Atlantic Flyway Disturbance Project Phase II

• Biological Data Collection Report •

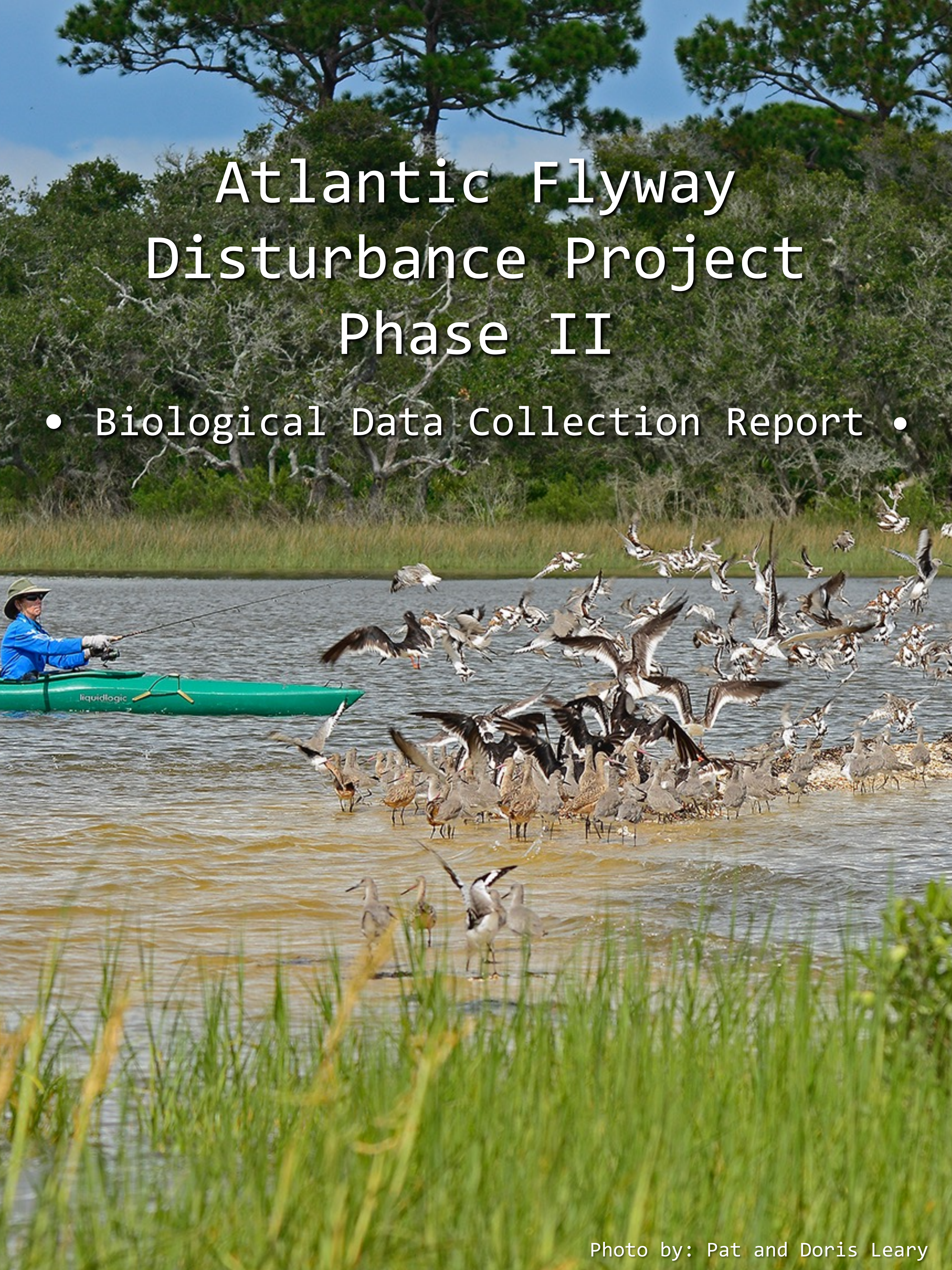

Photo by: Pat and Doris Leary

Report prepared by:

Daniel Gibson, Kelsi Hunt, Daniel Catlin (Virginia Tech Shorebird Program)

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With significant contributions from:
Walker Golder (National Audubon Society)
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EXECUTIVE SUMMARY

Background

Human disturbance is a significant threat facing shorebirds throughout the annual cycle, and threats to shorebird habitats may be exacerbated by increased human use (e.g., beach recreationists, off-leash dogs), reducing the amount of coastal habitat that is functionally available to shorebirds. We worked with partners across the Atlantic flyway to develop a standardized protocol for data collection to evaluate the effects of human disturbance on six Atlantic Flyway Shorebird Initiative (AFSI) focal species (American Oystercatchers [AMOY; *Haematopus palliates*], Piping Plovers [PIPL; *Charadrius melodus*], Red Knots [REKN; *Calidris canutus*], Sanderling [SAND; *Calidris Alba*], Semipalmated Sandpipers [SESA; *Calidris pusilla*], and Wilson's Plovers [WIPL; *Charadrius wilsonia*]).

Methods

Data collection for this project occurred in two phases. Phase 1 spanned from (November 2017–October 2018) and phase 2 from (March 2019–August 2020). Throughout the project, partners collected data at 52 sites from Nova Scotia to Florida. We chose sites with varying levels of potential perturbations and shorebird abundances. Point counts and behavioral samples were performed at these sites every 1–2 weeks. We also collected breeding season productivity data and broader, site-level information to categorize sites. Here, perturbations refer to a series of human-related actions or activities (e.g., dog walking, beach recreation) and correlated observations (e.g., presence of vehicles, predators) that were considered by stakeholders to potentially elicit a negative reaction (e.g., avoidance) from shorebirds.

To address the scale at which anthropogenic activities or perturbations (e.g., number of people, dogs, vehicles as well as predators of shorebirds or their nets varied and potentially impacted shorebirds, we developed a multi-scale analysis that explored how the 1) seasonal presence of a species or type of perturbation at a site; 2) the total number of individuals of each species or perturbations at each site during each survey; and 3) the distribution of individual birds or perturbations within each site conditioned on presence, varied across space and time, and ultimately the extent to which to the presence of specific perturbations influenced shorebird presence, abundance, or distribution across each spatial scale of inference. Additionally, in a second modelling framework, we assessed the extent to which the observed amount of each perturbation influenced shorebird behavior, which was conditioned on the recorded presence and within-site distribution of shorebirds.

Results

Anthropogenic perturbations were positively correlated with one another, which highlighted that sites with greater number of people would also have greater number of other perturbations. Sites that were more accessible to people (e.g., more parking, accessible by terrestrial vehicle) were more likely to be seasonally occupied by each type of perturbation. Sections of beach that were closed effectively reduced perturbations at the local- or point-scale, but the amount of beach closed to the public was not universally associated with reductions in the number of perturbations at a site. Closures, however, were associated with reductions in the number of dogs, vehicles, and predators on a beach. Most perturbations were more abundant during the peak of the Covid-19 pandemic relative to what was observed prior to the pandemic, as well as during the first two months of Covid-19 restrictions.

The seasonal site occupancy or presence of shorebirds at a site was not negatively associated with site perturbations. Similar to what was observed with perturbations, the number of each species of shorebird observed generally covaried with other species, meaning that sites that had greater abundances of one species were more likely to have greater abundances of other species, and vice versa. Although the individual impacts of specific perturbations (e.g., number of resting people, off-leash dogs) were not consistently supported to be associated with reductions in shorebird abundance, the combined impacts of people and dogs were negatively linked with the shorebird abundance. At the local, or point-scale, shorebirds strongly avoided certain perturbations, but the type of perturbations most associated with shorebird avoidance varied among species, with vehicles being the only perturbation associated with reductions in the presence of all shorebird species. At the point scale, all shorebird species preferred areas that were closed to the public. However, at the site-scale, only the temperate breeding species (i.e., PIPL, AMOY, and WIPL) that were present in the system year-round were more abundant at sites that had more sections of beach closed to the public. Shorebird behavior was also linked to perturbations; however, the perturbations most associated with shifts in shorebird behavior, and the type of behaviors affected, varied among species. All species were less likely to rest in the vicinity of vehicles, and more likely to be alert when dogs were nearby. However, behavioral responses to the presence of humans was mixed, with no clear pattern among species or behavioral responses. However, after controlling for the impacts of current perturbations that an individual shorebird was experiencing, shorebird behavior was supported to be different in areas that were closed to the public relative to open to the public, where most species were more likely to be found resting in closed areas relative to areas open to the public.

Future Directions

The protocol developed for this project provides a standardized way of measuring potential disturbances at a flyway scale, and they can be used as metrics to assess the success of any attempts to lessen disturbance, both the of occurrence of these activities and the response of shorebirds to any changes. The data presented here and collected throughout the two phases of the project provide a baseline measure of the abundance and distribution of potential disturbances, management strategies, and focal species. Finally, we are working to pair biological data collection and results with the findings from land manager surveys and interviews and surveys of dog walkers on selected beaches to inform the Community Based Social Marketing piece of this project. Using the data collected and the results from the 'Prioritizing Sites for Management,' we have worked with partners to choose both 'high' and 'low' disturbance sites for phase 3 of this project. In phase 3, partners will use the 'Guide to Applying Science and Management Insights and Human Behavior Change Strategies to Address Beach Walking and Dog Disturbance Along the Atlantic Flyway' to implement a community based social marketing campaign and we will continue to collect data to evaluate the effectiveness of these campaigns.

INTRODUCTION

Worldwide, shorebird populations are declining, with rapid declines reported for temperate breeding and coastal species (Brown et al. 2001). Habitats for shorebirds are being lost or degraded due to coastal alterations, including beach nourishment, inlet stabilization, sand mining, construction of dunes, groins, seawalls and revetments, and wrack removal, as well as potentially threatened by climate change through sea-level rise and changes in storminess (U.S. Fish and Wildlife Service 2012). In addition, threats to shorebird habitats are further exacerbated by increased human use (e.g., beach recreationists, off-leash dogs, off-road vehicles) that can reduce the amount of coastal habitat that is functionally available to shorebirds (Foster et al. 2009, Tarr et al. 2010).

Although many human activities are perceived by beachgoers as ecologically benign (Williams et al. 2009), disturbance by humans can affect shorebirds throughout their annual cycle. For breeding shorebirds, these effects include the exclusion or abandonment of otherwise suitable nesting or foraging habitat, crushing of nests or chicks, nest abandonment, exclusion of pre-fledged chicks from foraging habitats, reduced foraging rates, slow growth or reduced body mass of chicks, and reduced nest or chick survival (e.g., Flemming et al. 1988, Burger 1991, 1994; Patterson et al. 1991, Lord et al. 1997, Ruhlen et al. 2003, Weston and Elgar 2005, Colwell et al. 2005, Que et al. 2015, DeRose-Wilson et al. 2018). For non-breeding shorebirds, disturbance can result in reduced foraging time and efficiency, impacts to prey, exclusion or abandonment of otherwise suitable roosting and foraging habitat, and increased energetic costs, which together can reduce individual body condition, survival, or other fitness components, potentially leading to local population declines (e.g., Lafferty 2001, Thomas et al. 2003, Foster et al. 2009, Tarr et al. 2010, Schlacher et al. 2013, Burger and Niles 2013, Gibson et al. 2018)

Effectively managing the influence of human disturbance and other environmental variability on population demographic processes is a primary goal for natural resource managers. As a result, human disturbance has been recognized by the Atlantic Flyway Shorebird Initiative (AFSI; Threat 4.3; Strategy 2.3), shorebird researchers, and managers of important shorebird habitats as a significant threat facing shorebirds during breeding, migration, and winter. Furthermore, it is a threat that is likely to increase over time as more people inhabit the coastal zone and habitat declines as a result of development and sea level rise. Balancing public access and the needs of shorebirds will be imperative moving forward, as management of human use has the potential to greatly affect shorebird use, distribution, and demography.

To assess the effects of human disturbance on six focal species (American Oystercatchers [AMOY; *Haematopus palliates*], Piping Plovers [PIPL; *Charadrius melodus*], Red Knots [REKN; *Calidris canutus*], Sanderling [SAND; *Calidris Alba*], Semipalmated Sandpipers [SESA; *Calidris pusilla*], and Wilson's Plovers [WIPL; *Charadrius wilsonia*]) throughout the annual cycle, we developed a standardized protocol to collect data on potential disturbance types, shorebird distribution and abundance, shorebird behavior, breeding productivity, and management activities. We collected data at sites along the Atlantic Flyway that support breeding and non-breeding focal species, have different types and levels of human disturbance, and employ various human disturbance management techniques. The goals of this project were to:

1) develop a scalable, generalizable, standardized protocol to measure potential disturbances and their effects on shorebirds,
2) establish a baseline distribution and frequency of a suite of potential disturbances and disturbance mitigating measures during all seasons on the Atlantic Flyway,
3) assess the effects of these potential disturbances and management actions on the distribution, abundance, and behaviors of shorebirds,
4) to use these findings to help inform a concurrent effort to use Community Based Social Marketing to mitigate the potential effects of disturbance on the Atlantic Coast.

METHODS

Protocol Development

Beginning in October 2017, we worked with partners from Nova Scotia to Florida to develop a standardized protocol for data collection to evaluate the effects of human disturbance on shorebirds. We partly based the data collection protocol on previous disturbance work with SESA in the Bay of Fundy, as part of the 'Space to Roost' project (CEC 2017), and work conducted on shorebirds and disturbance during fall migration at USFWS refuges in the Northeast (Mengak et al. 2019). Following the initial development of the protocol, datasheets, and database, we had extensive discussions with partners before producing a final draft of the protocol and data collection materials. We focused on four types of data collection to provide information on the effect of potential human disturbance on the six focal species.

1. Point counts: Point counts served as the linkage between the frequency of human disturbance (perturbations) and shorebird demography and habitat use. By collecting human and shorebird use data simultaneously in specified locations, we can determine whether human activities directly impact fine-scale shorebird habitat use and local patterns in shorebird abundance.

2. Behavioral samples: Behavior data collected alongside point count data allowed us to understand the ecological mechanisms (e.g., altered feeding or resting regimes, habitat avoidance, etc.) that underpin human disturbance and shorebird population dynamics, which will better guide management decisions.

3. Productivity information: Reproductive activity and success data provided an opportunity to determine indirect associations between human use of shorelines and local production. In relation to ongoing management actions and human disturbances, these data also will allow us to determine the effectiveness of various management regulations on relative shorebird production.

4. Site information: Site information was used to classify the types and levels of human disturbances that are unique to a given site and to identify the similarities in experienced disturbance shared among monitored sites. This information will be used to identify the types of disturbances that may influence shorebird behavior and demography and will inform management objectives.

The first phase of data collection occurred from November 2017–October 2018 and the second phase of data collection occurred from March 2019–August 2020. Prior to phase 2, we made minor changes to the protocol based on lessons learned during data collection and analysis. The most notable change was adding SAND to the focal species included in data collection. During phase 1, focal species weren't often present in more disturbed areas, which resulted in proportionally fewer behavioral samples in these areas. Therefore, we believe that adding a species, such as SAND, that are perceived to be more disturbance tolerant, would result in more behavioral samples and further insight on how species react to potential disturbance.

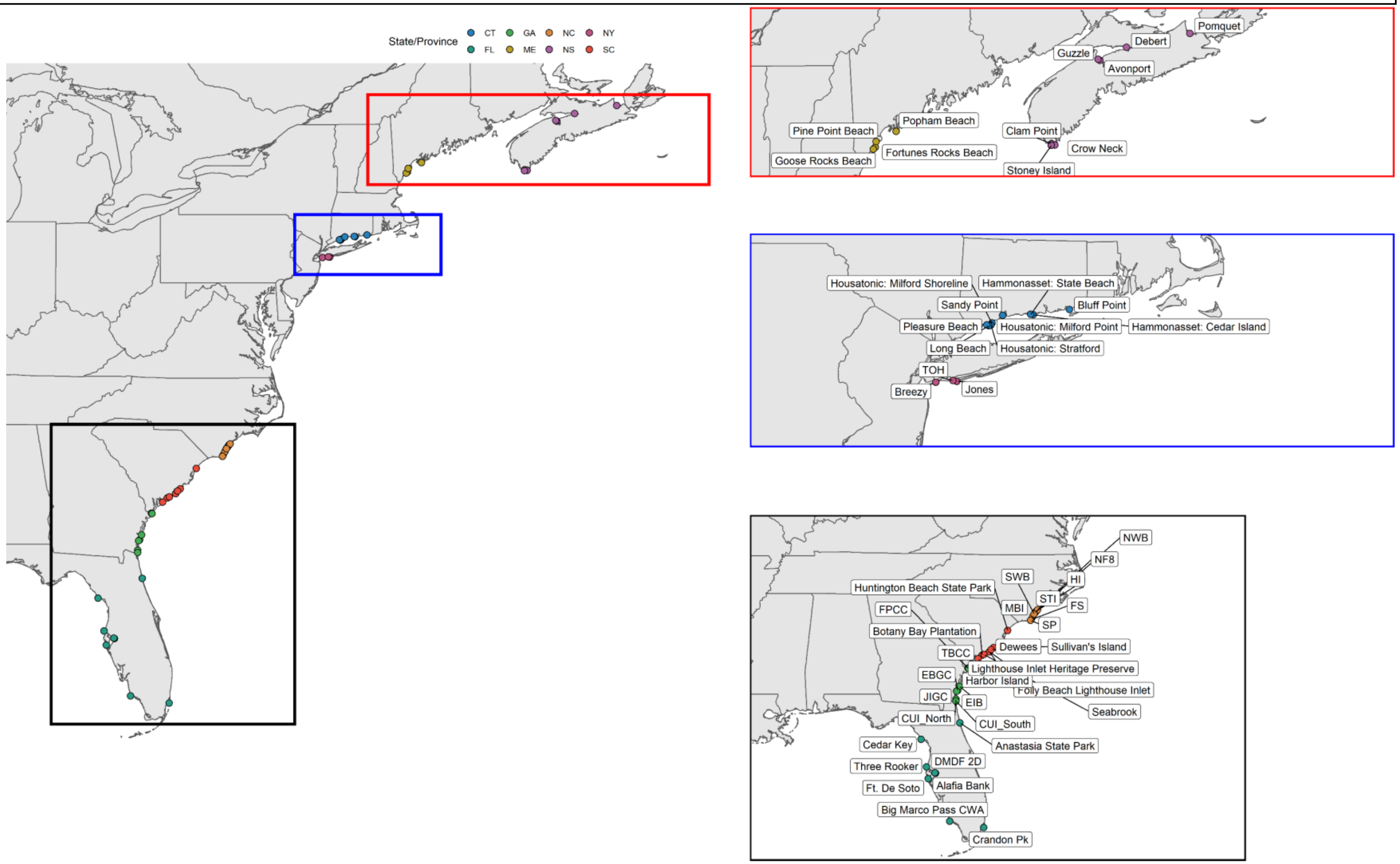
Study Area

We collected data at 52 sites from Nova Scotia to Florida (Table 1) from November 2017–October 2018 and March 2019–August 2020. We divided the year up into 'seasons' based on the shorebird annual cycle, which resulted in winter, spring migration, breeding season, and fall migration. As sites in this study represented a range of latitudes, the dates for each season varied depending on location and were decided on in consultation with the partners familiar with each site. Many sites that participated in the study collected data during more than one season, and this often varied by latitude as the more southern sites had birds present, or moving through their sites for a longer duration than sites further north.

Table 1. A summary of the number of sites along the Atlantic Flyway that participated in this study each season, from November 2017–October 2018 and March 2019–August 2020.

	Winter	Spring migration	Breeding season	Fall migration
Florida	5	4	8	4
South Carolina	5	3	5	5
North Carolina	4	5	8	5
New York	-	3	3	3
Connecticut	-	6	6	6
Maine	-	-	1	4
Nova Scotia	-	-	4	3
Total	**14**	**21**	**35**	**30**

Figure 1. A map of participating sites that have provided shorebird abundance and disturbance data. Colors indicate the state or province in which a particular site is located. Inset maps provide more detailed views of Maine and Nova Scotia (top right), New York and Connecticut (center right), and North Carolina, South Carolina, Georgia, and Florida (bottom left). Labels correspond with abbreviations and site delimiters created by data collectors.



Field Methods

We chose sites with varying levels of potential disturbance types and shorebird abundance. Once sites were selected, we chose fixed points at each site, that were at least 400 m apart, where point counts and behavioral samples were performed every 1–2 weeks. Due to COVID-19, data at most sites was collected less frequently during the 2020 spring migration and breeding seasons.

We recorded the time we arrived, the time of the first high tide that day, the temperature (°C), and the windspeed (km/hr) when entering the site at each survey. We then navigated to each point where we performed a point count followed immediately by one or more behavioral samples. When we arrived at the point, we waited 3 minutes to mitigate any potential observer disturbance and then performed a point count. During Each point count consisted of counting all focal species (AMOY, PIPL, REKN, SAND [only in phase 2], SESA, WIPL) and potential disturbance types (vehicles, boats, aerial disturbance, leashed dogs, unleashed dogs, people moving, people at rest, and predators) found within a 200 m radius of the observer. In addition, during phase 1, we recorded whether any of the 200 m radius fell within a closed area, including symbolic fencing or a larger area closed to the public. During phase 2 we recorded whether or not the 200m radius fell in an area completely closed to the public, partially closed to the public, or completely open to the public.

If during the point count, any of the focal species were located within the 200 m, we then performed 3-minute behavioral samples on one of each of the species immediately following the point count. During the 3-minute behavioral samples, we recorded the instantaneous behavior (mobile, alert, resting, foraging, flying, and out of site) of the individual every 10 seconds. We chose individuals for the behavioral samples randomly, such that if they were in a flock, we chose one near the center of the flock. If an individual left the area during the behavioral sample, we chose another individual if one was present. When we finished each survey, we recorded the time we left the site, the temperature (°C), and windspeed (km/hr).

During the breeding season we recorded productivity information for the focal, temperate-breeding species at each site. The productivity information focused on nest and brood success, if known. In addition to nest and brood productivity information, we also collected information regarding potential disturbance management techniques, including whether or not each nest was surrounded by symbolic fencing. Due to concerns regarding observer disturbance to nesting focal species as well as other beach-nesting species, behavioral samples were not performed or were performed at a much-reduced frequency during the breeding season.

In addition, we collected broad-scale, site level information. We recorded information about the site location and size, as well as landowner and manager information. We also recorded information that may influence potential disturbance at the site, including the number of pedestrian and vehicle access points, the nearest parking lot or boat ramp (km), whether or not dogs were allowed on the beach, and if beach raking, beach modifications, or major events occurred at the site. Finally, we recorded information on potential disturbance management at each site, including whether or not part or all of the site was open to vehicles and/or pedestrians, whether symbolic fencing was used, and if there were signs, monitors, and law enforcement at the site. **For data collection specifics, please see Appendix C for the standard operating procedures and datasheets used during this study.**

Analytical Methods

To address the scale at which anthropogenic activities varied and potentially impacted shorebirds, we developed a multi-scale analysis that explored how the 1) seasonal presence of a species or type of perturbation at a site; 2) the total number of individuals of each species or perturbations at each site during each survey; and 3) the distribution of individuals or perturbations within each site conditioned on presence, varied across space and time, and ultimately the extent to which to the presence of specific perturbations influenced shorebird presence, abundance, or distribution across each spatial scale of inference. Additionally, in a second modelling framework, we assessed the extent to which the observed amount of each perturbation influenced shorebird behavior, which was conditioned on the recorded presence and within-site distribution of shorebirds.

In regard to shorebirds, we focused on patterns in distribution and behavior of six species of shorebirds, three of which can be found breeding and overwintering within the study system (i.e., AMOY, PIPL, WIPL), and three of which breed in the high Arctic (i.e., REKN, SAND, SESA) and were, as a species, outside of our study system during periods of time throughout the annual lifecycle. Although individuals from each species migrated beyond the spatial confines of the study system during the non-breeding season, representatives of each species were observed during the non-breeding season within the study system.

Description of potential anthropogenic perturbations

In regards to the anthropogenic perturbations considered, we focused on patterns in the number of people and their possessions or activities (i.e., dogs, boats, terrestrial vehicles, aerial perturbations (e.g., kites, drones, low-flying aircraft) that were considered by land managers to be prevalent and both potentially manageable and detrimental to some aspect of shorebird conservation. Due to interest from land managers during the development of research protocols, people were classified as either active (e.g., walking, jogging, swimming) or resting (e.g., standing, lying down) and dogs were classified as either leashed (i.e., physically tethered to a person or fixed object) or unleashed (i.e., freely moving or only limited by voice control). Lastly, although not explicitly related to anthropogenic activities, we included observations of potential predators of shorebirds or their nests as a potential perturbation. Through this process, we were able to assess the extent to which both perturbations and shorebirds covaried amongst themselves, as well as the direct associations between perturbations and shorebird distributions and behaviors across the Atlantic Flyway.

Associations among potential perturbations and relative shorebird abundance

We determined the extent potential disturbances influenced relative shorebird abundance in a hierarchical modeling framework that independently assessed the environmental and anthropogenic conditions associated with the 1) seasonal occupancy; 2) site abundance; and 3) sub-site distribution of both perturbations and shorebirds across the study system.

Seasonal occupancy – The upper level of the model hierarchy focused on whether a series, *l*, of site-level characteristics influenced the absolute presence of each shorebird species, *m*, or type of perturbation, *p*, at each season-site combination, *k*, conditioned on perceived similarities in seasonal occupancy rates within each geographical region (i.e., states or provinces), *j*. The perturbation (equation 1) and shorebird (equation 2) models primarily differed in that the perturbation model was designed to assess the impact of physical descriptors of site conditions ($X_{l,k}$; i.e., amount of beach [size], number of pedestrian [p.acc] or vehicle [v.acc] access points, amount of parking, and whether the site was only accessible by boat) on the seasonal presence of each perturbation ($\Psi_{p,k}$), whereas the shorebird model assessed the extent to which the average amount of each type of perturbation ($P_{l,k}$) at each site influenced shorebird site occupancy ($\Psi_{m,k}$), in addition to a site latitude parameter (βLat) to account for seasonal shifts, *s,* in the geographical ranges of each species.

$$logit(\Psi_{p,k}) = l\_\bar{\Psi}_{p,j} + \beta_{p,l} X_{l,k} \quad (1)$$

$$logit(\Psi_{m,k}) = l_m + \beta_{m,l} P_{l,k} + \beta Lat_{m,s} Lat_k \quad (2)$$

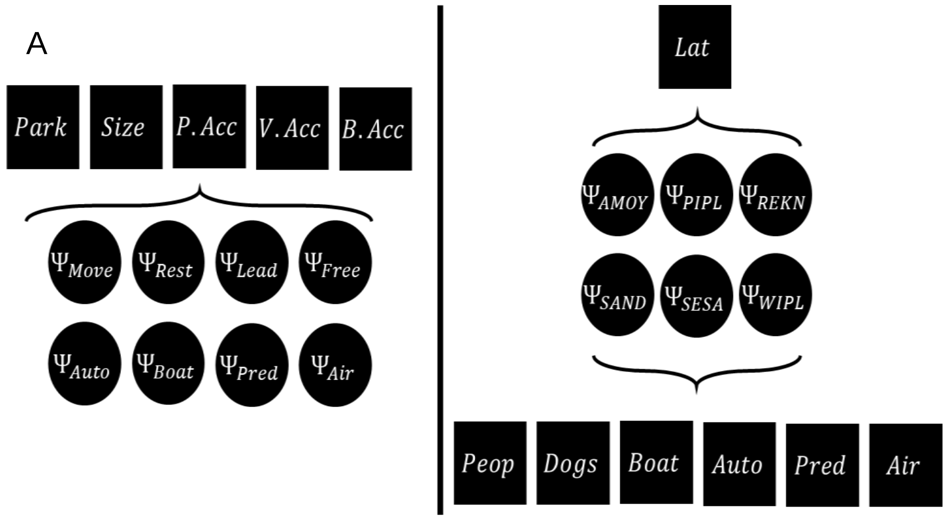


Figure 2. Schematic of the top-level of the abundance model hierarchy describing patterns in the seasonal occupancy (i.e., presence) of each monitored perturbation (A) and shorebird species (B) as a function of site-specific patterns in the inherent capacity of people to access a specific site (A) and the extent to which shorebirds were observed at a site as a function of perturbations (B). Brackets represent modelled directional relationships between each variable (closed end) and each estimated parameter (open end).

Relative site abundance – The next level in model hierarchy determined whether the relative abundance of each species or number of perturbations at a site during a specific visit, conditioned on the site being seasonally occupied, was influenced by shifts in environmental conditions, correlations with other shorebirds or perturbations, or temporal variation related to seasonal life history dynamics across the study system. The global abundance model was parameterized as a zero-inflated negative binomial regression (equation 3), in which the negative binomial count model represented the relative number, *N*, of each shorebird species, *m*, or perturbation, *p,* (*o* = *m* or *p)* observed at a specific site during a specific visit (i.e., site-visit, *i*), as a function of the relative abundance for each species or perturbation during a site-visit as a function of modeled variation in site conditions ($\bar{\lambda}_{o,i}$), a species-perturbation overdispersion term (θ), and the zero-inflation component for each species or perturbation was equivalent to the seasonal occupancy model (Ψ) at each season-site (equation 4). The linear model describing relative abundance term ($\bar{\lambda}_{o,i}$) included a species-perturbation specific intercept terms for each season, *l,* ($\beta_{0m,l}$) as well as modeled associations with observed environmental ($\beta c_o, \beta x_o, \beta p_o$) and latent ($\varepsilon T_m, \varepsilon S_m$) variation (equation 5), which are described in further detail below.

$$N_{o,i} \sim negBinomial(pN, \theta_o)$$
$$pN_{o,i} = \frac{\theta_o}{(\theta_o + \lambda_{o,i})} \quad (3)$$

$$\lambda_{o,i} = \bar{\lambda}_{o,i} \times \Psi_{o,k} \quad (4)$$

$$\bar{\lambda}_{o,i} = exp\left(\beta_{0m,l} + \beta c_m c_i + \sum_{x=1}^{X} \beta x_{m,x} x_{i,x} + \sum_{p=1}^{P} \beta p_{m,p}\, p_i + \varepsilon T_{m,w} + \varepsilon S_{m,i}\right) \quad (5)$$

The primary objective of this scale of analysis was to assess the extent to which variation in each perturbation type ($\beta p_{m,p}$) and the total impact of all perturbations (βD_m) were associated with the observed shorebird abundance as well as monitor the extent to which human perturbations and shorebirds responded to site management strategies (i.e., area closures; $\beta c_m c_i$), and the extent to which human use of the coastline varied during the Covid-19 pandemic ($\beta C_m C_i$). We used the proportion of point locations within each site that were currently opened to the public (c_i) during each survey as an index of the effect of management protections on relative abundance, which was fit as a time-varying covariate unique to each site-visit due to seasonal shifts in beach closures.

