Interannual Variation in Beach-Nesting Bird Communities Across Contrasting Coastal Habitats of the Rockaway Peninsula, New York (2025-2026)

Rolando Gutierrez[a]; Mariola Camacho-Lie[b]

[a]NGO-Conservation of Endangered Species; [b]Universidad de Guadalajara

Corresponding author: rolando@conservationes.org

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Abstract

The Rockaway Peninsula, along the southern boundary of Jamaica Bay in Queens, New York, provides a natural laboratory for examining beach-nesting shorebirds across contrasting coastal settings within a single barrier system. We characterized interannual variation in nest abundance, species composition, and spatial and temporal nesting patterns across a managed urban beach (Beach 37th-56th Streets; B), a semi-natural protected site (Fort Tilden; FT), an exposed ocean-facing sector (Breezy Point Ocean Side; OS), and a sheltered estuarine sector (Breezy Point Bay Side; BS) during the 2025 and 2026 breeding seasons. In 2025, 121 nests containing 269 eggs were recorded: 61 American Oystercatcher, 35 Least Tern, 15 Piping Plover, and 10 Common Tern nests. In 2026, abundance increased to 139 nests and 304 eggs, representing increases of approximately 15% and 13%, respectively. Community composition shifted markedly: Least Terns became dominant with 65 nests, followed by American Oystercatchers (44), Piping Plovers (22), and Black Skimmers (8), while Common Terns were not recorded. Nesting was strongly concentrated at B in both years, whereas FT and OS supported lower but spatially distributed nesting and BS consistently supported relatively few nests. Temporal patterns also varied among sites and species, with a pronounced mid-season concentration of Least Tern activity in 2026 and broader spatial and temporal use by American Oystercatchers. These results demonstrate substantial interannual variation in abundance, community composition, site use, and breeding phenology, supporting continued long-term monitoring across this heterogeneous urban coastal system. This exploratory framework provides a baseline for evaluating future environmental and management-related changes.

Keywords: Piping Plover; Least Tern; interannual redistribution; spatial breadth; barrier-beach nesting.

Introduction

Beach-nesting birds are important components of sandy beach and barrier-island ecosystems, where they exhibit diverse nesting strategies and habitat requirements. However, many North American bird populations have experienced substantial declines, raising concerns about the persistence of species and the ecological integrity of their habitats (Rosenberg et al. 2019). Shorebirds are of particular conservation concern, with widespread population declines documented across North America and evidence of accelerating losses in several species (Smith et al. 2023). Understanding the ecology and breeding patterns of coastal birds is therefore important for identifying variation in habitat use and supporting conservation efforts (Székely 2019).

Sandy coastal environments are dynamic and spatially heterogeneous, encompassing beaches, dunes, estuarine shorelines, and areas subject to different degrees of human modification and management. Within these environments, beach-nesting species differ in their nesting behavior, spatial organization, and habitat associations. American Oystercatchers and Piping Plovers commonly establish dispersed nesting territories, whereas several tern species exhibit more colonial nesting patterns. These differences may contribute to contrasting spatial distributions even within shared coastal systems. Previous research has also demonstrated that habitat protection and the management of recreational activities can influence the availability of suitable nesting habitat, with effects

that differ among species (Maslo et al. 2018). Such differences highlight the importance of considering individual species and local habitat characteristics when describing nesting communities.

Interannual comparisons provide an additional perspective on the variability of beach-nesting bird communities. Changes in total nesting abundance may be accompanied by differences in species composition, spatial occupancy, or the timing of breeding activity. Moreover, species occupying the same coastal system do not necessarily exhibit similar responses to shared environmental pressures, as illustrated by contrasting long-term population patterns among beach-nesting shorebirds (Kwon et al. 2021). Consequently, examining aggregate nest counts alone may provide an incomplete description of changes within a nesting community. Integrating species-specific abundance, spatial distributions, and temporal records can provide a more comprehensive characterization of interannual variation and establish a foundation for continued monitoring.

The Rockaway Peninsula, located along the southern boundary of Jamaica Bay in Queens, New York, provides an opportunity to examine nesting patterns across contrasting coastal settings within a single barrier system. The peninsula includes developed oceanfront beaches, protected coastal areas, exposed ocean-facing shorelines, and sheltered estuarine environments. Previous research has documented spatial variability in the peninsula's coastal morphology and sediment availability, reflecting the combined influence of geological characteristics, hydrodynamic processes, and human modifications (Wei and Miselis 2022). Studies of Piping Plovers at Rockaway Beach have also highlighted the relevance of nest locations and management practices within this urban coastal landscape (Arndtsen 2022). Nevertheless, an integrated comparison of multiple beach-nesting species across these contrasting sectors and consecutive breeding seasons can provide additional information on local community variation.

This study aimed to characterize interannual variation in beach-nesting bird communities across four coastal sectors of the Rockaway Peninsula during the 2025 and 2026 breeding seasons: Beach 37th-56th Streets, Fort Tilden, Breezy Point Ocean Side, and Breezy Point Bay Side. Specifically, we sought to (1) quantify changes in nest abundance, species composition, and recorded clutch sizes; (2) describe differences in the spatial distribution of nesting locations among species, sectors, and years; and (3) characterize temporal patterns in maximum recorded egg counts aggregated by observation date. By integrating these complementary descriptive measures, the study provides a baseline for identifying interannual and site-specific variation in nesting communities and for informing future monitoring across heterogeneous urban coastal habitats.

Study Area

The Rockaway Peninsula, located in Queens, New York City, forms a barrier beach system along the Atlantic coast and constitutes the southern boundary of Jamaica Bay. The peninsula is part of the broader chain of barrier islands extending along the southern shore of Long Island and the eastern seaboard of North America. Its geomorphology reflects long-term coastal processes driven by wave action, littoral drift, and sediment redistribution, which have promoted westward barrier growth and the formation of sandy beaches, dunes, and tidal habitats (Sanderson 2016, Greenlees 2020). These processes continue to shape shoreline morphology and sediment availability, producing substantial spatial variability in beach width and coastal structure over relatively short distances (Wei and Miselis 2022, Janda et al. 2025).

Barrier island systems such as the Rockaway Peninsula are inherently dynamic and shaped by interactions among geological framework, hydrodynamic forcing, and sediment supply. Variability in shoreface morphology and sediment thickness contributes to differences in beach stability and shoreline change rates, influencing how coastal segments respond to storms and sea-level rise (Wei et al. 2021, Wei and Miselis 2022). Along the south shore of Long Island, longshore sediment transport generally moves from east to west, promoting sediment accumulation near the western end of the peninsula while other segments experience more moderate shoreline change (Janda et

al. 2025). These processes are further modified by coastal engineering structures, nourishment projects, and other human interventions that alter sediment fluxes and shoreline morphology.

