Atlantic Flyway Disturbance Project

• Biological Data Collection Report •

FINAL

• Report prepared by •

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Highlights from the Atlantic Flyway Disturbance Project: Biological Data Collection Phase 1

- 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 flyway to develop a standardized protocol for data collection to evaluate the effects of human disturbance on five Atlantic Flyway Shorebird Initiative (AFSI) focal species including American Oystercatchers (AMOY; *Haematopus palliates*), Piping Plovers (PIPL; *Charadrius melodus*), Red Knots (REKN; *Calidris canutus*), Semipalmated Sandpipers (SESA; *Calidris pusilla*), and Wilson's Plovers (WIPL; *Charadrius wilsonia*).

- We collected data at 41 sites from Nova Scotia to Florida from November 2017–October 2018. Participants collected 5,073 point counts, 1,229 behavioral samples, and monitored 335 nests/broods in 7 states and provinces since the inception of this project. Surveys to date have encompassed over 300km of shorebird habitat.

- Partial and complete closures reduced the number of people and dogs that were observed near a particular point. For all species, the point counts with the largest numbers of shorebirds were generally associated with areas where the observers were the only humans nearby.

    - Although variable among species, most shorebirds were rarely observed near an area if there were over 15 people within 200m.

    - Shorebirds were estimated to be more abundant (0.91 (PIPL), 4.66 (AMOY), 12.55 (REKN), 0.92 (WIPL), and 62.91 (SESA) [birds/point]) at points partially or completely closed to the public, whereas 0.76 fewer people were observed at points closed to the public, relative to similar areas open to the public.

    - Most shorebirds were estimated to be less abundant (- 0.20 (PIPL), -0.21 (AMOY), -2.12 (REKN), and -0.06 (WIPL) [birds/point]) for each increase of approximately 10 people observed within 200 m.

- Shorebirds were estimated to be less abundant when dogs were present (-0.21 (PIPL), -1.36 (AMOY), - 2.20 (REKN), -0.05 (WIPL), -17.50 (SESA) [birds/point]) relative to when dogs were absent within 200 m.

- We found that shorebirds behaved differently in areas that were partially or completely closed to the public as opposed to completely open to the public.

- We found a consistent pattern across all species that suggested individuals were more alert, relative to resting, when dogs were present.

- Human recreational use of an area excluded the use of these points as potential nest sites for all species considered. Nest activity within a particular point for each of these species was predicted to be nearly zero if, on average, human densities were approximately 1 person per hectare.

- We identified sites as a function of predicted shorebird that may require shifts in management actions to improve outcomes (management priority) sites that should maintain current conservation guidelines, and perhaps serve as showcases for best practices, associated with high shorebird numbers and low disturbance (conservation priority). We identified the high and low performing sites for each species monitored.

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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 five Atlantic Flyway Shorebird Initiative (AFSI) focal species.

Methods

Project partners collected data at 41 sites from Nova Scotia to Florida. We randomly chose sites with varying levels of potential disturbance types and shorebird abundance. Point counts and behavioral samples were performed at these sites every 1–2 weeks. We also collected breeding season productivity data and site level information to categorize sites. We determined the extent to and mechanism by which potential disturbances influenced shorebird abundance by using zero-inflated multivariate Poisson regression that accounted for the innate correlations among the numbers of shorebird species and people associated with seasonal habitat or recreational preferences to link human recreational activities with shorebird abundance. We determined the association between the species behavior and the extent of current, nearby potential disturbances with a multinomial regression. Lastly, we determine the association between nest site preferences and recreational disturbance on the breeding grounds for each of the temperate nesting shorebird species.

Results

The frequency of key potential disturbances (e.g., dogs, people), abundances of focal species, and protection measures implemented varied substantially among the sites selected for the study. On average, we found fewer people where some or all of a point was closed, suggesting that site closures, to an extent, were effective at reducing the number of people that access an area. Moreover, human activity negatively impacted the abundance, behavior, and nest site preferences for all species considered. The prevalence of people and dogs throughout the study system were positively correlated with each other, but both people and dogs reduced the prevalence of shorebirds throughout their seasonal ranges.

Future Directions

Shorebirds in this study appeared to avoid sites with a greater abundance of people and where dogs were present. They behaved differently in these situations also, resting less and spending more time alert, which offers insight into potential mechanisms behind our observed counts. Closures appeared effective at reducing the frequency of disturbance, suggesting that efforts to lessen disturbance frequency and intensity could improve the quality and effective carrying capacity of some habitats.

These protocols provide 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 in terms of occurrence of these activities and the response of shorebirds to any changes. The data presented here and collected throughout the first year are a baseline measure of the abundance and distribution of potential disturbances, management strategies, and focal species. The protocol has expanded to other, related sites in Georgia and South Carolina, and there has been interest from other parties as well. In addition, we are working to pair biological data collection and results with the findings from land manager surveys and surveys of dog walkers on selected beaches to inform the Community Based Social Marketing piece of this project.

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 five focal species (American Oystercatchers [AMOY; *Haematopus palliates*], Piping Plovers [PIPL; *Charadrius melodus*], Red Knots [REKN; *Calidris canutus*], 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 Semipalmated Sandpipers 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.

2018). 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 five focal species.

1. Point counts: Point counts served 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 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.

Study Area

We collected data at 41 sites from Nova Scotia to Florida from November 2017–October 2018 (Table 1). We divided the year up into ‘seasons’ based on annual cycle of shorebirds, 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.

	Winter	Spring migration	Breeding season	Fall migration
Florida	4	4	4	3
South Carolina	-	2	5	-
North Carolina	3	4	8	5
New York	-	3	3	3
Connecticut	-	6	6	6
Maine	-	-	1	4
Nova Scotia	-	-	4	3
Total	**7**	**19**	**31**	**24**

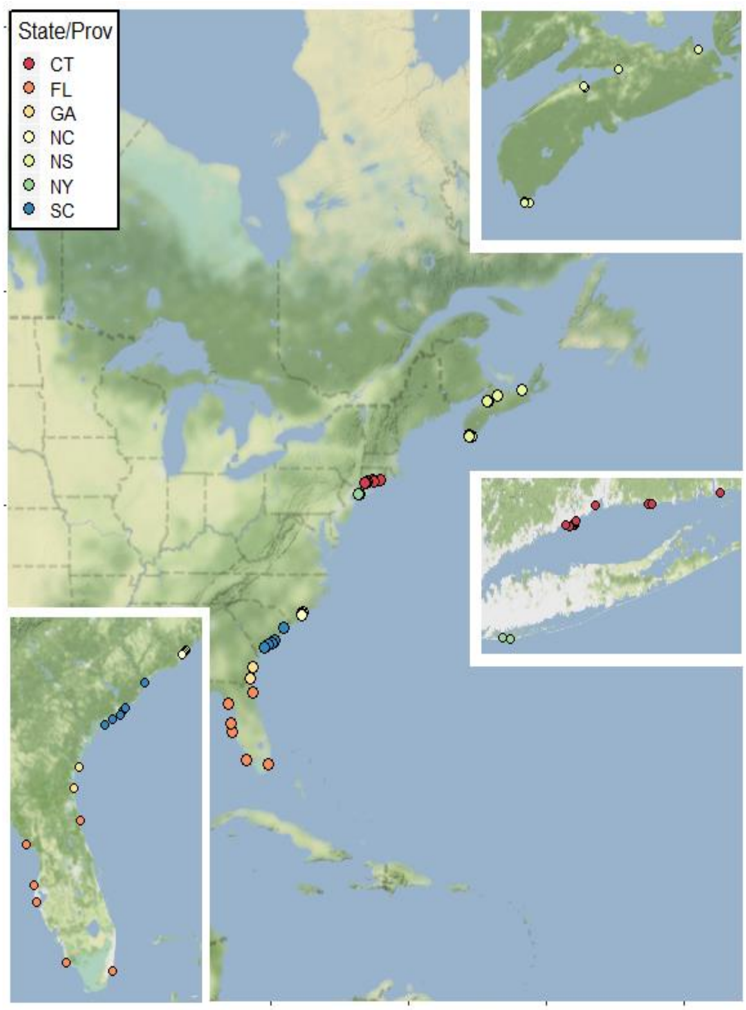


Figure 1. A map of participating sites that have provided shorebird abundance and disturbance data. Colors indicate the state or province in which a particular site is located. Inset maps provide more detailed views of Nova Scotia (top right), New York and Connecticut (center right), and North Carolina,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

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.

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. Each point count consisted of counting all focal species 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, 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.

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 focal species nesting 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. Please see Appendix A for detailed information.

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 standard operating procedures and datasheets used during this study, please see Appendix C.

Analytical Methods

We were primarily interested in 1) describing patterns in potential disturbance across space and time; 2) linking the observed variation in potential disturbance with shorebird abundance; and 3) investigating, conditioned on the presence of shorebirds, whether shorebird behavior was further influenced by nearby potential disturbances.

Description of potential anthropogenic disturbance

For this report, we investigated the observed variance 1) between the seasonal survey efforts and 2) across all surveyed sites, for two of the critical types of disturbance, the presence of dogs and the abundance of people. Additionally, we assessed the variation in the relative amount of area closed to the public and observed numbers of people and dogs among seasons and across all surveyed sites. Prior to model building, we investigated the potential for associations between disturbance and shorebirds by plotting the observed numbers of shorebirds against the number of people or dogs present, in addition to whether the site was open or closed to the public. When necessary, we used linear models to determine support for differences among specified groups.

Associations among potential disturbances and shorebird abundance

We determined the extent to and mechanism by which potential disturbances influenced shorebird abundance with a multivariate[1] zero-inflated[2] negative binomial regression, which provided a formal approach to account for 1) innate covariance in shorebird and human site-level abundances related to preferences in seasonal use of coastal areas that were similar (or dissimilar) among species; and 2) excess zero counts in data related to species-specific seasonal distributions, to explicitly model the impact of current human activity on point-level shorebird abundance.

1. The multivariate aspect of the model implies that an observation (i.e., count) of a specific shorebird species was not fully independent from the counts of each other shorebird species or of humans on the beach, due to latent positive or negative dependencies among taxa (Innoye et al. 2016). These dependencies could be a function of shared preferences in seasonal use of coastal areas, or broad-scale antagonistic relationships among species. In practice, if an observation of a piping plover on a beach generally meant that it was more likely that a Wilson’s plover also would be observed because of shared preferences of habitat type, these species would be considered positively dependent with each other. On the other hand, if an observation of an American oystercatcher generally meant that there were fewer red

knots observed, this result would suggest a negative dependency between these species. One of the outcomes of the multivariate model is the estimation of a variance-covariance matrix that describes the variance in the site-level abundance for each species that accounted for these species-species associations. Furthermore, if we assume that these species-species covariances describe both the similarities and dissimilarities in broad-scale habitat preferences, accounting for this source of variation in species abundance allows us to directly test the influence of human disturbance at the observation (survey-level) on local shorebird abundance, as site-specific patterns in abundance related to habitat preferences is explicitly controlled for.

2. If the lack of an observation of a species is the outcome of multiple different processes, it is likely that data based on observations of this system are zero-inflated, which negatively impacts model fit and inference. With these data, we expected that a number of zero counts of shorebirds would be observed as a function of both structural zero counts (e.g., a species is always absent from a point due to species-specific habitat preferences or seasonal range limits), and sampling zero counts (e.g., a species is sometimes absent from a point due to variation in fine-scale habitat use or detectability). Zero-inflated models account for these competing sources of variability in absences, or in other words, they separate absences into either structural or sampling absences. Of note, the zero-inflation term is equivalent to the site occupancy probability, which in this context is a seasonal estimate of the proportion of the study system occupied by each species (Kéry and Royle 2016).

$$1: y_{s,a} \sim pois\left(\lambda_{s,a} \times \left(1 - z_{s,m}\right)\right)$$
$$2: \lambda_{s,a} \sim gamma\left(k_{s,a}, \theta_{s,a}\right)$$
$$3: \theta_{s,a} = \frac{k_{s,a}}{\mu_{s,a}}$$
$$4: \mu_{s,a} = \exp(\alpha_s + \varepsilon_{s,m} + \beta_{s,c} X_{a,c})$$

We constructed a model that described the outcome, ***y**,* (e.g., observation or lack thereof of an individual or group of shorebird species or people, ***s***) of a specific point count, ***a***, to be a function of whether the site that the point count was associated with was ever occupied by that species $\left(1 - z_{s,m}\right)$ and, given that it was occupied, the realization ($\lambda_{s,a}$) from a negative binomial (*NB2*, Green 2007) distribution formalized as a gamma-Poisson (1, 2, 3) mixture informed by a log-linear model, ***μ*** (4), that described variation in abundance as a function of each species (α_s), site ($\varepsilon_{s,m}$), and a suite of explanatory variables, ***c***, ($\beta_{s,c} X_{a,c}$).

Site-level ($\varepsilon_{s,m}$) variation in species abundance was an outcome of a multivariate normal process with a species-specific mean (x_s) and precision matrix ($\Omega_{s,s}$), which was in turn an outcome of an inverse Wishart distribution, composed of a scale matrix (V) of the dimensions ***s*** $\times$ ***s*** with ***s*** degrees of freedom.

$$\varepsilon_{s,m} \sim mnormal(x_s, \Omega_{s,s})$$
$$\Omega_{s,s} \sim Wishart(V_{s,s}, S)$$

The inverse of $\Omega_{s,s}$ is the variance-covariance matrix ($\Sigma_{s,s}$), which can be translated into the more familiar correlation matrix ($\rho_{s,s}$). In this context, ρ represents the extent to which the relative abundances of two species were, on average, correlated with each other at the site level after accounting for the residual correlations with each other species.

Covariate development for abundance models

We accounted for survey-level environmental variation in shorebird and human abundance during each point count by including environmental variables previously observed to influence shorebird and human coastal activities (Pfister et al. 1992; Lafferty 2001; Gibson et al. 2018) into the linear abundance model. For this analysis, we included 1) minute of day; 2) wind speed; and 3) time (in minutes) until/since the most recent high tide, in which 5 minutes before is considered to be equivalent to 5 minutes after high tide, etc. We allowed the associations among environmental variables and shorebird species and humans to be independent (i.e., species-specific slopes). Lastly, we modelled the impact of survey-level human disturbances observed during each point count on local shorebird abundance by considering three metrics of human disturbance, or lack thereof. We included a 1) categorical variable (no/yes) describing whether any portion of the area within the point count boundary was closed to the public. Next, we included the 2) observed number of people within the point count boundary; and 3) a categorical variable (no/yes) describing whether any dogs were observed within the point count boundary. In addition to modeling these covariates on shorebird abundance, we also included them on the human abundance model as we also were interested in whether closed areas reduced human activity and whether people were positively associated with dogs, or if areas of high dog use may result in people avoiding an area.

Inferring Causality

The primary objectives for including the zero-inflation and multivariate components to the model were to control for patterns in seasonal species abundance that were not directly associated with concurrent human activities, but may potentially produce patterns that could be interpreted as an association with human activity (Fig. 2). A priori, we constructed a path diagram that detailed our initial hypotheses (Pearl 2009) regarding 1) how shorebird distributions (i.e., seasonal ranges) and local abundance may vary as a function of their life history (e.g., seasonal habitat preferences), inter and intraspecific associations with habitat, and local environmental conditions (e.g., tidal cycle, weather); 2) how human disturbance influences these associations (e.g., reduction in habitat quality); and 3) most importantly, how environmental conditions associated with shorebird abundance may influence the breadth and extent of human disturbance (e.g., seasonal and daily weather patterns, recreational preferences in coastal areas). Following this, we could build models that explicitly blocked the perceived competing pathways that indirectly link human disturbance with shorebird abundance, leaving only the direct, causal pathway. For example, inclusion of various features implicitly accounted for spatial and seasonal variation in species-specific abundances (including humans) related to habitat conditions, shorebird bird behaviors, community dynamics, and weather patterns. Thus, the implication is that any residual variation in shorebird abundance associated with human activity that remains in the data would be directly connected to the human activity (i.e., causality), as all major confounding features (i.e., pathways that indirectly link human disturbance with local abundance) driving species occupancy and abundance have been effectively accounted for, including broad-scale variability (and co-variability) in human use of coastal areas, and survey-level variables that may influence the local-scale temporal availability of shorebirds and people.

