Guidance and Best Practices for Evaluating and Managing Human Disturbances to Migrating Shorebirds on Coastal Lands in the Northeastern United States

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ATLANTIC FLYWAY SHOREBIRD INITIATIVE

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INTRODUCTION

BACKGROUND

Many shorebirds that nest, migrate, and/or over-winter in the United States are in decline and are of conservation concern due to threats and pressures they experience throughout their annual cycle (NABCI 2016). During migration, many shorebirds visit stopover sites in order to forage and roost before continuing their north or southward journey (Colwell 2010). The ability to rest and refuel at these stopover sites is essential to successful migration; however, the quality of these sites may be compromised by various factors, including human disturbance (Schlacher et al. 2013, Gibson et al. 2018). Disturbance can impact an individual bird's ability to continue its migration and could affect its reproductive fitness for the coming breeding season (Burger and Niles 2013a). In areas where disturbance levels are high, like coastal areas in the northeastern U.S., birds may be excluded from foraging areas, or if using these highly disturbed areas, may have to spend more time fleeing from perceived threats, than feeding or resting (Schlacher et al. 2013). Human disturbance at stopover sites has been identified as one of four main anthropogenic threats to migrating shorebirds by the Atlantic Flyway Shorebird Initiative (AFSI), shorebird researchers, and land managers, prompting AFSI to recommend developing best practices for managing human disturbance at stopover sites (Atlantic Flyway Shorebird Initiative 2015).

The Atlantic Flyway Shorebird Initiative is a collaborative conservation effort, involving numerous partners, with the goal of addressing shorebird declines at the Flyway scale. The Atlantic Flyway Shorebird Business Plan, published in 2015, identified key threats, as well as a suite of strategies and actions needed to conserve 15 focal shorebird species. AFSI and partners have been working to implement the recommended actions with the goal of increasing shorebird populations by 10-15% by 2025. Learn more about AFSI by visiting atlanticflywayshorebirds.org

APPROACH

This document was developed in support of the AFSI goal to identify best practices for managing human disturbance at stopovers and provides guidance for evaluating and managing shorebird disturbance during southward (often referred to as "fall") migration in the northeastern U.S. It represents a first step towards developing Atlantic Flyway-scale guidance for managing human disturbance during migration. The focus on southward migration was selected because, in general, there is more overlap between migratory shorebirds and human use of coastal habitats in the Northeast during fall (July-November) than during northward (or "spring") migration. As habitat use varies across stopover locations and between migratory periods, further work to develop best practices for other geographies within the Flyway, as well as during northward migration, is needed. However, much of the guidance in this document is sufficiently broad to have relevancy beyond southward migration at coastal stopovers in the Northeast.

We used a trans-disciplinary approach, in which insights from biological and social science fields were integrated, along with applied expertise and knowledge of land managers and conservation practitioners. Our approach could also be considered as following the best practices of science co-production whereby science producers work closely with science users throughout the scientific process. Our writing team included social and biological scientists, as well as migratory bird and National Wildlife Refuge System biologists. Input from shorebird experts, land managers, field biologists, visitor services staff, and other potential users was sought throughout the development and significantly shaped the content of the document.

The process of creating this document included the following: 1) development of a shared definition of human disturbance to shorebirds and a list of priority disturbance types (i.e., human activities that may cause disturbance to migratory shorebirds); 2) an extensive review of the biological and social science peer-reviewed and gray literature; 3) interviews with 28 staff at coastal sites in the Northeast Region, including biologists or managers, law enforcement officers, and outreach/visitor services staff; 4) a synthesis of the compiled literature and interviews to inform a set of "best practices" that provide guidance on managing or reducing human disturbance during southward migration; and 5) the development and pilot field testing of a shorebird disturbance monitoring method.

These document components provide a comprehensive overview of the current state of knowledge related to human disturbance during southward migration. This document provides a summary of available information, including published and gray literature and expert knowledge, that managers can use to inform decisions and actions on-the-ground.

While we aimed for a document that is relevant throughout the region, stopover sites vary greatly in characteristics that influence human disturbance management (such as amount of human and shorebird use, land ownership, interests and resources of stakeholders, and ecological setting). Thus, this document does not prescribe practices that apply to every site, nor is it intended to provide regulatory or policy guidance. Instead, it is intended to be a toolkit of guidance from which managers can select the most appropriate and feasible practices for conditions at their site, applying their local knowledge in decisions about how to best apply this guidance. In addition, managers can use the document to identify information needs (e.g., thresholds of disturbance for management action) to guide additional inquiry, in order to improve management practices at their sites.

Throughout this document, we refer to "priority disturbance types" or sometimes "disturbance types". We use these terms to refer to human activities that may cause disturbance to migratory shorebirds. The impacts of a particular activity will depend on many factors, and the presence of a human activity does not necessarily mean shorebirds are being disturbed.

Scope:

Species – The best practices apply to all coastal migratory shorebird species with an emphasis on the 15 AFSI focal species (AFSI: A Business Plan; http://atlanticflywayshorebirds.org/documents/AFSI_Business_Plan_11_2017.pdf).

- American Oystercatcher
- Semipalmated Sandpiper
- Red Knot
- Whimbrel
- Wilson's Plover
- Marbled Godwit
- Piping Plover
- Purple Sandpiper
- Red-necked Phalarope
- Ruddy Turnstone
- Sanderling
- Snowy Plover
- American Golden Plover
- Greater Yellowlegs
- Lesser Yellowlegs

Piping Plover is one of the 15 focal species in the Atlantic Flyway Shorebird Initiative Business Plan. Peter Paton

Spatial Scale – All coastal habitats (intertidal, salt marsh, islands, or dunes) from Maine to Virginia: U.S. Fish and Wildlife Service Northeast Region (Figure 1).

Temporal Scale – Southward (or fall) migration, defined as July 1 – November 15.

USER GUIDE

We created this document to serve the needs of a variety of user groups: land managers; biologists; interpretation, education, and communications professionals; and more. It can be read from cover to cover. Or, users can skip to sections that help answer urgent questions or fill specific information requests. To give you a sense of how this document might be useful to you, we developed a set of commonly-asked or representative questions related to the management of human disturbance of shorebirds for each of our key document users. Some of these questions emerged from our interviews with land managers; others came from the Atlantic Flyway Shorebird Initiative business plan; and others we have heard our colleagues ask in meetings or in the course of our work together. Our list is not meant to be comprehensive, but instead prompt your thinking of how this document can be useful to you.

Our user's guide is organized by user group (land managers, biologists, and interpretation, education, and communications professionals). In the left column we list representative questions relevant to each user group, and in the right column we provide the appropriate section of the document to find answers to each question. For some questions, the user is directed to an entire section of the document. For other questions, specific sub-sections, such as a specific best practice, are referenced in parentheses next to the question.


Figure 1. Map of the USFWS Northeast Region

Note: we reference the appendices in this table and throughout the document. These appendices are included in the full document and are also available for download at: https://atlanticflywayshorebirds.org/human-disturbance-guidance-and-best-practices-document/.

Volunteer beach steward. Nolan Schillerstrom/Audubon

Question that can be answered with the document	Section of the document
Land Managers	
What issues are other land managers dealing with and what actions are they taking? What current literature exists on various human activities that I could use to inform planning documents or decisions about allowable recreational uses at my site? What are the impacts of certain disturbances?	State of Knowledge on Priority Disturbance Types in the Northeast: Literature review and interview results
What types of data could be useful for helping evaluate whether management actions may be warranted? What approaches could my site use to measure whether a current management action is effective? What is known about disturbance thresholds for shorebirds?	Evaluating Shorebird Disturbance at a Site
How do I effectively implement a management action?	BPs: 2, 3, 4, 5, 6
What guidance can I use to inform beach-closure decisions?	BP: 3
How do I tackle a complex, high-stakes disturbance problem?	BPs: 1, 2
How do I choose whether to implement a management action to reduce human disturbance?	BP: 1, 3
How do I effectively interact with the public when there is a human disturbance issue?	BPs: 2, 4, 5, 6
How far away do people need to be kept from shorebirds to prevent disturbance?	BP: 3
What are key information gaps that my site should be aware of when deciding to manage for disturbance? What gaps need to be filled to help inform decisions about efficient allocation of resources for disturbance management?	Information Gaps and Information Needs
What issues are other land managers dealing with, and what actions are they taking?	Appendix 2
Biologists	
What issues are other biologists dealing with, and what actions are they taking? What are the impacts of certain disturbances? What disturbances have been more well-studied than others?	State of Knowledge on Priority Disturbance Types in the Northeast: Literature review and interview results
How do I conduct field surveys to evaluate shorebird disturbance at my site? What types of data could be useful for helping quantify the impacts of human activities and inform management?	Evaluating Shorebird Disturbance at a Site
How do I tackle a complex, high-stakes disturbance problem?	BPs: 1, 2
How do I effectively interact with the public when there is a human disturbance issue?	BPs: 2, 4, 5, 6
How far away do people need to be kept from shorebirds to prevent disturbance?	BP: 3
What are important questions or issues to answer in order to improve shorebird disturbance management?	Information Gaps and Information Needs
What issues are other biologists dealing with, and what actions are they taking?	Appendix 2
How do I conduct field surveys to evaluate shorebird disturbance at my site?	Appendix 3, 4
Interpretation, Education, Communication Professionals	
What disturbances should outreach/education focus on? (biological literature review) What disturbances are most impactful? (biological literature review) What are people's thoughts related to shorebirds? (human dimensions literature review)	State of Knowledge on Priority Disturbance Types in the Northeast: Literature review and interview results
What information can I use to explain to recreationists that there is science-based reasoning behind closures or other management actions? How do I explain to the public what biologists are doing in the field	Evaluating Shorebird Disturbance at a Site
How do I design an effective sign?	BP: 5
How can my site avoid conflict over new management activities or closures?	BP: 2, 3
What are key information gaps that I should be aware of when designing education or communications approaches?	Information Gaps and Information Needs
What are land managers' thoughts on the role of using education and interpretation to address disturbance?	Appendix 2

METHODS

DELPHI TECHNIQUE: DEFINING DISTURBANCE & PRIORITIZING DISTURBANCE TYPES

Our process began with creating a shared definition of human disturbance because definitions of disturbance found in the literature are not consistent. Having this shared definition allows users of this document to communicate using the same terminology, but it is not meant to represent a prescription for management. To develop a shared definition for human disturbance and a list of priority disturbance types, we used the Delphi Technique (Hsu and Sanford 2007). The Delphi Technique is an iterative, consensus-building technique used to capture expert judgments to address complex problems. This method is not meant to replace empirical evidence but to guide decision-making until empirical evidence can be obtained or to identify gaps in understanding. The results generated by a group of experts are likely to be more reliable and applicable across various settings than the opinion of a single expert. This method allows participants from varying geographic locations and types of expertise (managers, scientists, or manager-scientists) to participate while minimizing cost and logistics. With this iterative process, experts from across the Northeast Region created a shared definition of disturbance and a common list of disturbance types.

Fifty-four experts were selected for the Delphi by the authors and through suggestions of the Atlantic Flyway Shorebird Initiative Human Activities subcommittee. During the selection process, experts were considered to be either managers or scientists. Managers (n=30) were chosen if they actively manage disturbance issues for migrating shorebirds on their lands. Scientists (n=24) who had published at least one study on human disturbance to shorebirds in the Northeast Region in the last 10 years were also eligible for selection. During the first round of the Delphi, experts self-identified as manager, scientist, or both manager and scientist. We confirmed that the individuals had expertise through screening questions in our initial survey. See **Defining and Prioritizing Disturbance** for the definition of human disturbance and list of priority disturbance types.

LITERATURE REVIEW- BIOLOGICAL LITERATURE

We conducted a comprehensive review and synthesis of the peer-reviewed and gray literature (e.g., reports, conservation plans) related to human disturbance during southward migration. We started the search using the Virginia Tech library online search engine, Summons. We used combinations of "human disturbance," "fall migration," and "shorebirds" as keywords for our search. We also built upon a literature review compiled by Audubon North Carolina in 2015 of human impacts to waterbirds, shorebirds, and other coastal wildlife (Audubon North Carolina 2015). From an initial set of publications, we conducted backward (i.e., cited in) and forward searches (i.e., cited by) until reaching saturation (i.e., no new published studies were found that fit our criteria). We included papers from northward migration opportunistically, if they were included in our forward/backward search, prioritizing papers addressing our geographic focus. However, literature on studies conducted during this time period is not comprehensive. We also compiled information from across the globe and across a broad array of species to conduct the most comprehensive search possible. We sent members of the AFSI Human Disturbance Working Group an initial draft of the literature review and asked them to send references that were not included.

LITERATURE REVIEW- HUMAN DIMENSIONS LITERATURE

We also conducted a review of literature on human behavior related to the disturbance type categories identified by the Delphi process and possible management actions to reduce human disturbance (Table 1), in addition to beach management and outdoor recreation. These studies were not all specifically related to shorebird conservation because human behavior in contexts broader than birds is relevant. As with the biological literature review (above), we compiled information from across the globe, focusing mostly on the U.S., and across a range of outdoor recreation behaviors related to the disturbance types.

Our search process was similar to the biological literature review, though we also used Google Scholar in addition to the Virginia Tech search engine. We used combinations of disturbance types or variations on those types (e.g., “beach driving” OR “over-sand vehicles”) and keywords related to beach management or recreation (e.g., “beach management” AND “compliance”). We also used forward and backward searches from an initial set of publications. Unlike the biological literature search, we did not reach saturation due to the large number of publications and the broader context of our search. As an additional note, some publications fit under both the biological and human behavior literature search. Both literature searches were concluded in early 2018, and therefore, literature published after this time is not included.

Human dimensions (HD) is a field of study that applies the social sciences to examine research questions that have implications for wildlife conservation efforts (NABCI 2017).

LAND MANAGER INTERVIEWS

We interviewed staff at managed coastal sites (federal and nonfederal) located within the U.S. Fish and Wildlife Service (USFWS) Northeast Region (Virginia to Maine) to understand current management activities for human disturbance to migratory shorebirds at the site level, the current human activities at various sites, and any specific informational or management needs to improve management of southward migrating shorebirds.

Phone interview requests were sent to 30 individuals from October 2 to December 4, 2017. Potential participants were chosen to represent a range of geographies in the Northeast Region, duties (i.e., higher level managers, field biologists, law enforcement officers, outreach staff), and organizations (i.e., federal, state, local, non-profit). The contact list for potential participants was selected in collaboration with project partners at USFWS. Some interview participants also participated in the Delphi Technique (described above). Interview participants were asked to reflect on the disturbance definition and to characterize human activity and impacts at their sites using the priority disturbance types developed in the Delphi. Participants were then asked how their sites managed and monitored human disturbance. Lastly, participants were asked about site-specific needs for managing disturbance and what types of guidance they would like included in this management document.

All interviews were audio recorded and transcribed. Data were analyzed using qualitative methods. All responses were coded, or categorized, according to common topics, or themes and organized according to those themes. We present participants’ responses in summary form (e.g., “most,” “several”) rather than numerical form because these are qualitative data. We did not attempt to conduct a survey that was comprehensive or representative of all land managers in the Northeast; therefore the results are not generalizable to all management conducted in the Northeast on this issue, and we believe that quantifying responses could be misleading. Our goal was to gather a range of perspectives, rather than to collect generalizable data.

In total, we interviewed 28 people from federal agencies (n=17), state agencies (n=6), towns (n=1), and nonprofits (n=4), with representation from every coastal state in the Northeast, except New Hampshire. Twenty-four participants were biologists or managers; three were law enforcement officers; and two were outreach/visitor services staff. A report describing relevant results can be found in **Appendix 2**.

DEVELOPMENT AND FIELD-TESTING OF DISTURBANCE MONITORING METHODS

In consultation with project partners at USFWS and input from shorebird researchers at Virginia Tech, we developed and piloted a set of field methods for monitoring human disturbance to shorebirds. These methods were developed because existing methods in the literature are varied (see **Evaluating Shorebird Disturbance at a Site**) and do not always produce comparable data. Having comparable data across sites would improve our understanding of shorebird disturbance within the region, potentially allow an evaluation of management effectiveness throughout the region, and may facilitate cross-site collaboration in management. The methods developed represent one set of options for studying disturbance.

Pilot testing of these methods allowed valuable lessons to be learned and improvements to be incorporated. We pilot tested these methods at 3 sites: Amagansett National Wildlife Refuge (NWR), Elizabeth A. Morton NWR, and Chincoteague NWR. Field testing occurred from July-early September 2017. The methods were also field tested by staff at Parker River NWR from September- October 2017. Insights from their use of the method also helped shape the methods' final form. For more details about these methods, see **Considerations for Developing Standardized Field Methods to Evaluate Shorebird Disturbance or Appendix 3**.

DEFINING AND PRIORITIZING DISTURBANCE

As a first step in the creation of this document, we developed a definition of human disturbance to shorebirds and a list of priority disturbance types, using the Delphi Technique (see above). We prioritized disturbance types to assist us in focusing the scope of the document and increasing its relevance to managers. Here, we report the final results from the Delphi, which were used to drive the development of guidance and best practices.

We conducted four rounds of surveys from February-May 2017 (see **Appendix 1** for a final report with additional details on methodology). We had a response rate of over 80% for each round of surveys.

Based on this process, the final definition created was:

Human disturbance of shorebirds is a human activity that causes an individual or group of shorebirds to alter their normal behavior, leading to an additional energy expenditure by the birds. It disrupts or prevents shorebirds from effectively using important habitats and from conducting the activities of their annual cycle that would occur in the absence of humans. Productivity and survival rates may also be reduced.

DISTURBANCE TYPES

Participants provided a total of 506 potential disturbance types in the first round of the Delphi. From these, we identified 94 unique disturbance activities (see **Appendix 1** for comprehensive list of all disturbance activities). We categorized these activities into 23 disturbance type categories based on similarity of activity type and location where the disturbance activity occurs (e.g., open water, beach). In some cases, activities were grouped based on how they would be managed and/or the relative similarity of their effect on shorebirds. In round 2, we asked participants whether they agreed or disagreed that the types had been categorized appropriately (using a 5-point Likert-type scale). Adjustments to the categorizations were made based on their comments from this round.

In round 3, we asked participants to rate the 23 disturbance type categories based on their significance (in terms of frequency, extent, and/or effect on shorebird survival and behavior) during southward migration.

From these ratings, we determined the top 12 disturbance type categories and asked participants to rank them in the final round. We instructed participants to rank categories based on significance (see above) across the entire northeastern U.S.; therefore, the rankings may not represent the most significant disturbance type at a specific site (depending on what human activities are or are not allowed). Beach driving and dogs were considered the top two most significant disturbances to shorebirds in the northeast during southward migration (Table 1). For each of the disturbance types, a description of the included activities, summaries of the biological and social science literature, and manager insights from the interviews, are provided below.

Table 1. Average rankings for 12 disturbance type categories based on their significance (in terms of frequency, extent, and/or effect on shorebird survival and behavior) during southward migration in the northeastern U.S.

RANKING OF DISTURBANCE TYPES	
Category	Average Rank*
Beach Driving	10.84
Dogs	9.90
Direct Harassment	8.81
Beach Raking	8.35
Coastal Engineering	7.68
General Beachgoing	7.52
Events	5.45
Recreational Fishing	5.29
Motorized Watersports	3.87
Commercial Fishing	3.74
Unmanned Aircraft	3.42
Wind-powered Aircraft	3.13

**Average ranks calculated using the following formula: $x_1w_1 + x_2w_2 + \cdots + x_nw_n$/Total where x = response count for answer choice and w = weight of ranked position.*
**Categories with a higher average rank were considered by Delphi participants to be more significant than categories with a lower average rank.*

In further consultation with biologists and managers at USFWS, the disturbance type "non-motorized watersports" (e.g., kayaking, canoeing, stand-up paddleboarding, kite surfing, kite boarding) was added to the list of priority disturbance types. Non-motorized watersports are growing in popularity and are considered by USFWS to be an emerging threat in the Northeast for which management decisions will need to be made. Thus, we used this list of 13 priority disturbance types (12 types in Table 1 plus non-motorized watersports) to guide our literature review and land manager interviews.

American Oystercatchers quietly enjoying the surf. Patrick Leary

State of Knowledge on Priority Disturbance Types in the Northeast: Literature Review & Interview Results

The information presented below was summarized from the literature review and manager interviews (described above). This section is organized around the 13 priority disturbance types identified by the Delphi process and input from USFWS (also described above). For each disturbance type, we present biological literature, human dimensions literature, and manager interview results (when available). Some disturbance types do not contain a human dimensions section, which indicates that our search did not locate any literature specific to the activity. Lastly, we present a literature summary on "General Human Behavior," including studies in which many types of human disturbance are combined in the analysis. A complete list of all literature found is included in **Appendix 5**.

Unless otherwise stated, literature below focuses on studies conducted in the U.S. portion of the Atlantic Flyway. Also, unless otherwise specified, literature does not include the breeding season, though in some studies data may have been collected year-round or for multiple years. As a note, the terms "waterbird" or "wader" encompass a range of species beyond shorebirds. Unless the term waterbird or wader is used to describe the study species, the study was conducted on shorebirds or seabirds (e.g., terns, skimmers). Additionally, most of the studies discussed below are focused on beach habitat because these habitats generally experience higher levels of disturbance than other, less accessible habitats, like salt marsh.

BEACH DRIVING

This category includes: 4x4 vehicles, all-terrain vehicles/utility vehicle (ATV/UTV), beach buggies, and off-road vehicles/over-sand vehicles (ORV/OSV).

Displacement: Beach driving may displace shorebirds from important habitats. One study found that ORV use reduced the proportion of shorebirds using wet sand areas on the beach (Tarr et al. 2010). This study also showed effects of disturbance over multiple sampling intervals, suggesting that shorebirds did not quickly revert to their prior activities or locations after moving away from vehicles. A study by Forgues (2010) demonstrated that with increasing distance from the beach ORV entry point, vehicle abundance decreased while shorebird abundance and richness increased. The author also found that species richness and abundance of some species (Sanderlings: *Calidris alba*, Ruddy Turnstones: *Arenaria interpres*, Willets: *Tringa semipalmata*, Black-bellied Plovers: *Pluvialis squatarola*, Whimbrels: *Numenius phaeopus*)

Off road vehicles can cause behavioral changes in shorebirds. Creative Common image significantly declined with higher ORV frequency as did the number and size of shorebird roosts. A study conducted in Australia found that ORVs had the strongest influence on habitat selection in birds of all recreational activities studied (e.g., collecting bait, recreational angling, watercraft, dogs, beachgoing) (Meager et al. 2012).

Whimbrels are extremely sensitive to driving. Lynn Schmid

Effects on behavior: Beach driving may also cause behavioral changes in shorebirds. Forgues (2010) found that migrants spent less time foraging when ORVs were present and more time resting. Although, in another study, beach driving primarily affected the use of beach habitats for resting with birds spending more time active and less time resting (Tarr et al. 2010). Tarr (2008) found that transient individuals (those who did not defend feeding territories) spent less time in the disturbed areas (areas where driving was present) while territorial birds tolerated the disturbance and defended their feeding territories. One study conducted in Australia found that evasive behaviors by drivers (e.g., avoiding flocks or slowing down when approaching flocks) did not make a difference and birds were disturbed at the same rates as when vehicles took no action (Weston et al. 2014b). Although, another study conducted in Australia noted that increasing the separation distance between vehicles and birds was more important to reducing disturbance responses than changing vehicle speed (Schlacher et al. 2013). However, one study showed that Australian shorebirds had a shorter flight-initiation distance (FID) for approaching vehicles than for approaching pedestrians (McLeod et al. 2013).

Interspecies variation in effects: The literature also showed variable effects for different species of shorebirds. Harrington and Drilling (1996) found that roosting Semipalmated Plovers (*Charadrius semipalmatus*) and feeding Sanderlings flushed more frequently in response to vehicles than pedestrians, but all other species studied flushed equally often to pedestrians and vehicles. One study showed that Whimbrels appeared to be extremely sensitive to driving and always maintained a distance of at least 75 meters from approaching vehicles (Forgues 2010). Disturbance by vehicles decreased the proportion of time Sanderlings spent roosting and increased the time they spent active (Tarr 2008). Some species also showed variable responses to the type of driving approach. Rodgers and Smith (1997) found that Ruddy Turnstones had the smallest mean flushing distance of species exposed to experimental approaches by an ATV. The authors also found that Willets exhibited the largest mean flushing distance, while Western Sandpipers (*Calidris mauri*) had the smallest mean flushing distance of species exposed to experimental approaches by an automobile.

Insights from human dimensions literature: There may be disconnects between actual impact of beach driving and the perceived impacts of the activity by recreationists. Priskin (2003) found in a study conducted in Australia that the average perception of tourists was that four-wheel driving was harmful to beach environments, while those who engaged in four-wheel driving perceived it to be less harmful but still moderately so. This difference in perceived impacts could be due to responsibility denial, where participants minimize the impacts of the activity. To evoke acceptance of responsibility, a person must recognize the problem, be aware of a solution to the problem, and feel capable to enact that solution (Stern 2018). Those who participate in beach driving may also have different environmental beliefs and attitudes than those who do not. Understanding a recreationists' underlying beliefs and attitudes is important for communications efforts and potentially changing behavior (Ardoin et al. 2013). Thapa (2010) found that those who held higher technocentric (belief in technology to solve environmental problems) and lower ecocentric (belief that human impacts can be detrimental to the environment) and dualcentric (belief in the symbiotic dual equality between humans and the environment) attitudes were more likely to participate in motorized recreational activities and less likely to participate in appreciative activities (e.g., hiking, birdwatching). People that participate in beach driving may not feel that the activity has significant negative impacts, so framing pro-shorebird behaviors in a way that aligns with the participant's attitudes could be more effective. For example, asking people to lower their speeds when near other people or wildlife could be framed as a safety issue (i.e., safety to others on the beach and the drivers themselves).

Manager thoughts: Most interview participants said beach driving was allowed at their sites. All sites where driving was allowed had restrictions on driving during shorebird nesting season and early migration. These restrictions likely reduce the impact of driving, where it occurs, for early migrants. About equal numbers of participants said that beach driving represented a significant disturbance or a low to moderate disturbance to migrating shorebirds. Some participants noted that driving did not generally overlap with good quality shorebird habitat at their sites. Participants at sites where driving was not allowed said that driving was not significant at their sites. All sites, however, had some driving (even if not allowed for recreationists) due to enforcement patrols or maintenance (e.g., picking up trash). One participant noted that the behavior of the driver may have more influence on whether a shorebird or group of shorebirds would be disturbed than the driving itself. Another participant said that while they considered the impacts of driving to be relatively low, an important consideration is that beach driving could increase the number of people that access remote areas of the beach, potentially extending the spatial scale of human impacts.

DOGS

This category includes: leashed and unleashed dogs.

Displacement: Many studies showed that dogs can have an impact on shorebirds. Dogs may displace shorebirds from foraging or roosting habitats. Burger et al. (2007) found that shorebirds responded more strongly to the presence of dogs compared to other disturbances (e.g., people, vehicles) and did not return to the beach after being disturbed by a dog. Similarly, in a study conducted in Australia, Stigner et al. (2016) noted that the presence of dogs and people significantly increased the probability of shorebirds not occupying an area and that dogs had more than twice the effect of people. Dogs also reduced the probability of shorebirds occupying a study unit and the count of birds within the unit to a greater extent than people alone (Stigner et al. 2016). However, some studies did not find strong evidence of dogs displacing shorebirds. McCrary and Pierson (2000) did not find a significant relationship between dogs and shorebirds, though the authors note this may be due to a small sample size of dogs. Brindock and Colwell (2011) found that Snowy Plover (*Charadrius nivosus*) presence was negatively associated with dog tracks; however, the authors say that this effect was weak due to the variables having high standard errors and low relative importance.

