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Habitat Associations of Shoreline-Dependent Birds in Barrier Island Ecosystems During Fall Migration in Lee County, Florida

Casey A. Lott, Charlie S. Ewell, Jr., and Kelly L. Volansky

September 2009

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Final report

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Abstract: The tendency to survey shoreline-dependent birds by taxonomic grouping has led to an incomplete picture of avian habitat associations within Florida's Barrier Island ecosystems. Planning for the conservation of Florida's shoreline-dependent birds requires a greater understanding of regional and site-specific habitat associations within the community of shoreline-dependent birds during fall migration, when many species are near peak annual abundances. Between August 15 and October 28, 2006 almost 45,000 observations of 42 species at 10 coastal study sites were recorded in southwestern Lee County, Florida. Counts varied strongly by species, site, behavior, and habitat. This study documents striking differences in the community of birds using the study area for foraging and for roosting. Foraging birds were comprised of primarily shorebirds and herons using low-energy intertidal areas and wrack lines around bay beaches, lagoons, and inlet shorelines. Seabirds, particularly terns, skimmers, and pelicans were dominant roosting birds, using intertidal areas on flood shoals, bay beaches, and lagoons. Several plover species roosted almost exclusively along inlet shorelines in and around old, decaying wrack. A small number of heavily used sites contributed a majority of all observations, including a new inlet/washover area that was created by Hurricane Charley in 2004, known locally as Charley Pass.

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Contents

Figures and Tables iv

Preface ix

1 Introduction 1

Background 1

Shoreline-dependent bird habitat use 2

2 Methods 4

Bird counts 4

Interpretation of counts 8

3 Results 10

Counts summarized by behavior, species, and site 11

Counts summarized by habitat use 15

4 Discussion 21

References 24

Appendix A: Lee County Study Sites 26

Appendix B: Lee County Fall Migration Survey Data Form 71

Appendix C: Site-specific Results 75

Report Documentation Page

Figures and Tables

Figures

Figure 1. Lee County Study area. Surveyed sites are in yellow. 5
Figure 2. Foraging substrate use by 23 shoreline-dependent species with ≥33 cumulative observations.. 15
Figure 3. Roosting substrate use by 19 shoreline-dependent species with ≥17 cumulative observations.. 16
Figure 4. Foraging landform use by 23 shoreline-dependent species with ≥33 cumulative observations. 17
Figure 5. Roosting landform use by 19 shoreline-dependent species with ≥17 cumulative observations. 18
Figure 6. Correspondence plot illustrating foraging landform use for species with >33 cumulative foraging observations. 19
Figure 7. Correspondence plot illustrating roosting landform use for species with >17 cumulative roosting observations. 20
Figure A1. Charley Pass Survey Area. 26
Figure A2. P58-Charley Pass, North Captiva Island: Boats parked in the Gulf on the north side of the entrance to the pass. 27
Figure A3 P59-Charley Pass, North Captiva Island: Boat anchored on the shallow flood shoal on the bay side of the island in Pine Island Sound. 28
Figure A4. P60-Charley Pass, North Captiva Island: Mud flats and ephemeral pools on the flood shoal. 28
Figure A5. P61-Charley Pass, North Captiva Island: Early Dunlin (9-10-06) with Ruddy Turnstones and Sanderlings (juvenile and adult). 29
Figure A6. P62-Charley Pass, North Captiva Island: Roosting larids (Sandwich Terns, Royal Terns, Black Skimmers, Laughing Gulls) on flood shoal. 29
Figure A7. P63-Charley Pass, North Captiva Island: Roosting larids (Sandwich Terns, Royal Terns, Black Skimmers, Laughing Gulls) on flood shoal. 30
Figure A8. P64-Charley Pass, North Captiva Island: Walkers on the inlet shoreline. 30
Figure A9. Redfish Pass Survey Area. 31
Figure A10. P57-North side of Redfish Pass (North Captiva Island). 32
Figure A11. Sanibel Lighthouse Survey Area. 33
Figure A12. P54-Sanibel Lighthouse: The lighthouse and beach at the entrance to San Carlos Bay. 34
Figure A13. P55-Sanibel Lighthouse: The fishing pier extending into San Carlos Bay. 34
Figure A14. P56-Sanibel Lighthouse: The inlet shoreline with dense Red Drift Algae covering the intertidal zone.. 35
Figure A15. Bunche Beach County Preserve Survey Area. 36
Figure A16. Bunche Beach County Preserve. 37

Figure A17. P45-Bunche Beach County Preserve: Moderate fresh wrack (Red Drift Algae) in the intertidal zone at medium tide. 38

Figure A18. P46-Bunche Beach County Preserve, mudflats west of the parking area at low tide. Red Drift Algae is present in the intertidal zone 38

Figure A19. P47-Bunche Beach County Preserve: Little Blue Heron foraging in dense wrack (Red Drift Algae) in the intertidal zone. 39

Figure A20. P48-Bunche Beach County Preserve: Ephemeral pool located at the west end of the beach face area. 39

Figure A21. P49-Bunche Beach County Preserve: Mud flats and ephemeral pools located at the west end of the beach face area. 40

Figure A22. P50-Bunche Beach County Preserve: Great White Heron (form of Great Blue Heron) foraging in open water along the bay beach. 40

Figure A23. P51-Bunche Beach County Preserve: Mudflat and ephemeral pools located at the west end of the beach face area. 41

Figure A24. P52-Bunche Beach County Preserve: Mud flats and ephemeral pools located at the east end of the beach face area. 41

Figure A25. P53-Bunche Beach County Preserve: Shorebirds and Snowy Egrets foraging in an ephemeral pool at the east end of the beach face area. 42

Figure A 26. Bowditch Pointe County Park Survey Area. 42

Figure A27. P36-Bowditch Pointe County Park: The main shorebird and larid roosting and foraging area along the intertidal zone of the inlet shoreline at medium tide.. 43

Figure A28. P37-Bowditch Pointe County Park: Ephemeral pool (west end of Estero Island and entrance to San Carlos Bay) and the roosting and foraging area along the intertidal zone of the inlet shoreline at low tide (same area as P36). 44

Figure A29. P38-Bowditch Pointe County Park: Roosting group including Marbled Godwit, Willet, Short-billed Dowitcher, and Sandwich Tern. 44

Figure A30. P39-Bowditch Pointe County Park: Piping Plover roosting in old wrack. During the surveys, four to five Piping Plovers were usually present. 45

Figure A31. P40-Bowditch Pointe County Park: Snowy Plover roosting in old wrack. During the surveys, one to two Snowy Plovers were usually present 45

Figure A32. P41-Bowditch Pointe County Park: Dunlin and Western Sandpiper foraging in fresh wrack (Red Drift Algae) along the intertidal zone 46

Figure A33. P42-Bowditch Point County Park: Two people walking with a dog off-leash. Roosting shorebirds and larids were flushed as a result.. 46

Figure A34. P43-Bowditch Pointe County Park: A park worker driving on the beach. Birds were flushed as a result.. 47

Figure A35. P44-Bowditch Pointe County Park: Area where shorebirds and larids typically roost.. 47

Figure A36. Little Estero Lagoon Survey Area. 48

Figure A37. P26-Little Estero Lagoon: beach adjacent to the Holiday Inn where ephemeral pools can be found. 49

Figure A38. P27-Little Estero Lagoon: Beach concession stand on the beach face adjacent to the Holiday Inn. 50

Figure A39. P28-Little Estero Lagoon: Most recent location of the channel connecting the lagoon to the Gulf 50

Figure A40. P29-Little Estero Lagoon: Small sandbar located just outside the channel that presently connects the lagoon to the Gulf. 51
Figure A41. P30-Little Estero Lagoon: This area located in the central lagoon has been the main shorebird foraging and larid roosting area for the past 10 years 51
Figure A42. P31-Little Estero Lagoon: This mud flat area is a result of a previous inlet/cut area. 52
Figure A43. P32-Little Estero Lagoon: This is an area at the south end of the lagoon that Red Knot seemed to favor for foraging during the survey. 52
Figure A44. P33-Little Estero Lagoon: Red Knots foraging in an ephemeral pool at the south end of the lagoon. 53
Figure A45. P34-Little Estero Lagoon: Example of the banded Red Knots found in large numbers at the lagoon in September. 53
Figure A46. P35-Little Estero Lagoon: Area close to the southern tip of the lagoon. 54
Figure A47. Big Carlos Pass Survey Area. 54
Figure A48. P19-Big Carlos Pass: Bridge connecting Estero Island and Lover's Key. 55
Figure A49. P20-Big Carlos Pass: Boats are parked along this stretch of beach at Lover's Key almost daily. 56
Figure A50. P21-Big Carlos Pass: Lover's Key (south side) shoreline along Big Carlos Pass. 56
Figure A51. P22-Big Carlos Pass: Lover's Key (south side) shoreline along Big Carlos Pass. 57
Figure A52. P23-Big Carlos Pass: View of the entrance to Big Carlos Pass from Lover's Key. Estero Island is in the upper right. 57
Figure A53. P24-Big Carlos Pass: View from under the bridge over Big Carlos Pass from Estero Island (north side). 58
Figure A54. P25-Big Carlos Pass: View into Big Carlos Pass looking south from Little Estero Lagoon. 58
Figure A55. Lover's Key Lagoon Survey Area. 59
Figure A56. P14-Lover's Key lagoon: Posted dunes are shown in the foreground, the sand-bar in the upper right, and a small section of the tram bridge in the far right. 60
Figure A57. P15-Lover's Key lagoon: Dunes and postings that protect the area just to the north of the previous picture. 60
Figure A58. P16-Lover's Key lagoon: Tram bridge that crosses the lagoon. 61
Figure A59. P17- Lover's Key lagoon: Gazebo just behind a dune restoration area. 61
Figure A60. P18- Lover's Key lagoon: The beach face on the Gulf side of the lagoon is a very popular beach area on weekends and holidays. 62
Figure A61. New Pass Survey Area 62
Figure A62. P9-New Pass: View of Big Hickory Island across the pass from Lover's Key (north side). 63
Figure A63. P10-New Pass: Boats parked on Big Hickory Island (south side). 64
Figure A64. P11-New Pass: Beach and intertidal area along the pass shoreline on Lover's Key (north side). 64
Figure A65. P12- New Pass: Boat traffic in the pass. 65
Figure A66. P13- New Pass: Ebb shoal outside the pass.. 65
Figure A67. Big Hickory Pass Survey Area. 66
Figure A68. P1-Big Hickory Pass. 67

Figure A69. P2-Big Hickory Pass. 67
Figure A70. P3-Big Hickory Pass: Difference between low and high tide is apparent by comparing this spot with P2. 68
Figure A71. P4-Big Hickory Pass. 68
Figure A72. P5-Big Hickory Pass: The inlet side of the spit with fishermen on the Bonita Beach (south) side of the pass. 69
Figure A73. P6-Big Hickory Pass: This is the main foraging area for shorebirds when the mud flat and ephemeral pool are present at low tide. 69
Figure A74. P7-Big Hickory Pass: Ephemeral pool located on the mudflat on the Bonita Beach (south) side of the pass. 70
Figure A75. P8-Big Hickory Pass: View of Big Hickory Island, which is located on the north side of the pass. 70

Tables

Table 1. Distribution of site visits by survey week. Surveys began on August 15 and ended on October 28, 2006. 6
Table 2. Tide height and direction by survey week. Sites are sorted from northwest to southeast. 6
Table 3 . Species cumulative counts. 10
Table 4. Magnitude of site use by all species. 12
Table 5. Percent of foraging observations by site by species. 13
Table 6. Percent of roosting observations by site by species. 14
Table C1. Cumulative and maximum counts by behavior at Charley Pass. Species are listed in taxonomic order. 76
Table C2. Charley Pass disturbance factors. 77
Table C3. Cumulative and maximum counts by behavior at Redfish Pass. Species are listed in taxonomic order. 77
Table C4. Redfish Pass disturbance factors. 78
Table C5 Cumulative and maximum counts by behavior at Sanibel Lighthouse. Species are listed in taxonomic order. 79
Table C6. Foraging substrate and landform use by all species at Sanibel Lighthouse. 80
Table C7. Roosting substrate and landform use by all species at Sanibel Lighthouse. 80
Table C8. Sanibel Lighthouse disturbance factors. 80
Table C9. Cumulative and maximum counts by behavior at Bunche Beach. 82
Table C10. Species with >10 percent of their regional foraging observations recorded at Bunche Beach. 83
Table C11. Foraging substrate and landform use by all species at Bunche Beach. 84
Table C12. Bunche Beach disturbance factors. 84
Table C13. Cumulative and maximum counts by behavior at Bowditch Point. 86
Table C14. Foraging substrate and landform use at Bowditch Point. 87
Table C15. Roosting landform and substrate use at Bowditch Point. 87
Table C16. Bowditch Point disturbance factors. 87
Table C17. Cumulative and maximum counts by behavior at Little Estero Lagoon. 88

Table C18. Species with more than 10 percent of their regional foraging observations recorded at Little Estero Lagoon. 89
Table C19. Species with more than 10 percent of their regional roosting observations recorded at Little Estero Lagoon. 90
Table C20. Foraging substrate and landform use by all species at Little Estero Lagoon. 91
Table C21. Roosting substrate and landform use by all species at Little Estero Lagoon. 91
Table C22. Little Estero Lagoon disturbance factors. 91
Table C23. Cumulative and maximum counts by behavior at Big Carlos Pass. Species are listed in taxonomic order. 92
Table C24. Big Carlos Pass disturbance factors. 93
Table C25. Cumulative and maximum counts by behavior at Lover's Key Lagoon. Species are listed in taxonomic order. 94
Table C26. Foraging substrate and landform use by all species at Lover's Key Lagoon. 95
Table C27. Roosting substrate and landform use by all species at Lover's Key Lagoon. 95
Table C28. Lover's Key Lagoon disturbance factors. 96
Table C29. Cumulative and maximum counts by behavior at New Pass. Species are listed in taxonomic order. 96
Table C30. New Pass disturbance factors. 97
Table C31. Cumulative and maximum counts by behavior at Big Hickory Pass. 98
Table C32. Foraging substrate and landform use by all species at Big Hickory Pass 99
Table C33. Roosting substrate and landform use by all species at Big Hickory Pass. 99
Table C34. Big Hickory Pass disturbance factors. 99

Preface

This study was coordinated by American Bird Conservancy under contract with the U.S. Army Engineer Research and Development Center – Environmental Laboratory (ERDC-EL), as part of a larger effort to understand the impacts of coastal engineering on birds. Point of contact at ERDC-EL is Dr. Richard A. Fischer.

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At the time of publication, Director of EL was Dr. Beth Fleming. Dr. James R. Houston was Director of ERDC, and COL Gary E. Johnston was Commander and Executive Director.

1 Introduction

Background

In Florida, many different taxonomic groups of birds are frequently referred to as "shorebirds" due to their strong association with coastal habitats (http://myfwc.com/shorebirds/). A global term for this group of ecologically related species that may be less taxonomically misleading is "shoreline-dependent birds." Shoreline-dependent birds have at least one part of their annual cycle (e.g., breeding, migration, or winter) when a large part of their population is restricted to the mosaic of coastal habitat types near shorelines (e.g., intertidal areas, dry beaches and dunes, coastal wetlands, or near-shore shallow waters). Some shoreline-dependent birds spend their entire life on the coast and rarely occur at inland locations, such as American Oystercatchers (Nol and Humphrey 1994). However, others may have large inland populations (in addition to coastal populations), or individuals of some populations may spend at least one part of the year away from the coast (e.g., Great Blue Herons, White Ibises) (Butler 1992, Kushlan and Bildstein 1992).

The tendency to survey shoreline-dependent birds by taxonomic grouping (e.g., shorebirds or wading birds) or taxonomic subgroups with similar aggregating behaviors (e.g., solitary plovers, colonial waterbirds) has led to an incomplete picture of avian habitat associations within Florida's coastal Barrier Island or Estuarine ecosystems; particularly for non-breeding birds. For example, within any barrier island habitat complex, intertidal flats are extensively used for foraging by many species of both non-breeding shorebirds and wading birds, although these two taxonomic groups are infrequently surveyed together. Similarly, barrier island beaches and shoals are extensively used for roosting by many species of both non-breeding shorebirds and seabirds, although these two taxonomic groups are also infrequently surveyed together. Additionally, no large-scale coordinated efforts have attempted to count shoreline-dependent birds during fall or spring migration, when many birds are abundant at stopover sites in Florida.

Consequently, despite a large amount of coordinated (and uncoordinated) coastal bird surveys (Sprandel et al. 1997, Douglass and Coburn 2002, Ferland and Haig 2002, Lamonte et al. 2006, Gore et al. 2007) the year-round distribution, abundance, and habitat associations of Florida's shoreline-dependent birds is still

poorly known. This impedes sound management of Florida's coastlines for birds, since there are no data to assess if recommendations for one species may conflict with the needs of another. Similarly, it is impossible to propose management recommendations that would positively affect the entire community of shoreline-dependent birds when neither this community, nor the habitat needs of its constituents, has been adequately described. Similarly, impacts of various management activities on shoreline-dependent birds (e.g., coastal engineering, beach management activities) can be only partially addressed (relative to data for the limited number of species or seasons where data have been collected).

This report presents results of a regional survey of all shoreline-dependent birds during fall migration in Lee County, Florida, during the fall of 2006. This study was designed to describe behavior-specific (e.g., foraging or roosting) distribution, relative abundance, and habitat associations for all species, regardless of taxonomy. Similar surveys, following the methods of this study, in additional regions, and during all parts of the year (breeding season, fall migration, winter, and spring migration), would provide a much stronger foundation for the management and monitoring of shoreline-dependent birds than is currently present. In particular, surveys during fall and spring migration would help to assess the importance of different stopover sites during these important seasons for shoreline-dependent birds in Florida.

Shoreline-dependent bird habitat use

Shoreline-dependent birds are common during all seasons in Florida, and at least some shoreline-dependent wading birds, shorebirds, and/or seabirds are present in every month of the year (Stevenson and Anderson 1994, Pranty 2005). Typically the annual cycle of birds is divided into the breeding and non-breeding portions of the year. Population limitation can occur during any portion of the annual cycle and threats may differ during different portions of the annual cycle both within and among species (Newton 2004). The non-breeding period includes the entire time period from post-breeding dispersal of both young and adults away from the nesting area until the beginning of the next breeding season. During the non-breeding season, adults are no longer tied to nests or young and activity areas are typically larger and more complex than during the breeding season. Habitat requirements for individual shoreline-dependent birds can be different for foraging and for roosting. Therefore, the distribution of non-breeding birds may be related to some mosaic of foraging and roosting habitats that are regionally present at different times during the tidal cycle. The spatial

and temporal extent of movements among foraging and roosting sites during the non-breeding season is unknown for many species, but see Gunnels (1999).

