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Dredging Operations and Environmental Research Program

Florida Coastal Engineering and Bird Conservation Geographic Information System (GIS) Manual

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Final report

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Abstract: This report describes a Geographic Information System (GIS) that displays ~500 sand placement events in Florida between 1959 and 2006. These events include: beach nourishment projects, renourishment events, dune restoration projects, emergency berm placements, inlet by-passing, and beach dredged material disposal. Data were consolidated from disparate sources to provide a comprehensive GIS. Each event is represented by a unique line file containing attribute information on project type, year, action agency, data source, and borrow site (when available). The GIS also includes point files representing survey data on the distribution and/or abundance of six high-priority bird species from a variety of state-wide surveys. Bird data are presented for piping plover, snowy plover, red knot, least tern, black skimmer, and American oyster-catcher. This report provides an overview of coastal engineering activities in Florida, focusing primarily on sand placement; describes how these data have been tracked by agencies; and suggests ways that this GIS could be regularly updated to provide a highly useful tracking system. Detailed descriptions of data in attribute fields are provided for both sand place-ment and bird survey shape files. The report also discusses an approach to the simultaneous presentation of bird data from multiple surveys with different methodologies.

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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. Research conducted for this report was funded by the Shore Protection Assessment Program. The Technical Director of the program at the time of publication was Dr. Jack E. Davis and the Program Manager was William R. Curtis. The work was performed under the direction of Dr. William Martin, Director of the Coastal and Hydraulics Laboratory (CHL), U.S. Army Engineer Research and Development Center (ERDC). 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.

Several people assisted in compiling or reviewing data that were eventually incorporated into this GIS. For engineering project data, the authors wish to thank Roxane Dow of the Department of Environmental Protection–Bureau of Beaches and Coastal Systems DEP-BBCS, who provided updated Beach Management Plan documents and invaluable information regarding the status of many projects. Others that provided or extensively reviewed engineering project data include: Ann-Marie Lauritsen of the U.S. Fish and Wildlife Service (FWS), and Ken Dugger and Paul Stodola of the U.S. Army Engineer District, Jacksonville. Thanks to Sam Jackson (ERDC-EL) for creating the original line file that connected all R-monument points. This shapefile served as the foundation for the creation of final engineering line files in the GIS. Thanks to Paul Lang of FWS for his oversight and for allowing his GIS intern to devote considerable time to this project. Susannah Casey of American Bird Conservancy also helped to consolidate engineering project data. Both shapefiles and helpful insights regarding bird distribution and abundance data were provided by John Himes, Raya Pruner, Jeff Gore, and Nancy Douglass of Florida Fish and Wildlife Conservation Commission; and Ann-Marie Lauritsen, Marilyn Knight, and Billy Brooks of FWS.

Unit Conversion Factors

Multiply	By	To Obtain
feet	0.3048	meters
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters

1 Introduction

Document background

This Geographic Information System (GIS) was developed during two independent, but conceptually related, projects. First, American Bird Conservancy (ABC) has investigated how coastal engineering projects (present before and after major hurricanes) affect Piping Plover and Snowy Plover habitat and distribution in Florida (Lott 2009). Second, since 2006, the U.S. Fish and Wildlife Service (FWS) and the Corps have been engaged in a state-wide programmatic consultation in accordance with Section 7 of the Endangered Species Act, as amended (Act) (16 U.S.C. 1531 et seq.) regarding the effects of sand placement activities on federally threatened and endangered wildlife. The consultation will assess impacts of all activities associated with the placement of compatible sediment on beaches of the Atlantic and Gulf coasts of Florida. Taxonomic groups included in the consultation are sea turtles, beach mice, manatees, and piping plovers (U.S. Army Corps of Engineers (USACE) 2006).

To more effectively evaluate direct, indirect, and cumulative impacts to shorebirds during the consultation process, FWS requested a GIS layer depicting locations of all coastal Corps projects with the intention of superimposing known shorebird use areas with the project layer. The Corps had no such GIS capability. ABC committed to provide such a GIS project that depicts most pre-programmatic Corps and Florida Department of Environmental Protection (DEP) sand placement projects as well as shorebird data layers from various sources. ABC and the GIS staff of the USFWS Panama City Ecological Services Office, with the help of many partners, worked towards assembling both bird and coastal engineering project data into a single, cohesive GIS project, described herein.

How to use this document

This document is written in three sections: 1) background information on coastal engineering in Florida (Chapters 1 and 2); 2) integration of engineering data into the GIS project (Chapter 3); and 3) integration of bird data into the GIS project (Chapter 4). This document is specifically written to accompany the distribution of the coastal engineering and bird survey data represented in this GIS project. It provides information on data sources, contexts for interpretation, references for further reading, and descriptions and definitions of codes in attribute fields associated with specific shapefiles contained in the GIS project. More detailed metadata are included in each specific data layer. The final GIS is available for download at: http://el.erdc.usace.army.mil/ dots/coastalbirds.html. No original bird surveys were coordinated for use in this GIS project. Existing data were collected by many agencies and individuals with independent goals. Inclusion of these data into this GIS project was approved under the condition that this document be distributed with the final GIS project. Individuals who receive copies of the GIS project are strongly advised to read and understand this full document, and any necessary supporting documents, especially if they intend to present independent data summaries that rely extensively on this GIS project. Although this GIS project is a powerful tool for discussing bird distributions relative to coastal engineering projects, or assessing high-priority, shoreline-dependent bird distribution in Florida, there are limitations to many of the component data sources, and these limitations are discussed further in this document.

The authors request that users cite this document if used in future data summaries that rely on this GIS project. The user should also cite original reports from each bird survey if used for future data summaries. Citations are provided in this document and GIS project metadata. Secondary interpretations of data that arise from use of this GIS project do not represent the views of the authors of the data layers, nor their agencies, organizations, or individuals who contributed to original data collection.

2 Coastal Engineering in Florida, Agencies and Mechanisms for Sand Placement

U.S. Army Corps of Engineers (Corps) – Jacksonville and Mobile Districts

The Corps has two Districts in Florida. The Mobile District covers the Panhandle (Escambia County east to Jefferson County) and the Jacksonville District covers the rest of the state. The Corps places sand on Florida's beaches as part of two major long-term agency programs: Shoreline Protection and Navigation. Shoreline Protection Projects (SPPs) require congressional authorization and are funded by congressional appropriations. SPPs usually have an initial sand placement event (often called "beach nourishment" by the Corps and "beach restoration" by DEP) and then a maintenance period of up to 50 years, including multiple sand placement events (often referred to as "renourishment" events by the Corps or "nourishment" events by DEP). The Corps works with a local sponsor, typically a municipality or an erosion control district, on all SPPs. Federal funding comprises between 50 and 80% of federal SPPs with the remaining costs borne by either the local sponsor or in combination by the local sponsor and the DEP. The Corps also places sand on beaches during dredging related to creating or maintaining federally authorized navigation channels. If beach disposal of dredged material is the most cost-effective option, this material is placed on the beach at no cost to the recipient. If additional costs are incurred to place this material on the beach, these are borne either by local sponsors or the DEP. In addition to appropriations for SPPs and Navigation Projects, the Corps periodically receives Emergency Appropriations from Congress to either: 1) accelerate the maintenance nourishment of authorized SPPs ($62 million after the 2004 hurricane season), or 2) replace sand that was lost from a completed federally authorized SPP during a storm event (Public Law 84-89, which provided $148 million after the 2004 hurricane season).

Florida Department of Environmental Protection (DEP) – Bureau of Beaches and Coastal Systems (BBCS)

Florida DEP's Bureau of Beaches and Coastal Systems (BBCS) is a state agency that coordinates and/or provides funding for shoreline protection and the maintenance of recreational beaches in seven different regions covering the entire state of Florida (Figure 1). DEP's seven coastal regions are subdivided into 40 subregions based on coastal geomorphology and littoral transport. DEP is involved with sand placement through: 1) beach nourishment/restoration and subsequent renourishment/nourishment; 2) dune restoration; 3) emergency sand placement in response to storms; and 4) mitigation for the erosive effects of jettied inlets on downdrift beaches through inlet bypassing. DEP coordinates the annual funding of approximately $30 million in appropriations from the Florida legislature as well as any emergency state appropriations for shoreline protection or the creation of recreational beaches. Annually, local sponsors submit requests for funding for any of the above-listed project types and DEP develops a list of priority and alternate projects to receive funding. Alternate projects receive funding in years with larger appropriations or when priority projects fail to meet cost-share requirements or prepare pre-project documents on schedule. DEP's periodically revised regional Beach Management Plans (BMPs) incorporate strategies for inlet management developed in numerous Inlet Management Plans (Florida Department of Environmental Protection 2007). These plans, initially approved in 2000, have been updated in conjunction with the revision of regional BMPs.