Shorebirds roosting, nesting, and foraging can all be negatively impacted by dogs - both on and off leash. Creative Commons

Effects on behavior: Other studies have found that dogs may influence behavior of shorebirds, though results were mixed. One study conducted in British Columbia noted that shorebirds were much less likely to be disturbed (e.g., flying or running) when only people were within 100m than when people and dogs were within 100m of shorebirds (Murchison et al. 2016). Another study conducted in Malaysia found that all shorebirds (and other waterbirds) flew away as soon as being approached by a dog (Ramli and Norazlimi 2017). A study in California showed that direct approaches by dogs caused Snowy Plovers to flush the farthest from their roosting sites (Tingco 2011). In a study conducted in Australia, Paton et al. (2000) found walking with a dog on a leash was more disturbing than walking without a dog. In contrast, other studies have not found significant effects of dogs on shorebird behavior. Esrom (2004) found in a study in British Columbia that the presence of a dog did not make a significant difference compared to jogging and walking without a dog, and that there was no significant difference in shorebird behavior between passing a flock with or without a dog. Similarly, in a different study, the presence of dogs did not have an effect on vigilance behaviors (i.e., scan rate) in shorebirds (Fitzpatrick and Bouchez 1998).

Fitness: Despite these impacts of dogs, Weston et al. (2014a)'s review of dogs in parks and open spaces did not find any studies establishing a direct link between dog disturbance and individual or population fitness. However, studies that are able to link the effects of dogs (or other disturbance types) to potential fitness consequences are uncommon in the literature.

Benefits of leashing: Studies also showed the positive impact of leashing dogs. Lafferty (2001) found that 75% of birds disturbed by dogs flew and that leashing reduced the probability that dogs disturbed birds and the number of birds disturbed per incident. Milton et al. (2011) noted that unleashed dogs typically approach birds at higher speeds than if the animal was leashed, and therefore, the bird may be reacting to the speed of approach rather than the dog itself.

Leashing your dog reduces the probability of shorebird disturbance. Will Richards

Insights from human dimensions literature: Restricting access to sites for dogs, implementing new regulations, or maintaining compliance with existing regulations may be difficult due to people's relationships and perceptions of their pets. On one hand, dogs are perceived by people as "wild" and should be allowed to run free and "be a dog," while they are also socially constructed as family members or companions (Bowes et al. 2015). Because of this role as family member or friend, many dog owners may not recognize that they are responsible for their dog's bad behavior, instead often excusing or justifying it (Edwards and Knight 2006). During focus groups conducted in England, Edwards and Knight (2006) also found that participants generally lacked awareness or understanding of the consequences of their dogs' behavior on wildlife. Similarly, dog walkers in a park in Austria judged the impacts of dog walking on wildlife significantly lower than other user groups in the park (e.g., walking without dogs, bike riding) (Sterl et al. 2008). A study conducted in Australia during shorebird breeding season found that respondents did not think their own dog, if unleashed, would pose a threat to humans or beach-nesting birds and considered their own dog to be less of a threat to wildlife and humans than dogs in general (Williams et al. 2009). In a study conducted in Canada, a majority of beach visitors who brought their dog to the beach said that it was very or most important to bring their dogs (Esrom 2004). Additionally, how people view or relate to their dogs may impact how they react to different types of dog regulations. Blouin (2013) described 3 different orientations towards pets (specifically dogs) that may explain how people view or react to their pets. Those with a dominionistic orientation have a lower regard for their pets, valuing them primarily for the uses they provide their owners. In contrast, those with a humanistic orientation elevate their pets to the status of surrogate personhood. Those with a protectionistic orientation regard both pets and animals more generally highly. People with different orientations towards their pets may respond differently to outreach messaging or regulations/enforcement.

Perceptions of leashing behavior may be influenced by many factors. Ambivalence towards a behavior may influence whether individuals leash their dogs (Bowes et al. 2017). In a study the authors conducted in Canada, they found that beachgoers with low ambivalence towards leashing (i.e., did not hold conflicting beliefs about leashing their dog) were compliant with leashing regulations nearly all the time compared to a high ambivalence group that complied about a third of the time. In a study conducted in Australia, Hughes et al. (2009) found that walking a dog on- or off-leash was strongly associated with a prior intention to do so. Non-compliers arrived at the beach with a strong intention of walking their dogs off-leash, while compliers arrived with the intention of walking their dogs on leash. Belief in the benefits of off-leash exercise may influence a person's prior intentions. Edwards and Knight (2006) noted that if a person holds the belief that off-leash exercise meets a dog's needs and preferences, the owners will let their dog off-leash whenever possible, regardless of whether this may affect other users. Williams et al. (2009) found similar results- that dog owners were less likely to feel obligated to leash their dog if they considered unleashed exercise to be important. Additionally, others' behavior may affect dog walkers' decisions about their pets. Jorgensen and Brown (2017) found that a pet's safety was a more important factor influencing an owner's decision to leash their dog than the opinions of other beach visitors, possible consequences, or awareness of the leash laws in place. Rohlf et al. (2010) showed that perceived difficulty of certain dog "management" practices (e.g., microchipping, spaying/neutering, obedience training) was a significant predictor of many of these behaviors. In another study, leashing behavior was influenced by watching the behavior of other beachgoers and the apparent lack of enforcement of leash regulations (Bowes et al. 2015). Williams et al. (2009) found that dog owners were more likely to feel obligated to leash their dogs when they believed other people expected dogs to be leashed.

In summary, understanding how a person views or relates to their dog may help predict the person's reaction to certain restrictions or regulations regarding dogs. Those who believe dogs (or just their dogs) have an elevated status (similar to that of people) are likely to want fewer restrictions on allowing dogs. Providing alternative areas to support the interest in off leash exercise may reduce pressure for off leash dog use on beaches or around shorebirds.

Manager thoughts: More than half of the interview participants said dogs were allowed on at least one site they managed. Leash laws were variable across sites, from having no restrictions to requiring dogs to be leased at all times. However, all federal properties where dogs were allowed required them to be leashed at all times. The majority of participants thought dogs represented a significant disturbance. At some sites where dogs were not allowed, participants thought they were not a significant disturbance; yet, some sites with dog restrictions still had significant disturbance issues with dogs. Others stated dogs were not a large disturbance issue because dogs did not largely overlap spatially with shorebirds. Further, participants said restrictions on dogs in place for breeding shorebirds overlapped with the early part of the migration season and may help reduce disturbance during that period. Generally, participants thought that off-leash dogs cause more disturbance than leashed dogs.

Sanderlings. Tim Lenz

DIRECT HARASSMENT

Direct harassment is the chasing or harassing of shorebirds, not necessarily with malicious intent. Harassment in this document does not equate to "harass" as defined under the Endangered Species Act ("an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." 50 CFR 17.3). Harassment, as defined above, is a prohibited form of take under Section 9 of the ESA. This category does not include photographers or birders. These were included in the category "wildlife observation," which was not identified as a top disturbance (see **Defining and Prioritizing Disturbance**). Instances of direct harassment are not well documented in the published literature. In one study, Esrom (2004) found that all birds in a flock flushed when chased by a child; however, this was an anecdotal observation recorded while studying other disturbance issues.

Manager thoughts: Most interview participants said that direct harassment of shorebirds happens infrequently at their sites. However, many participants noted that when it does occur, it is generally caused by children chasing shorebirds. One participant said that they had witnessed adult beachgoers chasing or harassing shorebirds with malicious intent.

BEACH RAKING

This category includes: beach raking, scraping, or grooming. We found no literature related to human disturbance impacts of beach raking or scraping on migratory birds. Because most rakes are motorized, their effects may be similar to other motorized vehicles, though the difference in size and maneuverability for these beach raking machines may lead to different effects. Additionally, there may be other impacts of these practices on prey resources, habitat, etc. It was beyond the scope of this literature review to find information on the impacts of beach raking on shorebird habitat or potential prey resources. For literature addressing this topic, see the literature review by Comber and Dayer on the AFSI website.

Insights from human dimensions literature: It is often assumed that beachgoers prefer beaches without wrack or other natural debris. However, a study by

Playing on the beach is fun but can have serious consequences for wildlife trying to rest and feed. Florida Fish & Wildlife Conservation Commission

Schultz Schiro et al. (2017) found that reading an educational sign about the ecological importance of beach wrack significantly reduced overall opinion of beachgoers that managers should mechanically rake beaches to remove the wrack. Those surveyed also rated pictures of a wrack-covered beach as more beautiful after reading the educational sign, and the majority of these participants said they would continue to visit the beach if raking stopped. Further, a study with high school students found that students had no clear preference about removing beach debris (Nordstrom and Mitteager 2001). These studies indicate that if managers decide to reduce or eliminate raking, with proper advertising and education (see **Best Practice for Designing Effective Signage**), the public likely would accept this decision.

Manager thoughts: Some interview participants, mostly those who worked for or with municipalities, said beach raking or scraping was allowed at their sites. All participants mentioned restrictions on raking/scraping during the nesting season, which would overlap with the early migration season. In general, participants thought raking had a low disturbance impact on migrating shorebirds at their sites, but that it had more significant impacts on beach habitats themselves. In most locations, instances of beach raking declined throughout migration as beachgoing seasons ended, so there was more limited temporal overlap of raking and migrating shorebirds.

Beach nourishment projects can disturb shorebirds when foraging. Christopher Blunck

COASTAL ENGINEERING

Coastal engineering includes: beach nourishment (practice of adding sand or sediment to beaches to increase beach width or combat erosion), artificial dune stabilization, and construction projects. The literature on the impacts of activities related to coastal engineering was mixed. Burger (1988) found that birds moved away when construction activity (use of heavy machinery and cranes) began and moved back to their original foraging locations when the activity ceased, suggested that birds were disturbed while the activity was ongoing, but that foraging conditions in the area of construction activity were still favorable. The construction activity studied in this paper was conducted so as to cause less disturbance to foraging shorebirds and other waterbirds. In a study conducted in England, Burton et al. (1996) did not find evidence that monthly maximum numbers of Ruddy Turnstone and Purple Sandpipers (*Calidris maritima*) at an artificial roost site were lowered when building work was ongoing. However, in a study conducted in Wales, Burton et al. (2002) found that construction work (construction of a bridge and impoundment) significantly reduced the densities of Eurasian Oystercatcher (*Haematopus ostralegus*), Dunlin (*Calidris alpina*), Eurasian Curlew (*Numenius arquata*), and Common Redshank (*Tringa totanus*) in mudflats adjacent to the work. The authors also found the disturbance reduced the feeding activity of Dunlin, Eurasian Oystercatcher, and Common Redshank. Again, for this disturbance category, it was beyond the scope of the literature review to find information on the impacts of coastal engineering on shorebird habitat or potential prey resources, although we realize they may be considerable. For literature addressing this topic, see the literature review by Comber and Dayer on the AFSI website.

Manager thoughts: Most interview participants discussed coastal engineering projects (including restoration projects to protect or improve habitat) conducted at sites they manage. Most of these projects were not conducted every year. Examples of projects conducted regularly (i.e., every year or every few years) were dune stabilization and beach nourishment. Several participants mentioned timing restrictions on coastal engineering projects that included the southward migration period. Similarly to beach raking, participants noted that most coastal engineering projects did not overlap temporally with shorebird migration, though participants said that if current restrictions were not in place to limit the timing of these projects, coastal engineering projects would likely have a much larger impact on shorebirds.

GENERAL BEACHGOING

General beachgoing includes: walking, running/jogging, beachcombing, sunbathing, picnicking, ball playing/frisbee, and swimming. Impacts of general beachgoing on shorebirds found in the literature varies by activity.

Passive vs. active beachgoing: Several studies found that beachgoers engaged in more active behaviors (e.g., jogging or walking) were more likely to flush birds than those who were involved in more passive activities (e.g., sunbathing, fishing) (Burger 1981, 1986; Lafferty 2001; Mayo et al. 2015; Althouse 2016). In another study, joggers had the same probability of disturbing birds but disturbed twice as many birds compared to those engaged in more passive activities (Lafferty 2001). Similarly, a study conducted in Argentina found that the only cases where people and shorebirds were observed using the same beach were when people were sedentary or slow-moving (e.g., sunbathing, searching for seashells) (Botto et al. 2008). However, in one study the type of pedestrian (walker vs. jogger) did not affect the flush frequency for any species studied (Harrington and Drilling 1996).

Flight initiation distance: Many authors looked at flight-initiation distances (FIDs) to assess the effects of beachgoing on shorebirds. A study conducted in Australia showed that FID was a species-specific trait, at least for the eight species studied (Blumstein et al. 2003). Rodgers and Smith (1997) found that Sanderlings had the smallest mean flushing distance among species that were experimentally approached by a walker. One study showed that smaller sandpipers generally allowed pedestrians to approach closer than larger shorebirds (e.g., Black-bellied Plover and American Oystercatcher) before taking flight (Koch and Paton 2014). Similarly, a study in Australia found that species with higher body masses had longer FIDs (Glover et al. 2011). These differences may be a function of the lower energetic flight costs for smaller birds (Koch and Paton 2014). Other factors, like bird age, human activity, and season, may also affect FIDs in shorebirds. For example, Koch and Paton (2014) found that juveniles of all species studied had shorter FIDs than adults. These authors also found that FID generally increased as the number of pedestrians and flock size increased. Lastly, in a study conducted in Australia, researchers found that season impacted FIDs, with migrants having shorter FIDs than resident species (Glover et al. 2011). However, this result may also be affected by group size because, as the authors noted, migrants tend to occur in flocks more than resident species (Glover et al. 2011). For more information on FIDs, see **Recommended Disturbance Thresholds** section.

Effect on foraging: General beachgoing activities may have significant impacts on foraging shorebirds. Botto et al. (2008) found in a study conducted in Argentina that the presence of people in small numbers may decrease the intake rate of foraging shorebirds by up to 40%. In a study conducted in California, Thomas et al. (2003) demonstrated that the type of activity people were engaged in (running or walking) did not affect how close they could get to foraging Sanderlings; however, the type of activity did negatively impact the amount of time Sanderlings spent foraging. The authors also found that the number of people in a group affected how close people could get to foraging Sanderlings before they reacted with Sanderlings responding at shorter distances to approaches by two people than by one person. However, in a different study, the percent of shorebirds foraging did not relate to the number of people present nor the activity of those people (Burger and Niles 2014). Though, Koch and Paton (2014) found that FID was generally less for foraging birds.

Influence of flock sizes and species composition: Other factors, like flock size and species composition, may also affect how general beachgoing impacts shorebirds. Several studies found that flock size had an effect on how birds reacted to potential disturbances. In one study, smaller flocks were generally more easily disturbed than larger flocks (Burger 1986). Similarly, another study found that a higher percent of shorebirds in large flocks returned to areas they had been displaced from compared to shorebirds in smaller flocks (Burger and Niles 2013a).

However, another study by the same authors found that, compared to monospecific flocks, a lower percent of mixed-species flocks flew away when

American Oystercatcher can be negatively impacted by a casual beachgoer. Walker Golder disturbed, but a lower percent of mixed-species flocks returned after being disturbed (Burger and Niles 2014). Other studies have found species-specific responses to beachgoing. In a study by Koch and Paton (2014), Black-bellied Plovers and American Oystercatchers (*Haematopus palliatus*) were the most sensitive to disturbance, while Dunlin, Least Sandpiper (*Calidris minutilla*), and Semipalmated Sandpiper (*Calidris pusilla*) were the least sensitive of the species studied. A study conducted in Australia found that "flighty" species (those more likely to flush) were consistently flighty while more tolerant species were consistently tolerant to potential disturbance (Blumstein et al. 2003). A species' migratory status may affect its reaction to potential disturbance. A study conducted in India found that resident species allowed more people nearby and allowed closer approaches by people than migrants; however, the study also noted that migrants seemed to become less disturbed throughout the day, suggesting that they may become habituated as the day progresses (Burger and Gochfeld 1991).

Black-bellied Plover are highly sensitive to beachgoing activities. Mick Thompson

Insights from human dimensions literature: In several studies, beachgoers considered protecting shorebirds to be important and had an overall positive attitude towards shorebirds. Burger et al. (2017) reported that beachgoers surveyed rated protecting endangered species and the environment, restoring the beach, and designating off-limit areas to protect birds the highest of all survey items. These beachgoers rated providing more opportunities for jogging and allowing dogs on the beach the lowest. A study in Australia found that both coastal residents and tourists surveyed had an overall positive attitude towards bird conservation (Glover et al. 2011). Despite these positive attitudes towards shorebirds, people may be unaware of how their activities affect birds. In a study conducted in Australia, beach users did not consider activities like walking, swimming, and sunbathing to be disturbing to shorebirds (van Polanen Petel and Bunce 2012).

Manager thoughts: Most interview participants thought general beachgoing had a moderate impact on migrating shorebirds, though it was also rated as having high or low impacts by other participants. Several participants also noted that the effects of beachgoing may depend on the tidal stage. For instance, if the tide was high, birds may be disturbed from roosting locations because of the limited amount of beach for people. Participants mentioned that beach season corresponds generally with early migration, and depending on the location, peak migration may occur after peak beach season, which could reduce the effects of beachgoing. Participants also discussed that, in general, most beachgoers are not willing to walk very far past an access point to recreate (except jogging or walking/beachcombing), and this pattern of use may leave space for shorebirds to forage or roost undisturbed in areas further from access points.

EVENTS

Events include: fishing tournaments, festivals, parties, sports competitions, and fireworks. We found no papers conducted specifically on events, though the category "general beachgoing" does discuss the impacts of groups of people on shorebirds. A study conducted in the Netherlands using operational weather radar data strongly suggests that fireworks set off on New Year's Eve caused birds (study not specific to shorebirds) to take flight and fly to altitudes of several hundred meters (Shamoun-Baranes et al. 2011). The authors estimated that potentially hundreds of thousands of overwintering birds took flight in reaction to the fireworks.

Manager thoughts: Many of the interview participants said events were held at sites where they worked, managed, or helped make management decisions. Some participants said fireworks were allowed on their sites, but most said that even if fireworks were not allowed, many of their neighboring properties had fireworks. Most participants said these fireworks displays were done early in the migration season around 4th of July. Also, most fireworks displays by municipalities were required to be shot off from offshore barges, limiting impacts to shorebirds. One participant said their staff assists with managing crowds on the beach watching fireworks displays, but this was mainly to prevent accidental trampling of nests and chicks or sensitive beach areas. In general, most participants said events had a low impact on migrating shorebirds. Most events take place during early migration season, and restrictions in place for breeding birds likely reduce the impact of events on shorebirds.

RECREATIONAL FISHING AND SHELLFISHING

Recreational fishing and shellfishing includes: surf fishing/fishing, shell-fishing, clamming, worm-digging, crabbing, and bait collection. We did not consider the effects of driving in this category, though we acknowledge that fishing and driving are linked at many sites, and studies examining the effects of fishing without considering driving are relatively uncommon. Most of the literature in this category focused on impacts of shellfishing or bait collecting. Studies by Burger (1981) and Koch and Paton (2014) did not find significant impacts of shellfishers on shorebirds. Burger (1981) found that shorebirds were fairly close (15m) to shellfishers without showing signs of disturbance. Similarly, Koch and Paton (2014) found no evidence that shorebirds avoided areas with shellfishers. They also noted that microhabitats with recent shellfishing activity had a positive influence on the density of American Oystercatchers and Ruddy Turnstones. However, other studies did find negative impacts of shellfishing or bait digging. A study by Navedo and Masero (2007) conducted in Spain found that shellfish harvesting had a significant negative effect on foraging activity of Eurasian Curlews but also indicated that curlews were likely able to compensate for the impacts by foraging at different times. Townshend and O'Connor (1993) found, in a study conducted in England, that in years when bait-digging took place numbers of Bar-tailed Godwits (*Limosa lapponica*) and Common Redshanks were lower than in years when no bait-digging took place.

Insights from human dimensions literature: Similar to other disturbance types, there may be disconnects between those who participate in the activity and those who do not. Priskin (2003) found that those who fished during their trip rated fishing as less harmful to beach ecosystems than visitors who did not fish.

Manager thoughts: All interview participants said recreational fishing occurred at least at one site they managed. Shellfishing was not as common. Despite the link between fishing and beach driving, participants were asked to consider the impacts of fishing separately from the impacts of driving (many locations only allow driving if recreationists are fishing). Participants said that due to various water jurisdictions, they might not own or manage areas where people shellfish. In general, participants described the potential for some disturbance as recreationists travel to fishing or shellfishing areas, but once settled, these activities did not cause much disturbance as recreationists were generally more stationary and spread out along the beach or mudflats. Most participants said these activities had a low impact on migrating shorebirds.

Shellfishing has relatively low impact on shorebirds. Ruth Hartnup

MOTORIZED WATERSPORTS

Motorized watersports include: boats/speedboats, airboats, and jet-skis. Peters and Otis (2007) found little evidence to suggest that roost-site selection for most species was related to the level of boat disturbance around the roost. However, other studies found that boats did have an effect. For example, Deblinger et al. (1992) rarely observed shorebirds using beach areas where boaters concentrated. Most authors did not find much difference in impacts between types of motorized boat. Most shorebirds did not differ significantly in flush distance between approaches by jet-skis and outboard-powered boats, and larger waterbird species, like herons, exhibited greater average flush distances for both outboard-powered boats and jet-skis, than smaller bodied waterbirds, like shorebirds (Rodgers and Schwikert 2002). These authors did find considerable variation in flush distance within species, but this did not seem to be significantly related to the type of approach. Similarly, Harrington (2005) did not find evidence to suggest that flight durations were different for shorebirds flushed by small versus large boats, though, as mentioned by the author, this analysis had some limitations. However, Paton et al. (2000), in a study conducted on waterbirds in Australia, found that birds responded to jet-skiing at greater distances than for outboard-powered boats and canoes. Similarly, in another study conducted in Australia, birds reacted by leaving the study site for all disturbances by jet-skis (Milton et al. 2011).

Insights from human dimensions literature: Like for other disturbance types, people who participate in motorized watersports tend to think boating (or jet skiing) has less impact on shorebirds than it may actually have. In one study, about three quarters of boaters surveyed thought more measures should be taken to protect shorebirds, but less than a third thought boating was harmful to birds (Deblinger et al. 1992). Almost all the boaters in this study felt a strong personal obligation to protect shorebirds, but less than half were willing to reduce their number of visits to the site to help protect birds. Similarly, in a study conducted in Australia, the author considered boating to be “very harmful” (determined by a literature review) to beach environments; however, the average perception of visitors interviewed thought boating was “slightly harmful,” and a little less than half of visitors considered boating “harmless” (Priskin

Airboats and other motorized boats can cause shorebirds, like these Dunlins, to flush from areas where they are resting or feeding. Patrick Leary

2003). A study in Brazil used local knowledge to study patterns of shorebird occurrence and noted that locals claimed the population of migratory birds that used the area for foraging and resting had been reduced over time (Andrade et al. 2016). Those interviewed said that the main practices affecting the presence of migratory shorebirds were boat traffic and noise from bars and boats. Similar to other potential disturbance types (e.g., beach driving, recreational fishing or shellfishing), people may underestimate the impact their recreational activity has on birds or other wildlife.

Manager thoughts: All interview participants said their sites experience motorized watercraft recreation. Some participants mentioned that jet skis were prohibited in certain areas. Most participants said that if boats stayed offshore, then they did not represent a significant disturbance. However, recreationists who boat at high speeds and with large wakes in tidal creeks or other similar areas may cause a significant disturbance. In general, most participants noted that boat landings were a more significant issue than boats themselves. Participants said that motorized watercraft allows more people to access sensitive areas that may be important for migrating shorebirds.

COMMERCIAL FISHING AND AQUACULTURE

Commercial fishing and aquaculture includes: aquaculture, oyster racks, mariculture, horseshoe crab harvesting, clamming, worm digging, and seaweed harvesting. Similar to studies on recreational fishing and aquaculture, all studies focused on the impacts of aquaculture or bait collecting. Burger et al. (2015) found that when people (oyster growers and/or other beach goers) were present almost no Red Knots were observed in areas with oyster racks. Additionally, the authors reported anecdotally that shorebirds moved down the beach away from where growers were working on the racks during low tide. Similarly, Maslo et al. (2016) found that oyster tending activities appeared to have a negative effect on the abundance of Red Knots. However, both of these studies' findings are based on data collected during one season and at one site. Burger and Niles (2017a) observed that Red Knots (*Calidris canutus rufa*) avoided areas with oyster racks but did not avoid areas with artificial reefs. Watson et al. (2017) demonstrated that bait collector numbers in a study conducted in England negatively correlated with wader and gull abundance. In a study conducted in Wales, mechanized cockle harvesting was found to contribute to reduced apparent survival of Eurasian Curlews for two winters (Taylor and Dodd 2013). Like for beach raking and coastal engineering, we did not search for information on the impacts of coastal commercial fishing/aquaculture on shorebird habitat or potential prey resources. For literature addressing this topic, see the literature review by Comber and Dayer on the AFSI website.

Manager thoughts: Most interview participants said commercial fishing or aquaculture was allowed at or near their sites. Because of water jurisdictions, many commercial fishing or aquaculture operations are regulated by states, not by the property owner of the adjacent land. Commercial aquaculture operations were more commonly discussed than commercial fishing, as most commercial fishing was conducted farther off-shore. Participants mentioned issues with gear (e.g., oyster racks or bags) coming loose and washing up onshore, which could exclude shorebirds, though this would be more of a habitat impact than a disturbance issue. A few participants brought up seaweed harvesting as a new form of aquaculture that could have negative impacts on shorebirds. However, in general, most participants did not feel that commercial fishing/aquaculture was a significant disturbance for migrating shorebirds.

UNMANNED AIRCRAFT

Unmanned aircraft includes: drone, unmanned aerial vehicles (UAVs), and model aircraft. As a relatively new form of disturbance, there are few papers on the impacts of drones or UAVs. In an experimental trial conducted in France, Vas et al. (2015) showed that Common Greenshanks (*Tringa nebularia*) did not react to approaches by drones in most cases, and if the birds did react by flying off, the drone was within 4-10m. Birds (Greenshanks, Mallards, and captive Flamingos) did react more to drones approaching vertically (as opposed to approaches at 20°, 30°, and 60°). In another experimental study on drones in Australia, McEvoy et al. (2016) found that nonbreeding wild, mixed-species flocks of waterbirds (not specifically shorebirds) showed little or no obvious disturbance effects when UAVs were flown at least 60m above the water for fixed wing models or 40m above for multirotor models. However, the disturbance effects were more pronounced (swimming or flying away) when the UAV approached birds directly or rapidly changed direction or altitude near the birds. In an anecdotal observational study on Whimbrels in Mozambique, Allport (2016) observed all birds in the flock flying away once a drone flown by beachgoers rose to 20m above the ground. The authors noted that this response was consistent with the reaction of Whimbrels to threats by predators rather than normal human disturbances, which generally do not cause a significant reaction in this area.

Manager thoughts: All interview participants who worked at federal properties mentioned that regulations existed for drones or other types of unmanned aircraft. For other properties, drones were regulated during nesting season, but in many cases, regulations during migration were not clear or varied widely by site. Most participants described drones as an emerging potential disturbance issue. Additionally, a few participants said model aircraft were allowed on their sites. In general, participants said unmanned aircraft currently did not represent a significant disturbance, but use of drones/UAVs is likely to increase, potentially causing disturbance issues in the future.

WIND-POWERED AIRCRAFT

Wind-powered aircraft includes: kite flying, paragliding, hang-gliding, kite skating, and sand-yachting or cart sailing. The majority of studies on wind-powered aircraft, especially kite flying, are concentrated during the breeding season. In a report conducted on breeding Piping Plovers (*Charadrius melodus*), Hoopes et al. (1992) found that compared to other human disturbances (i.e., dogs, pedestrians, and off-road vehicle) kites caused plovers to move the longest distance away from the disturbance and to move for the longest duration. Hatch (1997) observed a wide range of reactions to kites in western Snowy Plovers from increased vigilance while roosting to walking or running away.

Manager thoughts: Several sites had restrictions for kites or other wind-powered aircraft. About a quarter of interview participants said their sites did not allow kites at any time, and all others mentioned kites being restricted around nesting areas. A few participants mentioned paragliding or hang-gliding, but in general, these activities were uncommon, even where they did occur. Most participants said that kites or other wind-powered aircraft represented a low to moderate disturbance. In general, most participants noted that kite flying was not very common, even on popular beaches.