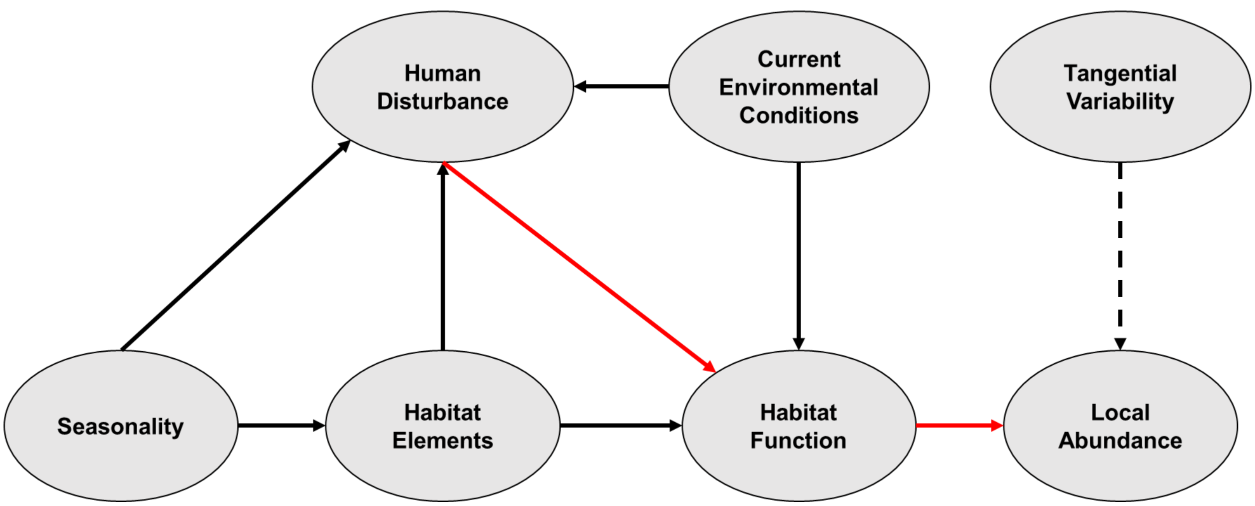


Figure 2. Directed acyclic path diagram that highlights the potential sources of confounding variability (solid black arrows) that reduce the ability to directly link human disturbance with shorebird abundance (red arrow pathway). In addition to confounding sources that must be accounted for to infer patterns between human disturbance and shorebird abundance, there are other sources of variation (dashed arrow) that influence shorebird abundance but are completely independent of human disturbance, which are modeled as excess variation and do not affect inference between the causal agent and outcome.

Association between potential disturbance and shorebird non-breeding behavior

We determined the associations between the species behavior and the extent of current, nearby potential disturbances with a multinomial regression, which estimated the proportion of each activity budget (i.e., the total number of observations (max = 18) of an 'individual' during a behavioral survey) that was spent 1) being alert; 2) foraging; 3) moving; 4) flying, or 5) resting. We used models to determine the extent to which the relative amount of time an individual was classified in a particular behavior was associated with 1) species; 2) environmental conditions (e.g., time of day, temperature, wind speed, and relative time until high tide); 4) season; and 5) random variation at the survey level. Simply, multinomial regression is an expanded parameterization of a logistic regression model, which allows for inference to be drawn between a single dependent variable and one (logistic regression) or more (multinomial regression) independent variables. Much like in habitat use models analyzed in a logistic regression framework, in which the likelihood of habitat use is relative to likelihood that habitat was not used, multinomial models constrain inference to be relative to a single category, or in our case behavioral state (Koster and McElreath 2017). Thus, we constrained inference as the likelihood of the three independent behaviors (i.e., Alert, Foraging, Moving, or Flying) being observed relative to a reference behavior, Resting. From an analytical perspective, the assignment of a particular group as the reference category does not affect inference, however, certain pairwise comparisons are more inferentially meaningful. For example, directly comparing the amount of time spent moving versus foraging may not be important, whereas directly comparing the amount of time spent being alert versus resting may be more important.

For this analysis, we only included species in which a sufficient number of behavioral surveys were collected across disturbed and less disturbed habitats, which included AMOY (N = 454), PIPL (N = 286), REKN (N = 117), SESA (N = 232), and WIPL (N = 98). Similar to the abundance models, we acknowledge that an unknown (likely small) proportion of SESA monitored may have been WESA or LESA.

Associations between potential disturbance and reproductive behavior

We determined the associations between species nest site preferences and nearby disturbances with a logistic regression, which estimated the probability a shorebird nested near each point within the breeding ranges of the three temperate breeding species (i.e., AMOY, PIPL, and WIPL). For each species, we assigned each nest found to the nearest point count location. If at least one nest occurred within 200 m of a monitored point (i.e., within the boundary of the point count) that point was considered to be occupied, and if no nests were found within 200 m of a specific point that point was considered to be unoccupied for each species. We then determined the extent to which the average amount of human or predator activity near each point during the entire breeding season influenced nest site preferences. The spatial extent of the available breeding range varied for each species (AMOY: CT, NC, SC, FL; PIPL:

NS, ME, CT, NY; WIPL: NC, SC, FL), therefore the number of used and unused points varied among species (AMOY: 101 unused, 37 used; PIPL: 47 unused, 48 used; WIPL: 76 unused, 21 used). We excluded NY from the AMOY analysis as AMOY productivity data from NY has not been received as of publication of the report. For this analysis, we used the 1) average number of people; and 2) nest predators at a specific point across all surveys during the breeding season; as well as the proportion of the surveys during the breeding season that a particular point was 3) partially closed to the public; or 4) occupied by a dog as explanatory variables describing nest site habitat preferences. We presented results as log-odds ratios, which represent the proportional change in nest site habitat use relative to a standard deviation increase in each explanatory variable.

Associations between potential disturbance and reproductive success

Given limitations in the capacity of field crews to monitor the fate of nests and broods, assessments linking disturbance with reproductive success were limited to patterns in the nest survival of American oystercatchers and piping plovers. Similar to nest site preferences, inference regarding nest survival occurred at the point-level. We used a binomial model to describe the probability of apparent nest survival for all nests that were found within 200m of a monitored point (*i*), which was informed by the summed total number of successful nests and summed total number of successful and unsuccessful nests found within 200m of each point for each species (*k*). We constrained apparent nest survival at a particular point to vary as a function of a species-specific intercepts and slopes that represented the associations between the 1) average number of people; and 2) nest predators at a specific point across all surveys during the breeding season; as well as the proportion of the surveys during the breeding season that a particular point was 3) partially closed to the public; or 4) occupied by a dog. As piping plover nests are frequently exclosed using cages as a management tool to reduce the threats of predation as well as reduce potential conflicts with people and their dogs, we also constrained piping plover nest survival to vary as a function of the proportion of piping plover nests monitored that were exclosed in each point. We presented results as log-odds ratios, which represent the proportional change in apparent nest survival relative to a standard deviation increase in each explanatory variable.

$$hatched\ nests_{k,i} \sim binom\left(app.nest\ survival_{k,i}, total\ nests_{k,i}\right)$$

Model diagnostics

We specified each model within R (R Core Team 2012) with the package jagsUI to call JAGS (Plummer 2003). For each model, we ran three chains of 175,000 iterations (thin = 2) with adapt and burn-in periods of 75,000 and 75,000 iterations, respectively. 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. All explanatory variables were z-standardized to allow for direct comparison among them.

Ranking sites for management priority

One of the primary objectives this this project was to establish a ranked list of priority areas that may most benefit from a targeted action campaign aimed to reduce the potential impact of people or dogs on seasonal shorebird communities. Here, we demonstrate an approach to preferentially rank sites using metrics of local shorebird abundance derived from model predictions to allow ecological models to inform management objectives. We estimated the average number of each shorebird species (***s***) that would be found at each site (***m***) as a function of the 1) site-specific abundance for each species; and 2) the survey-level associations between each disturbance type (i.e., site closures, people, dogs) and abundance.

$$\bar{n}_{s,m} = \overline{\left(\varepsilon_{s,m} + \beta_{s,c} X_{a,c}\right)}$$

We then plotted $\bar{n}_{s,m}$ against the average number of people observed per site and the average proportion of points within each site that observed a dog to identify outlier sites that either were associated with 1) high-levels of disturbance and low numbers of shorebirds (laggards) or 2) low-levels of disturbance and high numbers of shorebirds (leaders) (Fig. 3). Sites that fells outside the seasonal range of a particular species were excluded from each analysis, but unoccupied sites that occurred within states or providences with consistent observations (> 10 individuals) of that species during a particular season were included as potential, but unused habitat.

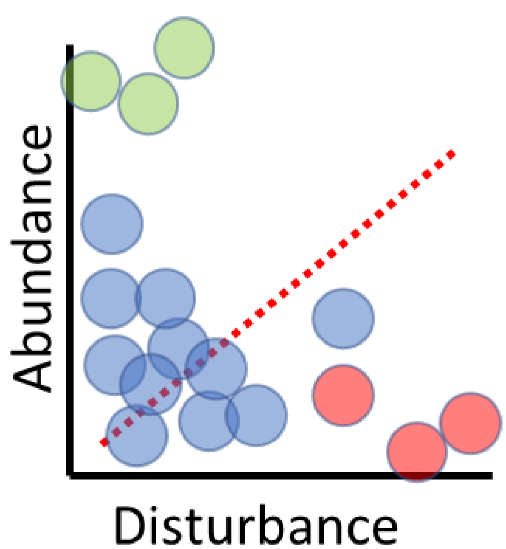


Figure 3. Example of management priority site ranking procedure that, after accounting for other sources of site-level variation in abundance, separates underperforming and highly disturbed areas (red) from the average (blue) site. Benchmark sites (green) that are associated with both high species abundance and low disturbances can also be identified.

RESULTS

Summary of Data Collection (to date)

Participants collected 5,073 point counts, 1,229 behavioral samples, and monitored 335 nests/broods in 7 states and provinces since the inception of this project (Table 2). Surveys to date have encompassed over 300km of shorebird habitat (Table 3**). For additional site summary information as well as summaries of disturbances and shorebird abundances, please see Appendix B.** Data received by 1/31/2019 was analyzed and included in the following results.

Table 2. Point counts and behavioral samples collected each season at 248 fixed points along the Atlantic Flyway from November 2017–October 2018, as well as nests monitored during the breeding season.

	Winter	Spring migration	Breeding season[a]	Fall migration	**Total**
Point counts	352	887	2468	1366	**5073**
Behavioral samples	153	399	232[a]	445	**1229**
Nests monitored	-	-	335	-	**335**

[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.

Table 3. Kilometers of habitat surveyed for potential disturbances and their effects on shorebird abundance and behavior along the Atlantic Flyway during data collection from November 2017–October 2018.

	Winter	Spring migration	Breeding season[a]	Fall migration[a]	**Total**
Kilometers surveyed	46	87	96	94	**323**

[a] Kilometers of habitat surveyed is subject to change, as we are still receiving breeding season data and fall migration data collection is ongoing.

Variation in observed potential disturbances throughout the study system

We found substantial variation among surveyed sites within the study system in regard to the amount of area potentially protected for shorebirds (Fig. 4A), as well as the magnitude of key potential disturbances, such dogs (Fig. 4B) and people (Fig. 4C) that shorebirds would experience. These results indicate that the selection of study sites was successful in collecting survey data across a range of possible disturbances and management regimes, which will provide insight into the average conditions along the Atlantic coast and provide an opportunity to directly test the behavioral and demographic consequences of these sources of environmental variability. We also found support for seasonal variation in the relative amounts of site closures (Fig. 4A, inset) and numbers of individuals observed in coastal areas (Fig. 4B inset). Although the proportion of each site that was closed to the public was not different during the spring and fall migrations, each other season combination was supported to be different.

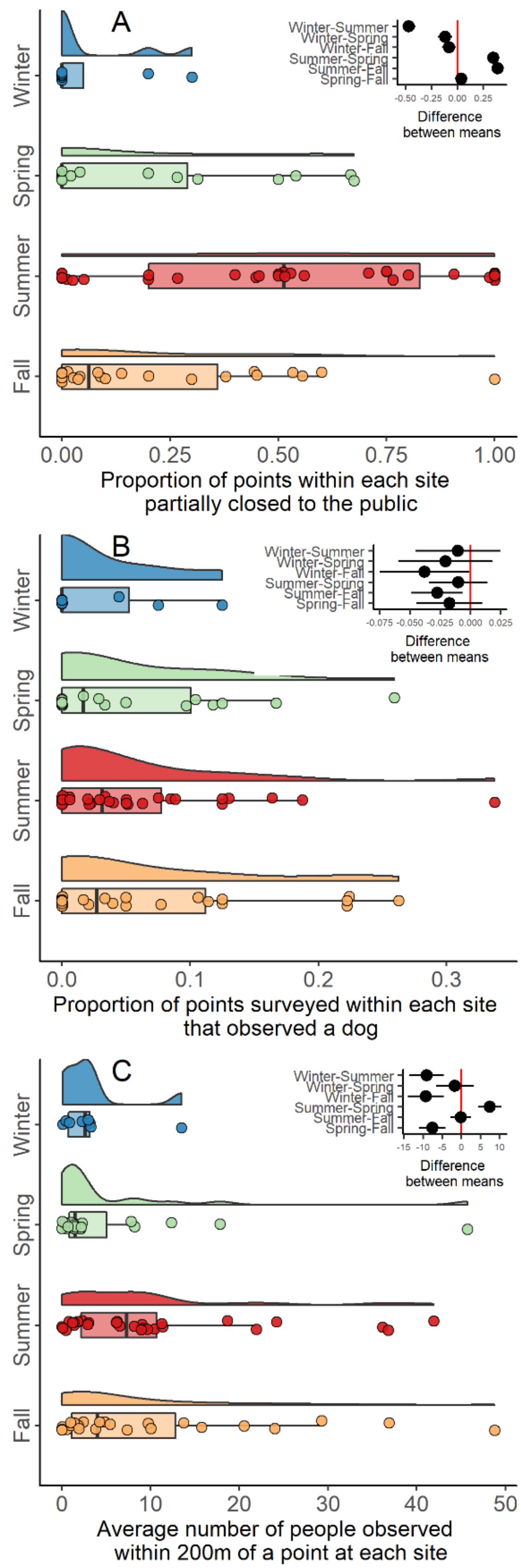


Figure 4 (A) The proportion (scatter plot) and distribution of proportions (bar, violin plots) of all points within each site that were at least partially closed to the public, and the average number (scatter plots) and distribution of average (bar, violin plots) B) dog presence, and C) number of people observed at each site during seasonal survey efforts. Insets represent differences between the seasonal means (and model support) for each season-season difference.

Furthermore, the average number of people observed per site during the winter and spring was substantially lower than during the fall and the summer, but there were no differences supported between the winter and the spring, or the fall and the summer, respectively. We found less support for seasonal differences in dog use of coastal areas (Fig. 4B, inset); however, there appeared to be fewer dogs on beaches during the winter and summer relative to the fall. Ultimately, we found that both the magnitude of observed recreational disturbance and the protections available to shorebirds varied throughout the year, and the general pattern was that recreational disturbances were more frequent during the summer and fall, but more of the study system had, at least, partial site closures, relative to the spring and winter.

Associations among human abundance, dogs, and beach closures

Fewer people and dogs were observed at points that were either partially or completely closed (Fig. 5). However, it was apparent that the disparity between the number of people near open or closed points was smaller during the summer, relative to the rest of the year, which we attribute to numerous small closures associated with active nests that are temporarily enforced by local officials during the summer that operate at a scale much smaller than the 200m radius circle. This results in more point counts occurring in an area with a partial closure (Fig. 3A) during the summer, but does not reduce human occupancy of an area to the extent of a larger site closure, which would be more likely during the non-breeding seasons (Fall-Spring). Also of importance was the observation

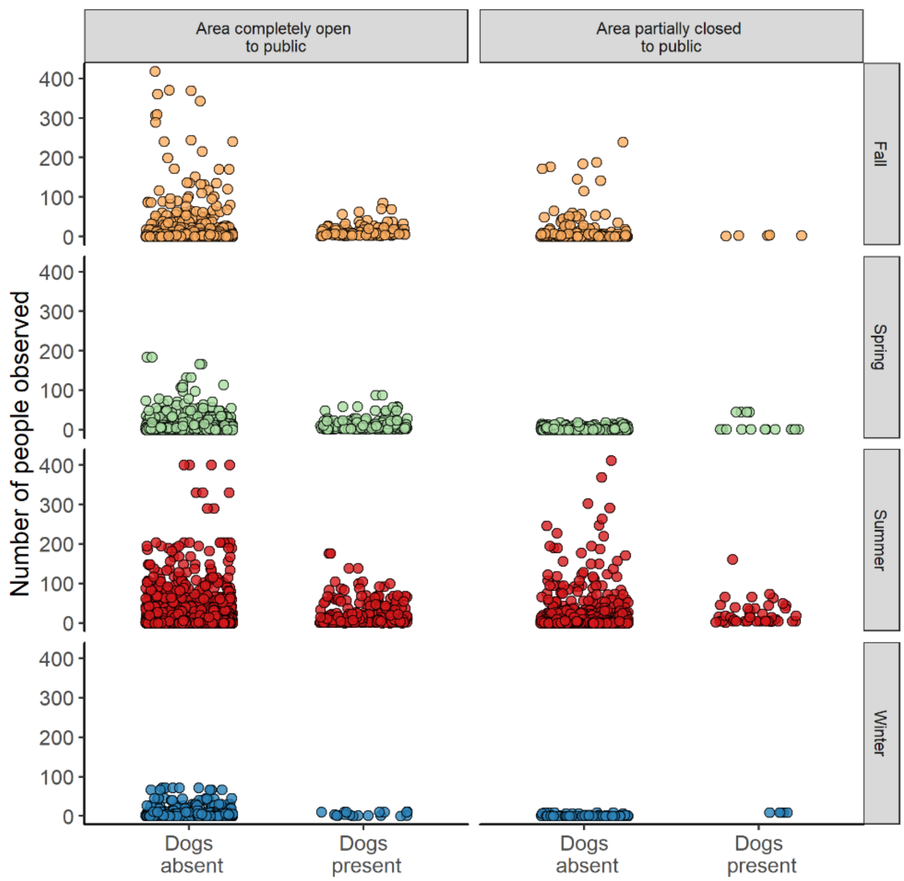


Figure 5. The number of people observed within 200m of each point relative to whether that point occurred within an area completely open (left panel) or partially closed (right panel) to the public and whether dogs were also absent or present from that survey during each season.

that the areas with dog activity were generally not associated with the areas of the densest human activity, which may indicate that certain beaches are more likely to have one or the other as their key disturbance type.

