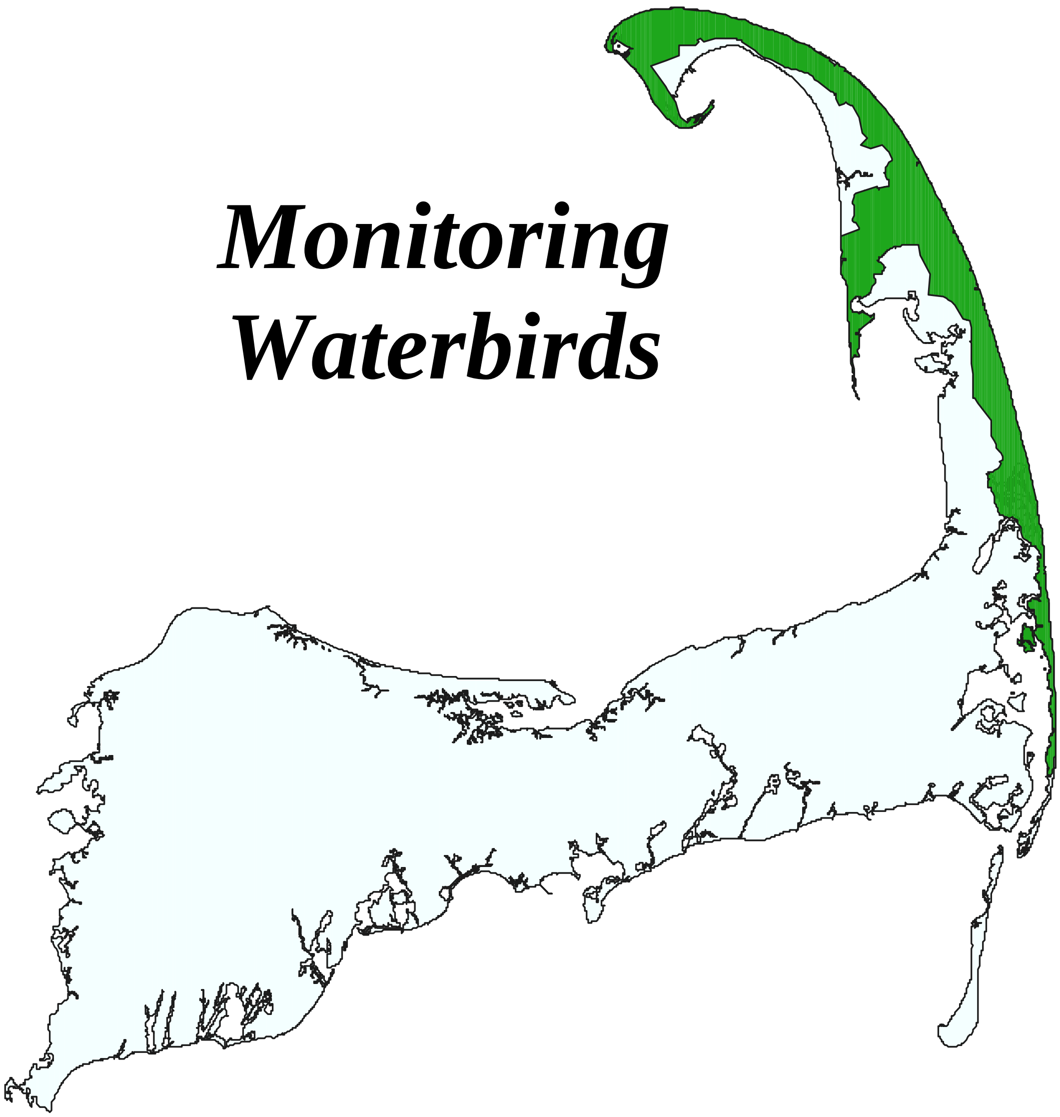


# *Monitoring Waterbirds*



**USGS Patuxent Wildlife Research Center**

**Cape Cod National Seashore**

# *Waterbird Monitoring Protocol for Cape Cod National Seashore and other Coastal Parks, Refuges, and Protected Areas*

A Protocol for the Long-term Coastal Ecosystem Monitoring Program
at Cape Cod National Seashore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Long-term Coastal Ecosystem Monitoring Program
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*This report is on the National Park Service Inventory and Monitoring website:*
http://www.nature.nps.gov/im/monitor/protocoldb.cfm