NON-MOTORIZED WATERSPORTS

Non-motorized watersports include: kayaking, canoeing, stand-up paddleboarding, sailing, parasailing, kite boarding, surfing, boogie boarding, kite surfing, windsurfing, and skimboarding. There were very few studies on the impacts of non-motorized watersports on shorebirds. One study conducted in Australia found that canoeing was the least disruptive experimental approach to the birds (other approaches were: walking, walking with a dog on a leash, boating, and jet-skiing) (Paton et al. 2000). Glover et al. (2015) found, in a study in Australia, that canoes evoked shorter flight initiation distances (FID) than walkers; though, this study was not conducted on shorebirds but on other waterbirds. Similarly, in a study conducted in the Netherlands, windsurfing elicited the longest escape flight distances of all disturbance types observed but was an infrequent activity during the fall (Madsen 1998).

Davenport and Davenport (2006) mentioned that kitesurfing may disturb near shore areas where shorebirds may feed. A review by Krueger (2016) discussed several studies that have examined the effects of kite surfing. Many of these studies were not written in English or were not published (or otherwise made available), so we discuss the findings highlighted in Krueger's review of these studies here. The original citations, when found, are included in the literature cited. One of the studies cited in this review found that kitesurfing appeared to have caused Variable Oystercatchers (*Haematopus unicolor*) in New Zealand to avoid feeding areas; however, this study was conducted over a time period of only 6 days and should not be generalized (Beauchamp 2009). Bergmann (2010), another study cited in the Krueger review, found that Eurasian Oystercatchers tolerated experimental approaches by a kitesurfer up to 100m away and feeding Dunlins, Red Knots, and Grey Plovers (Black-bellied Plovers) tolerated approaches from 100-200m away. This study was also conducted over a short time period and should not be generalized. However, Schikore et al. (2013), also cited in the Krueger review, found that the highest potential for disturbance from kite and windsurfing was observed when these activities were within 400m of waterbirds, but that no disturbances from kite or windsurfers should be expected if these activities take place 500m or further from the birds. Lastly, a study by Liley et al. (2011) conducted on wintering shorebirds in England found that 85% of disturbances by kitesurfers resulted in major flights (birds flying more than 50m). Additionally, in this study, disturbance by a kitesurfer or windsurfer resulted in about 8ha of intertidal habitat being unavailable to foraging birds, compared to a loss of 0.1ha caused by a walker in the intertidal area.

Insights from human dimensions literature: Priskin (2003) considered windsurfing and surfing "moderately harmful" to beach environments, as determined by a literature review. In contrast, the majority of visitors (or tourists) interviewed in the Priskin (2003) study considered these activities to be completely "harmless."
Manager thoughts: All interview participants said their sites had use from non-motorized watercraft. Some

sites had restrictions for activities like parasailing and kite surfing during nesting season, and a few sites even had restrictions on kite surfing year-round. Several participants noted that kite surfing may have more significant impacts than other non-motorized watersports. The majority of participants said that these activities had a low to moderate impact on shorebirds, but that this type of recreation was increasing in popularity rapidly and represents an emerging issue.

GENERAL HUMAN ACTIVITY

Here, we present studies on the impacts of human disturbance broadly, when the effects of individual disturbance types cannot be determined. In many studies, types of human disturbance are not separated out in the analysis. Information on different disturbance types may have been collected but was collated into a general "human disturbance" category.

Displacement: The presence of people may displace shorebirds. A study conducted in Northern Ireland noted that the arrival times of Eurasian Oystercatcher and Eurasian Curlew to foraging areas from roosting areas were significantly later when there were people on the beach, and that the departure times (departure from foraging to roosting areas) of Redshank and Oystercatcher were significantly earlier when disturbed, indicating that birds may be displaced by the presence of people (Fitzpatrick and Bouchez 1998). Other studies have found the presence of people may affect habitat use by shorebirds. Burger and Niles (2013b) showed that significantly more shorebirds moved to beach areas further from access points when the beach was open to public use and were more spread out across all areas of the beach when public use was closed. The authors reported similar results in another study where shorebirds concentrated in an area closed to vehicles and people (Burger and Niles 2014). Similarly, another study found that birds spent more time in protected beach areas closed to public use than in unprotected areas (Forys 2011). Like the previous study, a study conducted in Chile found birds were generally less abundant at areas located outside the edges of a marine reserve than those inside (Cornelius et al. 2001). This study also detected a negative relationship between waterbird abundance and the presence of people for all seasons, despite seasonal variation in number of birds and people. One study found lower shorebird counts at sites that the authors classified as "disturbed" than at non-disturbed sites and observed fewer shorebirds when large numbers of people and dogs were present (Drever et al. 2016). A study conducted in California did not find negative effects of trail use, when comparing trail to non-trail sites, on species richness, number of birds, or proportion of birds foraging (Trulio and Sokale 2008). However, this study also found that the number of shorebirds decreased with increasing trail use, with higher trail-use days averaging about 25% fewer birds than on lower trail-use days, though these results may indicate that local factors, like habitat quality or predation risk, were more important influences on bird presence.

Number of people: Other studies have shown that the number or density of people may also influence habitat use by shorebirds. At higher disturbance levels, front-beach species (those that occur in larger numbers along the front, or ocean, side of the beach), like Sanderlings and Semipalmated Sandpipers, moved their roosting sites to back-beach areas (Pfister et al. 1992). However, in the same study, back-beach species, such as Black-bellied Plover, did not show a large change in roosting site selection between disturbance levels. One study found shorebird numbers increased at a site while the number of people using the site decreased over the same time period, though this pattern is also influenced by the end of beach season and changing human use (Mizrahi 2000). Further, another study by Mizrahi (2002) detected significant negative relationships between the densities of people and shorebirds. Additionally, that study indicated that sites that allowed swimming had the highest densities of people and the fewest shorebirds. McCrary and Pierson (2000) found similar results to Mizrahi (2002) in a study conducted in California, where a significant negative relationship occurred between shorebirds and people when using total counts for shorebirds, people, and dogs at a site. Similarly, a study in Brazil showed a significant negative correlation between numbers of people and numbers of all shorebirds, especially Ruddy Turnstone, Red Knot, and Semipalmated Sandpiper (Hvenegaard and Barbieri 2010).

Another study conducted in Spain found similar results to the previous studies, showing a negative relationship between summer bird density and people for all species observed (Martín et al. 2015).

A study conducted in Brazil noted the probability of shorebirds occurring at a site decreased as the number of people increased (Cestari 2015). This study also found that when the number of people at a site exceeded 20, the presence probability of birds was almost zero. A study conducted in California estimated that a density of nine humans (or dogs) per kilometer of beach would displace an average of one bird species (Lafferty et al. 2013). Similarly, Watts (2017) found more than 80% of Red Knots used beaches with human densities below five people km^{-1}. Though, another study on Red Knots found that levels of disturbance were important factors in sandy beach use by knots, but this factor was secondary to prey resources (Karpanty et al. 2006).

Activity budgets: The presence of people may also influence the activity budgets of shorebirds, or the proportion of time that they spend in specific behaviors. In one study, Greater Yellowlegs (*Tringa melanoleuca*) showed increased alert and escape behavior and decreased maintenance behavior in the presence of people (Laskowski et al. 1993). Another study conducted in Spain showed that Kentish Plovers (*Charadrius alexandrinus*) spent more time foraging, preening, and resting when there were no people present, while they spent more time vigilant and running when any person was within 50m from the bird (Martín et al. 2015). The authors also found that vigilance time (percentage of time spent scanning area while feeding) was more than 10 times larger compared to non-disturbance situations. A study on Roseate Terns (*Sterna dougallii*) found that self-maintenance behaviors, like preening and feeding, in hatch-year birds were highest at low human activity sites. However, other results indicated that time of day and day of season were stronger effects on locomotion behaviors (Davis 2016).

*Flight response*s: Human activity may affect flight responses in shorebirds. One study showed that the type of disturbance did not affect how far shorebirds flew when they were disturbed (Harrington and Drilling 1996). However, another study found that flights due to human-caused disturbances tended to be longer than flights due to natural disturbances (Harrington 2005). Likewise, Burger et al. (2004) found that birds flew away and did not return to the area to forage in response to more than half of human disruptions. Other characteristics, like species and migratory status, have been shown to influence flight responses. Rodgers and Smith (1997) observed that shorebirds tended to flush at shorter distances in response to disturbance than other species of waterbird studied. Additionally, Blumstein et al. (2005) found that migratory species tended to have greater FIDs than resident species.

Impacts on foraging: Human activity may also impact foraging rates or patterns in shorebirds. In one study, the highest disturbance rates and lowest daily weight gains were observed at the same locations (Harrington and Drilling 1996). Similarly, another study found that the shorebirds foraging at fast rates versus those foraging at slow rates was influenced by the frequency of people present (Harrington 2005). Also, in one study, higher pedestrian rates were associated with a decrease in the number of prey items consumed by birds (Blumstein et al. 2005). In an experimental feeding trial with captive animals, the author demonstrated that dry matter intake of Dunlin tended to be higher in undisturbed than disturbed trials, and energy metabolized by disturbed Dunlin was lower than that of undisturbed Dunlin (Morton 1993). Responses to human disturbance may depend on the availability of prey. Yasue (2006) found that the time shorebirds took to resume feeding

Red Knot foraging. From the book Life on Delaware Bay Jan van der Kam.

Developing effective signs is a good way to remind people to keep their distance from shorebirds when nesting, roosting, and foraging. Scott Kruitbosch

after a disturbance was greater in areas of low prey availability, suggesting that shorebirds respond more to disturbances when the foraging cost is lower. The impact of human activities on foraging shorebirds likely varies by species. Although not statistically significant, a study in California noted that Sanderlings spent more time foraging when there were fewer people present (Thomas et al. 2003). In a study conducted in British Columbia, Yasue (2005) found that Semipalmated Plovers decreased feeding rates when there were more people present on the beach; however, there was no direct effect of human density on Least Sandpiper feeding rates. A study conducted in Northern Ireland found that prey capture rates of Eurasian Oystercatcher and Eurasian Curlew increased with moderately close human disturbance; however, Eurasian Curlew and Redshank also experienced a reduction in foraging time due to disturbance (Fitzpatrick and Bouchez 1998). In this study, shorebird scan rate increased with disturbance, but probing rate stayed essentially the same, suggesting that birds are able to search for food at the same rate with increasing vigilance. Overall, in this study, disturbance had the biggest impact on feeding time by influencing the arrival and departure of shorebirds at the foraging grounds.

Characteristics of potential disturbance: Other factors, like the distance from a potential disturbance and characteristics of approach, may impact shorebird behavioral responses, as well. In a study in British Columbia, shorebirds were disturbed about three-quarters of the time when people or dogs were within 50m (Murchison et al. 2016). The effect of distance is also likely influenced by species characteristics. Blumstein et al. (2005) found that larger species had greater alert distances (distance at which animals first orient towards an approaching potential threat) than smaller species. Characteristics of how potential disturbance sources approach shorebirds may also affect their response. In a study conducted in Australia, all species studied took flight at greater distances as the speed of approach increased, although there were no differences among approach speed, sources of disturbance, or species in the time it took birds to return to the site after the disturbance (Milton et al. 2011). Similarly, the faster people moved through an area, the more likely they were to disturb shorebirds (Murchison et al. 2016). The way shorebirds are approached by potential disturbances impacts their responses. A study conducted in British Columbia found that approaching shorebirds directly elicited a stronger response than passing flocks at a distance of 10m, regardless of speed or the presence of a dog (Esrom 2004). Likewise, direct approaches caused Snowy Plovers in California to flush significantly longer distances on average than tangential approaches, and direct approaches tended to elicit more intense reactions from the birds (Tingco 2011).

Potential fitness impacts: Human activity could have impacts on the fitness of shorebirds, though these impacts are generally much harder to study and quantify. Pfister et al. (1998) found that individuals remaining at a staging area long enough to accumulate excess body fat were almost twice as likely to return the following year compared to those below theoretically sufficient fat levels. Further, the authors hypothesized that any disturbance at staging areas that reduces the feeding efficiency of migrating shorebirds may lead to mortality. More specifically, a study in Australia showed that one or two disturbances per hour could result in the birds losing 20 minutes of foraging time per day (Paton et al. 2000). Another study conducted in Australia calculated the combined cost of flights to roosting locations and disturbance flights at roosts and found that these flights were up to a quarter of the total energy expenditure of Great Knots (*Calidris tenuirostris*) and about a fifth to a third of the energy expenditure of Red Knots (Rogers et al. 2006). Gibson et al. (2018) found that body mass of Piping Plovers was much lower for individuals in areas with greater disturbance than for individuals in less disturbed habitats. Additionally, this study found survival rates of individual plovers was lower in disturbed areas than at nearby less disturbed sites.

Insights from human dimensions literature: Opinions of various recreation groups towards shorebird conservation measures differ. Burger & Niles (2013a) observed that anglers and bird watchers were most compliant of a voluntary beach closure to protect shorebirds, while dog walkers, joggers, and OSV users were the least compliant. Not surprisingly, in this study, bird watchers were the most positive towards closures to protect shorebirds. A similar study by the same authors found that over half of people interviewed on the beach approved of a current beach closure for shorebirds (Burger and Niles 2013b). Anglers and ORV drivers had the lowest approval for closure, but still over half were positive towards the beach closure.

Differences in opinion about shorebird conservation measures may also exist between different demographic groups. A study conducted in Michigan during the breeding season found that while the overwhelming majority of participants said that recreation restrictions were acceptable to some degree, men were more likely to say that these restrictions were less acceptable than women. The same study also found that residents (of Michigan) were likely to be less tolerant of restrictions than visitors from out of state (Rutter 2016). Another study conducted during the breeding season in Australia found that women were more likely to comply with temporary beach closures to protect breeding birds than men. Priskin (2003) found that visitors who were women, university-educated, and/or younger considered coastal recreation activities to be more harmful than other groups. Similarly, another study conducted in South Africa noted that female, older, affluent, and educated beachgoers tended to prefer less intrusive (e.g., photography, walking, picnics, wildlife observation) recreation than other groups. These groups also accorded greater importance to the values of beach ecosystems and indicated greater ecological sensibility compared to other beachgoer groups (Lucrezi and van der Walt 2016). These patterns of demographic differences also may be true in other study systems examining conservation and recreational activities. Another study looking at conservation behaviors related to endangered tiger beetles and trail bike riding found that women were significantly more likely to say that they would slow down and dismount their bikes (both beneficial behaviors) in beetle habitat than men (Cornelisse and Duane 2013).

American Golden Plover. Dominic Sherony

EVALUATING SHOREBIRD DISTURBANCE AT A SITE

Collecting data on shorebird disturbance at a site can be done for the purpose of establishing a baseline inventory of conditions, monitoring status and trends, and/or monitoring to inform management (e.g., adaptive management), among other goals. The decision to collect field data is influenced by many factors, such as the current amount of knowledge about conditions on-the-ground (both shorebirds and disturbance), level of uncertainty around the current knowledge, and whether learning about the system and/or effectiveness of management actions is desired. Field data can help inform a decision about whether management action to reduce shorebird disturbance is required (see **Best Practices for Management**), particularly if the effects of a particular disturbance type on shorebirds are evaluated.

Snowy Plover. Lynn Schmid

Here, we present a literature summary of methods and metrics used to evaluate shorebird disturbance, as well as a literature summary of recommended disturbance thresholds. Disturbance thresholds can serve as management triggers, which link monitoring data with on-the-ground management action (when the value of a certain ecological attribute crosses a predetermined boundary, an action is taken; Cook et al. 2016). These summaries are intended to provide an overview of common field methods related to shorebird disturbance and to describe the current availability of thresholds in the literature. Lastly, we discuss considerations for developing standardized field methods for evaluating shorebird disturbance (methods developed and field-tested in 2017 are provided in **Appendices 3 and 4**).

We stress that some actions, like installing signage (see **Designing and Using Effective Signage**) with effective messaging (see **Effective Messaging for Education and Outreach**), could likely be implemented at a site, without first collecting data, because they are inexpensive and have proven effective elsewhere. This section is not intended to imply that collecting field data on shorebird disturbance is a necessary prerequisite for implementing management action. Rather, it provides resources that help managers think about how they may collect data as needed and better identify what the data may be used for.

METHODS AND METRICS FOR EVALUATING SHOREBIRD DISTURBANCE: LITERATURE REVIEW

Methods for measuring human disturbance in the literature are varied, and typically an individual study employs a variety of methods. Most commonly, authors use counts of shorebirds and potential disturbances and analyze their associations (e.g., Burger and Niles 2013a, Deblinger et al. 1992, McCrary and Pierson

2000, Cornelius et al. 2001, Mizrahi 2002, Tarr 2008, Hvenegaard and Barbieri 2010, Tarr et al. 2010, Stigner et al. 2016). Yet, there was no standardization of how potential disturbances are quantified, in terms of what was disturbance, how far from birds or a point potential disturbances were recorded, and how long those potential disturbances were recorded. Other authors have used long-term data sets, comparing contemporary and historic counts of shorebirds and potential disturbances (Foster et al. 2009, Drever et al. 2016).

Many others used behavioral observations to examine disturbance. Many studies have used or adapted classic observational sampling methods to examine behavioral responses to disturbance (see Altmann 1974). Several studies used a scan sampling method that records the proportion of a flock exhibiting different behavioral responses to potential disturbances near the flock (Laskowski et al. 1993, Navedo and Masero 2007, Forgues 2010, Althouse 2016). Others have focal sampling to record the behavior of a focal individual (e.g., Harrington and Drilling 1996, Fitzpatrick and Bouchez 1998, Thomas et al. 2003, Peters and Otis 2005, Burger et al. 2007, Navedo and Masero 2007, Forgues 2010, Martín et al. 2015, Davis 2016). However, there was variation among the individual studies in terms of when observations were recorded, which behaviors were recorded, and how potential disturbances were recorded.

Many studies used experimental disturbance trials to determine various disturbance responses. Most experimental disturbance trials were used to determine flight initiation distance (FID) or flush distances (Burger and Gochfeld 1991, Rodgers and Smith 1997, Rodgers and Schwikert 2002, Glover et al. 2011, McLeod et al. 2013, Koch and Paton 2014, Glover et al. 2015). Others looked at minimal approach distance, or the distance a person or group of people can get to a bird before changing its behavior (Ikuta and Blumstein 2003, Thomas et al. 2003, Martín et al. 2015). A few studies manipulated the amount of disturbance present by experimentally comparing shorebird use of an area with and without oyster racks (Burger and Niles 2017a) or experimentally closing sections of beach to public use (Burger and Niles 2013a).

There is also a large amount of variation in the literature for what the authors define as a disturbance or disturbance event (in response to this variation, we developed a group-consensus definition of disturbance for the purposes of this document; see **Defining and Prioritizing Disturbance**). Murchison et al. (2016) considered any event where a shorebird's (or group of shorebirds') behavioral state changed from a roosting or foraging state to a running or flying state to be a disturbance. Lafferty (2001) recorded disturbances that clearly caused birds to fly or move. Burton et al. (1996) and Burger and Niles (2014) recorded a flock as "disturbed" only when part or all of the roosting flock flew. More specifically, Deblinger et al. (1992) defined disturbance as when more than 50% of a flock took flight. Other authors group disturbance responses into categories. Milton et al. (2011) used 5 categories to classify disturbance responses: 1- looked alert; 2- walked away; 3- flew low for a short distance (<50m); 4- undertook extended high flight (>50m) before resettling; 5- flying off and leaving the site. Vas et al. (2015) similarly categorized bird responses to approaches by drones: type 1- no reaction; type 2- brief head and tail movement with movement away from the drone; type 3- flying off.

RECOMMENDED DISTURBANCE THRESHOLDS: LITERATURE REVIEW

This section focuses on thresholds at which shorebirds experience harmful effects from disturbance. Many components of disturbance have not been explored in the literature as thresholds. Therefore, there were very few disturbance thresholds explicitly stated in the literature. Althouse (2016) observed an increase in high energy behaviors (running, flying, walking, etc.) in staging Roseate Terns (*Sterna dougallii*) at sites with >3.72 disturbance minutes (minutes per sample birds were disturbed) per 10-minute period, which the author described as a potential threshold. Rogers et al. (2006) found that more than 10 minutes/hour in flight would likely lead to an energy deficit in shorebirds. Specifically, they calculated that an average 30-minute increase in the amount of time spent in alarm flights would increase the total energy expenditure of Great Knots by 13.3%. Lastly, Navedo and Masero (2007) found that an average density of bait harvesters in Spain of <0.56 people per 10ha is enough to significantly depress the amount of time that Eurasian Curlews spent foraging.

Other potential measures of thresholds could include flight initiation distance (FID), which is the distance at which a bird exposed to a human activity initiates escape behavior (Livezey et al. 2016). It is important to note, however, that an escape behavior does not necessarily mean a bird will experience detrimental consequences as a result. Therefore, use of FIDs as thresholds for when to implement management should be considered carefully. Here we present the FIDs from a review by Livezey et al. (2016) (Table 2). We have also included FIDs from a study by Koch and Paton (2014) in this table. Studies with more than one FID from the same species were conducted on multiple study areas.

Sites seeking to set and use disturbance thresholds to guide management actions could reference the FIDs and/or other potential thresholds shown above. However, this document does not recommend a specific threshold because existing guidance in the literature is minimal and varied. The development of thresholds is considered to be a priority future research need (see **Information Gaps and Information Needs**).

Table 2. Observed flight initiation distances for shorebirds in the scientific literature. These data can also be found at DOI: http://dx.doi.org/10.3996/082015-JFWM-078.S2 (205 KB XLSX), except for Koch and Paton (2014), which was added to the original table produced by Livezey et al. (2016).

OBSERVED FLIGHT INITIATION DISTANCES FOR SHOREBIRDS IN THE SCIENTIFIC LITERATURE.

Author and year	Location	Species	Disturbance	Mean FID (m)
Blumstein 2003	Australia	Ruddy Turnstone	Pedestrian	14
Weston et al. 2012	Australia	Red Knot	Pedestrian	21
Blumstein 2006	Europe	Black-bellied Plover	Pedestrian	36
Blumstein 2006	N. America	Black-Necked Stilt	Pedestrian	22
Blumstein 2006	N. America	Western Sandpiper	Pedestrian	16
Blumstein 2006	N. America	Least Sandpiper	Pedestrian	9
Blumstein 2006	N. America	Willet	Pedestrian	21
Blumstein 2006	N. America	Short-billed Dowitcher	Pedestrian	13
Blumstein 2006	N. America	Marbled Godwit	Pedestrian	18
Blumstein 2006	N. America	Whimbrel	Pedestrian	38
Glover et al. 2011	Australia	Black-bellied Plover	Pedestrian	44
Glover et al. 2011	Australia	Ruddy Turnstone	Pedestrian	30
Glover et al. 2011	Australia	Sanderling	Pedestrian	32
Glover et al. 2011	Australia	Whimbrel	Pedestrian	90
Ikuta and Blumstein 2003	N. America	Black-bellied Plover	Pedestrian	29, 43
Ikuta and Blumstein 2003	N. America	Black-necked Stilt	Pedestrian	17, 27, 29
Ikuta and Blumstein 2003	N. America	Western Sandpiper	Pedestrian	10, 24
Ikuta and Blumstein 2003	N. America	Least Sandpiper	Pedestrian	7, 25
Ikuta and Blumstein 2003	N. America	Willet	Pedestrian	17, 28, 29
Ikuta and Blumstein 2003	N. America	Greater Yellowlegs	Pedestrian	23, 28
Koch and Paton 2014	N. America	Least Sandpiper	Pedestrian	19 (median)
Koch and Paton 2014	N. America	Dunlin	Pedestrian	17 (median)
Koch and Paton 2014	N. America	Semipalmated Sandpiper	Pedestrian	19 (median)
Koch and Paton 2014	N. America	Semipalmated Plover	Pedestrian	22 (median)
Koch and Paton 2014	N. America	Sanderling	Pedestrian	25 (median)
Koch and Paton 2014	N. America	Short-billed Dowitcher	Pedestrian	25 (median)
Koch and Paton 2014	N. America	Ruddy Turnstone	Pedestrian	30 (median)
Koch and Paton 2014	N. America	Willet	Pedestrian	30 (median)
Koch and Paton 2014	N. America	Red Knot	Pedestrian	35 (median)
Koch and Paton 2014	N. America	American Oystercatcher	Pedestrian	50 (median)
Koch and Paton 2014	N. America	Black-bellied Plover	Pedestrian	55 (median)

Author and year	Location	Species	Disturbance	Mean FID (m)
Møller 2008	Europe	Black-bellied Plover	Pedestrian	36
Møller 2008	Europe	Northern Lapwing	Pedestrian	41
Møller 2008	Europe	Ruddy Turnstone	Pedestrian	50
Møller and Erritzøe 2010	Europe	Black-bellied Plover	Pedestrian	51
Møller and Erritzøe 2010	Europe	Sanderling	Pedestrian	18
Roberts and Evans 1993	Europe	Sanderling	Pedestrian	12 (median)
Rodgers and Schwikert 2002	N. America	Black-bellied Plover	Jonboat	23
Rodgers and Schwikert 2002	N. America	American Oystercatcher	Jonboat	30
Rodgers and Schwikert 2002	N. America	Willet	Jonboat	31
Rodgers and Schwikert 2002	N. America	Black-bellied Plover	Jetski	24
Rodgers and Schwikert 2002	N. America	American Oystercatcher	Jetski	29
Rodgers and Schwikert 2002	N. America	Willet	Jetski	24
Rodgers and Schwikert 2002	N. America	Short-billed Dowitcher	Jetski	21
Møller 2008	Europe	Northern Lapwing	Pedestrian	41
Møller 2008	Europe	Ruddy Turnstone	Pedestrian	50
Møller and Erritzøe 2010	Europe	Black-bellied Plover	Pedestrian	51
Møller and Erritzøe 2010	Europe	Sanderling	Pedestrian	18
Roberts and Evans 1993	Europe	Sanderling	Pedestrian	12 (median)
Rodgers and Schwikert 2002	N. America	Black-bellied Plover	Jonboat	23
Rodgers and Schwikert 2002	N. America	American Oystercatcher	Jonboat	30
Rodgers and Schwikert 2002	N. America	Willet	Jonboat	31
Rodgers and Schwikert 2002	N. America	Black-bellied Plover	Jetski	24
Rodgers and Schwikert 2002	N. America	American Oystercatcher	Jetski	29
Rodgers and Schwikert 2002	N. America	Willet	Jetski	24
Rodgers and Schwikert 2002	N. America	Short-billed Dowitcher	Jetski	21

Ruddy Turnstone. Beth Fishkind

CONSIDERATIONS FOR DEVELOPING STANDARDIZED FIELD METHODS TO EVALUATE SHOREBIRD DISTURBANCE

In 2017, we developed and tested a set of field methods for evaluating shorebird disturbance at the site level, which could serve as a basis for future coordinated work at multiple managed sites (e.g., refuges). See **Appendices 3 and 4** for the full methodology tested and a report on the pilot season data collection. The objective of this work was to come up with a set of common metrics for monitoring and measuring the effects of human disturbance to shorebirds at migratory stopovers, in order to better quantify, track, and compare responses to current and future management actions across sites. Methods were developed in conjunction with project partners at USFWS. Methods were pilot tested at three sites (Elizabeth A. Morton, Amagansett, and Chincoteague National Wildlife Refuges) from July – early September 2017. The methods were also field tested by staff at Parker River NWR from September- October 2017, and insights from their use of the method also helped shape the methods' final form.

Before conducting management for human disturbance, it is important to determine whether disturbance is an issue. Collecting field data to examine how disturbance may be impacting shorebirds at your site is an important step. Before adoption at any site, these field methods should be further tested and modified based on information and needs at the site. Specifically, these field methods do not include survey objectives, site-specific sampling designs, or data management and analysis guidance. Site managers should develop survey objectives based on information needed to make effective management decisions (see Elzinga et al. 2001 and USFWS 2013 for more details about survey objectives). Consultation with a statistician may be beneficial to develop a sampling design, and to ensure that the sampling design and field methods will result in data that addresses the survey objectives. Additionally, the methods described here may need to be adjusted to align with the resources (funds, staff time) available for conducting surveys. However, the methods tested provide a set of tools that can help managers determine how to effectively measure human disturbance and its effects on migratory shorebirds.