Beyond natural coastal dynamics, the peninsula lies within one of the most densely populated metropolitan regions in the world. Urban development, coastal infrastructure, and recreational use have substantially modified portions of the coastline while leaving other segments relatively undeveloped. Human alterations to Jamaica Bay, including dredging, inlet stabilization, and land reclamation, have modified hydrodynamics and storm tide propagation, increasing sensitivity to storm surge and coastal flooding (Orton et al. 2020). Consequently, coastal ecosystems in the peninsula reflect a complex interaction between geomorphic processes and anthropogenic pressures.

The system is also highly vulnerable to coastal hazards. Barrier beaches within the Gateway National Recreation Area exhibit varying susceptibility to shoreline change, overwash, and sea-level rise depending on local geomorphology, coastal slope, wave exposure, and historical shoreline change rates (Pendleton et al. 2005). Extreme events such as hurricanes and nor'easters can produce substantial coastal erosion, storm-surge flooding, and rapid morphological change, processes often amplified in densely developed coastal regions of the northeastern United States (Coch 2015).

Within this heterogeneous coastal landscape, four nesting sites were selected to represent contrasting environmental conditions and levels of human influence along the peninsula. In combination, these sites capture a gradient of geomorphological exposure, habitat configuration, and anthropogenic disturbance that enables examination of spatial variation in nesting ecology within a single urban barrier island system:

a) **Beach 37th St.-56th St.** represents a managed urban beach sector characterized by wide sandy beaches, low dune systems, and high recreational use. Although intensively maintained for public access, the site retains open sandy substrates suitable for beach-nesting shorebirds. Nesting habitat is strongly influenced by proximity to infrastructure, boardwalks, and pedestrian access, making this the most urbanized portion of the study system. Previous monitoring indicates that nesting often occurs within relatively small sections of shoreline where management actions such as fencing and symbolic barriers are implemented to reduce disturbance (Arndtsen 2022).

b) **Fort Tilden**, located within the Gateway National Recreation Area, comprises a semi-natural coastal landscape including oceanfront beach, dune systems, maritime vegetation, and adjacent wetlands. Compared with the urban sector, infrastructure density and human disturbance are lower, and dune systems are more structurally developed. Coastal protection structures have been implemented in parts of this site to mitigate storm impacts and protect natural and cultural resources (Bearmore et al. 2016).

c) **Breezy Point Ocean Side** represents a largely undeveloped and highly exposed ocean-facing environment at the western tip of the peninsula. The site contains extensive dune systems and wide beaches shaped primarily by Atlantic wave action and storm-driven processes. Sediment accumulation is influenced by longshore transport and coastal structures such as the Breezy Point jetty, which historically altered patterns of westward barrier growth (Pendleton et al. 2005, Greenlees 2020).

d) **Breezy Point Bay Side** contrasts strongly with the ocean-facing zones, bordering the sheltered waters of Jamaica Bay. This environment is characterized by tidal flats, salt marshes, and narrower sandy margins reflecting estuarine geomorphology rather than open-ocean exposure. Nesting habitat is more spatially constrained than on ocean-facing beaches, and the bay system has experienced substantial geomorphic change and wetland loss over the past century due to both natural processes and human modification (Sanderson 2016, Orton et al. 2020).

Together, these four study sites form a gradient of geomorphological exposure, sediment dynamics, habitat configuration, and anthropogenic pressure. This gradient provides an opportunity to examine how environmental conditions and landscape structure influence the spatial ecology and reproductive investment of beach-nesting shorebirds within a single metropolitan coastal system.

Methodology

This section outlines the methodological framework used to document nest abundance, species composition, and spatial and temporal nesting patterns of beach-nesting birds along the Rockaway Peninsula during the 2025 and 2026 breeding seasons. Field observations were designed to minimize disturbance to nesting birds while preserving the integrity of sensitive reproductive processes.

Nesting monitoring was conducted weekly over a 15-week period from late April to early August 2025 and a 15-week period from early May to early August 2026. Surveys covered four focal sectors: Beach 37th-56th Streets (B), Fort Tilden (FT), Breezy Point Ocean Side (OS), and Breezy Point Bay Side (BS), totaling approximately 30 observation hours per site during each breeding season. For the analysis, five bird species were monitored: American Oystercatcher, Piping Plover, Common Tern, Least Tern, and Black Skimmer. The objective was to identify, document, and geolocate nesting locations while minimizing human disturbance.

Upon first detection of a new nest, a rangefinder was used to determine its position relative to pre-established seasonal beach nest markers installed at each site before the breeding season. These reference markers were subsequently geolocated using a GPS unit after the nesting season, allowing nest coordinates to be reconstructed without approaching active nests. To prevent duplication, each nest was included only once in the final dataset, using its maximum recorded egg count. The observation date associated with this maximum was retained for the temporal analysis, and maximum egg counts were subsequently summed by date, species, and sector. Reproductive outcomes, including hatching success, were not assessed because they were beyond the scope of this study. All final GPS reference measurements used to reconstruct nest locations were obtained after the breeding season to avoid disturbance to active nests.

Results

Interannual Variation in Nest Abundance, Species Composition, and Recorded Clutch Size

A total of 260 nests containing 573 eggs were documented across the four study sectors during the 2025 and 2026 breeding seasons. Overall nest abundance increased from 121 nests and 269 eggs in 2025 to 139 nests and 304 eggs in 2026, representing increases of 14.9% and 13.0%, respectively (Tables 1 and 2). Despite these moderate increases, considerable differences were observed in species composition and the distribution of nests among sectors.

Table 1. Number of nests and maximum recorded egg counts by species and study sector across the Rockaway Peninsula, New York, during the 2025 breeding season. Values represent the number of nests and corresponding eggs (nests/eggs).

Species	B	FT	OS	BS	Total
American Oystercatcher	23 / 51	12 / 31	21 / 50	5 / 13	**61 / 145**
Common Tern	6 / 7	0 / 0	4 / 8	0 / 0	**10 / 15**
Least Tern	32 / 53	0 / 0	3 / 5	0 / 0	**35 / 58**
Piping Plover	4 / 16	4 / 12	4 / 13	3 / 10	**15 / 51**
Total	**65 / 127**	**16 / 43**	**32 / 76**	**8 / 23**	**121 / 269**

Table 2. Number of nests and maximum recorded egg counts by species and study sector across the Rockaway Peninsula, New York, during the 2026 breeding season. Values represent the number of nests and corresponding eggs (nests/eggs).