The total impact of all perturbations was implemented through the construction of composite variables through structural equation modeling (Grace et al. 2008), where composites represent the collective influence of multiple, but theoretically similar (e.g., numbers of dogs or people), variables on specified response (e.g., shorebird abundance). We grouped perturbations into one of two composites, which we will refer to as primary (D': People and Dogs) and secondary (D'': Cars, Boats, Aerial, Predators) disturbances, where these classifications were based solely on the objectives of the analysis and not the relative importance of specific perturbation on shorebird dynamics (equation 6). In short, each composite represented the species-specific responses (in abundance) to the summation of the constituent elements that comprised the composite variable (equation 6), which allows the original linear model (equation 5) to be re-written (equation 7) to simultaneously model the individual effects of each perturbation ($\beta p_{m,x}$), and the combined impact of all variables within a composite ($\beta_{m'};\ \beta_{m''}$). In the context of these data, these species-specific responses essentially can rank sites from those that exhibit the types and frequencies of perturbation associated with species-specific reductions in abundance to those that do not, which was one of the primary objectives of this project.

$$D'_{m,i} = \left(Rest_i + \beta p_{m,2} Move_i + \beta p_{m,3} Lead_i + \beta p_{m,4} Free_i\right) \quad (6)$$
$$D''_{m,i} = \left(Auto_i + \beta p_{m,6} Boat_i + \beta p_{m,7} Air_i + \beta p_{m,8} Pred_i\right)$$

$$\bar{\lambda}_{m,i} = exp\left(\beta_{0m} + \beta c_m c_i + \sum_{x=1}^{X} \beta x_{m,x} x_{i,x} + \beta_{m'} D'_{m,i} + \beta_{m''} D''_{m,i} + \varepsilon T_{m,w} + \varepsilon S_{m,i}\right) \quad (7)$$

As human activities and shorebirds may both respond to variation in the same environmental conditions ($\beta x_{m,x}$), the observed number of perturbations and shorebirds observed at any given location had the potential to covary with each other in the absence of a direct association between a specific perturbation-species combination. In other words, if the latent qualities associated with a specific site differentially impact the extent to which a human perturbation occurs relative to its use by shorebirds, a false association between the two entities may be supported by the model, which is counter to model objectives. To reduce the prevalence of this source of bias, we attempted to account for as much of the observed and latent variability within and among site conditions to improve our ability to infer direct patterns among site management, human perturbations, and shorebird abundance. To account for known sources of variation in the number of shorebirds or perturbations observed at a specific site, we included a series of visit-level covariates that were potentially associated with fine-scale temporal variation in both shorebird habitat use or human behaviors, which included 1) the time of day (in minutes); 2) temperature (in ℃); 3) wind speed (in km/hr); and 4) proportional tidal depth (TD), which ranged from 0 (slack tide) to 1 (high tide). We calculated TD for each survey by solving for the cumulative density function of a normal distribution (μ = 195 (minutes), σ = 65 minutes) based on the duration (in minutes) until/since the nearest high tide (range: 0 – 390 minutes), which sufficiently represented the distributional shape of tidal depths as a function of duration within a single tidal cycle. Temporal variation in relative abundance was modeled as a specific-specific random effect of week of year (*w*), which was drawn from a normal distribution, and represented flyway-level seasonal variation in the relative abundance in each species throughout the year.

$$\varepsilon T_{m,w} \sim normal(0, \sigma w_m) \quad (8)$$

Correlations among species – As our ability to quantify the primary environmental drivers of site abundances for each species was imperfect, we accounted for unmodeled heterogeneity in spatiotemporal variation in abundance ($\varepsilon S_{1:M}$) for each species as a function of how each species, *m,* covaried (ρ) with each of the five other species, *n*, respectively, across all site-visits, *i,* by accounting for similarities in abundances through a variance-covariance matrix ($\Sigma_{m,n}$; Riecke et al. 2019). In short, we assumed that the extent to which individual species responded numerically to the residual latent variation in site conditions were similar across sites, which would manifest itself as positive or negative correlations in the relative abundances between each pairwise group of shorebirds across sites and visits.

$$\varepsilon S_{1:M,i} \sim normal\left(0_{1:M}, \Sigma_{1:M,1:M}\right) \qquad (9)$$
$$\Sigma_{m,n} = \rho_{m,n} \times \sigma_m \sigma_n$$

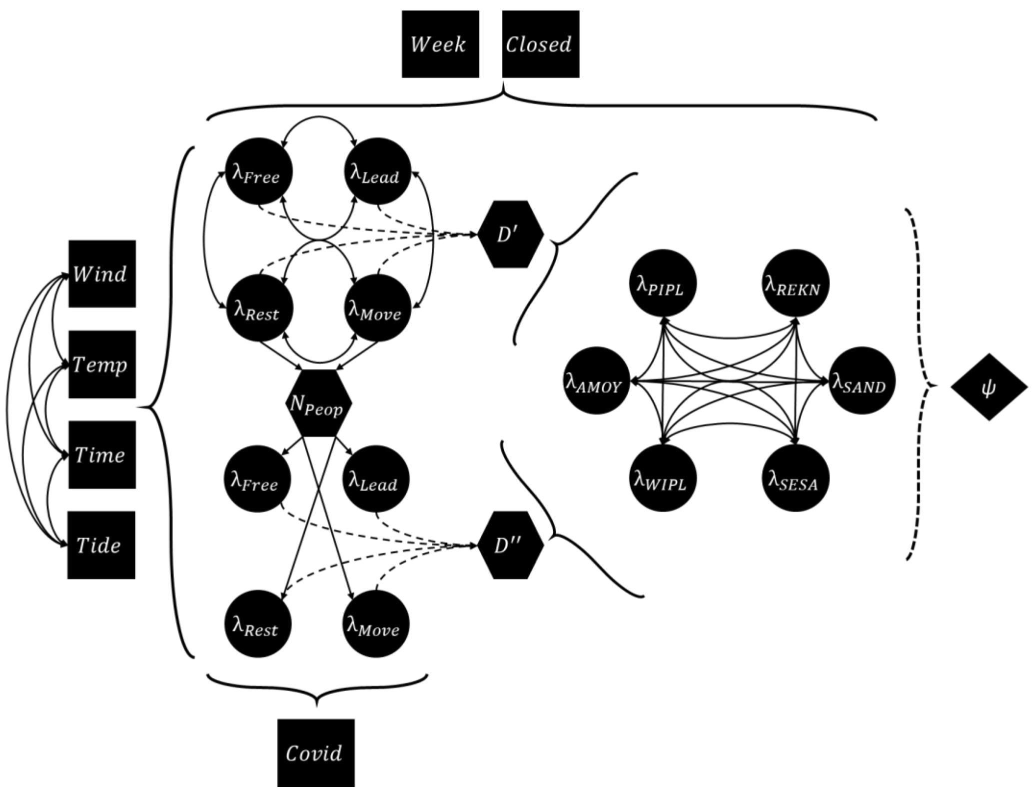
Associations among perturbations – We used a mixture of direct associations and correlations to model similarities in the relative abundances of perturbations among sites within this study system. We allowed the primary perturbations of interest (equation 10) active and resting people; as well as leased and unleashed dogs to covary with each other similar to the shorebird model. However, we constrained each of the secondary perturbations (i.e., vehicles, boats, aerial disturbances; and predators; equation 11) to only be unidirectionally influenced (βh_p) by the total number of people (active or resting) observed.

$$People|Dogs\ \bar{\lambda}_{p,i} = exp\left(\beta_{0p} + \beta c_p c_i + \beta C_p C_i + \sum_{x=1}^{X} \beta x_{p,x} x_{i,x} + \varepsilon T_{p,i} + \varepsilon S_{p,i}\right) \qquad (10)$$

$$Other{:}\ \bar{\lambda}_{p,i} = exp\left(\beta_{0p} + \beta c_p c_i + \beta h_p (H_i) + \beta C_p C_i + \sum_{x=1}^{X} \beta x_{p,x} x_{i,x} + \varepsilon T_{p,i}\right) \qquad (11)$$

Like the species abundance models, the models describing variation in site perturbations were constrained to be influenced by the same local environmental conditions (i.e., wind, temperature, time of day, proportional tidal depth; $x_{i,1:X}$), the proportion of the beach opened to the public (c_i), and broad-scale temporal variation ($\varepsilon T_{p,i}$), and were parameterized with identical, but independent prior conditions. The only novel parameter included in the perturbation model was the parameter that assessed the extent to which the relative abundance of each perturbation varied as a function of closures or lack thereof during the Covid-19 pandemic. This was treated as a group-level effect in which each site-visit was assigned to be either 1) completed prior to the widespread arrival of Covid-19 to North America (before March 1st 2020); 2) completed during the early stages of the Covid-19 pandemic (between March 1st-April 30th, 2020) or at a site that implicitly or explicitly informed restrictions to site access throughout the summer of 2020; and 3) completed after May 1st at a site in which access restrictions did not exist or were not enforced.

Figure 3. Schematic describing of the direction information was allowed to travel through the middle level of the abundance model hierarchy, which represented the relative site abundance of a shorebird or amount of a perturbation observed during a survey (circles). The model allowed variation in site conditions (squares) to influence the relative amount of each perturbation, which were both allowed to influence the relative abundance of each shorebird species, conditioned on the higher-level seasonal occupancy (diamond) of each perturbation and species. Hexagons are parameter composites, which represent the collective impacts of each of constituent parameter (types of perturbations) on a response (shorebird abundance). Solid brackets represent modelled directional relationships from each variable (closed end) to all downstream parameters (open end), whereas dashed brackets represent a directional relationship between a higher-level (i.e., site-occupancy) and lower-level parameter (i.e., abundance) of only the same type (i.e., a specific species or perturbation). Bi-directional, curved arrows represent modeled correlations, whereas straight lines present unidirectional relationships or constraints.



Within-site distribution – The bottom-level of model hierarchy in the abundance model explored patterns in how shorebirds or perturbations were distributed across points within each site as a function of current, local-scale conditions (e.g., nearby human activity, point closures), conditioned on their presence during each survey. The within-site distribution model was parameterized as a zer0-inflated multinomial regression (equation 12), in which the observed counts, *y*, of each species or perturbation, *o*, at each point, *j,* associated with each survey of a site, *i,* was the realization of a multinomial distribution conditioned on a vector of probability weights ($\pi_{o,i,1:J}$) scaled to sum to 1 that represented the relative proportion of the total number of individuals of each type counted during an entire survey ($N_{o,i}$) that were observed at each point during each survey, where $N_{o,i}$ was equivalent to the overall site abundance parameter described in the previous sub-model.

$$y_{o,i,j} \sim \begin{cases} 0, & N_{o,i} = 0 \\ dmulti(\pi_{o,i,j}, N_{o,i}), & N_{o,i} > 0 \end{cases} \qquad (12)$$

$$\pi_{o,i,j} = \frac{\pi'_{o,i,j}}{\sum(\pi'_{o,i,1:J})}$$

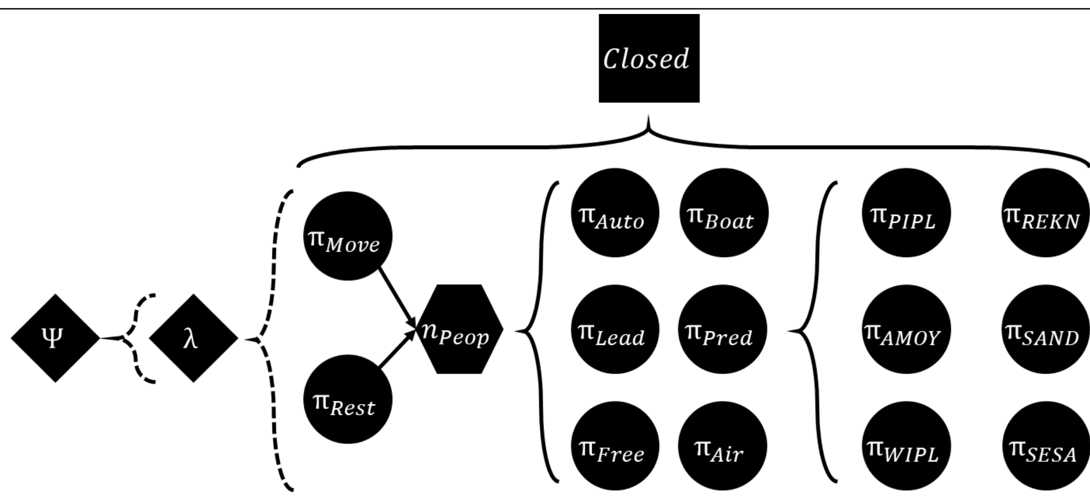
The multinomial logit model (equation 13) that described the distributions of shorebirds or perturbations included a species or perturbation specific intercept, $\bar{\pi}$, a beta coefficient describing the impact of whether each point was closed or opened to the public ($\beta_{o,c}$), and random error ($\varepsilon_{o,i,j}$), which was drawn from a normal distribution centered on zero with a species or perturbation specific error term (σ_m) and accounted for the residual uncertainty in the within-site distribution of individuals among site-visits.

$$\pi'_{o,i,j} = \begin{cases} = exp\left(\bar{\pi}_o + \beta_{o,c}c_i + \left(\sum_{p=1}^{P} \beta_{o,p}p_{p,i}\right) + \varepsilon_{o,i,j}\right), & o = shorebirds \\ exp(\bar{\pi}_o + \beta_{o,c}c_i + \varepsilon_{o,i,j}), & o = people \\ exp(\bar{\pi}_o + \beta_{o,c}c_i + \beta_o p + \varepsilon_{o,i,j}), & o = other\ pertubation \end{cases} \qquad (13)$$

At the point-scale, closures were recorded categorically as whether a specific area surveyed was currently considered as closed or open to the public, which prompted the use of a group-level covariate in which the ‘open’ classification was considered as the reference category. However, survey methods changed during the study to better facilitate conservation interests, therefore there were multiple classifications of ‘closure’, which included 1) the 200 m radius around point was completely closed to the public (Complete); 2) the 200 m radius around point was only partially closed to the public (Partial); and 3) the 200 m radius around a point was at least partially closed, but the survey was conducted prior to specifically reporting the extent to which a point was closed (Mixture), in which the final classification most likely consisted of a mixture of complete and partial closures.

The primary difference between models that described the within-site distribution of shorebirds, people, and other perturbations was the extent to which each feature was allowed to vary as a function of the current number of perturbations at the point. We constrained each of the shorebirds models to vary as a function ($\beta_{m,p}$) of the amount of each perturbation counted at the same point during the same survey ($P_{p,i}$), which was z-standardized to improve inference. However, for the perturbation models these parameters were omitted for the models describing the within-site distributions of people (active of resting), and we only considered the impact of all people on the within-site distributions for each of the other perturbations (i.e., leashed and unleashed dogs, vehicles, boats, aerial disturbances, and predators). Thus, these models were focused on understanding the extent to which shorebirds locally responded to variation in the local abundance of all perturbations, as well as the extent to which other perturbations varied as a function of the total number of people observed nearby, but assumed that people were the causal agent for these other features and were not influenced by the local abundance of shorebirds or other perturbations.

Figure 4. Schematic describing of the direction information was allowed to travel through the lowest level of the abundance model hierarchy, which represented the within-site distribution of a shorebirds or perturbations observed across points during a single survey (circles). The model allowed variation in point-level conditions (square) to influence the relative distribution of each perturbation, which were both allowed to influence the relative distribution of each shorebird species, conditioned on the higher-level estimates of seasonal occupancy and site abundance (diamonds) of each perturbation and species. Hexagons represent a parameter construct, which in this case was the sum of two modeled parameters. Solid brackets represent modelled directional relationships from each variable (closed end) to all downstream parameters (open end), whereas dashed brackets represent a directional relationship between higher-level (i.e., site-occupancy & relative abundance) and lower-level parameters (i.e., site distribution) of only the same type (i.e., a specific species or perturbation). Straight arrows represent unidirectional relationships or constraints.



Behavioral Model

Given that data that described variation in shorebird behavior was conditioned on the presence of shorebirds, we developed an independent model to explore the patterns and drivers of shorebird behavioral responses to human activities on the coastline as opposed to vastly increasing model complexity to include in a single likelihood. However, the environmental characteristics, perturbations, and shorebirds considered in this analysis, in addition to the general approach to inference was very similar to the relative abundance model, and to an extent, redundant as certain features needed to be included in both models to account for the same potential sources of confounding. Here, we used a multinomial regression model to determine the extent to which local perturbations and other environmental conditions influenced the relative proportion of time a surveyed individual shorebird was observed to be 1) alert; 2) foraging; 3) in flight; 4) moving (on the ground); relative to 5) engaging in self maintenance (e.g., sleeping, preening, or otherwise inactive). The sampling period of a single behavioral survey, Z_i, consisted of an observation, *j*, that classified what instantaneous activity a shorebird was engaging in every 10 seconds for 3 minutes, which resulted in a maximum of 18 behavior observations, *z*. However, this number of observations was conditioned on the individual remaining visible within the spatial confines of the survey point (i.e., ~200 m radius around the observer), thus certain samples may consist of fewer observations. Similar to π in the within-site distribution model, Ω represented a vector of probability weights that summed to 1.0 that described the proportion of total behavioral observations with a single sample, *Z*, assigned to each behavioral phenotype and *z* represented the frequency each specific behavior was observed.

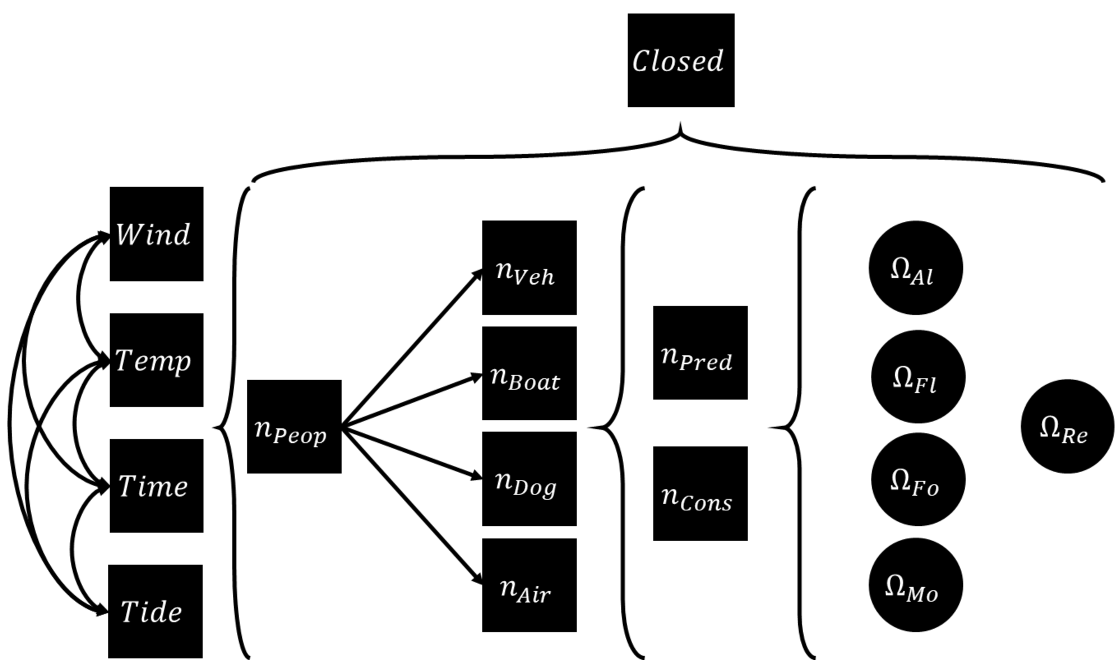
$$z_{m,i,j} \sim dmulti\left(\Omega_{m,i,j}, Z_{m,i}\right)$$
$$\Omega_{m,i,j} = \frac{\Omega'_{m,i,j}}{\sum\left(\Omega'_{m,i,1:J}\right)} \quad (14)$$

The multinomial-logit model (equation 15) that described the observed distribution of behaviors within a sample considered the impact of 1) whether a sample occurred within an area that was closed or open to the public (βc); 2) the relative number of conspecifics observed in the same sampling area as the sampled individual (βnc); 3) survey-level environmental conditions (e.g., temperature, wind speed, time of day, tidal depth; βx); 4) the relative number of each perturbation (i.e., people, dogs, vehicles, boats, and aerial disturbances; βnp) observed in the same sampling area as the sampled individual; and 5) species and behavior-specific intercept ($\bar{\Omega}$) and error (ε) terms.

$$\Omega'_{m,i,j} = exp\left(\bar{\Omega}_{m,j,s} + \beta c_{m,j} c_i + \beta nc_{m,j} n_i + \sum_{x=1}^{X}\left(\beta x_{m,j} x_i\right) + \sum_{p=1}^{P}\left(\beta n_{m,p} n_{p,i}\right) + \varepsilon_{m,j,i}\right) \quad (15)$$

Point closures were considered a known quantity and included into the model as time-varying sample-level covariate, which separated behavioral samples into two categories, those occurring in an area closed to the public and those occurring in area open to the public. All other survey (e.g., weather conditions) and sample-level (e.g., number of perturbations or conspecific abundances) variables were modeled as random variables, each informed by their own linear model (Fig. 5). Similar to the abundance model, the z-standardized survey-level weather conditions were considered to the realization of a multivariate normal distribution centered on zero with a variance-covariance matrix, Σ, in which its individual components, σ and ρ, were individually parameterized.

Figure 5. Schematic describing how current environmental and site conditions (squares) were modeled to influence the number of perturbations or conspecific abundances observed at a point, which were each allowed to influence shorebird behavior (Ω). Brackets represent modelled directional relationships from each variable (closed end) to each downstream parameter (open end), curved arrows represent modeled correlations, and straight lines present unidirectional relationships or constraints.



The linear models (equation 16) describing the amount of each perturbation or conspecific abundance within the sampling area during each behavioral sample were represented by three similar linear models, in which the 1) number of people considered the effect of whether the surrounding area was closed to the public and survey-level environmental conditions; 2) the amount of other perturbations considered the effect of the number of people in addition to point closures and environmental conditions; and 3) number of predators and conspecific abundances for each shorebirds considered the effect of each of the other perturbations, in addition to the number of people observed and environmental conditions.

$$\bar{n}_{s,k} = \begin{cases} \bar{\mu}_k + \beta_k C_s + \sum_{x=1}^{X} \left(\beta_k x_{s,x,}\right), & k = people \\ \bar{\mu}_k + \beta_k C_s + \sum_{x=1}^{X} \left(\beta_k x_{s,x,}\right) + \beta_k p_s, & k = dogs\ veh, air, boat \\ \bar{\mu}_k + \beta_k C_s + \sum_{x=1}^{X} \left(\beta_k x_{s,x,}\right) + \sum_{p=1}^{P} \left(\beta_k p_{s,p}\right), & k = predator\ or\ shorebird \end{cases} \quad (16)$$

Nest Success Model

Given the scale of data collection and minor inconsistencies among partners, species, and years, we analyzed the nest success data for two species (AMOY and PIPL) at the site-scale using a binomial regression, where the proportion of nests that were successful, *p*, for each species, *s*, at each site, *i*, was the outcome of a binomial model based on the total number of nests for each species found, *nests,* and hatched, *hatch*, at each site during each year. The linear model describing spatial variation in nest success was informed by a series of binary and continuous explanatory variables that explored whether broad-scale patterns in nest success were associated with patterns in human activities or protective measures. The continuous variables used for this analysis were the average number of 1) people (*P*); 2) dogs (*D*); 3) vehicles (*V*); and 4) predators (*PR*) observed during the nesting season at each site; as well as 5) the average proportion of points within each site that were closed to the public. The binary variables used were 1) whether the area around the nest site was closed, *CL*, to either a) vehicles, or b) pedestrians and vehicles; 2) whether the nest was a) covered, *EX*, by a nest exclosure; or b) not; and 3) the year, *YR,* of the study.

$$hatch_{s,i} \sim binomial\left(p_{s,i}, nests_{s,i}\right) \quad (17)$$
$$logit(p_{s,i}) = \bar{p}_s + \beta_{CL,i} + \beta_{EX,i} + \beta_{YR,i} + \beta_{P,i} + \beta_{D,i} + \beta_{V,i} + \beta_{PR,i} + \beta_{OP,i}$$

Model diagnostics

We specified each model using the Nimble package () within R (R Core Team 2012) For each model, we ran three chains of 150,000 iterations (thin = 2) with a burn-in period of 50,000 iterations. We interpret support for associations between disturbance variables and species presence, abundance, and behavior by whether the distribution of the posterior of a particular parameter was separate from zero using 90% highest posterior density intervals (HPDI). All explanatory variables were z-standardized to allow for direct comparison among them. If not explicitly mentioned otherwise, each beta coefficient was modeled as a hierarchical random slope in which the modeled effect between a specific environmental characteristic or perturbation (*z*) and either the relative amount of a specific shorebird or perturbation, or shorebird behavior (*o*) was drawn from a normal distribution described by a global mean ($\bar{\beta}_z$) and variance (σ_z), which represented the central tendency in which all species (or perturbations) responded to the same environmental characteristic or perturbation.

Presentation of Analytical Results

Although we prioritized consistency in how model results were presented, certain models and model output were often easier to interpret in slightly different fashions. The primary inferential approaches in the presentation of results were the following: 1) regression or slope coefficients (β); 2) correlation coefficients (ρ); 3) odds-ratios (OR); and 4) the percent change (PC), which are each derived from a common estimator. Slope (β) coefficients represent the observed change in response variable, *y*, per standard deviation change in the predictor variable, *x*. Correlation coefficients, ρ, represents the strength of the linear relationship between *x* and *y*, and can be derived by the following formula.

$$\rho = \beta \times \frac{sd(x)}{sd(y)}$$

Odd-ratios represent the proportional change in *y* given a standard deviation shift in *x*, and are derived by exponentiating β (e.g., exp($\beta = 0.5) \approx 1.64$, which would be interpreted as a standard deviation increase in *x* being associated with an 1.64 times increase in *y*). Lastly, the percent change is functionally similar to odds ratios but presents inference as a percent change as opposed to a proportional change (e.g., $\beta = 0.5$ = OR =1.64 = PC = 164% increase in *y* per standard deviation increase in *x*).

RESULTS

Summary of Data Collection (to date)

Participants collected 10,523 point counts (phase 1: 5,722; phase 2: 4,801), 3,464 behavioral samples (phase 1: 1,436; phase 2: 2,028), and monitored 552 nests/broods (phase 1: 347; phase 2: 205) at 52 sites throughout 8 states and provinces since the inception of this project (Table 2). **For additional site summary information as well as summaries of disturbances and shorebird abundances, please see Appendix B.** Data received by January 31, 2021 was analyzed and included in the following results.

Table 2. Point counts and behavioral samples collected each season at fixed points along the Atlantic Flyway from November 2017–October 2018 and March 2019–August 2020, as well as nests monitored during the breeding season.

	Winter	Spring migration	Breeding season[a]	Fall migration	**Total**
Point counts	1466	1716	4263	3078	**10,523**
Behavioral samples	649	851	546[a]	1418	**3464**
Nests monitored	-	-	552	-	**552**

[a] Due to potential observer disturbance to nesting focal species and other beach nesting species, behavioral samples were performed less frequently during the breeding season.

Descriptive Results

Variation in observed potential disturbances throughout the study system

Based on the raw data, within-site closures appeared to be far more prevalent during the breeding season (Fig. 6A) relative to the other seasons, which suggests that a shorebirds access to 'disturbance-free' areas may be limited for most periods of the year. Although there were generally more people observed during the breeding and fall seasons (Fig. 6B) relative to the spring and winter seasons, there were sites that consistently had large congregations of people throughout the year. Dogs were slightly less prevalent during the breeding season (Fig. 6C) relative to the rest of the year, which indicate that projected interested in limiting shorebird-dog conflicts may be more beneficial during the shoulder seasons, as current breeding season restrictions regarding dogs or seasonal variation in human activities involving their dogs may be currently limiting the risk of dog-based disturbances during the breeding season.

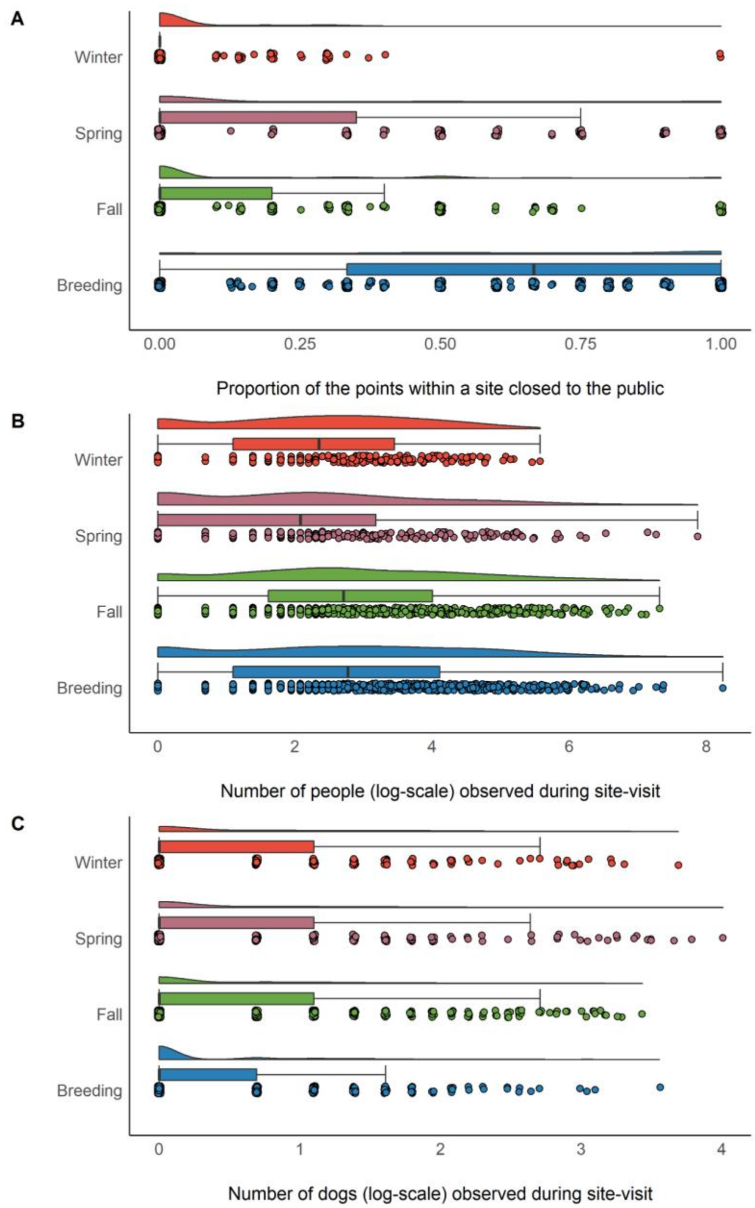


Figure 6 (A) The proportion (scatter plot) and distribution of proportions (bar, violin plots) of all points within each site that were at least partially closed to the public, and the observed number (scatter plots) and distribution of average (bar, violin plots) **B)** people, and **C)** dogs observed at each site during seasonal survey efforts (log-scaled).