Patterns in observed shorebird abundance between areas open and closed to public

All species used coastal habitat that were closed or open to the public (Fig. 6). 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. Together, these results highlight the potential for species-specific impacts of, and tolerances for, potential disturbances.

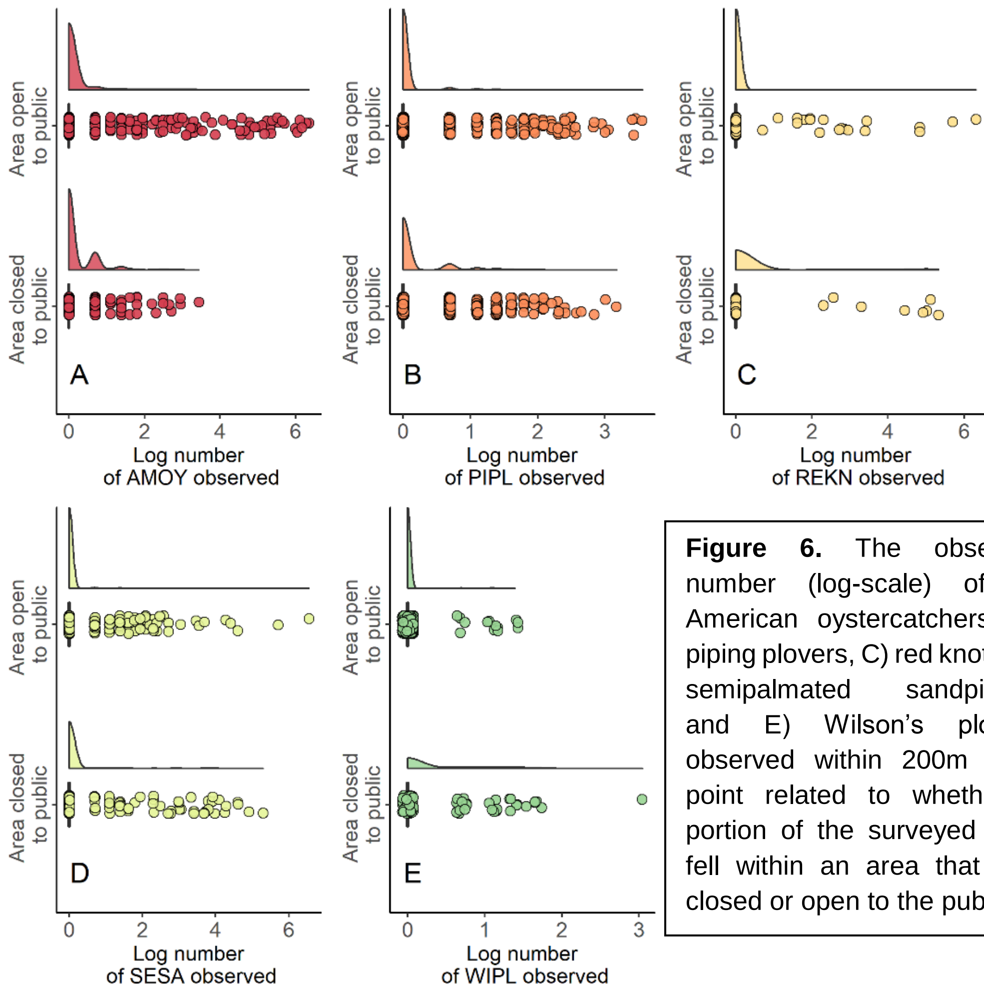


Figure 6. The observed number (log-scale) of A) American oystercatchers, B) piping plovers, C) red knots, D) semipalmated sandpipers, and E) Wilson's plovers observed within 200m of a point related to whether a portion of the surveyed area fell within an area that was closed or open to the public.

Association between the abundance of people and shorebirds

We found consistent associations among the number of people and the numbers of five species of shorebirds (AMOY, PIPL, REKN, SESA, and WIPL) observed within 200m of a point within their seasonal range limits (Fig. 7). Although variable among the species, most shorebirds were rarely observed near an area if there were over 15 people within 200m. For all species, the point counts with the largest numbers of shorebirds were generally associated with areas where the observers were the only humans nearby.

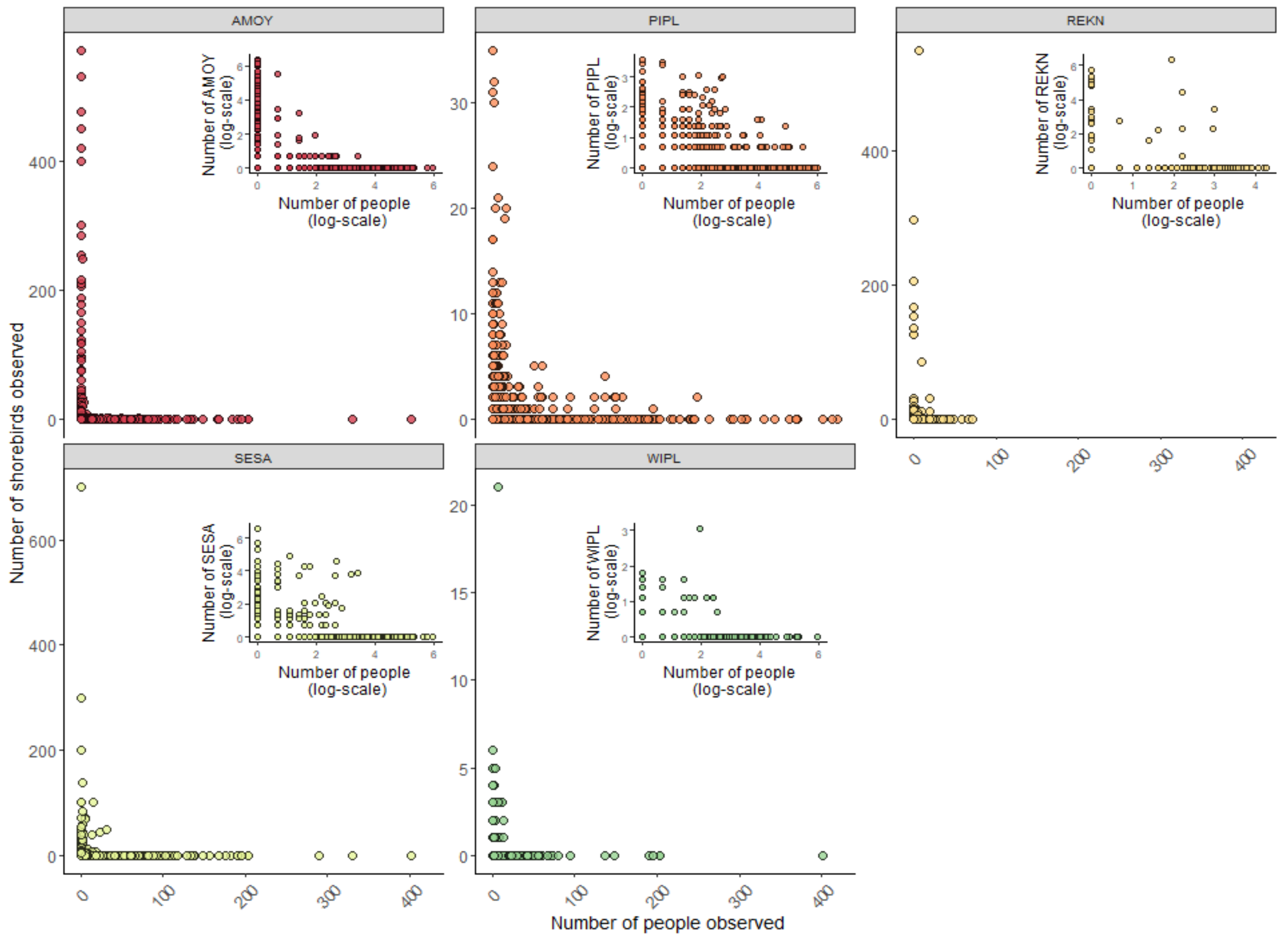


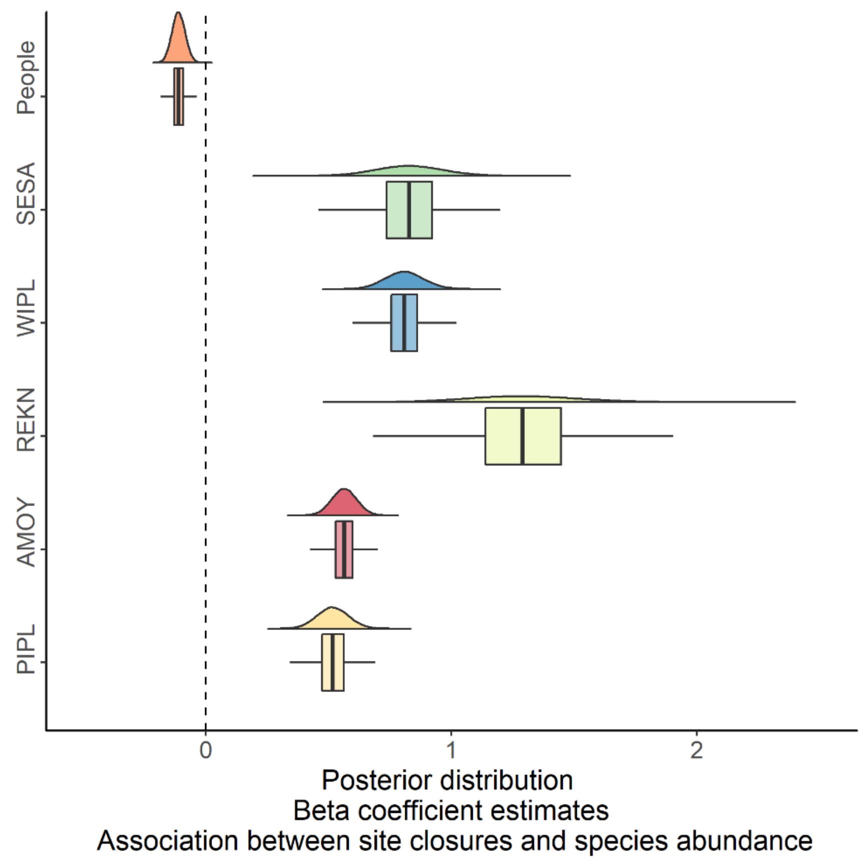
Figure 7. The association between people observed within 200m of a point and the number of A) American oystercatchers, B) piping plovers, C) red knots, D) semipalmated sandpipers, and E) Wilson's plovers observed there. Inset figures represent the same data but both the counts of people and shorebirds were presented on the log-scale to assist with pattern visualization.

Model Results

Determining the mechanistic relationships between potential disturbance and shorebird abundance

The most consistently supported relationship across species linking potential disturbance with the observed abundance of shorebirds at a point was whether the point was partially closed or open to the public (Fig. 8). After accounting for underlying differences in habitat, disturbances, and survey conditions, all five avian species monitored during this study were more abundant in areas that at least partially overlapped an area closed to the public, relative to a point that was completely open. Conversely, fewer people were observed in areas that were at least partially closed relative to areas completely open to the public, which indicated that these closures, to an extent, were effective at reducing human activity. In real numbers, the models predicted that after accounting site and survey-level variation in abundance, shorebirds were estimated to be more abundant (0.91 (PIPL), 4.66 (AMOY), 12.55 (REKN), 0.92 (WIPL), and 62.91 (SESA) [birds/point]) at points closed to the public, whereas 0.76 fewer people were observed at points closed to the public, relative to similar areas open to the public.

Figure 8. The posterior distributions from a multivariate zero-inflated negative binomial regression model that describe the effects of whether a portion of the 200m area was closed to the public on American oystercatcher, piping plover, red knot, semipalmated sandpiper, or Wilson's plover abundance as well as the number of people nearby. Values right of the dashed line indicate partial closures were positively associated with abundance, values on the left of the dashed line indicate a negative association between site closures and abundance.



Support for direct associations among the number of people or the presence of dogs and shorebird abundance was relatively consistent among species in that the presence of dogs or relative abundance of people nearby were generally associated with reductions in shorebird abundance. For example, AMOY (*f* = 0.99), PIPL (*f* = 0.93), REKN (*f* = 0.95), and SESA (*f* = 1.00) were supported to be less abundant in areas with greater dog activity (Fig. 9), and AMOY (*f* = 0.96), PIPL (*f* = 1.00), REKN (*f* = 1.00), and WIPL (*f* = 0.94) were supported to be less abundant in areas with greater human activity (Fig. 10), where *f* corresponds with the proportion of the posterior distribution that does not include zero. We found no support for a direct association between dogs and WIPL abundance, and found that SESA were positively associated with human abundance, which was counter to our hypothesis. However, given that part of the impact of human disturbance was partially accounted for by the site closure parameter, these results indicate that the impacts of human and dog activity was more spatially extensive, and human activities impacted the distribution of all shorebird species monitored across all active management areas throughout their seasonal ranges.

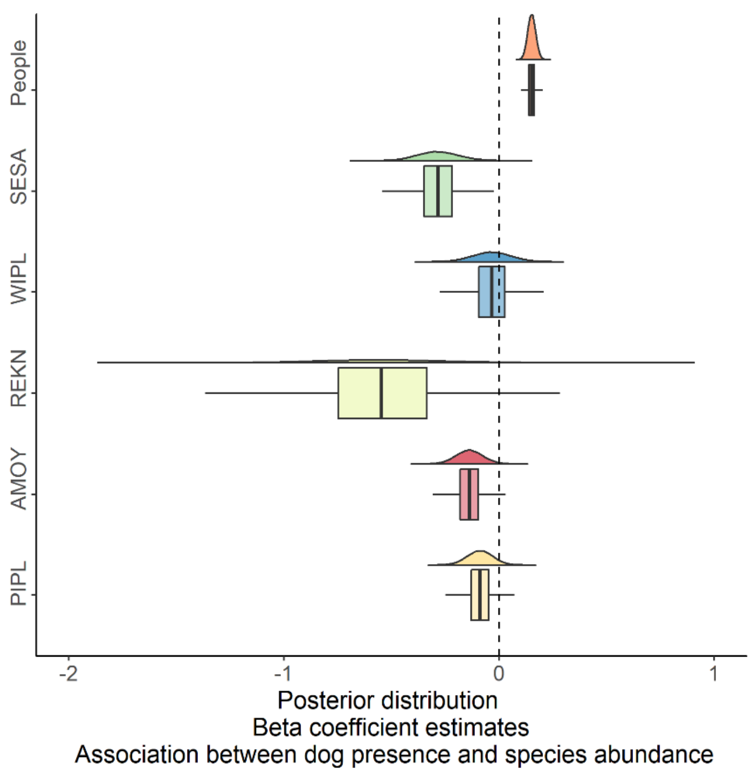


Figure 9. The posterior distributions from a multivariate zero-inflated negative binomial regression model that describe the effects of whether a dog was present with a 200m radius of a point on American oystercatcher, piping plover, red knot, semipalmated sandpiper, or Wilson's plover abundance as well as the number of people nearby. Values right of the dashed line indicate the presence of dogs was positively associated with shorebird abundance, values on the left of the dashed line indicate a negative association between dog presence and shorebird (or human) abundance.

The positive association between the presence of dogs and human abundance (Fig. 9) highlights the fundamental confounding between these two sources of disturbance, i.e., that dogs occur on beaches because humans choose to bring them.

This finding also suggests that issues related to dogs on beaches are essentially a human problem, as opposed to an issue of dogs, themselves.

In real numbers, the model predicted that, after accounting for site and survey-level variation in abundance, most shorebirds were estimated to be less abundant (-0.20 (PIPL), -0.21 (AMOY), -2.12 (REKN), and -0.06 (WIPL) [birds/point]) for each increase of approximately 10 people observed within 200 m. Similarly, shorebirds were estimated to be less abundant when dogs were present (-0.21 (PIPL), -1.36 (AMOY), -2.20 (REKN), -0.05 (WIPL), -17.50 (SESA) [birds/point]) relative to when dogs were absent within 200 m.