Species	B	FT	OS	BS	Total
American Oystercatcher	13 / 29	13 / 31	14 / 32	4 / 10	**44 / 102**
Least Tern	60 / 103	0 / 0	5 / 8	0 / 0	**65 / 111**
Piping Plover	4 / 11	4 / 11	13 / 43	1 / 3	**22 / 68**
Black Skimmer	8 / 23	0 / 0	0 / 0	0 / 0	**8 / 23**
Total	**85 / 166**	**17 / 42**	**32 / 83**	**5 / 13**	**139 / 304**

Abbreviations (for both tables): B = Beach 37th-56th Streets; FT = Fort Tilden; OS = Breezy Point Ocean Side; BS = Breezy Point Bay Side.

In 2025, American Oystercatcher was the most frequently recorded species, accounting for 61 nests (50.4% of the annual total) and 145 eggs, followed by Least Tern with 35 nests (28.9%) and 58 eggs, Piping Plover with 15 nests (12.4%) and 51 eggs, and Common Tern with 10 nests (8.3%) and 15 eggs. In 2026, Least Tern became the most frequently recorded species, increasing to 65 nests (46.8%) and 111 eggs, whereas American Oystercatcher declined to 44 nests (31.7%) and 102 eggs. Piping Plover increased to 22 nests (15.8%) and 68 eggs, while eight Black Skimmer nests containing 23 eggs were documented in 2026. Common Tern was not recorded during the second season. Thus, although four species were recorded in each year, their identities and relative contributions changed considerably.

The magnitude of these changes differed among study sectors. Beach 37th-56th Streets (B) consistently supported the highest nesting abundance, increasing from 65 nests and 127 eggs in 2025 to 85 nests and 166 eggs in 2026. This increase was primarily associated with Least Tern, whose abundance rose from 32 to 60 nests, while American Oystercatcher declined from 23 to 13 nests. Fort Tilden (FT) remained comparatively stable, with 16 nests and 43 eggs in 2025 and 17 nests and 42 eggs in 2026. Similarly, Breezy Point Ocean Side (OS) maintained 32 nests in both seasons, although the number of eggs increased from 76 to 83. In contrast, Breezy Point Bay Side (BS) exhibited the lowest abundance, declining from eight nests and 23 eggs to five nests and 13 eggs. These patterns indicate that the peninsula-wide increase in nesting abundance was concentrated primarily at B, rather than being distributed uniformly among sectors.

The distribution of maximum recorded egg counts per nest showed additional differences among species, sectors, and breeding seasons (Figure 1). In 2025, nests containing one or two eggs were particularly frequent at B, largely reflecting the abundance of Least Tern and Common Tern nests. Three-egg records were predominantly associated with American Oystercatcher, particularly at B, FT, and OS, whereas four-egg records were associated exclusively with Piping Plover. At FT and BS, recorded egg counts were distributed across several categories, with American Oystercatcher and Piping Plover representing the principal species.

In 2026, two-egg records became substantially more frequent at B, coinciding with the increase in Least Tern nests from 32 to 60. Three-egg records also remained represented in this sector, with contributions from American Oystercatcher, Piping Plover, and Black Skimmer. At OS, the increased abundance of Piping Plover was accompanied by a greater frequency of four-egg records compared with 2025, while American Oystercatcher continued to contribute substantially to the two- and three-egg categories. FT maintained a broadly similar distribution of recorded egg counts, whereas BS exhibited fewer nests across the represented categories.

Despite these changes, the mean maximum recorded egg count per nest remained similar, decreasing slightly from 2.22 in 2025 to 2.19 in 2026. Species-specific means also varied: American Oystercatcher averaged 2.38 and 2.32 eggs per nest in 2025 and 2026, respectively, Least Tern averaged 1.66 and 1.71, and Piping Plover averaged 3.40 and 3.09. The similarity between annual means contrasts with the pronounced changes in species composition and

nesting abundance, indicating that the increase in total recorded eggs was primarily associated with the increase in nest numbers rather than a substantial change in the overall mean egg count per nest.

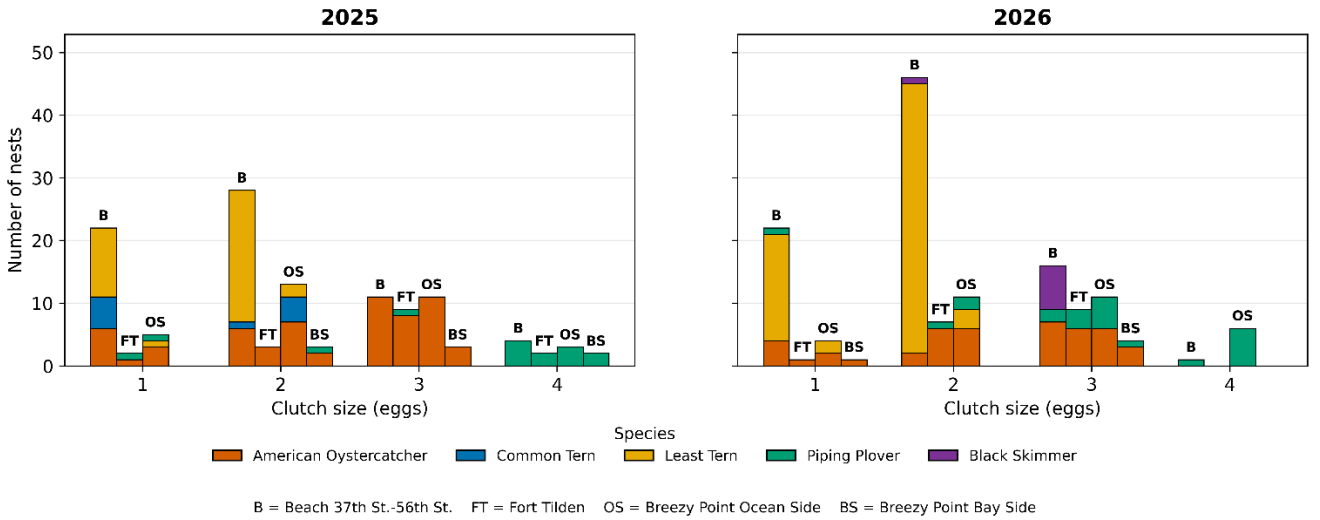

Figure 1. Distribution of maximum recorded egg counts per nest by species and study sector across the Rockaway Peninsula, New York, during the 2025 and 2026 breeding seasons. Stacked bars represent the number of nests within each egg-count category, with colors indicating bird species and labels above the bars identifying study sectors. Egg counts correspond to the maximum number of eggs recorded per nest during monitoring, rather than confirmed complete clutches.