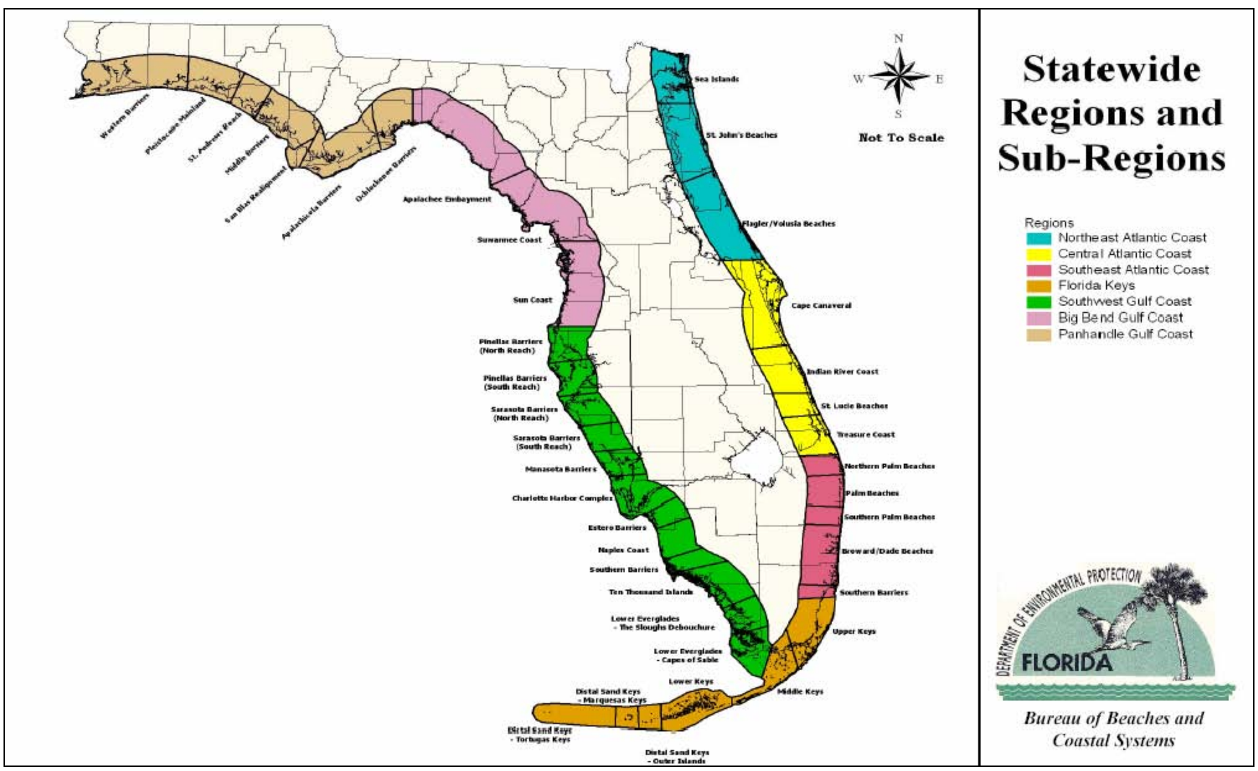

Figure 1. DEP state-wide regions and sub-regions.

Regional BMPs and the BBCS' long-range budget plan (with annual updates) are available online at: http://www.dep.state.fl.us/beaches/programs/bcherosn.htm#Statewide_Strategic_Beach_Managment_Plan). These documents give an overview of the extent of sand placement activities that have historically occurred in Florida and those that are planned state-wide in any given year. Unfortunately, a similar compendium detailing the history and location of hard structure construction (e.g., jetties, groins, seawalls) in Florida is not available. Therefore, this GIS project represents only information for sand placement events.

Local governments, land management agencies, and erosion control districts

Many coastal sand placement projects require the participation of a local sponsor. This is most frequently a county, a municipality, an erosion control district, or a land management agency (such as the Florida Park Service, also a branch of DEP). Local sponsors are frequently responsible for some percentage of the cost of a sand placement event, whether the majority of the funding comes from the federal government or the state (see above). In some cases, these same local entities cover 100% of the cost of a sand placement project (e.g., a county may pay a contractor directly to place sand on its beaches). This is relatively rare compared with the participation of local entities as sponsors on federal or state-funded projects, but sand placement events driven by (and paid for entirely) local governments may become more common in the future if federal and state funding for shoreline protection decrease.

Coastal engineering firms

Although both the Corps and DEP are capable of designing and constructing sand placement projects, this work is frequently done under contract with coastal engineering firms. Firms that have been particularly active in Florida since 1990 include: Applied Technology and Management, Inc.; Coastal Engineering Consultants, Inc.; Coastal Planning and Engineering, Inc.; Coastal Systems International, Inc.; Coastal Technology, Inc.; Olsen Associates, Inc.; and Taylor Engineering Inc. This list of engineering firms is not considered a comprehensive list nor does it represent an endorsement of any kind.

3 Engineering Data in the GIS

Coastal engineering data sources and the contents of this GIS project

Coastal engineering for shoreline protection is accomplished by a mix of hard structural methods (e.g., jetties, groins, seawalls) and sand placement methods (e.g., beach and dune restoration and nourishment, beach disposal of dredged-material, and sand bypassing around inlets). DEP's December 2006 revised draft regional BMP was used as the primary source of data for unique beach placement events to build this GIS project. Secondary sources were data on additional sand placement events from other DEP documents, which include annual Beach Management Planning Assistance Budget reports for FY 06–07 and FY 07–08 and Hurricane Recovery Plans written after the 2004 and 2005 hurricane seasons (Florida DEP 2004, 2005). Additional sand placement event data were acquired from the Corps' October 2006 draft RBA describing historic sand placement activities in Florida. Given the comprehensive nature of the BMPs, and their recent revision, the authors deferred to data in these documents when there were discrepancies in information among other data sources. The exception to this rule was for federal shoreline protection projects. In this case, when there were data discrepancies between the Corps' appendix and the BMPs, the Corps information was used as the primary source, but only for federal projects listed in the Corps appendix. For state and local projects, the BMPs were used.

Structure of the GIS

Data for individual sand placement events were recorded in a master database, with a number of attribute fields for each event. Attributes for each sand placement event fit into one of eight different categories: 1) location; 2) timeline; 3) project type; 4) sand source; 5) funding type; 6) project participants; 7) data source; and 8) fields necessary to convert original data into shapefiles. Detailed descriptions of attribute fields and data codes are included in the "GIS attribute data descriptions" section below.

A single record was created for each sand placement event that was unique in either time and/or space. For example, three nourishments of the same stretch of beach in three different years were documented as three unique events in the database. Similarly, events that took place at the same time, but were separated in space, were included as separate records in the database. For example, if nourishment took place between R-1 and R-10 and then the pipe was moved down the beach and sand was placed between R-14 and R-20, these sand placement episodes were recorded as two separate events, even though they may have been done by the same contractor, using the same materials, funding, and equipment only a few months apart. Taking this approach (splitting sand placement into discrete events in time and/or space and recording each event as a unique line in the database) allows representation of the true spatial and temporal extent of sand placement in Florida in a GIS. For example, one can choose to illustrate only sand placement events that took place between a narrow range of years (e.g., between 1980 and 1990 or between 2004 and 2006). When data for multiple nourishment events are combined into a single record, this is not possible. As a result, the draft GIS records ~500 unique sand placement events. Many of these events record the history of multiple sand placement episodes along the same highly populated and/or chronically eroding reaches of shoreline.

