analyzed oysters was  $2.5 \pm 1.1$ , with oysters infected with MSX and ciliates exhibiting significantly lower condition indices as compared to uninfected oysters.

**Table 2.** *P. marinus* infection prevalence and intensity

Mackin's Scale Stage	Number of Oysters
0.5 (Rare)	3
1 (Light)	1
2 (Light to Moderate)	0
3 (Moderate)	0
4 (Moderate to Heavy)	0
5 (Heavy)	0
Prevalence %: (Total infected/Total assessed) x 100 = <b>14.3%</b>	
Weighted Prevalence: (Sum of stages/Total assessed) = 0.09	

- All oysters displayed reproductive activity, with some appearing to have completed a spawning event, while others appeared to be beginning a new round of gonad development.

*Epibenthic Community Monitoring – Gabions and Reef Balls*

The epibenthic community monitoring on gabions and reef balls was conducted concurrently with the oyster performance monitoring outlined above. Key results from the June and September sampling events are as follows:

- During the June and September sampling periods, epibenthic and shell coverage ranged from 0% to 100% on sampled reef balls and gabions.
- Over the June and September sampling periods, species richness was higher on gabions, with 37 observed species, compared to 32 species on reef balls. Fewer encrusting organisms were present on the gabion shells than on reef balls; however, a greater number of small mobile species, were observed within the gabions compared to the reef balls.
- Successional changes were observed during the three-month interim between June and September sampling dates. In June, fewer encrusting organisms were present on the enhancement structures and the epibenthic community was at a less developed stage. As the year progressed and waters warmed, the percent coverage of encrusting organisms increased, and bare space decreased or was fully covered by the September sampling event. Although these successional changes were observed, they were not as pronounced as those observed in Year 2. The coverage of sessile encrusting species in Year 3 was less than in Year 2, which may be attributed to: 1) observed mud coverage, and/or 2) differences in seasonal sampling times.
- Epiphyte diversity was much higher in Year 3 compared to previous years, likely due to the revised and more intensive sampling and processing methodology used in Year 3.

Epibenthic Community Monitoring – Video Surveys of Pile Encasements and Biohuts

Divers captured videos using a GoPro camera equipped with a GoPro Clearwater Box at enhancement structures located at Pier 26 and at the Pier 32 pile field during surveys conducted on October 30, 2024. 2025. Three to six of each enhancement structure (biohut, concrete pile, timber pile, concrete pile jacket, and reef ball) were randomly selected for monitoring. Key results from the October sampling event is as follows:

- A total of 15 species/taxa (including unidentified barnacle and anemone specimens) were observed in the video footage across the substrate types
- The most diverse substrates were the concrete pile jackets (12 species/taxa) and biohuts (11 species/taxa), with the reef balls having the least diversity (7 species/taxa).
- Live oysters were observed in greater quantities on reef balls and concrete pile jackets than on concrete piles and biohuts, and were absent on timber piles.

**Table 3.** Epibenthic species/taxa observed in video surveys of enhancement structures during October 2024

	Scientific Name/Taxa	Common Name	Biohut	Concrete Pile	Timber Pile	Concrete Pile Jacket	Reef Ball
<b>Colonial</b>	<i>Cliona celata</i>	Boring sponge	X	X		X	
	<i>Halichondria</i> spp.	Breadcrumb sponge	X		X	X	X
	Actinaria (Unknown anemone species)	Anemones	X	X		X	
	Tubulariidae	Tubular hydroids	X	X			
	<i>Crisia</i> spp.	Bushy Bryozoa	X		X	X	X
	<i>Microciona prolifera</i>	Red beard sponge	X		X	X	
	<i>Scypha</i> spp.	Tubular sponge	X				
	Cirripedia (Unknown barnacle species)	Barnacles	X	X	X	X	
	<i>Molgula manhattensis</i>	Sea squirts		X	X	X	X
	<i>Botrylloides violaceus</i>	Pacific tunicate		X			
	<i>Botryllus schlosseri</i>	Golden star tunicate		X	X	X	X
Serpulidae (tubes observed)	Polychaetes	X	X		X		
<b>Solitary</b>	<i>Crassostrea virginica</i>	Eastern oyster	1	5		44	58
	<i>Geukensia demissa</i>	Ribbed mussel	1	48	15	10	19
	<i>Urosalpinx cinerea</i>	Oyster drill		3	6	2	3