Spatial Distribution and Site-Specific Nesting Patterns

Nest-location maps revealed contrasting spatial configurations among the four coastal sectors and differences in the representation of individual species between the 2025 and 2026 breeding seasons (Figures 2-5). These maps provide a descriptive comparison of recorded nesting locations within each study sector, complementing the interannual changes in abundance and species composition reported above.

Beach 37th-56th Streets (B). Nesting locations exhibited the most visually pronounced aggregation among the four sectors, primarily associated with Least Tern. In both seasons, Least Tern nests formed compact groups concentrated within the central portion of the beach, with a greater number of closely spaced nesting locations in 2026. In contrast, American Oystercatcher nests were distributed more broadly along the sector, extending across much of the mapped beach in both years. Piping Plover occurred at relatively few, spatially separated locations. Common Tern nests were recorded mainly toward the eastern portion of the sector in 2025, whereas Black Skimmer appeared in localized central and eastern areas in 2026. Overall, the mapped distributions show a persistent concentration of Least Tern nesting alongside a more dispersed distribution of American Oystercatcher.

Fort Tilden (FT). Nesting locations were distributed longitudinally along the narrow coastal strip, with American Oystercatcher and Piping Plover representing the only recorded species in both seasons. American Oystercatcher nests occurred across much of the sector, with noticeable gaps between groups of locations. Piping Plover nests were fewer and interspersed within the broader distribution of American Oystercatcher. Although individual nesting positions differed between years, the overall configuration remained relatively similar, consistent with the limited changes in nest abundance and species composition observed at this site.

Breezy Point Ocean Side (OS). Nesting locations followed a predominantly linear distribution along the shoreline, with American Oystercatcher occurring across much of the mapped sector in both years. However, the relative spatial representation of species changed between seasons. In 2025, American Oystercatcher accounted for most recorded nesting locations, while Piping Plover occurred at relatively few points. In 2026, Piping Plover nests were documented at more locations across the western, central, and eastern portions of the sector. Least Tern

remained represented by isolated nests or small groups, while Common Tern was recorded only in 2025. Thus, despite identical total nest counts in both seasons, the maps illustrate notable differences in the species occupying recorded nesting locations.

Breezy Point Bay Side (BS). This sector exhibited the sparsest and most discontinuous distribution of recorded nests. Nest locations occurred primarily toward the northern and southern portions of the narrow estuarine shoreline, while much of the central section had no documented nests. American Oystercatcher nests were spatially separated and occurred across different portions of the sector in both seasons. Piping Plover was recorded mainly toward the southern portion, with fewer nesting locations in 2026. Given the small number of nests in this sector, these patterns are interpreted descriptively.

Collectively, the maps highlight distinct spatial configurations across the peninsula, ranging from concentrated Least Tern nesting at B to longitudinally distributed nesting at FT and OS and sparse occupancy at BS. They also illustrate that interannual changes in nesting abundance did not necessarily correspond to equivalent changes in the locations or species represented within each sector.

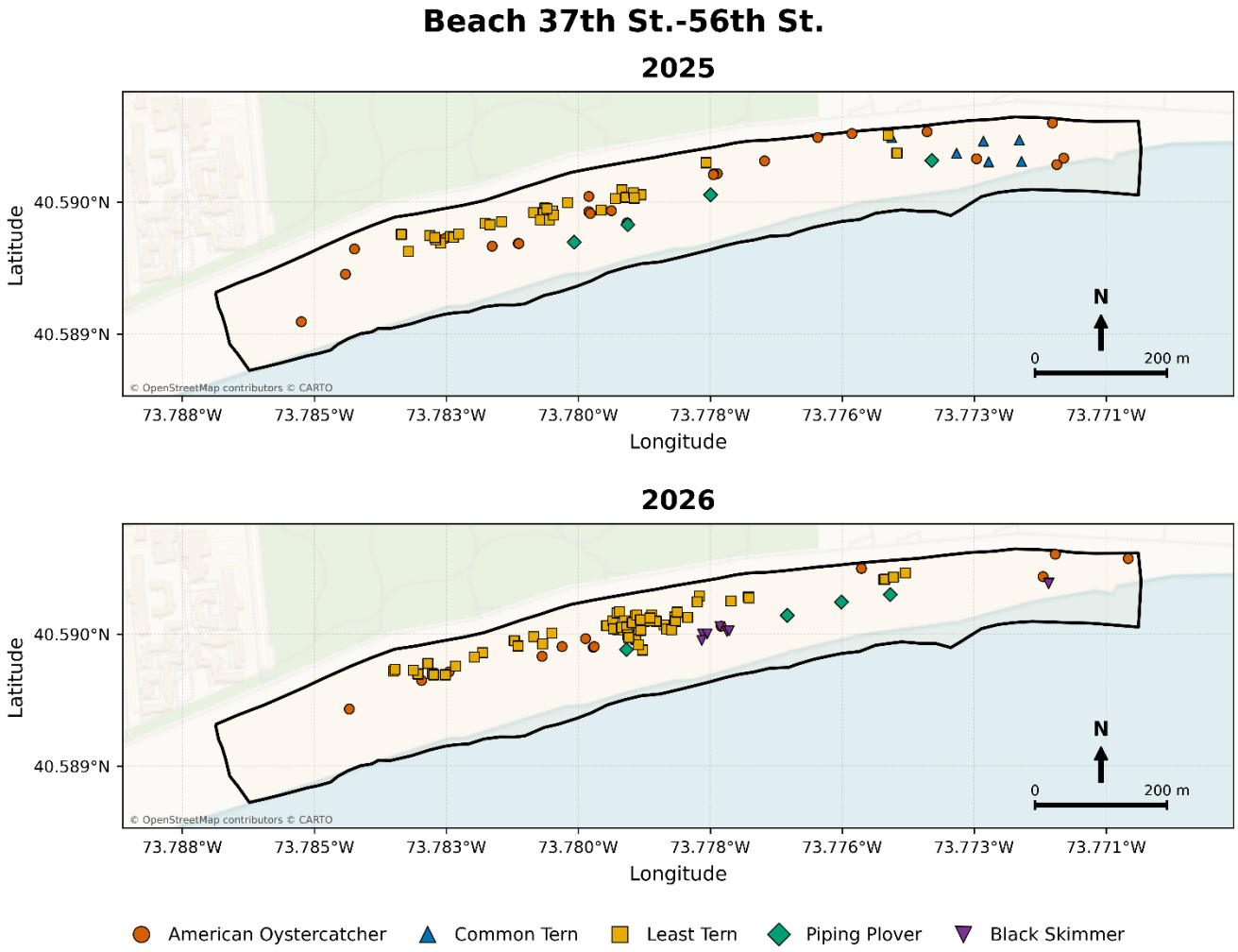

Figure 2. Recorded nest locations at Beach 37th St.-56th St. during 2025 and 2026.