In addition to natural coastal processes, the distribution and quality of bird habitat on Florida's coasts may be strongly affected by human disturbance or coastal engineering (Lamonte et al. 2006). Many habitats used by birds in Florida are affected by large scale beach management activities such as shoreline protection through beach nourishment, dune building and planting, or removal of wrack from beaches, otherwise known as "beach cleaning" or "beach raking." Florida's coastal bird habitats are also affected by inlet management through activities such as jetty construction or inlet bypassing. The effects of coastal sediment management on birds have rarely been studied in Florida (see http://el.erdc.usace.army.mil/dots/coastalbirds.html for efforts in other areas). Planning for the conservation of Florida's shoreline-dependent birds, and understanding the specific impacts of human disturbance or coastal engineering, both require a greater understanding of shoreline-dependent bird habitat associations. Understanding the specific habitat associations of different species and/or communities of shoreline dependent birds will help to frame the study of the effects of human disturbance and/or coastal engineering on habitat availability and quality. In an effort to better understand these relationships, American Bird Conservancy conducted a fall migration study at 10 coastal locations within Lee County, Florida during the fall of 2006.

2 Methods

Bird counts

Charlie Ewell, a board member of the Florida Ornithological Society, conducted regular counts of shoreline-dependent birds at 10 different sites in southwestern Lee County, between August 15 and October 28, 2006. The entire study area covered the southeastern portion of the chain of nine barrier islands in Lee County (from Gasparilla Island to Little Hickory Island) that front the large estuary of Charlotte Harbor and the adjacent Estero Bay. Figure 1 is a regional map of the study area. Within the southwestern Lee County study area, 10 sites were selected for several reasons: 1) to cover all major inlets between North Captiva Island and Bonita Beach, near the Collier County Line; 2) to include important shorebird areas around Charlotte Harbor's southeastern opening, San Carlos Bay; and 3) to cover two important lagoons near Estero Bay. These 10 study sites did not represent complete coverage of all possible locations used by shoreline-dependent birds in Lee County. In particular, the large lagoon at Cayo Costa (which was difficult to access) and the managed impoundments and mudflats of Ding Darling National Wildlife Refuge were not sampled.

Site selection was practically limited by the absence of roads connecting all of these barrier islands. Most of the 10 selected sites could be accessed by car; however, two sites (Charley Pass and Redfish Pass at the western limit of the study area) required boat access and these sites were visited less frequently. Figure 1 shows the location of all study sites and the two other sites listed above that were not sampled. Eight of the 10 study sites were surveyed on a regular rotation during the 11 weeks between August 15 and October 28, 2006, and individual sites were visited once every 10-12 days. This resulted in seven different counts for all sites except Sanibel Lighthouse, which was visited eight times. The two sites requiring boat access (Charley Pass and Redfish Pass) were visited only three times during the study period. Table 1 shows the distribution of site visits by week.

Since survey protocol dictated that sites were visited on a regular rotation throughout fall migration, and there was only a single surveyor for this study, it was not practical to schedule visits at consistent tides.

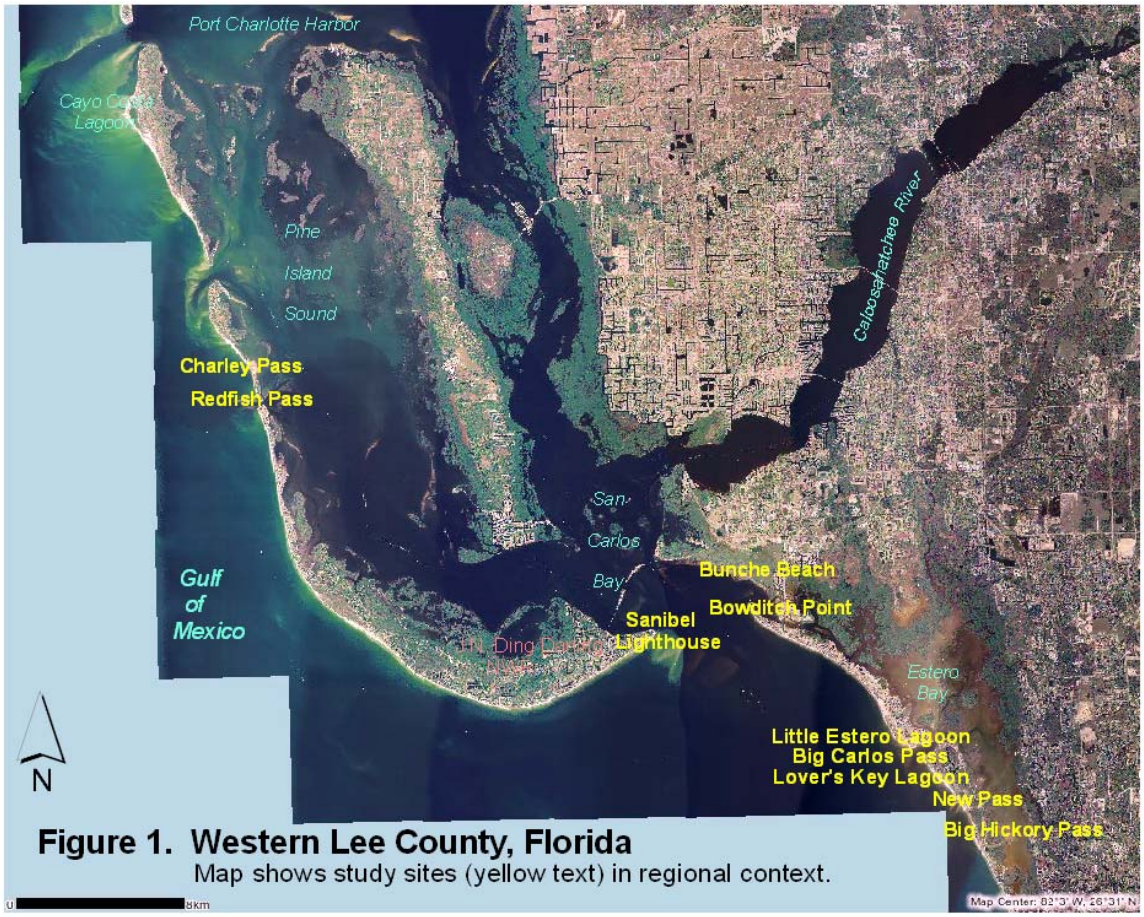

Figure 1. Lee County Study area. Surveyed sites are in yellow.

Therefore, different tide heights and directions were encountered at random at each site. Table 2 shows tide heights and direction for each site visit by week. Since counts are influenced by both date (due to the phenology of fall migration) and tides, a superior study design (if more resources were available) would be to conduct counts at each site at multiple standard tides (e.g. low, medium, and high tides) on each date (see protocols for the Wetland Bird Survey http://www.bto.org/survey/webs/index.htm). Controlling for tides in this manner would facilitate clearer comparisons of site use by both tide and date (and the interaction of these two factors).

Table 1. Distribution of site visits by survey week. Surveys began on August 15 and ended on October 28, 2006. Sites are sorted from northwest to southeast.

Site	1	2	3	4	5	6	7	8	9	10	11
Charley Pass		x		x		x					
Redfish Pass		x		x		x					
Sanibel Lighthouse	x	x	x		x	x	x		x		x
Bunche Beach	x	x	x			x	x		x		x
Bowditch Point	x		x		x	x	x		x	x	
Little Estero Lagoon	x	x		x	x	x		x		x	
Big Carlos Pass	x	x		x	x	x		x		x	
Lovers Key Lagoon	x		x	x		x	x	x		x	
New Pass	x		x	x		x	x	x		x	
Big Hickory Pass	x		x	x		x	x	x		x	

Table 2. Tide height and direction by survey week. Sites are sorted from northwest to southeast.

Site	1	2	3	4	5	6	7	8	9	10	11
Charley Pass		L, R		L, R		L, R					
Redfish Pass		L, R		L, R		L, R					
Sanibel Lighthouse	L, F	M, F	M, F		M, F	M, F	M, R		L, R		M, F
Bunche Beach	L, R	M, F	L, F			M, F	M, R		L, R		M, F
Bowditch Point	M, F		H, F		M, R	H, F	M, R		H, R	M, R	
Little Estero Lagoon	L, F	H, F		L, R	H, R	L, R		H, R		L, F	
Big Carlos Pass	L, F	H, F		L, F	H, R	L, R		H, R		L, R	
Lovers Key Lagoon	L, F		L, R	L, F		M, F	H, F	M, R		M, R	
New Pass	L, R		L, R	L, R		M, F	H, F	M, R		H, R	
Big Hickory Pass	L, F		L, F	L, F		H, F	H, F	M, R		M, R	

Tide height: L=Low M=Mid H=High Tide direction: F=Falling R=Rising

At each site, all potential foraging and roosting areas were surveyed with spotting scope and binoculars during each visit. Because of variation in the size of sites, some sites could be covered from a single observation location and other sites required walking or boating to multiple locations to cover the entire site. Appendix A includes maps that define the limits of survey coverage for each site and describe important foraging and roosting locations within each site. During each visit, in addition to bird observation data, data were also collected on: 1) survey effort, 2) weather conditions, 3) tide conditions, 4) possible disturbance factors, and 5) habitat conditions. For each site, individual bird observations were recorded separately based on unique combinations of four factors (each

with several levels): 1) species, 2) behavior (foraging or roosting), 3) habitat substrate (e.g., intertidal sand/mud, dry beach, old wrack), and 4) habitat landform (e.g., inlet shoreline, bayside beach, flood shoal). See Appendix B for the full datasheet, which includes a list of all possible levels for each factor.

Bird observations were recorded based on unique combinations of these four factors. For example, three dunlin foraging on intertidal flats on an inlet shoreline would be recorded as a single line on the datasheet. Two dunlin roosting on a dry beach along the same inlet shoreline would then be recorded on a separate line, and so on. This approach was slightly cumbersome in the field compared to simply counting numbers of birds; however, this level of detailed data collection was critical to document habitat use. This approach to field data collection allowed counts in the resulting database to be summarized by any combination of the four main factors, plus the additional factor of site (e.g. all dunlin counts, all dunlin foraging observations, all dunlin foraging observations in different habitat substrates, all dunlin roosting observations by landform, all species foraging substrate use by site). All data were entered and proofed from field datasheets to a Microsoft Access database, which is available from the lead author. If others wish to replicate this survey protocol, blank datasheets, and a blank database, ready for data entry, are available from the lead author.

Correspondence plots are used to illustrate patterns in both foraging and roosting habitat of the shoreline-dependent bird community. Correspondence analysis is a multivariate graphical technique that is useful to understand resource use in community ecology when observations are assigned to categories (McCune and Grace 2002). Correspondence analysis starts with a matrix of observations by category, for example, foraging landform use by species. Counts are then standardized as percentages prior to analysis to compare substrate use among species with different abundances. Correspondence analysis then uses matrix algebra to extract “dimensions” in the data that minimize the Euclidean distances between rows and columns. Frequently, the first two dimensions in the data explain a large percentage of the variation (which is known as “inertia” in correspondence analysis). Dimension scores for each species can then be graphed in a scatter plot to explore relationships among species and categories of observations. In our correspondence plots, each species is represented by a point and each landform type is represented by a red square. Data points for species with very strong associations with a single landform are closest to the red square for that landform. Data points for species that use more than one foraging landform are located between red squares for the two (or more) landforms that they use.

Therefore, data points for species with more generalist landform use are located further away from the red squares representing individual landforms than points for species that use only a single landform. Since most species had relatively strong substrate preferences (for both foraging and roosting), correspondence plots are based on foraging and roosting landform use, with substrate preferences represented by labels for individual species.

Interpretation of counts

Before presenting results of count data, a major point of interpretation must be clarified. The potential for pseudo-replication in this dataset is high (Hurlbert 1984). Since birds within the study area were unmarked, the degree to which counts on different dates (or at different sites on proximate dates) represent unique counts of new individuals or repetitive counts of the same individuals is unknown. Since the 11-week study period included fall migration for many species, it may be presumed that many individual birds are counted only once during stopover and that visits to the same site approximately 10 days apart would record different individual birds. If this were true, cumulative counts across all weeks would represent the total number of individuals using a site. However, if stopover lengths are longer than intervals between counts, or if some individuals are year-round or winter residents, then counts on different dates would include multiple counts of the same individuals. If all birds were resident, then average counts across all weeks would best represent the number of individuals using a site.

If most birds at a site are migrants, then average counts across all weeks would underestimate site importance since early or late-season counts will be much lower than counts during the peak migration time period (usually narrow) when most birds are passing through the study area (peak migration dates vary by species). In this case, the maximum number of birds counted during any one visit (for each species) might be the best index to site importance for migrants, and this number could be interpreted as the minimum number of birds that used a site during the entire study period. This number will almost always underestimate site use (since some different individuals are likely to be present on days before or after the date when the maximum count occurred); however, it is the only way to ensure that a count reflects unique individuals without marking all individuals within the population.

Additionally, since the spatial and temporal scale of movements of individuals among sites is unknown, it is impossible to know if individuals counted in the morning on site A are the same or different individuals than those counted in the afternoon at site B. In reality, for each site visit, some unknown proportion of counts is comprised of individuals that are counted only once and some unknown proportion of counts is comprised of individuals that are counted more than once. In this sense, all counts, whether cumulative, maximum, or averages, should be interpreted as indices of abundance, rather than population estimates. Estimating regional population size during the non-breeding season would require that all sites are counted at exactly the same time and date (to minimize movement of birds among sites within a region in response to changing tides). Regional population estimates of this sort would likely change throughout the migration period, as numbers of different species change due to date. Since most of the shoreline-dependent birds encountered during this study are migratory, and since the study took place during peak fall migration, count totals are reported as either cumulative or maximum counts, or both, depending on the objectives of individual data summaries. For species that were resident within the study area, both cumulative and maximum counts likely represent repetitive counts of the same individuals and are, as such, inflated indices of numbers of individuals.

3 Results

Almost 45,000 observations of 42 species were recorded during this study (Table 3). Twelve of these species were uncommon (≤12 total observations) and are not included in subsequent data summaries of habitat use. Counts varied strongly by species, site, behavior, and habitat. Count totals are summarized several different ways to describe regional relative abundance and habitat use, including several pooled data summaries (in the Overall Results section) and site-specific summaries (in the Site-specific Results Appendix (C).

Pooled data are used to present: 1) foraging and roosting observations by species (all sites combined); 2) foraging and roosting observations by site (all species combined); and 3) foraging and roosting substrate by species (all sites combined). Site-specific data for each of the 10 survey sites we present: 4) foraging and roosting observations by species; 5) foraging and roosting landform and substrate use; and 6) disturbance factors that may affect habitat use or quality.

Table 3 . Species cumulative counts. In this presentation, counts are pooled across all sites and weeks. Species are then sorted by the total number of observations. Counts are an index of abundance, not an estimate of total numbers of individuals.

	Cumulative counts		
Common Name	Foraging	Roosting	Total
Sandwich Tern	77	11,553	11,630
Laughing Gull	24	6,882	6,906
Western Sandpiper	3,469	1,306	4,775
Short-billed Dowitcher	3,103	569	3,672
Sanderling	2,060	157	2,217
Royal Tern	15	2,048	2,063
Brown Pelican	6	1,899	1,905
Semipalmated Plover	853	738	1,591
Black Skimmer		1,359	1,359
Least Sandpiper	1,230	24	1,254
Willet	851	280	1,131
Red Knot	1,018	17	1,035
White Ibis	848		848
Great Egret	729	2	731
Snowy Egret	653	10	663
Ruddy Turnstone	564		564

Common Name	Cumulative counts		
	Foraging	Roosting	Total
Black-bellied Plover	317	79	396
Wilson's Plover	176	211	387
Little Blue Heron	287		287
Least Tern	22	220	242
Double-crested Cormorant	1	200	201
Marbled Godwit	166	5	171
Forster's Tern		149	149
Semipalmated Sandpiper	128		128
Dunlin	104		104
Piping Plover	66	20	86
Reddish Egret	52		52
Roseate Spoonbill	46	5	51
Snowy Plover	33	17	50
Great Blue Heron	44		44
Black Tern	12		12
Spotted Sandpiper	11		11
American Avocet	4	2	6
Killdeer		5	5
Ring-billed Gull		5	5
Lesser Yellowlegs	2	2	4
Common Tern	2	2	4
Wood Stork	3		3
Whimbrel	3		3
Osprey		1	1
Cooper's Hawk	1		1
Caspian Tern		1	1

Counts summarized by behavior, species, and site

The 10 study sites had different magnitudes of site use, which varied strongly by behavior (foraging or roosting) (Table 4). To compare foraging and roosting observations among sites, counts were pooled across species and weeks. Some sites were important for both foraging and roosting (e.g., Bunche Beach, Little Estero Lagoon) and others had much higher numbers of roosting observations than foraging observations (e.g., Charley Pass, Bowditch Point, Big Hickory Pass, New Pass). Since the community structure and relative abundance of birds using any one site clearly differed by behavior, subsequent summaries of counts and

habitat use are presented by species separately for both foraging and roosting observations at each site in "Site-specific Results".

Table 4. Magnitude of site use by all species. Sites are sorted by total number of observations. Counts are an index of abundance, not an estimate of total numbers of individuals. Note that all sites were not visited the same number of times.

Site	N visits	Cumulative counts		
		Foraging	Roosting	Total
Bunche Beach	7	9,777	5,887	15,664
Charley Pass	3	982	10,452	11,434
Little Estero Lagoon	7	3,224	4,273	7,497
Bowditch Point	7	553	4,000	4,553
Lovers Key Lagoon	7	1,261	645	1,906
Big Hickory Pass	7	498	1,052	1,550
New Pass	7	54	1,117	1,171
Sanibel Lighthouse	8	357	184	541
Big Carlos Pass	7	252	1	253
Redfish Pass	3	22	157	179

Counts also varied strongly by behavior within and among species (Table 3). Note that some species were commonly observed both foraging and roosting in the study area (Semipalmated Plovers and Wilson's Plovers); however, most species were more frequently observed either foraging (e.g., Short-billed Dowitcher) or roosting (e.g., Sandwich Tern) in the study area.