Associations among seasonal counts of people and dogs in points that were open or closed to the public

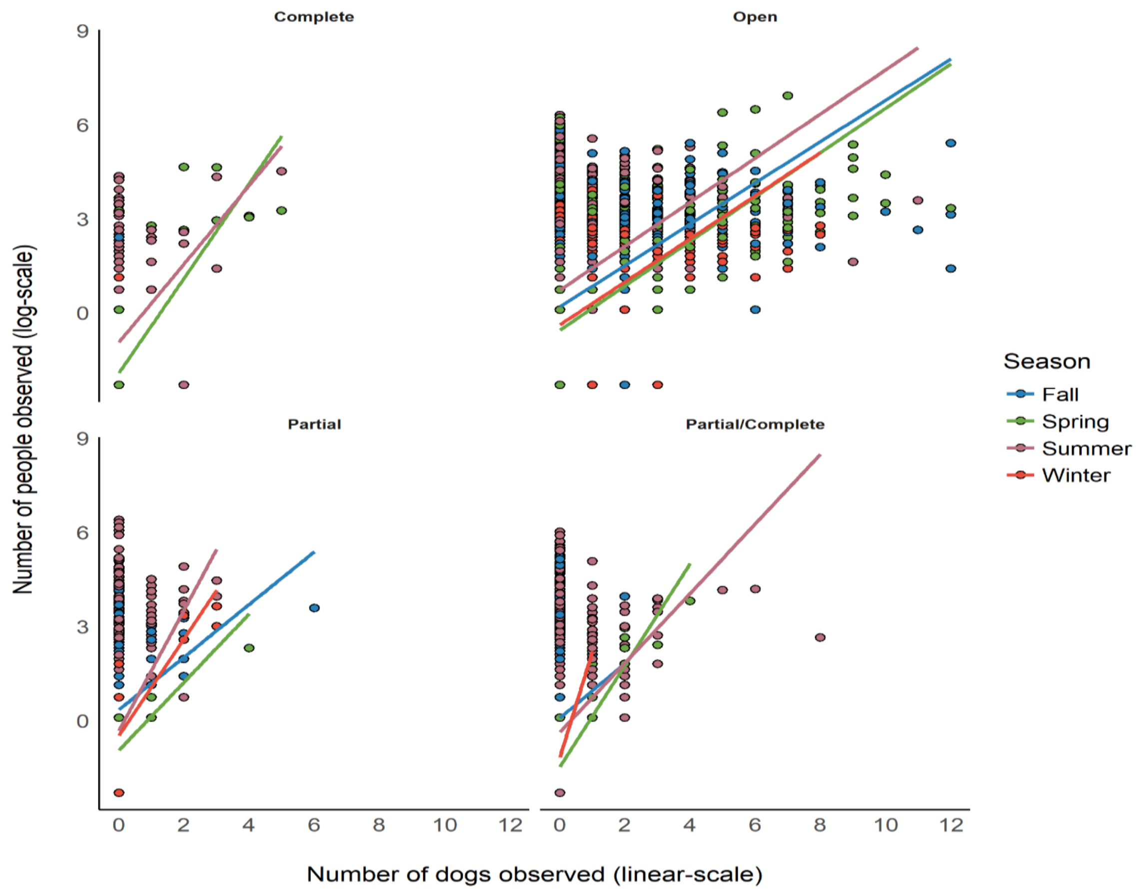


Figure 7. The number of dogs (x) regressed on the people (y) observed within 200m of each point relative to whether that point occurred within an area completely closed (Complete), completely open (Open), or partially closed (Partial) closed to the public during each season (colors). The final grouping separates points that were within a closure, but it was not determined to be a complete or partial closure.

The number of dogs and people were consistently associated with each other during each season regardless of whether a point was considered to be open or closed to the public (Fig. 7). However, there fewer people and dogs observed at points that were either partially or completely closed relative to points that were open to the public.

Patterns in observed shorebird counts relative in areas open or closed to public

All species used coastal habitat that were closed or open to the public (Fig. 8). Often, the largest flock counts for a particular species occurred in areas that were open to, but not necessarily currently utilized by, the public. For all species, the majority of point counts within the species seasonal range limit were recorded as absences, regardless of whether the point was open or closed to the public. However, all species were observed across a range of site closure ‘strategies’ (Fig. 8). Additionally, as the observed number of people and dogs 1) were seasonally variable (Fig. 6); 2) varied as a function of area closures (Fig. 7); and 2) covaried with each other (Fig. 7), it is likely that shorebirds experienced a range of disturbances throughout year, and the importance of protected areas to shorebirds, or their relative use, could vary throughout the annual lifecycle.

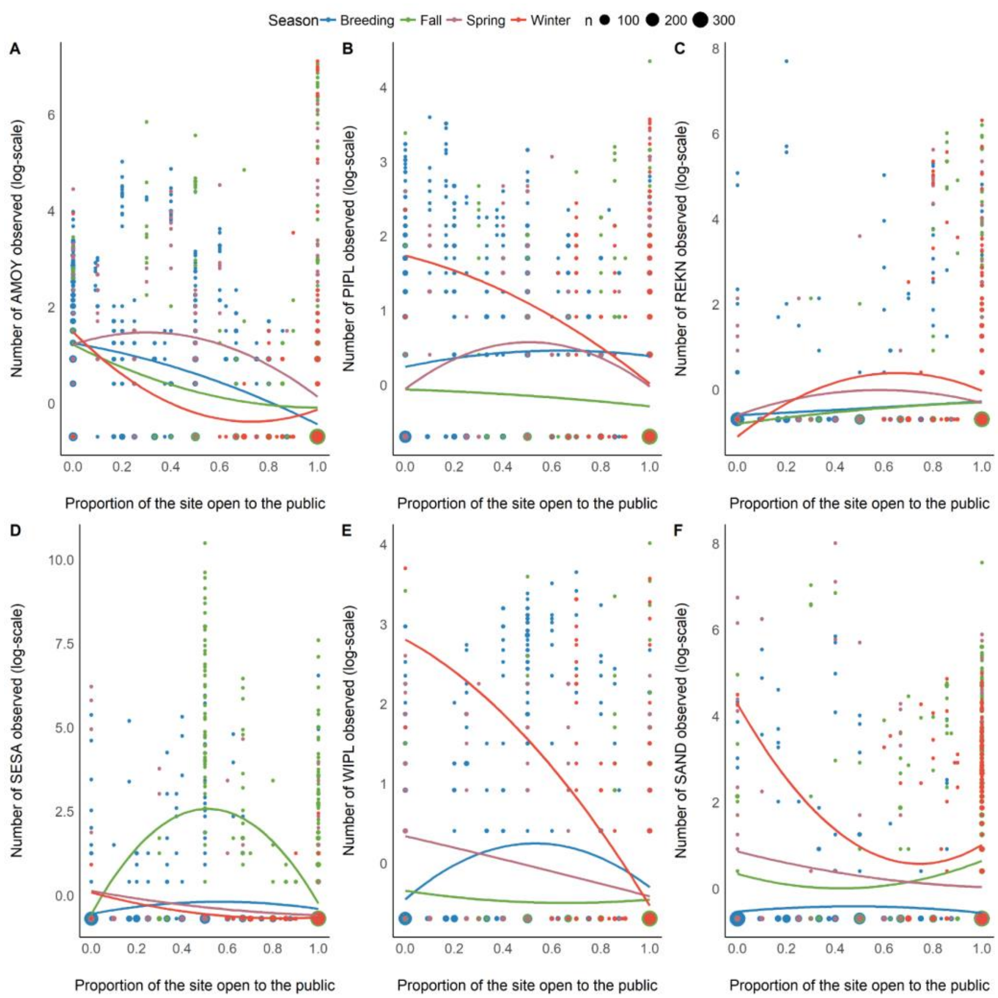


Figure 8. The observed number (log-scale) of A) American oystercatchers, B) Piping Plovers, C) Red Knots, D) Semipalmated Sandpipers, E) Wilson’s Plovers, and F) Sanderling observed during a survey as a function of seasonal variation in the proportion of the points within a site that were open to the public. Size of points represents the number of surveys that matched the observed outcome for a particular species abundance/closure combination.

Model Results

Determining the drivers of the seasonal occupancy of perturbations and shorebirds.

People and other human-associated perturbations at a site were more abundant at open sites (Fig. 9A). Specifically, larger sites and sites with greater amounts of parking available were approximately twice as likely to be associated with each perturbation. Barriers to site access, such as a site being only accessible by boat reduced the likelihood that a site would be occupied by most perturbations by approximately 50%. However, as expected, sites that were only accessible by boat were also more likely to be seasonally used by boats. Given that many of these site qualities (e.g., parking, access points) were most likely developed in response to demand, we discourage inferring causality. From the perspective of seasonal shorebird site occupancy (Fig. 9B), we found little evidence that shorebirds were less likely to seasonally occupy a site as a function of the average amounts of each perturbation observed during that season. Although the majority of associations between specific perturbations and shorebird occupancy were positive, which would suggest that sites were generally co-occupied by both shorebirds and perturbations, the amount of uncertainty associated with these estimates were large enough to reduce our ability to make firm statements at this spatial-scale.

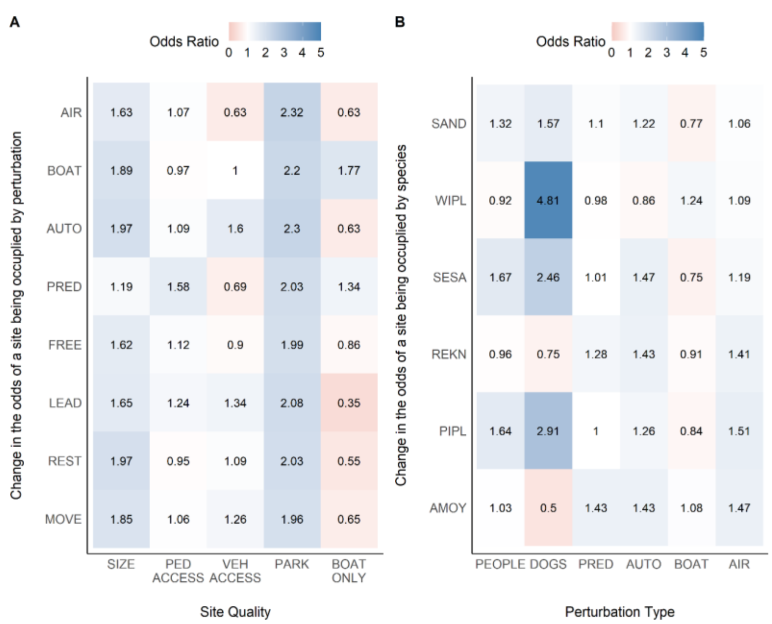


Figure 9. Estimated increase in the odds (i.e., odds ratios) of a site being occupied by (A) each type of perturbation and (B) each shorebird species, as a function of (A) site conditions and (B) the average amount of each perturbation at a site.

Determining the mechanistic relationships between potential disturbance and shorebird abundance

The average amount of a perturbation observed among sites, and the extent to which it varied throughout the calendar year differed among the perturbations considered (Fig. 10). Certain perturbations (e.g., leashed dogs, aerial disturbances) were observed in relatively low numbers but relatively consistently across time, whereas other less abundant perturbations (e.g., vehicles and boats) were more frequently observed during the summer months.

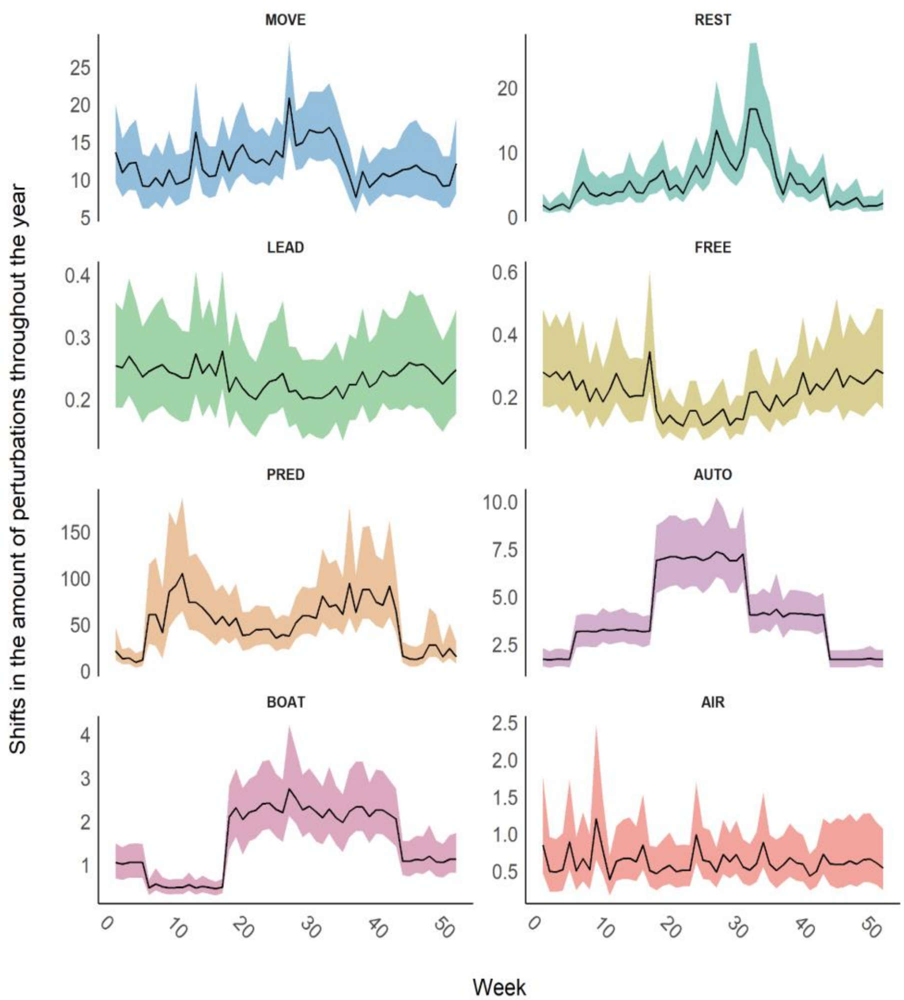


Figure 10. Temporal variation in average number of each monitored perturbations seen across the study system during each week of the calendar year. Error bands represent 95% Bayesian credible intervals. MOVE: people moving, REST: people at rest, LEAD: leashed dogs, FREE: unleashed dogs, PRED: predators, AUTO: vehicles, BOAT: boats, AIR: aerial disturbance.

People (both moving and resting) and predators were the most abundant perturbations, with resting people being more abundant during the summer, moving people being more evenly encountered throughout the year, and predators being encountered more frequently during the spring and fall month. Lastly, off-leash dogs were less frequently observed during the breeding season, which may be related to current and on-going site management/education campaigns during the shorebird nesting season.

Similar to perturbations, temporal variation in shorebird abundance differed among species, but generally followed one of two patterns (Fig. 11). The species that bred within with the study system (i.e., AMOY, PIPL, and WIPL) occurred in smaller but more consistent amounts, whereas the species that bred in the arctic (i.e., REKN, SAND, SESA) were highly variable throughout the year, but when they were extremely abundant when, and where, they were present.

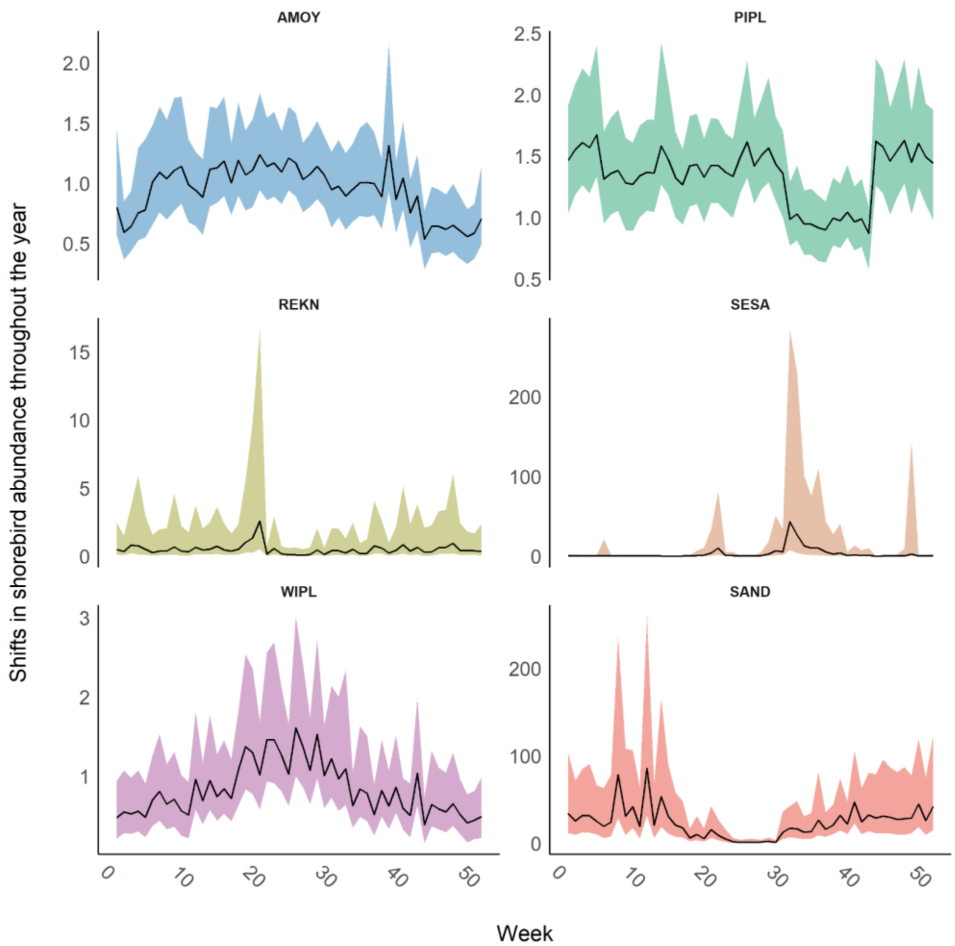


Figure 11. Temporal variation in average number of each monitored shorebird species observed across the study system during each week of the calendar year. Error bands represent 95% Bayesian credible intervals.

In addition to broad-scale temporal patterns in each perturbation, the amount of a particular perturbation covaried with each other perturbation (Fig. 12), which supported the idea that sites that were more actively used by people were also more likely to exhibit increased disturbance from other types of perturbations, and vice versa. As expect, the amount of people resting and moving were highly correlated with one another (*r* = 0.93), as were the number of leashed and unleashed dogs (*r* = 0.79), as well as between both classifications of people and both classifications of dogs. Although dogs (leashed or unleashed) were slightly more correlated with moving people relative to resting people, we cannot conclusively state that the observed difference was statistically or biologically relevant. As expected, the amount of people at a site was associated with each of the secondary perturbations, which further highlights that idea that people were the primary driver of coastal perturbations.

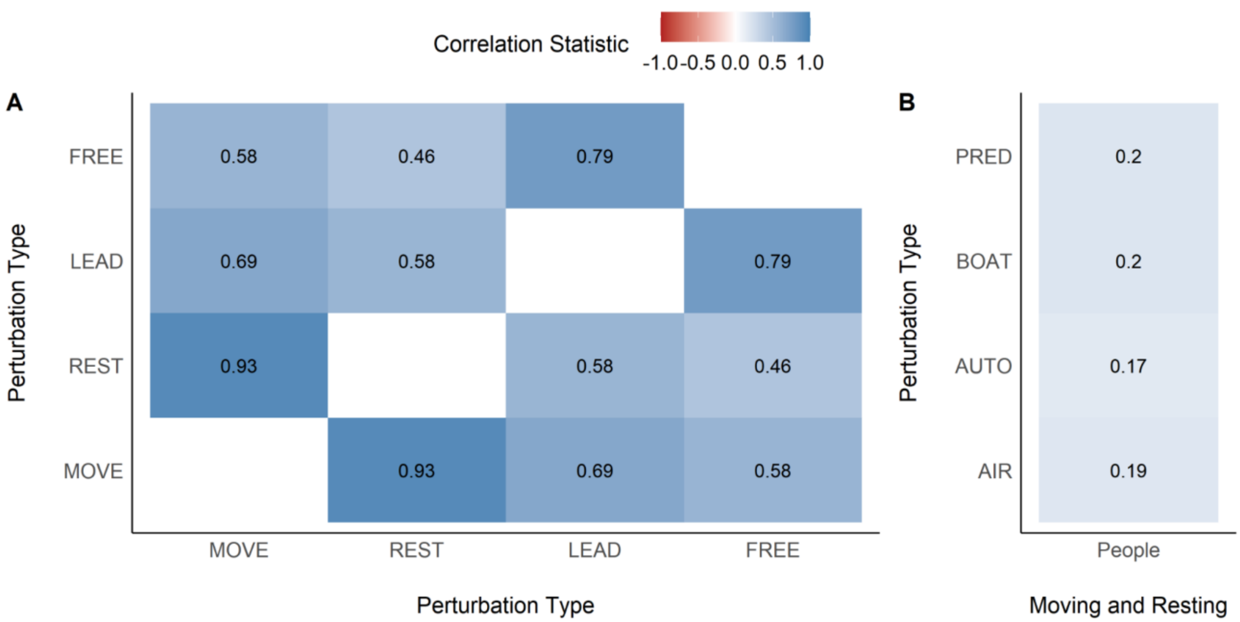
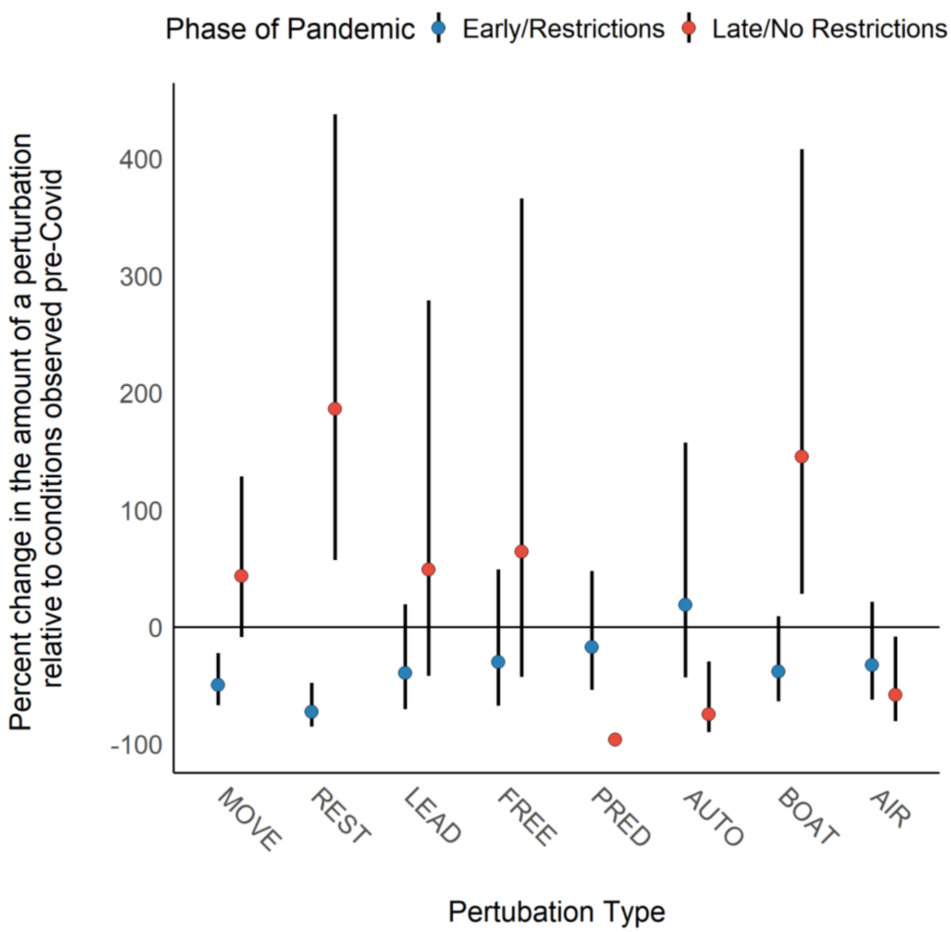


Figure 12. Estimated spatiotemporal variation among perturbations. The model was designed to measure bidirectional associations between each classification of beachgoer (moving or resting) and dog (leashed and unleashed), but constrained the associations between each of the secondary perturbations (i.e., boats, predators, vehicles, and aerial disturbances) to be unidirectionally associated with the total number of people (moving and resting) observed. Each measurement was scaled to represent a correlation coefficient, and are comparable among each other.

Beyond the aforementioned spatiotemporal variation in the amount of perturbations observed within the study system, we found that most perturbations were reduced (relative to conditions experienced prior to the Covid19 pandemic) during the initial pandemic response or at sites with restrictions to site access during the pandemic; however, this pattern reversed itself later in the pandemic during the summer months at sites with no Covid restrictions (Fig. 13). As the model was accounting for seasonal (e.g., spring vs summer) and spatial (e.g., site covariances) in perturbation abundances, this effect is more likely driven by human behaviors in response to the pandemic and not simply seasonal increases in beach activity during the warmer months.

Figure 13. The estimated percent change in perturbation abundance as a function of the surveys timing in relation to restrictions to site use related to the Covid 19 pandemic. Each category is in reference (horizontal line) to conditions observed prior to the pandemic, thus values below 0 suggest a reduction in perturbations and values above 0 suggest an increase in perturbations was observed during different stages or site restrictions associated with the pandemic response.



There was evidence that shorebirds and perturbations differentially in a numerical response to diurnal processes or local environmental conditions associated with a specific survey (Fig. 14). Most notably, shorebirds and predators were consistently more abundant earlier in the day, whereas human-associated perturbations were more abundant later in the day. Also, shorebirds were more abundant at higher tides and less abundant at lower tides, whereas perturbations were less consistent in their association with the tidal cycle. After accounting for shifts in abundance associated with seasonality, warmer weather was associated with increased numbers of people and boats, but fewer off-leash dogs, vehicles, and aerial disturbances relative to cooler weather. Although the parameter estimates describing the association between current temperature and shorebird abundance was consistently negative, support was weak and inconsistent. Likewise, shorebirds were non-responsive to windy conditions (or lack thereof); however, certain perturbation were more (aerial disturbances, predators) or less (active people, vehicles) abundant during windy conditions.

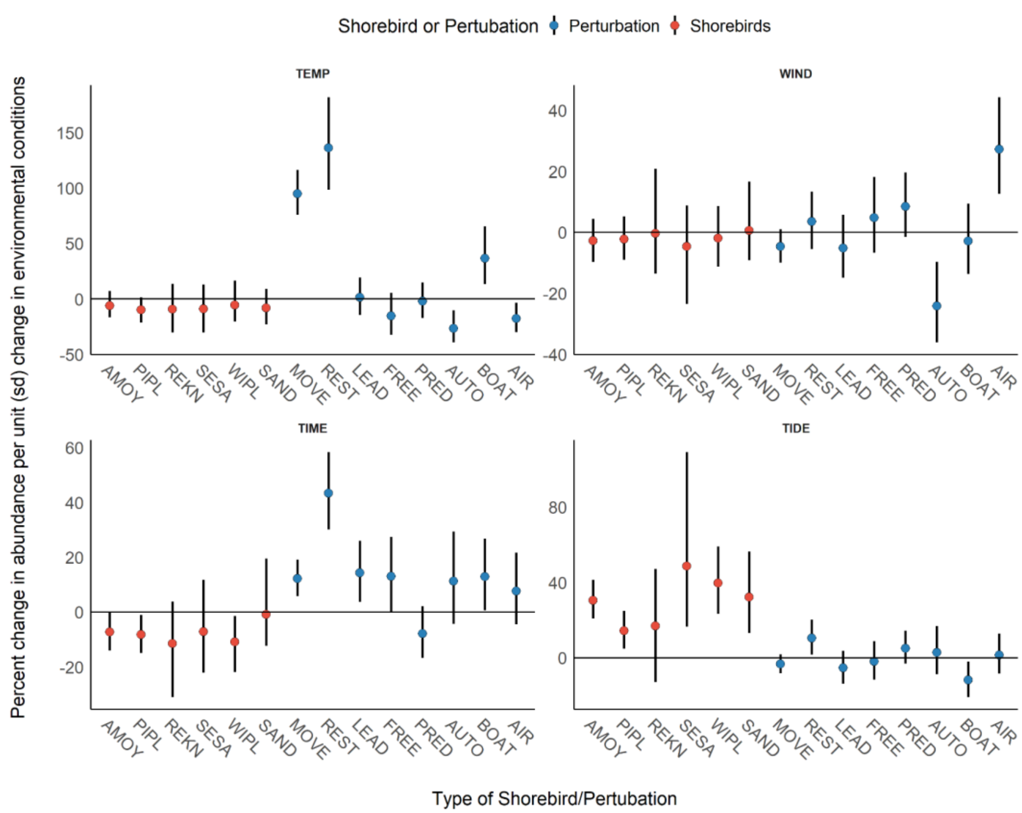


Figure 14. The estimated percent change in shorebird (red) or perturbation (blue) abundance as a function of the current temperature, wind speed, time of day, and relative tidal height.

Although the support and effect sizes (Fig. 15A) for individual associations between individual associations between types of dogs or people and shorebird abundance was weak, the total impact of the primary perturbations (i.e., combined impacts in the amount of people and dogs) were associated with noticeable reductions in the amount of each shorebird observed at a site (Fig. 15A, primary column). Among the different classifications of people and dogs, shorebird abundance was slightly more impacted by the number of off-leash dogs; however, given the extent to which these perturbations covaried with each other and the similarities in the effect sizes, we cannot definitively make that assessment. Although certain species (e.g., WIPL and vehicles) were substantially less abundant as a function of the secondary perturbations considered, the overall impacts were less consistent, relative to the primary perturbations, across species. Similar to perturbations, site-specific shorebird abundances covaried among species (Fig. 15B), which suggested that sites with more individuals of one species generally had more individuals of each other species. In other words, there was unmodeled heterogeneity in site conditions or species life-histories that resulted in certain areas being associated with more shorebirds relative to other sites.