### Epibenthic Community Monitoring – Benthic Infauna

Year 3 represented the first post-deployment sampling of the benthic and infaunal community within the Enhancement area since pre-deployment sampling was conducted in 2020. Benthic grab samples were collected at 26 sites located either immediately adjacent to enhancement clusters or at previously sampled random locations with mud sediments within the Tribeca Habitat Enhancement area on August 27, 2024. Key results are as follows:

- There was a clear change in benthic and infaunal species assemblage between the pre-deployment sampling and the post-deployment sampling, with little to no overlap in species assemblage. It was apparent that abundant species, not just rare species, drove the overturn. The difference in infaunal species assemblage may be attributed to one or more of the following factors: 1) the difference in the seasonal timing of the two surveys; 2) interannual variation in benthic assemblages; 3) the occurrence of two major storms and and/or 4) a strong change in salinity that occurred over the past four years.
- There was no effect of sample distance from enhancement cluster center, nor was there an interaction between distance and year, meaning that the shift in benthic community assemblage was likely not due to the presence of the enhancement structures.

### Mobile Community Monitoring and Water Quality

Species composition and relative abundance of fishes and large invertebrates within the study area were assessed weekly from mid-July through September using strings of two types of unbaited traps (larger “pots” and small “wire mesh traps”) deployed in the Enhancement area and in a nearby Control area. Water quality (dissolved oxygen [DO], salinity, temperature, pH, and turbidity) was measured both at the surface and bottom at each trap string during weekly sampling events in both the Enhancement and Control areas. Key results are as follows:

- Despite similar efforts to previous years, fewer fish and crabs were collected in 2024, with a total of 297 individuals captured over ten weekly trap recoveries between July and September. The only relatively abundant species were oyster toadfish (*Opsanus tau*) adults and juveniles, black sea bass (*Centropristis striata*) juveniles, and blue crab (*Callinectes sapidus*), all of which showed a decrease in abundance relative to 2022 and 2023.
- When standardized to unit effort (combining both trap types), the assemblage structure and abundance were very similar between the Enhancement and Control areas in 2024.
- Blue crab catch per unit effort (CPUE) was approximately three times higher in the Control area than in the Enhancement area for pots; however, the standard deviation was very high and similarities between areas were apparent. American eel, blue crabs, and northern pipefish were more abundant in the Enhancement area, particularly in wire mesh traps.
- Additional fish and invertebrates collected from enhancement structures during oyster health and performance sampling on the vessel deck included 10 nominal taxa. The species found among the enhancement structures were the same as those collected in traps during Years 2 and 3, except for conger eel (*Conger oceanicus*), which was only observed in the structures.

**Table 4.** Abundance (uncorrected for sample effort differences) of species abundance collected in pot traps only.

Species	Year			Grand Total
	2022	2023	2024	
American eel ( <i>Anguilla rostrata</i> )		2	1	3
Silver perch ( <i>Bairdiella chrysoura</i> )		1		1
Blue crab ( <i>Callinectes sapidus</i> )	99	82	30	211
Black sea bass ( <i>Centropristis striata</i> )	118	106	54	278
Smallmouth flounder ( <i>Etropus microstomus</i> )		1	1	2
Skilletfish ( <i>Gobiosox strumosus</i> )	2	1	9	12
Naked goby ( <i>Gobiosoma bosc</i> )	9		9	18
Seaboard goby ( <i>Gobiosoma ginsburgi</i> )	4	44	7	55
Unidentified goby ( <i>Gobiosoma</i> sp.)	1	2	3	6
Pinfish ( <i>Lagodon rhomboides</i> )	1			1
Spot ( <i>Leiostomus xanthurus</i> )			8	8
Longnose spider crab ( <i>Libinia dubia</i> )	3			3
Portly spider crab ( <i>Libinia emarginata</i> )	17	4	1	22
Unidentified spider crab ( <i>Libinia</i> sp.)	30	1	1	32
Tom cod ( <i>Microgadus tomcod</i> )	2		2	4
Striped bass ( <i>Morone saxatilis</i> )	1	2	2	5
Unidentified Moronid bass ( <i>Morone</i> sp.)		1		1
Oyster toadfish ( <i>Opsanus tau</i> )	98	131	70	299
Summer flounder ( <i>Paralichthys dentatus</i> )	2	6	1	9
Northern sea robin ( <i>Prionotus carolinus</i> )	6			6
Striped sea robin ( <i>Prionotus evolans</i> )	1			1
Winter flounder ( <i>Pseudopleuronectes americanus</i> )	4			4
Windowpane (flounder) ( <i>Scophthalmus aquosus</i> )		1		1
Tautog ( <i>Tautoga onitis</i> )	7		1	8
Cunner ( <i>Tautoglabrus adspersus</i> )	1	2	2	5
<b>Grand Total</b>	<b>406</b>	<b>387</b>	<b>202</b>	<b>995</b>