Standardization of field methods and data collection across multiple sites and management entities (or use of similar methods that are compatible across sites) can facilitate coordination across broader geographies and timescales, in order to better understand trends across wider segments of populations, more effectively compare success of management actions across sites and regions, and avoid duplication of efforts. Additional planning may be required to ensure that data collection, which may be specialized to meet site-specific needs, is also sufficiently compatible across sites so that meaningful comparisons can be made.

We employed three different field methods in our pilot testing: transect surveys, point counts, and behavioral observations. Each method possesses pros and cons and may be used to address different questions, as described below.

Transect surveys: Transect surveys can be used to measure shorebird occupancy, abundance, and distribution at the site (or subsite) level. Collecting human use data simultaneously allows users to connect the total number of shorebirds using a site/subsite to the total amount of human use over the same scale.

Purpose: Abundance data collected with transect surveys can provide an index of population size at a site. Transect surveys can also be used to detect changes in shorebird abundance relative to changes in human use or population trends, although care should be taken when interpreting changes in abundance, as many factors can influence them. In addition, occupancy and distribution data can be used to link changes in habitat use to changes in human use before and after a management action is taken at a specific location if the study is designed appropriately.

> *Pros*: Many sites may already conduct similar surveys (e.g., the International Shorebird Survey) and may be able to adapt current monitoring strategies to encompass transect surveys.

Cons: These surveys will not provide information on fine-scale habitat use. For example, if people typically congregate around a beach access point, shorebirds will likely congregate in areas away from this point. Conducting a survey that counts total number of people and total number of shorebirds along a transect will not show this difference in habitat use and instead will show a more "summarized" view that infers a relationship between human activity and shorebird use. One could geo-reference sightings of birds and potential disturbances, but analysis of such data is more complex. Also, simple abundance indices do not indicate disturbance, so researchers may need to couple these counts with behavioral observations if they wish to understand whether disturbance is causing differences in abundance.

Point counts: Point counts serve as the direct link between the frequency of human activities and shorebird habitat use. By collecting human and shorebird use data simultaneously at specified points, users can determine whether human activities directly impact fine-scale shorebird habitat use, as well as local patterns in shorebird abundance.

Purpose: Like transect surveys, point counts can be used as an index of abundance, occupancy, and distribution. But unlike transect surveys, point counts may give a more accurate picture of fine-scale habitat use and can be used to establish a direct correlation between human use and shorebird use at a point. These data can be used to detect change over time, if the surveys are conducted over multiple visits, although care should be taken when interpreting changes in abundance, as many factors can influence them. Also, these surveys could be used to explore changes in human use and shorebird habitat use and demography before and after a management action is taken at a specific location.

Pros: These surveys are more helpful for establishing links between human activities and shorebird habitat use than transect surveys. These surveys can also help researchers explore which human activities may be more disturbing to shorebirds. Additionally, point counts may be easier to conduct in challenging terrain (i.e., when terrain makes walking and counting at the same time difficult).

Cons: Point counts that use large count radii may fail to detect roosting individuals or those hidden by vegetation at farther distances from the observer. Also, simple abundance indices do not indicate disturbance, so researchers may need to couple point counts with behavioral observations if they wish to understand whether disturbance is causing differences in abundance.

Behavioral observations: Behavioral data enable managers to identify and understand how human disturbance may affect ecological mechanisms that have impacts on shorebird populations (e.g., altered feeding or resting regimes, habitat avoidance, etc.). This method is conducted using a focal sampling approach.

Purpose: Behavioral observations can be used to indirectly evaluate how human disturbance alters energy budgets. Behavioral observations also may be used to examine which human activities elicit a behavioral response. This method could be used to determine time budgets and frequencies of events or behaviors. These surveys can provide insights into how birds behave under baseline conditions. Determining these baselines can help managers understand how their management actions may impact shorebirds.

Pros: Behavioral observation surveys may provide insights into potentially harmful deviations from baseline behaviors. Like point count surveys, these surveys provide a more direct link between human disturbance and its potential impacts on shorebirds than transect surveys. Behavioral observations, coupled with simple abundance indices, can help elucidate a cause behind observed differences in abundance.

Cons: This method is the most time consuming of the three and is more easily conducted in pairs (though one person could conduct the work using a digital audio recorder and later transcribing their data). This method also requires additional training beyond shorebird identification. Human-induced effects on shorebird behavior does not inherently provide information on the impacts of those effects on shorebird fitness. Additional research may be needed to identify whether behavioral effects equate to demographic effects.

Potential adjustments: Depending on the types of information a manager wants to gather, certain adjustments can be made to this set of methods. For example, if a site already conducts surveys to measure abundance, then additional transect or point count surveys may not be necessary. However, managers may need to adjust surveys they already use to incorporate a more comprehensive assessment of human disturbance. If a site only wants to gauge shorebird and human use at their site broadly, then transect surveys may be sufficient. Because behavioral observations may be very time consuming, a site may choose not to conduct them if time-limited but should be aware that they may lose the ability to actually link disturbance to observed abundance. Sites may also consider including habitat characteristics in their surveys, depending on resources, time, and research question. Specific adjustments (e.g., changing types of disturbances counted, types of behaviors recorded, species counted) may be made, depending on site location, human use, research questions, and availability of resources for conducting surveys.

Conducting a shorebird survey. Peter Paton

BEST PRACTICES FOR MANAGEMENT

The best practices presented below were developed using information from a review of the available literature (described in the Methods section), the manager interviews (also described in the Methods section), and feedback from project partners and reviewers. We further drew upon biological and human dimensions literature to support the strategies and approaches described in these recommendations.

The best practices are organized from general to specific, ending with two disturbance type-specific practices. Management for these specific types, beach driving and dogs, is well-documented in both the biological and social science literature. Recommendations for managing other specific disturbance types are either not as well-documented or focus more on changing human behavior generally. Also, these best practices focus on beaches because this habitat is where most of the priority human disturbances likely occur.

These best practices are not meant to be prescriptive and not every best practice will be applicable to every site. Deciding when or how to manage human disturbance at a site will depend on many factors, including the site's current and historical use by humans and shorebirds, competing management objectives, resources available, law/policy, and stakeholder views.

Before conducting management for human disturbance, managers should first determine whether human disturbance is an issue at their site (see **Considerations for Developing Standardized Field Methods to Evaluate Shorebird Disturbance)**. Several factors may influence or threaten shorebird populations (Atlantic Flyway Shorebird Initiative 2015), and conducting management for disturbance without first determining the extent or severity of disturbance at a site may result in time or resources being spent addressing the wrong issue.

An understanding of the laws and policies in place to protect shorebirds, particularly threatened and endangered species, at a site is critical for management. Below are some resources for understanding how human disturbance may interpreted under the Endangered Species Act (ESA) in the United States.

- *The ESA prohibits unauthorized "take" of threatened and endangered wildlife.*
- *Take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct."*
- *Severe, prolonged, or repeated disturbance of federally listed shorebirds can rise to the level of "take" if the disturbance results in "injury" of the birds, for example by significantly disrupting essential behavioral patterns such as breeding, feeding or sheltering.*
- *Federal agencies responsible for managing public access or recreation have additional responsibilities to consult with the U.S. Fish and Wildlife Service, to assess whether or not their management actions are likely to result in take.*
- *Additional resources on the ESA: https://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf and https://www.fws.gov/endangered/laws-policies/index.html.*

BEST PRACTICE 1: USING DECISION SUPPORT FRAMEWORKS TO ADDRESS SHOREBIRD DISTURBANCE PROBLEMS

Overview

The Best Practices below discuss actions that can be taken, if appropriate at a specific site, to reduce shorebird disturbance. An action cannot be implemented without first making the decision to do so. Although this is an obvious sequence of events, the decision process can be overlooked or underestimated by site managers and unknowingly hamper their achievement of the desired goal. Investing an appropriate amount of careful thought during the decision-making process can greatly improve the likelihood of successfully implementing the action on the ground. Decision support frameworks can guide managers and conservation practitioners through a decision process while increasing rigor, stakeholder participation, transparency, and learning (Schwartz et al. 2018). Some frameworks commonly applied in conservation include Strategic Foresight, Systematic Conservation Planning, Open Standards for the Practice of Conservation, Evidence-based Practice, and Structured Decision Making (Schwartz et al. 2018). Here we describe how one framework, Structured Decision Making (SDM), can be used to bring clarity and insights to decision-makers faced with shorebird disturbance management problems.

Example: Structured Decision Making (SDM) Framework

SDM aids decision-makers in making a good choice by providing an organized, inclusive and transparent approach to complex problems. Ecological problems, such as addressing shorebird disturbance, are often multi-faceted and involve scientific uncertainty and sociopolitical considerations, among other challenges. SDM is well-suited for tackling difficult and/or controversial problems, although it can also be thought of as best practice for all kinds of decision-making, small or large. It promotes an organized method of decision-making that explicitly considers values (what's important) and consequences (what's likely to happen if an action is implemented) (Gregory et al. 2012). Other specific advantages of SDM as it relates to shorebird disturbance problems include: 1) well-suited for groups working collaboratively on controversial decisions, including diverse stakeholders (e.g., a Refuge biologist, park ranger, town mayor, and local beach-buggy club); 2) iterative process by which the decision can be updated when new data or models become available (e.g., a new paper linking frequency of shorebird escape flights with decreased migratory survival is published); 3) provides transparency so that the reasoning behind a decision can be shared with others, which may be important for increasing buy-in.

SDM analyzes a decision by breaking it into components, abbreviated "PrOACT" (Figure 2).

1. **Problem** – Define the problem to be addressed or clarify the decision context. Recognize that the problem at hand is actually a decision to be made. It is important to identify the decision-maker(s), stakeholders, and any other key players; the frequency and timing of the decision; the scope; the rough, desired outcome of the decision; and any constraints. It may be appropriate to conduct a stakeholder analysis during this phase (see **Best Practice Strategies to Minimize Social Conflict**).
2. **Objectives** – State the decision-maker(s)' values or what is most important to achieve with this decision. Things a decision-maker might value include maintaining shorebird populations, satisfying beach users, and minimizing cost. Effective objectives should be complete, non-redundant, concise, specific, and understandable (Keeney 2007).
3. **Alternatives** – Define the set of alternatives the decision-maker(s) is choosing from. These should specify the action to be taken, as well as the spatial area and time frame it will be applied over.
4. **Consequences** – Evaluate the consequences of each alternative on the objectives. This involves making a prediction using models (simple, mental models or complex, mathematical models).
5. **Trade-off and Decide** – Choose an alternative that achieves an acceptable balance across the objectives. Often, trade-offs between objectives will be required, which can be clearly and openly examined in the SDM process.

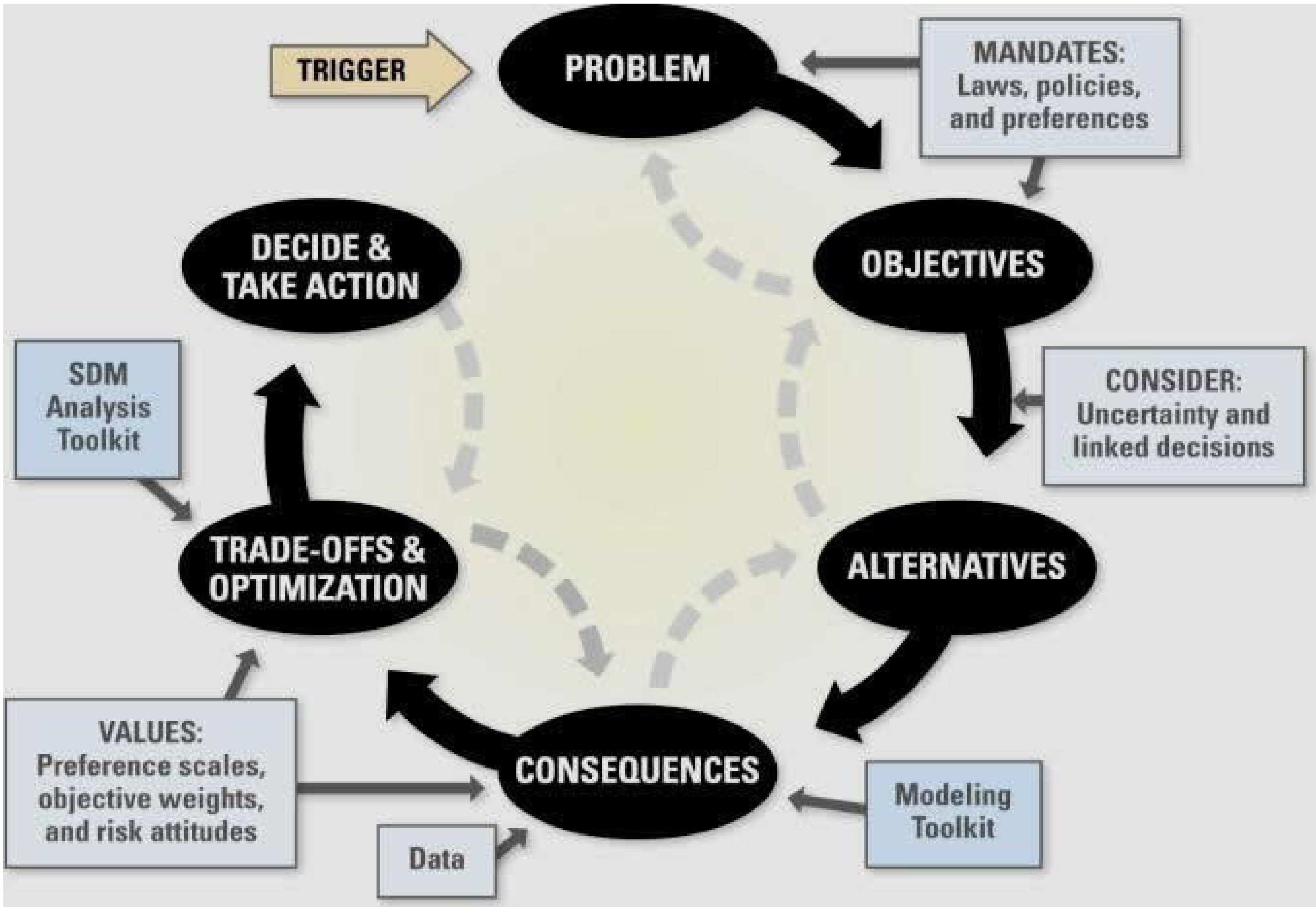


Figure 2. The PrOACT process of Structured Decision Making (https://nctc.fws.gov/courses/programs/decision-analysis/structured-decision-making-overview.html).

Mixed flock of Willet and Marbled Godwit. Ingrid Taylor

While SDM is often a useful tool that facilitates reaching a decision which achieves a site's objectives, it is also important to understand its limitations.

1. **Excessive dispute**. SDM may not be appropriate if there is significant dispute among decision-makers or stakeholders. For example, sometimes a group of stakeholders will be given joint decision-authority and need to work together to develop objectives and alternatives for a decision. Individual stakeholders often possess different values related to a decision. Sometimes these values can be incorporated through the use of multiple objectives and trade-off methods. However, if these stakeholders hold values positions that are so different they cannot agree on objectives, the SDM process will not work. In such a case, conflict resolution, mediation, or negotiation techniques (see box below for an example negotiation technique) are needed.

One approach to handling disputes among decision-makers or stakeholders is to use principled negotiation. Principled negotiation is an alternative to positional bargaining, where each party makes a specific demand followed by arguments and concessions from the other parties. Principled negotiation is based on four key principles:

1. **Separate people from the problem**. All negotiations include both the problem itself and the relationship of the negotiators. If negotiators are able to see themselves as partners instead of as antagonists, the chances of achieving mutually beneficial solutions will increase.
2. **Focus on interests rather than positions.** A position is an outcome desired by a party. Interests are the reasons that caused the party to decide on the position and underscore why a party desires a certain position. By focusing on interests, instead of positions, negotiators can move beyond winners and losers to solutions that are based on shared interests.
3. **Generate options for mutual gain.** Focusing on interests allows negotiators to explore multiple potential pathways to a solution. Exploring and understanding parties' underlying interests can allow negotiators to expose areas of common ground.
4. **Develop shared criteria to evaluate outcomes**. For complex issues, like shorebird disturbance, these shared criteria may range widely in terms of metrics and may be quite diverse to reflect all interests. The more specific the criteria, the easier it will be to develop and select mutually beneficial outcomes.

(Fisher et al. 1991, Stern 2018)

See Getting to Yes: Negotiating agreement without giving in by R. Fisher, W. Ury, and B. Patton for more information.

2. **Complexity**. While the SDM process is designed to handle any amount of complexity, including numerous stakeholders, multiple objectives, complex modeling, or optimization methods, complexity can intimidate participants and slow the process. In some cases, the use of a facilitator can greatly assist the process by ensuring that each stakeholder's view is expressed, the group stays on track, and the process is fully documented. Having a statistician assist with modeling can also benefit the process.
3. **Data Requirements**. A key component of SDM is measuring the impact of each alternative on all of the objectives, through the use of predictive models. While there is no specific type of model required to make SDM "work," the model's form should be driven by the decision context and should be sufficiently complex to enable the prediction of the consequences of the alternatives. Participants should remember that the output of any model is linked to the quality of the inputs, so the data feeding a model needs careful consideration. In the absence of field-measured data, models can be built using best expert opinion, but the decision-maker will need to have sufficient confidence in those predictions in order to act on the

outcome (see box below for other information gathering techniques). Thus, in some cases, sites may need to collect field data that is specifically designed to measure an objective of a decision. (See **Evaluating Disturbance at a Site** for insights on collecting data on shorebird disturbance disturbance and see **Information Gaps and Information Needs** for discussion of future data or information limitations regarding shorebird disturbance).

In the absence of empirical data or in situations of conflict, alternative approaches, like joint fact-finding, may be used to generate shared information. Joint fact-finding (JFF) brings different stakeholder groups together to collaboratively produce shared information that all parties can accept and use in their decision making. JFF processes should be tailored to each specific context, but using the set of guidelines outlined below is important to success.

1. Determine that there is a scientific or technical issue that all parties think would be beneficial for them to know more about for the purpose of decision-making.
2. Convene a process to bring stakeholders together (see Best Practice for Strategies to Minimize Social Conflict for information on identifying stakeholders). In this stage, stakeholders will frame issues and craft the research question collaboratively. They will also review existing information and identify information gaps.
3. Scope the research agenda. This stage involves identifying which methods to use to answer the research questions and which experts should be engaged to apply the methods. Participants may engage in the research process, but experts are typically engaged to do the work due to the technical complexities involved.
4. Conduct the research. This stage will require adaptability as the parties continue to work together to combine potentially disparate sources of data from multiple sources.
5. Evaluate the research. This can be done by using external expert evaluation and/or comparing the results to existing research.
6. Communicate the results. The different parties involved in JFF should communicate the findings to their respective constituencies and to the wider public.

(Matsuura and Schenk 2017)

Red-necked Phalarope. USFWS

Applying SDM to Shorebird Disturbance Decisions

Below are several resources that demonstrate how SDM can be applied to shorebird disturbance-related problems. They can serve as starting-points for an SDM process for a particular site management decision and are intended to be modified with relevant details. We encourage the use of rapid-prototyping, which involves sketching all the steps of PrOACT with low complexity and resolution. Doing a rapid prototype of a decision requires relatively low effort but may provide sufficient direction and confidence to the decision-maker that they can move forward immediately. Furthermore, it can bring clarity to the decision, identify the most challenging components of the decision for that specific problem, and create a framework for the decision that can be added to, as needed.

Example Decision Problem Statements

Decision problem statements are the first step in the SDM process. Below are several hypothetical statements that illustrate how SDM can be applied to shorebird disturbance-related decisions.

1. The manager at a town beach needs to determine what type of human activity restriction (buffer/setback distances, zones, or closures) should be implemented next year, given the considerations of minimizing shorebird disturbance, minimizing conflict with key stakeholders, and minimizing management costs.
2. The manager at a National Seashore wants to optimize the use of space on the beach by determining what sections of the beach should be closed to public use over the next 5 years in order to minimize shorebird disturbance and maximize the opportunity for public recreation.

Example Objectives Hierarchy

An objectives hierarchy is used to outline and group similar objectives. The hierarchy below is an example of some common things that a decision-maker may care about achieving when considering management to reduce shorebird disturbance. Remember that the meaning of each objective will depend on the specific decision context, so the following will need to be revised with decision-specific information.

- Reduce shorebird population declines
    - Minimize shorebird disturbance at key roosting and foraging stopover sites
- Maximize beach user satisfaction
    - Minimize negative feedback on beach restrictions received from users
    - Maximize visitor use of beach areas that are less important for shorebird foraging and roosting
- Minimize conflict with key stakeholders
- Minimize management costs
    - Minimize staff time spent implementing management
    - Minimize funds spent purchasing/acquiring equipment to do management

Refer to the following resources for in-depth guidance on using SDM:

Examples of using SDM in shorebird management:

- Stantial, M., R. Katz, J. Cohen, K. Amaral, J. Denoncour, A. Hecht, P. Loring, K O'Brien, K. Parsons, C. Spiegel, and A. Wilke. 2017. Structured Decision Making for Predator Removal to Benefit Piping Plovers and Other Beach Nesting Birds. Final Report.
- Cohen, J. B., A. Hecht, K. F. Robinson, E. E. Osnas, A. J. Tyre, C. Davis, A. Kocek, B. Maslo, and S. M. Melvin. 2016. To exclose nests or not: Structured decision making for the conservation of a threatened species. Ecosphere 7:1–15.

Printed Resources:

- Decision Making in Natural Resource Management: A Structured Adaptive Approach (2013) by M.J. Conroy and J.T. Peterson
- Smart Choices: A Practical Guide to Making Better Life Decisions (1999) by J.S. Hammond, R. L. Keeney, and H. Raiffa

Training and Workshops at the National Conservation Training Center:

- SDM case studies can be brought to Structured Decision Making Workshops (https://training.fws.gov/NCTCWeb/catalog/CourseDetail.aspx?CourseCodeLong=FWS-ALC3159)
- In-person courses on SDM are available for all levels (https://training.fws.gov/)
- "An Overview of SDM" webinar series (https://nctc.fws.gov/courses/descriptions/ALC3159-USFWS-USGS-Structured-Decision-Making-Workshops.pdf)

BEST PRACTICE 2: STRATEGIES TO MINIMIZE SOCIAL CONFLICT

Conflict, or stories of conflict, over shorebird management are likely familiar to most coastal managers. Conflict surrounding shorebird conservation occurs when people and wildlife compete for a limited resource, like space on the beach (Jorgensen and Bomberger Brown 2015). These types of conflict are thought to represent one of the most critical threats to wildlife conservation (Dickman 2010) and can exacerbate negative attitudes towards shorebirds and shorebird management, specifically. Conflicts surrounding wildlife management can be thought of as social conflicts, or "relationships of disagreement that arise between individuals and groups who express seemingly incompatible beliefs, values, or goals" (Crowley et al. 2017). Conflicts are not always avoidable, but potential for these conflicts to become intractable can be reduced through planning and an appropriate process (Crowley et al. 2017).

When making decisions or changing management at a site (see **Best Practice for Using Decision Support Frameworks**), consider involving the public in the decision-making process. The first step in any participatory process is conducting a stakeholder analysis (Reed et al. 2009). A stakeholder is any person who significantly affects or could be significantly affected by management decisions (Leong et al. 2012). A stakeholder analysis is a process that: 1) determines what aspects of a social or natural phenomenon are affected by a decision; 2) identifies who is affected by or can affect the phenomenon (i.e., stakeholders); and 3) prioritizes stakeholders for involvement (Reed et al. 2009, Prell et al. 2009).

Conducting a stakeholder analysis: A step-by-step approach

The following guidance on conducting a stakeholder analysis comes from Reed et al. (2009). The first step of a stakeholder analysis involves identifying the stakeholders. This can be done with or without the active participation of potential stakeholders. The level of participation in this step can also vary from a passive consultation where stakeholders provide information for the analysis to more active engagement where there is an exchange of information from stakeholders to analysts (i.e., those conducting the analysis). Identifying stakeholders is generally an iterative process where additional stakeholders are added as the analysis continues. Methods for identifying stakeholders could include using expert opinion, semi-structured interviews, focus groups, snowball sampling, or some combination of these. This step (and subsequent steps) should be conducted with a clear idea of which issue is under investigation.

The second step in a stakeholder analysis requires differentiating between and categorizing stakeholders. There are generally two approaches to classifying stakeholders: a top-down analytical categorization or a bottom-up reconstructive approach. In a top-down approach, those conducting the stakeholder analysis classify stakeholders based on their observations of the issue at hand. As an example, categories developed using this method could include: Key Players, those stakeholders that have a high level of interest and influence in the issue; Context setters, those with low interest and high influence; Subjects, those with high interest but low influence; and, Crowd, those with little interest or influence (people in this category may not need to be included, depending on their stake in the issue). Managers may wish to develop categories that differ from these, depending on the stakeholders and the issue at hand. A bottom-up approach allows the stakeholders to categorize themselves. The approach allows the stakeholder analysis to more closely reflect the concerns of stakeholders; however, use of this method requires more flexibility and may shift the original focus of the analysis. Stakeholder categories developed using this method will depend on the stakeholders.

The final step involves investigating the relationships between stakeholders. Methods for investigating these relationships range from creating simple matrices of stakeholders to more specialized methods, like a social network analysis. The simplest method, called actor-linkage matrices, involves listing stakeholders in rows and columns of a table and creating a grid so the relationships between stakeholders can be described using keywords. Conducting a social network analysis generally requires more specialized knowledge of the stakeholders and is best done by someone familiar with the method.

Throughout the decision-making process, from identifying stakeholders to carrying out the decision, using strategies to reduce the potential for conflict can help improve the final outcome. Managers can reduce conflict by: 1) paying explicit attention to the sociopolitical contexts of the management decision; 2) including the public early in a public engagement process; 3) and using open, responsive communication strategies (Crowley et al. 2017). A stakeholder analysis can also be integrated into a Structured Decision Making process (see **Best Practice for Using Decision Support Frameworks**), which also offers many advantages that can reduce conflict surrounding a decision.

For more guidance:

- See Lauber et al. (2012) for further explanation of stakeholder engagement in wildlife management.
- National Wildlife Refuges sometimes conduct stakeholder evaluations as part of the development of Comprehensive Conservation Plans, which often involve decisions about recreational beach use. A report on the stakeholder evaluation for Canaan Valley NWR is available (https://www.fws.gov/northeast/planning/Canaan%20Valley/pdf/USGSStakeholder_survey_summary_Report.pdf).