Individual line files were created for each sand placement event after data were compiled and reviewed (see below). Line files were originally created based on R-monument locations and then moved offshore. R-monuments are a series of reference points, spaced approximately ~1,000 ft apart, which follow the contour of Florida's shoreline in all regions except for the Big Bend Gulf Coast and the Florida Keys (http://www.dep.state.fl.us/beaches/data/gis-data.htm). If a beach restoration project took place between R-10 and R-20, a line file was created connecting each of the R-monuments between R-10 and R-20 with each other. This way, projects covering long stretches of shoreline follow the contours of the shoreline. The presence of R-monuments in Florida, and their use to describe locations of sand placement events, was critical to the creation of spatially explicit line files for individual events. When sand placement events did not reference R-monuments, and were instead described by general text (e.g., "sand was placed on downdrift beaches"), they could not be accurately represented spatially and therefore were not incorporated into the shapefiles.

Line files for different project types (e.g., beach restoration versus dune restoration) were offset from each other parallel to shore in order to display multiple projects for a single area in a way that events were not visually buried beneath each other. Therefore, individual line files do not represent the EXACT area of sand placement, but are rather a graphical representation of where the event occurred, offset to an offshore position, allowing all emergency berms, dune restoration projects, beach nourishment/restoration projects, and/or renourishment/nourishment events that have occurred across a stretch of shoreline over time to be viewed at the same time. This approach was taken because different types of projects may have either different scales of impacts or different regulatory histories. Line file offsets were designed far enough offshore so that bird distribution data could be visually represented (and not be buried by lines) and so that all sand placement events for an area could be easily seen when the GIS was viewed at a scale of 1:500,000 or greater (see illustration on cover page). A shapefile with the original location of lines connecting R-monuments is included in the GIS to facilitate analyses of linear extents of shoreline covered by different project types. Any such analyses should be based on the original R-monument line file, not the offshore line files, where line sizes may have been distorted by altering the original geometry of lines for graphical purposes.

Spatial and temporal coverage of the GIS

The GIS covers sand placement events in five different DEP regions, covering most of the state of Florida, and representing the vast majority of sand placement activity across the state. These regions are: 1) Panhandle Gulf Coast; 2) Southwest Gulf Coast; 3) Northeast Atlantic Coast; 4) Central Atlantic Coast; and 5) Southeast Atlantic Coast. The Big Bend Gulf Coast and Florida Keys regions were not included due to the lack of R-monuments and the relatively small number of sand placement events in each of these regions. It would be beneficial if R-monuments were created for both of these regions for the sake of future reference as the number of sand placement events in both of these regions is likely to increase.

The GIS includes ~500 unique sand placement events between the years 1959 and 2006. The number of sand placement events has increased in each decade over this time period (Figure 2). Although record keeping has also improved in recent years and some of this trend is due to information from early projects being lost, the trend towards more frequent sand placement in recent years is very real. In the current decade, 61 sand placement events were completed between 2000 and 2003. After the 2004 hurricane season, where four major storms made landfall in Florida, congressional and state appropriations for emergency repair to beaches

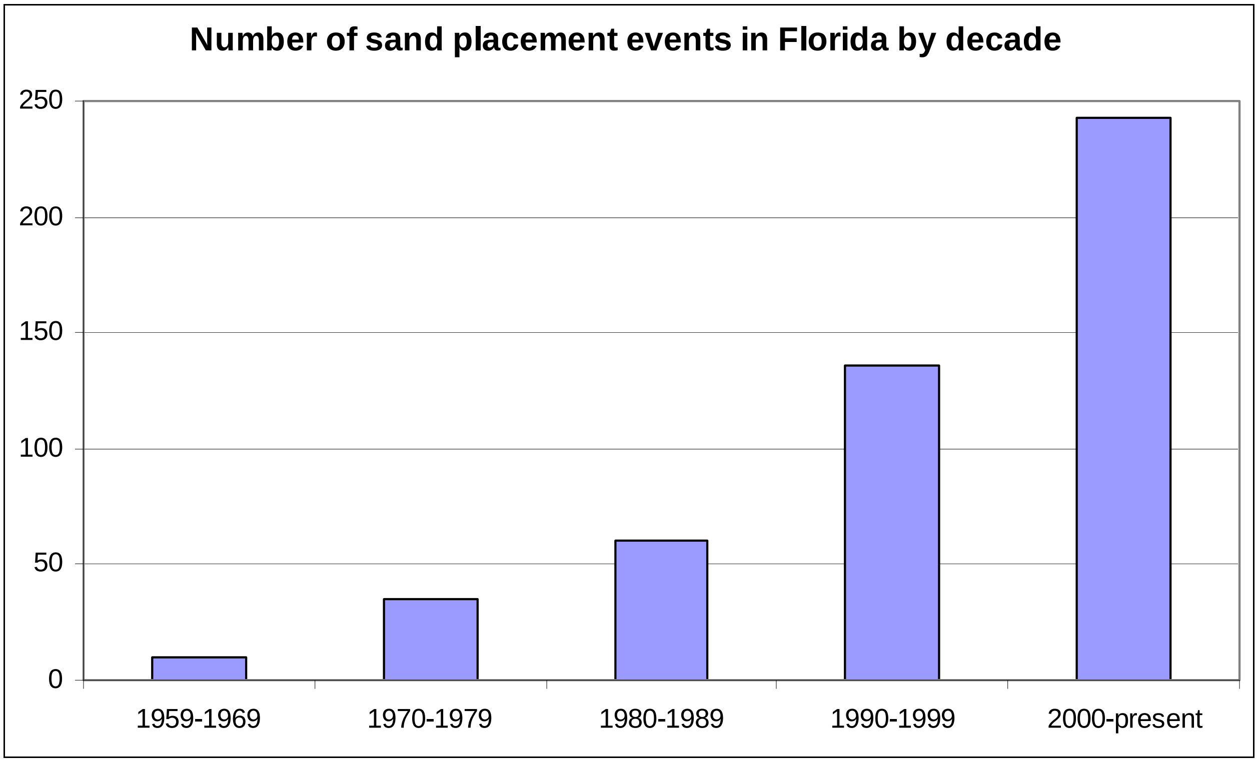

Figure 2. Sand placement events in Florida by decade.

resulted in the busiest time period for sand placement in Florida's history. In the three years between 2004 and 2006, 126 sand placement events were completed in Florida. This is nearly the same amount as occurred in the entire decade of the 1990s (136) and it is greater than all sand placement events that occurred in the 31 years between 1959 and 1989 (105). An additional 56 sand placement events were listed as either slated for completion in 2007 or in a funded stage of planning (e.g., feasibility or design).

Data review and accuracy of attribute data

Data were sent to coastal engineers and agency planning personnel for review and quality control after construction of the initial database. Data were sent to staff from the Corps, DEP, FWS, the Federal Emergency Management Agency (FEMA), and the Florida Fish and Wildlife Conservation Commission (FWC). This process helped to improve the accuracy of some project attribute data. However, there are still many projects that lack complete information. For example, 79 out of 491 (or 16%) sand placement events lacked data on R-monument locations for sand placement and only included narrative descriptions of project extents. This precluded a large number of sand placement events from being plotted in the GIS. As of February 2008, the GIS project could still benefit from more thorough review by coastal engineering professionals and agency personnel that represent the institutional knowledge necessary to improve these data. An excel version of the spreadsheet that was used to contribute attribute data for individual project shapefiles is available at http://el.erdc.usace.army.mil/dots/coastalbirds.html. For additional information regarding missing or uncertain attribute data (cells highlighted in yellow in the spreadsheet), contact FWS GIS personnel at the Panama City Ecological Services Office at 850/769-0552. They will revise the master spreadsheet and update attributes in the GIS.

Maintaining and expanding this GIS project

Updating the sand placement GIS project

The authors recommend that new sand placement events be incorporated into this GIS at least once a year and that a major effort be expended to update and verify the continued accuracy of the GIS at least once every 5 years (since many projects occur in a 5-year span and institutional memory can be short). This could happen in collaboration with DEP during the process of periodic revisions of beach management plans. Ideally, point persons should be designated within each of the major agencies involved with the planning or permitting of sand placement events in Florida to maintain records of each year's sand placement events following the format of the web-accessible spreadsheet referenced above. These point persons should communicate with all of their regional office staff to keep files up to date. Point persons would transmit each year's revisions or additions to the FWS GIS personnel at the Panama City Ecological Services Office at 850/769-0552. Once data have been received from all agency point persons, new shapefiles could be created, attribute data would be updated, and a revised set of shapefiles could be sent out to all cooperating agencies.