Site importance varied according to the interaction between species and behavior. In other words, some sites were particularly important to a species for foraging, particularly Bunche Beach, Little Estero Lagoon, and Lovers Key Lagoon for many species and Charley Pass and Bowditch Beach for some species (Table 5). Similarly, some sites were particularly important to a species for roosting, such as Charley Pass, Bunche Beach, Bowditch Point, and Little Estero Lagoon for many species and Lover's Key Lagoon for some species (Table 6). Appendix C, "Site-specific Results," discusses the importance of individual sites to different species in greater detail.

Table 5. Percent of foraging observations by site by species. Species are sorted by abundance (only species with >33 observations are included). Sites are sorted from west to east. The importance of Charley Pass is underemphasized in this table, since this site was visited less frequently than others.

Common Name	Total	Charley Pass	Redfish Pass	Sanibel Lighthouse	Bunche Beach	Bowditch Point	Little Estero Lagoon	Big Carlos Pass	Lover's Key Lagoon	New Pass	Big Hickory Pass
Western Sandpiper	3469	5.1%	0.0%	0.3%	59.3%	4.3%	18.8%	0.0%	8.8%	0.0%	3.4%
Short-billed Dowitcher	3103	1.5%	0.0%	0.0%	89.6%	0.7%	0.5%	0.0%	7.6%	0.0%	0.2%
Sanderling	2060	11.3%	0.5%	3.2%	28.3%	5.4%	35.6%	4.5%	6.3%	1.3%	3.6%
Least Sandpiper	1230	11.9%	0.0%	0.0%	46.6%	0.1%	14.0%	0.0%	13.8%	0.0%	13.7%
Red Knot	1018	3.9%	0.0%	0.2%	18.0%	0.0%	73.2%	0.6%	3.5%	0.0%	0.6%
Semipalmated Plover	853	10.3%	0.0%	0.0%	40.7%	10.8%	25.8%	0.0%	10.9%	0.0%	1.5%
Willet	851	6.6%	0.5%	4.6%	58.3%	4.7%	13.9%	4.5%	3.8%	0.6%	2.7%
White Ibis	848	0.0%	0.0%	0.0%	88.9%	0.0%	5.4%	0.0%	5.1%	0.0%	0.6%
Great Egret	729	0.0%	0.1%	1.6%	79.3%	0.0%	13.3%	1.8%	2.2%	0.4%	1.2%
Snowy Egret	653	0.0%	0.3%	7.7%	69.2%	0.0%	12.6%	2.5%	4.6%	0.5%	2.8%
Ruddy Turnstone	564	20.0%	0.5%	5.1%	19.0%	8.2%	22.0%	8.7%	9.2%	2.1%	5.1%
Black-bellied Plover	317	11.0%	0.3%	4.4%	49.5%	2.8%	15.5%	5.4%	9.8%	0.3%	0.9%
Little Blue Heron	287	0.0%	0.0%	0.0%	94.1%	0.0%	3.5%	0.7%	1.4%	0.0%	0.3%
Wilson's Plover	176	1.1%	0.0%	0.0%	19.9%	18.8%	50.6%	0.6%	7.4%	0.6%	1.1%
Marbled Godwit	166	0.0%	0.0%	0.0%	84.9%	0.0%	7.2%	0.0%	7.8%	0.0%	0.0%
Semipalmated Sandpiper	128	23.4%	0.0%	0.0%	56.3%	0.0%	3.9%	0.0%	3.9%	0.0%	12.5%
Dunlin	104	1.0%	0.0%	0.0%	73.1%	26.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sandwich Tern	77	0.0%	0.0%	96.1%	0.0%	0.0%	0.0%	3.9%	0.0%	0.0%	0.0%
Piping Plover	66	9.1%	0.0%	0.0%	48.5%	31.8%	10.6%	0.0%	0.0%	0.0%	0.0%
Reddish Egret	52	0.0%	0.0%	15.4%	38.5%	0.0%	19.2%	11.5%	15.4%	0.0%	0.0%
Roseate Spoonbill	46	0.0%	0.0%	0.0%	56.5%	0.0%	28.3%	0.0%	15.2%	0.0%	0.0%
Great Blue Heron	44	0.0%	0.0%	4.5%	52.3%	0.0%	13.6%	13.6%	6.8%	0.0%	9.1%
Snowy Plover	33	30.3%	0.0%	0.0%	9.1%	12.1%	48.5%	0.0%	0.0%	0.0%	0.0%

Table 6. Percent of roosting observations by site by species. Species are sorted by abundance (only species with >17 observations are included). Sites are sorted from west to east. The importance of Charley Pass is underemphasized in this table, since this site was visited less frequently than others.

Common Name	Total	Charley Pass	Redfish Pass	Sanibel Lighthouse	Bunche Beach	Bowditch Point	Little Estero Lagoon	Big Carlos Pass	Lover's Key Lagoon	New Pass	Big Hickory Pass
Sandwich Tern	11553	60.6%	0.7%	0.4%	22.5%	6.0%	3.2%	0.0%	1.9%	2.4%	2.2%
Laughing Gull	6866	17.0%	0.3%	1.6%	12.6%	13.8%	41.0%	0.0%	2.7%	5.0%	6.0%
Royal Tern	2048	41.0%	2.5%	0.4%	25.5%	6.9%	9.9%	0.0%	3.1%	4.9%	5.7%
Brown Pelican	1899	46.4%	0.0%	0.0%	22.3%	1.8%	4.7%	0.0%	3.1%	19.1%	2.6%
Black Skimmer	1359	35.7%	0.0%	0.0%	50.0%	3.3%	10.2%	0.0%	0.0%	0.0%	0.9%
Western Sandpiper	1306	0.0%	0.0%	0.0%	0.0%	81.5%	18.5%	0.0%	0.0%	0.0%	0.0%
Semipalmated Plover	738	5.4%	0.0%	0.0%	0.0%	70.2%	13.4%	0.0%	0.8%	0.0%	10.2%
Short-billed Dowitcher	569	0.0%	0.0%	0.0%	87.9%	6.7%	4.0%	0.0%	0.0%	0.0%	1.4%
Willet	280	1.8%	0.0%	0.0%	35.7%	17.1%	11.4%	0.0%	18.6%	2.1%	13.2%
Least Tern	220	0.0%	0.0%	0.0%	4.1%	75.5%	18.2%	0.0%	0.0%	0.0%	2.3%
Wilson's Plover	211	2.4%	0.0%	0.0%	0.0%	60.2%	23.7%	0.0%	1.4%	0.0%	12.3%
Double-crested Cormorant	200	0.0%	0.0%	0.0%	34.0%	0.5%	18.5%	0.0%	26.0%	15.0%	6.0%
Sanderling	157	0.0%	0.0%	0.0%	0.0%	62.4%	37.6%	0.0%	0.0%	0.0%	0.0%
Forster's Tern	149	2.0%	0.0%	1.3%	69.1%	11.4%	14.8%	0.0%	0.0%	0.0%	1.3%
Black-bellied Plover	79	31.6%	0.0%	0.0%	0.0%	19.0%	19.0%	0.0%	0.0%	0.0%	30.4%
Least Sandpiper	24	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
Piping Plover	20	0.0%	0.0%	0.0%	0.0%	90.0%	10.0%	0.0%	0.0%	0.0%	0.0%
Snowy Plover	17	0.0%	0.0%	0.0%	0.0%	58.8%	41.2%	0.0%	0.0%	0.0%	0.0%
Red Knot	17	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Counts summarized by habitat use

Habitat use was characterized by two different categories: substrate and landform. Both foraging and roosting substrate use was relatively consistent among sites within a species (exceptions are presented in Appendix C "Site-Specific Results"). Four different foraging substrates (shallow water, intertidal sands and muds, fresh wrack, and ephemeral pools) were important (>44 percent of all observations) for at least one species (Figure 2). Three other foraging substrates (dry beach, rock, and vegetation) were uncommonly recorded, comprising <7 percent of all observations for all species. Ranked by total foraging observations across all sites with all species pooled, the top 4 foraging substrates were: intertidal muds and sands (8,986 observations), shallow water (2,853), ephemeral pools (2,847), and fresh wrack (2,124). The majority of foraging observations occurred on intertidal substrate for 13 species, in shallow water for 8 species, in fresh wrack for 1 species, and in ephemeral pools for 1 species (Figure 2).

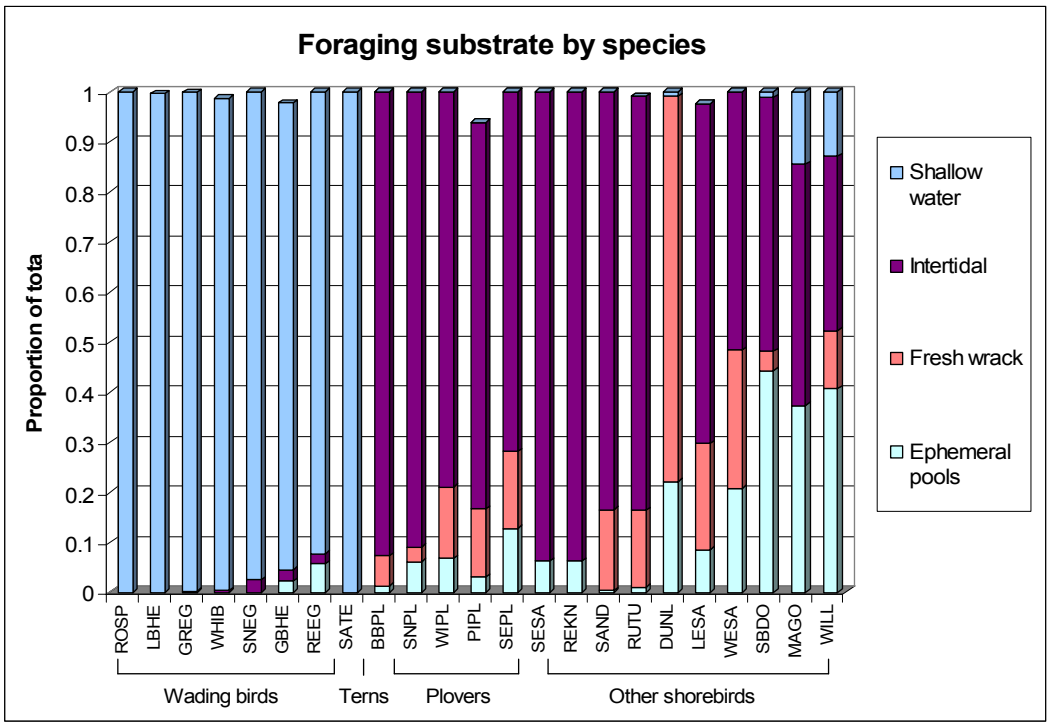

Figure 2. Foraging substrate use by 23 shoreline-dependent species with ≥33 cumulative observations. Species are grouped taxonomically and then within each taxonomic group by strength of substrate use.

Of 23 species, 19 had strong associations (>67 percent of all observations) with a single foraging substrate. Foraging substrate preference was consistent within taxonomic groups; shallow water was preferred for all wading bird species, intertidal substrates were preferred by all plovers and by most other shorebirds (with the exception of dunlins, which preferred fresh wrack).

Six different roosting substrates were important (>19 percent of all observations) for at least one species. Ranked by total roosting observations across all sites with all species pooled, the top six roosting substrates were: intertidal muds and sands (21,018 observations); dry sand (2,392); ephemeral pools (1,545); old wrack (1,197); and vegetation (52). Nine species had a majority of observations on intertidal substrates, six in old wrack, and four in dry sand (Figure 3). Of 19 species, 16 had very strong associations (>67 percent of all observations) with a single roosting substrate. Roosting substrate preference was not consistent among species within each taxonomic group, particularly among non-plover shorebirds. However, four out of five plover species had a high proportion of roosting observations in old wrack.

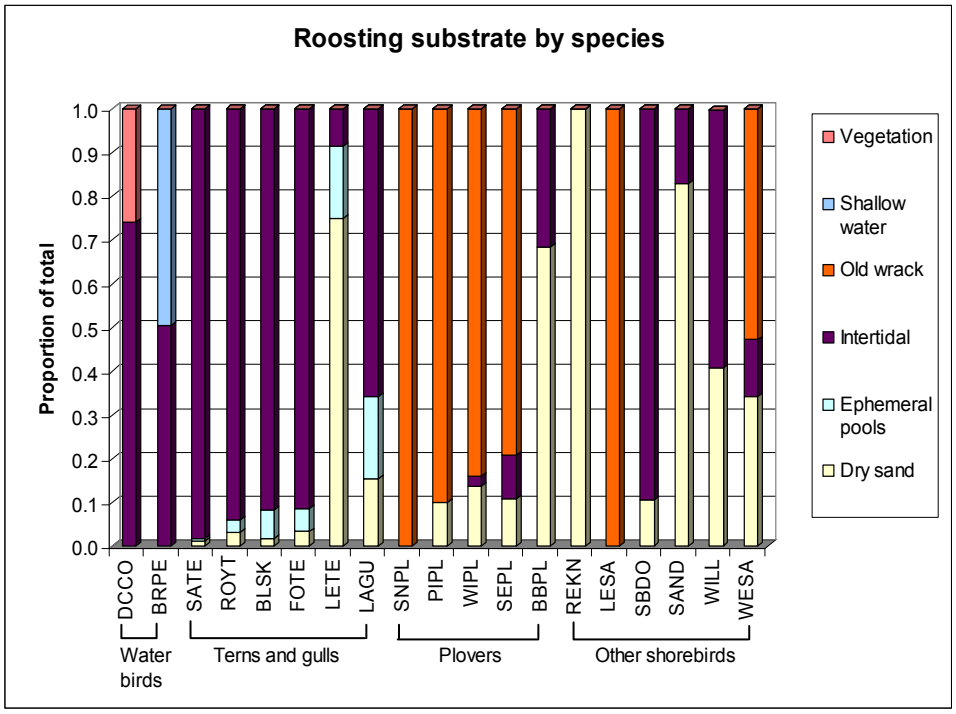

Figure 3. Roosting substrate use by 19 shoreline-dependent species with ≥17 cumulative observations. Species are grouped taxonomically and then within each taxonomic group by strength of substrate use.

Unlike substrate use, which was relatively consistent among sites, both foraging and roosting landform use varied considerably by site (see Appendix C "Site-specific Results"). Five major landforms were important (>36 percent of all observations) for foraging for at least one species (Figure 4). Ranked by total foraging observations across all sites with all species pooled, these were: bay beaches (9,812 observations); lagoons (2,444); ocean beaches (2,236); inlet shorelines (1,317); and flood shoals (1,050). Of 23 species, 17 had a majority of their foraging observations on bay beaches, 3 on ocean beaches, 2 in lagoons, and 1 along inlet shorelines (Figure 4). However, only 7 out of 23 species had very strong associations (>67 percent of all observations) with a single landform, compared to 19 of 23 species with very strong foraging substrate associations. Foraging landform preference was less consistent within taxonomic groups than it was for foraging substrates. Although bay beaches were preferred by most wading birds and inlet shorelines were preferred by terns, a mix of foraging landforms was used by different plover species and other shorebirds (Figure 4).

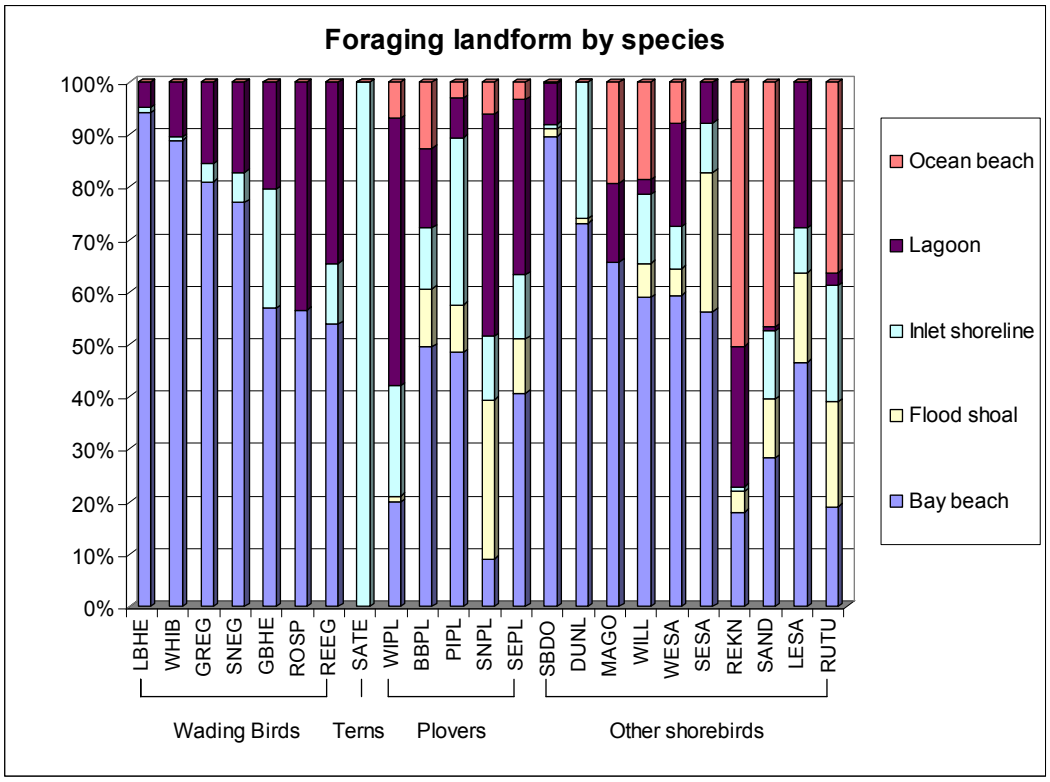

Figure 4. Foraging landform use by 23 shoreline-dependent species with ≥33 cumulative observations. Species are grouped taxonomically and then within each taxonomic group by strength of landform use.

Six different roosting landforms were important (>36 percent of all observations) for at least one species (Figure 5). Ranked by total roosting observations across all sites with all species pooled, these were: flood shoals (10,450 observations); bay beaches (5,900); ocean beaches (5,520); inlet shorelines (4,200); ebb shoals (1,117); and lagoons (525). Eight species had a majority of their roosting observations along inlet shorelines, four on bay beaches, three on flood shoals, three on ocean beaches, and one in lagoons (Figure 5). However, only 7 out of 19 species had very strong associations (>67 percent of all observations) with a single roosting landform compared to 16 of 19 species with very strong roosting substrate associations. Roosting landform preference was also less consistent within taxonomic groups than it was for roosting substrates. Although four out of five plover species preferred inlet shorelines for roosting, roosting landform preferences were mixed for other taxonomic groups (Figure 5).