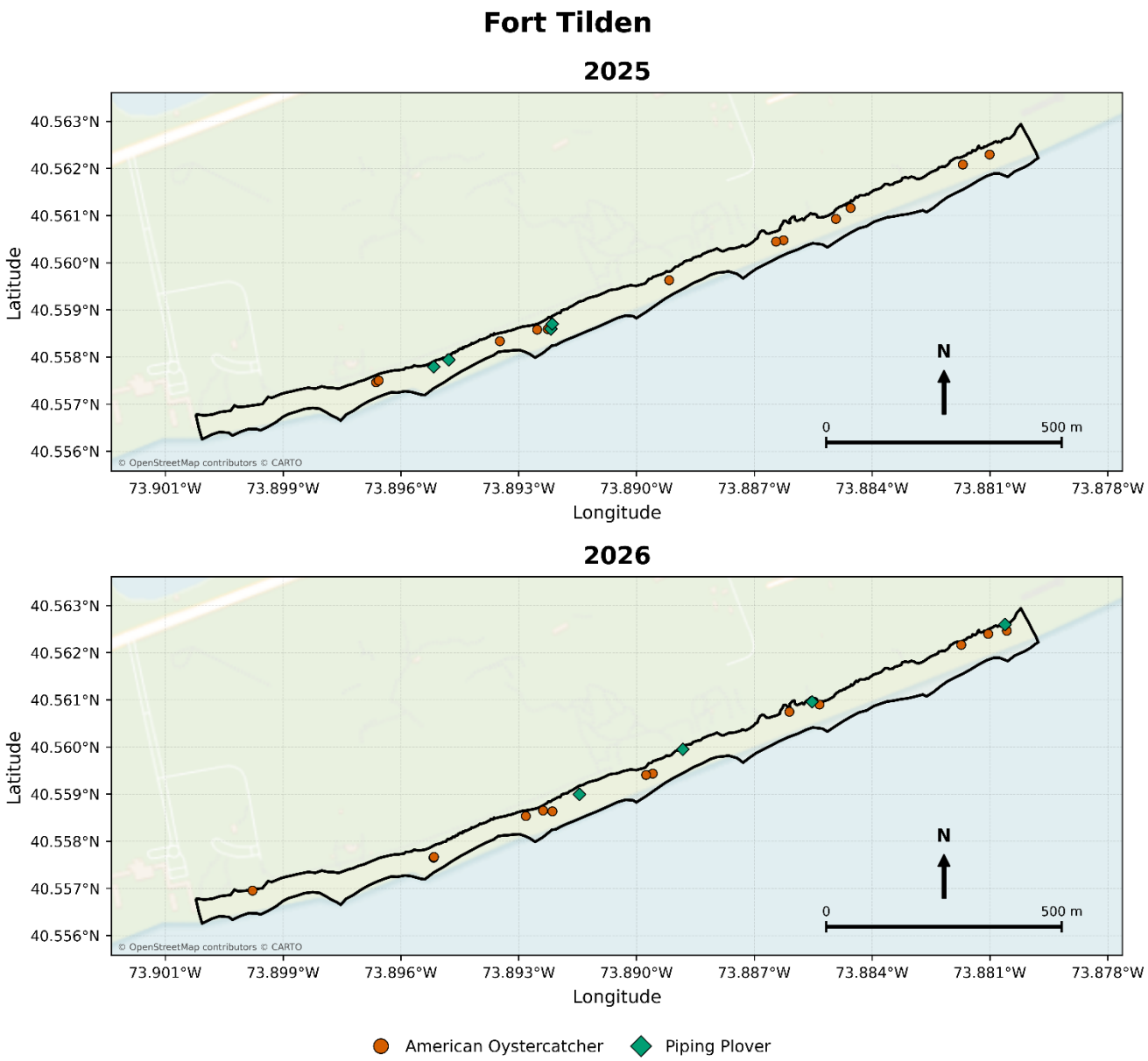

Figure 3. Recorded nest locations at Fort Tilden during 2025 and 2026.