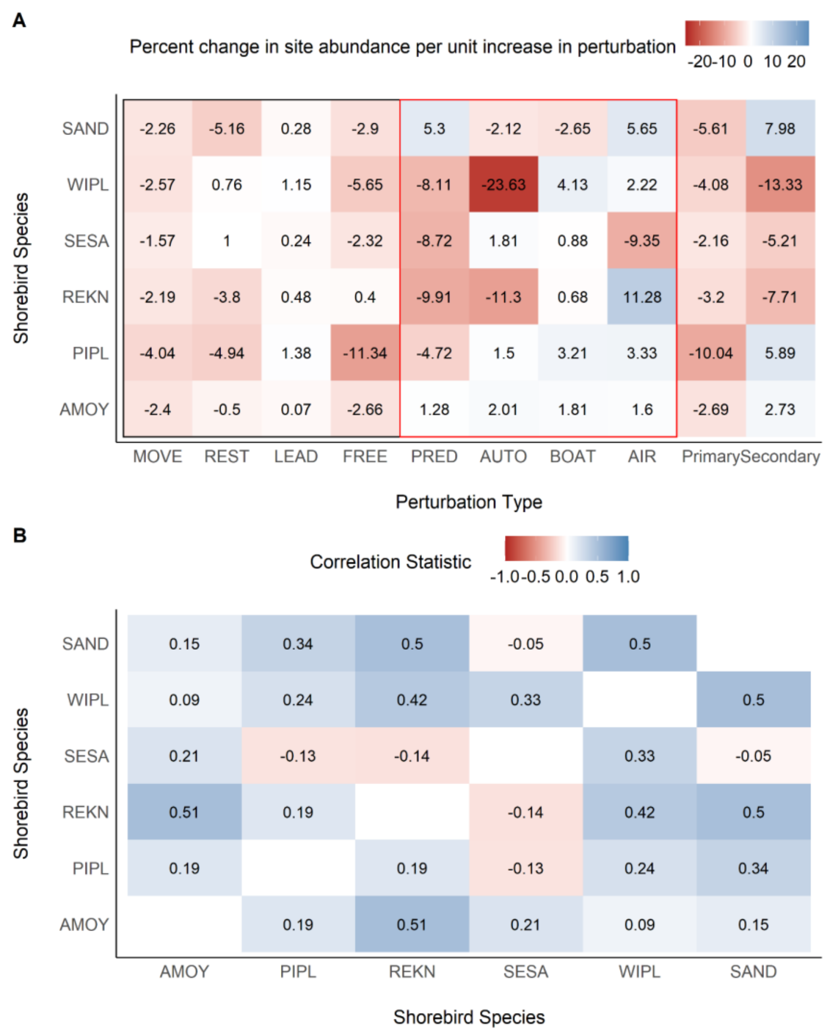


Figure 15. (A) The estimated percent change in shorebird site abundance per standard deviation increase in each primary (black box) and secondary (red box) source of perturbation as well as the total impact of all primary and secondary perturbations on shorebird abundance, and **(B)** the estimated correlations in abundance between shorebird species.

Of importance to this study, we found that the proportion of a site that was open and accessible to the public was negatively associated with each of the temperate breeding shorebirds (i.e., AMOY, PIPL, WIPL; Fig 16) with no clear pattern observed with seasonal migrants (i.e., REKN, SAND, SESA). From the perspective of the temperate breeders, the total site abundance doubled if 40% of the points within a site were closed to the public. Predators, leashed dogs and vehicles were more abundant in sites that were more open to the public, but resting people, boats, and aerial disturbances were more abundant in sites that offered some closures for shorebirds.

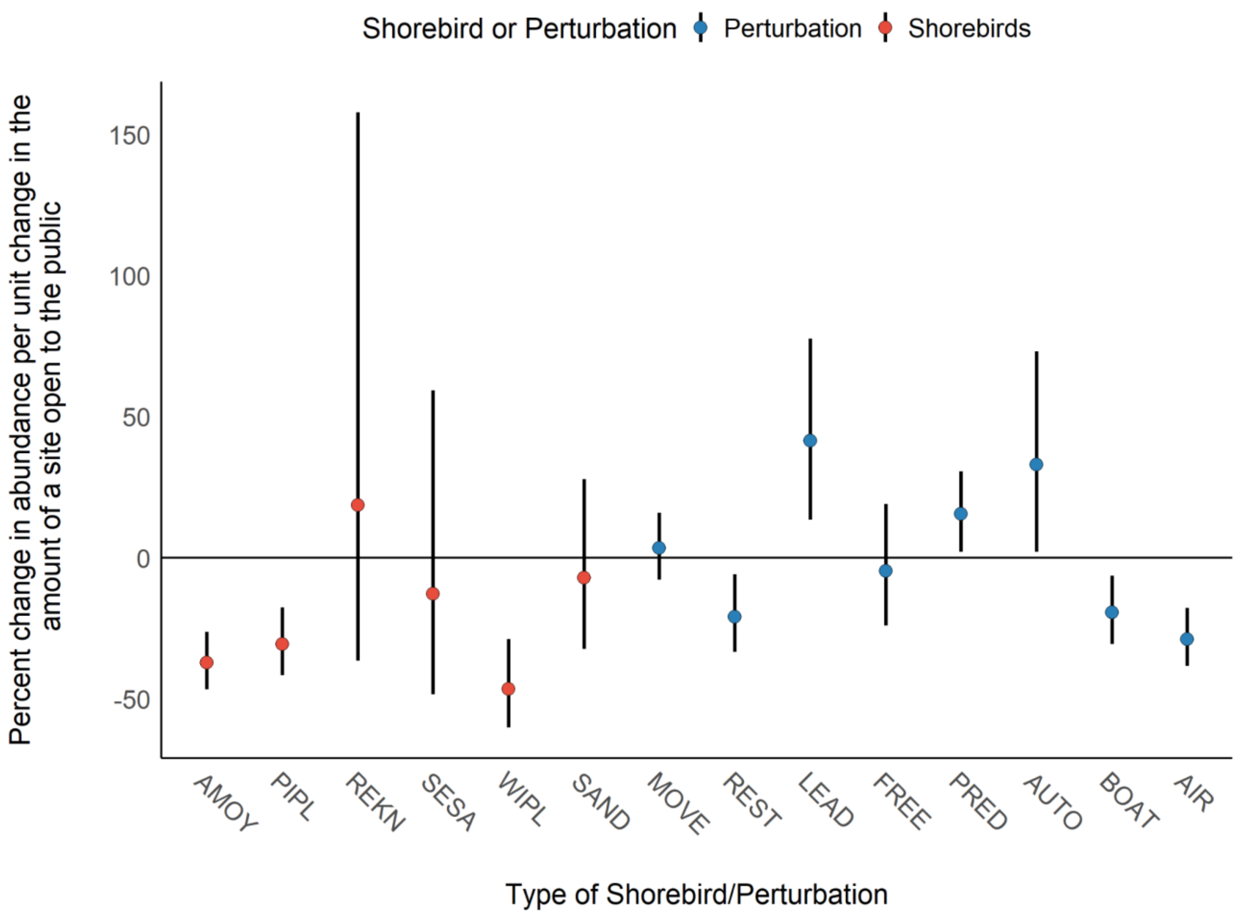


Figure 16. The estimated percent change in shorebird (red) or perturbation (blue) abundance as a function of the relative length of a site that was open to the public, which was measured as the proportion of points surveyed during a site visit that were not closed to the public relative to the number of points surveyed during a specific site visit.

Determining the mechanistic relationships between potential perturbations and shorebird sub-site distributions.

Conditioned on a species presence and abundance at a site during a specific survey, we found variable associations among the distribution of perturbations and the corresponding distribution of each shorebird species across the surveyed points within a site (Fig. 17). Although the associations were not ubiquitous across species, many species were negatively associated with either the number of dogs, people, or both dogs and people concurrently observed at a point. However, given that the number of people observed was associated with an increase in the number of each other perturbation, likely because they are inherently associated with human activity. From the viewpoint of the secondary perturbations, the presence of a vehicle at a point was consistently associated with a reduction in the number of shorebirds present at the same point, which for certain species (e.g., SESA and REKN) was essentially absolute (i.e., rarely, if ever, observed together).

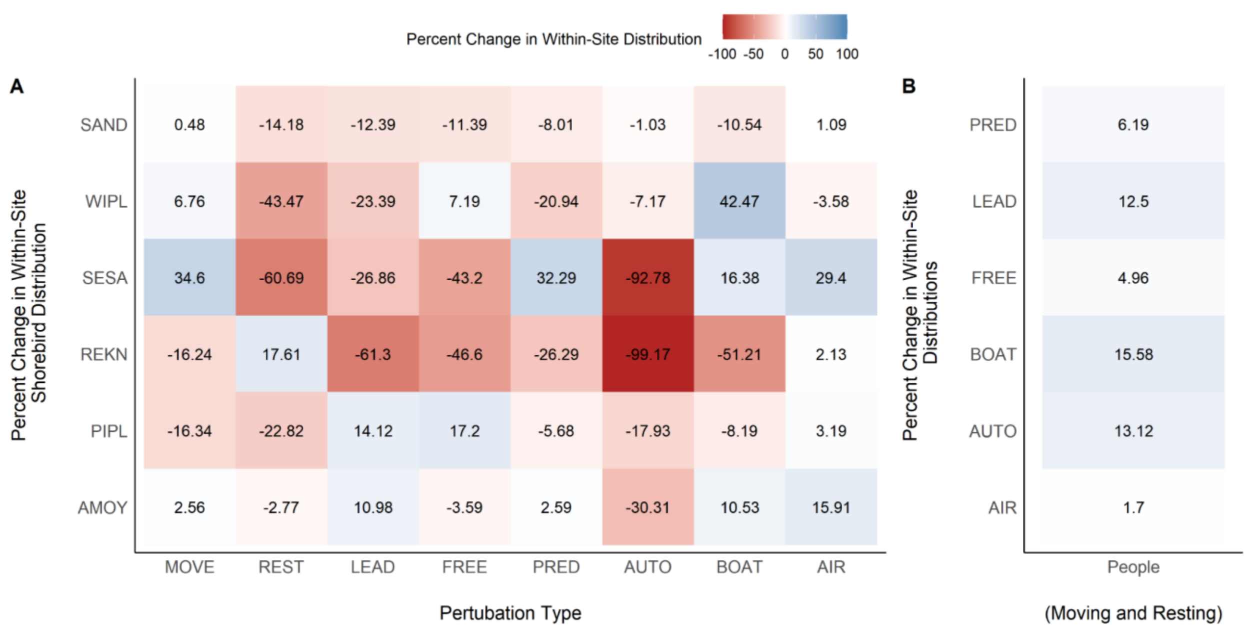


Figure 17. The estimated percent change in the point-level distribution of **(A)** shorebirds and **(B)** non-human perturbations as a function of the number of **(A)** all perturbations and **(B)** people observed at the same point. Estimates are conditioned on a species being currently available (observed during the site survey).

At the point-level, closures were generally effective at reducing the number of perturbations while being associated with relatively high use by shorebirds relative to points that were open to the public (Fig. 18). Human-driven perturbations were generally less abundant at completely closed points relative to partially closed points; however, predators, as expected, behaved more likely wildlife than humans, and were found in greater numbers in areas closed to the public. Notably, AMOY were less likely to use completely closed points relative to open points, but this pattern was not observed in the partial or mixed closed points, which suggests that this may be related to closures generally occurring above the wrack line and AMOY tendency to loiter in the intertidal regions. SESA and REKN had the greatest responses to closures, upwards of two orders of magnitude larger than other shorebirds (Fig. 18, right panel). We suspect that the rather large effects were predominantly related to these species innate flocking behavior and their reduced presence, relative to other species, within the study system, which potentially exacerbated the parameter estimate, but does not negate the underlying importance of closures to migratory shorebirds.

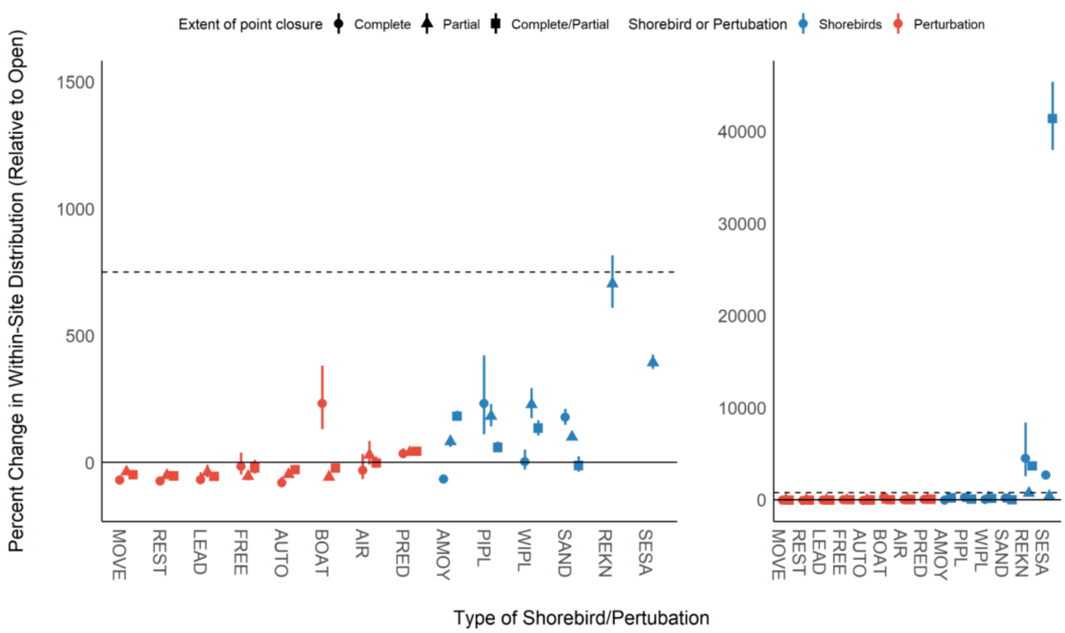


Figure 18. The estimated percent change in the point-level number of shorebirds (blue) and perturbations (red) conditioned on their current presence at a site during a survey as a function of whether the area (200m radius) around point was completely (circle), partially (triangle), or partially or completely (square) closed to the public. Panels represent the same data but at two numerical resolutions. Solid horizontal line delineates increasing and decreasing abundances relative to the point being open. Dashed line highlights an identical point between the two panels.

Determining the mechanistic relationships between disturbance and shorebird behavior

We found that the specific variables (Fig. 19) and types of variables (Fig. 20) most associated with shorebird behavior substantially varied among each of the six species. However, there were some similarities across species that were worth mention. From a disturbance perspective, almost all species were less likely to be resting than any other behavior in the presence of vehicles (Fig. 19). Likewise, most species were more likely to be alert in the presence of most perturbations (e.g., dogs), but this effect was not supported across all pairwise comparisons (e.g., people, Figs. 19, 20).

Shorebird behavior also was influenced by whether an individual was found in an area closed or open to the public. For example, PIPL and SAND were both more likely to be resting in closed area relative to any other behavior. However, other species also exhibited different behavioral responses as a function of whether a point was open or closed (e.g., SESA were less likely to be resting relative to each other behavior, REKN were more likely to be alert or resting).

Beyond management concerns, species behavior was also influenced by local environmental conditions and community dynamics. Most species were more likely to be resting during high tide and during windy conditions (Fig. 19). Additionally, all species were more likely to be resting when found near large groups of conspecifics, but were less responsive to the presence of potential predators. However, given that the predators observed were predominantly gulls or other nest predators, we may not expect to see a meaningful behavioral response outside of the nesting season.

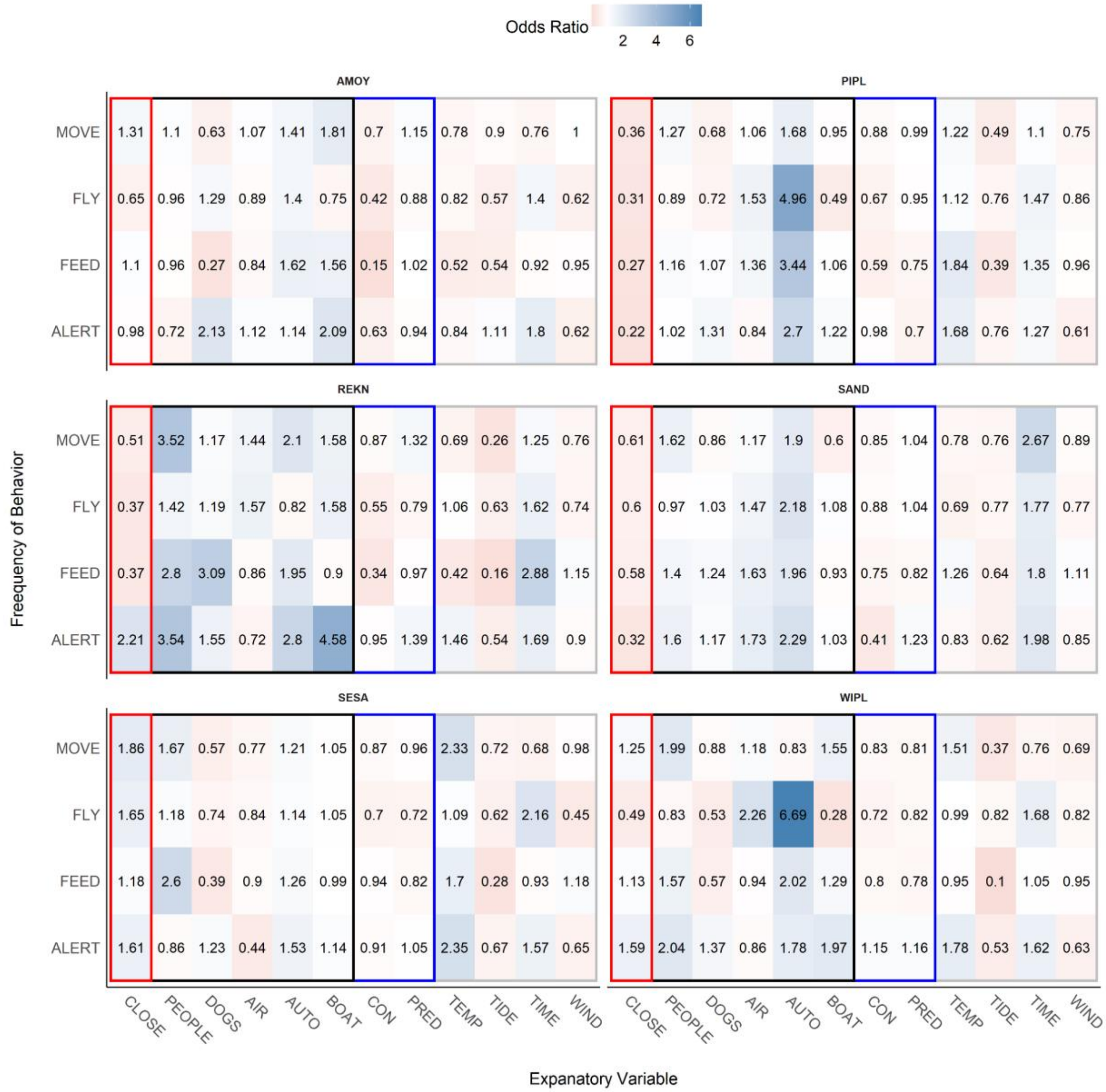


Figure 19. The estimated change in odds of a specific behavior (i.e., alert, feeding, flying, and moving) being observed relative to being observed at rest for each species (panels) as a function of variation in site closures (red box), local perturbations (black box), community dynamics (blue box), and current environmental conditions (gray box). Numbers represent odds ratios, shading ranges from a decrease in odds (red) to an increase in odds (blue).

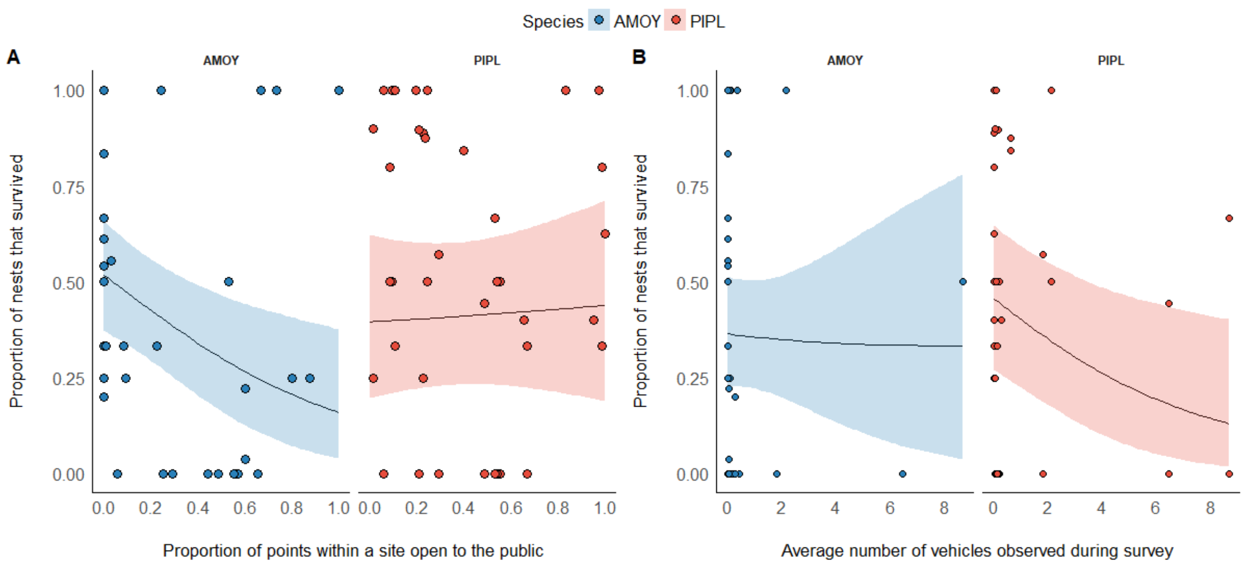
Figure 20. The proportion of the total variance in each shorebird behavior explained by each group of explanatory variables – Disturbance (people, dogs, aerial, boats, vehicles); Environment (wind, time of day, tide height, temperature); Community (conspecific abundance, predator abundance); and site closures, as well as the total amount of variance explained by all predictor variables.

Nest success

For this analysis, nest exclosures were placed on 68.5% (185/270) of the PIPL nests found throughout the study area; however, the remaining (n= 85) plover nests and all AMOY nests (n = 206) were not physically protected from predators through these exclosures. As designed, plover nests in exclosures (p = 0.90 [95% CI: 0.82–0.96]; β = 2.50 [95% CI: 0.34–3.18) were substantially more likely to hatch relative to plover nests not fitted with an exclosure (p = 0.45 [95% CI: 0.28–0.64]). Although AMOY nests were not fit with exclosures, buffers or flagged ‘closures’ were often constructed around nests, which either 1) prohibited driving but did not restrict pedestrian activities or 2) limited both pedestrian access and vehicle use near a nest. Nest survival was greater for AMOY nests that were flagged as protected from pedestrians and vehicles (p = 0.41

[95% CI: 0.30–0.53]; β = -0.48 [95% CI: -1.06 –0.09]) relative to vehicle-only protections (p = 0.30 [95% CI: 0.20–0.42]). In addition to the impact of nest-site scale protections on nest survival, the proportional amount of a site that was open to the public was negatively correlated with AMOY (β = -0.60 [95% CI: -1.06–0.15]), but not PIPL nest success (Fig. 21A). Whereas the amount of vehicle activity at a site was negatively associated with PIPL (β = -0.49 [95% CI: -0.89–0.0.8], but not AMOY nest success (Fig. 21B). However, given the sparsity of sites that exhibit high levels of vehicle use during the nesting season, we urge caution in the interpretation for both the lack of effect observed in AMOY and the effect observed in PIPL. We did not find support for an effect for the average number of people, dogs, or predators observed at a site on the average nest success for either species.

Figure 21. The fitted (regression line and bands) and observed (circles) association between A) the proportion of a site completely open to the public; and B) the average number of vehicles observed during a survey during the nesting season on the average nest success of American Oystercatchers (blue) and Piping Plovers (red). Each circle represents the observed proportion of nests of each species that hatched in a specific site during a single year plotted against the relevant explanatory variable. For this plot, the regression line for both species assumes the nests did have an exclosure.



Prioritizing sites for management

We ranked sites along a continuum of the predicted reduction in shorebird abundance during a survey as a function of the observed number of primary perturbations and species-specific associations with each primary perturbation. Here, the objectives were two-fold — first, we wanted to identify sites that may require shifts in management actions if the management of shorebirds and their habitats were a priority of the land stewards managing that site (Management priority). Second, we wanted to identify sites that should maintain current conservation guidelines, and perhaps serve as showcases for best practices, as the site was perceived to be highly functional habitat associated with high shorebird numbers and low disturbance (Conservation priority). Given that land managers may have different species priorities, sites were placed along a continuum in from Management Priority to Conservation Priority. Additionally, given that the 1) associations between specific perturbations and shorebird abundance; and 2) the geographic ranges differed among species, we provided ranking for each species (Figs 22–27). For each figure, sites are ranked from being a Management Priority (left most) to Conservation Priority (right most), where each individual boxplot represents the observed distribution of estimated reductions in abundance due to primary perturbations across all surveys at a specific site. Sites with wider boxplots were indicative of sites that experienced more variability in perturbations, whereas sites with narrow boxplots were indicative of sites that experienced a more consistent amount of perturbation across time. Species that exhibited a greater numerical response to variation in perturbation (e.g., PIPL, WIPL, Figs 23, 24) exhibited a steeper curve along the site-continuum relative to species that were less impacted (e.g., REKN, Fig. 25).

Figure 22. The ranked site disturbance profile for American Oystercatchers (see **Appendix A** for the full list of site names). Sites on the left most were associated with the types and number of perturbations most associated with reductions in American Oystercatcher abundance and were considered Management Priorities, whereas sites on the right were associated with lower levels of these perturbations and were considered Conservation Priorities.

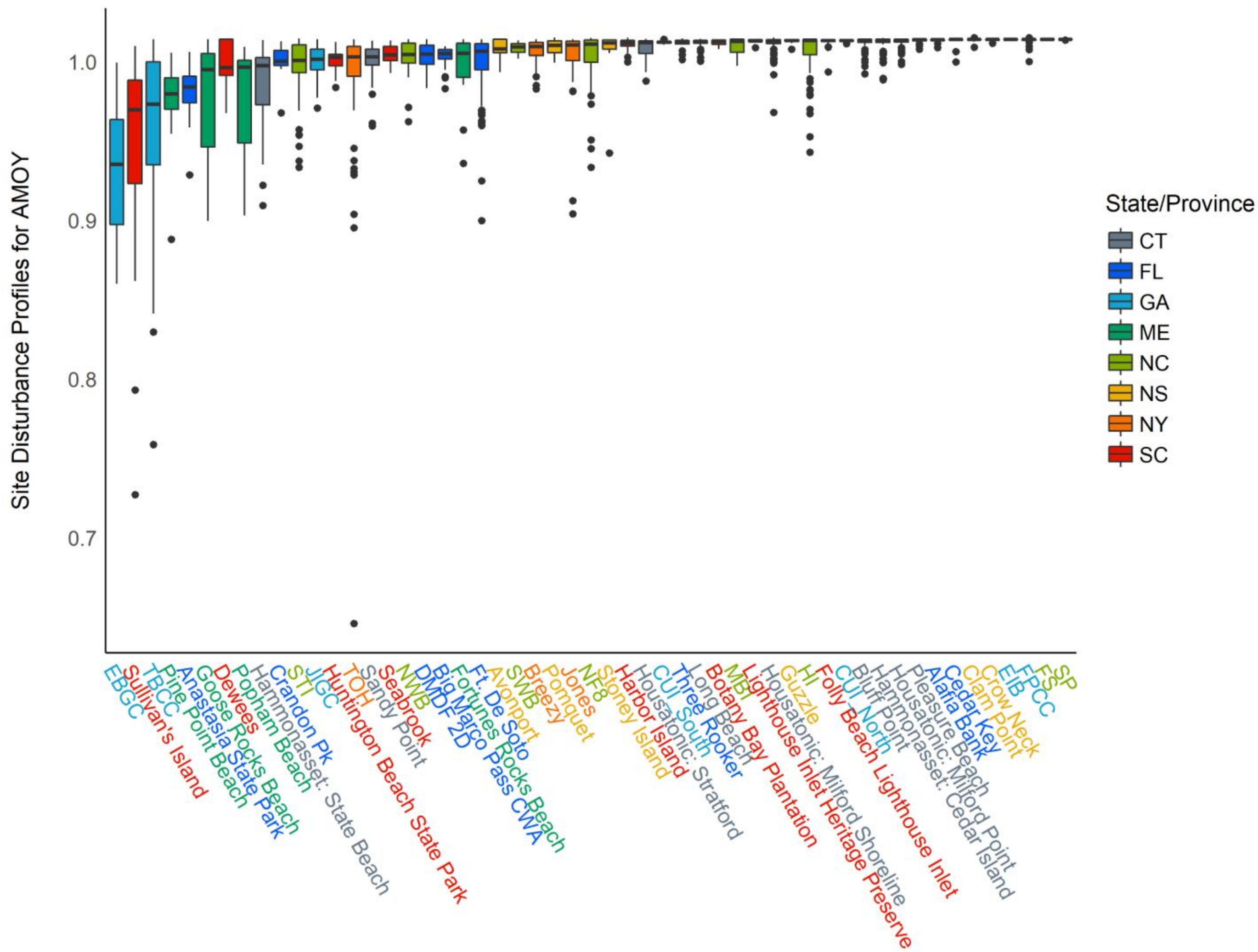


Figure 23. The ranked site disturbance profile for Piping Plovers (see **Appendix A** for the full list of site names). Sites on the left most were associated with the types and number of perturbations most associated with reductions in Piping Plover abundance and were considered Management Priorities, whereas sites on the right were associated with lower levels of these perturbations and were considered Conservation Priorities.