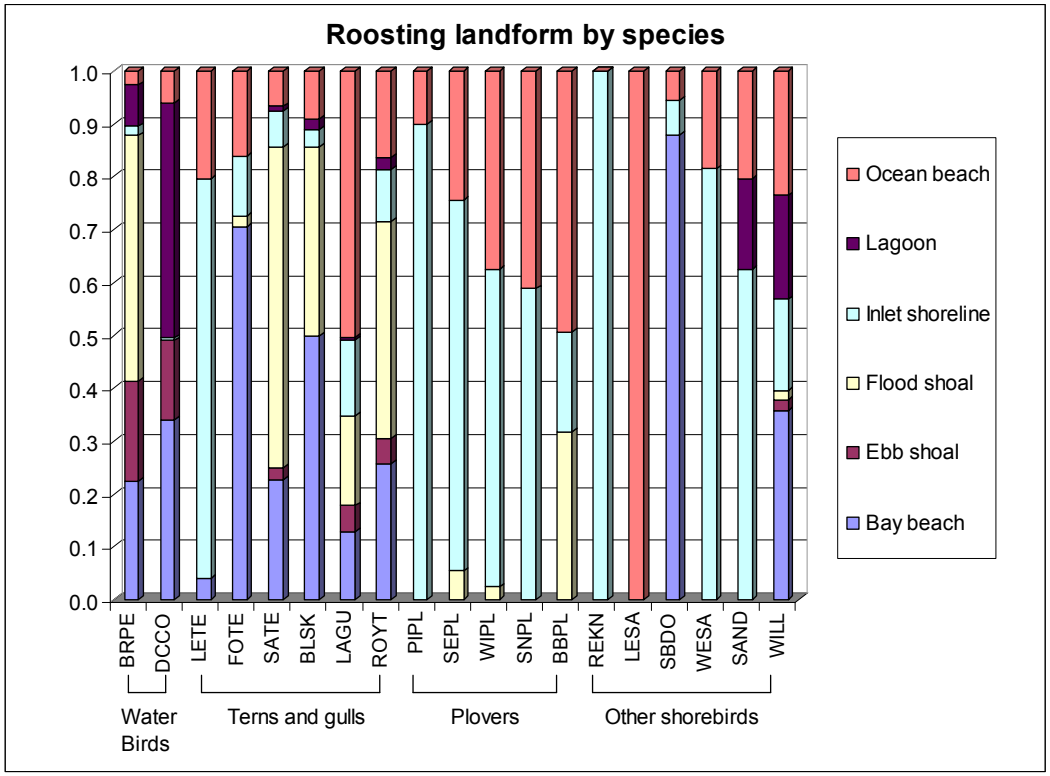

Figure 5. Roosting landform use by 19 shoreline-dependent species with ≥17 cumulative observations. Species are grouped taxonomically and then within each taxonomic group by strength of substrate use.

Correspondence plots combine information on substrate and landscape preferences by species, giving a graphical representation of how habitat resources are used by the entire shoreline-dependent bird community across all sites within the Lee County study area. The correspondence plot for foraging habitat use (Figure 6) illustrates three main patterns: 1) bay beach areas were heavily used by wading birds that foraged mostly in shallow water substrates; 2) ocean beaches were used mostly by three species of shorebirds that forage on intertidal substrates (Sanderling, Ruddy Turnstone, and Red Knot); and 3) all other species of shorebirds used a mix of landform types, regardless of their preference for intertidal substrates, fresh wrack, or ephemeral pools (Figure 6).

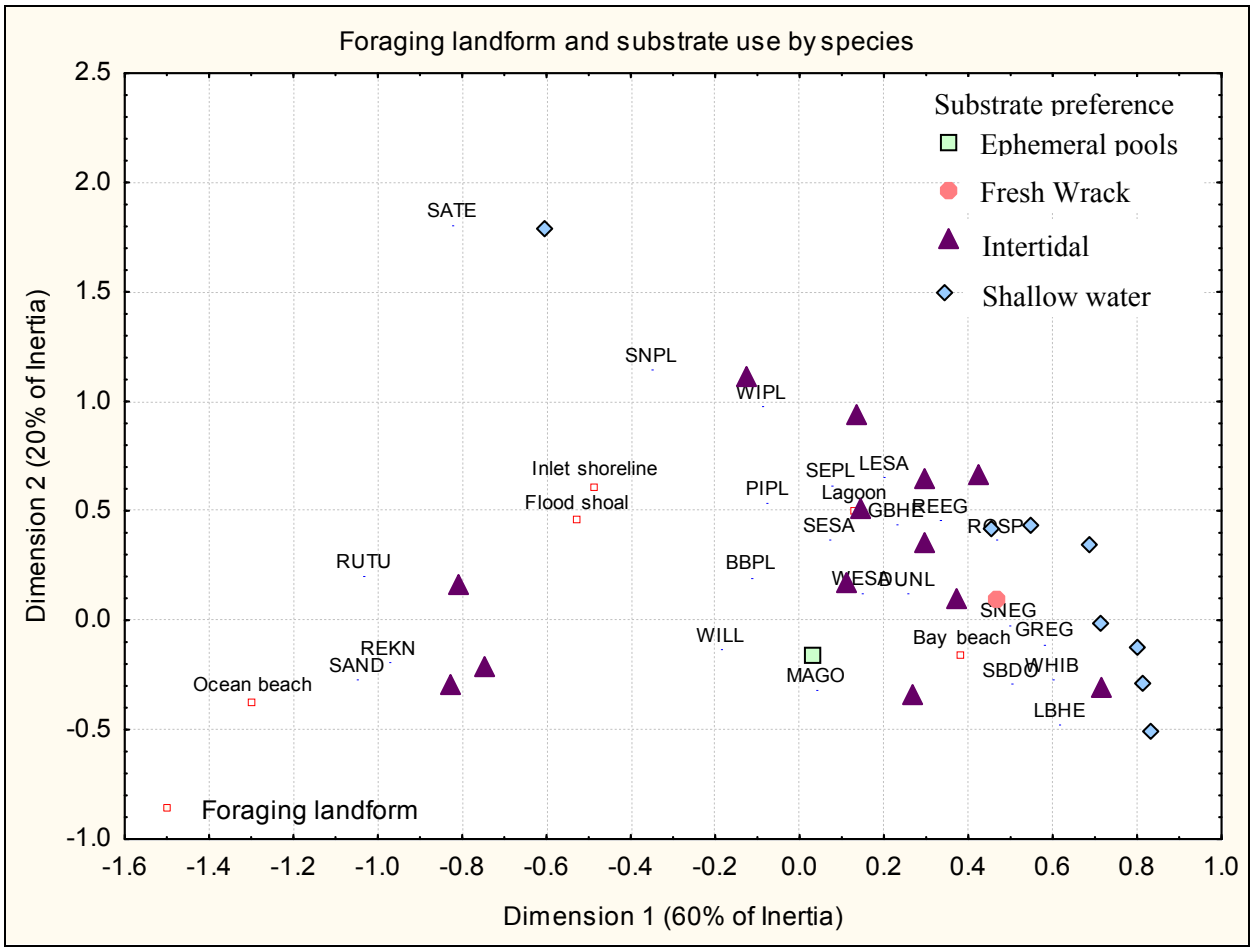

Figure 6. Correspondence plot illustrating foraging landform use for species with >33 cumulative foraging observations. Symbols indicate the substrate on which the majority of each species' observations occurred (see legend at top right of figure). Different landform types are represented by labeled squares. Species names for four-letter codes are listed in Appendix B.

The correspondence plot for roosting habitat use illustrates several strong patterns: 1) most species that roosted preferentially in old wrack substrates did so near inlet shorelines. This included 1) Western Sandpipers and all plover species except for Black-bellied Plovers; 2) three species that preferred to roost on inlet shorelines also roosted on dry sand (Least Terns, Red Knots, and Sanderlings; 3) birds that tended to roost on intertidal substrates roosted on a variety of different landform types; and 4) a few species that roosted on ocean beaches, with the exception of Black-bellied Plovers, Laughing Gulls, and Least Sandpipers, all of which used different substrates (Figure 7).

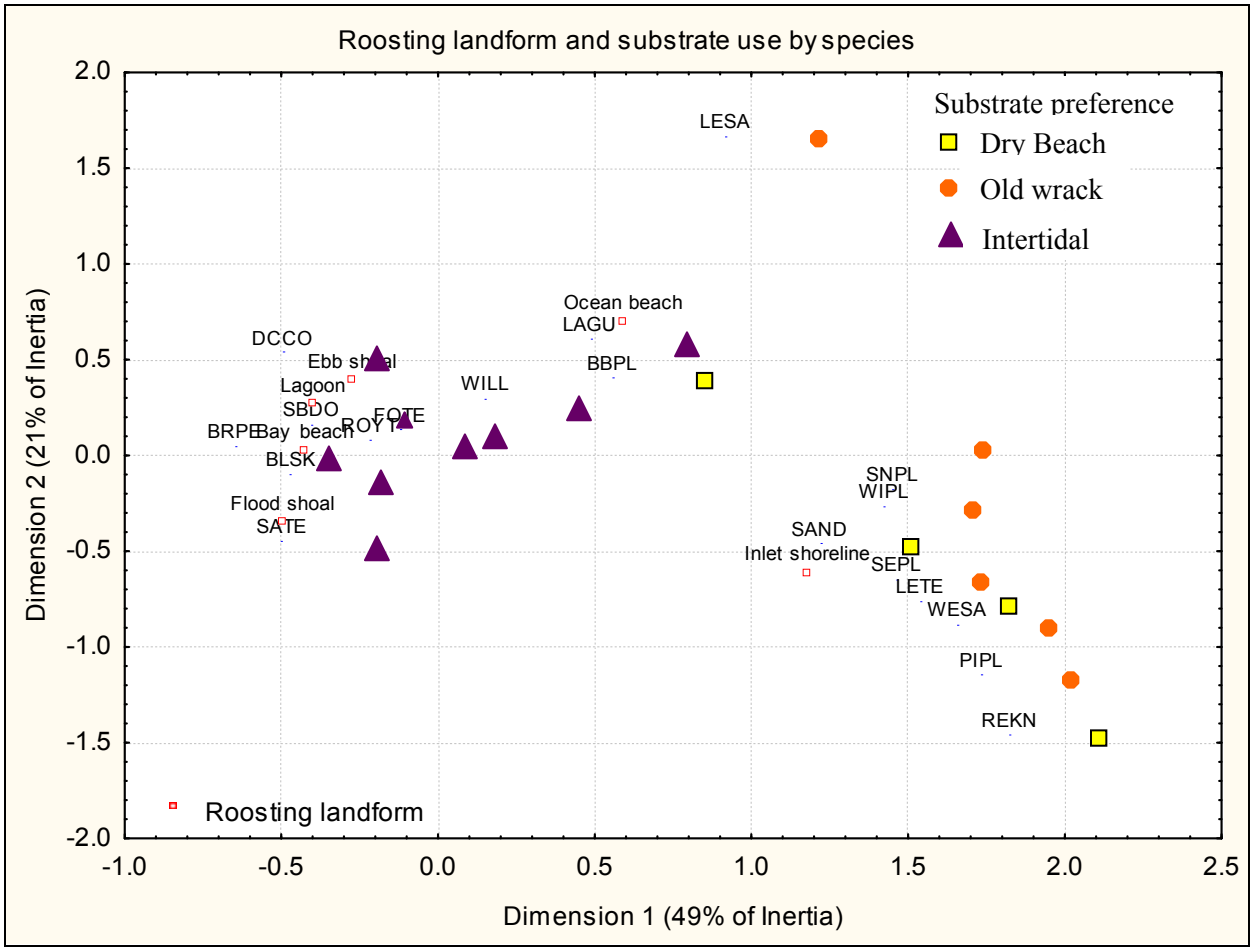

Figure 7. Correspondence plot illustrating roosting landform use for species with >17 cumulative roosting observations. Symbols indicate the substrate on which the majority of each species' observations occurred (see legend at top right of figure). Different landform types are represented by labeled squares. Species names for four-letter codes are listed in Appendix B.

4 Discussion

Survey protocols for non-breeding birds that are designed to demonstrate bird habitat associations across taxonomic lines are both feasible (since birds of many taxa occur at the same location at the same time) and advisable (since threats to coastal habitats, such as development and high human use, affect all shoreline-dependent birds, regardless of taxonomy). Conservation planning for shoreline-dependent birds will need to include strategies for both sites and species; however, protection of very important sites (such as Bunche Beach, Charley Pass, Little Estero Lagoon, Bowditch Point, and Lover's Key Lagoon) will be helpful to many species.

Within each site, different species use different resources and these resources differ depending on whether the species is foraging or roosting. In this study area, counts of foraging and roosting birds differed so strongly that it might even be said that different communities of shoreline-dependent birds used the study area for foraging and for roosting. Some species that were abundant roosting birds were scarcely observed foraging in the study area (terns, skimmers, and pelicans). Many species that were commonly observed foraging in the study area were much less frequently observed roosting (most shorebirds and herons). Capturing both foraging and roosting habitat use by all species would require an expansion of the study area chosen for this study. Most of the seabirds and waterbirds (terns, skimmers, and pelicans) that were common roosting birds in this study are known to forage offshore, in some cases, well offshore. Wading birds roosts are frequently observed outside of the barrier island/inlet system sampled during this study, in adjacent mangroves or other inland wetlands. It is less clear where important roosting areas for shorebirds, which we observed much more frequently foraging than roosting, might be located. It's possible that aerial surveys of the Charlotte Harbor Estuary at high tide would be able to locate large roosts of shorebirds. Conservation planning for shorebirds would benefit considerably from knowing the location of these roosts and achieving their protection.

Although habitat substrate and landform preference varied by species and site, some general patterns were striking within Lee County's shoreline-dependent bird community. Strongest, perhaps, was the association of

foraging birds with low-energy intertidal substrates. Some shorebirds also foraged on patchily distributed resources of fresh wrack and ephemeral pools, which were also frequently available at low-energy sites. However intertidal flats and adjacent shallow-water areas on bay beaches, lagoons, flood shoals, and inlet shorelines provided most of the foraging areas for the majority of all species. Only a few species used intertidal areas on beaches exposed to wave energy from the Gulf of Mexico and nearly no individuals used dry beaches for foraging. Given the strong association of shoreline-dependent birds with mudflats, habitat mapping of intertidal areas, although challenging (see Zharikov et al. 2005) could help to delineate important areas for shorebirds that have not been identified during road-based surveys. For example, it is possible that mudflats in remote, boat-accessible locations in Estero Bay, Pine Island Sound, and the northern bays of Port Charlotte Harbor may support large numbers of foraging birds.

Another striking pattern of habitat use was the strong preference of several plover species for roosting in old wrack on inlet shorelines. Again, few species used dry Gulf beaches for roosting, and the species that did not prefer roosting on inlet shorelines tended to roost in low-energy intertidal areas around bay beaches, flood shoals, and lagoons. An exception to this was the use of several ebb shoals for roosting, when tides were low enough to expose them.

Habitat conservation for the community of birds described in this study should focus on preservation of intertidal substrates in low-energy landforms. Engineering projects that may disrupt geomorphologic processes that create and/or maintain these habitat types should be avoided. For example, when new inlets are created during hurricanes, such as the inlet at Charley Pass, they should be allowed to remain open and/or close on their own, as long as they present no danger to human life. These areas become extremely important for both foraging and roosting birds, often supplying many acres of new intertidal substrates, which may be in short supply in some regions. Since these areas also receive tremendous recreational use (Charley Pass received by far the most disturbance of any site in this study) new inlets/washover areas should receive increased protection from state wildlife agencies. Similarly, areas that receive habitat renewal through overwash should not have this process altered by the installation of high berms.

Since the greatest amount of habitat use occurred in low-energy areas around bays and inlets, any engineering activity that increases wave energy in these areas, which may result in habitat loss through erosion or the coarsening of intertidal sediments, should be avoided. This may include the mining of ebb shoals for beach nourishment projects if shoal removal will result in an increase of wave energy that could damage an important site for shoreline-dependent birds. Similarly, mining flood shoals for material for beach nourishment projects, or to remove navigation hazards, could result in the direct loss of considerable habitat for shoreline-dependent birds.

In this study, wrack was used by several different species of shorebirds. Fresh red drift algae in the intertidal zone was commonly used for foraging by many species and older wrack, deposited higher on the beach by seasonally high tides or storm surges, was particularly important as a roosting substrate for several high-priority plover species. County and city ordinances to protect this resource should be enforced and wrack should not be removed from beaches unless a significant human health hazard can be documented.

Finally, this study focused only on the fall migration period in the barrier island/inlet system fronting the Charlotte Harbor Estuary in Lee County. Similarly detailed investigations of habitat use during other seasons (winter, spring migration, and breeding) and at other locations would be very helpful to determine the best strategies for the year-round conservation of shoreline-dependent birds in Florida. Additional regional surveys using these protocols would be helpful to understand the generality of patterns of habitat use observed in this study.

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Appendix A: Lee County Study Sites

This appendix contains aerial maps that define the limits of survey coverage for each study site. Each map contains a series of polygons and two letters. These represent important foraging and roosting locations within each site (Fx=features from description that follows) and photographs of these areas (Px=photo locations). Study sites are presented west to east.