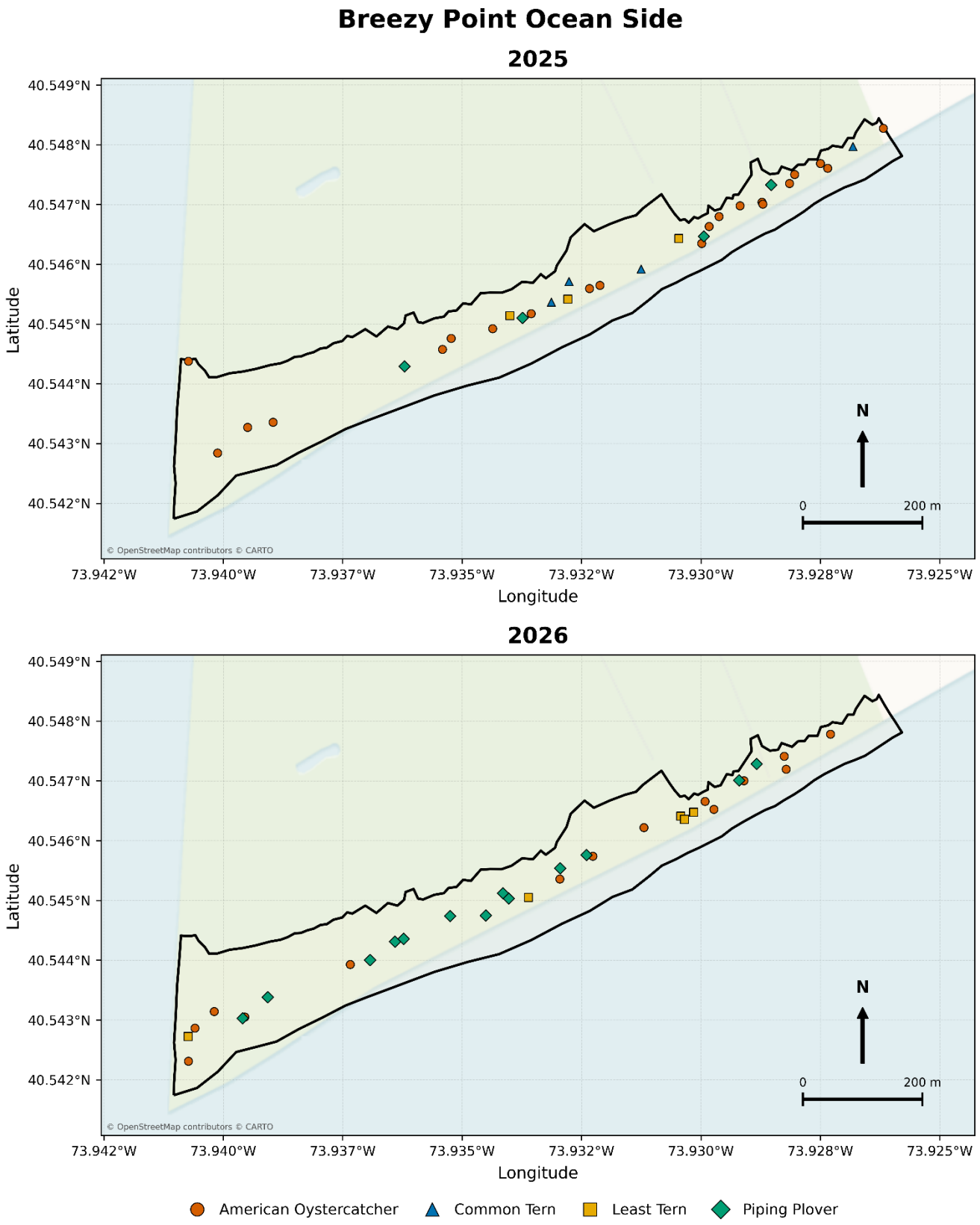

Figure 4. Recorded nest locations Breezy Point Ocean Side during 2025 and 2026.

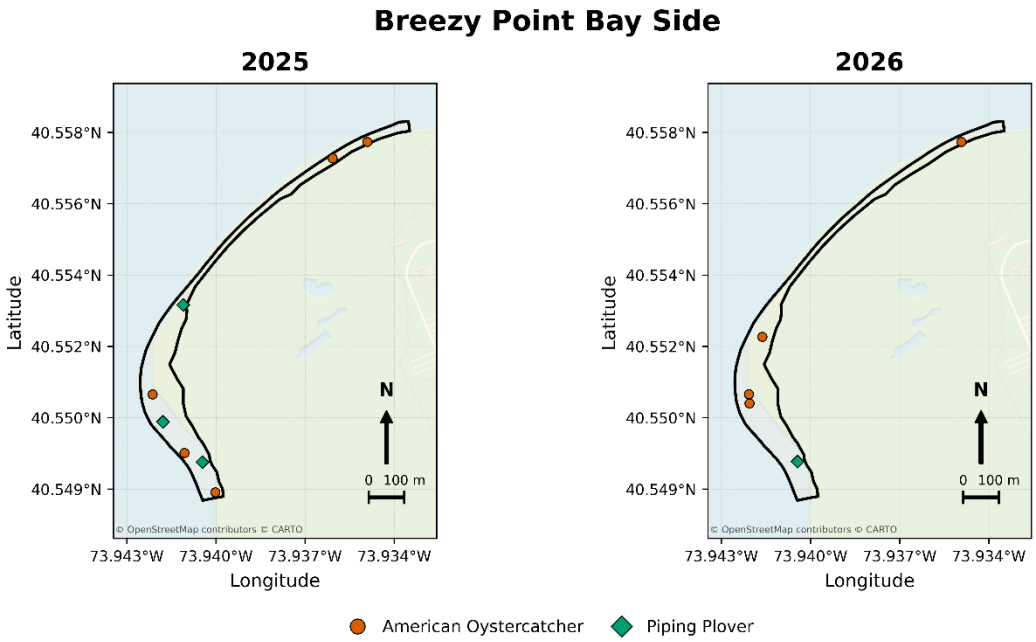

Figure 5. Recorded nest locations at Breezy Point Bay Side during 2025 and 2026.

Temporal Distribution of Maximum Recorded Egg Counts

The temporal distribution of maximum recorded egg counts varied among species, study sectors, and breeding seasons (Figure 6). Differences were particularly evident in the timing and magnitude of aggregated egg counts, with contrasting patterns observed across the four sectors. These temporal records complement the interannual comparisons of nesting abundance and spatial distribution by identifying dates on which the highest cumulative values of nest-level maximum egg counts were documented.

At Beach 37th-56th Streets (B), American Oystercatcher contributed maximum recorded egg counts across multiple observation dates in both breeding seasons, whereas Least Tern exhibited a more concentrated temporal pattern. In 2025, maximum recorded egg counts for Least Tern were distributed across several dates from late June through early August. In 2026, however, a pronounced concentration occurred in mid-June, when the summed maximum recorded egg counts of Least Tern reached their highest value, followed by lower values later in the season. Black Skimmer was also represented during the latter part of the 2026 monitoring period.

At Fort Tilden (FT), aggregated maximum recorded egg counts were comparatively low in both years and were associated exclusively with American Oystercatcher and Piping Plover. In 2025, the highest values for both species occurred around mid-May, followed by lower counts on subsequent dates. In 2026, American Oystercatcher remained the principal contributor, with the highest counts recorded early in the observation period. Overall, FT showed relatively limited temporal concentration compared with other sectors.

At Breezy Point Ocean Side (OS), temporal patterns differed markedly between years. In 2025, American Oystercatcher accounted for the highest summed maximum egg counts across several observation dates, while Least Tern, Common Tern, and Piping Plover were represented by lower values. In 2026, Piping Plover displayed a more pronounced temporal concentration, with a peak in late June. This pattern is consistent with the increased number of Piping Plover nests and their broader spatial representation in this sector during the second breeding season.

Breezy Point Bay Side (BS) exhibited the lowest aggregated maximum recorded egg counts and relatively few dates with observations. American Oystercatcher accounted for most of the maximum counts in both years,

whereas Piping Plover appeared less frequently and with lower values. No marked temporal concentration was evident in this sector.

Overall, the temporal distributions indicate that the timing and magnitude of maximum recorded egg counts differed among sectors and species. Particularly notable were the concentrated mid-season pattern of Least Tern at B and the increased late-June representation of Piping Plover at OS during 2026. These temporal results complement the interannual differences in nest abundance, species composition, and spatial distribution observed across the peninsula.