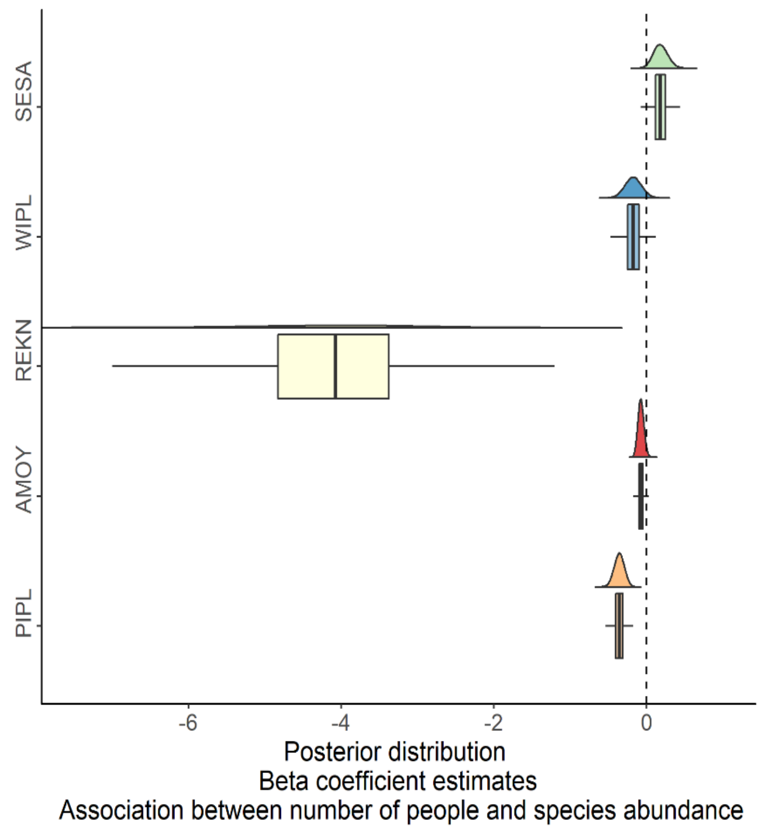


Figure 10. The posterior distributions from a multivariate zero-inflated negative binomial regression model that describe the effects of the number of people present with a 200m radius of a point on American oystercatcher, piping plover, red knot, semipalmated sandpiper, or Wilson's plover abundance. Values right of the dashed line indicate the number of people nearby was positively associated with shorebird abundance, values on the left of the dashed line indicate a negative association between the number of people nearby and shorebird abundance.

Inference from this shared model of human and shorebird abundance contains further valuable information. Beyond the mechanistic associations between real-time human activity and local shorebird abundance, our model allows for inference regarding more general associations among people and the shorebird community (Fig. 11). The species correlation matrix generated from the multivariate regression model can be interpreted as site-level associations between species abundances. For example, sites that comprised points occupied by greater numbers of people were associated with fewer AMOY, which indicated that AMOY were either the most sensitive to human activity, or AMOY habitat preferences differed from the recreational preferences of the people. Moreover, PIPL were positively correlated with all other species, which indicated that their presence was generally a sign that other species would be found in an area, and vice versa, potentially a measure of site quality.

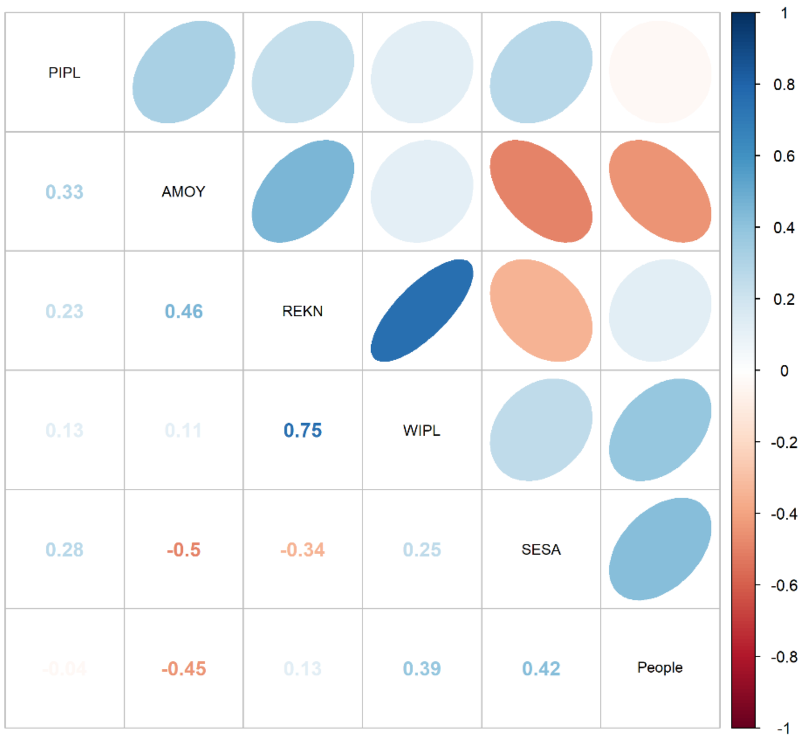


Figure 11. The species correlation matrix generated from the Multivariate negative binomial regression model indicates the positive (blue) and negative (red) site-level dependencies between each of the shorebird species and people.

Site Occupancy

People were the most ubiquitous species monitored throughout our study system as they only were not observed (researchers excluded) at 2 sites (Ferry Slip Island, NC; and Dewees Island, SC) throughout the entire study system (Fig. 12). Given that human activities were directly linked to shorebird abundance, it is important to reiterate that people recreate throughout the entire Atlantic Coast with very few exceptions, which highlights the importance of preserving and potentially creating new areas that are protected from human disturbance. Although site occupancy rates varied among the seasons and the species, all species were predicted to be present in over 25% of the sites surveyed during each season, which indicated that the sites chosen represented the habitat available for this community of shorebirds. Arctic breeders (SESA and REKN) were represented relatively poorly during the breeding season, but early migrants and non-breeders were observed during this period. Similarly, REKN and WIPL were represented relatively poorly during the fall migration due to low representation at northern latitudes. However, given that survey data during the winter was collected solely at the more southern sites (SC, FL; Fig. 13), site occupancy rates during this season were inflated high relative to the study system as a whole.

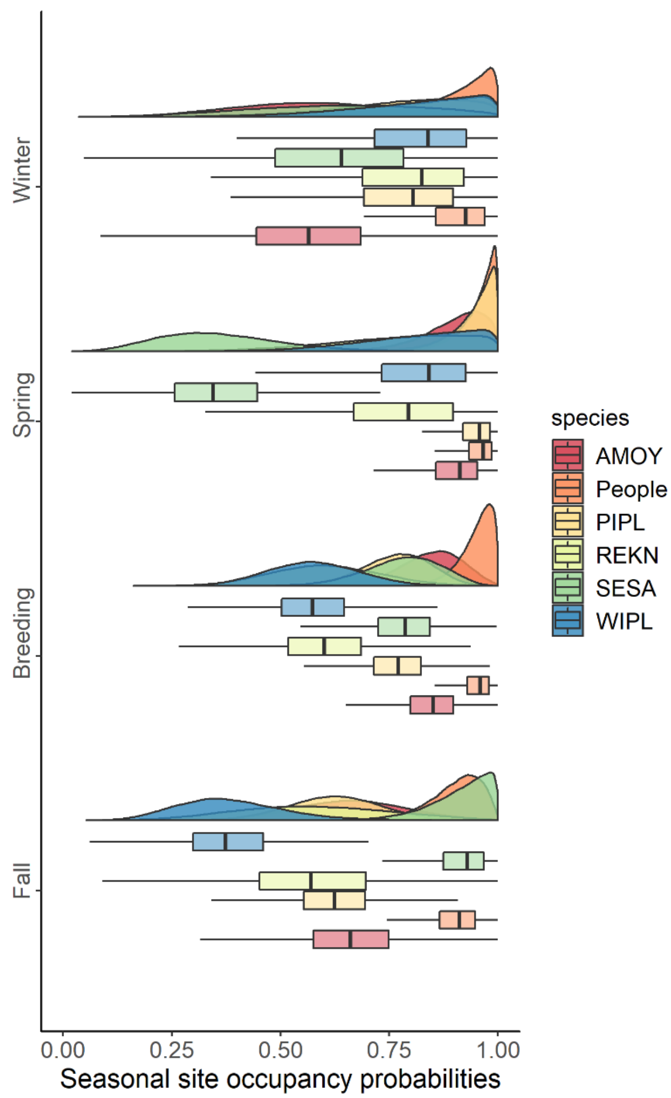


Figure 12. Seasonal site-occupancy probabilities for people and each shorebird species monitored throughout the seasonally variable study system. The distribution of probabilities represents the proportion of study sites in which a particular species could be observed with a particular season. As the spatial breadth of the study system shifts among seasons, direct comparisons in occupancy probabilities between seasons is not advised.

Although people were found throughout the study system, seasonal variability in the numbers of people were observed, which were most likely driven by a host of factors related to recreational interests, vacation availability, and access (Fig 13). In terms of the number of people, it is evident that the summer was the period in which the numbers of people were the greatest, and this was observed throughout the entire study system. There were clear geographical patterns of human recreational disturbance throughout the remainder of the year, in which more southern latitudes were generally associated with greater numbers of recreationists relative to more northern latitudes. However, during the fall, the pattern was inverted, as it appeared that more northern latitudes were generally associated with greater numbers of people than more southern latitudes. The mechanisms that resulted in this pattern were beyond the scope of this study, but we suspect it is related to human preferences or tolerances for certain weather conditions. However, the outcome of these recreational preferences are important, as it highlights that, depending on the season, certain areas may be experiencing greater levels of disturbance relative to other areas or seasons.

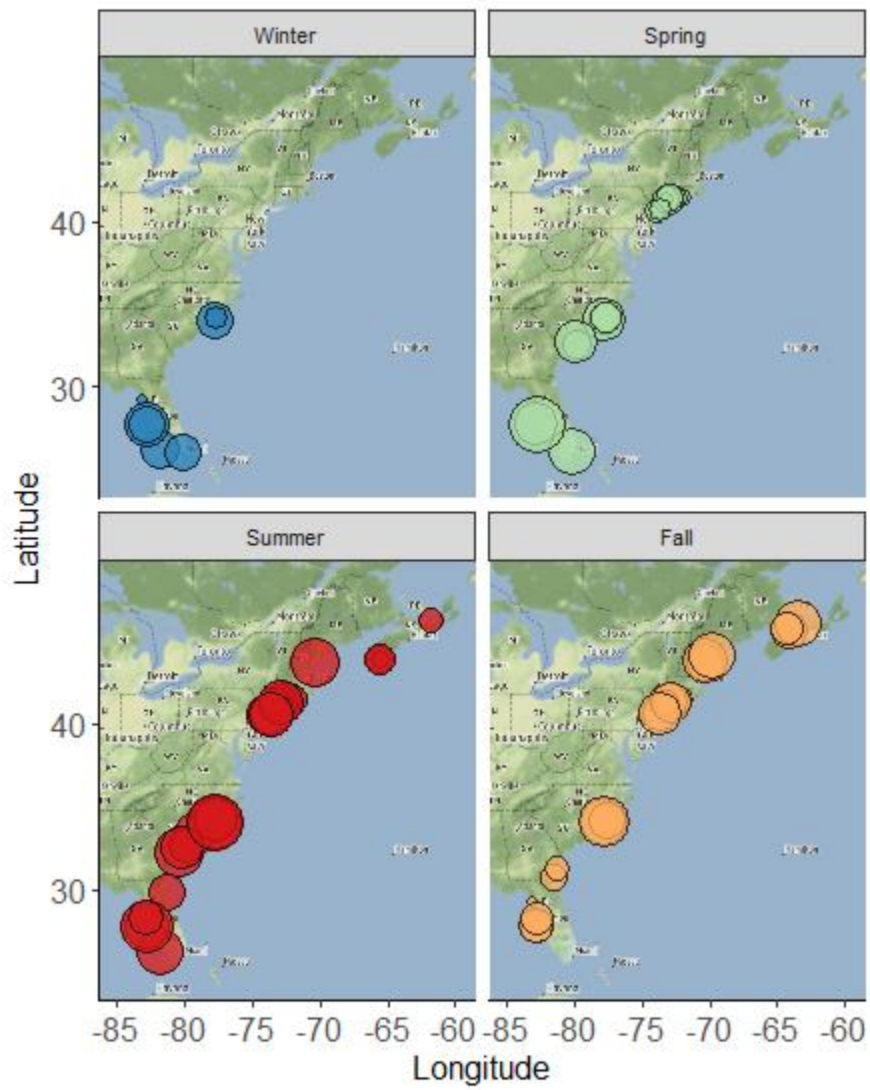


Figure 13. The spatial distribution of season-specific human abundances for each site within the confines of the study system. Size of each point represent the mean number of people at a site relative to all other sites (e.g., large circles represent high numbers of people, small circles represents few numbers of people).

Determining the mechanistic relationships between disturbance and shorebird behaviors

Given that data generated from behavioral samples was conditioned on presence, which was demonstrated to be sensitive to human disturbance, behavioral observations that coincided proximate to disturbance were limited, especially for disturbance intolerant species. Thus, additional data collection would be beneficial to clarify the patterns observed in the behavior analyses. For the five species with a sufficient number of behavioral samples performed to warrant analysis, two species (REKN and WIPL) were associated with modeling difficulty due to low numbers of observations of certain behaviors concurrently with certain disturbance types. The consequence of this source of data limitation was generally over-inflated error terms associated with these specific parameters, which resulted in little power to identify patterns for specific associations between disturbance and behavior for these species, but generally did not affect model fit for other species or behaviors. We reported estimates from this model as odds ratios (OR), which can be interpreted as the proportional increase (or decrease) in a particular behavior (i.e., Alert, Moving, Flying, or Foraging), relative to resting when exposed to a specific stressor. For example, an OR of 2.0 would indicate that a species was twice as likely to be foraging relative to resting when the individual was observed in a closed area, whereas an OR of 0.5 would indicate that an individual was half as likely to be foraging relative to resting when an individual was observed near a dog. Support for each relationship was inferred by whether the posterior distribution for a particular association was sufficiently separate from 1.0, as an OR of 1.0 indicated that a behavior was just as likely as another behavior when an individual was exposed to a particular stressor.

We found that shorebirds behaved differently in areas that were partially closed to the public as opposed to completely open to the public; however, these differences were often inconsistent among species. For example, PIPL were less likely to be alert (OR = 0.25) relative to resting in closed areas and, conversely, that they were 4 times more likely to be alert, relative to resting in areas open to the public (Fig. 14). Similarly, both PIPL and SESA were less mobile in closed areas relative to resting (OR: Walking – PIPL: 0.35, SESA: 0.66; OR: Flying – PIPL: 0.38), and therefore more mobile in areas open to the public. Also, PIPL, REKN, and SESA were each less likely to be foraging, relative to resting (OR = 0.29, 0.15, and 0.59, respectively) in closed areas, which suggests that these closed areas served as locations for rest or other body maintenance.

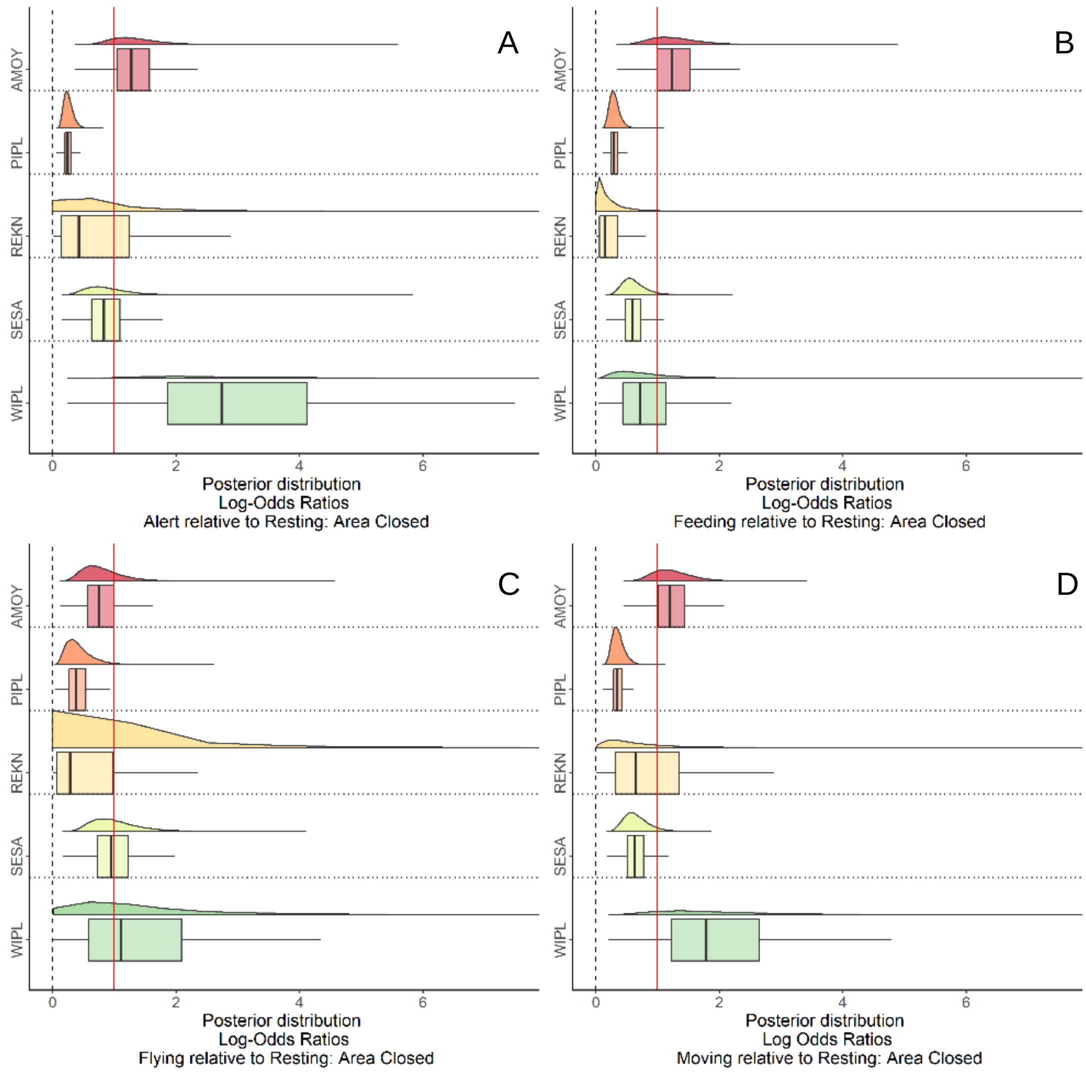


Figure 14. Log odds ratios describing the proportion increase or decrease in a particular behavior (A: Alertness, B: Resting, C: Flying, or D: Moving) relative to a Resting state as a function of whether the behavioral observation occurred in an area that was closed to the public. In this context, values to the right of the red line indicate a behavior was more likely to be observed relative to resting when an individual was in a closed area, or less likely to be observed relative to resting when an individual was in an open area. Whereas, values to the left of the red line indicate a behavior was less likely to be observed relative to resting in a closed area, or more likely to be observed in an area that was open to the public.