Charley Pass area (North Captiva Island)

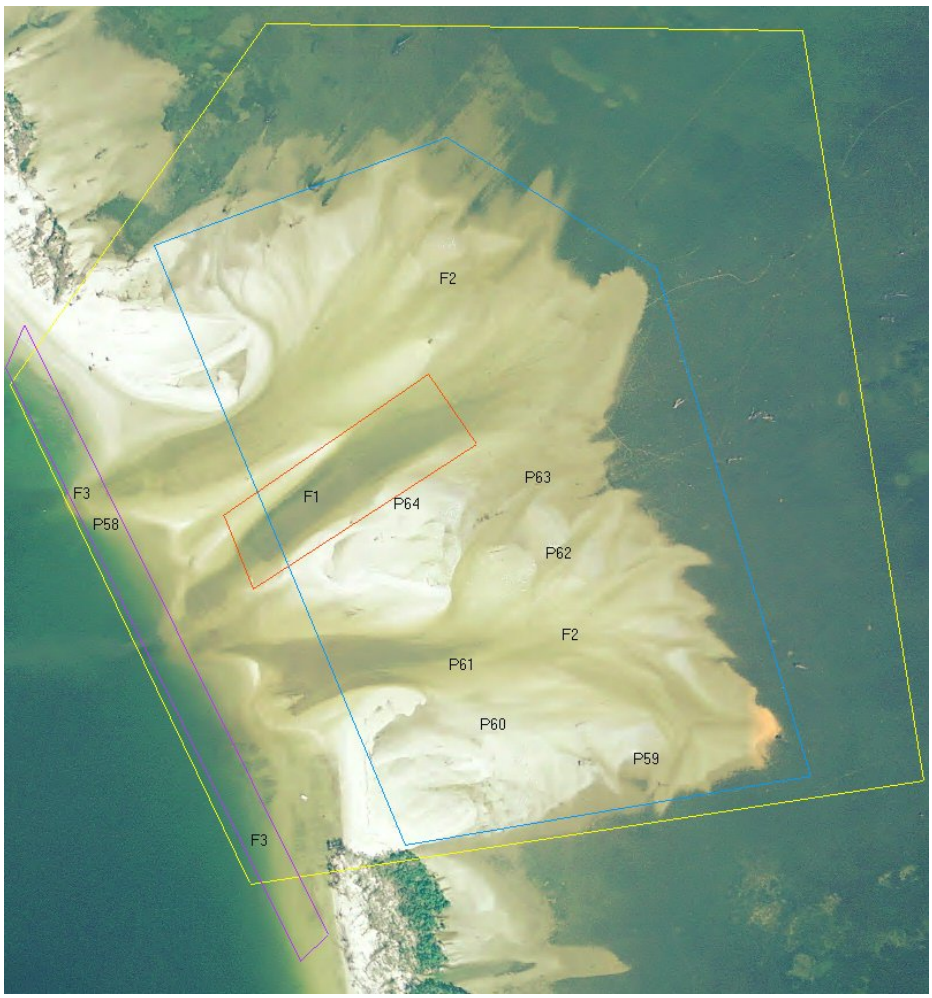

Figure A1. Charley Pass Survey Area.

Charley Pass: This area is the “pass” or “cut” that was created along a narrow stretch of North Captiva Island by the passage of Hurricane

Charley. It was initially described by the Florida DEP as being 0.3 mile wide. It has since narrowed to close to under 50 m by the authors estimation (F1). An extensive flood shoal was created as a result of the cut (F2). The shoal attracted thousands of birds in the fall of 2006, the majority being Sandwich Terns and immature Brown Pelicans. At low tide, it was an attractive foraging area for sandpipers and plovers, and at high tide the shoal was still shallow enough for most birds to use as a roost area. Charley Pass is a popular boating destination. Weekends and holidays outside of winter consistently host 30-50 boats anchoring outside the Gulf side of the pass (F3). Many boaters come ashore and explore the mudflats. Birds are typically flushed by these activities.

Figure A2. P58-Charley Pass, North Captiva Island: Boats parked in the Gulf on the north side of the entrance to the pass. This sight is duplicated on the south side of the pass as well. Both sides will have boats anchored offshore on weekends outside of winter.

Figure A3 P59-Charley Pass, North Captiva Island: Boat anchored on the shallow flood shoal on the bay side of the island in Pine Island Sound. This is not a common site due to the shallowness of the area. The majority of foraging and roosting birds are located on the bayside.

Figure A4. P60-Charley Pass, North Captiva Island: Mud flats and ephemeral pools on the flood shoal.

Figure A5. P61-Charley Pass, North Captiva Island: Early Dunlin (9-10-06) with Ruddy Turnstones and Sanderlings (juvenile and adult).

Figure A6. P62-Charley Pass, North Captiva Island: Roosting larids (Sandwich Terns, Royal Terns, Black Skimmers, Laughing Gulls) on flood shoal.

Figure A7. P63-Charley Pass, North Captiva Island: Roosting larids (Sandwich Terns, Royal Terns, Black Skimmers, Laughing Gulls) on flood shoal. Photo shows only a portion of the 2,000-3,000 larids that were consistently present during the survey.

Figure A8. P64-Charley Pass, North Captiva Island: Walkers on the inlet shoreline. This activity would result in birds flushing.

Redfish Pass

Figure A9. Redfish Pass Survey Area.

Redfish Pass: This inlet is between North Captiva Island and Captiva Island. All areas within the yellow polygon were surveyed during each visit. The north and south sides of the pass were surveyed separately. Redfish Pass has groins on each side of the inlet, with the North Captiva side (north side) having three (F1). Captiva Island has one groin, which was refurbished after Hurricane Charley (F2). Captiva Island also has an elevated area on the inlet beach that larids and shorebirds use for roosting (F3). The property behind this beach belongs to the South Seas Island Resort. The aerial photograph shows a golf course (F4) and small marina (F5) very close to the inlet. Bird use is minimal on the north side of the pass.

Figure A10. P57-North side of Redfish Pass (North Captiva Island).

Sanibel Lighthouse area

Figure A11. Sanibel Lighthouse Survey Area.

Sanibel Lighthouse: This area is a city park at the southeast end of Sanibel Island. It is on the northwest side of the entrance to San Carlos Bay. All areas within the yellow polygon were surveyed during each visit. The Gulf beach is very busy on weekends and holidays (F1), and a popular fishing pier exists on the bay side of the park (F2). Shorebirds and larids use the area sporadically, while wading birds seem to have a consistent presence on both the inlet beach (F3) and the pier.

Figure A12. P54-Sanibel Lighthouse: The lighthouse and beach at the entrance to San Carlos Bay.

Figure A13. P55-Sanibel Lighthouse: The fishing pier extending into San Carlos Bay.

Figure A14. P56-Sanibel Lighthouse: The inlet shoreline with dense Red Drift Algae covering the intertidal zone. Algae were present most of the survey. It began in the spring of 2006 and has continued into the spring season of 2007. Density of the algae varied and disposing of it is controversial on the island. The fresh wrack created by this condition was a popular foraging area for shorebirds throughout the survey area. As the algae aged and dried, fewer birds were observed foraging in it. Large amounts of algae would accumulate and begin to decompose. The associated smell was unpopular with tourists. The city is currently deciding on how to remove the algae and not disturb the island's population of Snowy Plovers once their nesting season begins in the spring of 2007.

Bunche Beach County Preserve

Figure A15. Bunche Beach County Preserve Survey Area.

Bunche Beach County Preserve: This area is located on the mainland side (north) of San Carlos Bay. The narrow beach face is approximately 1 mile long (F1) and has extensive mud flats and ephemeral pools at lower tides (F2). The beach face runs east-west, and is a portion of the 731-acre San Carlos Bay/Bunche Beach County Preserve. It is in Unit FL-25 Critical Habitat for Piping Plover as designated by US Fish and Wildlife. All areas within the yellow polygon were surveyed during each visit. This included the mudflats (F3) to the west of the beach face that are not accessible on foot, but easily viewed by spotting scope, as well as the mudflats (F4) and a wading bird roost island (F5) to the southeast (also not accessible on foot, but viewable by spotting scope). Most foraging and roosting by shorebirds, wading birds, and larids occur at or beyond the east and west ends of the beach face. These mud flats are cut off by the presence of tidal creeks. Bunche Beach is a popular destination with fishermen, beachgoers, and

walkers. Birds using the mud flats are typically flushed when people are present. Bunche Beach and similar habitat extending west to the Sanibel Causeway toll (the entrance to the Caloosahatchee River) are used by more birds for foraging and roosting than any other locations in Lee County. Bowditch Pointe County Park is located directly south across San Carlos Bay (F6).

Figure A16. Bunche Beach County Preserve. This image shows the entire Bunche Beach area: both the surveyed area (see Figure A15 for reference; the end of survey area on this image is delineated by yellow text and yellow line in center of photo) and the extensive mud flats to the west, which were not surveyed. These mud flats extend west to Sanibel Island Causeway (shown in left side of photo).

Figure A17. P45-Bunche Beach County Preserve: Moderate fresh wrack (Red Drift Algae) in the intertidal zone at medium tide. Old wrack is present at the high tide line. The parking area for the preserve is in the background.

Figure A18. P46-Bunche Beach County Preserve, mudflats west of the parking area at low tide. Red Drift Algae is present in the intertidal zone. The western side of the preserve is most used by shorebirds to forage and roost. Beach walking is common here. Foraging shorebirds are typically flushed by this activity (shorebirds are present just to the left of the people in the upper left of the picture).

Figure A19. P47-Bunche Beach County Preserve: Little Blue Heron foraging in dense wrack (Red Drift Algae) in the intertidal zone.

Figure A20. P48-Bunche Beach County Preserve: Ephemeral pool located at the west end of the beach face area.

Figure A21. P49-Bunche Beach County Preserve: Mud flats and ephemeral pools located at the west end of the beach face area.

Figure A22. P50-Bunche Beach County Preserve: Great White Heron (form of Great Blue Heron) foraging in open water along the bay beach.

Figure A23. P51-Bunche Beach County Preserve: Mudflat and ephemeral pools located at the west end of the beach face area.

Figure A24. P52-Bunche Beach County Preserve: Mud flats and ephemeral pools located at the east end of the beach face area.

Figure A25. P53-Bunche Beach County Preserve: Shorebirds and Snowy Egrets foraging in an ephemeral pool at the east end of the beach face area.

Bowditch Pointe County Park

Figure A 26. Bowditch Pointe County Park Survey Area.

Bowditch Pointe County Park: This is a 17-acre county park located at the northern tip of Estero Island. Seven acres are a developed park and 10 acres a preserve. It is located on the southeastern side of the entrance to San Carlos Bay and is directly across the bay from Bunche Beach. All areas within the yellow polygon were surveyed during each visit. The beach face at the tip of the island has benefited greatly from shifting sands and has grown since the time of the photo. The expanded area (F1) is primarily a roost location for larids and shorebirds that forage at Bunche Beach, but many small sandpipers and plovers also forage here along the intertidal zone or in the small ephemeral pools (F2) often present at lower tides. Bowditch Point is included with Bunche Beach in Unit FL-25 Critical Habitat for Piping Plover. It is a popular destination for beachgoers on weekends, and also with daily walkers who approach from the south. The beach is small in this area and birds are continuously flushed.

Figure A27. P36-Bowditch Pointe County Park: The main shorebird and larid roosting and foraging area along the intertidal zone of the inlet shoreline at medium tide. This picture shows the diversity of shorebirds and larids present at Bowditch Point. At almost all of the study sites, larids were typically observed roosting in the intertidal zone or on a mud flat and most shorebirds were typically observed roosting in wrack on the beach face, especially old wrack if present. This picture shows these seeming roosting preferences.

Figure A28. P37-Bowditch Pointe County Park: Ephemeral pool (west end of Estero Island and entrance to San Carlos Bay) and the roosting and foraging area along the intertidal zone of the inlet shoreline at low tide (same area as P36). Larids often roost in this general area and shorebirds often roost in old wrack on the beach face to the right. The beach at Bunche Beach County Preserve is visible in the background across San Carlos Bay.

Figure A29. P38-Bowditch Pointe County Park: Roosting group including Marbled Godwit, Willet, Short-billed Dowitcher, and Sandwich Tern.

Figure A30. P39-Bowditch Pointe County Park: Piping Plover roosting in old wrack. During the surveys, four to five Piping Plovers were usually present.

Figure A31. P40-Bowditch Pointe County Park: Snowy Plover roosting in old wrack. During the surveys, one to two Snowy Plovers were usually present.

Figure A32. P41-Bowditch Pointe County Park: Dunlin and Western Sandpiper foraging in fresh wrack (Red Drift Algae) along the intertidal zone.

Figure A33. P42-Bowditch Point County Park: Two people walking with a dog off-leash. Roosting shorebirds and larids were flushed as a result. City ordinances against flushing birds and walking dogs off-leash exist. The county also does not permit dogs in the county park. Bowditch Point is easily accessed by people with dogs, however, as only a sign is posted. No full-time staff is present and the ordinances are not enforced.

Figure A34. P43-Bowditch Pointe County Park: A park worker driving on the beach. Birds were flushed as a result. This was the only time this activity was witnessed. County administrators were provided with a picture in an effort to address use of the route used by maintenance workers.

Figure A35. P44-Bowditch Pointe County Park: Area where shorebirds and larids typically roost. The beach face for Bunche Beach County Preserve is seen across San Carlos Bay.

Little Estero Lagoon

Figure A36. Little Estero Lagoon Survey Area.

Little Estero Lagoon area: This long and narrow area is approximately 25 acres and receives an estimated 36,500 visitors annually. The lagoon stretches from Big Carlos Pass northward for approximately 1 mile. All areas within the yellow polygon were surveyed during each visit. The land side of the lagoon is mostly developed with residential buildings with some dune scrub (F1) present as a buffer along the southern half of the lagoon. The Gulf-side of the lagoon is comprised of an open beach and dune system (F2) in the southern two-thirds while the northern third has mangroves between the lagoon and the beach (F3). Foraging by shorebirds and wading birds occurs throughout the lagoon, but is more predominant in the northern two-thirds. Post Hurricane Charley, more spring and fall migrants have been observed in the southern third of the lagoon. An extensive mud flat exists in the central portion of the lagoon, which attracts numerous larids to roost and shorebirds to forage (F4). The channel connecting the lagoon to the Gulf is south of the mangroves and north of the largest mudflat (F5). The channel location changes

approximately every two years as the influence of weather and tides makes this a dynamic coastal area. The majority of nesting activity occurs along the outer beach dunes of the southern half of the lagoon where Least Tern, Wilson's Plover and an occasional Snowy Plover are known to nest. This stretch of beach has built up a higher elevation and supports suitable nesting vegetation (F6). At the northern end of the lagoon is a very wide beach face that begins at the Fort Myers Beach Holiday Inn and continues north for about 0.5 mile (F7). This beach area is controlled by the hotels and condominiums that border and maintain it. The beach is raked above the wrack line (a city ordinance protects the wrack). Multiple concession stands including beach chairs, umbrellas, cabanas, jet skis, and parasailing exist on the beach. While this is an extremely busy and disturbed area, it also can be quite active with shorebirds and larids both roosting and foraging. A few portions of this beach host large ephemeral pools after heavy rains or extreme high tides (F8). These areas were included in the surveys, although they are technically outside the critical wildlife area boundary. It should also be noted that locally the lagoon area is referred to as Little Estero Lagoon, but the official name of the area is state designated Little Estero Island Critical Wildlife Area. It is also Unit FL-26 Critical Habitat for Piping Plover as designated by US Fish and Wildlife.

Figure A37. P26-Little Estero Lagoon: beach adjacent to the Holiday Inn where ephemeral pools can be found. None were present this day, as they are reliant on heavy rains or extreme high tides. Cabanas are visible in the upper background.

Figure A38. P27-Little Estero Lagoon: Beach concession stand on the beach face adjacent to the Holiday Inn.

Figure A39. P28-Little Estero Lagoon: Most recent location of the channel connecting the lagoon to the Gulf. It is passable on foot at low tide and is a popular area with fishermen.

Figure A40. P29-Little Estero Lagoon: Small sandbar located just outside the channel that presently connects the lagoon to the Gulf.

Figure A41. P30-Little Estero Lagoon: This area located in the central lagoon has been the main shorebird foraging and larid roosting area for the past 10 years.

Figure A42. P31-Little Estero Lagoon: This mud flat area is a result of a previous inlet/cut area (closed by Hurricane Charley). It was the favored foraging area for the 10 Piping Plover that were present in the winter of 2005-2006.

Figure A43. P32-Little Estero Lagoon: This is an area at the south end of the lagoon that Red Knot seemed to favor for foraging during the survey. Ephemeral pools, shallow water areas, and mud flats are created here as the tide goes out. In general, spring and fall migrants use the south end of the lagoon to forage and roost, but summering and wintering shorebirds tend to favor the central lagoon area.

Figure A44. P33-Little Estero Lagoon: Red Knots foraging in an ephemeral pool at the south end of the lagoon (area was mentioned in P30).

Figure A45. P34-Little Estero Lagoon: Example of the banded Red Knots found in large numbers at the lagoon in September. Most of these birds were banded the previous winter in southwest Florida. This individual was banded 2 January 06 at North Captiva Island by Brian Harrington.

Figure A46. P35-Little Estero Lagoon: Area close to the southern tip of the lagoon. It is occasionally used by shorebirds for foraging and roosting; more so during migration periods than summer or winter.

Big Carlos Pass

Figure A47. Big Carlos Pass Survey Area.

Big Carlos Pass: This inlet is very wide and is located between Estero Island on the north and Lover's Key on the south. All areas within the yellow polygon were surveyed during each visit. The north and south sides of the pass were surveyed separately. The Estero Island side is completely developed with condominiums and beaches are raked from the buildings to the high tide line (F1). Most wrack below this point is not removed unless there is a nuisance situation. A city ordinance protects the wrack from removal. The north end of this area abuts the Little Estero Lagoon Critical Wildlife Area. The south end is at the base of a bridge and is popular with fishermen and waders. An extreme low tide here will expose a small mud flat that attracts shorebirds (F2). The Lover's Key side of the pass is an undeveloped state park (with the exception of some condominiums on the bay side of the bridge), but is accessible to beachgoers by a parking lot (F3). Bird use is limited on the south side of the pass as the beach is very narrow and is popular with beachgoers and boaters (F4). The proximity of Little Estero Lagoon to the north (F5) and Estero Bay (F6) to the east are also factors, as those locations may attract birds away from the busy inlet area.

Figure A48. P19-Big Carlos Pass: Bridge connecting Estero Island and Lover's Key.

Figure A49. P20-Big Carlos Pass: Boats are parked along this stretch of beach at Lover's Key almost daily.

Figure A50. P21-Big Carlos Pass: Lover's Key (south side) shoreline along Big Carlos Pass.

Figure A51. P22-Big Carlos Pass: Lover's Key (south side) shoreline along Big Carlos Pass.

Figure A52. P23-Big Carlos Pass: View of the entrance to Big Carlos Pass from Lover's Key. Estero Island is in the upper right.

Figure A53. P24-Big Carlos Pass: View from under the bridge over Big Carlos Pass from Estero Island (north side). A few wading birds were typically present at this location.

Figure A54. P25-Big Carlos Pass: View into Big Carlos Pass looking south from Little Estero Lagoon. This is where the survey area for the north side of Big Carlos Pass meets the survey area for Little Estero Lagoon Critical Wildlife Area.