# PREFACE

## Overview of the Long-term Monitoring Program

Cape Cod National Seashore serves as a National Park Service prototype monitoring park for the Atlantic and Gulf Coast biogeographic region. The USGS, in cooperation with the National Park Service, is charged with designing and testing monitoring protocols for implementation at Cape Cod National Seashore. It is expected that many of the protocols will have direct application at other Seashore parks, as well as U.S. Fish and Wildlife Service coastal refuges, within the biogeographic region.

The Long-term Coastal Monitoring Program at Cape Cod National Seashore is composed of numerous protocols that are relevant to the major ecosystems types (Estuaries and Salt Marshes, Barrier Islands/Spits/Dunes, Pond and Freshwater Wetlands, Coastal Uplands). The overall program is designed so that all of the protocols are interrelated. For example, information acquired from the Nekton, Shoreline, Salt Marsh, and Water Quality protocols may be especially relevant to interpreting observed trends for waterbirds. Roman and Barrett (1999) present a conceptual description of the entire monitoring program.

## Protocol Organization

To maintain some consistency among the various monitoring protocols, each protocol is organized as follows. PART ONE of the protocol is intended to provide detail on the objectives of the monitoring protocol and to provide justification for the recommended sampling program. Extensive incorporation of relevant literature and presentation of data collected during the protocol development phase of the project are used to justify a particular sampling design, sampling method, or data analysis technique. PART TWO is a step-by-step description of the field, laboratory, data analysis, and data management aspects of the protocol.

## Executive Summary

As part of the partnership between the USGS-BRD and the National Park Service for developing "Protocols for Long-Term Coastal Ecosystem Monitoring" at Cape Cod National Seashore (CACO) and other coastal parks and refuges, we present a series of recommendations for protocols to be followed for inventory and/or monitoring of four groups of waterbirds: Piping Plovers (*Charadrius melodus*) during nesting season, marsh birds (rails, bitterns, coots, grebes), nesting colonial waterbirds (gulls, terns, skimmers, herons), and migrating and/or wintering shorebirds and waterfowl. Because of the demands of this protocol in light of other competing monitoring needs, we suggest that not all aspects of this protocol be followed every year. We have also included some components (Beached Bird Surveys) that were never field evaluated, but are still important for coastal land management units to consider. We prepared this report with CACO as the prototype in mind, but wanted to make it broad enough to be applicable to other coastal parks, national wildlife refuges, and other conservation lands (*e.g.* The Nature Conservancy, or state parks). We conducted the field evaluation of these protocols during Fall 1999 to Winter 2001.

For Piping Plovers, a strict regimen is to be followed as already outlined in the Region 5 USFWS Recovery Plan for this threatened species. At highest priority is collecting data to determine annual estimates of numbers of breeding adults, numbers and locations of nests, hatching success, causes of nest loss, and fledgling numbers (*i.e.* annual fecundity). This effort is part of a cooperative federal, state, and NGO effort as described in the recovery plan and results are to be reported to the appropriate State coordinators. In addition, we recommend that, on an occasional basis, nesting habitat measurements be taken both at the nest site and in the surrounding landscape.