Incorporating hard structures into the GIS project

To more fully document the effects of coastal engineering on coastal ecosystems, two additional elements of spatial data should be included in future revisions to this GIS project: 1) hard structures; and 2) sand sources (borrow areas) for sand placement events. The authors suggest that a dedicated state-wide effort will be necessary to detail hard structure locations. This effort should result in a GIS that is compatible with (or part of) the sand placement GIS with line files representing the exact locations of hard structures at present. Since hard structure data have not historically been kept in one location and much of it is difficult (and perhaps impossible) to track down, it will be necessary to document exact hard structure locations on beaches across the state through an initial field inventory. The Florida Marine Research Institute (FMRI) has demonstrated that this can been done on foot across large geographic areas by walking along hard structures (such as a seawall) with a Global Positioning System (GPS) unit (with sub-meter accuracy) that continuously records position data in the field that can later be imported into a GIS.[1] Line files for shore-perpendicular structures (e.g., jetties and groins) that extend into the water and are not accessible on foot, could be created from aerial photography (particularly if their position at their base on the beach is noted during the initial on-foot assessment). However, hard structures on the beach (e.g., seawalls and revetments) cannot be reliably discerned from aerial photography. Therefore, a combination of on-foot GPS inventories of hard structures on the beach supplemented by aerial photography analyses (for jetties and groins) would be the most effective and accurate way to provide state-wide GIS data on hard structures. Once a hard structure GIS has been created, it should be updated on the same schedule as the sand placement events' GIS.

Incorporating sand sources (borrow areas) in future revisions

Similarly, future revisions of this GIS should include exact locations of borrow areas. These data are often only reported in the most general sense (e.g., "an offshore borrow area," or "the ebb shoal of Jupiter Inlet") and have been reported as such in the sand placement GIS. It would be preferable to create individual polygons mapping the spatial extent of each sand placement event's borrow area. Ideally, each sand placement event would be linked via an identifier in the database to a polygon (or polygons) indicating the borrow site(s) used for that project. For this to happen, permitting and funding agencies would need to require that dredging contractors create drawings of exact borrow areas on maps, photos, or navigation charts, or provide GPS coordinates so that these could later be converted into GIS by personnel at the Panama City Ecological Services Office at 850/769-0552. Target polygons should be borrow areas that were actually dredged, *not potential borrow areas listed in feasibility or design documents*. Since repeated mining of sand for beach placement can have major environmental effects, and since near-shore sources of beach quality

[1] Personal Communication. 2006. Tomo Hirama, GIS Specialist, Florida Marine Research Institute.

sand may be declining in some regions of Florida, information about borrow areas will be critical for regional planning and for documenting the regional environmental effects of shoreline protection. Borrow area data and sand placement data should be updated to coincide with GIS revisions.

Engineering file attribute data descriptions

1. Project Identification Number (**Geo_Sort**):
   This is a unique number given to an individual sand placement event. **These numbers provide a means to link individual projects with attribute data and they should never be revised.** Projects are ordered by region, subregion, and then year. In the GIS version, projects are numbered geographically; starting with the Panhandle and moving east and then south down the Southwest Gulf Coast to Collier County and then skipping to the Atlantic Coast and moving from north to south from Northeast Florida through the Southeastern Atlantic Coast. Sand placement events that are added to the GIS in the future will be given sequential numbers starting with the last sand placement event included in the database as of April 2006.

2. DEP Region (**Region_DEP**):
   All sand placement events are assigned to one of the seven DEP regions illustrated in Figure 1.

3. DEP Subregion (**SubReg_DEP**):
   All sand placement events are assigned to one of the 40 DEP subregions illustrated in Figure 1.

4. County (**County**):
   The county where a sand placement event takes place. When an event straddles a county line, the northernmost (or westernmost in the Panhandle) county is listed first, followed by the southernmost (or easternmost in the Panhandle) county.

5. Project Name (**Proj_Name**):
   Project names describe the location of the project and in some cases the purpose of the project. A standard naming convention has not been employed. With dredging projects, in some cases, the project is named after the areas where the sand was placed, for example, “Pensacola Pass Dredged Material Disposal- Perdido Key.” In other cases a dredging

project may be named for the area where sediment was dredged, for example, “Johns Pass Dredging.”

6. Project Type (**Type_Proj**):
All sand placement events have been assigned to one of 10 different types of projects. Some events could have been reasonably assigned to more than one different project type since many of these project types are related (for example, in some cases, either “dredged material disposal” or “inlet bypassing” would be fitting descriptions for the same project). Since there has not been a standard convention for assigning project types across the many agencies involved with sand placement in Florida, it was difficult to do so here. What follows are descriptions of the various project types used in this GIS. However, it should be clear that not all agencies use the same definitions when referring to different projects as one project type or another.

Note: Related project types that have similar purposes or take place in similar areas of the beach or dune have similar color types below.

Beach Restoration (BR) – The main objective of Beach Restoration projects is to increase beach width by placement of sand on the beach, **including areas below mean high tide**. This term is preferred by DEP to indicate the first placement of sand in an area that has not received large-scale sand placement in the past. The Corps frequently uses the term “beach nourishment” to mean the same thing. For the sake of this GIS, the term beach restoration was used for this event, which includes state/DEP-funded beach restoration projects, congressionally authorized beach nourishment projects, and locally funded large-scale placements of sand on the beach. Common sand sources for beach restoration include: off-shore borrow areas, inlet ebb shoals, dredged material from navigation channels, and upland borrow areas (such as confined dredged material disposal facilities). Less common sand sources for beach restoration projects include inlet flood shoals, inlet sediment traps, nearby beaches, imported sand, and other upland borrow areas (e.g., inland sand pits).

Renourishment (RN) – Similar to beach restoration, the main objective of beach renourishment episodes is to increase beach width by placement of sand on the beach, **including areas below mean high tide**. Renourishment, however, refers to any subsequent placement of sand on the beach after the initial beach restoration event. DEP often uses the term "nourishment" for this event. The authors used the term "renourishment" for this event in the GIS, since it tends to have more widespread use. Sand sources for renourishment projects are similar to those used for beach restoration projects.

Emergency Renourishment (ER) – Similar to beach restoration and renourishment, the main objective of emergency renourishment episodes is to increase beach width by placement of sand on the beach, **including areas below mean high tide**. This is a subcategory of the "renourishment" category and refers specifically to a renourishment episode that is intended to replace sand in a previously authorized project area that was documented to be lost during a specific storm event. Sand sources for emergency renourishment projects are similar to those used for beach restoration projects.

Emergency Berm (EB) – The main objective of emergency berm construction is short-term property protection after a major storm event. This refers to FEMA-funded berms, usually involving only small amounts of sand that are delivered by truck to the beach and graded into berms in front of structures by heavy equipment. Sources of sand for emergency berms are usually upland borrow areas.

Assisted Recovery (AR) – This is a category that was used only in the Panhandle Region prior to 2005, when it seems to have been supplanted by the term "dune restoration." The main objective of assisted recovery sand placement was to improve shoreline protection after storms by increasing the width of the beach or dune system **above mean high tide**. This refers to state and/or federal relief efforts after large tropical storms involving: the placement of sand above mean high water, usually as dunes; and sometimes including: supplementary sand fencing, and/or dune plantings. Sources of sand for assisted recovery projects are often upland borrow areas.

Dune Restoration (DR) - Similar to assisted recovery, the main objective of dune restoration is to improve shoreline protection by increasing the width of the beach or dune system **above mean high tide**. Sand is typically placed as a berm or dune feature that is often accompanied by supplementary sand fencing, dune planting, or both. This category overlaps with the assisted recovery category, except that dune restoration projects are not carried out exclusively in response to major storm events, although this is frequently the case. These dune restoration projects can occur in response to long-term shoreline erosion, as well as in response to short-term storm damage. Sources of sand for dune restoration projects are often upland borrow areas, but can be other sources as listed under beach restoration.