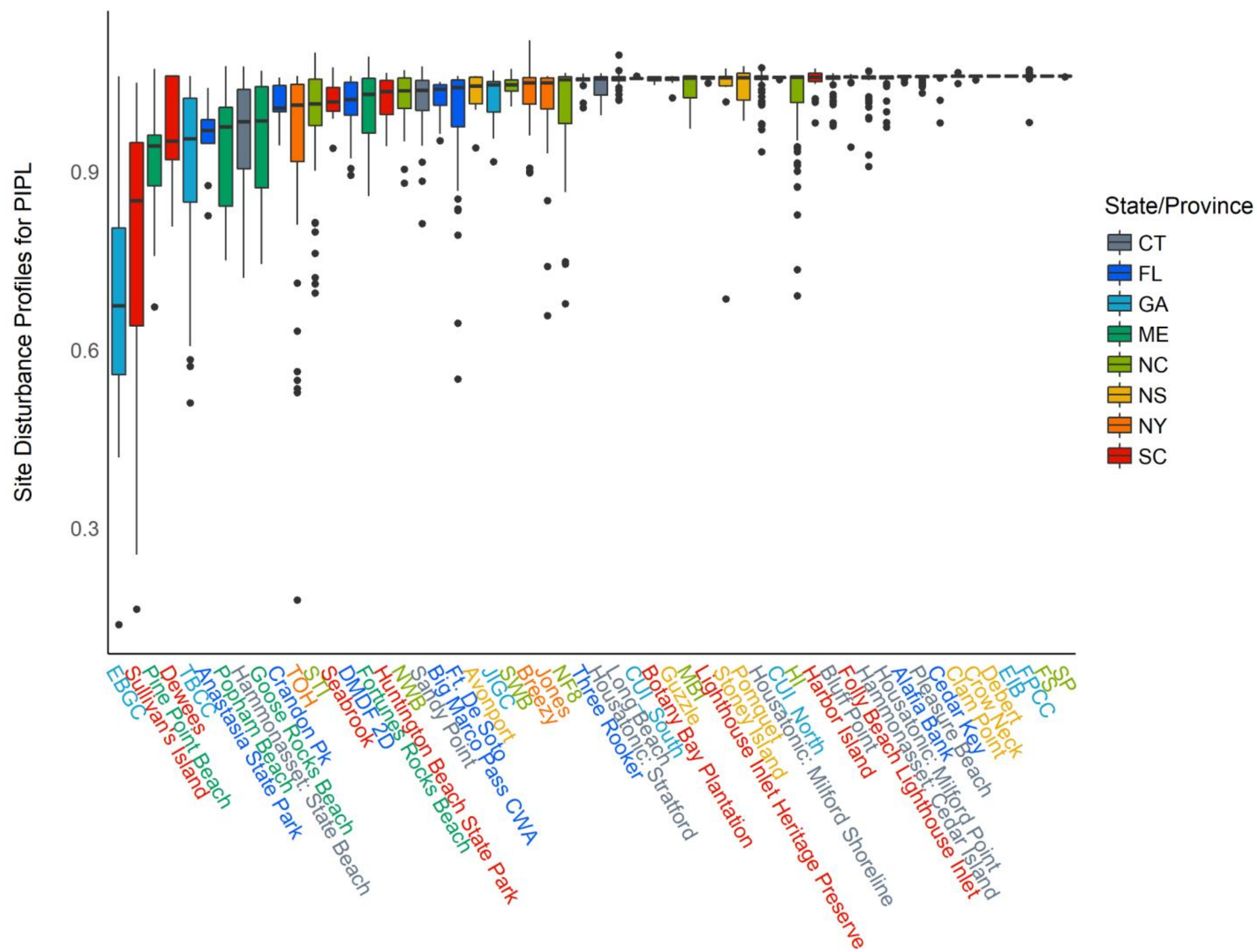


Figure 24. The ranked site disturbance profile for Wilson's Plovers (see **Appendix A** for the full list of site names). Sites on the left most were associated with the types and number of perturbations most associated with reductions in Wilson's Plover abundance and were considered Management Priorities, whereas sites on the right were associated with lower levels of these perturbations and were considered Conservation Priorities.

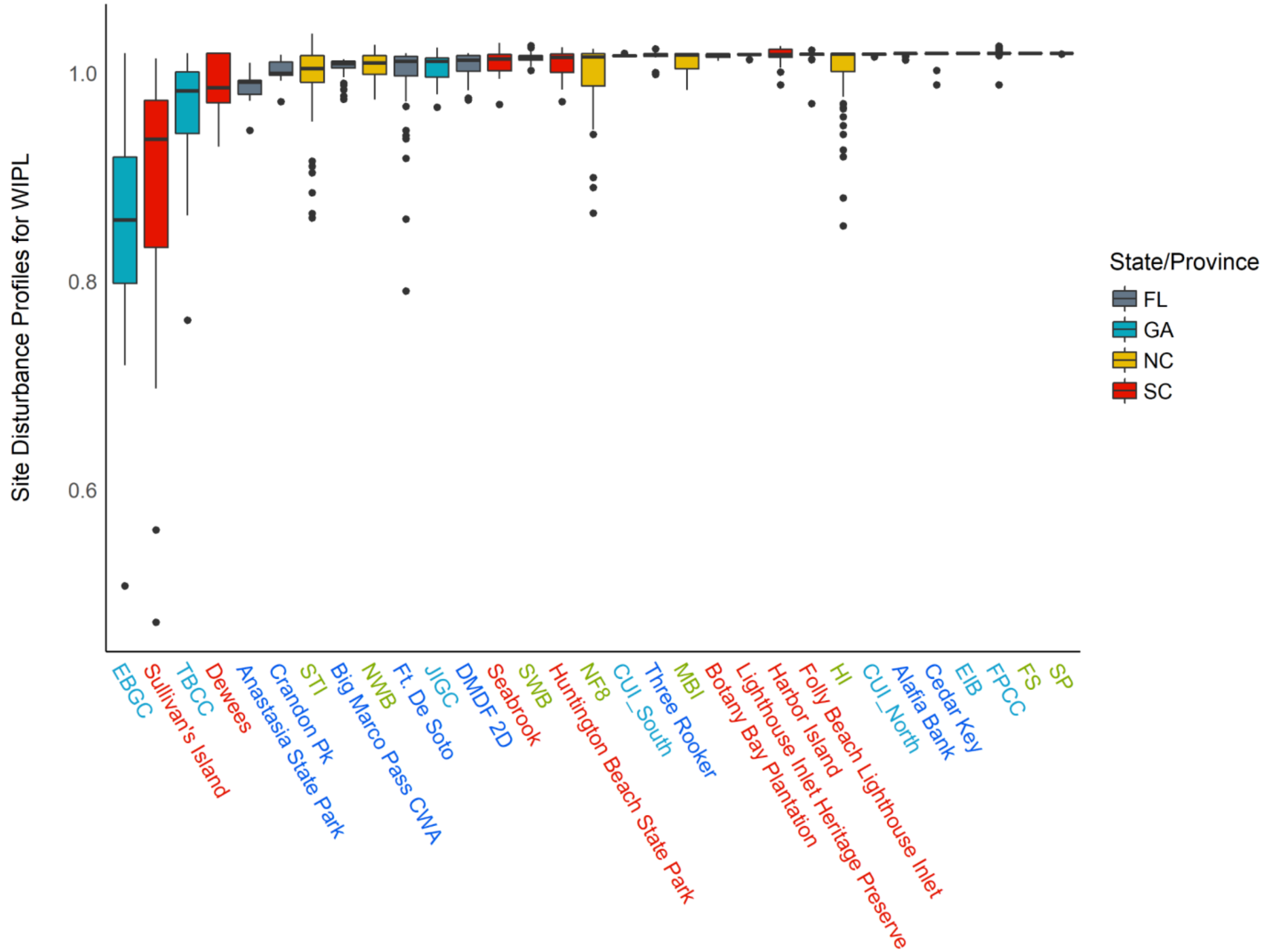


Figure 25. The ranked site disturbance profile for Red Knots (see **Appendix A** for the full list of site names). Sites on the left most were associated with the types and number of perturbations most associated with reductions in Red Knot abundance and were considered Management Priorities, whereas sites on the right were associated with lower levels of these perturbations and were considered Conservation Priorities.

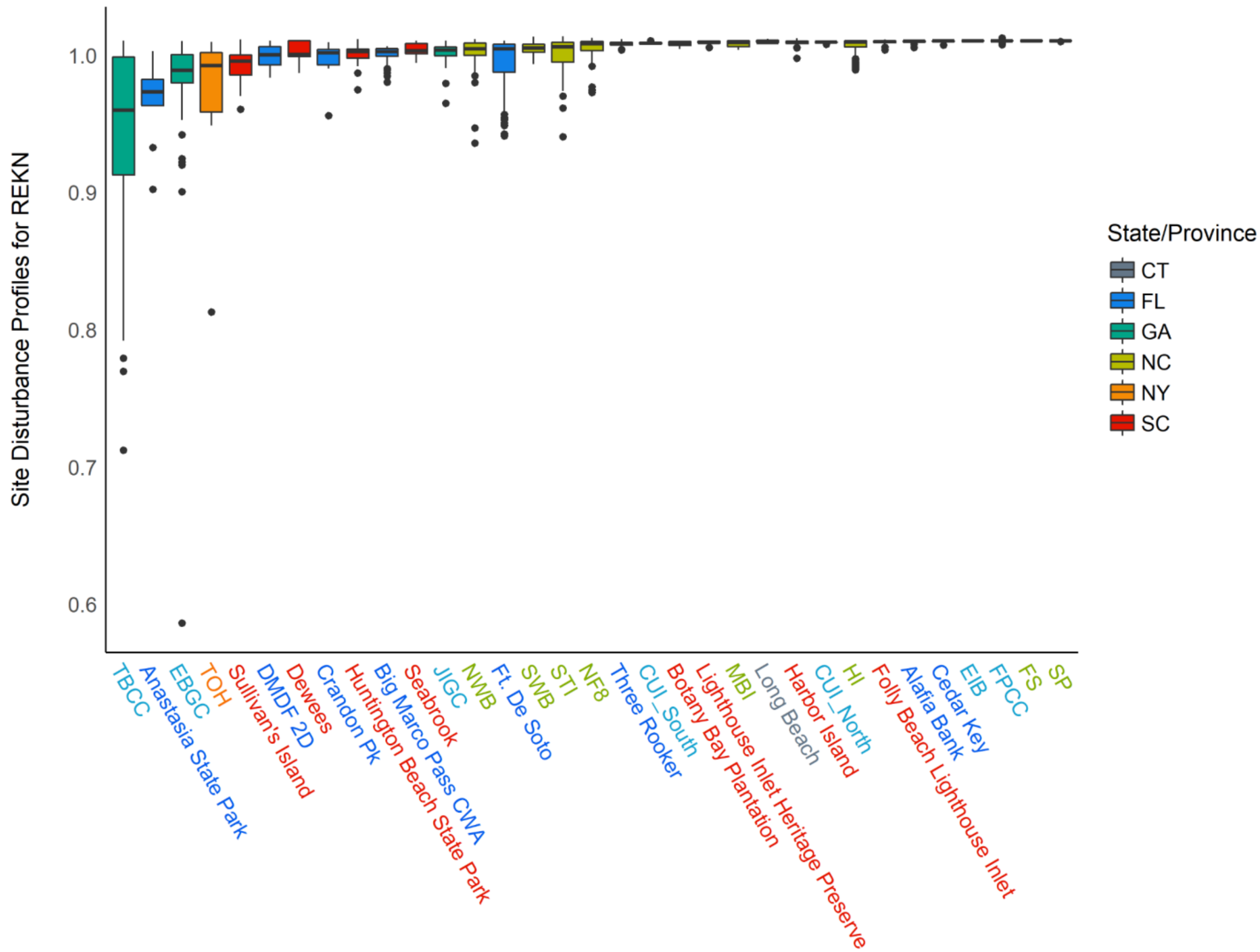


Figure 26. The ranked site disturbance profile for Sanderling (see **Appendix A** for the full list of site names). Sites on the left most were associated with the types and number of perturbations most associated with reductions in Sanderling abundance and were considered Management Priorities, whereas sites on the right were associated with lower levels of these perturbations and were considered Conservation Priorities.

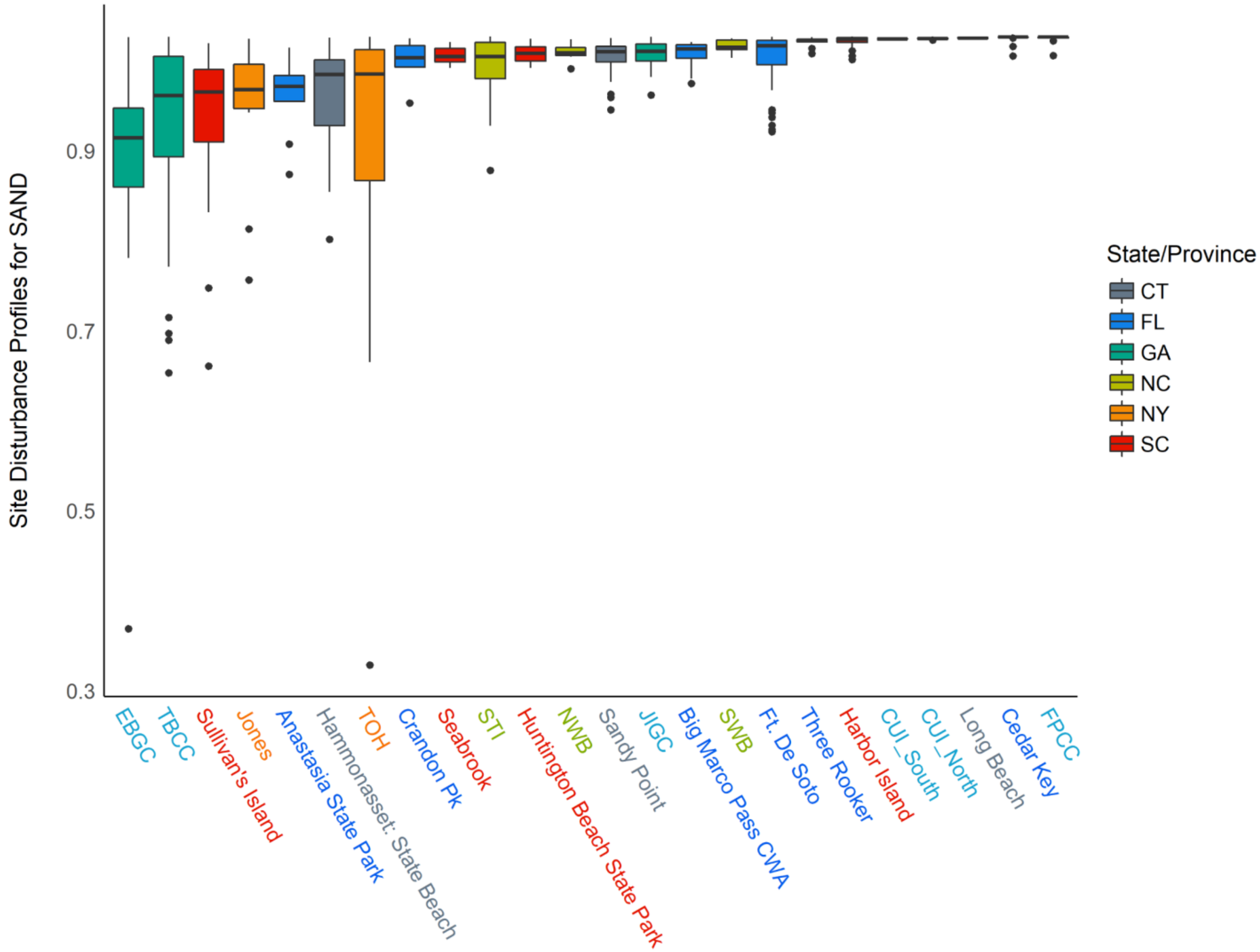
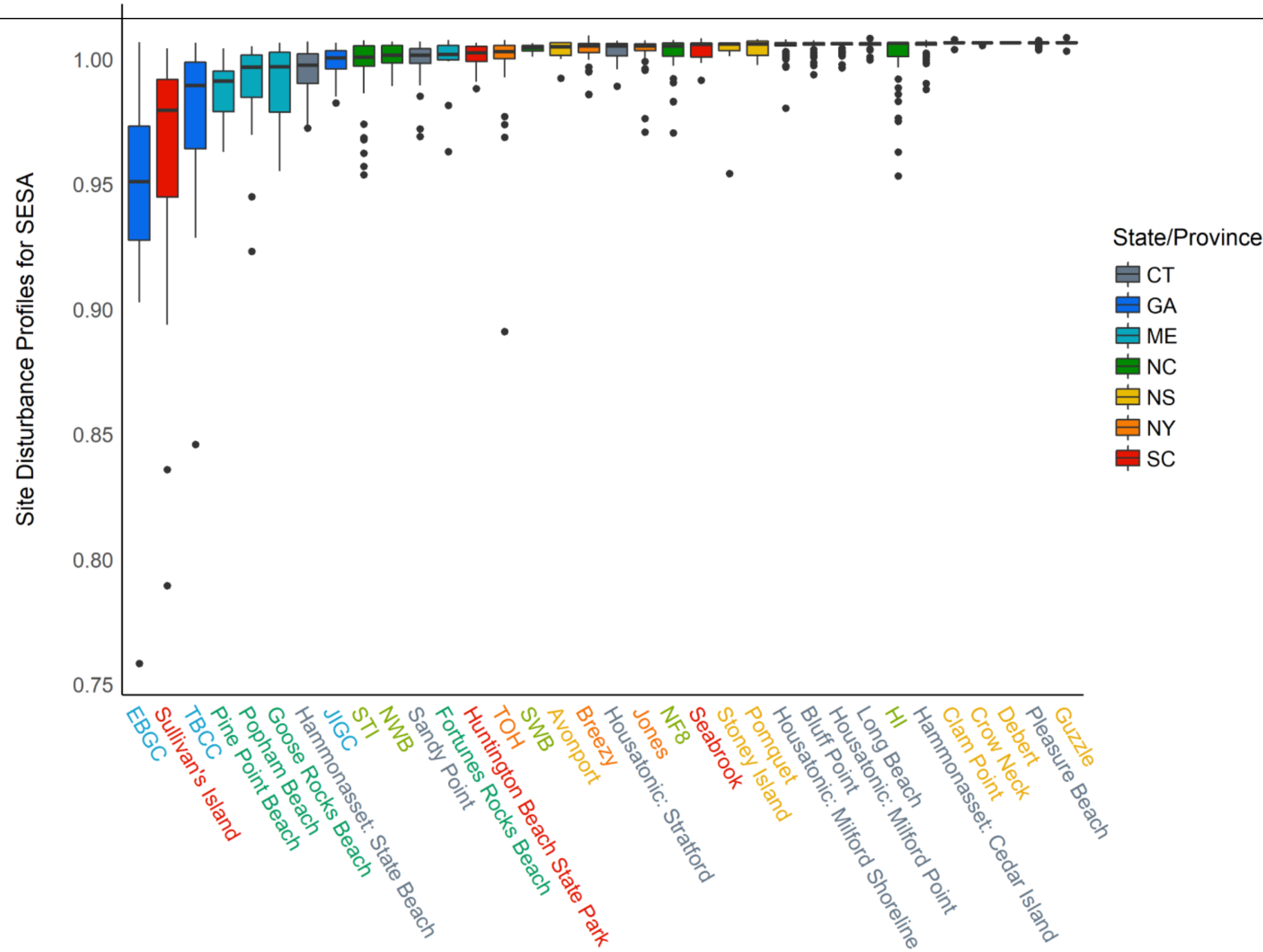


Figure 27. The ranked site disturbance profile for Semipalmated Sandpipers (see **Appendix A** for the full list of site names). Sites on the left most were associated with the types and number of perturbations most associated with reductions in Semipalmated Sandpiper abundance and were considered Management Priorities, whereas sites on the right were associated with lower levels of these perturbations and were considered Conservation Priorities.



KEY FINDINGS

Our results indicate that shorebirds were impacted by human recreational disturbance (referred to as perturbations) throughout their annual lifecycles. Human recreational use along the Atlantic Coast was widespread but variable in type and intensity. The consequences of disturbance were multifaceted as they were linked with shifts in the species habitat use and abundance of species in their seasonal ranges. Furthermore, there were conditional impacts, which were experienced by individuals following their decision to occupy or nest in a specific location, as both non-breeding (e.g., foraging rates, resting bouts) and breeding outcomes (i.e., nest survival) were negatively associated with local disturbance levels.

We found that people and other human-associated perturbations at a site were more abundant at sites without closures and that larger sites with more parking were twice as likely to be associated with each perturbation. In addition, we found that predators, leashed dogs, and vehicles were more abundant in sites without closures. Of importance, we also found that the proportion of a site that was open and accessible to the public was negatively associated with each of the temperate breeding shorebird species (e.g., AMOY, PIPL, WIPL). Shorebird behavior was also influenced by whether or not in an area closed or open to the public. For example, PIPL and SAND were both more likely to be resting in closed area relative to any other behavior.

Overall, people and predators were the most abundant perturbations. Perturbations varied seasonally, such that resting people were more abundant during the summer, moving people were more evenly encountered throughout the year, and predators were encountered more frequently during the spring and fall month. Off-leash dogs were less frequently observed during the breeding season, which may be related to current and on-going site management/education campaigns during the shorebird nesting season.

At the point-level, closures were generally effective at reducing the number of perturbations while being associated with relatively high use by shorebirds compared to points that were open to the public. The presence of a vehicle at a point was consistently associated with a reduction in the number of shorebirds present at the same point. Especially for SESA and REKN, which were rarely, if ever observed at a point that also had vehicles present within the 200m. We also found that shorebird behavior was influenced by perturbations, such that individuals were more likely to be ‘alert’ in the presence of any perturbation.

Of critical importance, the observed increase in most types of perturbations during the summer months of the Covid-19 pandemic highlights that the timing, extent, or magnitude of anthropogenic activity on a beach often may be beyond the control of land managers. Thus, management actions should prioritize strategies that minimize the impacts of disturbances present and are effective along a gradient of anthropogenic activities (i.e., types and magnitudes), as opposed to strategies that try to limit absolute human access to coastal areas. For example, localized closures were effective in lowering the number of anthropogenic perturbations and enhancing the population response of these species, suggesting that efforts to lessen disturbance frequency and intensity could be successful at increasing abundance and reproductive success at a site, thus improving the quality of the habitat and its capacity to service more birds. Therefore, we recommend considering expanding the use of closures to protect shorebirds from the effects of recreational disturbance. Considering that there were still people and dogs within 200m of partially and completely closed points, we recommend enhanced enforcement or outreach to promote compliance with closures. Knowledge of peak timing for key species at a site would help determine minimal windows where closures will be most effective while allowing for some human use outside of these times (Comber and Dayer 2019). It is important to note that in the context of this study, the amount of area ‘closed’ to the public ranged widely, from small, temporary buffers around nests or broods to complete closures of beaches. Regardless of these discrepancies, closures were associated with increased use by each shorebird species monitored. Although it is unlikely that full closures of popular beaches will resonate well with the public, a well-designed community based social marketing campaign, as described in the guidance document based on this project, paired with relatively small areas closed to the public across the flyway may be an effective and well-received approach to improve shorebird conservation on the Atlantic Coast.

It is imperative to note that the study design and model development applied here allowed for inference regarding the possibility of causal associations between human recreational activities and shorebird abundance and behaviors, and we found that across all species included in this assessment, human disturbance negatively effects shorebirds.

FUTURE DIRECTIONS AND BROADER IMPACTS

We developed this data collection protocol with suggestions and comments from numerous partners and it has now been field tested at 52 sites throughout two years of data collection. We believe that this protocol and our analytical methods could be used at other sites throughout the Atlantic Flyway, including the Caribbean and South America. We suggest that these methods are flexible and broadly applicable to a variety of sites and human disturbance issues even outside of the Atlantic Flyway. Partners in Georgia, who participated in the second phase of the project, have implemented data collection at a number of sites to quantify disturbance and to guide future management activities. In addition to the focal species included in this study, we have added additional species to fit their project-specific needs including, Dunlin (*Calidris alpina*), Ruddy Turnstones (*Arenaria interpres*), and Semipalmated Plovers (*Charadrius semipalmatus*). As the use of this protocol proliferates, the quantity of the data collected will ensure more robust conclusions and will improve our assessment of the effects of potentially important but somewhat rare disturbances.

In addition to the biological tracking afforded by these protocols, they also provide a standardized way of measuring human activities at a flyway scale. These measures can be used as metrics to assess the success of any attempts to lessen disturbance through campaigns focused on changing human behavior, both in terms of the occurrence of these activities and in terms of the response of shorebirds to any changes. Data collected as part of this project can serve as a baseline measure of the abundance and distribution of potential disturbances and management strategies in addition to information on species behavior and abundances.

Finally, we are working to pair biological data collection and results with the findings from land manager surveys and interviews and surveys of dog walkers on selected beaches to inform the Community Based Social Marketing piece of this project. Using the data collected and the results from the 'Prioritizing Sites for Management' we have worked with partners to choose both 'high' and 'low' disturbance sites for Phase 3 of this project. In phase 3, partners will use the 'Guide to Applying Science and Management Insights and Human Behavior Change Strategies to Address Beach Walking and Dog Disturbance Along the Atlantic Flyway' to implement a community based social marketing campaign at their sites and we will continue to collect data to evaluate the effectiveness of these campaigns.

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APPENDIX A: List of site codes associated with site priority figures

State or Province	*Site name*	*Code*	*State or Province*	*Site name*	*Code*
CT	Bluff Point	BLUF	NC	North Wrightsville Beach	NWRI
CT	Hammonasset	HAMM	NC	South Pelican Island	PELI
CT	Housatonic	HOUS	NC	South Topsail Island	TOPS
CT	Long Beach	LONG	NC	South Wrightsville Beach	SWRI
CT	Pleasure Beach	PLEA	NS	Avonport Beach	AVON
CT	Sandy Point	SAND	NS	Clam Point Beach	CLAM
FL	Anastasia State Park	ANAS	NS	Crow Neck Beach	CROW
FL	Big Marco Pass Critical Wildlife Area	MARC	NS	Debert Beach	DEBE
FL	Cedar Key	CEKE	NS	The Guzzle	GUZZ
FL	Crandon Park	CRAN	NS	Pomquet Beach	POMQ
FL	Ft. De Soto	FORT	NS	Stoney Island Beach	STON
FL	Outback Key	OUTB	NY	Breezy Point Beach	BREE
FL	Three Rooker Island	ROOK	NY	Jones Beach	JONE
ME	Fortunes Rocks Beach	FORT	NY	Town of Hempstead Beach	HEMP
ME	Goose Rocks Beach	GOOS	SC	Dewees Island	DEWE
ME	Pine Point Beach	PINE	SC	Harbor Island	HARB
ME	Popham Beach	POPH	SC	Huntington Beach State Park	HUNT
NC	Ferry Slip Island	FERR	SC	Lighthouse Inlet Heritage Preserve	LIGH
NC	Hutaff Island	HUTA	SC	Seabrook Island	SEAB
NC	Masonboro Island	MASO	SC	Sullivan's Island	SULL
NC	North Figure 8 Island	FIG8			

APPENDIX B: Atlantic Flyway Disturbance Project summary tables and information

Table 1. Site summary information for each state during each season that data was collected, from November 2017–October 2018 and March 2019–August 2020. This information was summarized from the 'Site Information' data collected by partners. The numbers in parentheses represent range values.

State or Province	Season	Mean # pedestrian access points	Mean # vehicle access points	Mean distance to nearest parking lot (km)	Mean # parking spots	Mean # major events	Prop. with major events	Prop. boat acces s only	Prop. with beach raking	Prop. with beach modifications
CT	Breeding	3.00 (1–4)	0.00	0.52 (0.1–3)	643.50 (100–1500)	0.70 (0–3)	0.60	0.10	0.45	0.20
CT	Fall	3.00 (1–4)	0.00	0.52 (0.1–3)	643.50 (100–1500)	0.10 (0–1)	0.10	0.10	0.40	0.20
CT	Spring	3.00 (1–4)	0.00	0.52 (0.1–3)	643.50 (100–1500)	0.00	0.00	0.05	0.10	0.20
FL	Breeding	2.25 (0–10)	0.42 (0–2)	0.30 (0.09–0.5)	802.00 (67–1800)	0.45 (0–5)	0.17	0.58	0.17	0.58
FL	Fall	5.00 (0–10)	1.00 (0–2)	0.20	1800.00	5.60 (0–25)	0.60	0.60	0.40	0.00
FL	Spring	7.67 (0–13)	5.33 (0–14)	0.22 (0.2–0.23)	2440.00 (1800–3080)	6.75 (0–25)	0.50	0.50	0.50	0.25
FL	Winter	6.17 (0–13)	1.33 (0–4)	0.33 (0.2–0.05)	1362.80 (67–3080)	4.86 (0–25)	0.57	0.29	0.43	0.14
GA	Breedig	27.00	0.00	0.04	320.00	0.00	0.00	0.00	0.00	1.00
GA	Fall	18.75 (0–70)	1.86 (0–6)	0.12 (0.04–0.34)	241.67 (85–320)	0.00	U	0.44	0.00	0.56

GA	Spring	13.00 (0–27)	2.00 (0–6)	0.04	320.00	0.00	0.00	0.67	0.00	0.33
GA	Winter	23.00 (0–70)	1.40 (0–6)	0.12 (0.04–0.34)	241.67 (85–320)	0.00	U	0.29	0.00	0.71
ME	Breeding	7.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
ME	Fall	4.00 (3–7)	0.80 (0–2)	0.06 (0–0.1)	212.00 (10–400)	0.00	0.00	0.00	0.20	0.40
NC	Breeding	2.06 (0–11)	0.31 (0–1)	1.35 (0–6.3)	65.33 (30–90)	0.13 (0–1)	0.13	0.50	0.00	0.75
NC	Fall	2.22 (0–4)	0.44 (0–6)	1.52 (0–6.3)	68.50 (30–90)	0.11 (0–1)	0.11	0.22	0.00	0.78
NC	Spring	2.25 (0–4)	0.38 (0–6)	1.74 (0–6.3)	72.57 (30–90)	0.00	0.00	0.25	0.00	0.75
NC	Winter	2.17 (0–4)	0.33 (0–6)	0.74 (0–2.9)	73.50 (30–90)	0.00	0.00	0.33	0.00	0.67
NS	Breeding	2.50 (1–4)	2.75 (0–8)	0.68 (0.1–2)	19.00 (2–50)	0.00	0.00	0.00	0.00	0.00
NS	Fall	2.57 (1–9)	1.00	0.03 (0.01–0.04)	8.00 (2–50)	0.00	0.00	0.00	0.00	1.00
NY	Breeding	13.60 (7–22)	3.40 (1–4)	0.19 (0.03–0.34)	4997.20 (80–7407)	0.60 (0–2)	0.40	0.00	0.60	0.40
NY	Fall	14.17 (7–22)	3.83 (1–6)	0.17 (0.03–0.34)	3759.17 (80–7407)	0.00	0.00	0.00	0.50	0.33
NY	Spring	14.17 (7–22)	3.83 (1–6)	0.17 (0.03–0.34)	4247.67 (80–7407)	0.00	0.00	0.00	0.67	0.33
SC	Breeding	3.60 (1–8)	0.60 (0–1)	0.77 (0.03–2)	66.00 (4–150)	0.00	0.00	0.20	0.00	0.40
SC	Fall	8.60 (1–30)	1.40 (1–3)	0.83 (0.05–2)	65.20 (6–150)	0.00	0.00	0.00	0.00	0.20
SC	Spring	13.00 (1–30)	1.67 (1–3)	1.03 (0.15–2)	94.00 (20–150)	0.00	0.00	0.00	0.00	0.33

SC	Winter	10.57 (1–30)	1.57 (1–3)	0.76 (0.05–2)	65.43 (6–150)	0.00	0.00	0.00	0.00	0.14

Table 2. Disturbance management summary information for each state during each season that data was collected, from November 2017–October 2018 and March 2019–August 2020. This information was summarized from the 'Site Information' data collected by partners. The numbers represent the proportion of sites (within each state and season) that used specific disturbance management techniques. The proportion related to 'Dogs' may not sum to one, which is a result of sites changing dog rules either daily or throughout the season.