Although confidence intervals overlapped 1.0, we found a consistent pattern across all species that suggested individuals were more alert, relative to resting, when dogs were present (Fig. 15). We suspect support for an effect of dogs on shorebird behavior was reduced due to the presence of dogs being negatively associated with shorebird abundance and the relative rarity of a dog presence during a point count and behavioral sample. Together, this reduced the power to detect a behavioral difference, but this may improve if additional data were collected. We found less evidence that shorebirds were behaviorally reacting to the number of people nearby (Fig. 16). However, similar to the associations with dog activity, avoidance is also a behavior, and the lack of clear patterns between disturbance and behavior may be primarily determined by individuals choosing to remove themselves from disturbance events that were deemed a threat, and generally ‘ignore’ other sources we perceived as disturbances. Given the improvement we observed in model fit after including two additional seasons (Summer and Fall) following initial model development (Winter and Spring), we are optimistic that additional survey efforts will improve the clarity of these results.

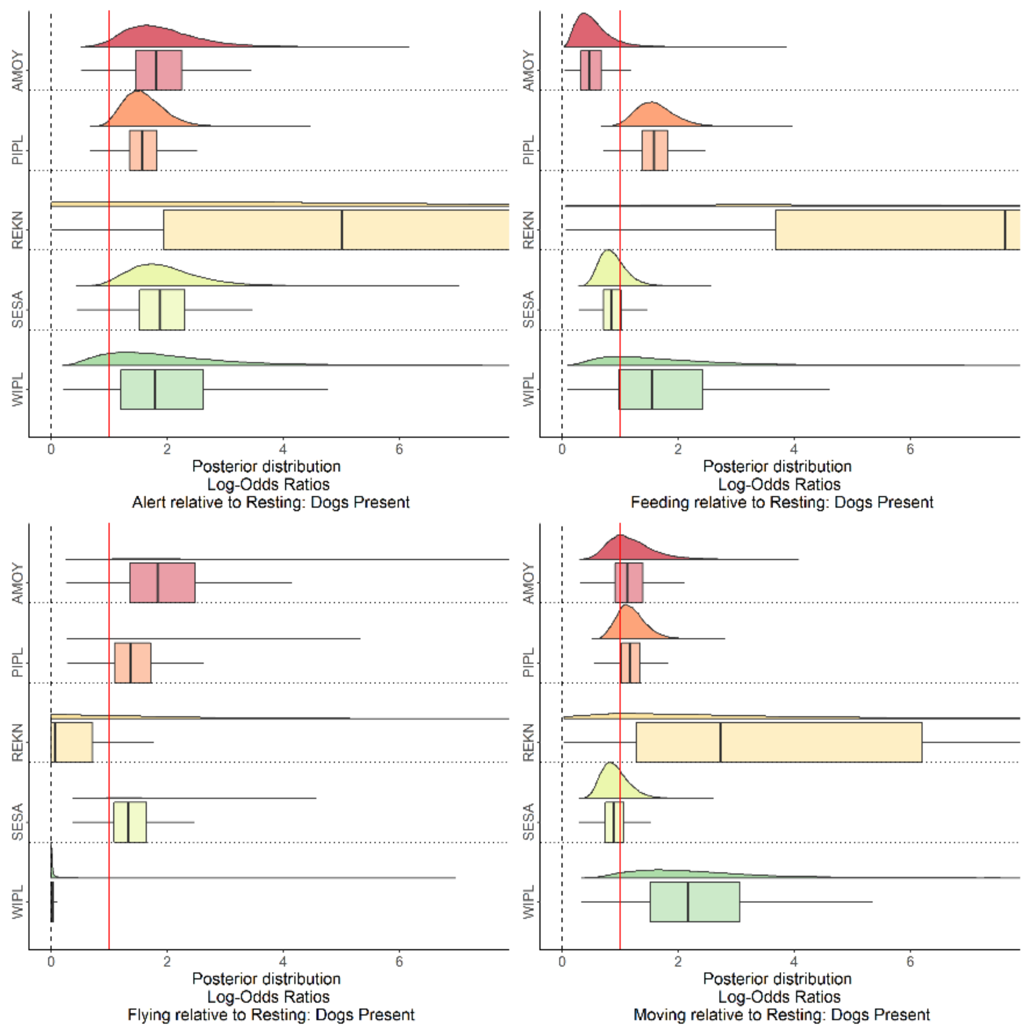


Figure 15. Log odds ratios describing the proportion increase or decrease in a particular behavior (alertness, resting, flying, or moving) relative to a Resting state as a function of whether the behavioral observation occurred in an area that was concurrently occupied by a dog. In this context, values to the right of the red line indicate a behavior was more likely to be observed relative to resting when an individual was near a dog or less likely to be observed relative to resting when an individual was not near a dog. Whereas, values to the left of the red line indicate a behavior was less likely to be observed relative to resting near a dog, or more likely to be observed in an area that was not near a dog. The figure was right truncated to focus on more reliable parameter estimates, and values that extended beyond the right margins of the figure were associated with estimates, that converged, but lacked statistical power to describe patterns.

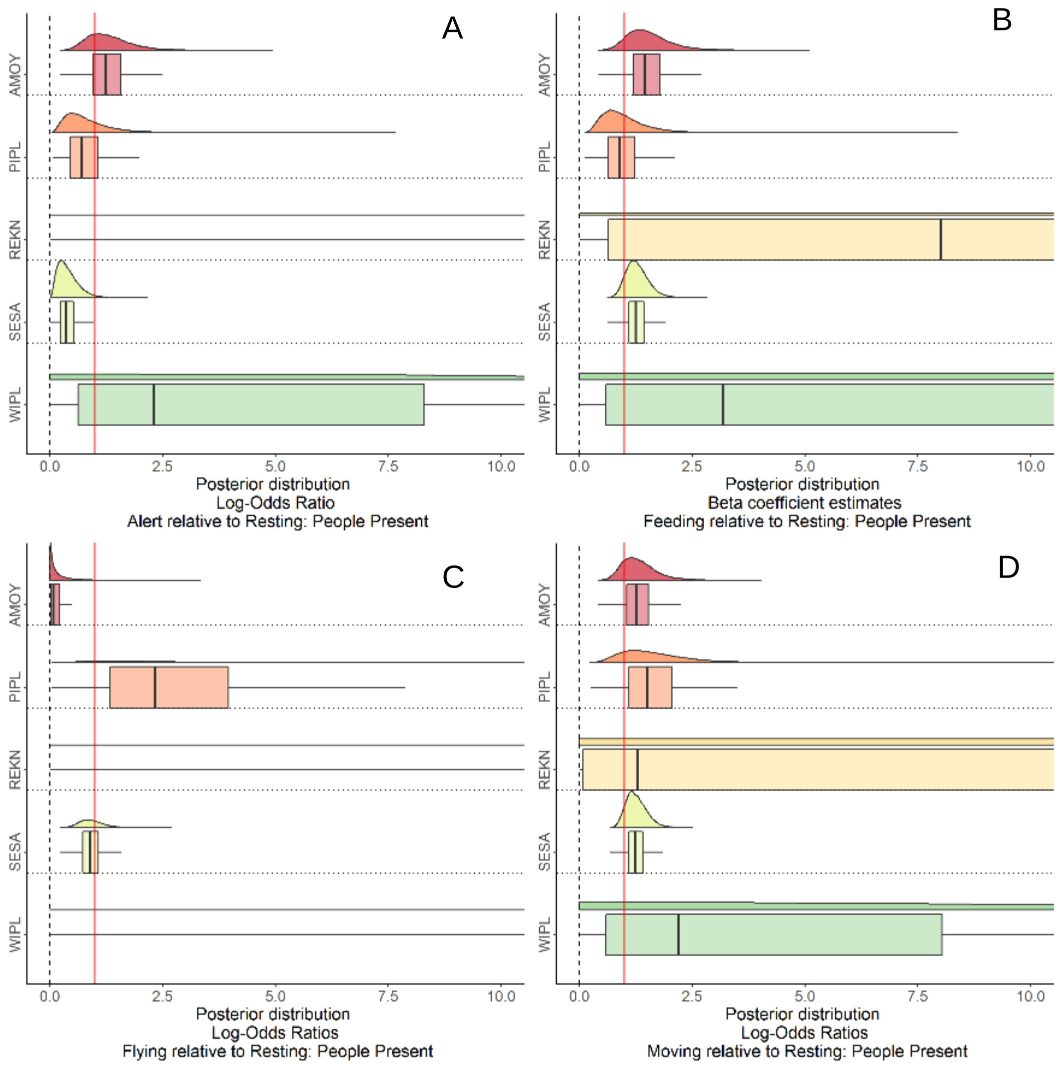


Figure 16. Log odds ratios describing the proportion increase or decrease in a particular behavior (A: Alertness, B: Resting, C: Flying, or D: Moving) relative to a Resting state as a function of the number of people that were observed in the 200m radius of the associated point count. In this context, values to the right of the red line indicate a behavior was more likely to be observed relative to resting when the individual was near more people, and less likely when observed near less people. Whereas, values to the left of the red line indicate a behavior was less likely to be observed relative to resting when the individual was near more people, and more likely when the individual was near less people. The figure was right truncated to focus on more reliable parameter estimates, and values that extended beyond the right margins of the figure were associated with estimates, that converged, but lacked statistical power to describe patterns.

Productivity

Table 4: Summary of the number of American oystercatcher, piping plover and Wilson's plover nests found, various metrics describing reproductive success (Nest success: Hatched/Total Nests; Brood success: Fledged broods/Total broods; Chick success: Fledged chicks/Total chicks; Total reproductive success: Fledged chicks/Total nests), and metric describing management (Proportion of nests a) exclosed from predators; b) marked with symbolic fencing; c) surrounding area protected from motorized vehicles; and d) closed to the general public) for sites that participated in data collection efforts during the breeding season. 'NA' represents instances such as when nest success was 0 and it was therefore not possible to have brood or chick success. 'U' represents instances where there was not enough information available to estimate brood success, chick success, etc.

State	Site	Species	# Nests	Nest success	Brood success	Chick success	Total reproductive success	Prop. exclosed	Prop. sym. fenced	Prop. closed driving	Prop. closed people
CT	Bluff Point	AMOY	4	0.25	0.00	0.00	0.00	0.00	0.75	1.00	0.00
CT	Hammonasset	AMOY	4	0.00	NA	NA	0.00	0.00	1.00	1.00	1.00
CT	Housatonic	AMOY	5	0.00	NA	NA	0.00	0.00	1.00	1.00	0.00
CT	Long Beach	AMOY	4	0.00	NA	NA	0.00	0.00	1.00	1.00	0.00
CT	Pleasure Beach	AMOY	1	0.00	NA	NA	0.00	0.00	1.00	1.00	1.00
CT	Sandy Point	AMOY	6	0.00	NA	NA	0.00	0.00	1.00	1.00	0.00
FL	Anastasia State Park	AMOY	1	1.00	0.00	U	U	0.00	1.00	0.00	0.33
FL	Ft. De Soto	AMOY	4	0.25	0.00	0.00	0.00	0.00	1.00	1.00	0.00
FL	Three Rooker Island	AMOY	4	0.25	0.00	0.00	0.00	0.00	0.75	1.00	0.00
NC	Ferry Slip Island	AMOY	18	0.61	0.64	0.90	0.50	0.00	0.00	1.00	1.00
NC	Hutaff Island	AMOY	8	0.25	0.00	NA	0.00	0.00	1.00	1.00	1.00
NC	Masonboro Island	AMOY	35	0.09	0.00	0.00	0.00	0.00	0.26	1.00	0.26
NC	South Pelican Island	AMOY	24	0.54	0.31	0.67	0.17	0.00	0.00	1.00	1.00
NC	South Wrightsville Beach	AMOY	5	0.20	0.00	NA	0.00	0.00	1.00	1.00	1.00
SC	Huntington Beach State Park	AMOY	1	0.00	NA	NA	0.00	0.00	1.00	1.00	0.00

SC	Lighthouse Inlet Heritage Preserve	AMOY	1	0.00	NA	NA	0.00	0.00	1.00	1.00	0.00
CT	Bluff Point	PIPL	16	0.69	0.73	0.47	1.13	0.38	1.00	1.00	0.00
CT	Hammonasset	PIPL	9	0.44	0.25	0.29	0.44	0.11	1.00	1.00	0.44
CT	Housatonic	PIPL	9	0.78	0.86	0.57	1.44	0.89	0.89	1.00	0.00
CT	Long Beach	PIPL	19	0.42	0.88	0.57	0.84	0.74	1.00	1.00	0.00
CT	Sandy Point	PIPL	10	0.50	0.60	0.55	0.60	0.90	1.00	1.00	0.00
ME	Goose Rocks Beach	PIPL	8	0.63	0.75	0.79	1.38	0.63	1.00	1.00	0.00
NC	South Topsail Island	PIPL	1	1.00	1.00	0.25	1.00	0.00	1.00	1.00	0.00
NS	Crow Neck Beach	PIPL	8	0.63	1.00	1.08	1.63	0.00	0.00	1.00	0.00
NS	Pomquet Beach	PIPL	5	0.40	1.00	0.88	1.40	0.00	0.20	1.00	0.00
NY	Jones Beach	PIPL	46	0.67	0.71	0.34	0.78	0.65	1.00	1.00	0.00
NY	Town of Hempstead Beach	PIPL	16	0.88	0.79	0.52	1.56	1.00	1.00	1.00	0.00
FL	Anastasia State Park	WIPL	14	0.50	U	U	U	0.00	0.29	0.00	0.33
FL	Big Marco Pass CWA	WIPL	18	0.44	U	U	U	0.00	0.00	1.00	0.00
FL	Ft. De Soto	WIPL	6	0.50	U	U	U	0.00	1.00	1.00	0.00
NC	Hutaff Island	WIPL	14	0.21	U	U	U	0.00	1.00	1.00	1.00
SC	Dewees Island	WIPL	5	0.60	U	U	U	0.00	0.60	1.00	0.00
SC	Harbor Island	WIPL	1	0.00	U	U	U	0.00	1.00	1.00	0.00
SC	Lighthouse Inlet Heritage Preserve	WIPL	2	0.00	U	U	U	0.00	1.00	1.00	0.00
SC	Seabrook Island	WIPL	3	0.33	U	U	U	0.00	1.00	1.00	0.00

Nest site preferences

The most striking result from the nest site preference models was that human recreational use of an area excluded the use of these points as potential nest sites for all species considered (Fig. 17C). As a reminder, these results as presented as log-odds ratios, which represent the proportional change in apparent nest survival relative to a standard deviation increase in each explanatory variable. In other words, a log-odds ratio of 2 would suggest for each standard deviation increase in an explanatory variable (e.g., site closure, number of people) was associated with a doubling of the probability of nest use, where as a logs-odds ratio of 0.5 would suggest a decline in nest usel by 50% for each increase in an explanatory variable. Functionally, this suggested that a standard deviation increase (8–9 individuals) from the average number of people observed at a particular point (5 individuals) was sufficient to reduce the probability of a nest being found near a particular point to approximately 0. In other words, nest activity within a particular point for each of these species was predicted to be nearly zero if, on average, human densities were approximately 1 person per hectare.