Dredged-material Disposal (DD) – The main objective of dredged-material disposal is to place sand from a major dredging event **on a beach**, **but sometimes includes areas below mean high tide.** The timing of these projects is driven by dredging needs, rather than sand placement needs, and sand placement during dredging disposal is often considered a beneficial use of dredged sand. Sand sources for dredged-material disposal sites are usually navigation channels, turning basins near ports, or sediment traps within inlets. Some DD events were probably recorded as beach renourishment events in the database when sand was placed in existing project areas.

Inlet Bypassing (IB) – The main objective of inlet bypassing projects is to provide sand to downdrift beaches that are starved for sediment due to engineered structures at navigation inlets, such as jetties, that disrupt littoral drift, causing sand to accumulate on beaches on the updrift side of the inlet (or in ebb shoals) rather than on downdrift beaches. The timing of these projects is driven by sand placement needs on the downdrift beach. Sand sources for inlet bypassing are often updrift beaches or inlet ebb shoals. Some IB events were probably recorded as beach renourishment events in the database when sand was placed in existing project areas.

Road Reconstruction (RR) – When roads have been destroyed by hurricanes, sand placement has frequently been a component of rebuilding roadbeds. Road reconstruction events involving sand placement were infrequently reported in the source documents reviewed for this GIS, but should be integrated into future versions of the GIS.

Feasibility Study (F)) – This is the early exploration of alternatives for shoreline protection or erosion control. Feasibility studies research alternative solutions and are usually accompanied by an economic analysis of alternatives. Feasibility studies result in recommended alternatives for future sand placement. Generally, sand placement events cannot occur in the absence of a feasibility study.

7. Range Monument Starting Point (**RM_Start**). The northern or western-most (in the Panhandle) R-monument at the beginning of a linear stretch of beach where sand placement has occurred. **This should always be a single number, not a range of numbers.**

8. Range Monument Ending Point (**RM_End**). The southern or eastern-most (in the Panhandle) R-monument at the end of a linear stretch of beach where sand placement has occurred. **This should always be a single number, not a range of numbers.**

9. Location Accuracy (**Loc_Accry**). This field refers to the quality of data regarding R-monument locations for each event. If exact R-monuments were provided, this field was coded E for exact. If R-monuments were not provided at all, this field was coded U for unknown. If R-monuments were provided, but their accuracy was uncertain, this field was coded NC for needs clarification.

10. Year Project Completed (**Yr_Comp**). This field records the year in which ALL sand placement for a single event was considered complete. If a single event started in one year but finished in another, only the year that the sand placement event was finished was recorded. **Do not enter a range of years in this field.**

    Ongoing projects in one of the four planning stages *prior to completion* (described below under status) are given a value of 9999 in this field to indicate an unknown future year of completion. When this project is complete (e.g., all planning phases are complete and all sand has been placed) the status of the project should be updated to complete and a year of completion should be entered to replace the 9999. At this time, any previous entries describing the project as in one of the planning phases should be deleted.

11. Status of the Project (**Status**). Sand placement projects generally proceed through four phases before they can be considered complete. This attribute field lists where each sand placement event is along the continuum from early planning to completion. The status of any given project can be assigned to one of five categories, with the first four indicating an incomplete project: 1) Feasibility; 2) Recommended; 3) Design and Permitting; 4) Under Construction/Ongoing; and 5) Complete. **Each sand placement event should only have a single line in the database.**

Therefore, when a project moves from the feasibility stage to the recommended stage, only the status field in the database needs to be updated, and a new line should not be added. Only completed projects should have a year in the "Yr_Complete" field (see above). All projects in the feasibility, recommended, design/ permitting, or under construction phases, should have a 9999 in the "Yr_Complete" field, indicating an unknown future year of completion.

Feasibility studies usually evaluate several different solutions to shoreline erosion problems and include economic analyses of these different options. When a feasibility study is complete, a strategy is recommended. This strategy will be one of the options from the Type_Project field (e.g., dune restoration, beach restoration, etc.). Once a project is "Recommended" it stays this way until there is funding for the "Design/ Permitting" phase. So, if a project has the status of "Recommended," this always means that a feasibility study has already been completed. Once a project has funding for additional planning it enters into the design/ permitting phase, which can be relatively quick or last for many years. Once this phase is complete and all permits are finalized, the project can move on to construction (pending funding). A project is considered under construction until the last sand is placed, at which point the project becomes complete.

12. Sand Source (**BorrowType**). Sand sources for beach sand placement events, often referred to as "borrow areas," were assigned to one of ten possible categories, which includes the category "unknown" when this information was not available.
    a. Offshore shoal (OS). Intended for shoals that are seaward of the barrier island or mainland beach that are NOT ebb shoals around inlets.
    b. Ebb shoal of inlet (ES). Sand accumulation on the seaward side of an inlet deposited by an interaction between littoral drift and tidal currents.
    c. Navigation channel or pass (NC/P). Material dredged specifically from the navigation channel to increase channel depth.
    d. Flood shoal of inlet (FS). Sand accumulation on the inside of an inlet as a result of interactions among tidal currents.
    e. Sediment trap of inlet (ST). Dredged reservoir for sediment accumulation inside an inlet that is usually designed to minimize shoaling in a navigation channel. Takes the place of a flood shoal in some inlets where flood shoals have been extensively dredged.

f. Nearby beach (NB). Cases where sand is taken from one beach to be placed on another.
g. Confined disposal facility (CDF). Either an upland area on the mainland or a diked island in a water body where dredged material from navigation channels is disposed.
h. Imported sand (I). Cases where sand is barged or trucked in from a distant region (e.g., the Bahamas for projects in Southeast Florida).
i. Upland (UP). Any sand source inland from the primary dune.
j. Unknown (U) source.

13. Description of Borrow Site (**BorrowSite**). A short text description that can provide a more specific location than the code for borrow site type. For example, "Jupiter Inlet ebb shoal" is more specific than the code ES for Ebb Shoal. Descriptions more detailed than the ones that have been given would be welcomed. For example, "offshore shoal" could be improved to "offshore shoal 3.2 miles SSW from R-44," or "Jupiter Inlet ebb shoal" could be improved to "Ebb shoal of Jupiter Inlet, 300 meters NNE of R-12." **Ideally, text descriptions like these would be replaced in future revisions of this GIS by spatially explicit polygons that represent exact borrow areas for each sand placement event.**

14. Funding Source (**Funding**). Currently, this field has only three possible codes, F for federal, S for state, and L for local. However, there are different types of federal, state, and local funding and future revisions of the GIS could be more specific about funding sources if so desired (for example, Public Law 84-89 could be listed as the source of federal funding). Most projects have more than one funding source. Therefore, multiple funding sources are listed in this field by separating each code by a slash, with the funding source that contributes the most dollars listed first. For example, a project that had a majority of federal funding but also some funding by a local sponsor is listed as F/L. Similarly, a project that had a majority of state funding, with lesser federal or local contributions, is listed as S/F/L. This field is suspected to be less accurate than other fields in the database, since until recently, project funding types have not been well tracked. A better protocol for describing funding sources and amounts for specific projects, and tracking them in this GIS, would be welcome.

15. Local Sponsor if Applicable (**LocSponsor**). This field lists the local sponsor for a project that was conducted in association with a coordinating agency (the Corps or DEP). Local sponsors are usually a municipality or an

erosion control district, but sometimes this can be a land management agency. Only a single local sponsor should be listed. Much information for this field is missing in the database and greater care should be taken to include these data as future sand placement events are added.