		Dogs			Disturbance management						Biological monitors and/or educational staff				Law enforcement			
State or Province	**Season**	**Dogs allowed**	**Leashed dogs allowed**	**No dogs allowed**	**Nest exclosures**	**Symbolic fencing**	**Pedestrian closed areas**	**Driving closed areas**	**Regulatory signs**	**Interpretive signs**	**Biological monitors**	**Educational staff**	**Both**	**None**	**Full-time**	**Periodic patrol**	**On-call**	**None**
CT	Breeding	0.10	0.55	0.75	0.85	0.90	0.25	1.00	0.60	0.90	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
CT	Fall	0.10	0.45	0.75	0.45	0.50	0.05	1.00	0.60	0.90	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
CT	Spring	0.10	0.60	0.75	0.00	0.45	0.15	1.00	0.80	0.30	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
FL	Breeding	0.17	0.00	0.83	0.00	0.50	0.67	0.83	1.00	0.17	0.83	0.00	0.17	0.00	0.00	0.67	0.33	0.00
FL	Fall	0.40	0.00	0.60	0.00	0.40	0.40	0.40	0.60	0.40	0.40	0.00	0.00	0.60	0.00	0.80	0.20	0.00
FL	Spring	0.50	0.00	0.50	0.00	0.00	0.00	0.25	0.25	0.75	0.25	0.00	0.00	0.75	0.00	0.50	0.50	0.00
FL	Winter	0.29	0.00	0.71	0.00	0.14	0.14	0.57	0.57	0.57	0.14	0.00	0.43	0.43	0.00	0.43	0.57	0.00
GA	Breeding	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
GA	Fall	0.33	0.33	0.56	0.00	0.22	0.22	0.78	1.00	0.44	0.11	0.22	0.00	0.67	0.22	0.56	0.22	0.00

GA	Spring	0.67	0.00	0.33	0.00	0.00	0.33	0.67	1.00	0.33	0.00	0.33	0.00	0.67	0.33	0.33	0.33	0.00
GA	Winter	0.29	0.43	0.57	0.00	0.14	0.14	0.86	1.00	0.57	0.14	0.29	0.00	0.57	0.14	0.71	0.14	0.00
ME	Breeding	1.00	0.00	0.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
ME	Fall	0.60	0.40	0.20	0.40	0.80	0.40	1.00	0.80	1.00	0.20	0.00	0.60	0.20	0.20	0.80	0.00	0.00
NC	Breeding	0.25	0.25	0.50	0.00	0.69	0.31	0.94	0.63	0.44	0.19	0.00	0.81	0.00	0.00	0.31	0.56	0.13
NC	Fall	0.56	0.67	0.11	0.00	0.89	0.44	0.89	0.33	0.44	0.22	0.00	0.67	0.11	0.00	0.44	0.22	0.33
NC	Spring	0.63	0.50	0.00	0.00	0.75	0.38	0.88	0.50	0.50	0.13	0.00	0.88	0.00	0.00	0.38	0.63	0.00
NC	Winter	0.67	0.50	0.00	0.00	0.00	0.17	0.67	0.00	0.33	0.00	0.00	0.67	0.33	0.00	0.33	0.17	0.50
NS	Breeding	0.25	0.75	0.00	0.00	0.25	0.00	1.00	1.00	0.75	1.00	0.00	0.00	0.00	0.00	0.75	0.25	0.00
NS	Fall	0.00	1.00	0.00	0.00	0.00	0.86	1.00	1.00	1.00	0.86	0.00	0.14	0.00	0.00	0.00	1.00	0.00
NY	Breeding	0.00	0.00	1.00	1.00	1.00	0.20	0.60	1.00	0.60	0.40	0.00	0.60	0.00	0.20	0.20	0.40	0.00
NY	Fall	0.00	0.33	0.67	0.33	0.67	0.17	0.17	1.00	0.67	0.33	0.00	0.67	0.00	0.00	0.33	0.50	0.00
NY	Spring	0.00	0.33	0.83	0.50	0.83	0.33	0.33	1.00	0.67	0.33	0.00	0.67	0.00	0.00	0.33	0.50	0.00
SC	Breeding	0.40	0.20	0.40	0.00	1.00	0.00	1.00	0.80	1.00	0.60	0.20	0.00	0.20	0.00	0.00	0.80	0.20
SC	Fall	0.20	0.40	0.60	0.00	0.40	0.20	1.00	0.80	0.80	0.60	0.20	0.00	0.20	0.20	0.00	0.80	0.00
SC	Spring	0.33	0.33	0.67	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.67	0.33	0.00
SC	Winter	0.29	0.29	0.57	0.00	0.00	0.00	1.00	0.71	0.71	0.14	0.00	0.00	0.86	0.29	0.00	0.71	0.00

Table 3. Point count summary information for each participating site, data was collected from November 2017–October 2018 and March 2019–August 2020. This information was summarized from the 'Point Count' data collected by partners. The numbers represent the average number of potential disturbance types and the average number of each shorebird species that were observed at each point throughout the duration of data collection.

State or Province	Site	# Point counts	Proportion of points closed	# Vehicles	# Boats	# Aerial	# Dogs, unleashed	# Dogs, leashed	# People, mobile	# People, at rest	# Predators	# PIPL	# AMOY	# REKN	# WIPL	# SESA or PEEPS	# SAND
CT	Bluff Point	304	0.47	0.00	0.49	0.16	0.02	0.01	1.10	0.80	4.44	0.57	0.30	0.00	0.00	0.13	0.01
CT	Hammonasset	549	0.35	0.24	0.67	0.03	0.11	0.22	10.13	9.78	6.52	0.34	0.15	0.00	0.00	0.13	0.09
CT	Housatonic	469	0.24	0.57	0.17	0.23	0.05	0.06	3.99	1.92	20.16	0.60	0.49	0.01	0.00	4.17	1.51
CT	Long Beach	354	0.38	1.93	0.08	0.36	0.00	0.04	1.14	1.21	23.73	0.86	0.22	0.01	0.00	0.82	8.31
CT	Pleasure Beach	240	0.22	0.08	0.25	0.15	0.00	0.00	0.68	0.72	17.35	0.15	0.16	0.00	0.00	0.35	0.05
CT	Sandy Point	482	0.26	7.24	0.08	0.02	0.06	0.27	6.17	2.19	20.03	0.45	0.28	0.01	0.00	1.25	0.67
FL	Alafia Bank	240	1.00	0.00	0.20	0.01	0.00	0.00	0.22	0.08	0.01	0.00	0.53	0.00	0.00	0.00	0.00
FL	Anastasia State Park	90	0.27	0.07	0.00	0.03	0.00	0.02	12.98	8.96	5.41	0.01	0.01	0.19	1.69	0.00	-
FL	Big Marco Pass CWA	490	0.44	0.00	0.43	0.00	0.02	0.00	3.49	1.36	1.02	0.17	0.01	0.14	1.54	1.13	-
FL	Cedar Key	314	0.00	0.01	0.21	0.00	0.01	0.00	0.11	0.01	0.07	0.23	59.94	10.06	0.11	0.96	5.93
FL	Crandon Pk	56	0.00	0.48	0.00	0.25	0.05	0.07	7.77	3.50	0.04	4.23	0.00	0.00	0.04	0.41	-
FL	DMDF 2D	240	1.00	0.00	0.60	0.00	0.02	0.02	0.78	1.48	0.03	0.00	1.13	0.00	0.00	0.69	0.00
FL	Fantasy Island	24	0.79	0.00	13.96	0.04	0.33	0.29	11.83	35.13	0.00	0.00	0.33	0.00	0.00	0.04	0.00
FL	Ft. De Soto	345	0.27	0.17	0.48	0.18	0.05	0.01	10.12	9.32	0.34	0.30	0.21	12.88	0.23	0.03	5.25
FL	Outback	110	0.14	0.02	2.02	0.32	0.36	0.07	5.03	2.20	0.33	1.86	0.19	12.59	1.81	0.01	9.66

FL	Three Rooker Island	98	0.14	0.00	1.36	0.16	0.02	0.02	1.44	0.99	69.38	0.90	0.32	0.31	0.32	0.00	-
GA	Cumberland Island	44	0.00	0.39	0.02	0.02	0.00	0.00	0.93	0.18	21.30	1.70	0.09	5.45	0.36	0.07	16.61
GA	East Beach	318	0.04	0.06	0.06	0.07	1.88	1.17	22.77	11.64	0.05	0.29	0.01	0.25	0.84	0.52	5.83
GA	Egg Island Bar	16	1.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	3.06	3.38	5.25	0.00	2.88	0.13	15.56
GA	Fort Pulaski	82	0.46	0.00	0.22	0.02	0.05	0.13	0.88	0.05	0.04	0.00	4.24	0.87	0.50	12.04	19.76
GA	Jekyll Island	266	0.18	0.03	0.02	0.01	0.05	0.26	7.04	0.24	0.00	0.03	0.38	0.00	0.05	0.05	4.16
GA	Tybee Island	240	0.09	0.41	0.10	0.03	0.00	0.02	22.95	16.49	0.01	0.02	0.15	0.15	0.00	0.00	1.29
ME	Fortunes Rocks Beach	79	0.00	0.00	0.04	0.06	0.05	0.18	7.67	6.08	9.41	0.04	0.00	0.00	0.00	2.56	-
ME	Goose Rocks Beach	159	0.01	0.00	0.48	0.09	0.05	0.09	17.73	12.61	3.16	0.53	0.00	0.00	0.00	4.09	-
ME	Pine Point Beach	76	0.00	0.33	1.03	0.17	0.30	0.37	15.96	12.92	7.88	0.00	0.00	0.00	0.00	4.92	-
ME	Popham Beach	120	0.36	0.02	0.03	0.03	0.12	0.09	18.97	18.46	1.92	0.07	0.00	0.00	0.00	19.01	1.20
NC	Ferry Slip Island	46	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.00	10.26	0.00	0.00	1.39	-
NC	Hutaff Island	430	0.44	0.00	0.65	0.05	0.18	0.02	1.67	1.10	4.08	0.16	0.43	0.04	0.42	0.70	4.24
NC	Masonboro Island	100	0.40	0.02	0.14	0.02	0.05	0.00	0.64	0.17	0.00	0.00	2.21	2.28	1.44	0.26	-
NC	N. Figure 8 Island	367	0.23	0.02	0.56	0.06	0.19	0.02	2.44	2.00	3.63	0.42	0.27	0.20	0.56	0.74	0.97
NC	N. Wrightsville Beach	160	0.38	0.06	0.34	0.08	0.07	0.16	9.22	5.27	6.66	0.02	0.18	0.05	0.58	0.91	-
NC	S. Pelican Island	46	1.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	14.02	0.00	4.83	0.00	0.00	0.00	-
NC	S. Topsail Island	568	0.00	0.19	0.22	0.05	0.18	0.29	4.72	3.58	3.17	0.36	0.00	0.19	0.04	0.02	2.24
NC	S. Wrightsvile Beach	112	0.75	0.32	0.04	0.21	0.03	0.21	8.52	7.85	6.10	0.05	0.81	0.09	0.01	0.07	0.24
NS	Avonport	40	0.50	0.65	0.08	0.00	0.23	0.03	2.48	3.08	1.08	0.00	0.00	0.00	0.00	1256.65	0.00
NS	Clam Point	20	0.00	0.45	0.15	0.00	0.00	0.05	0.95	0.45	2.75	0.20	0.00	0.00	0.00	0.00	-
NS	Crow Neck	44	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.18	1.73	2.43	0.05	0.00	0.00	2.98	-

NS	Debert	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	310.00	-
NS	Guzzle	58	0.43	1.07	0.02	0.03	0.02	0.03	0.84	3.88	1.07	0.12	0.00	0.00	0.00	1167.62	0.00
NS	Pomquet	80	0.05	0.00	0.00	0.00	0.08	0.20	0.70	0.49	1.35	0.44	0.00	0.00	0.00	0.00	-
NS	Stoney Island	40	0.00	1.05	0.00	0.00	0.30	0.08	2.00	1.05	1.53	0.18	0.00	0.00	0.00	0.00	-
NY	Breezy Point	530	0.33	0.08	0.02	0.01	0.04	0.10	1.60	2.61	6.66	0.11	2.44	0.00	0.02	3.27	0.03
NY	Jones Beach	515	0.69	0.07	0.15	0.18	0.00	0.01	3.35	6.57	21.93	0.77	1.50	0.31	0.00	0.41	8.84
NY	Town of Hempstead	464	0.60	0.58	0.07	0.46	0.03	0.02	8.06	26.38	26.79	0.86	6.79	0.03	0.00	0.11	61.62
SC	Botany Bay Plantation	65	0.00	0.03	0.03	0.02	0.00	0.00	1.26	0.23	0.86	0.00	0.20	1.14	0.02	0.03	1.05
SC	Dewees Island	48	1.00	0.00	1.33	0.00	0.38	0.08	0.88	5.65	0.02	0.00	0.04	0.00	0.77	0.00	-
SC	Folly Beach Lighthouse Inlet	172	0.00	0.00	0.06	0.02	0.02	0.01	1.06	0.14	0.03	0.12	0.51	1.82	0.13	0.00	3.55
SC	Harbor Island	76	0.21	0.00	0.00	0.00	0.07	0.28	2.83	1.50	14.54	1.29	0.11	0.36	0.79	0.59	27.96
SC	Huntington Beach State Park	220	0.25	0.00	0.47	0.07	0.05	0.28	4.31	2.77	0.02	0.01	0.06	0.00	0.15	0.05	1.68
SC	Lighthouse Inlet Heritage Preserve	79	0.34	0.00	0.03	0.03	0.00	0.00	1.03	0.44	0.00	0.11	0.47	0.05	0.57	0.19	-
SC	Seabrook Island	55	0.80	0.16	0.04	0.00	0.15	0.24	2.69	6.25	0.09	0.00	0.00	50.49	0.36	0.00	-
SC	Sullivan's Island	371	0.00	0.21	0.04	0.06	0.96	0.25	4.96	2.33	0.02	0.02	0.04	0.16	0.00	0.01	5.57

Table 4. Point count summary information and the number of behavioral samples and nests monitored for each participating site during each season that data was collected from November 2017–October 2018 and March 2019–August 2020. This information was summarized from the 'Point Count', 'Behavioral Sample', and 'Productivity' data collected by partners. The numbers represent the average number of potential disturbance types and the average number of each shorebird species that were observed at each point throughout the duration of data collection.

State or Province	Site	Season	# Point counts	Proportion of points closed	# Vehicles	# Boats	# Aerial	# Dogs, unleashed	# Dogs, leashed	# People, mobile	# People, at rest	# Predators	# PIPL	# AMOY	# REKN	# WIPL	# SESA or PEEPS	# SAND	# Behavioral samples	# Nests monitored
CT	Bluff Point	Breeding	165	0.84	0.00	0.75	0.16	0.02	0.00	1.54	1.30	1.72	0.96	0.45	0.00	0.00	0.04	0.01	4	40
CT	Bluff Point	Fall	95	0.05	0.00	0.26	0.19	0.04	0.03	0.68	0.21	6.95	0.00	0.08	0.00	0.00	0.34	0.00	6	-
CT	Bluff Point	Spring	44	0.00	0.00	0.00	0.07	0.00	0.00	0.36	0.16	9.23	0.34	0.18	0.00	0.00	0.00	0.00	12	-
CT	Hammonasset	Breeding	291	0.55	0.15	0.69	0.03	0.06	0.18	12.08	11.93	5.06	0.61	0.25	0.00	0.00	0.15	0.01	12	26
CT	Hammonasset	Fall	180	0.13	0.27	0.92	0.02	0.19	0.24	10.16	10.23	8.26	0.01	0.02	0.00	0.00	0.14	0.22	10	-
CT	Hammonasset	Spring	78	0.08	0.49	0.03	0.01	0.09	0.37	2.77	0.71	7.99	0.09	0.12	0.00	0.00	0.00	0.00	8	-
CT	Housatonic	Breeding	232	0.44	0.50	0.20	0.26	0.03	0.04	4.79	2.38	8.69	1.12	0.53	0.02	0.00	6.84	0.42	16	35
CT	Housatonic	Fall	150	0.03	0.69	0.21	0.20	0.05	0.05	3.96	2.20	21.89	0.00	0.51	0.00	0.00	2.46	3.63	34	-
CT	Housatonic	Spring	87	0.07	0.54	0.00	0.20	0.11	0.10	1.92	0.21	47.72	0.24	0.32	0.00	0.00	0.00	0.31	21	-
CT	Long Beach	Breeding	186	0.73	1.96	0.09	0.48	0.00	0.05	1.28	1.47	10.92	1.59	0.35	0.03	0.00	1.49	2.24	21	36
CT	Long Beach	Fall	114	0.00	1.91	0.11	0.24	0.00	0.03	1.14	1.10	28.07	0.00	0.06	0.00	0.00	0.10	12.48	20	-
CT	Long Beach	Spring	54	0.00	1.87	0.00	0.24	0.00	0.02	0.63	0.56	58.69	0.15	0.09	0.00	0.00	0.00	26.11	10	-
CT	Pleasure Beach	Breeding	132	0.39	0.08	0.26	0.17	0.00	0.00	0.85	1.02	16.66	0.27	0.25	0.00	0.00	0.64	0.08	4	6
CT	Pleasure Beach	Fall	72	0.00	0.13	0.25	0.10	0.00	0.01	0.61	0.53	22.17	0.00	0.07	0.00	0.00	0.00	0.00	4	-

CT	Pleasure Beach	Spring	36	0.00	0.00	0.25	0.14	0.00	0.00	0.17	0.03	10.25	0.00	0.03	0.00	0.00	0.00	0.00	0	-
CT	Sandy Point	Breeding	250	0.49	7.46	0.12	0.02	0.06	0.23	6.77	2.66	9.52	0.85	0.48	0.02	0.00	2.16	0.63	30	30
CT	Sandy Point	Fall	152	0.02	7.71	0.07	0.01	0.09	0.38	6.79	2.48	33.03	0.01	0.08	0.00	0.00	0.40	0.68	12	-
CT	Sandy Point	Spring	80	0.01	5.70	0.01	0.01	0.03	0.23	3.13	0.16	28.15	0.06	0.05	0.00	0.00	0.00	0.81	5	-
FL	Alafia Bank	Breeding	240	1.00	0.00	0.20	0.01	0.00	0.00	0.22	0.08	0.01	0.00	0.53	0.00	0.00	0.00	0.00	-	4
FL	Anastasia State Park	Breeding	90	0.27	0.07	0.00	0.03	0.00	0.02	12.98	8.96	5.41	0.01	0.01	0.19	1.69	0.00	-	-	15
FL	Big Marco Pass CWA	Breeding	340	0.51	0.00	0.58	0.00	0.02	0.00	3.93	1.77	1.46	0.02	0.01	0.16	1.75	0.36	-	-	18
FL	Big Marco Pass CWA	Winter	150	0.30	0.00	0.07	0.00	0.01	0.00	2.50	0.43	0.02	0.51	0.01	0.08	1.07	2.86	-	49	-
FL	Cedar Key	Fall	157	0.00	0.02	0.25	0.00	0.01	0.00	0.13	0.03	0.06	0.06	61.84	15.10	0.10	1.44	7.32	170	-
FL	Cedar Key	Spring	77	0.00	0.00	0.13	0.01	0.01	0.00	0.05	0.00	0.05	0.45	43.06	2.32	0.12	0.56	0.00	79	-
FL	Cedar Key	Winter	80	0.00	0.00	0.23	0.00	0.00	0.00	0.11	0.00	0.10	0.34	72.44	7.63	0.14	0.41	6.50	85	-
FL	Crandon Pk	Spring	31	0.00	0.61	0.00	0.35	0.03	0.13	12.39	5.42	0.00	3.65	0.00	0.00	0.03	0.74	-	9	-
FL	Crandon Pk	Winter	25	0.00	0.32	0.00	0.12	0.08	0.00	2.04	1.12	0.08	4.96	0.00	0.00	0.04	0.00	-	9	-
FL	DMDF 2D	Breeding	240	1.00	0.00	0.60	0.00	0.02	0.02	0.78	1.48	0.03	0.00	1.13	0.00	0.00	0.69	0.00	-	18
FL	Fantasy Island	Breeding	24	0.79	0.00	13.96	0.04	0.33	0.29	11.83	35.13	0.00	0.00	0.33	0.00	0.00	0.04	0.00	-	-
FL	Ft. De Soto	Breeding	155	0.35	0.33	0.21	0.14	0.00	0.00	10.05	7.99	0.61	0.12	0.21	7.17	0.25	0.01	3.84	42	14
FL	Ft. De Soto	Fall	85	0.20	0.05	1.18	0.04	0.19	0.01	7.45	10.64	0.27	0.88	0.19	16.80	0.34	0.05	9.32	86	-
FL	Ft. De Soto	Spring	35	0.20	0.00	0.17	0.09	0.03	0.03	21.66	24.03	0.00	0.09	0.26	29.20	0.14	0.11	-	21	-
FL	Ft. De Soto	Winter	70	0.19	0.03	0.37	0.50	0.00	0.04	7.76	3.31	0.00	0.09	0.21	12.60	0.10	0.01	1.64	30	-
FL	Outback	Breeding	56	0.25	0.04	2.29	0.23	0.20	0.09	6.18	1.46	0.64	0.91	0.21	4.00	2.29	0.00	4.11	6	6
FL	Outback	Fall	26	0.00	0.00	2.35	0.15	1.00	0.08	4.77	3.96	0.00	2.19	0.04	13.12	1.96	0.04	15.46	67	-
FL	Outback	Spring	6	0.00	0.00	2.83	0.00	0.17	0.00	6.67	5.67	0.00	4.33	0.17	12.50	1.17	0.00	-	4	-
FL	Outback	Winter	22	0.05	0.00	0.73	0.82	0.09	0.05	1.95	1.05	0.00	3.23	0.32	33.86	0.59	0.00	15.70	45	-
FL	Three Rooker	Breeding	50	0.20	0.00	1.46	0.16	0.02	0.02	1.86	1.06	115.28	0.16	0.54	0.00	0.02	0.00	-	-	4

FL	Three Rooker	Fall	48	0.08	0.00	1.25	0.17	0.02	0.02	1.00	0.92	21.56	1.67	0.08	0.63	0.63	0.00	-	40	-
GA	Cumberland Island	Fall	22	0.00	0.73	0.00	0.00	0.00	0.00	0.82	0.18	23.45	2.09	0.00	0.00	0.00	0.00	12.23	14	-
GA	Cumberland Island	Spring	22	0.00	0.05	0.05	0.05	0.00	0.00	1.05	0.18	19.14	1.32	0.18	10.91	0.73	0.14	21.00	56	-
GA	East Beach	Breeding	24	0.00	0.00	0.00	0.38	2.33	1.17	27.25	15.00	0.13	0.75	0.00	3.21	0.46	0.00	1.21	12	-
GA	East Beach	Fall	120	0.02	0.04	0.09	0.05	1.80	1.14	19.95	10.74	0.10	0.13	0.00	0.00	1.22	0.39	5.42	34	-
GA	East Beach	Spring	90	0.13	0.16	0.09	0.06	2.20	1.69	39.52	21.77	0.01	0.23	0.02	0.02	0.46	1.30	6.11	55	-
GA	East Beach	Winter	84	0.00	0.00	0.00	0.02	1.54	0.67	7.56	1.12	0.00	0.45	0.00	0.00	0.82	0.00	7.32	47	-
GA	Egg Island Bar	Fall	4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	7.25	7.75	0.00	0.00	0.00	7.00	14	-
GA	Egg Island Bar	Spring	4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	3.25	0.50	0.00	0.25	0.00	15.25	14	-
GA	Egg Island Bar	Winter	8	1.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	5.50	1.50	6.38	0.00	5.63	0.25	20.00	29	-
GA	Fort Pulaski	Breeding	6	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.83	0.00	1.50	0.00	0.00	8	1
GA	Fort Pulaski	Fall	32	0.31	0.00	0.22	0.06	0.13	0.16	1.19	0.06	0.03	0.00	3.06	2.00	0.09	0.22	3.66	22	-
GA	Fort Pulaski	Spring	22	1.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.09	0.00	8.09	0.27	1.32	44.55	67.09	33	-
GA	Fort Pulaski	Winter	22	0.00	0.00	0.14	0.00	0.00	0.27	1.55	0.09	0.00	0.00	0.05	0.05	0.00	0.00	1.23	7	-
GA	Jekyll Island	Fall	97	0.27	0.08	0.04	0.02	0.02	0.29	10.04	0.61	0.00	0.03	0.00	0.00	0.09	0.00	3.86	45	-
GA	Jekyll Island	Spring	60	0.00	0.00	0.00	0.00	0.08	0.32	6.15	0.00	0.00	0.00	1.70	0.00	0.07	0.17	6.38	19	-
GA	Jekyll Island	Winter	109	0.20	0.01	0.01	0.00	0.06	0.20	4.86	0.04	0.00	0.04	0.00	0.01	0.00	0.03	3.20	39	-
GA	Tybee Island	Fall	90	0.00	0.26	0.12	0.04	0.00	0.01	28.63	28.27	0.01	0.02	0.01	0.00	0.00	0.01	1.07	26	-
GA	Tybee Island	Spring	80	0.25	0.43	0.05	0.04	0.00	0.03	28.25	15.54	0.00	0.00	0.00	0.00	0.00	0.00	1.08	12	-
GA	Tybee Island	Winter	70	0.01	0.59	0.11	0.01	0.00	0.03	9.57	2.43	0.03	0.03	0.49	0.50	0.00	0.00	1.83	35	-
ME	Fortunes Rocks Beach	Fall	79	0.00	0.00	0.04	0.06	0.05	0.18	7.67	6.08	9.41	0.04	0.00	0.00	0.00	2.56	-	12	-
ME	Goose Rocks Beach	Breeding	83	0.01	0.00	0.23	0.08	0.01	0.12	21.67	14.47	3.28	1.01	0.00	0.00	0.00	0.08	-	-	8
ME	Goose Rocks Beach	Fall	76	0.01	0.00	0.76	0.09	0.09	0.05	13.42	10.58	3.03	0.00	0.00	0.00	0.00	8.46	-	16	-

ME	Pine Point Beach	Fall	76	0.00	0.33	1.03	0.17	0.30	0.37	15.96	12.92	7.88	0.00	0.00	0.00	0.00	4.92	-	10	-
ME	Popham Beach	Fall	120	0.36	0.02	0.03	0.03	0.12	0.09	18.97	18.46	1.92	0.07	0.00	0.00	0.00	19.01	1.20	39	-
NC	Ferry Slip Island	Breeding	46	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.00	10.26	0.00	0.00	1.39	-	1	34
NC	Hutaff Island	Breeding	125	1.00	0.00	1.66	0.02	0.22	0.07	3.69	3.04	1.12	0.15	0.69	0.06	0.87	0.62	0.76	18	40
NC	Hutaff Island	Fall	100	0.25	0.00	0.56	0.08	0.36	0.00	1.84	0.68	3.80	0.41	0.39	0.00	0.39	2.13	9.02	64	-
NC	Hutaff Island	Spring	95	0.42	0.00	0.14	0.02	0.08	0.00	0.55	0.17	3.24	0.08	0.64	0.12	0.33	0.01	5.06	58	-
NC	Hutaff Island	Winter	110	0.00	0.00	0.04	0.07	0.04	0.00	0.18	0.08	8.43	0.02	0.00	0.00	0.00	0.08	1.22	18	-
NC	Masonboro Island	Breeding	100	0.40	0.02	0.14	0.02	0.05	0.00	0.64	0.17	0.00	0.00	2.21	2.28	1.44	0.26	-	-	35
NC	N. Figure 8 Island	Breeding	90	0.56	0.02	1.53	0.02	0.34	0.03	5.36	5.46	0.74	0.14	0.56	0.19	1.29	1.86	0.33	25	-
NC	N. Figure 8 Island	Fall	120	0.10	0.01	0.46	0.07	0.15	0.03	1.94	1.63	6.07	0.30	0.18	0.00	0.51	0.32	1.42	60	-
NC	N. Figure 8 Island	Spring	97	0.25	0.02	0.14	0.08	0.14	0.00	1.38	0.44	0.62	0.82	0.26	0.58	0.29	0.67	0.27	60	-
NC	N. Figure 8 Island	Winter	60	0.00	0.02	0.00	0.05	0.08	0.02	0.80	0.07	7.97	0.40	0.03	0.00	0.00	0.02	1.18	19	-
NC	N. Wrightsville Beach	Breeding	40	0.75	0.05	1.28	0.10	0.00	0.00	20.68	16.08	8.80	0.00	0.20	0.00	1.73	3.45	-	1	-
NC	N. Wrightsville Beach	Fall	40	0.08	0.10	0.05	0.13	0.15	0.23	7.78	1.95	5.08	0.00	0.05	0.00	0.13	0.05	-	5	-
NC	N. Wrightsville Beach	Spring	40	0.68	0.05	0.03	0.10	0.05	0.18	5.83	2.40	1.20	0.08	0.48	0.20	0.45	0.10	-	22	-
NC	N. Wrightsville Beach	Winter	40	0.00	0.03	0.00	0.00	0.08	0.23	2.60	0.65	11.55	0.00	0.00	0.00	0.00	0.05	-	1	-
NC	S. Pelican Island	Breeding	46	1.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	14.02	0.00	4.83	0.00	0.00	0.00	-	-	28
NC	S. Topsail Island	Breeding	120	0.02	0.04	0.88	0.08	0.12	0.60	12.03	12.11	1.06	0.12	0.00	0.88	0.11	0.03	0.78	14	3
NC	S. Topsail Island	Fall	160	0.00	0.58	0.11	0.07	0.26	0.33	5.14	2.96	4.67	0.48	0.00	0.00	0.02	0.01	1.90	72	-
NC	S. Topsail Island	Spring	128	0.00	0.03	0.00	0.02	0.18	0.16	1.29	0.55	0.86	0.51	0.00	0.02	0.05	0.02	2.02	37	-
NC	S. Topsail Island	Winter	160	0.00	0.06	0.00	0.03	0.13	0.14	1.57	0.21	5.10	0.29	0.00	0.00	0.00	0.03	3.44	41	-
NC	S. Wrightsville Beach	Breeding	68	1.00	0.26	0.03	0.28	0.00	0.03	8.01	7.81	3.90	0.00	1.16	0.15	0.00	0.12	0.00	1	8