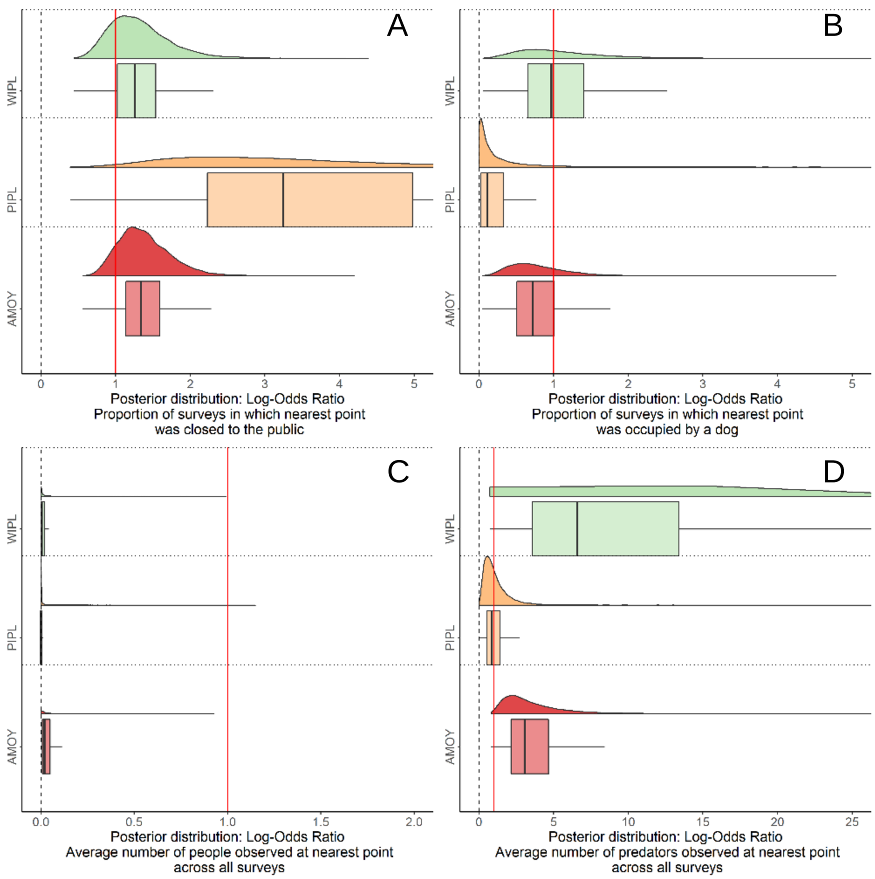
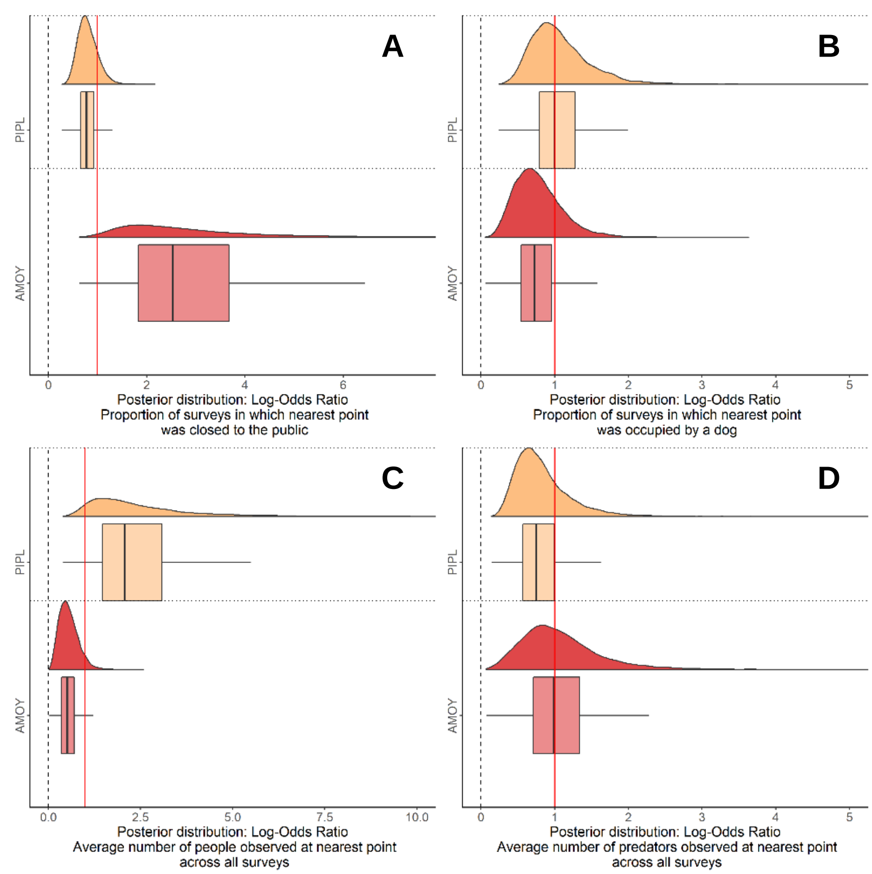


Figure 17. Log odds ratios describing the proportional increase or decrease in a nest site use as a function of the A) proportion of the breeding season a point was partially closed to the public; B) proportion of surveys in which a point was occupied by a dog; C) average number of people; or D) nest predators observed within 200m of a point during the breeding season. In this context, values to the right of the red line indicate an area was more likely to be used as a nest site as a function of an explanatory variable relative to not used as a nest site. Whereas, values to the left of the red line indicate an area was less likely to be used as a nest site as a function of an explanatory variable relative to not used as nest site.

Nest success

We found that nest survival for American oystercatchers across the study system was low (AMOY: 0.17 [±0.06 SD], or approximately half of the estimated nest survival for piping plovers when no nest exclosures were used (0.36 [±0.11 SD]) or five times lower than the estimated nest survival for piping plovers when all nests were exclosed (0.83 [±0.05 SD]). As nest exclosures may buffer PIPL nests from the direct (e.g., trampling, dog-related predation) and indirect (e.g., abandonment) consequences of recreational disturbance on nest success, we expected that the nest survival of AMOY may be more sensitive to observed human disturbances. We found that PIPL nest survival was relatively unaffected by recreational disturbance, but AMOY nest survival was greater in areas that had greater amounts of site closures (Fig. 18A) as well as fewer people (Fig. 18C). As a reminder, these results as presented as log-odds ratios, which represent the proportional change in apparent nest survival relative to a standard deviation increase in each explanatory variable. In other words, a log-odds ratio of 2 would suggest for each standard deviation increase in an explanatory variable (e.g., site closure, number of people) was associated with a doubling of nest survival, where as a logs-odds ratio of 0.5 would suggest a decline in nest survival by 50% for each increase in an explanatory variable.

Figure 18. Log odds ratios describing the proportional increase or decrease in apparent nest survival as a function of the A) proportion of the breeding season a point was partially closed to the public; B) proportion of surveys in which a point was occupied by a dog; C) average number of people; or D) nest predators observed within 200m of a point during the breeding season. In this context, values to the right of the red line indicate nests were more likely to hatch as function of an explanatory variable relative to failing. Whereas, values to the left of the red line indicate an area was less likely to hatch as function of an explanatory variable relative to failing.



Prioritizing sites for management

We identified sites as a function of predicted shorebird abundance of shorebirds relative to site disturbances, in which we were interested in separating out two distinct classes of sites. 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, we identified the high and low performing sites for each species monitored.

American oystercatcher – Conservation sites were consistently associated with both very low numbers of people and almost no dog activity (e.g., Cedar Key, FL; Ferry Slip and South Pelican Islands, NC). Although some sites had both large numbers of human disturbance and AMOY (Fig. 19A), no site had large numbers of AMOY paired with high dog activity (Fig. 19C). In fact, the sites with the most dog activity were consistently designated as Management sites. Of note, Topsail and North and South Wrightsville Beach, NC, were associated with high levels of dog and human activity but with low (South Wrightsville Beach) or no (Topsail and North Wrightsville Beach) AMOY during the summer or fall periods, despite large numbers of AMOY occupying nearby areas during similar periods. Sullivan's Island, SC was observed to be the area with the most dog activity that continued to have some AMOY present. More disturbed areas in Connecticut (Sandy Point) were also associated with low AMOY abundance during the fall migration.

Piping plover – Similar to AMOY, there were areas designated as Conservation sites that were associated with both low human and dog activity paired with high PIPL abundance (e.g., Outback Key, FL; Crow Neck, NS; Fig. 19). Although PIPL appeared to tolerate areas with moderate human and dog activity, areas of high dog activity were consistently assigned as Management priority sites (e.g., Sullivan's Island, SC, Sandy Point, CT, and Topsail Island and North and South Wrightsville Beach, NC).

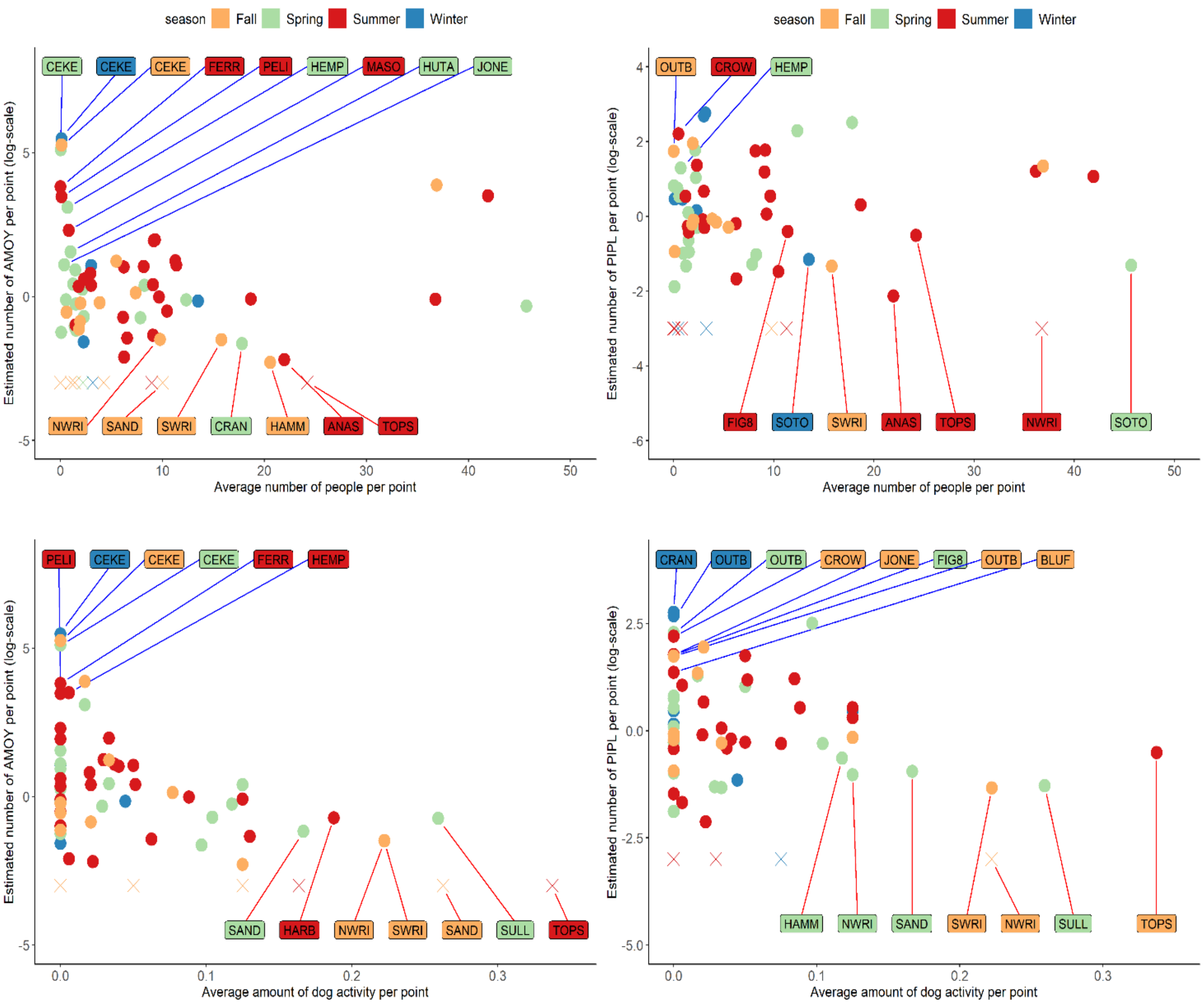


Figure 19. Seasonal (color) management priority areas for American oystercatchers (left) and piping plovers (right) relative to human (top panels) or dog (bottom panels) activity. Sites were considered to be a priority for management action (red lines) if they were associated with low abundance (< 25% quartile) and high disturbance (> 75% quartile) or a priority for continued conservation actions (blue lines) if they were associated with high abundance (> 75% quartile) and low disturbance (< quartile). Abundance is represented on the log scale. X's represent sites within the seasonal range of a species that were unoccupied by the species. Circles represent sites that were seasonally occupied. See Appendix A for site description codes.

Red knot – The geographic distribution of REKN had the least overlap with our study system of the species monitored; however, there were observations of non-breeding REKN throughout the four seasons. These observations were predominantly associated with areas of low human and dog activity in the southern portion of the study system (e.g., Cedar and Outback Key, FL; Fig 20). Masonboro Island, NC was also identified as a Conservation area, whereas nearby, but substantially more disturbed areas, such as Topsail and North Wrightsville Island were unoccupied by REKN and assigned as Management priorities.

Semipalmated sandpiper – SESA were the most abundant species observed, predominantly due to extremely large groups of individuals (> 5,000) observed during the fall migration at multiple sites. Although areas considered Conservation priorities often were associated with low human and dog activity (Debert and Crow Neck, NS), SESA exhibited the lowest site-level sensitivity to human disturbance, as areas considered to be Management priorities were not the most impacted by human activity (Fig. 20). Although areas with high dog activity were generally assigned as Management priorities (Topsail NC; Sullivan’s Island, SC; North Wrightsville Island, NC) the pattern was not as distinct as it was with the other species.

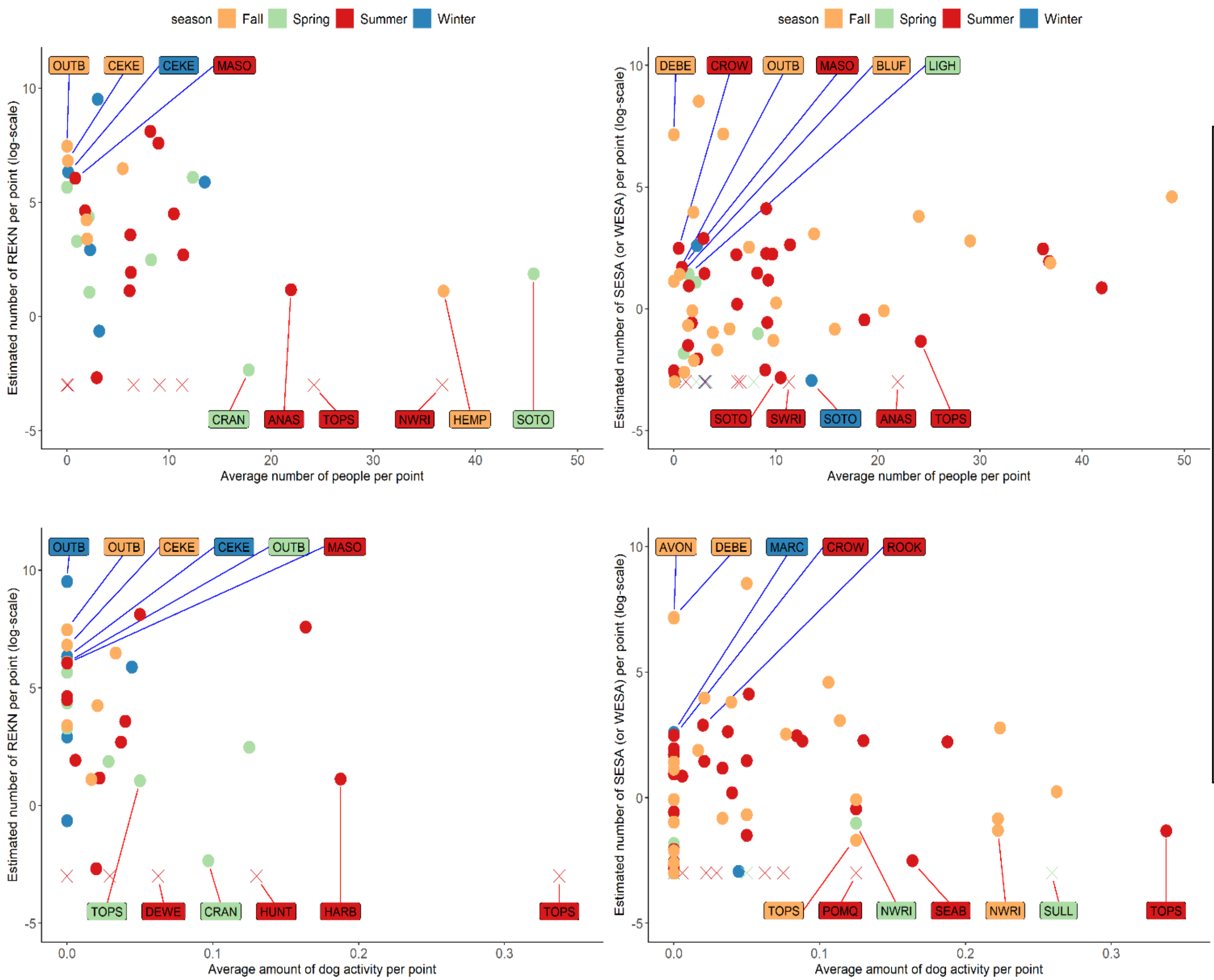


Figure 20. Seasonal (color) management priority areas for red knots (left) and semipalmated sandpipers (right) relative to human (top panels) or dog (bottom panels) activity. Sites were considered to be a priority for management action (red lines) if they were associated with low abundance (< 25% quartile) and high disturbance (> 75% quartile) or a priority for continued conservation actions (blue lines) if they were associated with high abundance (> 75% quartile) and low disturbance (< quartile). Abundance is represented on the log scale. X's represent sites within the seasonal range of a species that were unoccupied by the species. Circles represent sites that were seasonally occupied. See Appendix A for site description codes.

Wilson's plover – Although WIPL were geographically limited to the southern portion of the study system, we observed similar patterns as described with the other species. Areas with low human and dog activity were assigned as Conservation priorities (Masonboro Island, NC, Outback Key, FL, Lighthouse Inlet Heritage Preserve, SC), and areas with either high dog or human activity were associated with lower abundance than the rest of the range (Crandon Park and Fort DeSoto, FL, Sullivan's Island, SC, Topsail and North and South Wrightsville Islands, NC; Fig. 21).