For marsh birds, we recommend, as a moderate priority, occasional (3-5 year) breeding season surveys of freshwater marshes > 2 ha in size with emergent vegetation, using call broadcast surveys. Point counts with 50 m radius circles are to be placed every 200 m along streams and shorelines when conducting the May - June surveys. Surveys should be conducted at least 3 times during this period, during morning periods (0600 - 1100 h). Although marsh birds were rare in all seasons during our surveys from 1999 - 2001, we confirmed the presence of 7 species, with Sora Rails, Pied-billed Grebes and Virginia Rails, being most commonly detected. We suspected that an American Bittern overwintered at one Provincetown marsh, and that at least one pair of Least Bittern, Sora, and Virginia Rail bred at two different Provincetown marshes. Because of the rarity of this group, occasional status surveys are recommended, but insufficient data will preclude any attempt at trend assessments.

Monitoring colonial waterbirds, such as terns, gulls, cormorants, and wading birds, within federal land units should be given high priority and conducted annually. For most of the Atlantic Coast, the nesting surveys should be standardized and conducted between 5 and 20 June. Least Terns, because of their high potential for movement and renesting, should be surveyed 3 times during the period June 5 to ca. July 5. For large traditional colonies of waterbirds, permanent transects should be set up comprising a sample of at least 20%. When conducting ground estimates for gulls, terns, and cormorants, nests should be marked and a

mark-recapture method (*e.g.* Lincoln-Petersen Index) used for estimating total active numbers of nests. At wading bird colonies, nest counts along randomly selected transects, should be conducted as above, with nests apportioned among species based on estimated percentages of adults flushed from the colony. At least at a few of these transects, two separate counts should be made using Lincoln-Petersen methods to assess accuracy of counts. To minimize the effects of disturbance, late-season nest counts (August) should also be conducted to determine whether these counts are at all similar to those conducted when birds are nesting. For estimates of annual fecundity for ground-nesting terns or gulls, we recommend using either nest enclosures (poultry wire) at several locations to include >20 nests in different parts of the colony, or alternatively using blinds to monitor the survival of marked young at selected nests. Occasional collections should also be made of eggs to assess contaminant levels in regions where it is appropriate.

The monitoring protocol recommended for migrating shorebirds and wintering waterfowl focuses on conducting ground surveys at certain known concentration areas (*e.g.* Nauset Marsh, Wellfleet Bay) in conjunction with monitoring of other human activities such as aquaculture and recreation. A high priority need is to identify "hotspots" that are consistently used by feeding or roosting congregations of shorebirds or waterfowl at local (embayment) scales. These surveys are to be conducted on the ground. Aerial surveys were tested at CACO but proved to be untenable because of constant weather and scheduling problems, especially in winter. In other areas, near sites with federal pilots and survey aircraft, this would be more feasible. These do not need to be conducted annually, but perhaps every 3 years or so. Some analyses of the survey data for two years suggested that count variation was so high that detecting population trends for this group would be very difficult, with power usually less than 0.50 for detecting trends of 25% over a 20-year period even when surveying every year on a weekly basis during fall migration. Dropping to surveying every 2 years dramatically reduced power further.

We outline the recommendations for establishing a Beached Bird Survey using volunteers, although there were insufficient resources to conduct a field evaluation during 1999-2001. Selected beach segments 2-4 km in length are suggested with late winter-early spring surveys (March - June) conducted at ca. 10-day intervals. Records to be maintained include dead or dying birds in the shoreline surf zone or on the beach. Remains of birds are to be collected for later identification if necessary, however collections require permits.

We realize that following these protocols will be expensive and labor intensive and therefore, some of the details and some groups may have to be omitted in any given year. Loss of precision about trend information may however be less important than identification of certain areas within the Park or Refuge that are of regular or traditional use by particular species or guilds. Determining which flora and fauna to monitor will require policy decisions by Park (or other) management; however, we suggest as guidance that managers: (1) include common species as well as rare or "charismatic" species in any large-scale inventory and monitoring program, (2) select species that occupy a number of different trophic levels and food webs, (3) consider for highest value those monitoring plans where species/guilds fit into current management activities (*e.g.*, ORV management) so that an adaptive management approach may be applied, (4) take advantage of ongoing operational surveys to couple new initiatives (*e.g.*, adding American Oystercatcher and Least Tern monitoring to Piping Plover monitoring), and (5) tying biological monitoring of species into chemical (water quality) and physical (shoreline change) monitoring whenever possible.