NC	S. Wrightsville Beach	Fall	40	0.40	0.45	0.05	0.13	0.05	0.45	9.60	8.40	10.40	0.03	0.25	0.00	0.03	0.00	0.40	12	-
NC	S. Wrightsville Beach	Spring	4	0.00	0.00	0.00	0.00	0.25	1.00	6.25	3.00	0.50	1.25	0.50	0.00	0.00	0.00	0.00	2	-
NS	Avonport	Fall	40	0.50	0.65	0.08	0.00	0.23	0.03	2.48	3.08	1.08	0.00	0.00	0.00	0.00	1256.65	0.00	20	-
NS	Clam Point	Breeding	20	0.00	0.45	0.15	0.00	0.00	0.05	0.95	0.45	2.75	0.20	0.00	0.00	0.00	0.00	-	-	-
NS	Crow Neck	Breeding	44	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.18	1.73	2.43	0.05	0.00	0.00	2.98	-	-	8
NS	Debert	Fall	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	310.00	-	8	-
NS	Guzzle	Fall	58	0.43	1.07	0.02	0.03	0.02	0.03	0.84	3.88	1.07	0.12	0.00	0.00	0.00	1167.62	0.00	48	-
NS	Pomquet	Breeding	80	0.05	0.00	0.00	0.00	0.08	0.20	0.70	0.49	1.35	0.44	0.00	0.00	0.00	0.00	-	-	5
NS	Stoney Island	Breeding	40	0.00	1.05	0.00	0.00	0.30	0.08	2.00	1.05	1.53	0.18	0.00	0.00	0.00	0.00	-	-	-
NY	Breezy Point	Breeding	120	0.50	0.03	0.06	0.03	0.00	0.04	2.11	7.15	0.01	0.37	2.02	0.00	0.00	4.23	-	96	-
NY	Breezy Point	Fall	200	0.32	0.12	0.02	0.01	0.01	0.15	0.95	1.75	9.65	0.04	4.13	0.00	0.00	5.24	0.00	65	-
NY	Breezy Point	Spring	210	0.24	0.06	0.00	0.00	0.08	0.09	1.93	0.82	7.61	0.04	1.07	0.00	0.04	0.84	0.05	112	-
NY	Jones Beach	Breeding	275	0.91	0.09	0.20	0.22	0.00	0.01	5.57	11.21	19.47	1.23	2.17	0.00	0.00	0.76	12.97	88	81
NY	Jones Beach	Fall	140	0.23	0.04	0.16	0.11	0.00	0.01	1.07	2.05	40.00	0.06	0.71	1.14	0.00	0.01	2.10	48	-
NY	Jones Beach	Spring	100	0.72	0.05	0.01	0.15	0.00	0.00	0.42	0.15	3.39	0.46	0.77	0.00	0.00	0.00	10.52	55	-
NY	Town of Hempstead	Breeding	230	0.72	0.60	0.12	0.41	0.01	0.00	13.94	44.00	22.89	0.73	7.11	0.00	0.00	0.17	6.00	147	35
NY	Town of Hempstead	Fall	130	0.54	0.65	0.04	0.54	0.02	0.03	3.01	16.12	49.91	1.20	7.65	0.12	0.00	0.08	78.76	122	-
NY	Town of Hempstead	Spring	104	0.40	0.44	0.01	0.46	0.08	0.03	1.37	0.25	6.52	0.75	5.01	0.00	0.00	0.00	110.20	105	-
SC	Botany Bay Plantation	Fall	40	0.00	0.05	0.05	0.03	0.00	0.00	1.70	0.28	1.38	0.00	0.20	1.80	0.03	0.05	1.60	17	-
SC	Botany Bay Plantation	Winter	25	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.16	0.04	0.00	0.20	0.08	0.00	0.00	0.28	5	-
SC	Dewees Island	Breeding	48	1.00	0.00	1.33	0.00	0.38	0.08	0.88	5.65	0.02	0.00	0.04	0.00	0.77	0.00	-	-	5
SC	Folly Beach Lighthouse Inlet	Fall	40	0.00	0.00	0.18	0.03	0.00	0.03	0.90	0.48	0.03	0.13	0.63	0.23	0.40	0.00	4.40	65	-

SC	Folly Beach Lighthouse Inlet	Spring	8	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	1.50	27.25	0.88	0.00	0.00	18	-
SC	Folly Beach Lighthouse Inlet	Winter	124	0.00	0.00	0.02	0.02	0.02	0.01	1.12	0.04	0.04	0.12	0.40	0.69	0.00	0.00	3.44	90	-
SC	Harbor Island	Breeding	16	1.00	0.00	0.00	0.00	0.06	0.25	4.38	1.75	0.00	0.25	0.13	0.06	0.38	2.56	-	-	1
SC	Harbor Island	Fall	33	0.00	0.00	0.00	0.00	0.03	0.09	2.85	2.33	32.00	1.76	0.06	0.79	0.58	0.12	45.17	53	-
SC	Harbor Island	Winter	27	0.00	0.00	0.00	0.00	0.11	0.52	1.89	0.33	1.81	1.33	0.15	0.00	1.30	0.00	8.85	32	-
SC	Huntington Beach State Park	Breeding	100	0.56	0.01	0.65	0.10	0.06	0.27	5.77	3.29	0.03	0.03	0.07	0.00	0.33	0.00	-	-	1
SC	Huntington Beach State Park	Fall	50	0.00	0.00	0.28	0.02	0.04	0.14	2.84	3.70	0.00	0.00	0.12	0.00	0.00	0.00	2.18	36	-
SC	Huntington Beach State Park	Winter	70	0.00	0.00	0.36	0.07	0.04	0.40	3.27	1.36	0.01	0.00	0.00	0.00	0.00	0.16	1.33	30	-
SC	Lighthouse Inlet Heritage Preserve	Breeding	36	0.75	0.00	0.00	0.03	0.00	0.00	0.92	0.86	0.00	0.00	0.31	0.11	0.75	0.08	-	-	3
SC	Lighthouse Inlet Heritage Preserve	Spring	43	0.00	0.00	0.05	0.02	0.00	0.00	1.12	0.09	0.00	0.21	0.60	0.00	0.42	0.28	-	19	-
SC	Seabrook Island	Breeding	55	0.80	0.16	0.04	0.00	0.15	0.24	2.69	6.25	0.09	0.00	0.00	50.49	0.36	0.00	-	-	3
SC	Sullivan's Island	Fall	80	0.00	0.00	0.14	0.11	0.40	0.30	6.49	5.54	0.01	0.00	0.00	0.00	0.00	0.03	7.66	42	-
SC	Sullivan's Island	Spring	81	0.00	0.02	0.01	0.01	1.67	0.41	5.21	2.62	0.01	0.05	0.12	0.00	0.01	0.00	-	5	-
SC	Sullivan's Island	Winter	210	0.00	0.36	0.00	0.05	0.90	0.17	4.28	1.00	0.03	0.01	0.03	0.29	0.00	0.00	3.89	38	-

APPENDIX C: Atlantic Flyway Disturbance Project Standard Operating Procedures and Datasheets (used during data collection)

Atlantic Flyway Disturbance Project Data Collection

• Standard Operating Procedures •

This project is a collaborative effort between the National Audubon Society, the Virginia Tech Shorebird Program and the Dayer Human Dimensions Lab, and the Department of Fish and Wildlife Conservation at Virginia Tech.

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Audrey DeRose-Wilson

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Introduction

Hello!! Thank you for your participation in the Atlantic Flyway Disturbance Project funded by the National Fish and Wildlife Foundation. We are happy to have you on board and look forward to working with you throughout the duration of this project. The purpose of this project is to develop standardized, scientifically-sound guidelines and metrics for assessing the impacts of disturbance that can be applied across the Atlantic Flyway and guide the design of effective social marketing campaign(s) for changing human behavior causing detrimental disturbance. This project will assess the types of human disturbance, frequency, response of shorebirds, and effectiveness of various techniques used to control disturbance. With the information collected, we will determine the associations among coastal habitat conditions, human disturbance, and shorebird foraging behavior, habitat use, and demography. This information will help identify the human dimensions focus of this project (studying the drivers of critical human behaviors causing disturbance) and ultimately recommending how to design social marketing campaigns.

Below you will find standard operating procedures (SOP) for each of the data types (both in the field and out of the field) that our team is collecting. With this SOP you should have also received:

- ✧ An excel database for data entry that contains tables for each of the data types we will be collecting/sharing.
- ✧ An excel form with the two datasheets for use in the field.

When you first receive this information, we suggest reading through the SOP and having the database and datasheets open or available to ensure everything is clear and that we've provided enough information for you to collect data correctly and efficiently. If you have questions while perusing these resources, or at any point during data collection, **please contact Kelsi Hunt (hunt0382@vt.edu, 540.315.0551).** Below is a brief overview of the data we will be collecting and how it will be used:

- ✧ **Site information:** Site information will be used to classify the types and levels of human disturbances that are unique to a given site, as well as identify the similarities in experienced disturbance shared among monitored sites. This information will be used to identify the types of disturbances that may influence shorebird behavior and demography, which can then be used to inform management objectives.
- ✧ **Point counts:** Point counts will serve as the linkage between the frequency of human disturbance and shorebird demography and habitat use. By collecting human and shorebird use data simultaneously in specified locations, we can determine whether

human activities directly impact fine-scale shorebird habitat use, as well as local patterns in shorebird abundance.

- **Behavioral samples (not collected on nesting species during the breeding season):** Behavior data collected alongside point count data will provide us with the opportunity to identify and understand the ecological mechanisms (e.g., altered feeding or resting regimes, habitat avoidance, etc.) linking human disturbance and shorebird population dynamics, which will better guide management decisions.
- **Productivity information:** Reproductive activity and success will provide an opportunity to determine indirect associations between human use of shorelines and local production. Depending on the variety of ongoing management actions and human disturbances, this will also allow us to determine the effectiveness of various management regulations on relative shorebird production.

Field Procedures: Point Counts and Behavioral Samples

Before going into the field

Step 1: Choose sites to be included

You will need to choose sites to be included in this study. In general, we suggest that sites have different landowners. **We also suggest that you choose sites with both high and low levels of disturbance as well as varying numbers of the focal species of this project (American Oystercatcher, Piping Plover, Wilson's Plover, Sanderling, Red Knot, and Semipalmated Sandpiper).** The site size doesn't necessarily matter (but see more in Step 2 and the FAQ's). It is fine if the level of disturbance varies throughout the site, using the methods described in Step 2, we should be able to detect the variance in disturbance.

Step 2: Designate points at each site where you will conduct point counts with a 200m radius and behavioral samples.

Please take your site and divide it into 12 equal (or almost equal parts), which will give you 10 locations (skipping the beginning and ending point) where you will take point counts (with a 200 m radius) and behavioral samples and enter these locations into your GPS unit (latitude/longitude in decimal degrees). We will also ask you to provide some information about these points/locations in the 'Point Count Locations' form of your database (see Non-Field Data Entry below for specifics). **If your site is smaller than 4 km (the site size needed to accommodate 10 points with a 200 m radius around the point), please try to fit as many points as your site can accommodate, making sure that the radii of the**

circles do not overlap. Please see the FAQ's if you have questions about the size of your site or how to get the 10 locations.

Step 3: Pre-data collection practice

As we are counting potential disturbances as well as numbers of focal species within a 200 m radius, it will be beneficial to take time to measure out 200 m so you get an idea of what the distance looks like, prior to going into the field.

FAQ's

1. What about sandbars that are underwater at high tide but that would be places where the focal species forage at mid or low tide? Should those be included? As a separate site or part of a larger inlet area? There would be different management regimes from one place to another.

Good question. If they are a different management regime, we recommend leaving them out.

2. Should we include high tide roost sites, even though we may not be able to visit/collect data as frequently due to the tide?

Great question. We think that high tide roost sites and the behaviors associated are very important and therefore we suggest that you do include these sites (if you have them), with the understanding that you may not be able to visit as frequently.

3. What if my site or sites are less than 4 km and the 200 m radius for the point counts will overlap? Or what if my site or sites are large and the 10 points may not capture the true human activity or the counts of the focal species?

We developed the datasheets and standard operating procedures without knowing the specific sites that would be participating, but these methods are flexible. If your site or sites fall into either of the above categories, please contact Kelsi Hunt (hunt0382@vt.edu, 540.315.0551) to talk about ways to solve this. **The main point to make is that we don't want the 200 m radii to overlap, so less than 10 points at smaller sites will be necessary.**

4. Related to the site size question, how many points should there be, minimum?

There really isn't a minimum number of points at a site per se, although we would prefer that each site has at least three points. What we would be concerned about is the lack of point count and behavioral samples in terms of data analysis. So, if all of your sites are small in size with a low number of points each, we may have to think about increasing the number of samples you take during each site visit.

5. ***Do you have any suggestions for ways to get the points?***

Feel free to use any technique to get the points to be used for the point count/behavioral sample locations. If you are unsure, you can use the line transect tool in Google Maps or Earth and enter the points into your GPS prior to your first time in the field. Another option could be to get the total distance of your site, split it into equal parts, figure out the distance between your points and then take the locations in the GPS on your first field visit.

6. ***After we break up a site into 12 segments (if large enough), how should we determine where the survey points are? Randomly pick a point within each segment but >400m from the other points?***

Yes, as long as the point counts don't overlap, you can choose where you would like the point to be within each segment. It is also important that you are not choosing point based on where you think the birds will be or where the most disturbance will be. You can, however, shift the points in order to better see the entire 200 m, or to get a better view of the habitat.

7. What about visual impediments at points? For example, can the circle include water? Or what about a situation where a dune in the middle of a peninsula would block the ability to see both shores?

In a perfect world for point count data collection, you would be able to see the entire 200 m radius. However, we understand that this isn't going to be possible everywhere. So yes, it's ok to have some of circle over water and it's ok if some of your view included in the 200 m radius is obstructed. If this is the case, we ask that you add a brief description of this to the comments of the 'Point Description' spreadsheet (explained in detail below).

8. ***What if our point ends up being too close to a nest? Is it OK to move it?***

Yes, moving the point count to an area close by where you're not disturbing the nest would be best.

9. If we collected data during Phase 1 of the project, should we use the same sites and points or choose new ones?

For those that collected data during Phase 1, it would be best (if possible) to continue to collect data at the same sites and use the same points, rather than choosing new ones. If the beach has changed and you need to move the point slightly, that definitely works.

Collecting data in the field

We hope to collect field data **10–12 time per site per season** (fall migration, winter, spring migration, and the breeding season) that you are participating in the Disturbance Project. As potential disturbances may change depending on the time of day, we ask that you collect field data 5–6 times per site per season in the morning (sunrise to noon) and 5–6 times per site per season during the afternoon (noon to sunset). To capture human use and shorebird counts throughout the season, it would be beneficial if the data collection was spread out throughout the season, if possible. As weekends and holidays may have some of the highest levels of disturbance, it will also be beneficial to attempt to get point count and behavioral samples at those times, if possible.

We recommend that you have at **least two people** in the field each time you are collecting data. This will optimize your ability to do point counts and especially behavioral samples, as you can have one person recording the data and the other conducting the point count and behavioral sample. If you are unable to go out with a partner, we recommend using a voice recorder or a voice recording smartphone app and transcribing the data onto a datasheet later.

When collecting data, please follow these steps:

Step 1: Make sure you have all of the equipment you will need, including:

- ✧ **Datasheets:** please bring your point count and behavioral sample datasheets into the field with you each time you collect data. Please bring one datasheet of both types per site that you plan to visit that day.
- ✧ **Optics:** please bring a spotting scope and binoculars.
- ✧ **GPS unit:** please bring your GPS unit with your programmed points where you will conduct point counts and behavioral samples.
- ✧ **Watch/stopwatch/smart phone:** please bring something to keep time, as well as a stopwatch or smart phone with an app that will beep every 10 sec during behavioral samples.
- ✧ **Clicker counter:** please bring a clicker counter if you think it will be beneficial for counting potential disturbance types and shorebirds (i.e., if you have a very busy site for people and/or birds).
- ✧ **Kestrel/smart phone:** please bring something that will allow you to get the temperature (C°), wind speed (km/hr), and wind direction when you enter and exit the site. A Kestrel would be ideal as it allows you to take temperature and wind speed in real time, but a smartphone app that gives info for the nearest weather station will work as well.

Step 2:

When you enter your site, please fill out the top of the ‘point count’ datasheet with the site, date, weather and tide information.

Step 3:

Navigate to your first location. When you reach the location, wait **3 minutes** prior to conducting your point count. This will allow you to get your gear ready and will also allow for the birds to settle. If you come to a point without any focal shorebird species or potential disturbance sources, you will still wait the 3 minutes. After the 3 minutes you will conduct a point count where you count all potential disturbances listed on the datasheet as well as the number of focal species (American Oystercatcher, Piping Plover, Wilson's Plover, Red Knot, Sanderling, Semipalmated Sandpiper (or peeps)) within a 200 m radius (with the observer(s) at the center and counting focal species and potential disturbances within 200 m in all directions).

A few things to note:

- ✧ We don't have a set amount of time for the point counts. We hope for them to be a fairly quick 'snapshot' of what's going on at the point. However, if you have a lot of species and/or disturbance types, it may be challenging to be 'quick'. We don't have a specific amount of time set as it will vary by how many birds and potential disturbances as well as how familiar you are with the technique.

- ✧ If you have large flocks of birds, it is suggested that instead of counting individuals, you estimate the flock size. For example, you could focus your scope on a flock and count the number of individuals within the scope and then extrapolate that for the rest of the flock. If you counted 50 individuals and it would take 10 scope views to cover the entire flock, then you would have a flock of 500 birds.

- ✧ Inevitably birds will move in and out of the 200 m. If they fly or walk into the 200 m in front of where you've counted, they **would** be included in the total count. If you observe them flying or walking into the area that you've already counted, they **would not** be included in the total count.

- ✧ Depending on the number of focal shorebird species and what is most efficient for you and your partner, feel free to count all species at once as you scan through the point count, OR you can count each species separately. The same is true for potential disturbance sources.

- ✧ If you think at **any time** throughout data collection that you will had trouble distinguishing Semipalmated sandpipers from Western Sandpipers, please lump them together and count/record the number of 'peeps' within a 200 m radius. If you feel that you will **<u>always</u>** be able to distinguish between the two, please count/record only the number of Semipalmated Sandpipers.

Step 4:

Immediately following the point count, you will conduct behavioral samples at the same location. **We will conduct behavioral samples during the winter and both migrations, but <u>not on nesting species during the breeding season</u>. However, if you have migratory species (SESA, REKN, SAND) using your site during the 'breeding season', and you're able to do so without disturbing the nesting species, it would be great if you could collect behavioral samples on the migratory species.** To start, scan the area within the 200 m for one of the focal species. If you locate an individual, you will conduct a sample on that individual. If you locate a flock, choose an individual in the middle of the "flock" and conduct the sample. If you lose sight of the individual, chose another individual from the middle of the "flock" and continue the observation. When you've completed the sample, scan the area again for a different focal species, choose the individual that will be sampled, and complete the sample. Continue this until you've scanned for each of the five focal species. Depending on your general location in the flyway, or season, you will end up with **0–6 behavioral samples per location, totaling 0–60 samples per site visit.** We know that 60 samples seems like A LOT… however, we expect that it will be extremely rare (nearly impossible) to locate all species at each sampling location. If you think this will be a regular occurrence at your site, let's discuss ways to reduce the number of samples. Having a sufficient sample size to understand behavior across a range of species will be difficult, and we are trying to maximize this sample where possible to ensure that our hard work is not in vain.

For example, if you scan the area and only find American Oystercatchers, you will end up with one behavioral sample for that location. If you scan and locate and American Oystercatchers and Red Knots, you will end up with two samples for that location. If you scan and locate all six focal species, you will end up with six samples for that location. If you scan and locate none of the focal species, then there will be no behavioral sample for that location.

Step 5:

Repeat Steps 2–3 until you've visited all points at your site. Please be mindful of your own disturbance while conducting point counts and behavioral samples. For example, try to keep a 50 m buffer between yourselves and the focal bird species (see minimum approach distances in Livezey, Fernandez-Juricic, & Blumstein, 2016). However, if the 50 m buffer is not possible given the width of your beach, as long as the birds continue or return to 'normal behavior', a buffer of < 50 m should be fine.

Step 6:

Fill out the rest of the information at the top of the datasheet regarding the weather as you exit the site.

Step 7:

Enter your data into the Excel database. We suggest that you enter data into the database as often as possible. After each occasion in the field would be preferable, however we understand that may not be possible and suggest that you attempt to enter data at least once/week. At the start of each season, we may ask that you enter data more frequently so we can troubleshoot any issues and make sure that data collection is going well. **Please send your data to Kelsi Hunt (hunt0382@vt.edu) at the end of each season.**

FAQ's

9. Why do we need to collect so much data?

We appreciate that the amount of data that we're collecting may seem overwhelming. However, our ability to detect an effect of disturbance on the focal shorebird species is dependent on the number of samples we are able to collect. For most seasons, 10-12 field occasions will require you to collect data at each site about one time/week. If this doesn't seem possible, we are open to discussing ways to make the data collection procedures work for you. If you have multiple sites, we are definitely open to reducing the number of samples taken per site. **We really appreciate all of the effort you are putting into this project; thank you!!**

10. Can we choose the survey period time frames for spring migration, breeding, fall migration, and winter? And if the season is shorter, do we still need to collect 10–12 points?

Yes, you can definitely choose the timing of your season depending on your location and when migration/breeding/wintering happen at your site. And for any of the shorter periods, it works to decrease the number of visits you make. As a rough guideline, it would be great if you could try to visit each site once a week, but we understand and are flexible if that's not a possibility. We've added 'season start date' and 'season end date' columns into the 'site information' spreadsheet so you can let us know how you divided up the seasons.

11. Do you have any smart phone app suggestions for behavioral samples?

We've used 'Interval Timer' on other projects and found it to be user friendly. It allows you to set the total time as well as how often you would like it to beep. It even lets you choose what sound you'd like to hear when it beeps!

12. Do you have any smart phone app suggestions for collecting weather data?

You may know better than we do what weather apps are the most accurate in your area. A few that we've used in the past are 'The Weather Channel', 'Weather Underground', 'Weather Bug,' and 'Marine Weather Forecast'.

13. Do the point counts have to be done one after another (i.e., no other work like counts for ISS can be done between each point count/behavioral observations)?

It would be great if all of the point counts and behavioral samples at a site were done one right after the other, however we understand that you are busy and may have other field tasks to accomplish during your visit. Therefore, as long as each pair of point counts and the accompanying behavioral samples occur one right after the other, it's fine if you complete other field tasks between the points.

14. Can you better explain how you choose individuals for the behavioral samples?

If you have multiple individuals of the same focal species ("flock"), you will choose an individual in the middle of the flock. If you lose track of that individual, please locate another individual and continue to behavioral observation. We understand that not all of the focal species spend time in "flocks" but the premise will be the same. For example, if you have 4 Piping Plovers within the 200 m, and one flies away, choose another and continue to sample. However, if you have just one individual and it leaves or your view of it becomes obstructed, you will continue the sample, choosing 'OS' (out of sight, see below) as the behavior code.

15. Do you have any idea how long each visit may take? Or how long it will take to conduct a point count/behavioral sample at each point?

There will be a lot of variation due to site size, both in the number of points and how long it takes to walk between points. It will also depend on the number of target species and number of potential disturbances for the point count and also the number of target species for the behavioral sample. It will also depend on the experience of the observer, as for something like point counts, you may get faster/more efficient with experience. Below is an example of how long it could take to do one point count/behavioral sample with a high number of birds and potential disturbances (so potentially the maximum amount of time at the point).

1. Arrive at point
2. Wait for birds to resume 'normal behavior' and get gear ready: **3 minutes**
3. Conduct a point count with a high number of birds and disturbance types: **5 minutes** (this is just an estimate as there is no set time for point counts)
4. Behavioral samples with all target species present: **18 min (3 min for each of the 6 species)**
5. Leave point

That would be 26 minutes, which is a lot. However, we don't expect that you will have many situations where all 6 species are present in your point count/for your behavioral sample. As we mentioned before, if it becomes too time consuming, we are happy to chat about ways to make it more efficient and work for you.

For the entire survey, when Lara Mengak followed a similar protocol for our Refuges project, it took, generally, 1 hour to conduct each pass of a site (approximately 1.5 miles long with 6 points). Depending on the number of focal species at a site, behavioral observations may have taken up to 1.5 hours per site. She did behavioral observations in one direction and point counts (as well as transect counts with a more extensive human activity component) in the opposite direction.

16. Do you have any suggestions for training to make sure the data is being collected consistently at sites?

If you have the time, we suggest a trial run where observers collect the point count and behavioral samples together to ensure correct identification of birds and classification of disturbance sources. Please take time to discuss the data you collected and the differences in the data collected to identify potential issues. Data collected during this trial will not be entered in database. We are happy to discuss and consult as needed..

Field Datasheets and Data Entry: Point Counts and Behavioral Samples

Point Counts: Complete this form every time you conduct a point count

Please print off the 'Point Count' datasheet to fill out in the field and enter the data in the corresponding excel forms in your database when you return from the field.

- **STATE:** Record the state abbreviation.
- **SITE:** Record the name of the site. Please be consistent with how you record your site name(s) throughout each spreadsheet in the database.
- **SEASON:** Record the season.
  - **F: Fall**
  - **W: Winter**
  - **S: Spring**
  - **B: Breeding**
- **DATE:** Record the date **(mm/dd/yyyy)**.

- **1ST HIGH TIDE:** Record the time **(24-hour clock)** of the first high tide of the day. You can obtain this from your favorite tide chart or website.
- **TIME IN:** Record the time **(24-hour clock)** you enter the site.
- **TIME OUT:** Record the time **(24-hour clock)** you leave the site.
- **TEMP IN:** Record the temperature **(C°)** when you enter the site.
- **TEMP OUT:** Record the temperature **(C°)** when you leave the site.
- **WIND SPEED IN:** Record the wind speed **(km/hr)** when you enter the site.
- **WIND SPEED OUT:** Record the wind speed **(km/hr)** when you leave the site.
- **OBSERVER(S):** Record the name(s) of observers conducting the point count and subsequent behavioral observation.
- **POINT #:** Please record the point/location number. These numbers should correspond with the locations you chose and entered into your GPS unit prior to fieldwork. These should also match the 'Point #' for the behavioral sample(s) done at the same location.
- **START TIME:** Record the time **(24-hour clock)** when you start each point count.
- **POINT IN CLOSED AREA OR SYMBOLIC FENCING? (C/P/N):**
  - **C (fully closed):** place a 'C' here if **all** of your 200 m radius fall within a closed area or within symbolic fencing.
  - **P (partially closed):** place a 'P' here if **part** of your 200 m radius fall within a closed area or within symbolic fencing.
  - **N (not closed):** place an 'N' here if **none** of your 200 m radius fall within a closed area or within symbolic fencing.
- **# VEHICLES:** Record the number of vehicles (e.g., cars, trucks, ORVs) parked or moving within 200 m.
- **# BOATS:** Record the number of boats **PARKED ONSHORE** within 200 m.
- **# AERIAL:** Record the number of human-related aerial disturbances (airplanes, helicopters, drones, kites, kite surfers, parasails etc.) within 200 m and up to 500 m vertically.
- **# DOGS, UNLEASHED:** Record the number of unleashed dogs within 200 m.
- **# DOGS, LEASHED:** Record the number of leashed dogs with 200 m.
- **# PEOPLE, MOVING:** Record the number of moving people within 200 m, **count people BOTH in and out of the water**. You will not count yourselves in this.

- **# PEOPLE, AT REST:** Record the number of people at rest within 200 m, **count people BOTH in and out of the water**.
- **# PREDATORS:** Record the number of potential predators of adult shorebirds (e.g., peregrine falcon, merlin, cats, fox, gulls etc.) within 200 m.
- **# PIPL:** Record the number of Piping Plovers within 200 m.
- **# AMOY:** Record the number of American Oystercatchers within 200 m.
- **# REKN:** Record the number of Red Knots within 200 m.
- **# SAND:** Record the number of Sanderling within 200 m.
- **# WIPL:** Record the number of Wilson's Plovers within 200 m.
- **# SESA:** Record the number of Semipalmated Sandpipers within 200 m.
- **# PEEPS:** If you are not confident that you will **ALWAYS** be able to distinguish SESA from WESA, please use this column to record the number of SESA/WESA or 'peeps' within 200 m.
- **COMMENTS:** Note any important information from the point count.

Behavioral Samples: Complete this form every time you conduct a behavioral sample

Please note: We will conduct behavioral samples during the winter and both migrations, but <u>not on nesting species during the breeding season</u>. However, if you have migratory species (SESA, REKN, SAND) using your site during the 'breeding season', and you're able to do so without disturbing the nesting species, it would be great if you could collect behavioral samples on the migratory species during this time.

Please print off the 'Behavioral Sample' datasheet to fill out in the field and enter the data in the corresponding excel forms in your database when you return from the field.

- **STATE:** Record the state abbreviation.
- **SITE:** Record the name of the site. <u>Please be consistent with how you record your site name(s) throughout each spreadsheet in the database.</u>
- **SEASON:** Record the season.

- F: Fall
- W: Winter
- S: Spring
- B: Breeding

- **DATE:** Record the date. **(mm/dd/yyyy)**
- **POINT #:** Please record the point/location number (1-10). These numbers should correspond with the locations you chose and entered into your GPS unit prior to fieldwork. These should also match the 'Point #' for the point count done at the same location.
- **SPECIES:** Record the species abbreviation (AMOY, PIPL, REKN, WIPL, SAND, SESA (or peeps)) that you are conducting the behavioral sample on.
- **0:10-3:00:** Record the behavior of the bird every 10 seconds using the codes below. Please record direct disturbance events (e.g., being chased by a dog, being displaced due to a human running along the beach, being pursued by a predator, etc.) in the comments noting disturbance type, distance from bird, and time
  - **F:** foraging (these are referring to instantaneous behavior so you would only use this if the individual is pecking, probing, carrying prey, etc. when the timer beeps.
  - **M:** mobile
  - **R:** resting (roosting, loafing, etc.)
  - **A:** alert/vigilant (this would include territorial disputes)
  - **FL:** flying
  - **OS:** out of sight If there is a "flock" of individuals and you are choosing a new individual of the same species if you lose track of the original, you shouldn't record multiple 'OS' in a row. However, if there was only one individual of a specific species, you would continue to record 'OS' until you've completed the 3-minute sample or another individual arrives at your location.
  - **O:** other (please describe in comments)

COMMENTS: Note any other important information from the sample.

Non-Field Data Entry: Point Count Locations, Site Information & Productivity Information

Point Count Locations: Please complete this after you've selected the locations where you will conduct point counts and behavioral samples

Please fill this out after you have selected the locations where you will conduct point counts and behavioral samples. As each site will have up to 10 locations where point counts and behavioral samples are conducted, the numbers in the 'Point #' column correspond to each point. If you have more sites, please copy and paste 1-10 for as many sites as you have. **Thank you!**

- **STATE:** Record the state abbreviation.
- **SITE:** Record the name of the site. Please be consistent with how you record your site name(s) throughout each spreadsheet in the database.
- **POINT #:** The point number at the specified site.
- **LATITUDE:** Record the point latitude in **decimal degrees**.
- **LONGITUDE:** Record the point longitude in **decimal degrees**.
- **COMMENTS:** Note any important information regarding the point. For example, if your view is impeded for a portion of the point or part of the point is over water, please provide a brief description here.