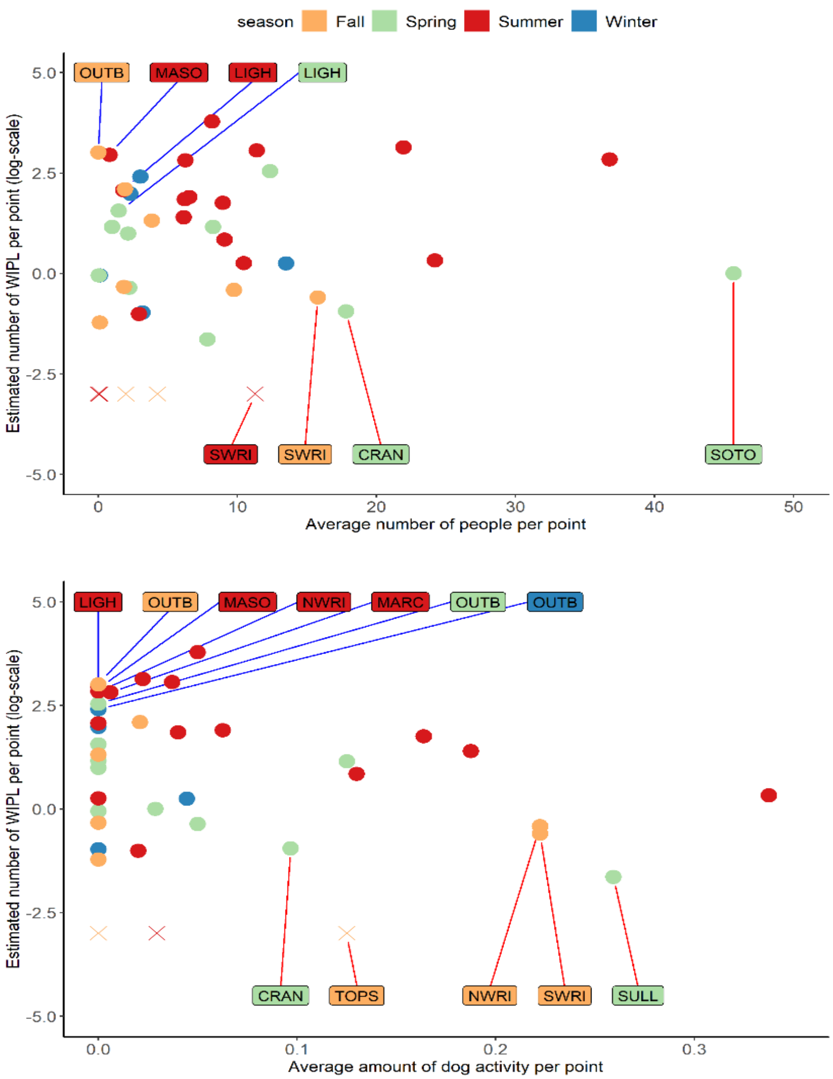


Figure 21. Seasonal (color) management priority areas for Wilson's plovers relative to human (top panel) or dog (bottom panel) activity. Sites were considered to be a priority for management action (red lines) if they were associated with low abundance (< 25% quartile) and high disturbance (> 75% quartile) or a priority for continued conservation actions (blue lines) if they were associated with high abundance (> 75% quartile) and low disturbance (< quartile). Abundance is represented on the log scale. X's represent sites within the seasonal range of a species that were unoccupied by the species. Circle represent sites that were seasonally occupied. See Appendix A for site description codes.

KEY FINDINGS

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

Area closures, however, were effective in lowering the number of recreational disturbances 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 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 where possible, and outreach to educate beach users about the importance of closed areas. 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. 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 the local shorebird community. Although it is unlikely that full closures of popular beaches will resonate well with the public, a well-designed information campaign paired with relatively small closures 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 41 sites throughout an entire year. We believe that this protocol and our analytical methods could be 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. For example, the protocol we developed is currently being used by additional sites that were not originally participating in this study. Partners in Georgia and additional partners in South Carolina 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*), Sanderling (*Calidris alba*), and Semipalmated Plovers (*Charadrius semipalmatus*). As the use of this protocol proliferates, the quality of the data collected will ensure more robust conclusions and will improve our assessment of the effects of potentially important but somewhat rare disturbances.

If continuation of flyway-wide data collection is implemented, we also suggest including species that are perceived to be more disturbance tolerant, such as Sanderlings. During this study, 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 species such as Sanderlings, that are perceived to be more disturbance tolerant, may result in more behavioral samples and further insight on how species react to potential disturbance.

In addition to the biological tracking afforded by these protocols, they also provide a standardized way of measuring potential disturbances at a flyway scale. These measures can be used as metrics to assess the success of any attempts to lessen disturbance both in terms of the occurrence of these activities and in terms of the response of shorebirds to any changes. This first year of data collection 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. In addition, we are working to pair biological data collection and results with the findings from land manager surveys and surveys of dog walkers on selected beaches to inform the Community Based Social Marketing piece of this project.

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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	Jone 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. This information was summarized from the ‘Site Information’ data collected by partners. The numbers in parentheses represent range values.

State or Province	Season	# Sites	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 access only	Prop. with beach raking	Prop. with beach modifications
CT	Breeding	10	3.00 (1–4)	0.00	0.52 (0.1–3)	643.50 (100–1500)	0.70 (0–3)	0.40	0.10	0.40	0.20
CT	Fall	10	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	10	3.00 (1–4)	0.00	0.52 (0.1–3)	643.50 (100–1500)	0.00	0.00	0.00	0.00	0.20
FL	Breeding	4	3.75 (0–10)	0.75 (0–2)	0.26 (0.1–0.5)	714.33 (67–1800)	1.25 (0–5)	0.25	0.25	0.25	0.25
FL	Fall	3	3.33 (0–10)	0.67 (0–2)	0.20	1800.00	0.33 (0–1)	0.33	0.67	0.33	0.00
FL	Spring	3	7.67 (0–13)	2.00 (0–4)	0.22	2440.00 (1800–3080)	9.00 (0–25)	0.67	0.33	0.67	0.33
FL	Winter	4	6.25 (0–13)	1.50 (0–4)	0.31 (0.2–0.5)	1649.00 (67–1800)	6.75 (0–25)	0.50	0.25	0.50	0.25
ME	Breeding	1	7.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
ME	Fall	4	3.75 (2–7)	0.50 (0–2)	0.05 (0–0.1)	165.00 (10–400)	0.00	0.00	0.00	0.25	0.25
NC	Breeding	8	2.75 (0–11)	0.25 (0–1)	1.84 (0–6.3)	66.80 (30–90)	0.13 (0–1)	0.13	0.50	0.00	0.75
NC	Fall	5	2.20 (0–4)	0.40 (0–1)	1.84 (0–6.3)	66.80 (30–90)	0.00	0.00	0.20	0.00	0.80
NC	Spring	4	2.25	0.25	0.97	68.00	0.00	0.00	0.25	0.00	0.75

			(0–4)	(0–1)	(0–2.9)	(30–90)					
NC	Winter	3	2.00 (0–4)	0.33 (0–1)	0.00	60.00 (30–90)	0.00	0.00	0.33	0.00	0.67
NS	Breeding	4	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	3	4.00 (1–9)	1.00	0.02 (0.01–0.04)	6.67 (2–10)	0.00	0.00	0.00	0.00	1.00
NY	Breeding	3	13.00 (7–22)	3.00 (1–4)	0.16 (0.03–0.3)	4177.67 (80–7407)	1.00 (0–2)	0.67	0.00	0.33	0.33
NY	Fall	3	13.00 (7–22)	3.00 (1–4)	0.16 (0.03–0.3)	3751.00 (80–7407)	0.00	0.00	0.00	0.33	0.33
NY	Spring	3	13.00 (7–22)	3.00 (1–4)	0.16 (0.03–0.3)	4177.67 (80–7407)	0.00	0.00	0.00	0.67	0.33
SC	Breeding	5	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	Spring	2	15.50 (1–30)	2.00 (1–3)	0.55 (0.15–0.95)	66.00 (20–112)	0.00	0.00	0.00	0.00	0.00

Table 2. Disturbance management summary information for each state during each season that data was collected. 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. A few of the proportions related to 'Dogs' don't 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	# Sites	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	10	0.00	0.40	0.80	0.80	0.90	0.20	1.00	0.60	0.90	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00
CT	Fall	10	0.00	0.20	0.80	0.00	0.60	0.00	1.00	0.60	0.90	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00
CT	Spring	10	0.00	0.50	0.80	0.00	0.30	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00
FL	Breeding	4	0.00	0.00	1.00	0.00	0.75	0.25	0.50	1.00	0.25	0.25	0.00	0.75	0.00	0.00	0.25	0.75	0.00
FL	Fall	3	0.33	0.00	0.67	0.00	0.33	0.33	0.33	0.67	0.33	0.00	0.00	0.67	0.33	0.00	0.67	0.33	0.00
FL	Spring	3	0.33	0.00	0.67	0.00	0.00	0.00	0.33	0.33	0.67	0.00	0.00	0.33	0.67	0.00	0.33	0.67	0.00
FL	Winter	4	0.25	0.00	0.75	0.00	0.00	0.00	0.50	0.50	0.50	0.25	0.00	0.25	0.50	0.00	0.25	0.75	0.00
ME	Breeding	1	1.00	0.00	0.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
ME	Fall	4	0.75	0.25	0.00	0.25	0.75	0.25	1.00	0.75	1.00	0.75	0.00	0.00	0.25	0.25	0.75	0.00	0.00
NC	Breeding	8	0.25	0.25	0.50	0.00	0.75	0.38	0.88	0.63	0.38	0.75	0.00	0.25	0.00	0.00	0.38	0.63	0.00

NC	Fall	5	0.40	0.60	0.20	0.00	1.00	0.20	0.80	0.40	0.40	0.80	0.00	0.20	0.00	0.00	0.60	0.40	0.00
NC	Spring	4	0.50	0.50	0.00	0.00	0.75	0.75	0.75	0.50	0.50	1.00	0.00	0.00	0.00	0.00	0.50	0.50	0.00
NC	Winter	3	0.67	0.33	0.00	0.00	0.00	0.33	0.33	0.00	0.67	1.00	0.00	0.00	0.00	0.00	0.67	0.33	0.00
NS	Breeding	4	0.00	1.00	0.00	0.00	0.25	0.00	1.00	1.00	0.75	0.00	0.00	1.00	0.00	0.00	0.75	0.25	0.00
NS	Fall	3	0.00	1.00	0.00	0.00	0.00	0.67	1.00	1.00	1.00	0.33	0.00	0.67	0.00	0.00	0.00	1.00	0.00
NY	Breeding	3	0.00	0.00	1.00	1.00	1.00	0.33	1.00	1.00	0.67	1.00	0.00	0.00	0.00	0.00	0.33	0.67	0.00
NY	Fall	3	0.00	0.33	0.67	0.00	1.00	0.33	0.33	1.00	0.67	1.00	0.00	0.00	0.00	0.00	0.33	0.67	0.00
NY	Spring	3	0.00	0.33	0.67	0.33	1.00	0.33	0.33	1.00	0.67	1.00	0.00	0.00	0.00	0.00	0.33	0.67	0.00
SC	Breeding	5	0.40	0.20	0.40	0.00	1.00	0.00	1.00	0.80	1.00	0.00	0.20	0.60	0.20	0.00	0.00	0.80	0.20
SC	Spring	2	0.50	0.50	0.50	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00

Table 3. Point count summary information for each participating site. 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 point counts closed	# Vehicles	# Boats	# Aerial	# Dogs, unleashed	# Dogs, leashed	# People, mobile	# People, at rest	# Predators	# PIPL	# AMOY	# REKN	# WIPL	# SESA
CT	Bluff Point	159	0.51	0.00	0.42	0.16	0.01	0.00	0.91	0.59	4.03	0.75	0.34	0.00	0.00	0.20
CT	Hammonasset	276	0.32	0.24	0.44	0.03	0.05	0.18	8.70	7.28	6.94	0.32	0.18	0.00	0.00	0.12
CT	Housatonic	263	0.25	0.32	0.21	0.13	0.05	0.08	5.06	2.23	26.98	0.74	0.40	0.02	0.00	6.97
CT	Long Beach	192	0.35	1.73	0.04	0.23	0.00	0.06	1.37	0.83	17.45	0.35	0.22	0.00	0.00	1.27
CT	Pleasure Beach	136	0.24	0.07	0.24	0.13	0.00	0.00	0.69	0.29	11.38	0.10	0.04	0.00	0.00	0.62
CT	Sandy Point	264	0.28	6.42	0.06	0.02	0.09	0.24	6.54	1.75	19.87	0.36	0.16	0.02	0.00	0.82
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	220	0.46	0.00	0.51	0.00	0.03	0.00	4.04	1.41	1.17	0.14	0.02	0.30	1.62	0.00
FL	Cedar Key	197	0.00	0.01	0.20	0.01	0.02	0.00	0.07	0.00	0.04	0.35	57.19	8.59	0.08	0.00
FL	Crandon Park	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	0.00
FL	Ft. De Soto	190	0.20	0.05	0.17	0.15	0.01	0.02	9.27	6.83	0.27	0.10	0.21	12.87	0.12	0.00
FL	Outback Key	40	0.00	0.00	2.15	0.03	0.25	0.05	5.03	1.80	0.55	3.15	0.50	26.15	2.65	0.00
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
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	66	0.38	0.03	0.00	0.00	0.06	0.12	22.26	26.52	0.15	0.09	0.00	0.00	0.00	34.26
NC	Ferry Slip Island	26	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.77	0.00	11.08	0.00	0.00	0.00
NC	Hutaff Island	210	0.50	0.00	0.37	0.01	0.16	0.01	1.57	0.72	3.78	0.13	0.49	0.09	0.32	0.00
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	0.00
NC	North Figure 8 Island	187	0.30	0.01	0.69	0.06	0.26	0.01	3.08	2.42	1.02	0.54	0.46	0.34	0.98	0.00
NC	North 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	0.00
NC	South Pelican Island	26	1.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	21.04	0.00	6.77	0.00	0.00	0.00
NC	South Topsail Island	321	0.01	0.04	0.29	0.03	0.14	0.32	4.49	3.36	3.21	0.38	0.00	0.01	0.04	0.00
NC	South Wrightsville Beach	54	0.81	0.44	0.02	0.35	0.02	0.28	7.28	5.35	4.67	0.02	0.50	0.00	0.02	0.00
NS	Avonport Beach	18	0.44	0.06	0.00	0.00	0.33	0.00	1.89	2.94	2.28	0.00	0.00	0.00	0.00	938.83
NS	Clam Point Beach	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 Beach	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 Beach	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	The Guzzle	20	0.45	0.00	0.00	0.00	0.05	0.05	0.60	1.85	3.05	0.00	0.00	0.00	0.00	2208.65
NS	Pomquet Beach	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	250	0.44	0.02	0.04	0.01	0.00	0.14	1.49	4.49	0.00	0.21	4.17	0.00	0.00	6.20

NY	Jones Beach	275	0.81	0.06	0.10	0.23	0.00	0.01	1.27	5.48	16.09	1.04	1.35	0.58	0.00	0.01
NY	Town of Hempstead Beach	290	0.63	0.60	0.02	0.66	0.01	0.01	3.84	28.50	28.63	0.83	8.67	0.05	0.00	0.04
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	Harbor Island	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
SC	Huntington Beach State Park	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
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	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

Table 4. Point count summary information for each participating site during each season that data was collected. 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	Season	# Point counts	Proportion of point counts closed	# Vehicles	# Boats	# Aerial	# Dogs, unleashed	# Dogs, leashed	# People, mobile	# People, at rest	# Predators	# PIPL	# AMOY	# REKN	# WIPL	# SESA	# Behavioral samples	# Nest monitored
CT	Bluff Point	Breeding	85	0.91	0.00	0.65	0.24	0.01	0.00	1.44	0.87	2.14	1.22	0.49	0.00	0.00	0.02	1	20
CT	Bluff Point	Fall	45	0.09	0.00	0.24	0.07	0.00	0.00	0.29	0.29	4.67	0.00	0.13	0.00	0.00	0.67	3	-
CT	Bluff Point	Spring	29	0.00	0.00	0.00	0.10	0.00	0.00	0.31	0.24	8.59	0.52	0.21	0.00	0.00	0.00	11	-
CT	Hammonasset	Breeding	144	0.53	0.17	0.61	0.03	0.05	0.20	10.37	8.29	5.50	0.56	0.27	0.00	0.00	0.13	6	13
CT	Hammonasset	Fall	81	0.15	0.11	0.40	0.04	0.05	0.16	10.53	9.78	7.91	0.01	0.01	0.00	0.00	0.19	5	-
CT	Hammonasset	Spring	51	0.00	0.65	0.02	0.00	0.06	0.18	1.06	0.43	9.45	0.14	0.18	0.00	0.00	0.00	8	-
CT	Housatonic	Breeding	137	0.45	0.13	0.20	0.10	0.04	0.05	5.88	3.12	11.99	1.34	0.55	0.03	0.00	10.83	11	14
CT	Housatonic	Fall	78	0.03	0.38	0.35	0.09	0.03	0.09	5.49	1.87	29.58	0.00	0.31	0.00	0.00	4.47	15	-
CT	Housatonic	Spring	48	0.04	0.77	0.00	0.25	0.13	0.15	2.02	0.27	65.56	0.23	0.13	0.00	0.00	0.00	8	-
CT	Long Beach	Breeding	96	0.71	1.81	0.04	0.29	0.00	0.09	1.91	1.10	10.99	0.61	0.41	0.00	0.00	2.46	7	23
CT	Long Beach	Fall	60	0.00	1.57	0.05	0.17	0.00	0.05	1.00	0.40	16.37	0.00	0.00	0.00	0.00	0.13	3	-
CT	Long Beach	Spring	36	0.00	1.81	0.00	0.17	0.00	0.00	0.56	0.83	36.50	0.22	0.08	0.00	0.00	0.00	6	-
CT	Pleasure Beach	Breeding	72	0.44	0.06	0.26	0.14	0.00	0.00	0.92	0.33	11.00	0.19	0.07	0.00	0.00	1.17	1	1