BEST PRACTICE 3: SELECTING AND IMPLEMENTING HUMAN ACTIVITY RESTRICTIONS

Imposing a restriction on human activity in the form of buffer/setback distances, restriction zones, or closures can reduce shorebird disturbance at a site. We were unable to find a common definition for these terms in our literature search and believe that none are readily available for management of migratory shorebird stopovers within our focal area. Therefore, we have developed working definitions for the purposes of this document, which describe the management actions in terms of the degree of overall restriction on recreation or other activities that they impose (Figure 3). Despite their great potential for reducing disturbance, selecting and successfully implementing these actions can be difficult and/or controversial. Reasons for this include:

- Tradeoffs with other management objectives
- Social acceptability
- Uncertainty about the impact of the current human activity to shorebirds (short or long-term; individual or population-level effects)
- Uncertainty about how critical the specified site is to a migratory population, and whether nearby alternatives exist
- Uncertainty about when to implement a restriction
- Geographic limitations of a site (e.g., small amounts of available habitat, large tidal fluctuations)
- Legal mandates for protecting natural resources

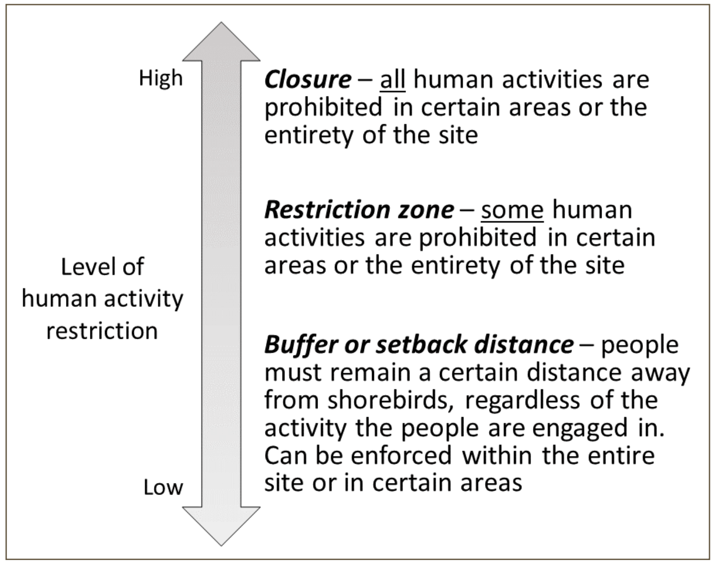


Figure 3. A conceptual model showing the spectrum of human activity restrictions described in this Best Practice and the working definitions of these activities developed for the purposes of this document.

These considerations may be relevant at various stages of the process, beginning with the decision process to select the management action and ending with the actual implementation of the action on the ground. Thus, this Best Practice is divided into two subsections: 1) Choosing a buffer/setback distance, restriction zone or closure to use (the decision), and 2) Strategies for effectively implementing a buffer, restriction zone or closure (the action).

Choosing a Human Activity Restriction Type

The decision to employ a buffer/setback distance, restriction zone, or closure can be very difficult and complex. When key stakeholders express opposing views about potential limitations imposed on human use, strategies to minimize social conflict can be employed (see **Best Practice for Strategies to Minimize Social Conflict**). Additionally, a transparent and systematic decision-making framework, such as Structured Decision Making (SDM) can be used to deconstruct the problem, identify the values of the decision-maker(s), and specify the consequences of the alternative actions in a transparent manner (see **Best Practice for Using Decision Support Frameworks**). A rapid-prototype SDM can be useful for quickly clarifying the decision and providing insight with relatively low time investment.

The literature provides insight about developing alternatives for restricting human activity in a managed area. Alternatives are simply the list of specific actions that the decision-maker is choosing between (the realistic options on the table). In the case of a decision about human activity restriction, hypothetical alternatives may include: close a section of beach to all human activity during southward migration; restrict beach driving to certain sections of the beach; implement a buffer distance of 100m throughout the beach; make no change to management (maintain status quo).

Below is a list of key considerations from the literature that may be referenced when developing alternatives for an actual decision:

Buffer distances:

- Reference published buffer distances by species and location to inform the development of a buffer zone size (see Table 3).
- It is recommended to use one buffer distance, as different buffers for different species or recreational activities will likely confuse the public (Paton et al. 2000).
- Some authors have recommended, at stopover sites where mixed-species flocks congregate, that managers should use the largest of the appropriate buffer distances (Koch and Paton 2014).
- It may be possible to shorten buffer distances in areas where physical barriers prevent direct visual contact between birds and quiet disturbance activities (Rodgers and Smith 1997).
- Buffers are typically set up around important shorebird habitats, though this may be difficult in areas that are also popular for recreation (Rodgers and Smith 1997, Paton et al. 2000, Koch and Paton 2014).
- Buffers can also be established as distances people should stay away from individual birds or flocks, though this method may require extensive outreach.

Restriction zones or closures:

- Avoid creating too many zones, as this may be confusing to beachgoers (Paton et al. 2000)
- If partial site closures or zoning is possible, close off wide sections of beach during peak migration because it has been found that shorebirds spend more time on wider beaches (Murchison et al. 2016).

Strategies for Effectively Implementing a Human Activity Restriction

Once the management action has been chosen, the literature also suggests strategies that can improve the success of implementation. Buffers and restriction zones rely on high compliance to be effective, and therefore social support is critical. A study conducted in Australia found that both beach visitors and nearby residents reported that some level of buffer would be required to manage activities that are potentially disturbing to shorebirds (Glover et al. 2011). These distances and zones, and their purpose, should be clearly communicated both internally to all staff and to the public in order to encourage compliance. When communicating the purpose with the public, try to provide a rationale that aligns with the values of beach recreationists (see **Best Practice for Effective Messaging for Education and Outreach**).

Use of multiple sources of information (or media types) will likely be the most effective strategy, as research has generally shown a positive association between the number of information sources and the level of awareness (van Polanen Petel and Bunce 2012). Thus, using several of the following options may increase effectiveness:

- Consider using temporary signs (see **Best Practice Designing and Using Effective Signage**), information at visitor centers, and social media posts or press releases to communicate with the public.
- Consider using string fencing (with explanatory signage and outreach) to protect important roosting areas.

- Using volunteers could further increase compliance of these buffer distances or zones (see **Best Practice for Using Volunteers or Stewards**).

Regardless of the media chosen to communicate with the public, all communications should be strategic and well-planned (see **Best Practices for Effective Messaging for Education and Outreach** and **Designing and Using Effective Signage**).

Lastly, it may also be beneficial to coordinate buffer distances between neighboring sites, if possible, though these distances may depend on species present and beach morphology (see Meretsky et al. 2012 for more information on collaborative conservation).

At this beach it was determined that signs were the best way to reduce disturbance to important habitat. Audubon

Table 3. Calculated buffer distances for shorebirds and waterbirds in the scientific literature.

CALCULATED BUFFER DISTANCES FOR SHOREBIRDS IN THE SCIENTIFIC LITERATURE.			
Species	**Buffer Distance**	**Study Location**	**Citation**
Roseate Tern	100m	Cape Cod NS (Massachusetts)	Althouse et al. 2018
Least Sandpiper Semipalmated Sandpiper Semipalmated Plover Sanderling Dunlin Short-billed Dowitcher	61-97m	Monomoy NWR (Massachusetts)	Koch and Paton 2014
Willet Red Knot Ruddy Turnstone American Oystercatcher Black-bellied Plover	113-186m	Monomoy NWR (Massachusetts)	Koch and Paton 2014
Plovers Sandpipers	100m	Florida	Rodgers and Schwikert 2002
Pelecaniformes Ciconiiformes Charadriiformes	Calculated formula: -mean plus 1.6495 standard deviations of observed flushing distance plus 40 m Exp [μ+1.6495σ] + 40	Florida	Rodgers and Smith 1997
20 shorebird species	>50m	British Columbia	Murchison et al. 2016
Sanderling	>30m	California	Thomas et al. 2003
Dunlin Sanderling Kentish Plover Ringed Plover	>80m	Spain	Martín et al. 2015
Waterbirds (non-shore-birds)	89.5m	Australia	Glover et al. 2015
10 shorebird species	350m	Australia	Paton et al. 2000
Waterbirds	100m (approaches by drones)	France	Vas et al. 2015

BEST PRACTICE 4: EFFECTIVE MESSAGING FOR EDUCATION AND OUTREACH

Educating the public is often suggested as an effective management technique for reducing disturbance. However, while most researchers agree that knowledge is a key factor in encouraging people to action, knowledge alone often does not change people's behavior (Kollmus and Agyeman 2002).

Informing people with factual information can be critical to help them understand issues, like human disturbance of shorebirds, but different types of information may be more effective in certain situations (Ardoin et al. 2013). Generally, procedural information, or specific action-related information, is more likely to motivate action, while systems knowledge, or broad, background information, is least likely to be motivating (Schultz 2002). For example, in addition to explaining to people that human disturbance may negatively impact shorebirds it is important to have a specific call to action (e.g., leashing your dog).

In addition to providing information, understanding people's values, attitudes, and beliefs is essential for designing effective educational messages.

Values are fundamental core constructs used to evaluate desirability of a specific mode of conduct (Rokeach 1973, Schwartz and Bilsky 1987). Values generally form early in life, are very difficult to change, and transcend specific situations (e.g., family, honesty, faith) (Schwartz and Bilsky 1987, Vaske and Donnelly 1998). People may tend to accept or reject information based on their values. Attitudes represent an individual's tendency to respond favorably or unfavorably towards a specific "object" or action (e.g., birds make me happy) (Fizbein and Ajzen 1974). Attitudes can shift based on experience, and as such, are much more fluid than values (Fulton et al. 1996). Beliefs are what a person perceives to be true and can include both learned facts and misconceptions (e.g., birds are important for the environment; my needs are more important than the needs of birds) (Bem 1970, Vaske and Manfredo 2012).

Designing communications and education efforts to align with the public's existing attitudes and values is key for influencing behavior. However, it is also important to remember that people do not always hold consistent attitudes towards something. Effective messages not only need to align with a person's values but also need to be framed in a way that causes the audience to care and consider the issue (i.e., reducing disturbance) important enough to act (Lakoff 2010).

People often look to others for cues on how to act in a situation. When asking people to take (or not take) certain actions, pay particular attention to how the request is presented. Use messages that create the impression that a desired behavior (e.g., leashing dogs) is the norm. Also, try to ensure that a person's physical environment also exhibits the desired norm. For example, people are far less likely to litter in an area that is free from litter than in an area that is heavily littered (Cialdini et al. 1990).

Other suggestions for using educational/outreach messages to change behavior (Ardoin et al. 2013):

- People need to feel they can take action and that their actions can make a difference (Bandura 1977). If possible, provide specific information about how a targeted behavior can affect the desired outcome.
- Encourage people to adopt behaviors that are easy and rewarding. Identify the barriers that exist between visitors and the desired behavior and try to reduce or remove those barriers (see McKenzie-Mohr 2011 for more information). For example, Comber and Dayer (2019) found that key barriers to walking dogs on

leash include: owners feel that leashing prevents their dogs from socializing, leashing prevents their dogs from exercising, and owners felt their dogs responded well to their commands.

- Giving people too many choices can lead to inaction. Target a small set of behaviors, preferably those with the smallest barriers and greatest potential impact to mitigating shorebird disturbance (Ardoin et al. 2013).

To create a successful education/outreach program, consider using the Planning, Implementation, and Evaluation ("PIE") framework (Jacobson et al. 2015). The planning stage involves identifying the program's goals, objectives, and audiences. Implementation is the process of carrying out the program. Finally, evaluation helps identify areas of success as well as components in need of improvement. Additional information on this process can be found in *Conservation Education and Outreach Techniques* (Jacobson et al. 2015).

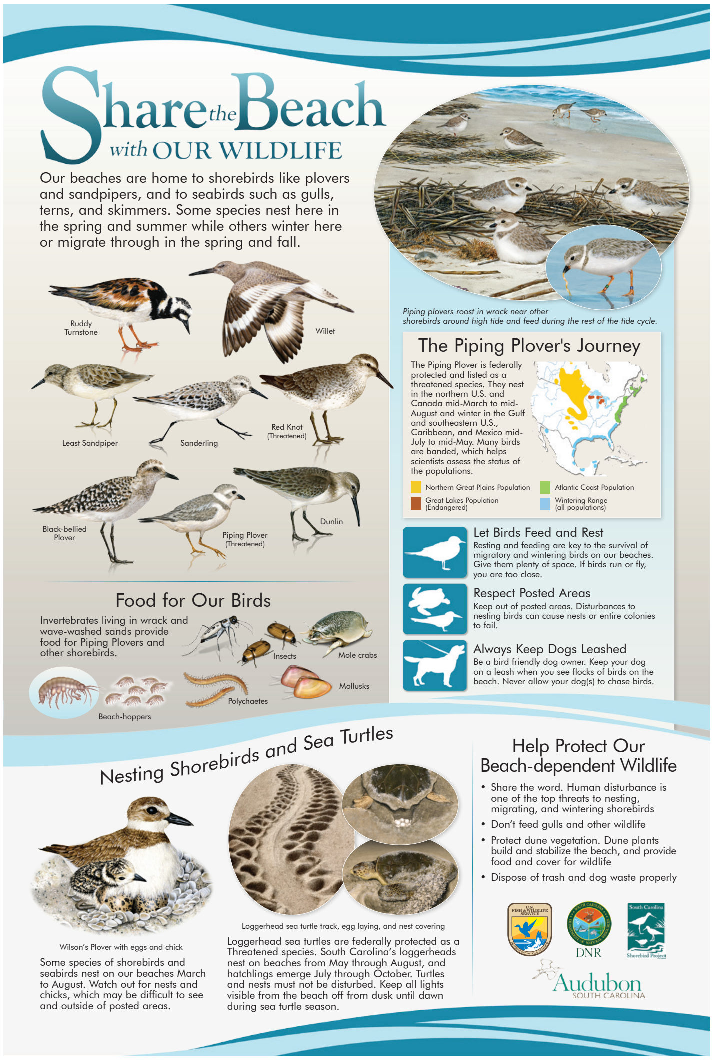
There are many resources available for creating and implementing effective education/outreach programs.

For information on designing effective education/outreach programs, see these recommended resources:

- "Influencing Conservation Action: What Research Says about Environmental Literacy, Behavior, and Conservation Results" by Ardoin et al. (2013) summarizes key research on understanding and changing pro-environmental behavior. This publication can be used to understand how or why people behave in certain situations and how to create messaging rooted in this understanding.
- *Communication Skills for Conservation Professionals* by Jacobson (2009) and *Conservation Education and Outreach Techniques* by Jacobson et al. (2015) provide techniques for communicating about conservation issues and for creating effective outreach and education programs for conservation.
- *Fostering sustainable behavior: An introduction to community-based social marketing* by McKenzie-Mohr (2008, 2011) provides an introduction on community-based social marketing (CBSM). CBSM is a process to promote sustainable behavior change.
- *Social Science Theory for Environmental Sustainability: A Practical Guide* by Stern (2018) summarizes key social science theories and provides strategies and examples for how to apply them to solving environmental problems.

For a library of existing resources, see the following:

- Atlantic Coast Piping Plover Strategic Communications Plan for outreach messages, tools, and strategies designed for various audiences to reduce human disturbance of Piping Plovers. These messages can be adapted for other species.
- AFSI Shorebird Outreach Resource Directory for a library of outreach and education materials used by sites across the Atlantic Flyway.
- Florida Shorebird Alliance outreach materials for a library of outreach and education materials used in Florida.



Example outreach materials available from the AFSI Resource Directory.

BEST PRACTICE 5: DESIGNING AND USING EFFECTIVE SIGNAGE

Signs can be an effective way of changing behavior (Meis and Kashima 2017). Many sites rely on regulatory signage to explain site rules and possible sanctions for rule violations. Regulatory signs that explain possible sanctions can be more effective for certain people, particularly for those with low social responsibility, which is a dispositional trait that reflects an individual's sense of obligation to the group and willingness to accept consequences of their own behavior (Gramann et al. 1995). However, another study conducted in Australia on Hooded Plovers and signage found that beachgoers rated signs with descriptions of fines and authoritative language as the least effective compared to signs with colorful images and clear definitions of the issue and appropriate behavior (Rimmer et al. 2013). Use of regulatory signs can be effective, but they should be paired with education or outreach signs, as well. These signs meant to educate beachgoers or encourage pro-bird behaviors should be colorful (or attention getting), relevant to the visitor, and clearly define the issue and the desired behavior (Rimmer et al. 2013, Stern 2018).

Studies have found that signage at beach access points is the most likely to be read or viewed and is reported to be the most effective method for reaching beach users (Ormsby and Forys 2010, van Polanen Petel and Bunce 2012). Additionally, signage placed close to the object or area (e.g., a closed area) where visitor attention is needed/desired is also highly likely to be read or viewed (Bitgood 2000).

Other suggestions for designing effective signage include (Trapp et al. 1994):

- Use personal pronouns or language to relate to the visitor's experience.
- Use a message pyramid. The most important messages should be at the top of the sign, with decreasing importance as you read.
- Keep messages short and use simple language. Remember, in general, the fewer the words on the sign, the more likely it is to be read and understood!
- Use interesting, informative graphics that are integrated with the sign's message.
- Make sure the sign text contrasts with its background (Bitgood 2000).

The AFSI Shorebird Outreach Resource Directory provides example signage and additional resources.

Often, the simplest of signs can be the most effective. NC Audubon

BEST PRACTICE 6: USING VOLUNTEERS OR STEWARDS

Volunteer beach stewards are a valuable resource for communicating with beachgoers. Parks Canada

Using official-looking volunteers can be very effective at increasing compliance with certain regulations. Forys (2011) found that the presence of a bird steward (i.e., person wearing brightly colored vest who educates beachgoers about birds) decreased the number of people entering a protected area for shorebirds, and almost 9 times more people went into a closed beach area when there was no bird steward compared to when a steward was present. Additionally, people who still entered the closed area when a steward was present generally entered from the side farthest from where the steward was stationed. Similarly, a study in New Zealand found that just the presence of an official-looking observer (someone wearing a colored vest in plain sight but who did not interact with visitors unless directly approached by them) reduced the percentage of groups who harassed (e.g., approached, touched, threw object at) young fur seals on the beach by about two-thirds compared to when the observer was not present (Acevedo-Gutierrez et al. 2011).

Before the season begins, some sites have found it useful to hold a few (how many will depend on the number of volunteers and their availability) informational training sessions for new and existing volunteers. The sessions can be used to give volunteers background on migrating shorebirds (including identification of common migrants) and human disturbance, prepare volunteers for various situations they may encounter, and give them specific talking points or outreach messages. Stationing volunteers at busy access points or closures will likely encourage compliance with activity restrictions or other regulations. These volunteers should be clearly identifiable (i.e., wearing a colored vest, volunteer T-shirt, or other type of identifier that can be recognized from a distance) and able to provide some information to beachgoers about what is allowed or not allowed at the location (though just the presence of a volunteer may also encourage compliance).

Resources for engaging and training volunteers:
National Audubon Society Coastal Bird Stewardship Toolkit. See also Wallace and Gaudry (2005) for a method volunteers could use (Authority of the Resource Technique) when engaging or educating beachgoers.

BEST PRACTICE 7: STRATEGIC PUBLIC ACCESS POINTS

Most beachgoers concentrate near access points or amenities, like bathrooms, concessions stands, and parking lots. Changing the way people access the beach may help confine potentially disturbing activities to a smaller area. This is particularly true for disturbances like dogs, general beachgoing, and recreational fishing. It may be less effective at containing the impacts of beach driving.

In some areas, changing beach access may not be possible. However, in areas where changes can be made, consider measures that limit the spatial extent of visitor impacts (Coombes et al. 2008). Visitor density is negatively correlated with distance from access points, and the location of access points can be used to limit visitor density at certain sites (Tratalos et al. 2013). If possible, paths can be defined through dunes and down to the water to limit wandering. The total number of these paths should be limited (Coombes et al. 2008). Access points and other infrastructure, like dune crossovers, parking lots, boardwalks, can also be placed away from important shorebird habitats or areas where shorebirds tend to congregate (Lafferty 2001, U.S. Fish and Wildlife Service 2012). Additionally, if possible, managing boat landing locations, like docks or ramps, to channel people away from important habitats may also help reduce disturbance (U.S. Fish and Wildlife Service 2012).

BEST PRACTICE 8: STRATEGIES TO MANAGE BEACH DRIVING

Beach driving may displace shorebirds from important habitats or prevent them from using certain habitats (see **beach driving literature summary**). Many shorebird researchers recommend beach closures or decreasing the area where driving is allowed, but these recommendations will need to be considered in light of the historical use of a site, its current management, and the thoughts of stakeholders in the area (see **beach driving literature summary**). These decisions can be highly conflictual (Merritt 2009) and require the use of best practices to minimize social conflict (see **Best Practice for Minimizing Social Conflict**).

To reduce the impacts of beach driving if closures cannot be implemented, but management changes can be made, consider reducing the area over which driving is allowed, or restricting driving to habitats less important to shorebirds (see **Best Practice for Selecting Human Activity Restrictions**). Some research has advised restricting driving access on narrower beaches and on more stable beaches, which may not recover as quickly as more dynamic beaches (Davies et al. 2016). Ideally, also consider prohibiting or restricting driving on more natural and dynamic beaches, as well. There may be potential tradeoffs when managing beach driving between reducing disturbance and negatively impacting foraging quality. It was beyond the scope of this work to examine the impacts of beach driving on prey resources or habitat, but before implementing changes in beach driving, this literature should be consulted. Also, implementing buffer distances between vehicles and shorebirds can greatly reduce potential disturbance (Schlacher et al. 2013). However, before implementing driving restrictions or buffer distances, beach recreationists, particularly those that engage in beach driving, should be considered and engaged, if possible (see **Best Practice for Minimizing Social Conflict**).

Implementing speed limits may reduce disturbance to shorebirds and will likely improve the safety of those driving and people using areas where driving is allowed. For example, Parker River NWR uses a 10mph speed limit where beach driving is allowed (https://www.fws.gov/uploadedFiles/2017_Surf_Fishing_Final_Rev.pdf). Chincoteague NWR uses a speed limit of 25mph but requires that all drivers slow to 15mph when within 100 feet of other vehicles, wildlife, pedestrians, or people on horseback (https://www.nps.gov/asis/planyourvisit/upload/2018-OSV-Regulations.pdf).

Commonly, there are disconnects between the impact of a recreational activity, like beach driving, and the perception of those impacts by the participants (Priskin 2003). In general, recreationists tend to blame other user groups for disturbance to wildlife and fail to understand that they can have a significant impact on wildlife (Taylor and Knight 2003). Because of these beliefs, support for changes in management may be low, in some instances. Education is commonly suggested to change these misperceptions (Priskin 2003); however, while education is an important aspect of management, education alone may not change behavior (Ardoin et al. 2013). Consider pairing education or outreach with a community involvement process when changing or reducing areas where beach driving is allowed. Including community members in decision-making may help reduce conflict surrounding the management of beach driving (see **Best Practice for Minimizing Social Conflict**).

Beach driving can impact bird behavior. Beth Wilson

BEST PRACTICE 9: STRATEGIES TO MANAGE DOGS

It is well documented that dogs may have negative impacts on migrating shorebirds (see **dog literature section**). Many areas have developed leash laws or other dog restrictions for all or part of the year. Understanding people's perceptions of their dogs may help encourage higher compliance with leash regulations or with other existing dog restrictions (see **dog human dimensions literature section**). Several authors (Edwards and Knight 2006, Jorgensen and Brown 2017) have shown that signage that emphasizes risks to off-leash dogs were likely to be effective at persuading dog owners to leash their pets or adhere to regulations. Consider creating signage that highlights the risks faced by off-leash dogs, including risks to their safety (e.g., potential confrontations with other dogs or people, being struck by vehicles). See **best practice for other tips on designing effective signage**. Further, managers could consider conducting outreach specific to dog owners/ dog walkers. (See the Atlantic Coast Piping Plover Strategic Communications Plan, https://www.fws.gov/northeast/pipingplover/pdf/Communications_Plan_for_Reducing_Human_Disturbance_to_Atlantic_Coast_Piping_Plovers.pdf, for outreach messages specific to dog walkers.)

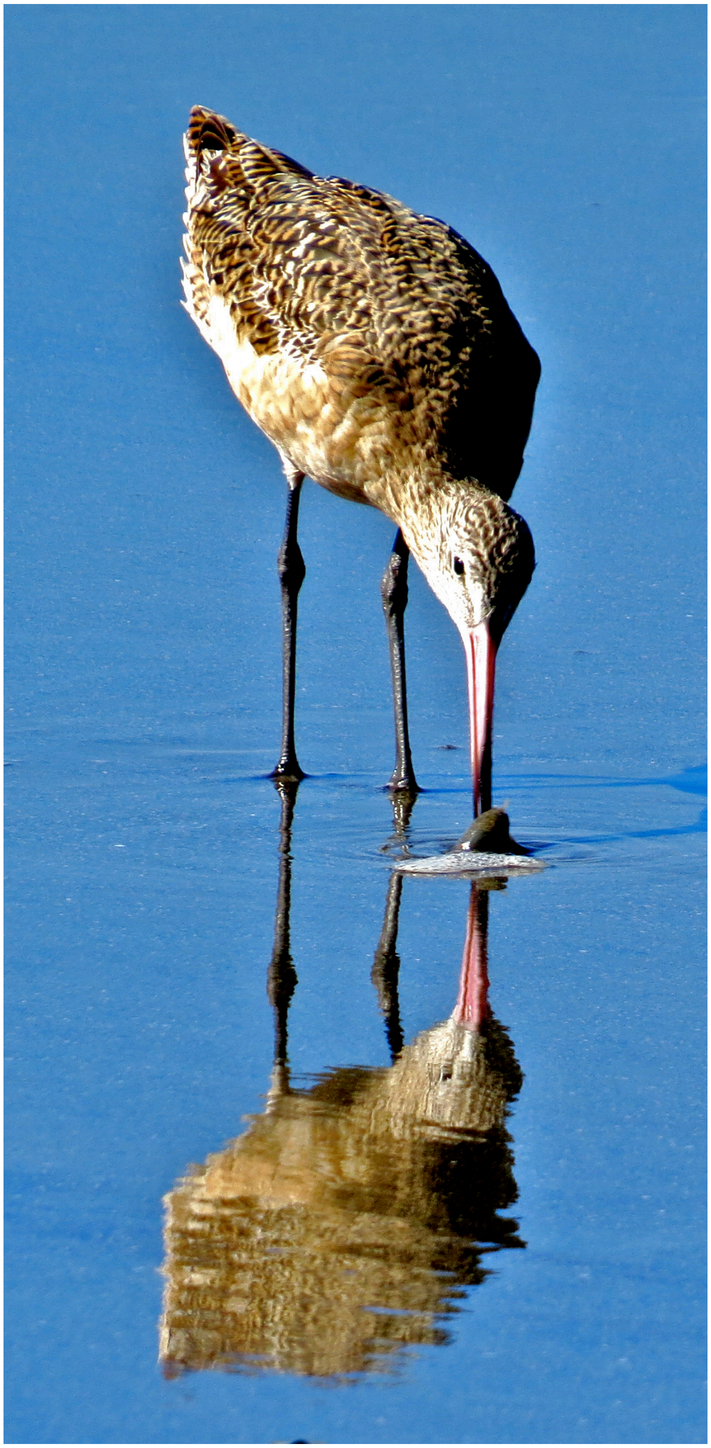
It is also important to continue to cultivate good relationships with those who comply with dog regulations. Owners who already act responsibly most of the time are more likely to respond positively to programs that promote additional responsible behaviors (Rohlf et al. 2010). For example, if a person consistently leashes their dog at the beach, they may be more likely to be open to messaging about picking up their dog's waste.

There are many dog owners who believe that off-leash exercise is important for their dog's health and well-being (Edwards and Knight 2006, Comber and Dayer 2019). If possible, providing other areas where dogs can run off leash may make it easier for beach visitors with dogs to be compliant in areas where off-leash recreation is not allowed. If dogs are not allowed at the site or if off-leash dogs are not allowed, consider making information about nearby dog parks available through printed materials and/ or having staff members trained to provide this information verbally to beach users. At sites where dogs are allowed, consider creating specific "dog zones" to concentrate their activity and reduce their overall impact to shorebirds at the site.

Leashing dogs can reduce disturbance to migrating shorebirds. Michael Goghlan

INFORMATION GAPS AND NEEDS

As evidenced by our literature review, several studies have looked at disturbance during southward migration and made important contributions to the conservation of migratory shorebirds. However, many information gaps still exist. Specifically, further research into the impacts of certain under-studied potential disturbance types, like non-motorized watersports (and especially emerging watersports like kite-boarding), beach raking, coastal engineering, and fishing/aquaculture (recreational and commercial), could help fill gaps about what types of activities to allow, when to allow them, and how to manage them in light of migratory shorebird conservation. Furthermore, as the aforementioned potential disturbance types were considered "priorities" by experts in the northeastern US (see **Defining and Prioritizing Disturbance Section**), this mismatch in data availability and potential significance to shorebirds should be addressed. Additionally, research that links the effects of human disturbance to shorebird demography or fitness is particularly needed.