16. Source of Data (**Source**). This field lists the information source for data on each sand placement event. Fourteen different data sources were possible, although data sources 1-5 and 10 (below) provided the bulk of the data.

    a. SWGC BMP=DEP South West Gulf Coast Beach Management Plan (12-2006 revision)
    b. PAN BMP= DEP Panhandle Gulf Coast Beach Management Plan (12-2006 revision)
    c. NE BMP=DEP Northeast Atlantic Coast Beach Management Plan (12-2006 revision)
    d. CE BMP=DEP Central Atlantic Coast Beach Management Plan (12-2006 revision)
    e. SE BMP=DEP Southeast Atlantic Coast Beach Management Plan (12-2006 revision)
    f. DEP 06-07=DEP Beach Management Funding Assistance Program Budget FY 06-07
    g. DEP 07-08=DEP Beach Management Funding Assistance Program Budget FY 07-08
    h. HRP04=DEP Hurricane Recovery Plan 2004
    i. HRP05=DEP Hurricane Recovery Plan 2005
    j. CORPS=Appendix in Corps' draft regional biological assessment
    k. FWS=FWS staff input
    l. FWC=FWC staff input
    m. FEMA=FEMA staff input
    n. DEP= DEP staff input

17. Entity that Coordinates Project (**Coord_Enty**). In the case of congressionally authorized civil works projects for either shoreline protection or maintenance of federally authorized navigation channels, this will be the U.S. Army Corps of Engineers, coded as Corps in this field. When a project is a state-funded beach and/or a dune restoration project, this will be the Florida Department of Environmental Protection - Bureau of Beaches and Coastal Systems, coded as DEP in this field. The coordinating entity pairs with a local sponsor (see below). In cases where a municipality or property

owner works independently of the Corps and/or DEP to coordinate and move forward a sand placement event, the municipality or property owner is listed in this field. This field is most accurate for projects where the Corps is the coordinating entity.

18. Project Type Code (**Proj_Code**). This field was added to the original database to aid in converting to GIS shapefiles. Each project was given one of six numeric codes depending on which of the six different shapefiles it was assigned to: 1) Road Construction (RR), 2) Emergency Berm (EB), 3) Dune Restoration (DR) and Assisted Recovery (AR), 4) Beach Restoration (BR) and Feasibility Study (F), 5) Dredging Disposal (DD) and Inlet Bypassing (IB), and 6) Renourishment (RN) and Emergency Renourishment (ER).

19. Unique GIS Project Identifier (**RM_Join**). This field was added to the original database in order to convert the original data to GIS shapefiles. Within each of the six different line files representing different project types (e.g., emergency berms, beach restoration/nourishment), a unique identifier was created by using the first three letters of the county followed by a number unique to each engineering event. For example, Escambia R-1 to R-10 would be labeled ESC1. The next project in this Escambia County would be labeled ESC2, etc.

20. Legend (**Legend**). This field was added to the original database in order to symbolize projects that were “in progress” as dotted lines. All projects with 9999 values in the year field were symbolized as dotted lines.

4 Bird Distribution and Abundance Data in the GIS

Conditions for future data summaries based on this GIS

Simultaneously viewing multiple data layers from independent bird surveys on the same map often equates to increased difficulty with interpretation. The user must carefully consider the underlying properties and limitations of the mapped bird count data represented in the GIS prior to reaching any conclusions. Careful reading of this manual and the relevant sections of original survey reports (each are included with the GIS in the folder "Bird data/Reports") is necessary to prevent data misrepresentation. Presentation of bird data from this GIS out of context is an inappropriate use of this GIS and violates the permissions for data use that were given by data contributors. The following text outlines the properties of the data displayed in this GIS. Descriptions of bird shapefile attributes are included in the project metadata. At the request of data contributors, some attributes for bird survey data were removed from final shapefiles. Additionally, some attributes were removed prior to distribution of this GIS because original data contributors did not provide field-specific data descriptions similar to those provided for engineering project data (see previous section). Accordingly, minimum information is reported to describe bird distribution and/or abundance. Some of the original spatial datasets for these surveys may include additional attributes of interest to readers. Interested parties should request these data sets directly from the agencies or authors of the final reports that describe these surveys in detail (see below).

Taxonomic scope of bird data included in the GIS

This GIS includes distribution and abundance data for only a select number of shoreline-dependent bird species that regularly occur in Florida. The data represent a limited number of seasons for each species. Bird data are restricted to six high-priority species that have either federal status (as threatened or endangered species), state (FWC) conservation status, or have had petitions filed on their behalf for listing under the federal Endangered Species Act. The bird data used include mid-winter surveys for Piping Plovers, Snowy Plovers, and Red Knots as part of the International Piping Plover Census (IPPC) and dedicated breeding season surveys, organized by FWC, for Snowy Plovers in 2002 and 2006, American Oystercatchers in 2001, and Least Terns and Black Skimmers in 1998, 1999, and 2000 (Ferland and Haig 2002; Lamonte et al. 2006; Himes et al. 2006; Douglass 2006; and Gore et al. 2007). Table 1 summarizes data sources included in the GIS. Several additional species of conservation concern are strongly associated with coastal habitats during at least part of their year along Florida's coasts. This list includes, but is not limited to: Wilson's Plovers, Brown Pelicans, Reddish Egrets, Little Blue Herons, Tri-colored Herons, White Ibises, Wood Storks, and Roseate Spoonbills (Brown et al. 2001; Kushlan and Steinkamp 2002). Future versions of this GIS may benefit from the inclusion of data for these, and other species, strongly associated with Florida's shorelines.

Table 1. Important properties of the bird data layers included in this GIS.

Species	Year(s)	Season	N visits	Type of Count	Metric(s)
Piping Plover	2001	Winter	1	Single count	Individuals
Piping Plover	2006	Winter	1	Single count	Individuals
Snowy Plover	2001	Winter	1	Single count	Individuals
Snowy Plover	2006	Winter	1	Single count	Individuals
Red Knot	2006	Winter	1	Single count	Individuals
Snowy Plover	2002	Breeding	10	All nest locations	Individual nest
Snowy Plover	2006	Breeding	10	All nest locations	Individual nest
American Oystercatcher	2002	Breeding	1	Single count	Pairs or individuals
Least Tern, Black Skimmer	1998-2000	Breeding	1-3	Maximum n nests	Total nests

Spatial coverage and intensity of survey efforts

This GIS contains only data from bird surveys with state-wide survey coverage. Data from regional (within Florida) or site-specific surveys are not included. With data from state-wide surveys, the absence of birds in a location should reflect an actual 0 count (in other words, the area was surveyed and no birds were detected). Similarly, with statewide survey coverage, counts from one location may cautiously be compared with counts at other locations, since theoretically all locations have been surveyed the same way, during the same time period. However, not all birds are detected during each site visit and detectability varies from site to site, depending on the habitat, tide, time of year, and survey methodology. Therefore, site comparisons from statewide surveys should be made carefully, particularly when sites are visited only once, as is the case with the IPPC. IPPC data reflect the number of birds that were seen at a particular location at a particular time. Zero counts during the IPPC do not mean that a particular area is not used by the species, just that they were not seen at the time of the survey.

State-wide surveys for nesting Snowy Plovers, American Oystercatchers, and colonial seabirds; or wintering Piping Plovers, Snowy Plovers, and Red Knots all had different protocols to ensure survey coverage. The degree to which each survey protocol resulted in true state-wide coverage is best assessed by reading the detailed methods sections of original survey reports. Readers are strongly advised to read the original survey reports (citations above) to inform interpretation or representation of the bird data in this GIS in other contexts. It is clear from reading these reports that some efforts are more intensive or comprehensive than others. For example, state-wide surveys for nesting Snowy Plovers and colonial seabirds included multiple visits to the same areas within the entire nesting season. By contrast, the 2006 IPPC, which provided state-wide survey data for Piping Plovers, Snowy Plovers and Red Knots, included only a single visit to each site across a narrow 2- to 3-week window in mid-winter. Within state-wide surveys it is common for a subset of locations with a known or suspected history of bird use to be surveyed with greater intensity than areas where birds are known or suspected to be less common. Without equal-effort survey coverage at all locations, it is impossible to know the degree to which final counts are biased by differing intensities of survey coverage.

In addition to variation in survey intensity and surveyor expertise among sites, none of the state-wide surveys that included data for this GIS estimated detection probabilities, which is a critical element of abundance estimation (MacKenzie et al. 2006). In this sense, each of these surveys is probably best interpreted as an index to true state-wide distribution or population size. Since detection probabilities for counts are not known, but are likely to be lower than 1, these indices are most likely biased low relative to true population size, and bird distributions from state-wide surveys are probably conservative compared to true distributions. If detection probabilities vary by survey type (e.g., if a greater proportion of the birds that are truly present are likely to be counted during some surveys rather than others) then the relative accuracy of counts is likely to vary among surveys. Understanding issues of survey coverage by reading methods sections from individual survey reports is critical to interpreting count data from different surveys when they are presented on the same map.