CT	Pleasure Beach	Fall	40	0.00	0.13	0.13	0.08	0.00	0.00	0.68	0.35	12.90	0.00	0.00	0.00	0.00	0.00	0	-
CT	Pleasure Beach	Spring	24	0.00	0.00	0.38	0.21	0.00	0.00	0.04	0.04	10.00	0.00	0.04	0.00	0.00	0.00	0	-
CT	Sandy Point	Breeding	136	0.51	6.44	0.12	0.04	0.08	0.15	7.61	2.04	10.51	0.66	0.28	0.03	0.00	1.30	14	16
CT	Sandy Point	Fall	80	0.04	7.01	0.00	0.00	0.15	0.40	7.83	2.19	29.63	0.00	0.00	0.00	0.00	0.50	3	-
CT	Sandy Point	Spring	48	0.02	5.38	0.00	0.02	0.02	0.21	1.35	0.17	30.10	0.10	0.08	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	170	0.51	0.00	0.66	0.00	0.04	0.01	4.45	1.80	1.52	0.04	0.02	0.32	1.65	0.00	-	18
FL	Big Marco Pass CWA	Winter	50	0.30	0.00	0.00	0.00	0.00	0.00	2.64	0.08	0.00	0.48	0.02	0.24	1.52	0.00	22	-
FL	Cedar Key	Fall	80	0.00	0.03	0.19	0.00	0.03	0.00	0.09	0.00	0.04	0.09	54.26	12.89	0.03	0.00	83	-
FL	Cedar Key	Spring	57	0.00	0.00	0.16	0.02	0.02	0.00	0.02	0.00	0.00	0.61	48.04	2.84	0.12	0.00	65	-
FL	Cedar Key	Winter	60	0.00	0.00	0.25	0.00	0.00	0.00	0.10	0.00	0.08	0.45	69.78	8.33	0.12	0.00	59	-
FL	Crandon Park	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	0.00	9	-
FL	Crandon Park	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	Ft. De Soto	Breeding	75	0.20	0.09	0.08	0.05	0.00	0.00	7.09	3.36	0.39	0.05	0.19	7.32	0.15	0.00	7	10
FL	Ft. De Soto	Fall	35	0.20	0.06	0.03	0.00	0.00	0.00	1.71	0.26	0.66	0.23	0.17	1.20	0.00	0.00	8	-
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	0.00	21	-
FL	Ft. De Soto	Winter	45	0.20	0.00	0.42	0.49	0.00	0.04	9.13	4.36	0.00	0.09	0.24	18.49	0.16	0.00	22	-
FL	Outback Key	Breeding	20	0.00	0.00	2.70	0.05	0.35	0.10	6.80	1.35	1.10	1.70	0.60	11.15	3.85	0.00	-	-
FL	Outback Key	Fall	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.50	0.00	1.50	5.00	0.00	4	-
FL	Outback Key	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	3	-

FL	Outback Key	Winter	12	0.00	0.00	1.25	0.00	0.17	0.00	2.08	0.92	0.00	4.92	0.58	62.08	1.00	0.00	31	-
FL	Three Rooker Island	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 Island	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	-
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	66	0.38	0.03	0.00	0.00	0.06	0.12	22.26	26.52	0.15	0.09	0.00	0.00	0.00	34.26	28	-
NC	Ferry Slip Island	Breeding	26	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.77	0.00	11.08	0.00	0.00	0.00	-	18
NC	Hutaff Island	Breeding	50	1.00	0.00	1.10	0.00	0.30	0.04	3.76	2.44	1.38	0.18	0.74	0.14	0.66	0.00	5	22
NC	Hutaff Island	Fall	50	0.30	0.00	0.22	0.04	0.14	0.00	1.52	0.30	3.30	0.26	0.08	0.00	0.14	0.00	11	-
NC	Hutaff Island	Spring	60	0.67	0.00	0.18	0.00	0.12	0.00	0.78	0.20	4.57	0.08	1.02	0.18	0.47	0.00	46	-
NC	Hutaff Island	Winter	50	0.00	0.00	0.02	0.00	0.08	0.00	0.38	0.06	5.70	0.00	0.00	0.00	0.00	0.00	0	-
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	0.00	-	35
NC	North Figure 8 Island	Breeding	60	0.50	0.00	1.48	0.03	0.38	0.03	6.18	4.73	1.03	0.12	0.72	0.12	1.78	0.00	12	-
NC	North Figure 8 Island	Fall	60	0.10	0.00	0.47	0.08	0.22	0.00	1.65	2.18	1.58	0.27	0.32	0.00	0.85	0.00	15	-
NC	North Figure 8 Island	Spring	67	0.31	0.01	0.18	0.07	0.18	0.00	1.58	0.55	0.51	1.16	0.36	0.84	0.39	0.00	54	-
NC	North 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	0.00	1	-
NC	North 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	0.00	5	-
NC	North 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	0.00	22	-

NC	North 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	0.00	1	-
NC	South Pelican Island	Breeding	26	1.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	21.04	0.00	6.77	0.00	0.00	0.00	-	24
NC	South Topsail Island	Breeding	80	0.03	0.06	1.14	0.08	0.15	0.68	12.66	11.53	1.46	0.16	0.00	0.00	0.11	0.00	1	1
NC	South Topsail Island	Fall	80	0.00	0.03	0.03	0.04	0.19	0.30	3.20	1.04	4.54	0.23	0.00	0.00	0.00	0.00	5	-
NC	South Topsail Island	Spring	81	0.00	0.04	0.00	0.01	0.12	0.12	1.37	0.80	1.20	0.72	0.00	0.02	0.06	0.00	23	-
NC	South Topsail Island	Winter	80	0.00	0.05	0.00	0.01	0.10	0.20	0.76	0.11	5.66	0.40	0.00	0.00	0.00	0.00	11	-
NC	South Wrightsville Beach	Breeding	34	1.00	0.26	0.03	0.41	0.00	0.03	5.85	5.41	3.59	0.00	0.76	0.00	0.00	0.00	-	5
NC	South Wrightsville Beach	Fall	20	0.50	0.75	0.00	0.25	0.05	0.70	9.70	5.25	6.50	0.05	0.05	0.00	0.05	0.00	3	-
NS	Avonport Beach	Fall	18	0.44	0.06	0.00	0.00	0.33	0.00	1.89	2.94	2.28	0.00	0.00	0.00	0.00	938.83	10	-
NS	Clam Point Beach	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 Beach	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 Beach	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	The Guzzle	Fall	20	0.45	0.00	0.00	0.00	0.05	0.05	0.60	1.85	3.05	0.00	0.00	0.00	0.00	2208.65	16	-
NS	Pomquet Beach	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 Beach	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	-	-
NY	Breezy Point	Fall	100	0.35	0.00	0.02	0.00	0.00	0.28	1.00	2.47	0.00	0.07	7.87	0.00	0.00	10.43	51	-
NY	Breezy Point	Spring	30	0.50	0.00	0.00	0.00	0.00	0.03	0.63	0.60	0.00	0.03	0.47	0.00	0.00	0.00	8	-
NY	Jones Beach	Breeding	165	0.99	0.05	0.09	0.26	0.01	0.00	1.67	7.47	15.28	1.53	1.73	0.01	0.00	0.00	30	46
NY	Jones Beach	Fall	60	0.53	0.08	0.18	0.15	0.00	0.03	0.95	4.52	30.85	0.15	0.77	2.65	0.00	0.03	30	-

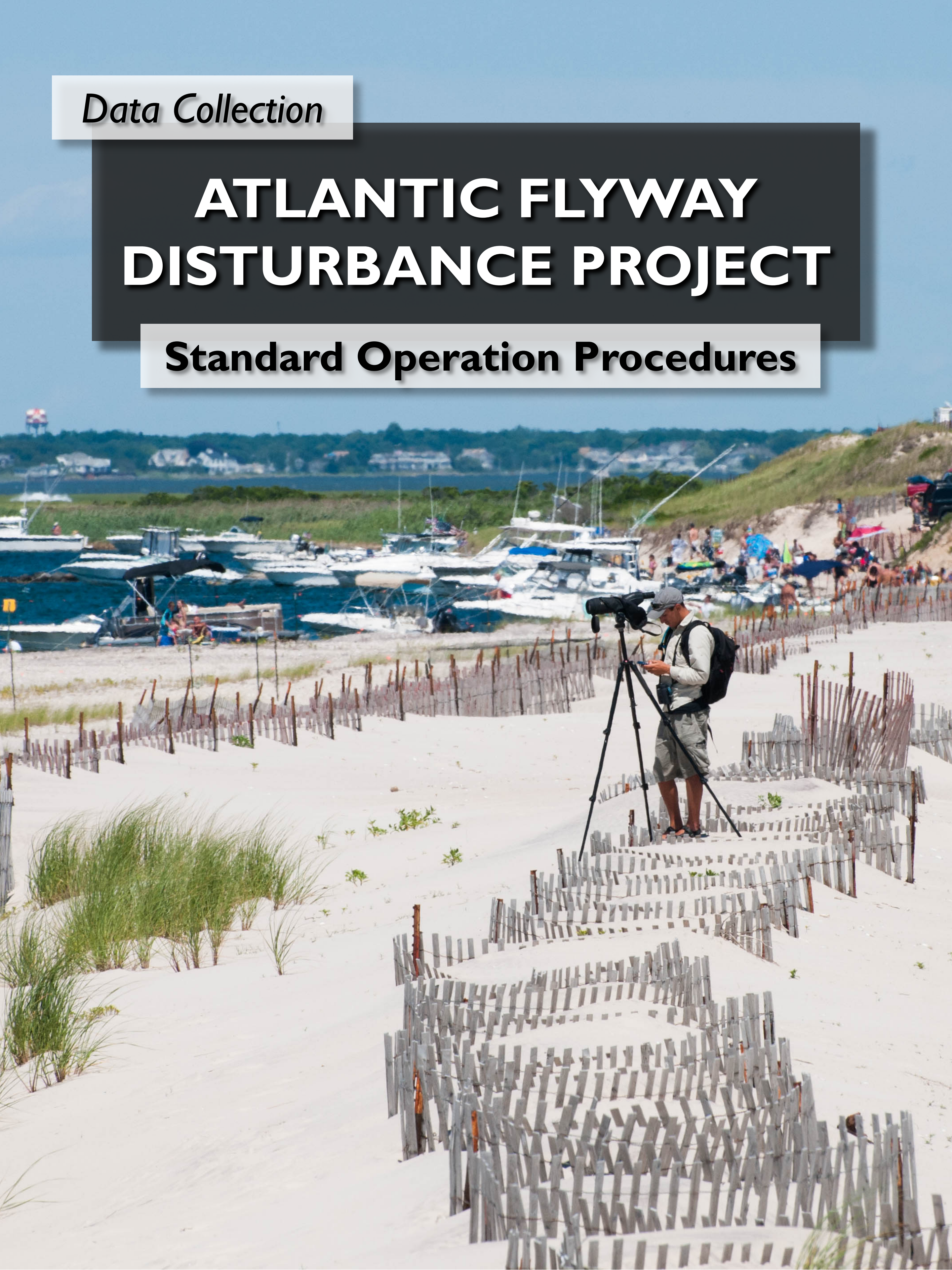
NY	Jones Beach	Spring	50	0.54	0.04	0.02	0.24	0.00	0.00	0.32	0.06	1.06	0.48	0.80	0.00	0.00	0.00	30	-
NY	Town of Hempstead Beach	Breeding	170	0.76	0.60	0.02	0.50	0.01	0.01	5.08	36.82	23.48	0.85	7.72	0.00	0.00	0.02	40	16
NY	Town of Hempstead Beach	Fall	60	0.60	0.75	0.05	1.07	0.00	0.02	3.55	33.33	62.53	0.83	14.33	0.25	0.00	0.13	61	-
NY	Town of Hempstead Beach	Spring	60	0.27	0.43	0.00	0.70	0.03	0.02	0.63	0.07	9.33	0.80	5.72	0.00	0.00	0.00	55	-
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	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	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	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	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	-

APPENDIX C: Atlantic Flyway Disturbance Project Standard Operating Procedures and Datasheets (used during 2017/2018 data collection)

Data Collection

ATLANTIC FLYWAY DISTURBANCE PROJECT

Standard Operation 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 you 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 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, 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.

Collecting data in the field…

We hope to collect field data **10–12 time per site per season** (fall migration (August 1- October 31), winter (November 1- January 31), spring migration (February 1 – March 31), and the breeding season (April 1 – July 31)) 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, 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 always 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 during the breeding season</u>.** 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 **0–5 behavioral samples per location, totaling 0–50 samples per site visit.** We know that 50 samples seems like A LOT… however, we expect that it will be extremely rare (nearly impossible) to locate all five 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 five focal species, you will end up with five 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.

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 adjust 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 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.

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: **15 min (3 min for each of the 5 species)**
5. Leave point

That would be 23 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.

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 need be.

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.
- **DATE:** Record the date **(mm/dd/yyyy)**.
- **1ST HIGH TIDE:** Record the time **(military time)** of the first high tide of the day. You can obtain this from your favorite tide chart or website.
- **TIME IN:** Record the time **(military time)** you enter the site.
- **TIME OUT:** Record the time **(military time)** 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 (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 behavioral sample(s) done at the same location.

- **START TIME:** Record the time **(military time)** when you start each point count.
- **POINT IN CLOSED AREA OR SYMBOLIC FENCING? (Y/N):** Place a 'Y' here if **you or any part 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.
- **# 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, BEHAVIOR SAMPLES WILL NOT BE CONDUCTED DURING THE BREEDING SEASON**

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.
- **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, 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.
- **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.
- **SITE LEGNTH:** Record the length of your site (m).
- **SEASON:** Record the season(s) that you are completing the NFWF Disturbance Project point counts and behavioral samples.
    - **Fall**
    - **Winter**
    - **Spring**
    - **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.
- **# 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.
- **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.
- **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 this column:
        - **A:** Dogs (leashed or unleashed) are allowed at the site.
        - **L:** Leashed dogs only are allowed at the site.
        - **N:** Dogs are not allowed at the site.
    - **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.

- **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.

- **DISTURBANCE MANAGEMENT:** Please record any of the following site-level disturbance management information that occurred at your site during the specified season.
  - **SYMBOLIC FENCING MANAGEMENT START DATE?:** If you used symbolic fencing, please record the date that you started putting up symbolic fencing. **(mm/dd/yyyy)**
  - **SYMBOLIC FENCING MANAGEMENT END DATE?:** If you used symbolic fencing, please record the date that you finished taking down symbolic fencing. **(mm/dd/yyyy)**
  - **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.
  - **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. For our purposes, we define closed area as areas are completely closed and they may not be the entire site. This can be IN ADDITION to symbolic fencing. **(mm/dd/yyyy)**
  - **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. For our purposes, we define closed area as areas are completely closed and they may not be the entire site. This can be IN ADDITION to symbolic fencing. **(mm/dd/yyyy)**
  - **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. For our purposes, we define closed area as areas are

completely closed and they may not encompass the site. This can be IN ADDITION to symbolic fencing. **(mm/dd/yyyy)**

- **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. For our purposes, we define closed area as areas are completely closed and they may not encompass the entire site. This can be IN ADDITION to symbolic fencing. **(mm/dd/yyyy)**
- **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.
- **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, REKN, WIPL, SESA) 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 an 'Y' here if the nest was exclosed at any point during incubation, place a 'N' if it was not.
- **DATE EXCLOSED (IF KNOWN):** Please record the date the nest was exclosed, if known. **(mm/dd/yyyy)**
- **SYMBOLIC FENCING? (Y/N):** Place an 'Y' here if the nest was surrounded by symbolic fencing at any point during incubation, place a '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.
- **NEST FAILED (Y/N)?:** Place a 'Y' here is the nest failed, place a '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)**
- **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.

- **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 'U' here if you are unsure how many eggs hatched.
- **HATCH DATE:** Record the hatch date (if known). If you are unsure, record the date that you observed the nest hatched. **(mm/dd/yyyy)**
- **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. If the fate of the brood is unknown, place a 'U' here.
- **# CHICKS FLEDGED:** Record the number of chicks fledged (if known), place a 'U' here if you are unsure of the exact number.
- **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.
- **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)**
- **COMMENTS:** Note any important information regarding the nest/brood.

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*