Marbled Godwit. Loren Chipman

Broadly, future research needs to focus on evaluating the success of management actions, which can help managers use limited resources more wisely by ensuring that all management practices used are effective at reducing disturbance. After conducting an evaluation, results should be shared broadly, through a forum such as AFSI, so that other sites can learn from successes and failures, implement practices that may work at their site, or make adjustments to practices currently used.

There is also a need to identify disturbance thresholds that trigger a management action. Disturbance thresholds can be based on either biological significance to shorebirds or on values-based information. As part of the development of this document, we collated disturbance thresholds found in published literature (see **Evaluating Shorebird Disturbance at a Site section**), but we found very few thresholds and only minimal guidance on this subject. However, some managers in the northeast want to use thresholds to inform the implementation of management actions at their site in order to create a more targeted management approach that may increase the efficiency of resource use. Therefore, we recommend that future research be focused on developing a framework or process by which sites can identify disturbance thresholds. We recommend that thresholds be site-specific when possible, as many factors may impact how disturbance affects shorebirds at different sites. Additionally, research that links the effects of human disturbance to shorebird demography or fitness would be of benefit to the development of thresholds.

During the interview process, many participants pointed out the need for information that could tie together site-specific management to Flyway-level impacts. Research designed to meet this need is critical. Additionally, continuing to use existing information-sharing networks (e.g., AFSI working groups or Flyway technical committees) and working to include groups or organizations that may not currently have access to these networks is critical to scaling up site-level management.

In addition to filling information gaps on the biological impacts of disturbance on migratory shorebirds, work that studies the human dimensions of shorebird management needs to be supported. This literature significantly lags behind the biological literature, and, in many cases, we had to draw on literature from non-shorebird management contexts in the development of this document. Conducting studies on acceptability of management actions by impacted recreation groups is critical to increasing the success of management actions. Studies to understand the drivers of human behavior related to potential disturbance activities can inform effective education and outreach campaigns, as well as other approaches to incentivize or deter certain human behaviors. Incorporating human dimensions research, hiring human dimensions staff, and training existing staff to apply the results of human dimensions research are critical needs moving forward.

More research can be done to understand the biological and social implications of shorebird disturbance management. Ashley Dayer

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APPENDIX 1. SUMMARY OF THE FINAL ROUND OF THE SHOREBIRD DISTURBANCE DELPHI

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THE DELPHI TECHNIQUE

To develop a shared definition for human disturbance and a list of priority disturbance types, we used the Delphi Technique. The Delphi Technique is an iterative, consensus-building technique used to capture expert judgments to address complex problems. This method is not meant to replace empirical evidence but to guide decision-making until empirical evidence can be obtained or to identify gaps in understanding. The results generated by a group of experts are likely to be more reliable and applicable across various settings than the opinion of a single expert. This method allows participants from varying geographic locations and types of expertise (managers, scientists, or manager-scientists) to participate while minimizing cost and logistics.

Experts were selected for the Delphi (n=54) in collaboration with Caleb Spiegel and Rebecca Longenecker at USFWS and through suggestions of the Atlantic Flyway Shorebird Initiative Human Activities subcommittee. During the selection process, experts were considered either managers or scientists. Managers were chosen if they actively manage disturbance issues for migrating shorebirds on their lands. Researchers who had published at least one study on human disturbance to shorebirds in the NE Region in the last 10 years were eligible for selection. During the first round of the Delphi, experts self-identified as manager, scientist, or both manager and scientist. We confirmed that the individuals had expertise through screening questions in our initial survey. After rounds 1 and 2 those who did not respond were removed from the list.

Here we present the results of round 4 – the final round – of the Delphi. This information will be integrated into the Best Management Practices for Evaluating and Managing Anthropogenic Disturbances to Migrating Shorebirds on Coastal Lands in the Northeastern United States document. Additionally, we intend to analyze these results further and publish them as part of a manuscript.

RESPONDENTS

We received 31 completed surveys (out of 36) in round 4 of the Shorebird- Human Disturbance Delphi. The response rate was 86%. Ninety percent of respondents indicated that they were satisfied (either "extremely satisfied" or "somewhat satisfied") and 10% of respondents indicated that they were dissatisfied (either "extremely dissatisfied" or "somewhat dissatisfied") with the overall Delphi process.

DISTURBANCE DEFINITION

In this round, respondents were presented with a draft definition developed through responses in the previous three rounds and were asked to provide final comments on the definition. Ninety percent of respondents indicated that they were satisfied (either "extremely satisfied" or "somewhat satisfied") and 10% of respondents indicated that they were dissatisfied (either "extremely dissatisfied" or "somewhat dissatisfied") with the definition.

The definition presented to participants in round 4 for feedback was:
Human disturbance of shorebirds is a human activity that causes an individual or group of shorebirds to alter their normal behavior, leading to an additional energy expenditure by the birds. It disrupts or prevents shorebirds from effectively using critical habitats and from conducting the activities of their annual cycle over and above the disturbances that occur in the absence of humans. Productivity and survival rates may also be reduced.

Based on respondents' comments, we have made the following changes to the definition:
1. Several respondents pointed out that "critical habitat" has a specific meaning under the Endangered Species Act. We have changed the phrase to read "important habitats."
2. A few respondents commented that the wording "activities of their annual cycle over and above the disturbances that would occur in the absence of humans" was confusing. We have changed the phrase to read "activities of their annual cycle that would occur in the absence of humans"

The final definition is as follows:
Human disturbance of shorebirds is a human activity that causes an individual or group of shorebirds to alter their normal behavior, leading to an additional energy expenditure by the birds. It disrupts or prevents shorebirds from effectively using important habitats and from conducting the activities of their annual cycle that would occur in the absence of humans. Productivity and survival rates may also be reduced.

DISTURBANCE TYPES

Respondents ranked the disturbance type categories (developed through previous rounds) based on their significance (in terms of frequency, extent, and/or effect on shorebird survival and behavior) during fall migration from Maine to Virginia. We calculated the average rank of each disturbance type category (Table 1). Categories with a higher numerical rank were considered more important by participants. The top ranked disturbance type category was beach driving followed by dogs and direct harassment. See below for the rest of the rankings.

Table 1. Average rankings for disturbance type categories based on their significance (in terms of frequency, extent, and/or effect on shorebird survival and behavior) during fall migration.

RANKING OF DISTURBANCE TYPES	
Category	Average Rank*
Beach Driving	10.84
Dogs	9.90
Direct Harassment	8.81
Beach Raking	8.35
Coastal Engineering	7.68
General Beachgoing	7.52
Events	5.45
Recreational Fishing	5.29
Motorized Watersports	3.87
Commercial Fishing	3.74
Unmanned Aircraft	3.42
Wind-powered Aircraft	3.13

**Calculated using the following formula: $x_1w_1 + x_2w_2 + \cdots + x_nw_n / Total$ where x = response count for answer choice and w = weight of ranked position. Weights are applied in reverse order (e.g., item ranked 1 would have a weight of 12).*

In response to a concern noted by a few participants:

1. As noted in the last summary report, we use the term fall migration as a synonym for southbound migration. This migration period begins around July 1 and ends around November 15, as defined by the USFWS. This will be detailed in the BMP.

The activities that define the categories (as provided in the last two reports) are listed in Table 2.

Table 2. Categorized disturbance types including edits from round 2 responses.

Category	Activity
Beach driving	4x4 ATV/UTV Beach buggies ORV OSV
Beach raking	Beach raking or scraping
Coastal engineering (previously Beach maintenance)	Beach nourishment Beach raking or scraping Artificial dune stabilization Construction projects
Bike riding	Bike riding Cycling Fat tire bikes
Camping	Camping on beach Bonfire
Cats	Cats Feral cat colonies
Direct harassment	Actively chasing birds
Dogs	Dogs Unleashed dogs Leashed dogs Pets
Events	Fishing tournaments Festivals Parties Sports competitions Fireworks
Falconry	Falconry Hack-raised falcons
Fishing (commercial) and aquaculture	Aquaculture Oyster racks Mariculture Horseshoe crab harvest Clamming Worm digging Seaweed Harvest
Fishing and shellfishing, recreational	Surf fishing Fishing Shell-fishing Clamming Worm-digging Crabbing Bait collection

Category	Activity
Food attractants	Feeding wildlife Leaving bait Leaving trash
General beachgoing	Walking Running/jogging Beachcombing Sunbathing Picnicking Ball playing Frisbee Other beach games Swimming Fast walking
Horseback riding	Horseback riding
Hunting	Hunting
Manned aircraft	Aircraft Helicopters Low-flying planes Banner planes Blimps Microlight aircraft Military planes Jet planes
Motorized watersports	Boats Airboats Speedboats Jet-skis
Non-motorized watersports	Kayak Canoe Paddleboard Sailboat Parasailing Kite boarding Surfing Boogie boards Kite surfing Wind surfing Skimboarding
Official patrols	Litter patrols Emergency vehicles Law enforcement patrol Lifeguards Municipal patrols Marine mammal stranding response
Other	Seaweed harvest Predator fencing Activities that exacerbate erosion
Unmanned aircraft	Drone UAVs Model aircraft Unmanned, remotely operated toys Rocket launches
Wildlife observation	Birdwatching Nature photography Bird call playbacks

Category	Activity
Wildlife research	Wildlife surveys Sea turtle surveys Banding/netting
Wind-powered aircraft	Paragliding Hang-gliding Kite flying Kite skating Sand-yachting or cart sailing

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Jim Fraser
Michael Gochfeld
Heidi Hanlon
Brian Harrington
Anne Hecht
Kevin Holcomb
Erin King
Ryan Kleinert
Jack Kumer
Larry Niles
Erica Nol
Katharine Parsons
Peter Paton
Todd Pover
Lindsey Reis
Virginia Rettig
Ted Simons
Lindsay Tudor
Kristina Vagos
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Appendix 2. Highlights of Shorebird Disturbance Land Manager Interview Responses

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BACKGROUND

Here, we present summarized highlights from our interviews to inform the Best Management Practices for Evaluating and Managing Anthropogenic Disturbances to Migrating Shorebirds on Coastal Lands in the Northeastern United States. We interviewed staff at coastal sites in the U.S. Fish and Wildlife Service (USFWS) Northeast Region (Virginia to Maine) to determine current management activities for human disturbance to migratory shorebirds, the current human activities at various sites, and any specific informational or management needs to improve management of fall migrating shorebirds.

INTERVIEW PARTICIPANTS

Phone interview requests were sent to 30 individuals from October 2 to December 4, 2017. Potential participants were chosen to represent a range of geographies in the Northeast Region, duties (i.e., higher level managers, field biologists, law enforcement officers, outreach staff), and organizations (i.e., federal, state, local, non-profit). The contact list for potential participants was selected in collaboration with project partners Caleb Spiegel and Rebecca Longenecker at USFWS.

In total, we interviewed 28 people from federal agencies (n=17), state agencies (n=6), towns (n=1), and nonprofits (n=4), with representation from every coastal state in the Northeast, except New Hampshire. Twenty-four participants were biologists or managers; three were law enforcement officers; and two were outreach/visitor services staff.

NOTE

Several important notes about this report:

1. We do not discuss specific sites to protect the confidentiality and anonymity of interview participants.
2. We present participants' responses below in summary form (e.g., "most," "several") rather than numerical form because these are qualitative data. We did not attempt to conduct a survey that was comprehensive or representative of all land managers in the Northeast; therefore the results are not generalizable, and we believe that quantifying responses could be misleading. The intention of these interviews was, instead, to understand the breadth of interviewee experiences and how they would use a BMP, so that we can tailor the BMP to its audience.
3. This report contains results from a subset of questions most relevant to sharing insights amongst our survey participants. Additional results will inform and be presented in the BMP document, a Masters thesis, and/or a journal article.

OCCURRENCE AND MANAGEMENT OF DISTURBANCE TYPES

We asked participants to characterize the human use and regulations at their sites during the fall migration period (July 1-November 15) using the list of disturbance types developed by this project in spring 2017. We asked participants to consider all the sites where they worked, managed, or helped make management decisions. Because of the seasonal overlap between the end of nesting season and the beginning of fall migration, many participants discussed restrictions or regulations for certain activities for nesting shorebirds that would also be in place for early fall migration.

Most participants said beach driving was allowed at their sites. All sites where driving was allowed had restrictions on driving during shorebird nesting season and early migration. More than half of participants said dogs were allowed on at least one site they managed. Leash laws were variable across sites, from having no restrictions to requiring dogs to be leased at all times. However, all federal properties where dogs were allowed required them to be leashed at all times. Many of the participants said events were held at sites where they worked, managed, or helped make management decisions. Some participants said fireworks were allowed on their sites, but most said that even if fireworks were not allowed, many of their neighboring properties had fireworks. Most participants said these fireworks displays were done early in the migration season around 4th of July. Also, most fireworks displays by municipalities were required to be shot off from offshore barges, limiting impacts to shorebirds. Some participants mentioned sending technicians or volunteer monitors to help with managing crowds during events at neighboring sites they partnered with but did not actively manage.

Most participants said commercial fishing or aquaculture was allowed at or near their sites. Because of water rights or laws, many commercial fishing or aquaculture operations are regulated by states, not by the property owner of the adjacent land. Commercial aquaculture operations were more commonly discussed than commercial fishing, as most commercial fishing was conducted farther off-shore.

Beachgoing, recreational fishing/shellfishing, and watersports (motorized and nonmotorized) were allowed at least at one site where each person worked. However, there was variation in the amount or location of human use allowed. Some sites did not allow beachgoing unless someone in the party was actively fishing. Others reported also managing off-shore islands where no human use was allowed. Everyone mentioned restrictions on beachgoing, fishing, and boat landings during nesting season. In many cases, these restrictions overlapped with early fall migration.

Some participants, mostly those who worked for or with municipalities, said beach raking or scraping was allowed at their sites. Again, all participants mentioned restrictions on raking/scraping during nesting season. Most participants discussed coastal engineering projects (including restoration projects to protect or improve habitat) conducted at sites they manage. Most of these projects were not conducted every year. Examples of projects conducted regularly (i.e., every year or every few years) were dune stabilization and beach nourishment. Several participants mentioned timing restrictions on coastal engineering projects that included the fall migration period.

All participants who worked at federal properties mentioned regulations for drones or other types of unmanned aircraft. For other properties, drones were regulated during nesting season, but in many cases, regulations during migration were not clear or varied widely by site. Most participants described drones as an emerging potential disturbance issue. Additionally, a few participants said model aircraft were allowed on their sites. Similarly, several sites had restrictions for kites or other wind-powered aircraft. About a quarter of participants said their sites did not allow kites at any time, and all others mentioned kites being restricted around nesting areas. A few participants mentioned paragliding or hang-gliding, but in general, these activities were uncommon, even where they did occur.

Fat tire bikes were the most commonly mentioned activity not included on our list of potential disturbance types. These bikes were described by many as another emerging activity that was increasing in popularity. Other activities not included on our list were: horses, rocket launches, birders/photographers, researchers, illegal camping, and ultralight aircraft. Many participants discussed how birders or nature photographers would accidently cause disturbances by getting too close to birds.

Across these human activities, most participants indicated that the majority of management for fall migrating shorebirds was limited to the period when migration overlaps with breeding season. A few participants said they would close sections of beach during migration where and when they knew birds stopped over in significant numbers. Many participants discussed the various challenges to managing human use during fall migration. Several mentioned that it was more difficult for beachgoers to understand why migrants needed protection (i.e., easier for people to understand why protecting chicks is important). Others mentioned conflict with recreationists as limiting management for fall migrating shorebirds (discussed in more detail below).

MONITORING DURING FALL MIGRATION

Most participants reported that their sites conduct some type of monitoring for shorebirds during fall migration. Of those, several sites participated in International Shorebird Surveys (ISS), and a few sites reported doing Integrated Waterbird Management and Monitoring (IWMM) surveys. Additionally, several participants said they conducted species-specific monitoring, with most of those conducting Piping Plover surveys and fewer monitoring Red Knots. Additionally, several participants reported that they monitored for fall migrants but did not specify what type of monitoring surveys were done. Those who do not currently monitor for fall migrating shorebirds indicated that their sites have conducted monitoring in the past.

Some sites reported that they conducted some sort of monitoring for human disturbance. However, in most cases, this monitoring was conducted opportunistically (e.g., anecdotal observation when in the field for other purposes). Some participants reported conducting counts during a shorebird survey for dogs, people, and/or vehicles. Additionally, a few participants said their sites had participated in human disturbance research projects in the past.

In some cases, monitoring described by participants was used to make management decisions at a site or sites, though not all decisions were specifically about disturbance management. Monitoring influenced water levels and drawdown times at freshwater impoundments. Other participants discussed how bird count data informed participants on where important bird habitat areas are at their sites. Additionally, several participants said that determining these locations can be useful during a permitting process, so participants can make decisions about issuing a special use permit or putting a project under a time of year restriction. In one instance, a participant reported that shorebird surveys were important for extending a vehicle closure, as the surveys showed that birds were spending more time in the area during the fall migration than originally thought. In other cases, disturbance monitoring was helpful for participants or biologists to determine where to spend more time enforcing rules or addressing noncompliance issues.

MANAGEMENT OVERLAP

We asked participants to describe how their management for shorebirds may benefit other non-shorebird species and vice versa. While discussing this management, participants also described how the timing of certain management practices can provide benefits to shorebirds during non-target times (e.g., management for breeding birds may benefit migrants).

Participants reported that fencing off areas provides benefits to both shorebirds and non-shorebirds. Areas that are fenced off for shorebirds may provide areas of low human disturbance for other species, like endangered plants (e.g., seabeach amaranth, seabeach knotweed), endangered tiger beetles, diamondback terrapins, and other bird species. Additionally, in many cases, closures for endangered breeding shorebirds and terns create protected areas for early season fall migrants. One participant discussed how requirements for creating buffers around resting seals may also help shorebirds in those areas. Participants also discussed the cases where areas fenced off for endangered beach plants creates places with reduced disturbance for shorebirds. One participant suggested that fencing put up for endangered plants may have contributed to plovers showing back up in an area they had previously been absent.

Participants also discussed how managing and restoring habitats for certain species or at certain times could also benefit shorebirds. One participant described how restrictions on dredging or other kinds of coastal engineering projects for finfish and shellfish spawning in the fall would likely benefit migrating shorebirds by reducing disturbances at those times of year. Others discussed how marsh restoration projects at their sites were creating habitat for shorebirds; though, as one interviewee discussed, in some cases this habitat creation would be only temporary until open marsh areas became revegetated. In other cases, marsh restoration conducted to restore ecosystem functioning also benefited shorebirds. Participants also described how managing impoundment water levels at certain times would benefit shorebirds and other waterbirds by creating foraging or roosting areas.

Lastly, a few participants discussed how management implemented at other times of year could benefit migrating shorebirds. Some participants said that predator management for breeding shorebirds (and terns) could benefit both migrating shorebirds and other non-shorebird species, including other breeding waterbird species. Additionally, one participant mentioned that managing areas to make them appealing for horseshoe crabs also makes them good areas for migrating shorebirds; though, as one participant stated, this benefit is likely mostly for spring migrating shorebirds.

CONFLICTS WITH RECREATIONISTS

We asked participants if they or their sites experienced any issues with conflict and which (if any) user groups were involved in those conflicts.

Everyone mentioned getting pushback or negative comments from individual recreationists. While fairly common, most agreed that these negative interactions were outweighed by positive feedback or outreach. In general, participants said that most beachgoers were accustomed to restrictions and closures for nesting birds. Though in areas with lots of tourism, this acceptance may not be as common because the beachgoers are constantly changing.

At some locations, user groups created more pushback than individuals and in some ways influenced management. In most cases, participants described these conflicts as making managing more difficult, requiring more time and outreach than issues without conflict. Common user groups that were involved in these issues were fishing groups, dog walkers, ORV/OSV users, kite surfers and parasailers, and boaters (both motorized and nonmotorized).

In some cases, these conflicts (both from individuals and user groups) influenced management decisions for migrating shorebirds. Some participants mentioned being hesitant to extend closures beyond the breeding season requirement to avoid potential conflict. At sites where people were less friendly towards breeding bird closures, one participant mentioned their biological field staff changed the timing of their monitoring surveys to avoid potential negative interactions with beachgoers.

A few participants mentioned that they had good working relationships with certain user groups. Because we did not ask specifically about positive relationships with user groups, it may be the case that other sites had similar experiences that were not mentioned. One participant said their site often worked closely with kayak rental companies or kayak groups to reduce disturbance issues. Several others mentioned how birders and birdwatching organizations usually had a close relationship with their sites and were quick to report issues of disturbance or make sure other birders/photographers were minimizing their disturbance.

SUMMARY & NEXT STEPS

We would like to thank our participants for their participation in this interview phase of the project. We presented results in this report that we hope will help participants see how their site-based actions fit into the broader picture of management for human disturbance to fall migrating shorebirds in the Northeast Region. Further, results from these interviews will be used to identify informational gaps or needs that, when possible, will be addressed by the BMP. A final draft of this BMP will be completed by fall 2018.

APPENDIX 3. METHODS FOR MONITORING SHOREBIRD DISTURBANCE AT REFUGES DURING SOUTHWARD MIGRATION

These methods were piloted in 2017 at three Northeast National Wildlife Refuges, so reference is made to "Refuge" and "Refuge Biologists" throughout. However, the methods may be adapted for use by other groups.

METHODS OVERVIEW

Surveys will be conducted on coastal beach habitat. Each site to be surveyed will be further divided into subsites. Subsites should be selected based on management type (ex: closed, open to the public) within the refuge, in consultation with Refuge biologists (see below for more guidance).

Three types of surveys will be conducted- transect surveys, point counts, and behavioral observations. Sample datasheets for all survey types are included at the end of this appendix. Transect surveys and point counts should be done on one pass through the site and behavioral observations on another pass (e.g., transects/ point counts on the "first pass," followed by behavioral observations in the "second pass" or return trip, although the order should be alternated). If possible, all surveys should be done with two observers, and these methods are written accordingly. Using double observers can allow the researcher to detect differences in detection probabilities and may increase detection probabilities. Transect surveys and point counts will be done simultaneously by two observers without sharing results. Behavioral observations will be conducted as a team. Surveyors should ensure the consistency and accuracy of their measurements by following the steps for **alignment of paired observers**, if applicable, found at the end of this appendix.

All surveys should be conducted on foot, if possible. Surveys should be scheduled with attention to ensuring diversity of day of week (i.e., weekend/holiday vs. weekday), time of day, and tidal stage.

Survey equipment

Make sure you have all of the equipment you will need before beginning the surveys, including:

- Datasheets: Ensure you have the appropriate number and type (transect, point count, and behavioral observation) before beginning.
- Binoculars and spotting scope
- GPS unit: During your first visit, mark and save all point locations for future survey visits with an easy-to-use naming system (e.g., subsiteabbreviation_pointnumber).
- Subsite maps: Bring printed maps of each subsite, containing aerial imagery, any important site features for orientation (piers, walkways), the subsite extent, and the location of the transect and point counts.
- Kestrel/handheld weather meter: Select a meter that measures the temperature (C°), wind speed (km/hr), and wind direction. You can use a smartphone that gives information from the nearest weather station, but this likely will not be as accurate as measuring on-site.
- Watch/stopwatch/smart phone: A device that will beep every 30 seconds when conducting the behavioral observations.

- Range finder: Using a rangefinder will ensure accurate measurement of distances, especially when conducting point counts.
- Clicker counter: Using a counter may be beneficial for counting disturbance types and/or shorebirds at busy sites (i.e., large numbers of people and/or birds).

Subsite Selection
Each site, depending on its size, should be broken down into subsites. Points should be 400m apart. It is recommended that subsites are selected based on management type. We also suggest selecting subsites based on disturbance levels at the site, including both high and low disturbance subsites.

Species Selection
These field methods are designed to focus on the focal species (see below) selected by the Atlantic Flyway Shorebird Initiative (AFSI). However, depending on site specific needs, biologists may choose to focus on different or additional shorebird species. If using different species, make sure to edit the datasheets appropriately.

Focal species:
- American Oystercatcher
- Semipalmated Sandpiper
- Red Knot
- Whimbrel
- Wilson's Plover
- Marbled Godwit
- Piping Plover
- Purple Sandpiper
- Red-necked Phalarope
- Ruddy Turnstone
- Sanderling
- Snowy Plover
- American Golden Plover
- Greater Yellowlegs
- Lesser Yellowlegs

Disturbance Types Selection
Like for selecting focal species, these field methods were designed to focus on a set of potential disturbance types (see below). For further explanation of disturbance types, see **Description of potential target human disturbances**. However, potential disturbance types may need to be added or removed, depending on what types of human activities are present at a site. Disturbance types may also be broken down further or combined (e.g., combining walking and jogging). It may additionally be useful for surveyors to keep track of potential violations at a site (e.g., someone brings a dog to a site where dogs are not allowed) and report these violations to the appropriate contact at the survey site.

Potential target human disturbances
- Beach driving: both parked and driving
- Dogs, noting leashed and unleashed
- General beachgoing: People
- Anglers
- Motorized watersports: boats and other personal watercraft
- Commercial fishing
- Unmanned aircraft: drones, etc.

- Wind-power aircraft: kites, parasailing, etc.
- Other, human- explain potential disturbance
- Other, non-human- explain potential disturbance, including species, if known

Subsite Categorization

On the first visit of the season to each subsite, record the following information (this does not have to be recorded again unless conditions change). It may be helpful to sketch a site map that includes the features below:

- Locations of human access points (take GPS points)
- List all human activities permitted at the site (talk to Refuge staff about this)
- Locations of management activities: exclosures, fencing, closed/open areas
- Locations of facilities: piers, swimming areas, parking lots, bathrooms, trash, etc.

TRANSECT SURVEYS

Transect surveys will be conducted as continuous counts along a transect. Depending on the tide, surveyors will walk on wet sand near the high tide line to minimize disturbance to foraging birds during surveys. To further avoid disturbing birds, the surveyors will walk around any birds encountered on the transect, leaving as large a buffer as possible, and will follow all Refuge-specific guidelines for minimizing disturbance. Each transect survey will be conducted for the entire length of a subsite and is equal to the width of the beach (i.e., water to dunes).

Record the following on the data sheet for each survey:

- Date/time start and time end
- Site/subsite
- Observer(s) (list your own initials first)
- Tidal stage
- Weather conditions- wind speed/direction, temp, cloud cover (Sky)
- Time of first high tide
- GPS track name

When an individual bird or group of birds from a focal species is detected, surveyors will count the number of birds of each focal species present within the group. While conducting these continuous counts, surveyors will also count potential disturbances to birds (see **Description of potential target human disturbances** for explanations of the disturbance types). Every 400m at fixed locations on the transect, stop and conduct a visual point count (see "Point Counts" below).

Notes:

- Birds and disturbance sources will be counted up to 200m from the surveyors. The transect width is equal to the width of the beach or 200m, whichever is less.
- In-movement: Birds and disturbances (e.g., people, dogs) that move into the surveyed area from behind the surveyors will not be counted. Fly-overs will not be counted, regardless of direction of approach. Only birds that land within 200m (when coming from in front of the researchers) will be counted. This rule should be followed for both the transect surveys and the point counts.
- If possible, at least 2 surveys per subsite will be conducted in each tidal stage. We divide the tidal cycle into four, 3-hour tidal stages that are repeated to cover the entire 24-hour day. Those stages are: low, mid-rising, high, and mid-falling.

POINT COUNTS

Every 400m at fixed locations on the transect, surveyors will conduct visual point counts. Researchers will use the same methods above for avoiding disturbance to birds. Coordinates of each point will be taken on a GPS unit at the time of the first survey. The coordinates will be used to relocate the point for subsequent (repeat visit) surveys and years. Surveyors will orient themselves in a common direction (ex: north) and count all focal species in a complete circle around the point up to 200 m. Surveyors will then repeat and count all potential target human disturbances (see above for definition of focal species and potential human disturbances) in a complete circle around the point up to 200 m. The 200 m-radius survey area for each point should not overlap with the survey area for any other points.