Lover's Key Lagoon

Figure A55. Lover's Key Lagoon Survey Area.

Lover's Key Lagoon area: This area is within Lover's Key State Park and includes a lagoon with a sandbar area that may have resulted from past storm washovers. The sandbar is built up enough to be partially present at high tide, making it a popular roosting and foraging area. Low tide exposes a mud flat around the sandbar (F1). The lagoon itself is often shallow enough for wading birds to forage or roost at any tide. An area of exposed dead mangroves is a popular roosting area for Double Crested Cormorant and Brown Pelican (F2). The dune area between the lagoon and the Gulf was a Least Tern nesting area in spring 2006 and is posted year round (F3). The beach is a popular public destination with a gazebo, rest rooms, and a food concession (F4). The beach is accessed via a tram that shuttles people across the lagoon from the parking lot (F5).

Figure A56. P14-Lover's Key lagoon: Posted dunes are shown in the foreground, the sandbar in the upper right, and a small section of the tram bridge in the far right.

Figure A57. P15-Lover's Key lagoon: Dunes and postings that protect the area just to the north of the previous picture.

Figure A58. P16-Lover's Key lagoon: Tram bridge that crosses the lagoon.

Figure A59. P17- Lover's Key lagoon: Gazebo just behind a dune restoration area. Restrooms are beyond the gazebo, and a food concession is in the background to the right.

Figure A60. P18- Lover's Key lagoon: The beach face on the Gulf side of the lagoon is a very popular beach area on weekends and holidays. Least Terns nest on the right side of the sting fence at this location. ATV tracks that run parallel to the fence belong to the Florida Park Service.

New Pass area

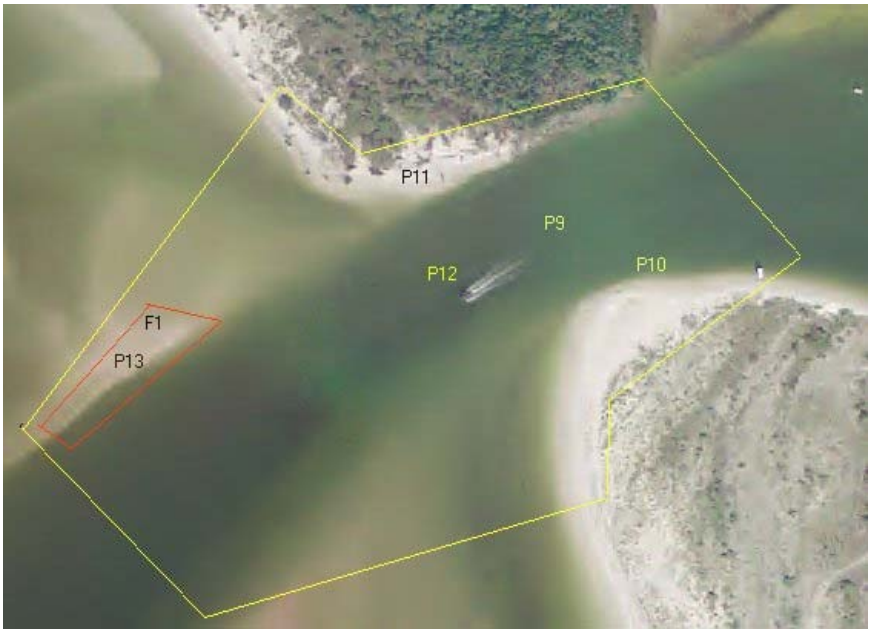

Figure A61. New Pass Survey Area

New Pass: This inlet is between Lover's Key on the north and Big Hickory Island on the south. All areas within the yellow polygon were surveyed during each visit. North and south sides of the pass were surveyed separately. Neither side of this pass is heavily used by birds, as both shorelines are fairly narrow. This pass is about 75 m in width and is heavily used by boaters to access the Gulf. There is an ebb shoal 100+ m outside the pass that is exposed at low tide and used primarily for roosting by larids and pelicans (F1). Boaters also use this shoal to anchor and fish or wade in the shallow water.

Figure A62. P9-New Pass: View of Big Hickory Island across the pass from Lover's Key (north side).

Figure A63. P10-New Pass: Boats parked on Big Hickory Island (south side).

Figure A64. P11-New Pass: Beach and intertidal area along the pass shoreline on Lover's Key (north side). Photo shows the limited amount of land available for bird use on this side of the pass. During the previous spring, this area was built up with more sand and was used as a roost area by larids. ATV tracks in the intertidal zone are from the Florida Park Service. They are the only operators of ATVs, as the entire island is a state park.

Figure A65. P12- New Pass: Boat traffic in the pass.

Figure A66. P13- New Pass: Ebb shoal outside the pass. The shallowness of the area can be seen, as well as the boat usage (which can be quite heavy at times) and people wading. When a sandbar is exposed, it is a popular roosting area for larids.

Big Hickory Pass

Figure A67. Big Hickory Pass Survey Area.

Big Hickory Pass: This inlet separates Big Hickory Island on the north and Bonita Beach on the south. All areas within the yellow polygon were surveyed during each visit. North and south sides of the pass were surveyed separately. The south side of this location is used by shorebirds and larids for both roosting and foraging. A spit and mudflat area create a narrow pass (estimated 35-40 m in width). Much of this area remains exposed at high tide (F1), but there is an ephemeral pool created during varying low tides (F2). It is an attractive area to fishermen. Roosting and foraging birds are disturbed at all tide levels as the fishermen move around the area. The north side of the pass is limited to a small beach face that boaters use as a parking area (F3). There are three groins on the south side of the inlet (F4).

Figure A68. P1-Big Hickory Pass. Three groins are located on the Bonita Beach (south) side of the pass. Few birds were observed near or between the groins during the fall surveys. The southernmost groin is in the foreground.

Figure A69. P2-Big Hickory Pass. This is low tide and the northernmost of the three groins is in the foreground. The exposed area to the center right is a spit and the far right is a mudflat on the inlet shoreline. The mud flat holds an ephemeral pool at low tide.

Figure A70. P3-Big Hickory Pass: Difference between low and high tide is apparent by comparing this spot with P2. Northernmost groin is just to the left of this picture. The spit (center top of picture) is a popular roost site for larids. Mud flat to the right is submerged at high tide.

Figure A71. P4-Big Hickory Pass. A fisherman on the Gulf side of the spit on the Bonita Beach (south) side of the pass. A number of vehicle tracks are present.

Figure A72. P5-Big Hickory Pass: The inlet side of the spit with fishermen on the Bonita Beach (south) side of the pass.

Figure A73. P6-Big Hickory Pass: This is the main foraging area for shorebirds when the mud flat and ephemeral pool are present at low tide. Larids are seen roosting and bathing, while shorebirds are foraging in and along the inlet side of the spit as the tide is receding and the flat and pool are exposed.

Figure A74. P7-Big Hickory Pass: Ephemeral pool located on the mudflat on the Bonita Beach (south) side of the pass. This is another view of at the area in Figure A73 (P6) at a lower tide.

Figure A75. P8-Big Hickory Pass: View of Big Hickory Island, which is located on the north side of the pass. The pass is very narrow (the picture was taken from the south side). A few boats can be seen parked in the top center of the photo. This area is heavily used on weekends.

Appendix B: Lee County Fall Migration Survey Data Form

Florida Coastal Bird and Bird Habitat Survey Datasheet **Page 1**

Survey location

Site Name _____ **Survey segment type (*circle one below*)**
Island Name (if applicable)_____ **Point to point (linear) area search (polygon)**

Start GPS location (if linear survey) N_____W_____
End GPS location (if linear survey) N_____W_____
Record a general GPS location for survey areas for area searches in the Start GPS field only.

Limits of all area search sites should be illustrated by drawing polygons on top of aerial photos

Survey effort details (use 24hr clock, e.g., 1400)

Date _____ Weekend? y n Observer _____ Start Time _____ End Time _____

Weather and tide conditions

Temp (°F) _____ General weather (circle one) Sunny Partly cloudy Cloudy Rain Fog
Wind speed (Beaufort scale) _____ Wind direction (16 points, e.g. NNE) _____
Tide (circle one) low (intertidal area 76-100% exposed) medium (26-75%) high (0-25%)
Tide direction (circle one) falling rising

Bird observations (*shorebirds, seabirds, wading birds, raptors, and egg predators only*)

Sp.	Number	Individ./ Prs./chks (i/p/c)	Behav.[b] (nC/nS/r/f)	GPS location[c] North	West	Substr./ Habitat[d]	Landsc.[e]	Band[f]

Lee County Coastal Bird and Bird Habitat Survey Datasheet **Page 2**

Disturbance data

 # people (on foot) present _____
ATVs or ATV tracks present y n **location (circle one) beach dune both**
Vehicles or vehicle tracks present y n **location (circle one) beach dune both**
Dog tracks present y n **location (circle one) beach dune both**
Racoon tracks present y n **location (circle one) beach dune both**
# of dogs observed _____ # of cats observed _____
# of boats parked within 50m of shore _____ # of boats traveling within 50m of shore _____
# of major access points (parking lot, major trail, dune walkover, or marina) _____
Notes on disturbance _____
_____
_____
_____

Habitat data

% shoreline covered with wrack (linear coverage parallel to shore) _____
Average width wrack (perpendicular to shore) in .25 meter increments (e.g., 1.75, 3.5) _____
Wrack density (circle one) sparse moderate dense
Beach cleaning (e.g., raking, wrack removal) evident y n % of area cleaned _____

Washover fans present y n **Ephemeral pools present y n**
Sand spits present y n **Emergent offshore shoals present y n**
Bay side flats accessible to chicks y n **Lagoon areas accessible to chicks y n**

% of area immediately landward of beach covered by various landforms (sum = 100)
Sparsely vegetated dunes _____ **Heavily vegetated dunes _____**
Houses or other buildings _____ **Engineering structures _____**
Coastal scrub or climax vegetation ___ Other _____ _____

Footnotes describing codes and formats
[b] nC= nesting confirmed, nS= nesting suspected, r= roost/loaf/preen, f= foraging
[c] Provide GPS locations for the following two types of observations only: 1) all color banded birds (any season); 2) all SNPL, WIPL, AMOY, BLSK, or LETE nesting pairs (nS), nests (nC), or colonies (nC) (breeding only).
[d] dry sand (ds), intertidal sand or mud (in), fresh wrack (fw), old wrack (ow), ephemeral pool (ep), vegetation (ve), rubble/rock (ru), open water (ow).
[e] ocean beach (ob), bay beach (bb), washover/blowout (wa), dune (du), back dune (bd), supratidal/salt pan (st), upland (up), inlet shoreline (in), ebb shoal (es), flood shoal (fs), salt marsh (sm), tidal creek (tc), lagoon (la), dredged-material island (di), natural island (ni), oyster reef/shellfish bed (oy), river outlet (ri), mangrove (ma), seagrass (sg). Rocky shore (rs), jetty/groin (je), developed (de), shallow water (sw).
[f] Reporting format for color bands describes bands in four different positions with a standard syntax. This is: upper left (tibia), lower left (tarsus): upper right (tibia) , lower right (tarsus). The standard syntax is a comma between upper and lower bands and a colon between left and right leg (or x,x:y,y where x is the bird's left leg and y is the bird's right leg). Codes for different bands are: X: metal, f: flag, R: red, Y: yellow, O: orange, B: dark blue; b: light blue; W: white, G: dark green; g: light green; L: black; A: gray; T: other (describe); –: no band; N: band not seen; /: split band; //:triple split band. Report split bands as top color/ bottom color (e.g. L/g is a split band with black over light green). Report stacked bands as top color bottom color with no syntax (e.g., Lg is a black band stacked on top of a light green band). Report colored flags with the color code and then the letter f for flag with no syntax (e.g., Rf is a red flag).

Beaufort scale number	Descriptive term	Units in km/h	Units in knots	Description on Land	Description at Sea
0	Calm	0	0	Smoke rises vertically	Sea like a mirror.
1-3	Light winds	19 km/h or less	10 knots or less	Wind felt on face; leaves rustle; ordinary vanes moved by wind.	Small wavelets, ripples formed but do not break: A glassy appearance maintained.
4	Moderate winds	20 - 29 km/h	11-16 knots	Raises dust and loose paper; small branches are moved.	Small waves - becoming longer; fairly frequent white horses.
5	Fresh winds	30 - 39 km/h	17-21 knots	Small trees in leaf begin to sway; crested wavelets form on inland waters.	Moderate waves, taking a more pronounced long form; many white horses are formed - a chance of some spray.
6	Strong winds	40 - 50 km/h	22-27 knots	Large branches in motion; whistling heard in telephone wires.	Large waves begin to form; the white foam crests are more extensive with probably some spray.
7	Near gale	51 - 62 km/h	28-33 knots	Whole trees in motion; inconvenience felt when walking against wind.	Sea heaps up and white foam from breaking waves begins to be blown in streaks along direction of wind.
8	Gale	63 - 75 km/h	34-40 knots	Twigs break off trees; progress generally impeded.	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks along the direction of the wind.
9	Strong gale	76 - 87 km/h	41-47 knots	Slight structural damage occurs -roofing dislodged; larger branches break off.	High waves; dense streaks of foam; crests of waves begin to topple, tumble and roll over; spray may affect visibility.
10	Storm	88 - 102 km/h	48-55 knots	Seldom experienced inland; trees uprooted; considerable structural damage.	Very high waves with long overhanging crests; the resulting foam in great patches is blown in dense white streaks; the surface of the sea takes on a white appearance; the tumbling of the sea becomes heavy with visibility
11	Violent storm	103 -117 km/h	56-63 knots	Very rarely experienced - widespread damage.	Exceptionally high waves; small and medium sized ships occasionally lost from view behind waves; the sea is completely covered with long white patches of foam; the edges of wave crests are blown into froth.
12+	Hurricane	118 km/h or more	64 knots or more		The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.

ENGLISH NAME	CODE	SCIENTIFIC NAME	ENGLISH NAME	CODE	SCIENTIFIC
American White Pelican	AWPE	Pelecanus erythrorhynchos	American Avocet	AMAV	Recurvirostra
Brown Pelican	BRPE	Pelecanus occidentalis	Greater Yellowlegs	GRYE	Tringa
Double-crested Cormorant	DCCO	Phalacrocorax auritus	Lesser Yellowlegs	LEYE	Tringa flavipes
Great Cormorant	GRCO	Phalacrocorax carbo	Solitary Sandpiper	SOSA	Tringa solitaria
Great Blue Heron	GBHE	Ardea herodias	Willet	WILL	Catoptrophorus
Great Egret	GREG	Ardea alba	Whimbrel	WHIM	Numenius
Snowy Egret	SNEG	Egretta thula	Long-billed Curlew	LBCU	Numenius
Little Blue Heron	LBHE	Egretta caerulea	Hudsonian Godwit	HUGO	Limosa
Tricolored Heron	TRHE	Egretta tricolor	Marbled Godwit	MAGO	Limosa fedoa
Reddish Egret	REEG	Egretta rufescens	Ruddy Turnstone	RUTU	Arenaria
Cattle Egret	CAEG	Bubulcus ibis	Red Knot	REKN	Calidris canutus
Green Heron	GRHE	Butorides virescens	Sanderling	SAND	Calidris alba
Black-crowned Night-Heron	BCNH	Nycticorax nycticorax	Semipalmated Sandpiper	SESA	Calidris pusilla
Yellow-crowned Night-Heron	YCNH	Nyctanassa violacea	Western Sandpiper	WESA	Calidris mauri
White Ibis	WHIB	Eudocimus albus	Least Sandpiper	LESA	Calidris minutilla
Glossy Ibis	GLIB	Plegadis falcinellus	Dunlin	DUNL	Calidris alpina
Roseate Spoonbill	ROSP	Platalea ajaja	Curlew Sandpiper	CUSA	Calidris
Wood Stork	WOST	Mycteria americana	Short-billed Dowitcher	SBDO	Limnodromus
Osprey	OSPR	Pandion haliaetus	Unidentified Dowitcher	UNDO	Limnodromus
Bald Eagle	BAEA	Haliaeetus leucocephalus	Long-billed Dowitcher	LBDO	Limnodromus
Northern Harrier	NOHA	Circus cyaneus	Laughing Gull	LAGU	Larus atricilla
Sharp-shinned Hawk	SSHA	Accipiter striatus	Ring-billed Gull	RBGU	Larus
Cooper's Hawk	COHA	Accipiter cooperii	Herring Gull	HERG	Larus
Unidentified Accipiter Hawk	UNAH	Accipiter (sp)	Lesser Black-backed Gull	LBBG	Larus fuscus
Red-shouldered Hawk	RSHA	Buteo lineatus	Unidentified Gull	UNGU	Larus (sp)
Red-tailed Hawk	RTHA	Buteo jamaicensis	Gull-billed Tern	GBTE	Sterna nilotica
American Kestrel	AMKE	Falco sparverius	Caspian Tern	CATE	Sterna caspia
Merlin	MERL	Falco columbarius	Royal Tern	ROYT	Sterna maxima
Peregrine Falcon	PEFA	Falco peregrinus	Sandwich Tern	SATE	Sterna
Black-bellied Plover	BBPL	Pluvialis squatarola	Roseate Tern	ROST	Sterna dougallii
Snowy Plover	SNPL	Charadrius alexandrinus	Common Tern	COTE	Sterna hirundo
Wilson's Plover	WIPL	Charadrius wilsonia	Least Tern	LETE	Sterna
Semipalmated Plover	SEPL	Charadrius semipalmatus	Yellow-billed Tern	YBTE	Sterna
Piping Plover	PIPL	Charadrius melodus	Black Skimmer	BLSK	Rynchops niger
Killdeer	KILL	Charadrius vociferus	American Crow	AMCR	Corvus
American Oystercatcher	AMOY	Haematopus palliatus	Fish Crow	FICR	Corvus
Black-necked Stilt	BNST	Himantopus mexicans	Unidentified Crow	UNCR	Corvus (sp)

Appendix C: Site-specific Results

Counts by species varied considerably from site to site. Therefore, cumulative and maximum counts are presented separately by species for each site. Site-specific summaries highlight sites where >10 percent of a species' foraging or roosting observations occurred. Foraging and roosting landform use showed considerable variation among sites, as there was greater variation in the presence of different landforms among sites than substrates, which were consistently available at multiple sites. Where more than one landform or substrate was used at a site, tables describe habitat use for all species combined. Site-specific results are presented from northwest to southeast.