Site Specific Information: Please complete this for each site during each season

Please complete the 'Site Information' form in your excel database for each of the site(s) where you are collecting data related to the NFWF Disturbance Project. This data will be used to gather information about larger-site level potential disturbances as well as information regarding site-level disturbance management. **As potential disturbances and management can change depending on the season, we ask that you fill out one row of data per site per season (totaling 1–4 rows per site)**. For example, if you are a site that is participating and collecting data during fall migration, winter, spring migration, and the breeding season, you would fill out four rows for each site. If you are a site that is participating and collecting data in the winter, you would fill out one row for your site. Below you will find details and descriptions for each of the columns in the form **Thank you!**

- **STATE:** Record the state abbreviation.
- **SITE:** Record the name of the site. <u>Please be consistent with how you record your site name(s) throughout each spreadsheet in the database.</u>
- **SITE LEGNTH:** Record the length of your site (km).
- **SEASON:** Record the season.
  - **F: Fall**
  - **W: Winter**
  - **S: Spring**
  - **B: Breeding**
- **SEASON START DATE:** Record the start date of your season. As seasons may vary depending on location, we wanted to give you the flexibility to dictate when each season starts and ends. **(mm/dd/yyyy)**
- **SEASON END DATE:** Record the end date of your season. As seasons may vary depending on location, we wanted to give you the flexibility to dictate when each season starts and ends. **(mm/dd/yyyy)**
- **SITE STARTING POINT:** Record the latitude and longitude at the starting point of your site in decimal degrees.
- **SITE ENDING POINT:** Record the latitude and longitude at the ending point of your site in decimal degrees.
- **MANAGING AGENCY OR GROUP:** Record the agency, group, etc. responsible for managing natural resources (shorebirds) at the site.
- **LANDOWNER:** Record the name(s) of the site landowner(s), please record uknown if you do not have information regarding the landowner.
- **# PEDESTRIAN ACCESS POINTS:** Record the number of pedestrian access points at your site. This should include both formalized access points such as boardwalks as well as information trails used to access the site. If there are none, please record ‘0’.

- **# VEHICLE ACCESS POINTS:** Record the number of vehicle access points at your site. This should include formalized access points as well as information (or illegal) trails used to access the site. If there are none, please record '0'.
- **NEAREST PARKING LOT:** Record the distance (in km) from the site entry point to the nearest parking lot. If there are multiple lots or entry points, record the closest distance (km) between a parking lot and entry point.
- **# OF PARKING SPOTS:** Record your best guess at the number of parking spots available used to access the site.
- **BOAT ACCESS ONLY (Y/N):** Place a 'Y' here if the site is only accessible by boat, place an 'N' here if it is not.
- **DISTANCE TO NEAREST PUBLIC RAMP (km; if boat access only):** If you placed a 'Y' in the previous column, please record the distance (in km) to the nearest boat ramp. Place and 'NA' here if your site isn't boat access only.
- **POTENTIAL DISTURBANCE INFORMATION:** Please record any of the following site-level potential disturbance information that occurred at your site during the season specified.
  - **DOGS ALLOWED?**: Please use the codes below:
    - **A:** All dogs (leashed and unleashed) are allowed at the site.
    - **L:** Leashed dogs only are allowed at the site.
    - **N:** Dogs are not allowed at the site.
    - **A/L:** Whether or not all dogs (leashed and unleashed) or leashed dogs are allowed changes either daily or throughout the season, or depends on the point.
    - **L/N:** Whether or not leashed dogs or no dogs are allowed at the site changes either daily or throughout the season, or depends on the point.
    - **A/N:** Where or not all (leashed and unleashed) dogs or no dogs are allowed at the site changes either daily or throughout the season, or depend on the point,
  - **CHANGE IN DOG RULES:** If you recorded 'A/L', 'L/N', or 'A/N' in the previous column, please use the codes below, otherwise place an 'NA' here.
    - **S:** The dog rules changed throughout the season.

        - **D:** The dog rules changed depending on the time of day.
        - **P:** The dog rules were different depending on the point.
    - **BEACH RAKING? (Y/N):** Place a 'Y' here if beach raking occurred, place a 'N' if beach raking did not occur.
    - **BEACH RAKING FREQUENCY:** Record how often beach raking occurred.
    - **BEACH MODIFICATION? (Y/N):** Place a 'Y' here if beach modifications (e.g., renourishment, stabilization, inlet relocation or filling) have occurred in the last 10 years, place an 'N' if beach modifications have not occurred.
    - **YEAR OF LAST BEACH MODIFICATION:** Record when the last beach modification occurred. Record an 'NA' here if there hasn't been beach modification.
    - **MAJOR EVENTS? (Y/N):** Place a 'Y' here if any major events (e.g., concerts, weddings, large parties, etc.) have occurred, place an 'N' if major events have not occurred.
    - **# OF MAJOR EVENTS THIS SEASON?:** Record the number of major events that have occurred in the specified season. Place a '0' here if there were no major events.
- **DISTURBANCE MANAGEMENT:** Please record any of the following site-level disturbance management information that occurred at your site during the specified season.
    - **IS SYMBOLIC FENCING USED? (Y/N)** Place a 'Y' here if symbolic fencing was used at your site, place an 'N' here if symbolic fencing was not used.
    - **SYMBOLIC FENCING MANAGEMENT START DATE?:** If symbolic fencing was used, please record the date that you started putting up symbolic fencing. **(mm/dd/yyyy)** If symbolic fencing was not used, record 'NA' here.
    - **SYMBOLIC FENCING MANAGEMENT END DATE?:** If symbolic fencing was used, please record the date that you finished taking down symbolic fencing. **(mm/dd/yyyy)** If symbolic fencing was not used, record 'NA' here.
    - **NEST EXCLOSURES? (Y/N):** Place a 'Y' here if nest exclosures were used at any point throughout the season, place an 'N' here if nest exclosures were not used.

- **IS PART OR ALL OF THE SITE CLOSED TO DRIVING? (Y/N):** Place a 'Y' here if part or all of your site was closed to driving, place an 'N' here if part or all of your site was open to driving. For our purposes, we define closed area as areas that are completely closed and they may not encompass the site. This can be IN ADDITION to symbolic fencing.
- **DRIVING CLOSED AREA START DATE?:** If part or all of your site was closed to driving during this season, please record the date that the FIRST area was closed. **(mm/dd/yyyy)** If your site was open to driving, record 'NA' here.
- **DRIVING CLOSED AREA END DATE?**: If part or all of your site was closed to driving during this season, please record the date that the LAST closed area was removed. **(mm/dd/yyyy)** If your site was open to driving, record 'NA' here.
- **IS PART OR ALL OF THE SITE CLOSED TO PEDESTRIANS? (Y/N):** Place a 'Y' here if part or all of your site was closed to pedestrians, place an 'N' here if part or all of your site was open to pedestrians. For our purposes, we define closed area as areas that are completely closed and they may not encompass the site. This can be IN ADDITION to symbolic fencing.
- **PEDESTRIAN CLOSED AREA START DATE?**: If part or all of your site was closed to pedestrians during this season, please record the date that the FIRST area was closed. **(mm/dd/yyyy)** If your site was open to pedestrians, record 'NA' here.
- **PEDESTRIAN CLOSED AREA END DATE?**: If part or all of your site was closed to pedestrians during this season, please record the date that the LAST closed area was removed. **(mm/dd/yyyy)** If your site was open to pedestrians, record 'NA' here.
- **REGULATORY SIGNS? (Y/N):** Place a 'Y' here if regulatory signs or signs indicating permitted and unpermitted behavior (e.g., signs designating where people can/cannot go, signs regarding whether or not dogs are allowed on the beach, signs indicating that dogs must be on leash, etc.) were used at **the site entrance, access points or parking lots, etc.**, place an 'N' here if regulatory signs were not used.

- **INTERPRETIVE SIGNS? (Y/N):** Place a 'Y' here if interpretive signs related to shorebird disturbance (e.g., signs describing the effects of human disturbance, etc.) were used at **the site entrance, access points or parking lots, etc.**, place an 'N' here if interpretive signs were not used.
- **MONITORS OR EDUCATORS?:** Use the codes below to fill out this column:
  - **M:** Place an 'M' here if biological monitors were present at your site.
  - **E:** Place an 'E' here if educational staff (managing disturbance or educating the public about disturbance) were present at your site.
  - **B:** Place a 'B' here if both biological monitors and educational staff were present at your site.
  - **N:** Place an 'N' here if there were not biological monitors or educators present at your site.
- **LAW ENFORCEMENT?:** Use the codes below to fill out this column:
  - **1:** Full-time law enforcement
  - **2:** Periodic patrol
  - **3:** On-call
  - **4:** None
- **RECORD COMPLIANCE? (Y/N):** Place a 'Y' here is you record compliance (e.g., footprints inside closures, off-leash dogs where not permitted, etc.) and report on that data (internally, externally), place a 'N' here if you do not.
- **OTHER?:** Place a 'Y' here if you used another form of disturbance management not listed above at your site and add a description to the comments section, place a 'N' here if you did not use another form of disturbance management.

- **COMMENTS:** Note any other important information regarding the site and its human use.

Productivity Information: Please complete this form for each focal species nest/brood.

If you are a site or sites participating in the NFWF Disturbance Project during the breeding season of one or more of the focal species (American Oystercatcher, Piping Plover, or Wilson's Plover), please complete the 'Productivity' excel form in your database. **This information is not directly related to the point count samples and therefore please include information for ALL focal species nests at your sites (if you collect it), even if they occur outside of your point count circles.**

This data will be used in an attempt to link disturbance to productivity. **Each nest/brood will require that you give it a unique ID and that fill out as much information as possible (totaling 1 row of data per nest/brood).** We understand that you may not collect all of the data asked in this form, especially in regard to brood information, but please fill out what you can. Below you will find details and descriptions for each of the columns in the form. **Thank you!**

- **ID:** Please give each nest/brood a unique ID.
- **STATE:** Record your state abbreviation.
- **SITE:** Record the site where the nest was located. <u>Please be consistent with how you record your site name(s) throughout each spreadsheet in the database.</u>
- **NEST LATITUDE:** Record the nest latitude in decimal degrees.
- **NEST LONGITUDE:** Record the nest longitude in decimal degrees.
- **SPECIES:** Record the species abbreviation (AMOY, PIPL, WIPL) of the nest/brood.
- **FOUND ON DATE:** Record the date you found the nest. **(mm/dd/yyyy)**
- **INITIATION DATE:** Record the date that the nest was initiated (if known), place a 'U' here if you are unsure of the initiation date. **(mm/dd/yyyy)**
- **EGG #:** Record the highest (total) number of eggs observed.
- **EXCLOSED? (Y/N):** Place a 'Y' here if the nest was exclosed at any point during incubation, place an 'N' if it was not.
- **DATE EXCLOSED (IF KNOWN):** Please record the date the nest was exclosed, if known, **(mm/dd/yyyy)**, otherwise record an 'NA'.
- **SYMBOLIC FENCING? (Y/N):** Place a 'Y' here if the nest was surrounded by symbolic fencing at any point during incubation, place an 'N' if it was not.
- **AREA CLOSED?:** If the nest was within a closed area, please use the following codes for the area closed column, if the nest was within a closed area:
    - **N:** The area was not closed.

- **D:** The area was closed to driving, however people, pets, etc. could still use the area.
- **P:** The area was closed to the public, this should be <u>IN ADDITION</u> to symbolic fencing.

- **DATE NEST WAS LAST KNOWN ACTIVE (mm/dd/yy):** Whether or not it hatched or failed, please record the date that the nest was last known to be active. This should be the date of your last visit prior to hatching or failure.
- **NEST FAILED (Y/N)?:** Place a 'Y' here is the nest failed, place an 'N' here if it was successful.
- **FAIL DATE:** Record the date of nest failure. If you are unsure, record the date that you observed the nest failed. **(mm/dd/yyyy)**, place an 'NA' here if the nest was successful.
- **HOW DID THE NEST FAIL?**: Please use the following codes for the different types of nest failure.
  - **A:** Place an 'A' here if the nest failed due to **abandonment**.
  - **P:** Place a 'P' here if the nest failed due to **predation**.
  - **W:** Place a 'W' here if the nest failed due to **weather**.
  - **T:** Place a 'T' here if the nest failed due to the **tide**.
  - **H:** Place an 'H' here if the nest failed due to **human interference**. Please record the specific type of human interference (if known) in the comments.
  - **O:** Place an 'O' here if the nest failed due to **another reason** not listed above and please provide details in the comments.
  - **U:** Place a 'U' here if the nest failed but the reason for failure is **unknown**. This would include nests that failed without evidence before the expected hatch.
  - **NA:** Place an 'NA' here if the nest was successful.
- **NEST SUCCESSFUL (≥ 1 egg hatched; Y/N):** Place a 'Y' here if the nest hatched ≥1 egg, place an 'N' here if the nest failed.
- **# EGGS HATCHED:** Record the number of eggs hatched (if known), place a '0' here of the nest failed, place a 'U' here if you're unsure how many eggs hatched.

- **HATCH DATE:** Record the hatch date (if known), if you weren't present on hatch day, record the date that you observed the nest hatched. **(mm/dd/yyyy)** Place a 'U' here if you're unsure of the hatch date, place an 'NA' here if the nest failed.
- **BROOD FATE (S/F/U)?:** Place an 'S' here if the brood survived to fledging, place an 'F' here if the brood did not survive to fledging, place a 'U' here if the fate of the brood is unknown, place an 'NA' here if the nest failed.
- **# CHICKS FLEDGED:** Record the number of chicks fledged (if known), place a 'U' here if you are unsure of the exact number, place a '0' here if the nest or brood failed.
- **FLEDGE DETERMINATION:** Record the method you used to determine that the chicks had fledged. For example, some locations considered chicks to be fledged at 25 days, and some wait until confirmed flight. Place an 'NA' here if the nest or brood failed.
- **FLEDGE DATE:** Record the date of fledging (if known), if you are unsure record the date that you first observed the chicks fledged. **(mm/dd/yyyy)** Place an 'NA' here if the nest or brood failed.
- **COMMENTS:** Note any important information regarding the nest/brood.

Supplemental Material

Disturbance Project Protocol Questions and Discussion: Conference call with partners 11/16/2017

For additional clarification, please see below for questions and discussion from a conference call with partners during protocol development.

SITE SELECTION

Site size and management
How big should a site be (how big were you imagining sites to typically be as you were developing the protocol), and should it all be under the same management regime? (North Carolina)

How do you define a site- by land owner, land manager, or disturbance level? Some of our sites are large (4+ miles) and have varying levels of disturbance in different areas and/or different landowners. Should we break up these large stretches of beach into two or more sites? (New York)

We really didn't have any preconceived notions for site size when drafting this original protocol. In thinking about sites, our first thought was that they would be an area with a geographic boundary to define the area. But in thinking about it, it would be best if you defined sites by landowners.

For example, if you have a site (that can fit 10 points) and it has two landowners, it would be best to divide it into two sites, and would be fine if each of those could only fit 5 points.

Most of our sites are large and highly disturbed. Sites with less disturbance tend to be much smaller. Is that okay? Can we break up large sites that have a gradient in disturbance levels to get more variety? (New York)

That is fine that the site sizes and disturbance levels differ. We suggest leaving the large site as one and if the samples occur evenly (or somewhat evenly) we should be able to pick up on the variation in disturbance levels that are occurring at your site.

Related to the site size question, how many points should there be, minimum? Our sites are likely to be smaller than will fit 10 200m radius circles (for example, take a look at the north and south ends of Lea-Hutaff Island in NC). (North Carolina)

There really isn't a minimum number of points at a site per se. What we would be concerned about is the lack of point count and behavioral samples in terms of data analysis. So, if all of your sites are small in size with a low number of points each, we may have to think about increasing the number of samples you take during each site visit.

Taking a possible Phase 2 into consideration, should these sites be ones where we have some kind of management authority, or is any area good? (North Carolina)

At this point, any sites or areas are good.

Visual impediments at points

Can some of the circles be over water? We will have a hard time avoiding this if we prioritize not disturbing the birds. What should we if we could not see all of the area in the 200 m radius circle due to topography or other visual impediments? (North Carolina)

The biggest issue in CT is our sites typically peninsulas and are pretty small (not that long, and not very wide, and often with a dune in the middle that obstructs the view of the opposite shore). I think we might need to be creative to get 10 points at a site (Ex. combine 3-4 sites that are close to each other to make one site or zigzagging points). (Connecticut)

We have sites that are peninsulas, where there is shore on both sides. But if you stood in the middle, it would be hard to see activity on either side due to obstructions. We might have to create a zigzag of points at sites like this. If we had some points where the birds would be concentrated to the North, and others where the birds would be concentrated to the south, could those point circles overlap? (Connecticut)

In a perfect world for point count data collection, you would be able to see the entire 200 m radius. However, we understand that this isn't going to be possible everywhere. So yes, it's ok to have some of circle over water and it's ok if some of your view included in the 200 m radius is obstructed.

It's fine if you are unable to get 10 points at a site due to size/configuration, etc. It would work to have zig-zagging points, as long as your field of vision in the 200 m radius is not overlapping. In the case of an island with the North and South ends have birds but the 200 m would overlap, it would be best to choose one or the other.

What about sandbars that are underwater at high tide but that would be places where the focal species forage at mid or low tide? Should those be included? As a separate site or part of a larger inlet area? There would be different management regimes from one place to another. (North Carolina)

Good question. If they are a different management regime, we recommend leaving them out.

<u>Species presence</u>
7.) Do there have to be nesting birds at the site during the breeding season in order to use that site for breeding data collection? (This is based off Dan Gibson's comment about not necessarily ruling out a site because it has no or few of the focal species.) (North Carolina)

No, there do not have to be nesting birds at the site during the breeding season in order to use that site for data collection. However, we are looking for productivity information as well, so hopefully some of the breeding sites will have nesting birds.

METHOD SPECIFICS

<u>Point selection</u>
After we break up a site into 12 segments (if large enough), how should we determine where the survey points are? Randomly pick a point within each segment but >200m from the other points?

Yes, as long as the point counts don't overlap (we made a mistake in the first draft, see above) you can choose where you would like the point to be within each segment.

<u>Timing of surveys</u>

How much should we consider tides in this? Should I try to mix up tide stage, as well as time of day and weekend/weekday? Seems like not, but would it be bad if most were at particular tide? (North Carolina)

It would be great if you could mix up the tide stages and the time of day and weekend/weekday. In the SOP we mention, "As potential disturbances may change depending on the time of day, we ask that you collect field data 5-6 times per site per season in the morning (sunrise to noon) and 5-6 times per site per season during the afternoon (noon to sunset). To capture human use and shorebird counts throughout the season, it would be beneficial if the data collection was spread out throughout the season, if possible. As weekends and holidays may have some of the highest levels of disturbance, it will also be beneficial to attempt to get point count and behavioral samples at those times, if possible." That being said, although variety would be best, we are definitely flexible due to logistical constraints.

Do the point counts have to be done one after another (i.e., no other work like counts for ISS can be done between each point count/behavioral obs)? (North Carolina)

It would be great if all of the point counts and behavioral samples at a site were done one right after the other, however we understand that you are busy and may have other field tasks to accomplish during your visit. Therefore, as long as each pair of point counts and the accompanying behavioral samples occur one right after the other, it's fine if you complete other field tasks between.

<u>Timing of seasons</u>

Can we adjust the survey period time frames for spring migration, breeding, and fall migration? For spring migration, in NY we don't really start getting many shorebirds until early March. Then, our breeding season starts in early April and continues until mid-August. I'm concerned about the timing of spring migration surveys because we'll have just about a month to get all of our spring migration surveys completed. (New York)

The spring period is a bit shorter than the others. It's also a busy time. What if we can't do 10-12 visits/season in the spring? Is there a number below which the data is not helpful? (North Carolina)

Is there flexibility in when we collect spring data? We don't really start to get birds moving through until late February, and the peak is in late April/early May. Also our field techs don't typically start until mid-March. (Canada)

Yes, you can definitely adjust the timing of your season depending on your location and when migration/breeding/wintering happen at your site. And for any of the shorter periods, it works to decrease the number of visits you make. As a rough guideline, it would be great if you could try to visit each site once a week, but we understand and are flexible if that's not a possibility. We've added 'season start date' and 'season end date' columns into the 'site information' spreadsheet so you can let us know how you broke up the seasons.

<u>How long will it take?</u>
For how many minutes should we conduct behavior surveys of each individual bird?

The behavioral samples will be 3 minutes long, recording instantaneous behavior every 10 seconds.

Do you have any idea (from previous similar work) how long each visit might take under different circumstances (i.e., few focal species, some, many, etc.)?

About how long do you think it will take to conduct the survey at each point? What about for a whole site? I know that that will vary depending on site length, number of shorebirds, etc. but a general estimate or range would be helpful.

These are great questions, but unfortunately rather difficult to answer. There will be a lot of variation due to site size, both in the number of points and how long it takes to walk between points. It will also depend on the number of target species and number of potential disturbances for the point count and also the number of target species for the behavioral sample. It will also depend on the experience of the observer, as for something like point counts, you may get faster/more efficient with experience. Below is an example of how long it could take to do one point count/behavioral sample with a high number of birds and potential disturbances (so potentially the maximum amount of time at the point).

Arrive at point
Wait for birds to resume 'normal behavior' and get gear ready: 3 minutes
Conduct a point count with a high number of birds and disturbance types: 5 minutes
Behavioral samples with all target species present: 18 min (3 min for each of the 6 species)
Leave point

That would be 26 minutes, which is a lot. However, we don't expect that you will have many situations where all 5 species are present in your point count/for your behavioral sample. As we mentioned before, if it becomes too time consuming, we are happy to chat about ways to make it more efficient and work for you.

FROM ASHLEY ON THE PHONE CALL (and updated slightly): **When Lara Mengak followed a similar protocol for our Refuges project, it took, generally, 1 hour to conduct each pass of a site (approximately 1.5 miles long with 6 points). Depending on the number of focal species at a site, behavioral observations may have taken up to 1.5 hours per site. She did behavioral observations in one direction and point counts (as well as transect counts with a more extensive human activity component) in the opposite direction.**

<u>Potential researcher disturbance</u>

In regard to attempting to keep a 50 m buffer– Going to be tough to do as our beaches are typically less than 50 m wide. (Connecticut)

That's ok! We just used the 50 m buffer as a suggestion, if the birds settle back down or return to normal behavior, a less than 50 m buffer will be fine.

Guidance on what to do if point is too close to nest. OK to move or skip it? (Nova Scotia)

Good question, I think moving the point count to an area close by, but where you're not disturbing the nest would probably be best.

So the best view of the surrounding area would be in some case in the middle of string fenced areas or gull colonies. I don't think that will work. We are likely going to have to either offset the count circles or conduct them from a point that is not in the middle. (Connecticut)

It's fine to move your point if you feel that it will be, for example, disturbing a gull colony. Are you allowed inside the string fencing? If so, we would still suggest that you conduct counts inside (where you're not disturbing birds). When you fill out the 'Point Count Datasheet' we have a column where you answer Yes/No if you're in a closed area and it will be interesting to see if the point counts/behavioral samples differ depending on this.

<u>Other</u>

We don't have spotting scopes for all staff. We do have megazoom cameras.

Ok, good to note. We think it would work to have you use the camera for point counts and binoculars for behavioral observations, if you think that you'll be able to see within the 200 m.

FIELD DATA COLLECTION SPECIFICS

<u>Point counts</u>

In regard to 'TIME IN:' on the point count datasheet –The whole site or each individual point?

Good question, this refers to the time you enter the site to conduct the point counts/behavioral observations.

In regard to '#Aerial': on the point count datasheet– But wouldn't the impact of an airplane at 1000 ft be different than the impact of a kite surfer or drone at a much closer distance? Should these really be in the same category?

Good point, in terms of analyzing the data it will be hard to have more categories, which is why we lumped some of the potential disturbance types together. However, we've decided to include a 500 ft ceiling and will update the SOP to reflect this change.

In regard to '# PEOPLE, MOVING:' on the point count datasheet– Do we include volunteer piping plover monitors in this #?

You would not count yourself (or the other person/people with you conducting the point counts/behavioral observations) for potential disturbance types, however if you had volunteer monitors within the 200 m, you would count them.

In regard to '# PREDATORS': on the point count datasheet– What about gulls?

Yes, gulls could be included here.

Is this a fairly quick snapshot whereby one will turn around 360 deg? Or is there a specific amount of time we need to spend watching/ counting at the point?

How long are the point counts?

This should be a fairly quick snapshot. However, if you have a lot of species and/or disturbance types, it may be challenging to be 'quick'. We don't have a specific amount of time set as it will vary by how many birds and potential disturbances as well as how familiar you are with the technique.

<u>Behavioral observations</u>
Should we choose a bird within 200m radius?

Yes, you should choose a bird within the 200 m radius as it may be challenging to do a behavioral sample on individuals further away than 200 m. Depending on your view and equipment, you may even have to choose a closer individual.

In regard to 'R: resting (roosting, loafing, etc.) on the behavioral observation datasheet– Maybe consider splitting this into Resting and Preening.

Good suggestion. For the purposes of future data analyses, we have decided to include some of the behaviors together.

In regard to 'A: alert/vigilant' on the behavioral observation datasheet– Would this include behavior associated with territorial disputes?

Yes, this should also include behaviors associated with territorial disputes, we've added this to the SOP.

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NON-FIELD DATA COLLECTION AND DATA ENTRY

<u>Site information</u>

The law enforcement column - what does on call mean? Aren't they on call about anywhere? I can call them about any of our sites. Whether they actually can come or not is different.

Good question. In that instance, we think you would still use the 'on-call' in the situation you've described above. And this may be a better question for the larger group as to if all sites have access to 'on-call' law enforcement.

FROM PHONE CALL: Ashley will work to figure out what exactly we want to specify here.

In regard to '# PEDESTRIAN POINTS'– Obviously include formalized access like boardwalks, but what about informal trails that people regularly use?

As this may be included as a human use variable in analyses, we would recommend including formal and informal trails used to access the site. We will add information to the SOP for clarification.

In regard to '# VEHICLE ACCESS POINTS'– Does this include illegal ORV/ truck trails on to beach?

As this may be included as a human use variable in analyses, we would recommend including formal and informal (or illegal) trails used to access the site. We will add information to the SOP for clarification.

In regard to 'MANAGING AGENCY OR GROUP'– Would this include Bird Studies Canada who would be conducting habitat management for the focal species? Or do you mean landowner/ land manager?

Good question, since we have information about the landowner, we would like the name of the agency or group that is managing for shorebirds. In this case then yes, this would refer to Bird Studies Canada. We've added information to the SOP to reflect this.

In regard to 'LANDOWNER'– This will be unknown for some sites that have multiple landowners and that are privately owned

We are hoping to define sites by landowner, however, if the site has multiple landowners then you could record all of them (that you know) in this column. If the land is privately owned or you are unaware of the landowner, you can enter unknown into this column. We will add more information to the SOP description to reflect this.

In regard to 'NEAREST PARKING LOT'– There may be multiple entry points. Maybe: if there are multiple lots or entry points, record closest distance (km) between a parking lot and a site entry point.

That's a great suggestion, we will add that to the SOP for clarification.

In regard to POTENTIAL DISTURBANCE INFORMATION'– In the year surveyed or ever?

Good question, for most of the 'POTENTIAL DISTURBANCE INFORMATION' columns, this will refer to what has occurred at that site, in that season. For example, for 'beach raking' and 'major events', you would record whether or not these occurred at a specific site during that season and then the number or frequency that occurred a specific site during that season. We will add more information to the SOP for clarification.

<u>Productivity information</u>

In regard to 'P: nest failed due to predation'– Assume only choose if there are tracks at nest site or crushed eggs found and not including eggs that disappear (no tracks or evidence) before hatch.

Yes, this refers to nests that have evidence of predation (e.g., eggshells, tracks, predated eggs, etc.). We would include those nests without evidence that disappear prior to hatch in the 'unknown failure' category.

In regard to 'U: unknown failure'– Includes nests that disappear before expected hatch?

Yes, we generally refer to 'unknown failure' as a catch-all for nests that you don't have any information on or nests that have no evidence of failure but there are not eggs left and/or hatching isn't confirmed.

In regard to '# CHICKS FLEDGED:'– In E. Canada our "official" fledge date is 20 days. Do you want 25 days for this study or when we confirm flight? (Canada)

Good question, as fledging time for each species may vary by latitude or even within a site due to a variety of factors (prey availability, disturbance, etc.), feel free to use your preferred metric of determining fledging, whether that be a certain number of days or confirmed flight. Due to these differences, we've added a column to the 'Productivity Database' where you enter how you determined 'fledging'. We've added information to the SOP to reflect these changes.

FROM PHONE CALL: DO THE NESTS MONITORED HAVE TO BE WITHIN THE POINT COUNT CIRCLES?

This was a great question, and no, the point count/behavioral samples will not be directly related to the productivity data. If you're monitoring productivity, it'd be

great to get information for all of the nests (of focal species) that you have at a site, no matter if they fall within the 200 m radius of your point counts.

Would you like more information about the collaborators and funders?

National Audubon Society
www.audubon.org

Virginia Tech Shorebird Program
http://vtshorebirds.fishwild.vt.edu

Dayer Human Dimensions Lab
http://www.dayer.fishwild.vt.edu/

National Fish and Wildlife Foundation
www.nfwf.org

POINT COUNT DATASHEET

State: state abbreviation. **Site:** site name. Date: today's date. 1st High Tide: the first high tide of the day. **Time In:** time **(military time)** you enter the site. **Time out:** time **(military time)** you leave the site. **Temp In:** temperature **(C°)** when you enter the site. **Temp out:** temperature **(C°)** when you leave the site. **Wind Speed In:** wind speed **(km/hr)** when you enter the site. **Wind Speed Out:** windspeed **(km/hr)** when you leave the site. **Observers:** the names of the observers. **Point #:** this should correspond to the pre-determined location in your GPS as well as the behavioral sample(s) you will subsequently conduct. **Start Time:** time **(military time)** when you start the point count. **Point in closed area or within symbolic fending? (Y/N):** whether or not you or any of your 200 m point count is in a closed area or an area within the symbolic fencing. **#Vehicles - # Predators:** the number of potential disturbance types within 200m. **# PIPL - # SESA:** the number of each of the focal species within 200m. **Comments:** note any important information from the point count.

State:	Date:	Time In:	Temp In:	Wind Speed In:	Observers:
Site:	1st High Tide:	Time Out:	Temp Out:	Wind Speed Out:	

			Number of potential disturbance types								**Number of each species**						
Point #	Start Time	Point in closed area or within symbolic fending? (Y/N)	# Vehicles	# Boats	# Aerial	# Dogs, unleashed	# Dogs, leashed	# People, moving	# People, at rest	# Predators	# PIPL	# AMOY	# REKN	# WIPL	#SESA	#Peeps	Comments
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

BEHAVIORAL SAMPLING DATASHEET

State: state abbreviation. **Site:** site name. **Date:** today's date. **Point #:** this should correspond to the pre-determined location in your GPS as well as the point count you just conducted. Species: focal species abbreviation (AMOY, PIPL, REKN, WIPL, SESA), **0:10-3:00:** record the behavior of the bird every 10 sec using the following codes: **F=foraging, M=mobile, R=resting (roosting, loafing, etc.), A=alert/vigilant (including terretorial disputes), FL=flying, OS=out of site, O=other (explain in comments)** *Record direct disturbance events in the comments noting disturbance type, distance from bird, and time. **Comments:** note any important information from the behavioral sample.

State:	Site:	Date:

Point #	Species	0:10	0:20	0:30	0:40	0:50	1:00	1:10	1:20	1:30	1:40	1:50	2:00	2:10	2:20	2:30	2:40	2:50	3:00	Comments*