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## ACKNOWLEDGEMENTS

Development of this protocol was supported by the USGS-Biological Resources Division, with funds administered by the USGS Patuxent Wildlife Research Center at the University of Rhode Island. Special thanks are extended to the Superintendent and natural resource management staff at Cape Cod National Seashore (CACO) for providing logistical support. We thank Mary-Jane James-Pirri for proof editing this report. Photo credit: D. Thompson (Tern).

# PART ONE
# Background and Justification for the Waterbird Monitoring Protocol

## INTRODUCTION

Description of Issues

The National Park Service (hereafter NPS) and other land management agencies should be actively concerned and involved in monitoring and managing waterbird resources because: (1) these species have strong Federal and State mandates for management and protection, especially the species that are considered Federally Threatened or Endangered such as Piping Plovers (*Charadrius melodus*) and Roseate Terns (*Sterna dougallii*) or State Endangered, Threatened, or Species of Special Concern (*e.g.* Least Tern, *Sterna antillarum,* Least Bittern, *Ixobrychus exilis*, or Northern Harrier, *Circus cyaneus*); (2) they provide major recreational and aesthetic benefits to the public; (3) some species may be effective as biomonitors of habitat quality and change (for example, their tissues, eggs, or young can be used as contaminant bioassays); and (4) there is historical significance to certain waterbird resources. Some of the earliest American conservation and bird monitoring efforts focused on Cape Cod's Common Tern (*Sterna hirundo*) populations, a landmark effort headed by the Austins (lands that are now within the national seashore boundaries) beginning in the late 1920s.

Waterbirds are significant avian resources to Cape Cod National Seashore (hereafter, CACO, see Fig. 1), and at larger scales to Massachusetts, New England and the Atlantic coastal for ecological, economic, and aesthetic reasons (see Eddleman *et al.* 1988, website http://www.waterbirdconservation.org for the North American Waterbird Conservation Plan). Although the functional significance of waterbirds in the estuarine food web may not be substantial across all estuaries (Bildstein *et al*. 1982), their feeding can have marked cascading, or "top down," effects at least locally on some invertebrate populations (Goss-Custard *et al.* 1977, Quammen 1984). Numerous authors have suggested that the presence and/or abundance of waterfowl, colonial waterbirds, or shorebirds may represent bioindicators of the quality or quantity of the food resources (*e.g.* submerged plants, fish, invertebrates) of an estuary (Chabreck 1988, see bird chapters in Funderburk *et al.* 1991, Erwin *et al.* 1993, Erwin and Custer 2000). Similarly, in freshwater wetlands, rails, bitterns or other marsh birds may be sensitive barometers of contaminants, changes in distribution of native plant species, invasions by exotic plants, or human disturbance. The abundance, habitat use, and success of beach-nesting and Federally Threatened Piping Plovers and Least Terns are often correlated with the degree of management protection from human recreationists and off-road vehicles along the Atlantic coast beaches.

In addition, shorebird and waterfowl abundance may also be used to indicate acute environmental "insults" such as chemical or oil spills, (*e.g.,* Burger 1994) or more chronic effects of aquaculture (Kelly *et al.* 1996). Regular counts of dead seabirds and waterfowl along coastal beaches, known as "Beached Bird Surveys," have been conducted along many U.S. and Mexican coastlines over the years (Hass and Parrish 2000), although many of the results have not been well standardized or published in peer-reviewed outlets (D.W. Anderson, University of California-Davis, pers. comm.). Standardized beach surveys, if well designed, can be very