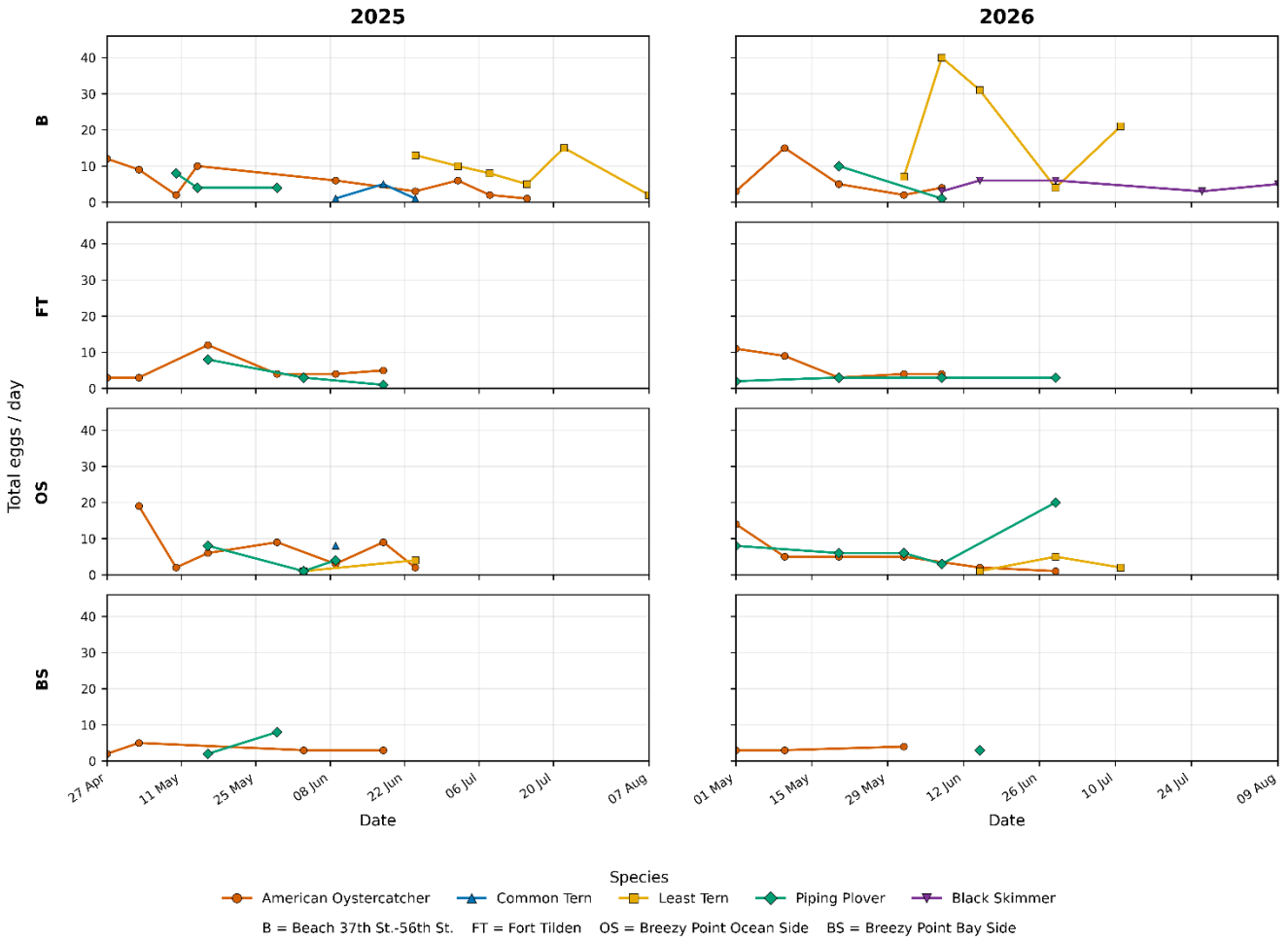

Figure 6. Temporal distribution of aggregated maximum recorded egg counts by species and study sector across the Rockaway Peninsula, New York, during the 2025 and 2026 breeding seasons. Columns represent breeding seasons, and rows represent the four study sectors. For each nest, the maximum recorded egg count was assigned to its corresponding observation date, and values were summed by date, species, and sector. Lines and symbols distinguish species. Values represent aggregated maximum egg counts rather than daily egg production.

Discussion

Interannual Changes in Nesting Community Composition

The comparison of the 2025 and 2026 breeding seasons revealed that a moderate increase in overall nesting abundance was accompanied by substantial changes in species composition. Although the total number of nests increased by 14.9%, this change was not uniform among species. American Oystercatcher was the most frequently recorded species in 2025, whereas Least Tern became dominant in 2026. Piping Plover also increased, while Common Tern was not recorded during the second season and Black Skimmer appeared in the 2026 records. These

observations indicate that changes in total nest abundance can conceal important differences in the relative representation of individual species.

Contrasting responses among species occupying shared coastal environments have been documented in previous research. Kwon et al. (2021), for example, reported different long-term population trajectories for Piping Plover and American Oystercatcher across two national seashores in North Carolina, demonstrating that species exposed to broadly similar environmental pressures may exhibit different population patterns. Although our study covers a much shorter period, the contrasting changes observed in Rockaway similarly emphasize the importance of examining species-specific records rather than relying exclusively on aggregate nest counts.

Changes in local nesting abundance may also occur in dynamic coastal systems where habitat conditions vary over time. Cohen et al. (2009) documented changes in Piping Plover nesting populations associated with storm- and human-related habitat modifications on Long Island, New York. Their findings provide a relevant regional context for interpreting variability in nesting records across barrier-island environments. However, the present study did not evaluate environmental drivers or reproductive success, and the observed changes cannot be attributed to particular habitat modifications or management actions. Likewise, the absence of Common Tern and appearance of Black Skimmer in the second-season records should be interpreted as changes in documented occurrence rather than permanent disappearance or colonization.

Contrasting Spatial Patterns Across Coastal Sectors

The four study sectors exhibited distinct spatial configurations and interannual changes. Beach 37th-56th Streets supported the largest number of nests and the greatest increase in abundance, primarily associated with Least Tern. In contrast, Fort Tilden maintained relatively stable abundance and composition, Breezy Point Ocean Side exhibited changes in species representation despite unchanged total nest counts, and Breezy Point Bay Side consistently supported relatively few nests. These differences indicate that the monitored sectors did not exhibit a uniform pattern of interannual variation.

Species-specific nesting behavior provides one possible ecological context for these contrasting spatial configurations. Baasch et al. (2017) found that Interior Least Terns preferentially selected nest sites near conspecifics, whereas Piping Plovers tended to avoid nesting near individuals of the same species. Palestis (2014) likewise emphasized the importance of colony-site selection, conspecific attraction, and dispersal behavior in tern ecology and conservation. These studies provide a useful framework for interpreting the visually concentrated Least Tern nests at B and the comparatively dispersed locations of other species. Nevertheless, the mapped patterns in Rockaway were assessed descriptively, and no formal spatial aggregation or nest-site selection analysis was conducted.