Charley Pass

Counts by species

The 11,434 observations at Charley Pass comprised 25.6 percent of all observations across the study area. Roosting observations for this site totaled 10,452, which amounted to 91.4 percent of all the observations for the site and 37.6 percent of all roosting observations for the entire study area. Twenty-one species were observed at Charley Pass, several of which were recorded in relatively large numbers for both foraging and roosting (Table C1). Of the 23 species with >33 foraging observations across the entire study area, seven species had >10 percent of their regional foraging observations at this site. From the highest to lowest percentage of regional foraging observations, these were: Snowy Plover, Semipalmated Plover, Ruddy Turnstone, Least Sandpiper, Sanderling, Black-bellied Plover, and Semipalmated Plover (Table 5 in the main text). Snowy Plovers were recorded foraging at only four locations. The 10 foraging observations for Snowy Plover at Charley pass represent 30.3 percent of all foraging observations for this species. Six species had >10 percent of their regional roosting observations at this site. From the highest to lowest percentage of regional roosting observations, these were: Sandwich Terns, Brown Pelicans, Royal Terns, Black Skimmers, Black-bellied Plovers, and Laughing Gulls (Table 6 in the main text). The 7,000 roosting observations

for Sandwich Terns represented 60.6 percent of all roosting observations for this species.

Table C1. Cumulative and maximum counts by behavior at Charley Pass. Species are listed in taxonomic order.

Species	Code	Cumulative Counts		Maximum Count	
		Foraging	Roosting	Foraging	Roosting
Brown Pelican	BRPE		881		500
Black-bellied Plover	BBPL	35	25	15	25
Snowy Plover	SNPL	10		6	
Wilson's Plover	WIPL	2	5	2	5
Semipalmated Plover	SEPL	88	40	50	40
Piping Plover	PIPL	6		6	
Willet	WILL	56	5	29	5
Lesser Yellowlegs	LEYE		2		2
Ruddy Turnstone	RUTU	113		42	
Red Knot	REKN	40		26	
Sanderling	SAND	232		103	
Semipalmated Sandpiper	SESA	30		17	
Western Sandpiper	WESA	178		100	
Least Sandpiper	LESA	146		54	
Dunlin	DUNL	1		1	
Short-billed Dowitcher	SBDO	45		23	
Laughing Gull	LAGU		1167		925
Forster's Tern	FOTE		3		3
Royal Tern	ROYT		839		500
Sandwich Tern	SATE		7000		3000
Black Skimmer	BLSK		485		200

Habitat use by landform and substrate

All foraging and roosting observations at this site were recorded on a single landform, the large flood shoal that was created when this new inlet opened during the passing of Hurricane Charley in 2004. Refer to Figures A1 through A8 for images of the flood shoal at Charley Pass. All observations were either on intertidal or shallow water substrates, and substrate preferences by species at this site closely matched the overall substrate preferences shown in Figures 2 and 3 in the main text.

Disturbance

Disturbance was high at this site as the flood shoal at Charley Pass is a very popular destination for boaters (Table C2). This site had the highest numbers of people, parked boats, and dogs within the entire study area, despite the fact that this site required boat access.

Table C2. Charley Pass disturbance factors.

Avg N people	37
Max N people	42
ATVs present	No
Vehicles present	No
Ave N dogs	2
Ave N parked boats	22
N access points	1
Beach cleaning present	No

Redfish Pass

The 179 observations at this site comprised 0.4 percent of all observations across the study area. Species diversity was low at Redfish Pass as only nine species were observed at this site (Table C3). No species had >11 foraging observations at this site and the majority of observations (87.7 percent) at this site were roosting larids (Table C3). No species had >10 percent of their regional foraging or regional roosting observations at this site.

Table C3. Cumulative and maximum counts by behavior at Redfish Pass. Species are listed in taxonomic order.

		Cumulative Counts		Maximum Count	
Species	Code	Foraging	Roosting	Foraging	Roosting
Great Egret	GREG	1		1	
Snowy Egret	SNEG	2		2	
Black-bellied Plover	BBPL	1		1	
Willet	WILL	4		2	
Ruddy Turnstone	RUTU	3		3	
Sanderling	SAND	11		6	
Laughing Gull	LAGU		22		11
Royal Tern	ROYT		52		27
Sandwich Tern	SATE		83		32

Habitat use by landform and substrate

All foraging and roosting observations at this site were recorded at a single landform, the inlet shoreline. Refer to Figures A9 and A10 for images of the Redfish Pass study area. No wrack was present at this site and all observations occurred either on intertidal or shallow-water substrates, with substrate preferences by species at this site closely matching the overall substrate preferences shown in Figures 2 and 3 in the main text.

Disturbance

Disturbance at Redfish Pass was very low relative to other sites (Table C4).

Table C4. Redfish Pass disturbance factors.

Avg N people	1
Max N people	3
ATVs present	No
Vehicles present	No
Ave N dogs	0
Ave N parked boats	0
N access points	0
Beach cleaning present	No

Sanibel Lighthouse

The 541 observations at this site comprised only 1.2 percent of all observations across the study area. Sixty-six percent of all observations at this site were foraging observations. Of the 19 species observed at Sanibel Lighthouse, a majority (>68 percent) of these used the site exclusively for foraging (Table C5). Counts within each species observed, however, were relatively low. Of the 23 species with >33 foraging observations across the entire study area, only two species, Sandwich terns and Reddish Egrets, had >10 percent of their regional foraging observations at this site (Table C5) and no species had >10 percent of their regional roosting observations at this site. Across the whole study area, very few Sandwich Terns were observed foraging (compared to the large number observed roosting). The 74 Sandwich Tern foraging observations at Sanibel Lighthouse represented 96.1 percent of all foraging observations for this species.

Table C5. Cumulative and maximum counts by behavior at Sanibel Lighthouse. Species are listed in taxonomic order.

Species	Code	Cumulative Counts		Maximum Count	
		Foraging	Roosting	Foraging	Roosting
Brown Pelican	BRPE	1		1	
Great Blue Heron	GBHE	2		1	
Great Egret	GREG	12	2	4	2
Snowy Egret	SNEG	50	10	12	10
Reddish Egret	REEG	8		2	
Black-bellied Plover	BBPL	14		4	
Willet	WILL	39		8	
Ruddy Turnstone	RUTU	29		7	
Red Knot	REKN	2		2	
Sanderling	SAND	66		19	
Western Sandpiper	WESA	10		10	
Short-billed Dowitcher	SBDO	1		1	
Laughing Gull	LAGU	19	112	17	32
Least Tern	LETE	1		1	
Black Tern	BLTE	12		12	
Common Tern	COTE	2		2	
Forster's Tern	FOTE		2		2
Royal Tern	ROYT	15	9	15	7
Sandwich Tern	SATE	74	49	62	21

Habitat use by landform and substrate

Birds were observed foraging at three major landforms at Sanibel Lighthouse (Table C6). From most to least common, these were: the inlet shoreline, the ocean beach, and the bay beach. Refer to Figures A11 through A14 for images of the Sanibel Lighthouse study area. Foraging observations were common for three substrates. From most to least common, these were: shallow water, fresh wrack, and intertidal sands and muds (Table C6).

Birds were observed roosting at three landforms at Sanibel lighthouse (Table C7). From most to least common, these were: ocean beach, inlet shoreline, and bay beach. Birds were observed roosting mostly on intertidal substrates, or secondarily, on dry sand. A very small number of birds were observed roosting in shallow water (Table C7).

Table C6. Foraging substrate and landform use by all species at Sanibel Lighthouse.

Foraging substrate	Foraging landform			
	Bay beach	Inlet shoreline	Ocean beach	Totals
Fresh wrack		65	82	147
Intertidal	22	2	7	31
Shallow water	58	121		179
Totals	80	176	89	357

Table C7. Roosting substrate and landform use by all species at Sanibel Lighthouse.

Roosting substrate	Roosting landform			
	Bay beach	Inlet shoreline	Ocean beach	Totals
Dry sand	10		46	56
Intertidal	26	47	53	126
Shallow water	2			2
Totals	38	47	99	184

Disturbance

As Sanibel Lighthouse is located within a city park, it is a popular public destination. A high number of people were observed at Sanibel Lighthouse and dogs were recorded present during four of the eight site visits (Table C8).

Table C8. Sanibel Lighthouse disturbance factors.

Avg N people	26
Max N people	45
ATVs present	No
Vehicles present	No
Ave N dogs	1
Ave N parked boats	0
N access points	2
Beach cleaning present	No

Bunche Beach

Bunche Beach proved to be the most important of the study sites as the greatest number of birds (both foraging and roosting combined) were recorded here. Despite the high count totals for Bunche Beach, these are likely underestimates, since extensive mud flats exist to the immediate west of where the survey area ended and extend west to the Sanibel Island Causeway. These mud flats were not accessible by foot, since they are separated from the accessible mudflats by a tidal creek, nor could they be viewed by spotting scope. Birds using these flats for foraging and/or roosting were therefore not included in these counts. Figure A15 delineates the area that was surveyed at Bunche Beach. Figure A16 shows all of Bunche Beach including these extensive flats to the west that were not able to be surveyed.

The 15,664 observations at this site comprised 35 percent of all observations across the study area. Foraging observations at Bunche Beach totaled 9,777, which amounted to 62.4 percent of all observations at this site and 57.6 percent of all foraging observations for the entire study area. Roosting observations totaled 5,887, which amounted to 37.6 percent of all the observations for the site and 21.2 percent of all roosting observations for the entire study area. Bunche Beach ranked highest in species diversity with 39 species observed; 22 of the 39 species (>56 percent) used Bunche Beach exclusively for foraging (Table C9).

Bunche Beach is a very important site for many foraging and roosting species. Of the 23 species with more than 33 foraging observations across the entire study area, 21 species had more than 10 percent of their regional foraging observations at this site (Table C10). Bunche Beach is so important for foraging species that 12 of these 21 species had more than 50 percent of their regional foraging observations recorded at this site (Table C10). Piping Plovers were recorded foraging at only four sites with the highest count recorded at Bunche Beach. The 32 foraging observations for Piping Plover at this site represented 48.5 percent of all foraging observations for this species.

Table C9. Cumulative and maximum counts by behavior at Bunche Beach. Species are listed in taxonomic order.

Species	Code	Cumulative Counts		Maximum Count	
		Foraging	Roosting	Foraging	Roosting
Brown Pelican	BRPE		424		156
Double-crested Cormorant	DCCO		68		33
Great Blue Heron	GBHE	23		12	
Great Egret	GREG	578		200	
Snowy Egret	SNEG	452		100	
Little Blue Heron	LBHE	270		144	
Reddish Egret	REEG	20		6	
White Ibis	WHIB	754		400	
Roseate Spoonbill	ROSP	26	5	10	5
Wood Stork	WOST	3		3	
Osprey	OSPR		1		1
Black-bellied Plover	BBPL	157		42	
Snowy Plover	SNPL	3		1	
Wilson's Plover	WIPL	35		6	
Semipalmated Plover	SEPL	347		60	
Piping Plover	PIPL	32		6	
American Avocet	AMAV	4	2	4	2
Spotted Sandpiper	SPSA	1		1	
Willet	WILL	496	100	177	100
Lesser Yellowlegs	LEYE	2		2	
Marbled Godwit	MAGO	141		32	
Ruddy Turnstone	RUTU	107		42	
Red Knot	REKN	183		140	
Sanderling	SAND	584		180	
Semipalmated Sandpiper	SESA	72		40	
Western Sandpiper	WESA	2057		500	
Least Sandpiper	LESA	573		137	
Dunlin	DUNL	76		53	
Short-billed Dowitcher	SBDO	2781	500	800	500
Laughing Gull	LAGU		863		200
Ring-billed Gull	RBGU		3		2
Least Tern	LETE		9		8
Caspian Tern	CATE		1		1
Common Tern	COTE		1		1
Forster's Tern	FOTE		103		40
Royal Tern	ROYT		523		250
Sandwich Tern	SATE		2605		2000
Black Skimmer	BLSK		679		215

Nine species had more than 10 percent of their regional roosting observations at this site. From the highest to lowest percentage of regional roosting observations, these were: Short-billed Dowitcher, Forster's Tern, Black Skimmer, Willet, Double-crested Cormorant, Royal Tern, Sandwich Tern, Brown Pelican, and Laughing Gull (Table C10). The 500 Short-billed Dowitcher roosting observations at Bunche Beach represented 87.9 percent of all roosting observations for this species. The 103 Forster's Tern roosting observations at Bunche Beach represented 69.1 percent of all roosting observations for this species. The 679 Black Skimmer roosting observations at Bunche Beach represented 50 percent of all roosting observations for this species.

Table C10. Species with >10 percent of their regional foraging observations recorded at Bunche Beach.

Species	N Foraging	Regional Percentage of Foraging Observations
Little Blue Heron	270	94.1%
Short-billed Dowitcher	2781	89.6%
White Ibis	754	88.9%
Marbled Godwit	141	84.9%
Great Egret	578	79.3%
Dunlin	76	73.1%
Snowy Egret	452	69.2%
Western Sandpiper	2057	59.3%
Willet	496	58.3%
Roseate Spoonbill	26	56.5%
Semipalmated Sandpiper	72	56.3%
Great Blue Heron	23	52.3%
Black-bellied Plover	157	49.5%
Piping Plover	32	48.5%
Least Sandpiper	573	46.6%
Semipalmated Plover	347	40.7%
Reddish Egret	20	38.5%
Sanderling	584	28.3%
Wilson's Plover	35	19.9%
Ruddy Turnstone	107	19.0%
Red Knot	183	18.0%

Habitat use by landform and substrate

Birds were observed foraging at two major landforms at Bunche Beach (Table C11). Essentially all foraging observations (99.7 percent) were recorded on the bay beach with the remaining small number of observations recorded on the ocean beach. Refer to Figures A15 through A25 in Appendix A for images of the Bunche Beach study area. Foraging observations were commonly recorded on four substrates. From most to least common, these were: intertidal substrates, ephemeral pool, shallow water, and fresh wrack (Table C11).

All roosting observations at Bunche Beach were recorded on a single landform, the bay beach. Essentially all roosting observations were recorded on intertidal substrates, with only 5 out of 5,887 observations occurring in shallow water.

Table C11. Foraging substrate and landform use by all species at Bunche Beach.

	Foraging Landform		
Foraging Substrate	Bay Beach	Ocean Beach	Totals
Ephemeral pool	2164		2164
Fresh wrack	1550		1550
Intertidal	3912	32	3944
Shallow water	2119		2119
Totals	9745	32	9777

Disturbance

Bunche Beach is a county preserve and is a popular public destination. A high number of people were recorded at Bunche Beach (Table C12).

Table C12. Bunche Beach disturbance factors.

Avg N people	22
Max N people	38
ATVs present	No
Vehicles present	No
Ave N dogs	0
Ave N parked boats	0
N access points	1
Beach cleaning present	No

Bowditch Point

The 4,553 observations at this site comprised 10.2 percent of all observations across the study area. Roosting observations at Bowditch Point totaled 4,000, which amounted to 87.9 percent of all observations at this site and 14.4 percent of all roosting observations for the entire study area. Twenty-two species were recorded at Bowditch Point with only three species using this site exclusively for foraging (Table C13). Of the 23 species with more than 33 foraging observations across the entire study area, five species had more than 10 percent of their regional foraging observations at this site. From the highest to lowest percentage of regional foraging observations, these were: Piping Plover, Dunlin, Wilson's Plover, Snowy Plover, and Semipalmated Plover (Table 5 in the main text). Bowditch Point recorded the second highest count for foraging Piping Plovers. The 21 foraging observations for Piping Plover at this site represented 31.8 percent of all foraging observations for this species. Bowditch Point was very important for many roosting species. Twelve species had more than 10 percent of their regional roosting observations at this site. From the highest to lowest percentage of regional roosting observations, these were: Red Knot, Piping Plover, Western Sandpiper, Least Tern, Semipalmated Plover, Sanderling, Wilson's Plover, Snowy Plover, Black-bellied Plover, Willet, Laughing Gull, and Forster's Tern (Table 6 in the main text). All Red Knot roosting observations in this study were recorded at Bowditch Point. Piping Plovers and Snowy Plovers were recorded roosting at only two locations, one of which was Bowditch Point. The 18 Piping Plover roosting observations at Bowditch Point represent 90 percent of all roosting observations for this species. The 10 Snowy Plover roosting observations at Bowditch Point represent 58.8 percent of all roosting observations for this species.

Table C13. Cumulative and maximum counts by behavior at Bowditch Point. Species are listed in taxonomic order.

Species	Code	Cumulative Counts		Maximum Count	
		Foraging	Roosting	Foraging	Roosting
Brown Pelican	BRPE		34		34
Double-crested Cormorant	DCCO		1		1
Black-bellied Plover	BBPL	9	15	3	5
Snowy Plover	SNPL	4	10	2	3
Wilson's Plover	WIPL	33	127	14	47
Semipalmated Plover	SEPL	92	518	44	125
Piping Plover	PIPL	21	18	5	4
Willet	WILL	40	48	8	25
Marbled Godwit	MAGO		5		5
Ruddy Turnstone	RUTU	46		15	
Red Knot	REKN		17		11
Sanderling	SAND	111	98	37	45
Western Sandpiper	WESA	148	1064	75	400
Least Sandpiper	LESA	1		1	
Dunlin	DUNL	27		27	
Short-billed Dowitcher	SBDO	21	38	21	17
Laughing Gull	LAGU		947		420
Least Tern	LETE		166		165
Forster's Tern	FOTE		17		9
Royal Tern	ROYT		142		55
Sandwich Tern	SATE		690		500
Black Skimmer	BLSK		45		21

Habitat use by landform

All foraging and roosting observations at Bowditch Point were recorded on a single landform, the inlet shoreline. Refer to Figures A26 through A35 for images of the Bowditch Point study area. Birds were observed foraging mostly in fresh wrack, or secondarily, on intertidal substrates. Small numbers of birds were observed foraging in ephemeral pools, dry sand, and shallow water (Table C14).

Roosting observations were recorded on three substrates. From most to least common these were intertidal substrates, old wrack, and dry sand (Table C15).

Table C14. Foraging substrate and landform use at Bowditch Point.

Foraging substrate	Foraging landform Inlet shoreline
Dry sand	9
Ephemeral pool	35
Fresh wrack	325
Intertidal	178
Shallow water	6
Totals	553

Table C15. Roosting landform and substrate use at Bowditch Point.