There is no set amount of time for each point count to be conducted, but the counts should be as instantaneous as possible. Depending on the number of focal shorebird species and surveyor preference, you may count each species or disturbance type separately. If there are a large number of birds or people at the point, it may also be helpful to count disturbance types first (in a complete circle around the point), then birds (or vice versa).

BEHAVIORAL OBSERVATIONS

Behavioral observations will be conducted in the opposite pass of walking the subsite transect from the monitoring/point count surveys. For example, transect surveys/point counts will be conducted walking north to south on the beach, and behavioral observations will be done as researchers return walking south to north. The researchers will rotate the order of the monitoring transects/point counts with the behavioral observations to avoid systematic influence or bias of which direction they walked first.

Surveyors will conduct 3-minute focal species observations at the same fixed locations that were used for the point counts. The focal species for the behavioral observations – Whimbrel, Red Knot, Semipalmated Sandpiper, Piping Plover, and Sanderling – were selected from the focal species list above based on habitat, foraging guild, and protected status. Depending on specific informational needs, a site may choose different focal species. At the point count locations, researchers will select a focal flock within 200m and observe one of the focal species in the middle of the flock for 3 minutes, and then move on to the next species, until all of the species present from the list of 5 focal species are observed for 3 minutes. Depending on location and focal species, up to 5 behavioral observations may be conducted for a point. For example, if you locate only Sanderling at a point, there will be just one behavioral observation. If you locate none of the focal species, then no observations will be done at that point. If you locate all five focal species, then there will be 5 observations for the point.

Researchers should rotate the order in which the focal species are observed. While the behavioral observations are being conducted, the researchers should try to keep a 50m buffer between themselves and the focal bird (see minimum approach distances in Livezey, Fernandez-Juricic, & Blumstein, 2016).

During the 3-minute observation, the researchers will record the instantaneous behaviors of the individual every 30 seconds. The instantaneous behaviors will be recorded as the following behaviors: foraging, walking, maintenance (resting, preening, etc.), alert/vigilant, flying, other. One researcher will use their scope for observation while the other records the data. If only one person is conducting the observations, then the observer should use a voice recorder to record the behaviors. All potential disturbances occurring within 200m of the flock will also be recorded (see above for potential disturbances). If a disturbance event occurs (defined as birds changing their behavior in reaction to a human source), the time and source of the disturbance will be recorded, if possible.

Notes:

- If the focal individual can no longer be observed (e.g., bird flies away, observer can't determine which bird is being observed, view is obstructed), locate another individual and restart the behavioral observation. However, if only one individual is present at the point and it can no longer be observed, continue the sample and record "out of sight" as the behavior code.

DESCRIPTION OF POTENTIAL TARGET HUMAN DISTURBANCES:

--Note: Surveyors should not count themselves. Record all potential disturbances up to 200m.

- Beach driving: Count vehicles (4x4, ATV/UTV, beach buggies, ORV, OSV), including both parked vehicles and vehicles in motion
- Dog, unleashed
- Dog, leashed
- Walkers: include dog walkers
- Joggers
- Ball players: This category includes those actively engaged in a game.
- People, stationary: This category includes people who are stationary on the beach (those sitting in chair, on towel, reading, napping, etc.). If a person changes their activity during the count, do not record their new behavior.
- People, swimming: This category includes all people in the water. Do not count people who are using some type of watercraft (motorized or nonmotorized) or who are resting (stationary) in the intertidal area.
- Motorized watersports: Count any type of personal water craft (PWC)- boats, airboats, power or speed-boats, jet skis. Record boats up to 200m offshore. Note if you see a boat on the beach.
- Nonmotorized watersports: Count any type of watercraft that does not use a motor or engine- kayaks, canoes, stand-up paddleboards, kite surfing, kite boarding, surfing, wind surfing, parasailing, etc. Count sailboats if they are not currently using a motor/engine. Record nonmotorized watercraft up to 200m offshore. Note if you see a boat or board on the beach.
- Unmanned aircraft: Record the following up to 200m in any direction (including above): drone, UAVs, model aircraft, remotely operated toys.
- Wind-powered: Record the following: kites, paragliding, hang-gliding, kite skating, sand-yachting, or cart sailing. Do not include kite surfing or other type of water-based activity that uses a kite or sail.
- Anglers: Count the number of people actively fishing or checking the rods. Count others who may be near the rods under the other beachgoing categories above, depending on their activity.
- Aquaculture: Record people engaged in any of the following: aquaculture, oyster racks, mariculture, horseshoe crab harvest, crabbing. Note if you see the presence of aquaculture or fishing gear (e.g., crab pots, oyster racks) up to 200m.
- Raptors: Count falcons, hawks, etc. that fly over or are present in the study area (within 200m).
- Cats: Count cats observed in the study area (within 200m).
- Other: Explain. Record with short description.
    - Note evidence of events such as fire rings, fireworks and firework debris, beer cans, etc.
- Other- nonhuman: Count gulls, foxes, coyotes, or raccoons if you see an active disturbance event occurring. Record with description of event (animal cause, distance to bird, etc.).

ALIGNMENT OF PAIRED OBSERVERS

On the first day of training for a new pair of observers, researchers will conduct transects (monitoring) and point count surveys together to ensure correct identification of birds and classification of disturbance sources. They will discuss the data they are collecting, particularly any differences in data collected between researchers. If differences occur, pause the survey and discuss what each observer recorded and why, with the goal of reaching agreement on what should have been recorded. Data collected during this day will not be entered in a database.

One the second day of training, researchers will conduct monitoring and point count surveys on their own but stop after every point to compare data and discuss discrepancies, determining any issues in identification of birds or definition of disturbances. Data collected during this day will not be entered in the database.

A third day of training may be necessary if the observers are not consistent. Please note that there may be some differences in detectability (i.e., one observer may not see a flock or individual bird) but that it is essential there are not systematic issues with differences in identification of birds or definition of disturbance types.

On the first day of collecting actual data, monitoring and point count surveys will be conducted as described in the methods above. At the end of a monitoring transect of a subsite, the researchers will compare data. Differences in data will discussed. Data will not be changed. If there are still major discrepancies between researchers this day, observers will return to training together. At the end of the training period, researchers will conduct the surveys as described above.

Human Disturbance Transect Data Sheet

Site: _______________Subsite: _______________ Date:____________ Transect ID: ______________ Observer(s): _____________

Air temperature: ______Sky: _____ Wind speed: _____ Wind direction: _______ Tidal stage: ________ First high tide: ______________ Visit #: ______

Transect Coordinates (*coplete on first visit only*)	Latitude	Longitude
Endpoint 1		
Endpoint 2		

Time start: _________ Time end: ________

Focal Species Counts

Species	**No. of Birds**	**Species**	**No. of Birds**
Sanderling		Greater Yellowlegs	
Piping Plover		Lesser Yellowlegs	
Ruddy Turnstone		Red-necked Phalarope	
Semipalmated Sandpiper		American Golden Plover	
American Oystercatcher		Snowy Plover	
Red Knot		Wilson's Plover	
Whimbrel		Purple Sandpiper	
Marbled Godwit		"Peep" sandpiper	

Disturbance Sources

Disturbance Type	**Number**	**Disturbance Type**	**Number**	**Disturbance Type**	**Notes**
Vehicle		Motorized watersports		Other, human	
Dog, unleashed		Nonmotorized watersports		Other, non-human	
Dog, leashed		Unmanned aircraft			
Walkers		Wind-powered			
Joggers		Anglers			
Ball players		Aquaculture			
People, stationary		Raptors			
People, swimming		Cats			

Subsite: first letter of site, section name **Transect ID**: Subsite code, date **Air temp:** Celsius **Sky:** 0 = 0-25% cloud cover; 1 = 25-75% cloud cover; 2 = 75%-100% cloud cover; 4 = fog/smoke; 5 = rain **Wind speed** (km/h): average **Wind direction:** N, NE, E, SE, S, SW, W, NW **Tidal stage:** 1= low, 2= mid rising, 3= high, 4=mid falling **First high tide:** time of first high tide of day (hh:mm)

Human Disturbance Point Count Data Sheet

Site: ______________ Subsite: ______________ Point ID: __________________________ Observer(s): ______________________________________

Date:_______________ Visit #: ________ Time start: ___________ Time end: ________________

Point Coordinates (*complete on first visit only*): Latitude:_________________________________ Longitude: __________________________________

Focal Species Counts

Species	No. of Birds	Species	No. of Birds
Sanderling		Greater Yellowlegs	
Piping Plover		Lesser Yellowlegs	
Ruddy Turnstone		Red-necked Phalarope	
Semipalmated Sandpiper		American Golden Plover	
American Oystercatcher		Snowy Plover	
Red Knot		Wilson's Plover	
Whimbrel		Purple Sandpiper	
Marbled Godwit		"Peep" sandpiper	

Disturbance Sources

Disturbance Type	Number	Disturbance Type	Number	Disturbance Type	Notes
Vehicle		Motorized watersports		Other, human	
Dog, unleashed		Nonmotorized watersports		Other, non-human	
Dog, leashed		Unmanned aircraft			
Walkers		Wind-powered			
Joggers		Anglers			
Ball players		Aquaculture			
People, stationary		Raptors			
People, swimming		Cats			

Notes:

Subsite: first letter of site, section name **Point ID:** first two letters of subsite name, two-digit point number **Visit #:** 1, 2, 3, etc

Human Disturbance Behavioral Observation Data Sheet

Site: _______________ Subsite: _______________ Date:____________ Point ID: ______________ Observer Name: ______________________________________

Recorder Name: ___________________________ Air temperature: _______ Sky: ______ Wind speed: ______ Wind direction: ________ Tidal stage: ________

First high tide: ________ Visit #: ________ Point Coordinates (*complete on first visit only*): Latitude:_____________________ Longitude: ________________

Behavioral Observation

Species	Time Start	Time 1 0:30	Time 2 1:00	Time 3 1:30	Time 4 2:00	Time 5 2:30	Time 6 3:00	Comments*

Behavior Codes: For= foraging; W= walking; M=maintenance (preening, resting, etc.); A= alert/vigilant; Fly=flying; AGR= aggression; OS=out of sight; O= other, explain
*Record disturbance events in the comments, note disturbance type, distance from bird, and time.

Disturbance Sources

Disturbance Type	Number	Disturbance Type	Number	Disturbance Type	Notes
Vehicle		Motorized watersports		Other, human	
Dog, unleashed		Nonmotorized watersports		Other, non-human	
Dog, leashed		Unmanned aircraft			
Walkers		Wind-powered			
Joggers		Anglers			
Ball players		Aquaculture			
People, stationary		Raptors			
People, swimming		Cats			

Subsite: first letter of site, section name **Point ID:** first two letters of subsite name, two-digit point number **Observer:** Person observing birds **Recorder:** Person recording data **Air temp:** Celsius **Sky:** 0 = 0-25% cloud cover; 1 = 25-75% cloud cover; 2 = 75%-100% cloud cover; 4 = fog/smoke; 5 = rain **Wind speed** (km/h): average **Wind direction:** N, NE, E, SE, S, SW, W, NW **Tidal stage:** 1= low, 2= mid rising, 3= high, 4=mid falling **First high tide:** time of first high tide of day (hh:mm)

Appendix 4. Field-Testing Shorebird Disturbance Monitoring Methods Report

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BACKGROUND

In 2017, we developed and tested a set of field methods to collect data for evaluating shorebird disturbance at a site. These methods were developed with input from project partners at USFWS and shorebird researchers at Virginia Tech. The methods provide a potential set of common metrics for monitoring and measuring the effects of human disturbance to shorebirds at migratory stopovers, in order to better quantify, track, and compare responses to current and future management actions across sites. Development of common metrics for monitoring and measuring the effects of disturbance could improve our understanding of shorebird disturbance at sites within the Northeast region, help managers evaluate the effectiveness of their actions across sites at a regional scale, and facilitate more efficient cross-site collaboration.

The objective of this pilot study was to develop and field test a set of methods, which could be used for future coordinated monitoring efforts. Specifically, these methods can be adapted across multiple sites and management entities to facilitate coordination across broader geographies and timescales, in order to better understand trends across wider segments of populations, more effectively compare success of management actions across sites and regions, and avoid duplication of efforts. Pilot testing allowed us to make adjustments to the methods to improve the feasibility and ease of collecting data.

The purpose of this report is to present the data collected from this pilot season and discuss the preliminary data analyses. The results presented in this report represent two months of data collection, and therefore, these results should not be generalized beyond what is discussed in this report. More robust analyses can be run using these methods but a larger dataset (i.e., more sites and years) would be required.

METHODS

Study Sites and Subsites

Surveys were conducted at 3 sites: Amagansett National Wildlife Refuge (NWR) on Long Island, New York, Elizabeth A. Morton NWR on Long Island, New York (Figure 1), and Chincoteague NWR in Virginia. Sites were further divided into subsites and selected based on management type (ex: closed, open to the public) within the refuge, in consultation with Refuge biologists.

Amagansett and Elizabeth A. Morton National Wildlife Refuges

Amagansett NWR and Elizabeth A. Morton NWR are part of the Long Island National Wildlife Refuge Complex. Due to its small area (quarter mile of beach), Amagansett NWR (ANWR) only included a single subsite (Figure

2). This refuge is closed to the public inland of the high tide line during breeding season for Least Terns and Piping Plovers. The closed area is indicated by a rectangular fence that runs the length of the refuge.

Morton NWR (MNWR) was divided into three subsites (Figure 3), two of which were closed to the public (MPEC and MNOY) and one quarter mile stretch of beach open for public recreation (MPUB). MPEC was on the Little Peconic Bay side of the Jessup's Neck peninsula and was 1.5 miles in length. MNOY was on the Noyack Bay side of the peninsula and was 1 mile in length.

Figure 1. Map of Long Island showing the locations of Amagansett and Elizabeth A. Morton National Wildlife Refuges.

Figure 2. Map showing Amagansett National Wildlife Refuge subsite, transect, and point count locations.

Figure 3. Map showing subsites, monitoring transects, and point count locations at Elizabeth A. Morton National Wildlife Refuge. MPUB transect is shown in pink. MPEC transect is shown in blue. MNOY transect is shown in green.

Chincoteague National Wildlife Refuge

Chincoteague NWR (CNWR) is located on the Virginia side of Assateague Island (Figure 4). The Refuge is one of the most visited in the United States and also is a critically important stopover site for migratory shorebirds. This site was divided into 5 subsites, based on visitor access (Figure 5). All subsites at Chincoteague were 1.5 miles long. The southernmost subsite, CHOOK, was closed to all public use from March 15-August 31. The adjacent subsite, COSV, was completely closed to public use from June 21-August 15. The closure dates for this subsite depend on Piping Plover breeding activity. Both of these subsites allowed over-sand vehicles (OSV) when open to public use. An additional subsite, CSWILD, allowed OSVs from May 23-August 31. This subsite was open to nonmotorized public use year-round, even when OSVs were not allowed. The other two subsites, CREC and CNWILD, did not allow OSVs but were open to public use year-round.

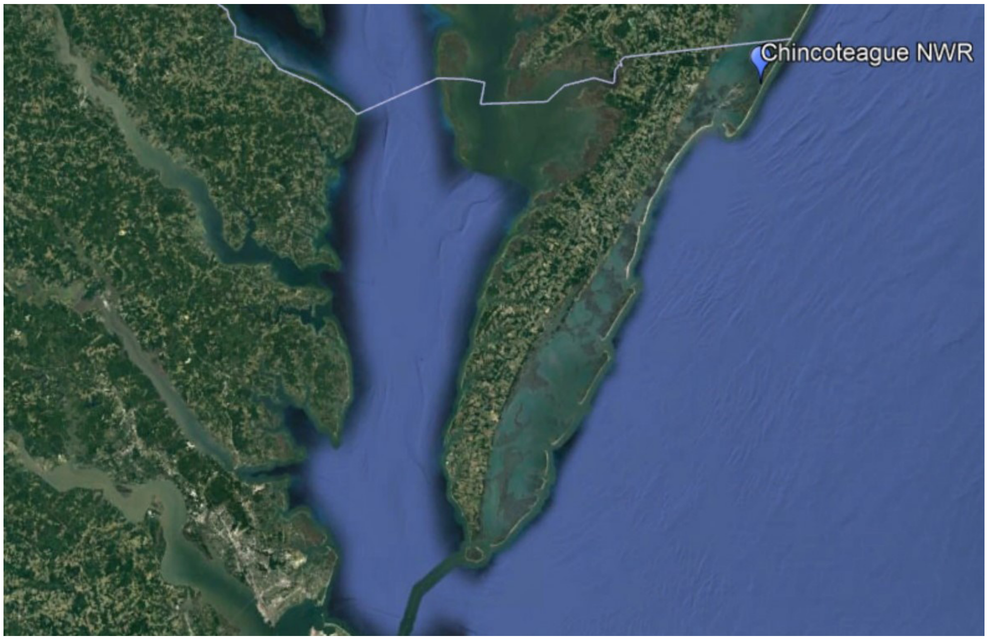

Figure 4. Map of Eastern Virginia showing the location of Chincoteague National Wildlife Refuge.

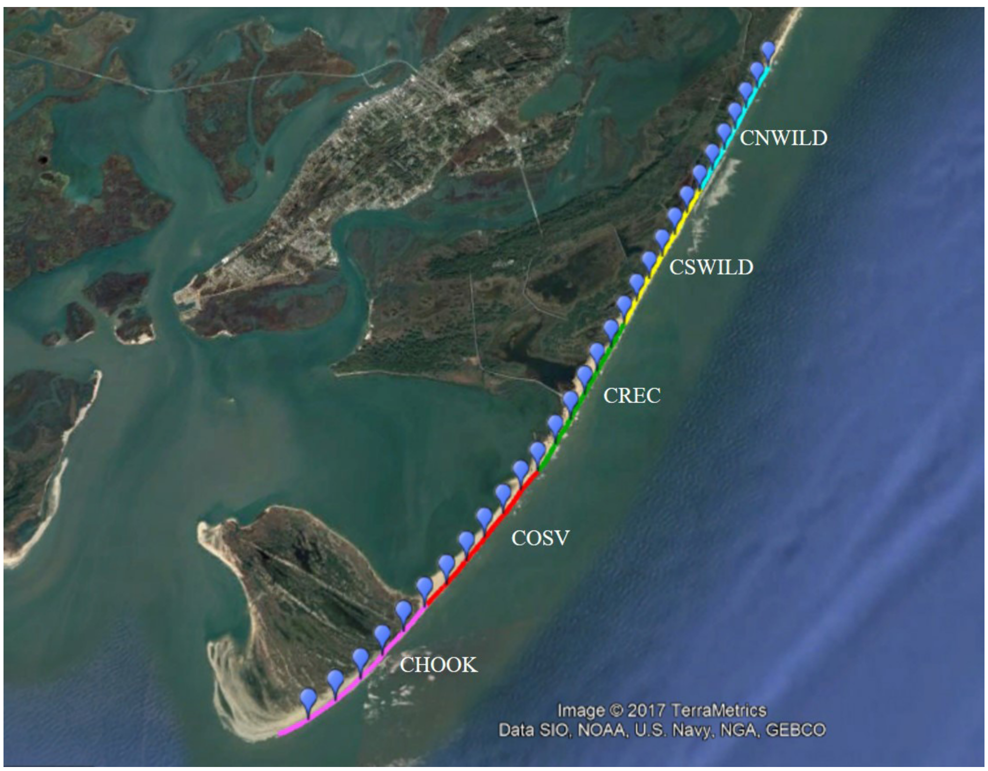

Figure 5. Map showing subsites, monitoring transects, and point count locations at Chincoteague National Wildlife Refuge. CHOOK transect is shown in pink. COSV transect is shown in red. CREC transect is shown in green. CSWILD transect is shown in yellow. CN-WILD transect is shown in blue.

Focal species

Atlantic Flyway Shorebird Initiative (AFSI) focal species were targeted for the pilot study: Sanderling, American Oystercatcher, Semipalmated Sandpiper, Red Knot, Whimbrel, Wilson's Plover, Marbled Godwit, Piping Plover, Purple Sandpiper, Red-necked Phalarope, Ruddy Turnstone, Snowy Plover, American Golden Plover, Greater Yellowlegs, and Lesser Yellowlegs.

At Chincoteague NWR, we adjusted our focal species based on consultation with the refuge biologists, in order to more adequately include expected species. We added Semipalmated Plover, Whimbrel, and Black-bellied Plover to our species list and excluded Greater Yellowlegs, Lesser Yellowlegs, and American Golden Plover. None of the species removed from the list were observed at Amagansett or Elizabeth A. Morton NWRs, and we did not observe Whimbrel or Black-bellied Plover at these sites. We did, however, have counts of Semipalmated Plovers from these sites as "incidentals," and these counts were included in our analyses.

Potential disturbance types

The potential disturbance types chosen for this pilot study were based on the disturbance type categories developed during a group prioritization process (see **Appendix 1. Summary of the Final Round of the Shorebird Disturbance Delphi** for more information about this process). Potential disturbances included: beach driving, dogs (leashed and unleashed), walkers, joggers, sun bathers, ball players, beachgoing-other, beach raking, coastal engineering (beach nourishment, construction, artificial dune stabilization), motorized watersports, unmanned aircraft, kites, anglers, commercial fishing gear or boats, events, direct harassment, cats, and raptors.

Data collection

Data were collected at each subsite using transect surveys, point counts, and behavioral observations (see **Appendix 3. Field Methods for Monitoring Shorebird Disturbance at Refuges during Southward Migration**). These methods may be used to address different questions related to evaluating and monitoring effects of human disturbance on shorebirds, and each has unique strengths and weaknesses (see **Considerations for Developing Standardized Field Methods to Evaluate Shorebird Disturbance** section of main document for more details).

All surveys were conducted on foot. Transect surveys and point counts were conducted simultaneously by two observers without sharing results. Behavioral observations were conducted as a team.

Transect surveys were conducted as continuous counts of all focal species along a transect. All potential disturbances were also counted simultaneously on the transect. Each transect survey was conducted for the entire length of a subsite and was equal to the width of the beach (i.e., waterline to dunes).

Visual point counts were conducted every 400m along the transect at fixed points. Researchers counted all focal species and all potential disturbances within a 200m circle around each point. Due to the various sizes of the subsites, the numbers of points varied by subsite.

Behavioral observations were conducted by walking a subsite transect in the opposite direction from a transect/point count survey. Researchers conducted 3-minute focal species observations at the same fixed points as the point counts. The focal species for behavioral observations were a subset of the species list for the monitoring and point count surveys: Whimbrel, Red Knot, Semipalmated Sandpiper, Piping Plover, Ruddy Turnstone, and Sanderling. These species were selected based on foraging guild and protected status. To conduct an observation at a point, researchers selected a nearby focal flock within 200m of the point and observed one individual of the focal species in the middle of the flock for 3 minutes, and then moved on to the next species, until all of the species present from the list of 5 focal species were observed. Researchers rotated the order in which the focal species were observed at each point. During the 3-minute observation, researchers recorded the instantaneous behaviors of the focal individual every 30 seconds. Instantaneous behaviors were recorded as the following: foraging, walking, maintenance (i.e., resting, preening), alert/vigilant (i.e., actively scanning surroundings), aggression (i.e., chasing or harassing other birds), flying, other. All potential disturbances occurring within 200m of the flock also were recorded. When a disturbance event occurred (defined as birds changing their behavior in a perceived reaction to a human source) during the 3-minute observation, the time and source of the disturbance were recorded. One researcher conducted the observations while the other recorded the data. The same observer conducted all behavioral observations.

Surveys were conducted at the Long Island sites (Morton and Amagansett NWRs) from July 11- July 31, 2017. We surveyed both Long Island sites for 11 survey days. Surveys were conducted at Chincoteague NWR from August 5-September 4, 2017. We conducted survey at Chincoteague NWR for 23 survey days. Surveys were scheduled with attention to ensuring diversity of day of week (i.e., weekend/holiday vs. weekday), time of day, and tidal stage. Tidal stage included four, 3-hour tidal stages: 1=low, 2=mid-rising, 3=high, and 4=mid-falling.

Data analysis

Summary statistics are presented for all survey types. For the point count and transect data, we conducted all statistical analyses using the program R (R Development Core Team). We used negative binomial regression models to examine how different types of disturbance impacted shorebird counts. Due to small sample sizes of shorebird species, we ran these models on the most commonly observed species - Sanderling (SAND) - at the site where they were observed most frequently--Chincoteague NWR. For these analyses, we combined walkers and joggers into the category “active people” because of their similarity and to increase sample sizes. Survey effort was the amount of time in minutes spent surveying during each transect or at each point count location. While the data from the pilot study did not allow these robust analyses for all species or sites, we offer this as an example of the types of analyses that may be conducted.

We then used Akaike’s Information Criterion to rank models in our candidate set. We considered the top model(s) to be those within <2 ΔAICc (Burnham and Anderson 2004). We used these ranked models to examine differences in the results between point count and transect models.

We summarized behavioral observation data into time budgets, where we calculated the proportion of time focal species were observed engaged in each recorded behavior. We present these summarized data for all sites for Piping Plover (PIPL), Ruddy Turnstone (RUTU), Sanderling, and Semipalmated Sandpiper (SESA).

RESULTS AND DISCUSSION

We conducted 195 transect surveys, 946 point counts, and 522 behavioral observations during 34 days. Greater Yellowlegs, Lesser Yellowlegs, American Golden Plover, Marbled Godwit, Red-necked Phalarope, Snowy Plover, Wilson’s Plover, and Purple Sandpiper were not observed during any of the surveys. Additionally, the following disturbance types were not observed: beach raking, coastal engineering, unmanned aircraft, cats, events, and direct harassment.

Transect surveys

The five most commonly observed species during the transect surveys were Sanderling (93% of all birds observed), Willet (2%), Ruddy Turnstone (1.5%), Semipalmated Plover (1.5%), and Piping Plover (1%) (Table 1). The most commonly observed disturbance types were sunbathers (68% of all disturbances observed), beachgoing-other (20%), and walkers (6%) (Table 2). Counts of beachgoing-other included people in the water and people whose activity could not be determined.

Table 1. Counts of species observed during transect surveys at each subsite through the field season. Species that were not observed are not included.

Site	Transect	Open*	SAND		PIPL		RUTU		SESA		AMOY		REKN		WILL		SEPL		WHIM		BBPL	
Observer			**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
ANWR	ANWR	1	81	133	38	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CNWR	HOOK**	0	5853	5834	1	1	55	55	6	6	32	30	10	10	136	136	83	64	0	0	58	55
	NWILD	1	3408	3441	1	1	27	30	9	5	0	0	0	0	36	45	45	33	1	1	26	27
	OSV**	0	4909	5120	60	65	124	137	4	3	23	28	106	103	106	111	69	65	0	0	8	10
	REC	1	976	939	4	5	13	11	0	0	0	0	0	0	32	42	11	8	0	0	3	3
	SWILD	1	2864	3184	0	0	39	50	9	16	0	0	0	0	40	43	76	105	4	3	14	18
MNWR	NOY	0	31	21	11	19	24	14	0	0	1	0	0	0	0	0	7	0	0	0	0	0
	PEC	0	3	3	32	35	0	0	0	0	0	0	0	0	0	0	5	6	1	1	0	0
	PUB	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table 2. Counts of a subset of disturbance types observed at each subsite throughout the field season during the transect surveys.