The persistent concentration of more than 90% of recorded Least Tern nests at B in both seasons identifies this sector as the principal documented nesting concentration for the species within the monitored area. Maslo et al. (2018) demonstrated that suitable nesting habitat and potential conservation benefits can differ among beach-nesting species, supporting the importance of considering species-specific habitat requirements. However, the concentration of nests at B does not establish that this sector provides higher-quality nesting habitat or greater reproductive success than other locations.

The changes observed at OS are particularly informative because total nesting abundance remained constant while the relative representation of American Oystercatcher and Piping Plover changed considerably. Previous research at Rockaway Beach has examined relationships between Piping Plover nest locations and reproductive success (Arndtsen 2022), demonstrating the local relevance of spatially explicit nesting information. Our findings extend

this descriptive perspective across multiple species and coastal sectors, illustrating that stable overall nest counts do not necessarily indicate stable community composition or nesting locations.

Species-Specific Egg Counts and Temporal Nesting Patterns

Maximum recorded egg counts per nest differed among species, although the overall mean remained similar between breeding seasons. Piping Plover exhibited relatively high recorded egg counts per nest, while Least Tern was predominantly represented by one- and two-egg records. These observations are broadly consistent with documented differences in reproductive characteristics among beach-nesting species. Cairns (1982), for example, reported that four-egg clutches predominated in a Piping Plover population in Nova Scotia, while Baker and Michael (1980) examined breeding schedules and clutch characteristics of American Oystercatchers in Virginia.

The relatively stable mean maximum recorded egg count, despite changes in the relative abundance of species, suggests that the increase in total eggs was associated primarily with the greater number of recorded nests. However, maximum observed egg counts do not necessarily represent complete clutches, particularly when nests were first detected at different stages of development. Therefore, these observations should not be interpreted as evidence of stable reproductive performance or nesting success.

Temporal records revealed additional variation among species and sectors. In 2026, Least Tern at B exhibited a pronounced concentration of maximum recorded egg counts around mid-June, while Piping Plover showed an increased late-June concentration at OS. These differences are consistent with the broader recognition that reproductive timing varies among species and nesting environments. Cohen et al. (2009) documented seasonal changes in Piping Plover clutch size and reproductive outcomes in coastal New York, illustrating the importance of considering timing when interpreting breeding records.

Nevertheless, the temporal patterns in our study reflect the observation dates associated with maximum recorded egg counts rather than actual egg-laying or nest-initiation dates. The magnitude of individual peaks also depends on the number of nests represented on each date. Consequently, the observed concentrations provide descriptive information about the temporal organization of monitoring records but cannot independently establish changes in breeding synchrony or reproductive phenology.

Conservation and Management Implications

The contrasting changes documented across the Rockaway Peninsula highlight the importance of maintaining species-specific and spatially differentiated nesting records. Monitoring based exclusively on total nest abundance could overlook important changes in species composition, particularly at sectors such as OS, where the overall number of nests remained constant despite substantial changes in the relative abundance of individual species.

This interpretation is consistent with Kwon et al. (2021), who demonstrated that sympatric beach-nesting shorebirds may exhibit contrasting population trajectories, and with Cohen et al. (2009), who documented differences in habitat-related population responses between nearby coastal sites. These studies reinforce the value of long-term monitoring that considers both individual species and local environmental context.

The persistent concentration of Least Tern nests at B suggests that this sector warrants continued attention within nesting monitoring programs. Palestis (2014) emphasized that tern conservation should consider colony behavior, site fidelity, and connections among breeding locations, rather than treating individual colonies as isolated units. Accordingly, maintaining observations across B and OS, the two sectors where Least Tern nests were recorded, could provide useful information on future changes in the distribution of nesting activity.

At the same time, the broader distribution of American Oystercatcher and Piping Plover nests supports continued monitoring across all four coastal sectors. Maslo et al. (2018) demonstrated that managing human disturbance can increase available nesting habitat for several beach-nesting species, although responses and potential benefits differ among species. The present study does not evaluate disturbance intensity or management effectiveness, but its descriptive baseline could support future studies investigating how nesting distributions relate to environmental characteristics and conservation measures.

Limitations and Future Research

This study was limited to two consecutive breeding seasons and provides a descriptive comparison rather than an assessment of long-term population trends. Although nest abundance, species composition, and spatial and temporal records differed between years, the environmental and demographic mechanisms underlying these patterns were not directly evaluated.

Spatial interpretations were based on mapped nest locations without formal point-pattern analyses, while temporal comparisons used maximum recorded egg counts assigned to observation dates rather than directly observed laying or nest-initiation dates. Furthermore, reproductive outcomes, including hatching success and chick survival, were not assessed. Differences in nest abundance among sectors may also reflect variation in the extent and availability of suitable nesting habitat, which was not standardized in the present analysis.

Continued monitoring over additional breeding seasons, combined with standardized habitat measurements and reproductive outcome data, would help distinguish recurring patterns from short-term variation and provide a stronger basis for evaluating the factors associated with nesting distributions. Such information could complement the present baseline and support future conservation assessments across this heterogeneous urban coastal system.

Conclusions

This study documented interannual variation in nest abundance, species composition, and spatial and temporal nesting patterns of beach-nesting birds across four contrasting coastal sectors of the Rockaway Peninsula during the 2025 and 2026 breeding seasons. Although overall nest abundance increased moderately, species-specific changes were more pronounced, including a shift in dominance from American Oystercatcher to Least Tern. These changes were not spatially uniform: Beach 37th-56th Streets supported the greatest nesting concentration and increase in abundance, Fort Tilden remained relatively stable, Breezy Point Ocean Side exhibited substantial compositional changes despite unchanged total nest counts, and Breezy Point Bay Side consistently supported fewer nests. Differences in maximum recorded egg counts and their temporal distributions further highlighted variation among species and sectors.

These findings demonstrate that changes in total nest abundance alone may not adequately represent variation within beach-nesting bird communities. Integrating species-specific nest counts, spatial distributions, and temporal records provides a more comprehensive characterization of nesting patterns across heterogeneous coastal environments. Although the two-year dataset does not establish long-term population trends or identify the environmental mechanisms underlying these differences, it provides a comparative baseline for continued monitoring. Maintaining species-specific and sector-level observations may help identify future changes in nesting communities and inform conservation planning and management assessments across the Rockaway Peninsula.

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