Roosting substrate	Roosting landform Inlet shoreline
Dry sand	796
Intertidal	2074
Old wrack	1130
Totals	**4000**

Disturbance

Bowditch Point is a popular destination for the public. ATV's were recorded during each of the seven site visits (Table C16).

Table C16. Bowditch Point disturbance factors.

Avg N people	9
Max N people	24
ATVs present	Yes
Vehicles present	No
Ave N dogs	0
Ave N parked boats	0
N access points	1
Beach cleaning present	No

Little Estero Lagoon

The 7,497 observations at this site comprised 16.8 percent of all observations across the study area. Foraging observations at Little Estero Lagoon totaled 3,224, which amounted to 43 percent of all observations at this site and 19 percent of all foraging observations for the entire study area. Roosting observations totaled 4,273, which amounted to 57 percent of all the observations for the site and 15.4 percent of all roosting observations for the entire study area. Little Estero Lagoon (Table C17), ranked second highest in species diversity, with 34 species observed.

Table C17. Cumulative and maximum counts by behavior at Little Estero Lagoon. Species are listed in taxonomic order.

Species	Code	Cumulative Counts		Maximum Count	
		Foraging	Roosting	Foraging	Roosting
Brown Pelican	BRPE		89		32
Double-crested Cormorant	DCCO		37		12
Great Blue Heron	GBHE	6		2	
Great Egret	GREG	97		56	
Snowy Egret	SNEG	82		19	
Little Blue Heron	LBHE	10		4	
Reddish Egret	REEG	10		3	
White Ibis	WHIB	46		19	
Roseate Spoonbill	ROSP	13		12	
Cooper's Hawk	COHA	1		1	
Black-bellied Plover	BBPL	49	15	13	8
Snowy Plover	SNPL	16	7	6	5
Wilson's Plover	WIPL	89	50	25	25
Semipalmated Plover	SEPL	220	99	139	53
Piping Plover	PIPL	7	2	3	2
Killdeer	KILL		5		5
Willet	WILL	118	32	20	29
Whimbrel	WHIM	3		1	
Marbled Godwit	MAGO	12		11	
Ruddy Turnstone	RUTU	124		34	
Red Knot	REKN	745		432	
Sanderling	SAND	734	59	200	32
Semipalmated Sandpiper	SESA	5		5	
Western Sandpiper	WESA	651	242	211	132
Least Sandpiper	LESA	172	24	52	24

Species	Code	Cumulative Counts		Maximum Count	
		Foraging	Roosting	Foraging	Roosting
Short-billed Dowitcher	SBDO	14	23	8	23
Laughing Gull	LAGU		2812		1000
Ring-billed Gull	RBGU		2		2
Least Tern	LETE		40		36
Common Tern	COTE		1		1
Forster's Tern	FOTE		22		9
Royal Tern	ROYT		203		44
Sandwich Tern	SATE		371		82
Black Skimmer	BLSK		138		63

Little Estero Lagoon is a very important site for many foraging and roosting species. Of the 23 species with more than 33 foraging observations across the entire study area, 16 species had more than 10 percent of their regional foraging observations at this site (Table C18). Little Estero Lagoon recorded the highest number of foraging Red Knots and Snowy Plovers. Fourteen species had more than 10 percent of their regional roosting observations at this site (Table C19). All Least Sandpiper roosting observations in this study were recorded at Little Estero Lagoon.

Table C18. Species with more than 10 percent of their regional foraging observations recorded at Little Estero Lagoon.

Species	N Foraging	Regional Percentage of Foraging Observations
Red Knot	745	73.2
Wilson's Plover	89	50.6
Snowy Plover	16	48.5
Sanderling	734	35.6
Roseate Spoonbill	13	28.3
Semipalmated Plover	220	25.8
Ruddy Turnstone	124	22.0
Reddish Egret	10	19.2
Western Sandpiper	651	18.8
Black-bellied Plover	49	15.5
Least Sandpiper	172	14.0
Willet	118	13.9
Great Blue Heron	6	13.6
Great Egret	97	13.3
Snowy Egret	82	12.6
Piping Plover	7	10.6

Table C19. Species with more than 10 percent of their regional roosting observations recorded at Little Estero Lagoon.

Species	N Roosting	Regional Percentage of Roosting Observations
Least Sandpiper	24	100.0
Snowy Plover	7	41.2
Laughing Gull	2812	41.0
Sanderling	59	37.6
Wilson's Plover	50	23.7
Black-bellied Plover	15	19.0
Western Sandpiper	242	18.5
Double-crested Cormorant	37	18.5
Least Tern	40	18.2
Forster's Tern	22	14.8
Semipalmated Plover	99	13.4
Willet	32	11.4
Black Skimmer	138	10.2
Piping Plover	2	10.0

Habitat use by landform and substrate

All foraging and roosting observations were recorded on two major landforms at Little Estero Lagoon, the lagoon and the ocean beach. Refer to Figures A36 through A46 for images of the Little Estero Lagoon study area. Foraging observations were recorded on five substrates. The majority of observations were recorded on intertidal substrates followed by ephemeral pools and shallow water. A very small number of foraging observations were recorded in shallow water and rubble/rock (Table C20). Roosting observations were recorded on four substrates. From most to least common these were ephemeral pools, dry sand, intertidal substrates, and old wrack (Table C21).

Table C20. Foraging substrate and landform use by all species at Little Estero Lagoon.

Foraging substrate	Foraging landform		Totals
	Lagoon	Ocean beach	
Ephemeral pool	27	373	400
Intertidal	1112	1397	2509
Rubble/rock	11		11
Shallow water	264	10	274
Vegetation	30		30
Totals	1444	1780	3224

Table C21. Roosting substrate and landform use by all species at Little Estero Lagoon.

Roosting substrate	Roosting landform		Totals
	Lagoon	Ocean beach	
Dry sand		1355	1355
Ephemeral pool		1545	1545
Intertidal	344	651	995
Old wrack		378	378
Totals	344	3929	4273

Disturbance

Little Estero Lagoon has four access points, making it one of the most easily accessed sites. As a result, Little Estero Lagoon experiences high disturbance. In addition to a high number of people, ATV's and vehicles were present during each site visit and beach cleaning was recorded on six of the seven site visits (Table C22).

Table C22. Little Estero Lagoon disturbance factors.

Avg N people	28
Max N people	41
ATVs present	Yes
Vehicles present	Yes
Ave N dogs	0
Ave N parked boats	0
N access points	4
Beach cleaning present	Yes

Big Carlos Pass

The 253 observations at this site comprised 0.6 percent of all observations across the study area. Over 99 percent of all the observations recorded here were foraging observations. Fifteen species were recorded at Big Carlos Pass with 14 of them using the site exclusively for foraging (Table C23). Of the 23 species with more than 33 foraging observations across the entire study area, only two species, Great Blue Heron and Reddish Egret, had more than 10 percent of their regional foraging observations at this site (Table 5 in the main text) and no species had more than 10 percent of their regional roosting observations at this site.

Table C23. Cumulative and maximum counts by behavior at Big Carlos Pass. Species are listed in taxonomic order.

		Cumulative Counts		Maximum Count	
Species	Code	Foraging	Roosting	Foraging	Roosting
Brown Pelican	BRPE	1		1	
Great Blue Heron	GBHE	6		1	
Great Egret	GREG	13		3	
Snowy Egret	SNEG	16		4	
Little Blue Heron	LBHE	2		1	
Reddish Egret	REEG	6		1	
Black-bellied Plover	BBPL	17		5	
Wilson's Plover	WIPL	1		1	
Willet	WILL	38		6	
Ruddy Turnstone	RUTU	49		9	
Red Knot	REKN	6		6	
Sanderling	SAND	92		15	
Laughing Gull	LAGU		1		1
Least Tern	LETE	2		2	
Sandwich Tern	SATE	3		3	

Habitat use by landform and substrate

All foraging and roosting observations occurred along the inlet shoreline Substrate use by species was the same as shown in Figures 2 and 3. Refer to Figures A47 through A54 for images of the Big Carlos Pass study area.

Disturbance

Big Carlos Pass experienced several disturbance factors. In addition to a moderate number of people present, ATV's, vehicles, and beach cleaning were recorded during each of the seven site visits (Table C24).

Table C24. Big Carlos Pass disturbance factors.

Avg N people	6
Max N people	13
ATVs present	Yes
Vehicles present	Yes
Ave N dogs	0
Ave N parked boats	0
N access points	1
Beach cleaning present	Yes

Lover's Key Lagoon

The 1,906 observations at this site comprised 4.3 percent of all observations across the study area. Over 66 percent of all observations at Lover's Key Lagoon were foraging observations. Of 26 species observed at Lover's Key Lagoon, 18 of them used this site exclusively for foraging (Table C25). Of the 23 species with more than 33 foraging observations across the entire study area, four species had more than 10 percent of their regional foraging observations at this site. From the highest to lowest percentage of regional foraging observations, these were: Reddish Egret, Roseate Spoonbill, Least Sandpiper, and Semipalmated Plover (Table 5 in the main text). Two species, Double-crested Cormorant and Willet, had more than 10 percent of their regional roosting observations at this site (Table 6 in the main text).

Table C25. Cumulative and maximum counts by behavior at Lover's Key Lagoon. Species are listed in taxonomic order.

Species	Code	Cumulative Counts		Maximum Count	
		Foraging	Roosting	Foraging	Roosting
Brown Pelican	BRPE		59		24
Double-crested Cormorant	DCCO		52		12
Great Blue Heron	GBHE	3		1	
Great Egret	GREG	16		4	
Snowy Egret	SNEG	30		11	
Little Blue Heron	LBHE	4		1	
Reddish Egret	REEG	8		2	
White Ibis	WHIB	43		15	
Roseate Spoonbill	ROSP	7		7	
Black-bellied Plover	BBPL	31		12	
Wilson's Plover	WIPL	13	3	7	3
Semipalmated Plover	SEPL	93	6	32	6
Spotted Sandpiper	SPSA	10		4	
Willet	WILL	32	52	12	52
Marbled Godwit	MAGO	13		8	
Ruddy Turnstone	RUTU	52		12	
Red Knot	REKN	36		23	
Sanderling	SAND	129		32	
Semipalmated Sandpiper	SESA	5		5	
Western Sandpiper	WESA	306		82	
Least Sandpiper	LESA	170		39	
Short-billed Dowitcher	SBDO	236		164	
Laughing Gull	LAGU	5	188	4	84
Least Tern	LETE	19		19	
Royal Tern	ROYT		64		35
Sandwich Tern	SATE		221		142

Habitat use by landform and substrate

All foraging and roosting observations were recorded on two major landforms at Lover's Key Lagoon, the lagoon and the ocean beach. Refer to Figures A55 through A60 for images of the Lover's Key Lagoon study area. Foraging observations were recorded on three substrates with the majority of foraging observations occurring on intertidal substrates followed by

shallow water. A small number of birds were recorded in fresh wrack (Table C26).

Roosting observations were recorded on four substrates. From most to least common these were intertidal substrates, shallow water, vegetation, and dry sand (Table C27).

Table C26. Foraging substrate and landform use by all species at Lover's Key Lagoon.

Foraging substrate	Foraging landform		Totals
	Lagoon	Ocean beach	
Fresh wrack		48	48
Intertidal	909	175	1084
Shallow water	128	1	129
Totals	1037	224	1261

Table C27. Roosting substrate and landform use by all species at Lover's Key Lagoon.

Roosting substrate	Roosting landform		Totals
	Lagoon	Ocean beach	
Dry sand		37	37
Intertidal	76	421	497
Shallow water	59		59
Vegetation	52		52
Totals	187	458	645

Disturbance

Lover’s Key Lagoon is visited by a moderate number of people. This site also experiences disturbance by ATV’s, which were present during six of the seven site visits. A small number of boats were observed on two of the seven site visits (Table C28).

Table C28. Lover's Key Lagoon disturbance factors.

Avg N people	17
Max N people	24
ATVs present	Yes
Vehicles present	No
Ave N dogs	0
Ave N parked boats	1
N access points	1
Beach cleaning present	No

New Pass

The 1,171 observations at this site comprised 2.6 percent of all observations across the study area. Over 95 percent percent of all observations at New Pass were roosting observations. Twelve species were observed at New Pass (Table C29). Of the 23 species with more than 33 foraging observations across the entire study area, no species had more than 10 percent of their regional foraging observations at this site and two species, Brown Pelican and Double-crested Cormorant, had more than 10 percent of their regional roosting observations at this site (Table 6 in the main text).

Table C29. Cumulative and maximum counts by behavior at New Pass. Species are listed in taxonomic order.

		Cumulative Counts		Maximum Count	
Species	Code	Foraging	Roosting	Foraging	Roosting
Brown Pelican	BRPE	2	362	2	100
Double-crested Cormorant	DCCO		30		10
Great Egret	GREG	3		1	
Snowy Egret	SNEG	3		2	
Black-bellied Plover	BBPL	1		1	
Wilson's Plover	WIPL	1		1	
Willet	WILL	5	6	2	6
Ruddy Turnstone	RUTU	12		5	
Sanderling	SAND	27		8	
Laughing Gull	LAGU		343		106
Royal Tern	ROYT		100		28
Sandwich Tern	SATE		276		76

Habitat use by landform and substrate

All but three foraging observations were recorded on the inlet shoreline. Refer to Figures A61 through A66 for images of the New Pass study area. Foraging observations were recorded on three substrates. From most to least common, these were: intertidal substrates, fresh wrack, and shallow water. All roosting observations were on intertidal substrates on the inlet's ebb shoal.

Disturbance

A relatively low number of people were recorded at New Pass throughout the entire study period. ATV's, however, were present during each of the seven site visits (Table C30).

Table C30. New Pass disturbance factors.

Avg N people	2
Max N people	10
ATVs present	Yes
Vehicles present	No
Ave N dogs	0
Ave N parked boats	1
N access points	1
Beach cleaning present	No

Big Hickory Pass

The 1,550 observations at this site comprised 3.5 percent of all observations across the study area. Almost 68 percent percent of all observations at Big Hickory Pass were roosting observations. Twenty-four species were observed at Big Hickory Pass (Table C31). Of the 23 species with more than 33 foraging observations across the entire study area, only two species, Least Sandpiper and Semipalmated Sandpiper, had more than 10 percent of their regional foraging observations at this site (Table 5 in the main text). Four species had more than 10 percent of their regional roosting observations at this site. From the highest to lowest percentage of regional roosting observations, these were: Black-bellied Plover, Willet, Wilson's Plover, and Semipalmated Plover (Table 6 in the main text).

Table C31. Cumulative and maximum counts by behavior at Big Hickory Pass. Species are listed in taxonomic order.

Species	Code	Cumulative Counts		Maximum Count	
		Foraging	Roosting	Foraging	Roosting
Brown Pelican	BRPE	2	50	2	19
Double-crested Cormorant	DCCO	1	12	1	5
Great Blue Heron	GBHE	4		1	
Great Egret	GREG	9		3	
Snowy Egret	SNEG	18		8	
Little Blue Heron	LBHE	1		1	
White Ibis	WHIB	5		3	
Black-bellied Plover	BBPL	3	24	2	8
Wilson's Plover	WIPL	2	26	2	7
Semipalmated Plover	SEPL	13	75	6	24
Willet	WILL	23	37	6	19
Ruddy Turnstone	RUTU	29		8	
Red Knot	REKN	6		5	
Sanderling	SAND	74		16	
Semipalmated Sandpiper	SESA	16		8	
Western Sandpiper	WESA	119		42	
Least Sandpiper	LESA	168		64	
Short-billed Dowitcher	SBDO	5	8	5	8
Laughing Gull	LAGU		427		140
Least Tern	LETE		5		5
Forster's Tern	FOTE		2		2
Royal Tern	ROYT		116		24
Sandwich Tern	SATE		258		72
Black Skimmer	BLSK		12		12

Habitat use by landform and substrate

Foraging observations at Big Hickory Pass were recorded on three landforms: a flood shoal, an inlet shoreline, and the ocean beach (Table 38). Refer to Figures A67 through A75 for images of the Big Hickory Pass study area. Foraging observations were recorded on three substrates. From most to least common, these were ephemeral pools, intertidal substrates, and shallow water (Table C32).

All roosting observations at Big Hickory Pass were recorded on one landform, the ocean beach. The majority of all roosting observations were recorded on intertidal substrates followed by dry sand substrates (Table C33).

Table C32. Foraging substrate and landform use by all species at Big Hickory Pass

	Foraging landform			
Foraging substrate	Flood shoal	Inlet shoreline	Ocean beach	Totals
Ephemeral pool	4	251		255
Intertidal	64	23	112	199
Shallow water		44		44
Totals	68	318	112	498

Table C33. Roosting substrate and landform use by all species at Big Hickory Pass.

	Roosting landform
Roosting substrate	Ocean beach
Dry sand	162
Intertidal	874
Totals	1036

Disturbance

People were observed at Big Hickory Pass during six out of seven visits. Boats were present at four of the seven site visits and typically were in small numbers (three or less; one visit recorded 10 boats) (Table C34).

Table C34. Big Hickory Pass disturbance factors.

Avg N people	3
Max N people	13
ATVs present	No
Vehicles present	No
Ave N dogs	0
Ave N parked boats	1
N access points	1
Beach cleaning present	No

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14. ABSTRACT

The tendency to survey shoreline-dependent birds by taxonomic grouping has led to an incomplete picture of avian habitat associations within Florida's Barrier Island ecosystems. Planning for the conservation of Florida's shoreline-dependent birds requires a greater understanding of regional and site-specific habitat associations within the community of shoreline-dependent birds during fall migration, when many species are near peak annual abundances. Between August 15 and October 28, 2006 almost 45,000 observations of 42 species at 10 coastal study sites were recorded in southwestern Lee County, Florida. Counts varied strongly by species, site, behavior, and habitat. This study documents striking differences in the community of birds using the study area for foraging and for roosting. Foraging birds were comprised of primarily shorebirds and herons using low-energy intertidal areas and wrack lines around bay beaches, lagoons, and inlet shorelines. Seabirds, particularly terns, skimmers, and pelicans were dominant roosting birds, using intertidal areas on flood shoals, bay beaches, and lagoons. Several plover species roosted almost exclusively along inlet shorelines in and around old, decaying wrack. A small number of heavily used sites contributed a majority of all observations, including a new inlet/washover area that was created by Hurricane Charley in 2004, known locally as Charley Pass.

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