- In Year 3, a priority effects experiment was conducted to test whether traps fished differently depending on which species entered the trap first. Statistical analyses of two response metrics indicated that traps seeded with adult oyster toadfish did not fish differently than unseeded traps.
- Water quality in Year 3 was typical of a healthy oligo-mesohaline estuarine location.

#### Sedimentation

Diver surveys documenting sedimentation around the enhancement clusters were conducted by Moffat and Nichol from June 21 to June 25 and from August 29 to September 9, 2024. At multiple locations around each enhancement cluster, divers measured sediment depths from the mudline to the suspected bottom edge of enhancement structures. Key results are as follows:

- Average sediment depths per cluster ranged from 2.4 centimeters to 10.5 centimeters. No distinct spatial trends in sedimentation were observed.
- The sedimentation depths are likely a result of sediment deposition rather than the sinking of the enhancement structures into the sediment and were generally consistent with expectations for this location in the Hudson River after three years of deployment.

#### Current Perspective and Looking Ahead

As in previous years, data indicated that both reef balls and gabions are effective enhancement structures for restoring oyster populations. Although Year 3 monitoring revealed a decline in the overall restored oyster population (as measured by oyster density), but oyster size frequency data showed growth comparable to that observed in other studies in the Hudson River Estuary. Although overall oyster densities on enhancement structures decreased, this decrease is more pronounced on reef balls than on gabions. Additionally, more spat were observed on shell within gabions than on reef balls. These findings are consistent with oyster densities observed on similar enhancement structures in the Tappan Zee area. It is important to note that both types of structures have their advantages and disadvantages. While oyster densities have been higher on gabions, the structural integrity of the gabions tends to be compromised over time in this high energy environment, particularly for those gabion structures that are brought to the surface as part of the monitoring program. This compromises their stability, putting gabions at a disadvantage compared to reef balls as long-term enhancement structures. Although oyster densities have been lower on the reef balls, they are better suited for the high energy conditions in the Tribeca Enhancement area and for being lifted out of the water for sampling and have shown no signs of degradation or damage over the past three years. Future monitoring in Years 4 and 5, along with a clearer understanding of any differences in spat settlement densities between the two structure types during the pre-deployment settlement process, will provide further insights into the relative effectiveness of these two types of structures.

While epibenthic and nektonic species, as well as both natural and restored oyster populations, exhibit some interannual variability, the ultimate goal is to establish a self-sustaining oyster-based community that shows stability and succession over longer timeframes. Three years of monitoring have shown that the epibenthic community present on the enhancement structures is robust and exhibiting seasonal successional cycles typical of the Hudson River Estuary. Furthermore, the enhancement structures are being utilized as habitat by mobile fish and invertebrates. In Year 3, analyses of tissue and gonad condition and disease incidence provided evidence that the oyster population is relatively healthy and is reproductively active. Continuing these studies of oyster tissue, gonad condition, and disease incidence will provide a more comprehensive understanding of the health of the Tribeca oyster population and their contribution of spat to the waters of the Hudson River Park and the Hudson River Estuary. While the main source of oyster spat in the Hudson River Estuary is in the Tappan Zee area, it is possible that the Tribeca restored oyster population may be self-seeding. If genetic studies in the Park were to determine that the Tribeca population is, in fact, self-seeding, this would mark a vital milestone in the development of Tribeca as a self-sustaining oyster-based community.

The monitoring data collected in the first three years of the monitoring program, along with future data from Years 4 and 5, will offer valuable insights into the longevity and health of the Tribeca Habitat Enhancement Project. This database, combined with the eDNA data to be collected at Tribeca in Year 4 and data from monitoring at the Gansevoort Peninsula Habitat Enhancement area, will help inform and guide HRPT's future habitat restoration projects.