Data from surveys local or regional in coverage are not included in this version of this GIS. Depending on the frequency of surveys, site-specific surveys provide better seasonal use and abundance patterns for a site versus state-wide surveys with their one-time visit limitations such as detectability and seasonality. For example, John S. Phipps Preserve in Franklin County, FL reported 17 Piping Plovers during the 2006 IPPC. In 2006, the USFWS and American Bird Conservancy funded Apalachicola Riverkeeper to collect shorebird abundance and distribution data throughout Franklin County. Survey data were collected from August 2006 through May 2007. Attempts were made to visit each primary site at least twice monthly with a total of 24 visits to The Preserve during the survey period. Numbers of piping plover recorded ranged from zero to a high of 47 piping plovers observed on two different visits (Smith and Engstrom 2008). Accordingly, additional data from local or regional bird survey efforts could be added to future versions of the GIS. However, data from surveys with incomplete coverage must be interpreted carefully, since it is hard to gage the importance of one site relative to others when not all sites have been surveyed with the same amount of effort. Similarly, it is difficult to interpret the absence of bird observations from incomplete-coverage surveys, since it is impossible to determine if the absence of birds indicates a true absence or just an absence of survey coverage.

Data interpretation when various bird surveys are displayed in the same GIS

Given the diverse origins of survey data displayed in this GIS, it is critical that when data from different survey efforts are presented on the same map, they are interpreted with an understanding of methodological differences among individual surveys. Three examples below show how differences in survey methods translate into different interpretations of data that are displayed as points in the GIS:

1. Nesting snowy plover surveys documented exact nest locations. However, due to regular re-nesting after nest failure, or re-nesting after fledging a successful brood, numbers of Snowy Plover nests should not be summed to estimate numbers of pairs, since the number of nests attributable to any pair is unknown. In this case, points displaying Snowy Plover nest

locations best indicate the spatial extent of nesting habitat use only, not abundance.

2. Nesting colonial seabird surveyors (for Least Terns and Black Skimmers) summarized counts by numbers of nests in a colony. Since colony size varied site to site, from only a few nests to several hundred nests, these data are presented as graduated symbols, with larger symbols indicating larger colonies. Graduated symbols were not used for rooftop colonies, where counts were not made. In this case, dots indicate only the location of rooftop colonies, not abundance estimates. Therefore, counts of all Least Tern and Black Skimmer colonies from this GIS should not be summed to come up with whole population counts. In all cases, the location of the symbol representing tern and skimmer counts is only an approximation of the center of a colony and does not depict the outer boundaries of a colony, which vary from site to site.

3. IPPC surveys counted numbers of individual non-breeding birds that were aggregated in foraging or roosting groups (e.g., 12 birds foraging near each other on a mudflat are represented as a single point). In this case, points in the GIS represent aggregations of birds using the same patch of habitat. The size and characteristics of the habitat patch over which sightings were aggregated by field crews was unspecified, and probably varied among observers. Similar to the seabird data, non-breeding bird observations varied from only a few birds to larger congregations of birds. These data are also presented as graduated symbols, with larger symbols indicating larger groups of birds. The exact location of the symbol is the approximate center of the habitat patch being used by the group.

Scale of data summary and representation of survey area

Bird survey data are not always summarized at the same spatial scale. Ideally, bird survey data would be summarized at one of three scales: 1) the exact location of the nest or bird; 2) a spatially delimited survey area; or 3) a discrete habitat patch within a survey area. Bird counts at exact locations are relatively straightforward to plot in a GIS, as long as GPS coordinates are recorded accurately (e.g., the location represents where the bird occurred, not where the observer was standing when he or she counted the bird) and with precision (e.g., coordinates are recorded to four or five decimal places in decimal degrees). When accuracy or precision is questionable, points should probably be interpreted as approximations, with some unknown buffer area size.

In the physical world, ALL survey areas are truly polygons that contain the entire area that was searched by naked eye, binoculars, or spotting scope. Ideally, bird survey data would be represented by two paired shapefiles: a polygon shapefile representing survey coverage and a point file representing the exact or summarized locations of birds. Without survey area polygons, it is impossible to know the relationship between points that represent summarized counts and the actual area in the physical world that was covered by the survey. Data become difficult to interpret when counts that truly represent polygons in the world (e.g., a wading bird colony, a flock of shorebirds on a mudflat) are represented as points. In this case, points representing summarized bird observations should be contained within larger polygons representing either: 1) the entire survey area over which observations are summarized, which might include multiple habitat types, or 2) a specific habitat type over which bird observations are associated and location data are summarized. With this, density calculations can be made, although density calculations based on discrete habitat types will have much greater biological relevance than density calculations across large survey areas with multiple habitat types, some of which may not be suitable.

Expressing bird densities as numbers of birds per acre of habitat is preferable to densities per linear kilometer of shoreline for several reasons. Habitat areas vary tremendously in width per linear kilometer of shoreline. Consequently, most species of shoreline-dependent birds are not distributed evenly along linear sections of shoreline. In real space, shoreline-dependent birds are usually distributed patchily in relation to patchily distributed resources (e.g., foraging or roosting areas) (Lott et al. 2009). This results in large sections of linear shoreline that are unused by birds punctuated with concentrations of birds in areas where resources are present. Thus, summarizing counts by discrete habitat types within the mosaic of habitat types that comprise barrier islands might be the best way to calculate habitat-specific densities for comparison of counts across sites and to focus conservation attention on specific habitat patches.

Symbolizing data on maps when abundance varies among sites and species

Problems of scale occur in any GIS when comparing point files representing counts of species with different abundances. For example, site-specific counts of solitary, low-abundance species such as Piping Plovers (which usually range from 1–30 birds at a site) are almost always low relative to counts of flocking, relatively high abundance species such as Red Knots (which typically range from 30–750 birds at a site). Therefore, within a given survey effort, point size was scaled independently for each species, and separate symbol shapes were used for each species, so that counts can be compared among locations within the same species but not across different species. When coastal bird count data are compared among sites, counts typically have non-normal distributions, with large numbers of sites with small counts, and a few sites with very large counts. The Jenks natural breaks classification scheme was used to assign sites to one of four abundance categories represented by symbols of increasing size. This classification scheme works better to show differences between abundance categories rather than “percentage of total” or “equal interval” schemes when data are not normally distributed.

Within each species, the four abundance categories, represented by symbols of different size, can be interpreted as low, medium, high, and very high counts. Since abundances were categorized separately for each species, the range of counts represented in the same abundance categories varies by species (e.g., the “high” abundance category for Snowy Plovers is 8–12 birds and the “high” abundance category for Red Knots is 131–210 birds). Using this classification scheme and symbolization approach, relative site importance can be assessed when data from more than one different survey effort or species are plotted together on the same map. When multiple surveys existed for the same species using the same survey methodology (e.g., Piping Plover and Snowy Plover counts from the IPPC in 2001 and 2006,) data were pooled from both years prior to categorizing counts by abundance. This resulted in identical abundance scales for the two different survey years for each species, facilitating direct comparison of counts between years.

Various count metrics displayed in the GIS

During the breeding season, adults are tied to relatively small areas, since they need to incubate eggs on nests or feed flightless chicks, which can only travel limited distances from nest sites before they can fly. Therefore, if GPS coordinates for nests are accurately and precisely acquired in the field, nest locations can provide documentation of at least one important habitat need for breeding birds (the nest site). GPS coordinates for nest locations can also provide an important link to the larger area (best represented as a polygon surrounding the nest that varies in size and shape by species) where either: 1) adults acquire food resources for themselves during incubation, 2) adults of species that provision their chicks find food for young (e.g., Least Terns, Black Skimmers, American Oystercatchers), or 3) pairs raise self-feeding, precocious young once they have hatched (e.g., Snowy Plovers). In the future, GIS layers that provide exact locations of brood-foraging habitat for species whose chicks feed themselves (e.g., Snowy Plovers and Wilson's Plovers) would be very useful, since the distribution of this habitat type, relative to nest locations, may limit the number of locations that can be used for nesting.