Site	Transect	Open*	OSV		Dogs		Walker		Jogger		Ball Player		Sunbather		Beachgoing - other		Angler	
Observer			**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
ANWR	ANWR	1	0	0	1	1	30	43	8	8	8	8	77	61	12	21	0	0
CNWR	HOOK**	0	14	18	0	0	7	4	0	0	0	0	0	7	0	0	2	0
	NWILD	1	1	1	0	0	20	23	0	0	0	0	14	16	0	0	0	0
	OSV**	0	71	73	0	0	104	91	4	2	4	2	226	231	95	52	7	12
	REC	1	2	2	2	2	479	650	113	133	113	133	7517	8175	1924	2561	18	16
	SWILD	1	16	17	0	0	84	87	0	0	0	0	182	160	63	50	10	8
MNWR	NOY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PEC	0	1	1	0	0	1	0	0	0	0	0	2	2	3	5	0	0
	PUB	1	0	0	0	0	0	0	0	0	0	0	56	49	38	61	2	2

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We conducted 108 transect surveys at Chincoteague NWR. For the transect surveys, the global model was the top ranked model (Table 3). The adjusted R^2 of this model was 0.78. Five variables were significant predictors within the top ranked model (Table 4). Two of the variables were counts of potential disturbance types: active people (combined counts of walkers, joggers, and ball players) and sunbathers. Both active people and sunbathers had a negative influence on Sanderling counts. The model indicates that sunbathers had more of an effect on Sanderlings than active people.

The other three significant predictors were wind speed, date, and public access. Wind speed and public access both had a negative influence on Sanderling counts. Our results indicated that open areas have a negative effect on Sanderling counts, showing that fewer Sanderlings are present when the beach is open to public use. Lastly, as expected, date had a positive effect on counts of Sanderlings, likely due to the progression of the migration season with more birds arriving at the site later in our season.

Table 3. Results of model selection examining effects of disturbance on counts of Sanderlings at Chincoteague National Wildlife Refuge during the transect surveys. We present the model results, including β coefficients, of all models in our candidate set.

Model	A	S	V	WI	TS	D	O	E	κ	AICc	ΔAICc	w_i
Global[1]	-0.13	-0.34	0.05	-0.12	-0.01	0.27	-0.40	0.01	8	1292	0.00	0.99
People	-0.18	-0.34				0.18		0.02	4	1321	28.53	0.00
Inactive		-0.50				0.17		0.02	3	1326	33.83	0.00
Active	-0.47					0.22		0.02	3	1341	48.57	0.00
Open						0.30	-0.64	0.02	3	1419	126.78	0.00
Weather				-0.16	-0.03	0.27		0.02	4	1438	146.06	0.00
Vehicle			0.02			0.09		0.01	3	1442	150.02	0.00

Variable abbreviations: Active people-walkers, joggers, ball players (A); Sunbathers (S); Vehicle (V); Wind speed (WI); Tidal stage (TS); Date (D); Open or closed to public access (O); Survey effort (E)
[1]Global model=A+S+V+WI+TS+D+O+E

Table 4. Parameter estimates for the best performing model examining effects of disturbance on counts of Sanderlings at Chincoteague National Wildlife Refuge during the transect surveys.

Variables	β coeff	SE	Lower 95% CI	Upper 95% CI	p value
Active people	-0.13	0.06	-0.24	-0.01	0.03
Sunbathers	-0.34	0.06	-0.46	-0.22	<0.01
Vehicle	0.05	0.03	-0.01	0.11	0.08
Wind speed	-0.12	0.03	-0.19	-0.06	<0.01
Tidal stage	-0.01	0.03	-0.07	0.05	0.68
Date	0.27	0.10	0.07	0.48	0.01
Public access	-0.40	0.08	0.25	0.56	<0.01
Survey effort	0.01	0.01	-0.00	0.03	0.07

Point count surveys

The five most commonly observed species during the point count surveys were Sanderling (94% of all birds observed), Willet (2%), Ruddy Turnstone (1%), Semipalmated Plover (1%), and Black-bellied Plover (1%) (Table 5). The most commonly observed disturbance types were sunbathers (60% of all disturbances observed), beach-going-other (27%), and walkers (6%) (Table 6).

Table 5. Counts of species observed at each subsite throughout the field season during the point count surveys. Species that were not observed are not included.

Site	Transect	Open*	SAND		PIPL		RUTU		SESA		AMOY		REKN		WILL		SEPL		WHIM		BBPL	
	Observer*		**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
ANWR	ANWR	1	98	87	15	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CNWR	HOOK**	0	4852	4756	2	3	69	62	1	0	23	17	3	11	136	132	40	35	0	0	50	53
	NWILD	1	3511	3590	0	1	20	17	4	6	0	0	0	5	33	33	21	16	1	1	25	21
	OSV**	0	2532	3587	35	38	88	73	6	2	7	12	70	59	84	65	61	58	0	0	9	7
	REC	1	665	737	0	0	6	5	0	0	0	0	0	0	26	19	2	1	0	0	2	2
	SWILD	1	2292	2597	0	0	36	34	7	7	0	0	0	0	45	46	61	46	4	3	17	20
MNWR	NOY	0	27	18	0	1	13	11	0	0	0	0	0	0	0	0	5	0	0	0	0	0
	PEC	0	4	2	21	20	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	PUB	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table 6. Counts of a subset of disturbance types observed at each subsite throughout the field season during the point count surveys.

Site	Transect	Open*	OSV		Dogs		Walker		Jogger		Sunbather		Ball Player		Beachgoing - other		Angler	
	Observer*		**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
ANWR	ANWR	1	3	1	10	14	30	43	1	3	644	602	34	43	114	287	0	0
CNWR	HOOK**	0	14	14	0	0	12	10	0	0	18	23	0	0	0	0	2	0
	NWILD	1	1	1	0	0	11	19	0	0	27	26	0	0	2	0	0	0
	OSV**	0	80	79	0	0	119	110	2	2	591	557	2	13	252	231	26	21
	REC	1	0	1	0	0	316	441	10	13	4019	4467	38	50	1754	2341	9	7
	SWILD	1	14	16	0	0	52	58	1	4	138	164	0	3	52	40	4	3
MNWR	NOY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PEC	0	0	0	0	0	1	1	0	0	2	2	0	0	4	5	0	0
	PUB	1	0	0	0	0	0	0	0	0	56	51	0	0	31	65	2	2

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We conducted 648 point counts at Chincoteague NWR. For the point count surveys, the global model was the top ranked model (Table 7). The adjusted R^2 for this model was 0.43. Eight variables were significant predictors within the top ranked model (Table 8). Three of these variables were counts of potential disturbance types: active people (combined counts of walkers, joggers, and ball players), sunbathers, and vehicles. Active people and sunbathers both negatively impacted Sanderling counts. However, vehicles had a slight positive effect.

Additionally, the two other significant variables were weather-related: wind speed and tidal stage. Similar to the transect surveys, wind speed had a negative effect on Sanderlings. Tidal stage had a positive effect on Sanderling counts, indicating that higher tidal stages had a positive effect on Sanderling counts. The remaining three significant variables were date, public access, and survey effort. Date and survey effort had positive effects, and public access had a negative effect. Again, date positively affected counts due to the number of migrating Sanderlings increasing as the migration season progresses. Survey effort had a positive effect, suggesting that spending more time observing birds at each point increases detection. However, the effect of this variable was relatively small (β=0.11). Like for the transect surveys, our results indicated that open areas have a negative effect on Sanderling counts.

Table 7. Results of model selection examining effects of disturbance on counts of Sanderlings at Chincoteague National Wildlife Refuge during point count surveys. We present the model results, including β coefficients, of all models in our candidate set.

Model	A	S	V	WI	TS	D	O	E	κ	AICc	ΔAICc	w_i
Global[1]	-0.28	-0.42	0.10	-0.22	0.09	0.43	-0.42	0.11	8	5933	0.00	1.00
People	-0.31	-0.44				0.20		0.17	4	6010	77.84	0.00
Inactive		-0.54				0.14		0.15	3	6079	146.63	0.00
Active	-0.44					0.17		0.18	3	6128	195.55	0.00
Open						0.23	-0.52	0.10	3	6221	288.71	0.00
Weather				-0.24	0.07	0.28		0.14	4	6230	297.39	0.00
Vehicle			0.04			0.08		0.14	3	6263	330.36	0.00

Variable abbreviations: Active people-walkers, joggers, ball players (A); Sunbathers (S); Vehicle (V); Wind speed (WI); Tidal stage (TS); Date (D); Open or closed to public access (O); Survey effort (E)
[1]Global model=A+S+V+WI+TS+D+O+E

Table 8. Parameter estimates for the best performing model examining effects of disturbance on counts of Sanderlings at Chincoteague National Wildlife Refuge during the point count surveys.

Variables	β	SE	Lower 95% CI	Upper 95% CI	p value
Active people	-0.28	0.03	-0.34	-0.21	<0.01
Sunbathers	-0.42	0.03	-0.48	-0.35	<0.01
Vehicle	0.10	0.02	0.05	0.15	<0.01
Wind speed	-0.22	0.03	-0.28	-0.16	<0.01
Tidal stage	0.09	0.03	0.03	0.14	<0.01
Date	0.43	0.06	0.30	0.55	<0.01
Public access	-0.42	0.07	-0.55	-0.28	<0.01
Survey effort	0.11	0.02	0.05	0.17	<0.01

Behavioral observations

We observed 92 “disturbance events” during our behavioral observations, which were defined as a bird changing its behavior in a perceived reaction to a human source. While this is a fairly subjective measure of disturbance, counting these disturbance events allows for potential disturbances to be recorded outside of the 30-second survey time points.

Sanderlings were observed at 54% of the points surveyed (Table 9). Ruddy Turnstones were observed at 15% of the points. Piping Plovers were observed at 8% of points. Red Knots and Semipalmated Sandpipers were both observed at around 2% of points. Whimbrels were observed at >1% of points. At 18% of the point locations, no birds were observed. Like for the other surveys, the most commonly observed potential disturbance types during the behavioral observations were sunbathers, beachgoing-other, and walkers (Table 10).

Table 9. Total number of behavioral observation surveys of each species at each subsite

Site	Subsite	Open*	SAND	PIPL	RUTU	SESA	REKN	WHIM	None observed***
ANWR	ANWR	1	7	16	0	0	0	0	3
CNWR	CHOOK**	0	65	1	15	3	4	0	1
	CNWILD	1	60	0	13	1	0	1	0
	COSV**	0	71	20	36	2	6	0	1
	CREC	1	62	1	5	1	0	0	4
	CSWILD	1	72	0	21	4	0	4	1
MNWR	MNOY	0	6	5	5	1	0	0	41
	MPEC	0	3	8	2	1	0	0	56
	MPUB	1	0	0	0	0	0	0	10
Percent of total observations			54.1	8.0	15.2	2.0	1.6	0.8	18.3

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***Open to public use for part of the season*
****Number of surveys where no birds were observed*

Table 10. Counts of a subset of potential disturbance types observed at each subsite throughout the field season during the behavioral observation surveys.

Site	Transect	Open*	OSV	Dogs	Walker	Jogger	Ball Player	Sunbather	Beachgoing-other	Angler
ANWR	ANWR	1	0	1	66	7	2	85	50	0
CNWR	HOOK**	0	4	0	6	0	0	4	0	0
	NWILD	1	0	0	46	1	0	13	6	2
	OSV**	0	67	2	242	6	0	173	41	25
	REC	1	0	0	246	14	47	2704	1040	2
	SWILD	1	38	0	135	3	0	159	33	8
MNWR	NOY	0	2	0	0	0	0	0	0	0
	PEC	0	0	0	0	0	0	0	1	0
	PUB	1	0	0	0	0	0	44	52	2

**Open (1) or closed (0) to public access*
***Open to public use for part of the season*

Piping Plovers

In areas closed to the public (Figure 6b), Piping Plovers spent a larger proportion of time foraging than in areas open to public access (Figure 6a). They spent more time walking in areas open to the public. They were also observed exhibiting alert or vigilant behaviors in open subsites (2% of the time), while they were not observed exhibiting these behaviors in closed subsites. These data suggest that Piping Plovers spend more time engaged in active behaviors at subsites open to public access and less time foraging.

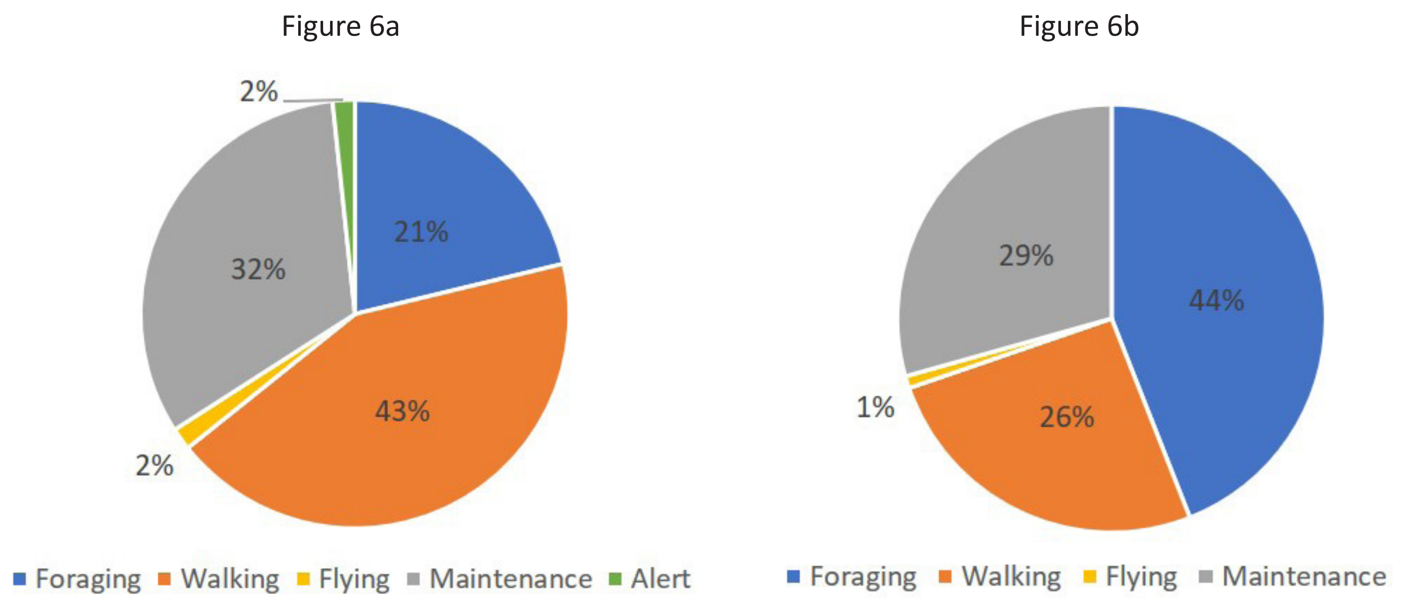


Figure 6. Proportion of behaviors observed for Piping Plovers at Amagansett, Morton, and Chincoteague NWRs in areas (6a) open to public access (n=32) and (6b) areas closed to public access (n=19).

Ruddy Turnstone

In subsites closed to the public (Figure 7b), Ruddy Turnstones spent more time engaged in maintenance behaviors than in subsites open to the public (Figure 7a). They were observed spending a higher proportion of time walking in open subsites. However, they were observed flying an equal proportion of time in open and closed subsites. Like for Piping Plovers, Ruddy Turnstones appear to spend a larger proportion of their time engaged in foraging behaviors at subsites closed to the public, though the differences between the proportions at closed or open subsites was not as great as for Piping Plovers.

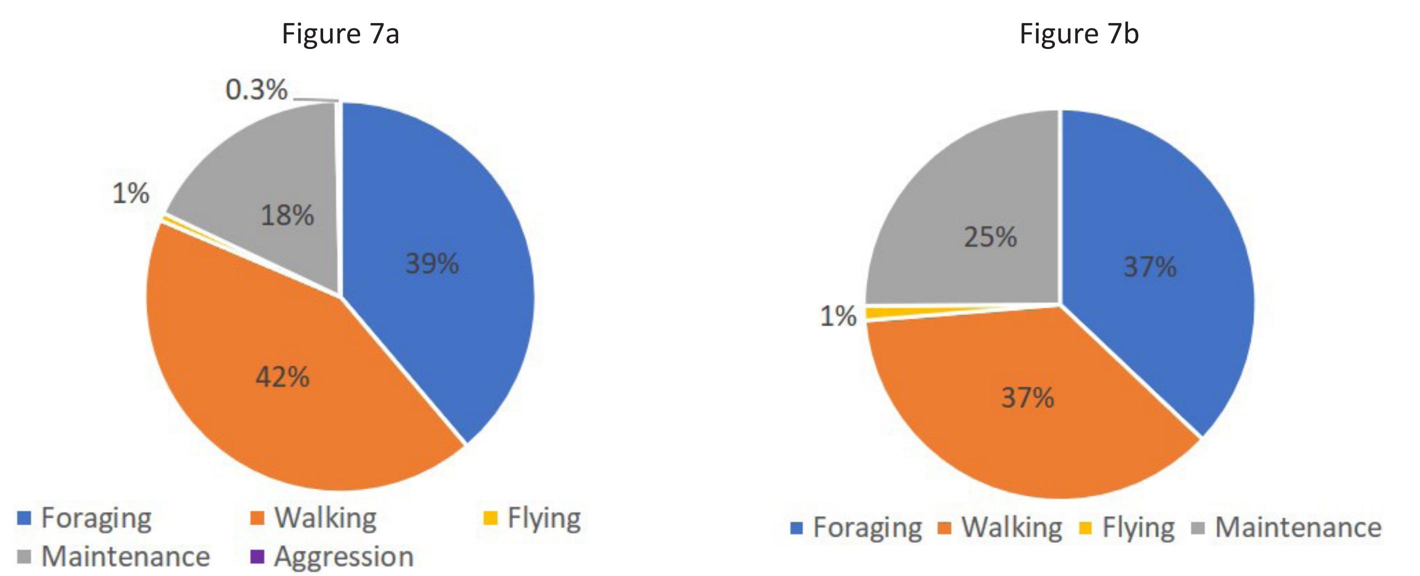


Figure 7. Proportion of behaviors observed for Ruddy Turnstones at Amagansett, Morton, and Chincoteague NWRs in areas (7a) open to public access (n=54) and (7b) areas closed to public access (n=43).

Sanderling

Sanderlings spent an equal proportion of time foraging, walking, and flying in open (Figure 8a) and closed areas (Figure 8b). They also spent an almost equal proportion of time engaged in maintenance behaviors and aggressive behaviors (e.g., chasing) towards other shorebirds, with a slightly higher proportion of these behaviors in open subsites. We also observed a very small proportion of time spent engaged in alert or vigilant behaviors in open subsites.

While we observed more Sanderlings in closed subsites, we noticed that Sanderlings were the only species that were consistently observed continuing to forage or roost in areas of high human use. Therefore, it appears Sanderlings are likely not as affected by potentially disturbing activities as the other species studied.

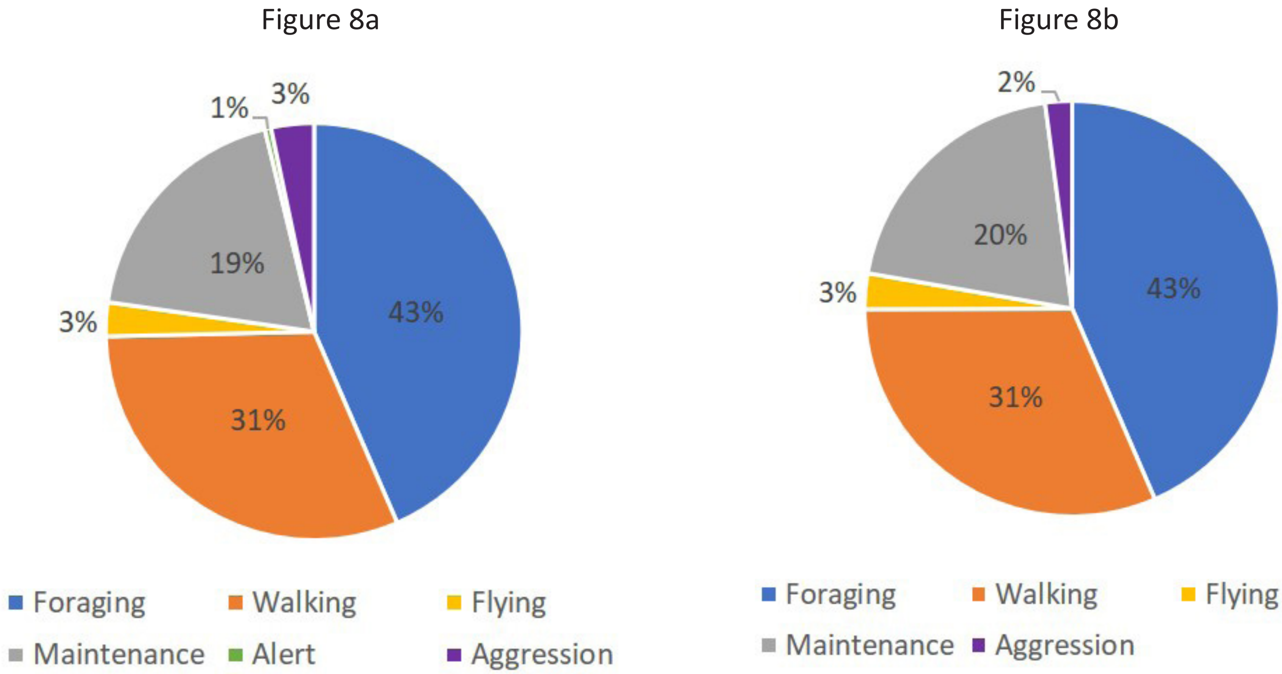
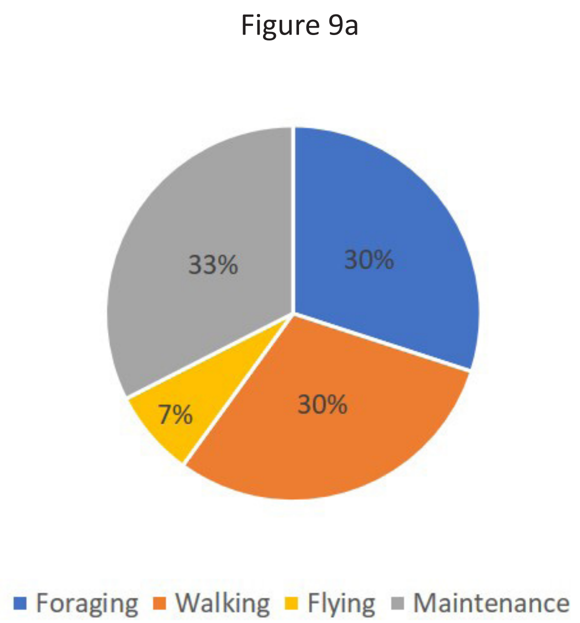


Figure 8. Proportion of behaviors observed for Sanderlings at Amagansett, Morton, and Chincoteague NWRs in areas (8a) open to public access (n=248) and (8b) areas closed to public access (n=98).

Sanderling foraging. William Majoros

Semipalmated Sandpiper

Like for Piping Plovers, Semipalmated Sandpipers spent a greater proportion of time foraging in closed subsites (Figure 9b), though this difference was less pronounced than for Piping Plovers. They spent more time engaged in maintenance behaviors in open subsites (Figure 9a). They spent an equal proportion of time walking in both open and closed subsites. Lastly, they spent an almost equal proportion of time flying in both types of subsites.



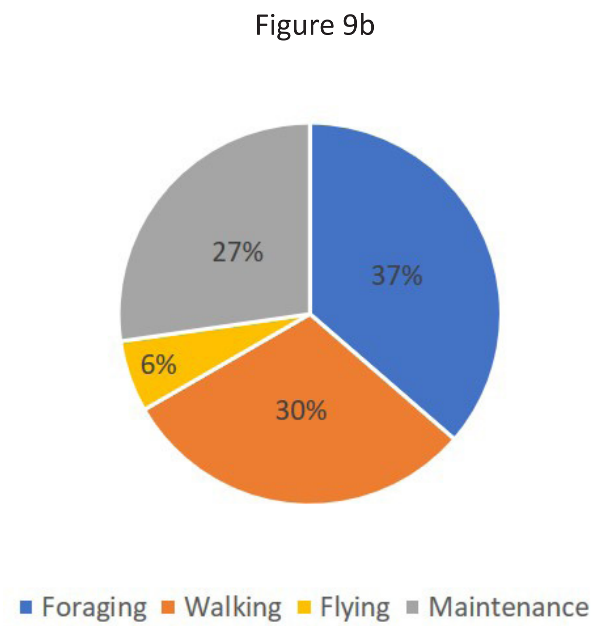


Figure 9. Proportion of behaviors observed for Semipalmated Sandpipers at Amagansett, Morton, and Chincoteague NWRs in areas (9a) open to public access (n=7) and (9b) areas closed to public access (n=6).

CONCLUSION

Pilot testing of these methods allowed valuable lessons to be learned and for improvements to be incorporated (e.g., adjusted some disturbance categories, added more detail to datasheets). Because the purpose of this study was to field test these methods, as stated above, these results should not be generalized beyond what is presented in this report.

Comparison of survey methods

While the transect and point count survey model results cannot be directly compared, they had several similarities. For both surveys, the global model was the top model. For both global models, active people and sunbathers negatively affected Sanderling counts. Date had a significant positive effect in both models, again likely due to the progression of the migration season. Lastly, public access had a significant negative effect with similar effect sizes in both models.

However, based on the R^2 values of the top models for both survey types, the global model did not perform as well for the point count data. The transect surveys may have performed better in this pilot study due to characteristics of the site, Chincoteague NWR, and the study species, Sanderlings. Chincoteague NWR has a long, linear beach that is clearly divided into management sections. This allowed us to easily subdivide sections of the beach into transects of equal length that had a consistent management strategy throughout. Additionally, Sanderlings are generally not as disturbance sensitive as other species. We observed at this site that Sanderlings were generally more spread out than other species, like Red Knots. Because of this, it may not have been as necessary to capture fine-scale spatial variability, like point counts allow.

If possible, we recommend conducting both transects and point counts, as these methods can be used to answer different questions (see **Considerations for Developing Standardized Field Methods to Evaluate**

Shorebird Disturbance). However, managers using these methods may be constrained by time or staff, and therefore, may have to choose between the different survey methods tested in this study. While transects performed better in this analysis, we recommend that managers wanting to select one of these survey methods (transects or point counts) follow a similar approach to this report. While these methods cannot be directly compared, it is possible to examine and compare broad trends between the methods. We recommend trying both types of surveys for an entire migration season and then comparing the results between the different methods, like in this report.

Limitations

The surveys for this pilot study were conducted in July and August, a period that does not fall with peak migration season for sites surveyed. This timing affected what birds and disturbances were seen. For instance, at all refuges surveyed certain areas of the beach were closed to public use to protect nesting birds, and during the peak migration season at these sites, these areas would be open to public use. Surveys were conducted during the early migration season due to constraints on the availability of the surveyors. Sites using these methods should conduct surveys over the entire migration, making sure to capture the peak migration at their site.

Future use

These methods represent one potential set of common metrics for evaluating shorebird disturbance at a site. Using similar methods across multiple sites and management types can facilitate coordination among these sites and may help understand trends across multiple areas. A more standardized approach may also help compare success of management actions across sites and avoid duplication of efforts. Additional data collection is needed before conclusions about how the individual methods described in this report complement one another to provide a complete picture of shorebird disturbance can be drawn.

Before adopting these methods at a site, they should be modified based on site-specific information and needs, and survey objectives should be clearly defined before beginning any data collection. Depending on the types of information a manager wants to gather, certain adjustments can be made to this set of methods. For example, because behavioral observations may be very time consuming, a manager may choose not to conduct them if time-limited but should be aware that they may lose the ability to actually link disturbance to observed abundance. Managers may also consider including habitat characteristics in their surveys, depending on resources, time, and research question. Specific adjustments (e.g., changing types of disturbances counted, types of behaviors recorded, species counted) may be made, depending on site location, human use, research questions, and availability of resources for conducting surveys. Additionally, consultation with a statistician may be beneficial when developing a sampling design and to ensure that the sampling design and field methods will result in data that addresses the specific survey objectives.

APPENDIX 5. RELEVANT LITERATURE: HUMAN DISTURBANCE OF SHOREBIRDS DURING MIGRATION

This list of relevant literature includes all literature cited in the Best Practices document and additional resources on human disturbance to migrating shorebirds or human behavior related to the priority disturbance types or management that may not have been cited directly in the Best Practices document.

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