When individual adults are counted during the breeding season, the proportion of these birds that actually breed (which varies by species and location) is almost always unknown. Therefore, adult counts should not be divided by two (or any other divisor) and reported as an estimate of the number of breeding pairs. Adult counts during the breeding season should be interpreted simply as the minimum number of adults present in the survey area. Several different survey methods result in counts of numbers of nests, and methods exist to estimate the detectability of nests. However, interpretation of nest count data, even once detectability issues have been addressed, is not straightforward. For most shoreline-dependent birds, nests are incubated by two adults (although usually only one adult is near at most times, and sometimes, both adults may be away from the nest). If nests are counted, this number may be multiplied by two to give a minimum estimate of the number of breeding pairs at the time of the survey. However, not all breeding pairs will be associated with a nest at any given time during the breeding season (e.g., if a pair is engaged in courtship prior to nest building or brood-rearing after a nest has hatched).

The relationship between a nest count and the true number of pairs will depend on the timing of this count relative to nesting phenology of the entire population, which changes across the breeding season as some nests fail, some succeed, and other new nests are initiated. Therefore, repeat counts of nests during the breeding season usually result in different numbers of nests. The maximum count may be reported but probably represents an underestimation that will be strongly influenced by the timing and frequency of counts relative to the peak nesting period. In all cases, the relationship between a single nest count or a maximum nest count to the true number of pairs using a site will be unknown if the population is unmarked. Counts of pairs are often desirable since this is the metric most frequently used for population modeling. However, direct counts of pairs require banding and regular re-sighting of all adults within a population. Since this rarely happens, survey crews often develop series of assumptions, based on the behavior of birds, to determine numbers of pairs within a survey area. These assumptions are difficult to verify without marking birds and assumptions should be considered when interpreting counts of pairs in unmarked populations.

During the non-breeding season, adults are no longer tied to nests or young and activity areas are typically larger and more complex than they were during the breeding season. At this time, 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 poorly known for many species, but it is often very large. Therefore, locations of non-breeding bird counts represent habitat use and a specific activity at only a single point in time. Since non-breeding activity ranges may be large, habitat use is certainly not restricted to this point and individuals are likely to use relatively large areas within some distance of this data point at other parts of the tidal cycle.

Connecting bird observations to conservation: Behavior and habitat use

Planning for the conservation of Florida's shoreline-dependent birds requires much more than just plotting bird distribution data from counts in a GIS. In fact, plotted counts on their own yield little specific information on habitat use, conservation threats, or habitat quality, although large aggregations of birds may be interpreted as inferring high quality habitat. Linking bird count data with habitat conditions or threats at a spatial scale relevant to conservation (e.g., site, geographic region, or landscape) is a difficult task and usually requires more information than is typically present. Plotting shoreline-dependent bird distributions, along with spatial data on large-scale habitat modifications, such as coastal engineering projects, is a first step in this direction.

Adding habitat layers to the GIS may help to understand relationships between habitat availability and bird distribution. However, this would require that habitat delineations provide information that is ecologically relevant to the distribution of shoreline-dependent birds. This may be difficult using remotely sensed habitat layers, since discrete habitat types that are important to many shoreline-dependent birds are exceedingly difficult to map accurately (see Zharikov et al. 2005). For example, the location and areal extent of exposed intertidal habitat within any region changes both throughout the year and within each day in response to many factors, such as water temperature, phase of the moon, barometric pressure, and wind direction. Conversely, aerial photography delineations of intertidal habitats are based on a single moment in time, when the photo was taken, and aerial photographs are typically not scheduled to be taken at exactly the same tide across a region. Teasing out microhabitats associated to a specific bird species would be virtually impossible via aerial photographs. Similarly, accurate mapping of beach microhabitats above mean high tide that are important to shoreline-dependent birds using remote sensing (such as wrack, ephemeral pools, or sparsely vegetated dunes) is either impossible (since old wrack can't be seen in many photos), illogical (since the location of ephemeral pools changes regularly), or very difficult (since the difference between flat beach and sparsely vegetated dune is often not discernible in photos).

Even within delineated habitat types, the distribution and abundance of shoreline-dependent birds may vary tremendously. For example, not all "intertidal habitat" is equal to different species of shorebirds. Bird species occur in connection with substrates that favor abundant populations of specific invertebrate prey items and specific water depths that allow prey capture. Within the same complex of intertidal flats, Piping Plovers may forage in muddy areas with abundant polychaete worms, Red Knots may forage in sandy areas with large concentrations of coquina clams, and American Oystercatchers may forage on a variety of bivalves that are patchily distributed in areas where hard substrates allow these sessile invertebrates to attach. Understanding the factors that affect the year-round distribution of shoreline-dependent birds often requires more information, such as data on prey resources or disturbance regimes, than is present even with the best possible remote habitat delineation data.

To account for the needs of all shorebirds collectively, important components of ecologically sound barrier beach management must include perpetuation of natural dynamic coastal formation processes. Man-made structures along the shoreline or manipulation of natural inlets upset the dynamic processes and result in habitat loss or degradation (Melvin et al. 1991). Over time, both actions result in loss of shorebird habitat.

Additional investigation is warranted to determine the extent to which these disturbance factors affect shorebirds on a cumulative nature.

Connecting bird observations to conservation: Assessing habitat quality

Recent work with individual- and behavior-based modeling in Europe has provided a tool to see how the regional (e.g., a small estuary) distribution of foraging substrates (e.g., intertidal sediments) affects invertebrate prey abundances; and these models have been used to predict the over-winter survival of shorebird species with different foraging ecologies (Stillman 2003). Recent applications of European “shorebird models” have been used to predict the consequences of different habitat disturbances on shorebird survival in specific environments (e.g., the Seine Estuary in France) (Goss-Custard et al. 2006). This ecological and quantitative approach to impact assessment requires a detailed understanding of regional shorebird diet; as well as site-specific data collection on intertidal foraging area size, invertebrate prey availability for different habitat patches, shorebird foraging behavior, and bird responses to human disturbance. Despite the absence of research or modeling studies to address issues of regional habitat quality in Florida, large-scale presentations of bird distribution and landscape alteration data, such as this GIS, may be adequate to demonstrate, qualitatively, regions where habitat alteration seems to be affecting the distribution of birds. It is the authors’ hope that this GIS may help to understand where future habitat alteration should not be allowed, or where detailed research studies may be advisable to predict the consequences of further habitat alteration on avian fitness.

Understanding how projects forestall the formation of highly productive overwash habitats and eliminate connectivity of oceanfront nesting and roosting or bayside foraging habitats is important to many shorebird species. Past and ongoing stabilization projects along the Florida coastline have fundamentally altered the naturally dynamic coastal processes that create and maintain beach strand and bayside habitats. Hard shoreline stabilization structures such as jetties and groins interrupt littoral drift, while artificially created berms and large-scale nourishment projects prevent overwash. Such stabilization has encouraged residential and commercial development on barrier islands, which leads to a long-term commitment to shoreline protection activities that limit the formation of productive shorebird habitats. The degree to which shoreline stabilization activities alter the dynamic coastal processes that create and maintain beach strand and bayside habitats must be understood across large regions to fully understand the cumulative impacts of shoreline protection on shorebirds. Detailed ecological modeling of the interactions between shorebirds, their habitat, and major disturbances to their habitat has not yet occurred in North America.

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14. ABSTRACT

This report describes a Geographic Information System (GIS) that displays ~500 sand placement events in Florida between 1959 and 2006. These events include: beach nourishment projects, renourishment events, dune restoration projects, emergency berm placements, inlet bypassing, and beach dredged material disposal. Data were consolidated from disparate sources to provide a comprehensive GIS. Each event is represented by a unique line file containing attribute information on project type, year, action agency, data source, and borrow site (when available). The GIS also includes point files representing survey data on the distribution and/or abundance of six high-priority bird species from a variety of state-wide surveys. Bird data are presented for piping plover, snowy plover, red knot, least tern, black skimmer, and American oystercatcher. This report provides an overview of coastal engineering activities in Florida, focusing primarily on sand placement; describes how these data have been tracked by agencies; and suggests ways that this GIS could be regularly updated to provide a highly useful tracking system. Detailed descriptions of data in attribute fields are provided for both sand placement and bird survey shape files. The report also discusses an approach to the simultaneous presentation of bird data from multiple surveys with different methodologies.

15. SUBJECT TERMS

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