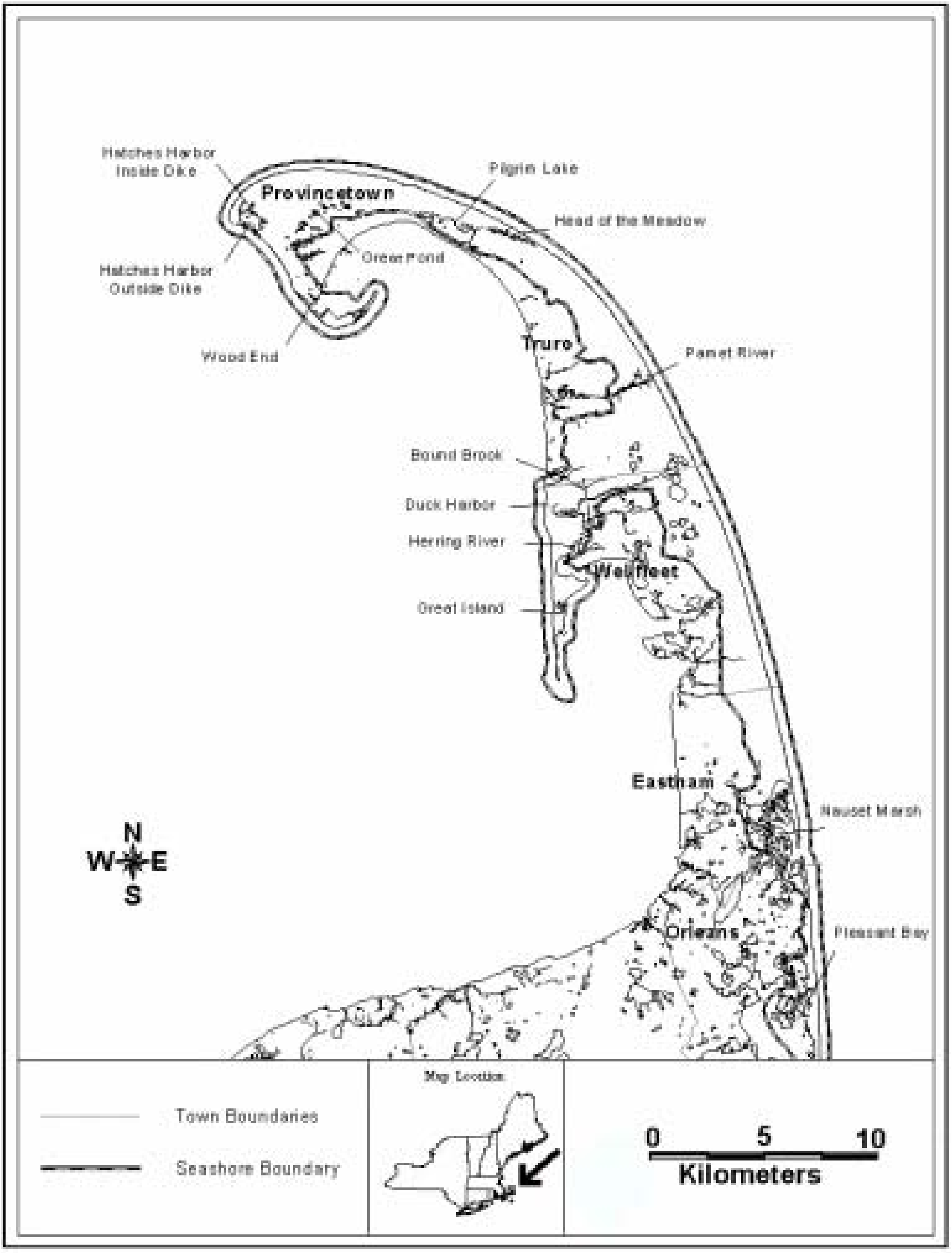


Figure 1. Cape Cod National Seashore boundaries relative to townships on lower Cape Cod, Massachusetts. The administrative boundary extends along the eastern Atlantic Ocean side south of Pleasant Bay to South Beach, Chatham, but is not shown because field work was not performed there.

useful for establishing baseline catastrophe, *e.g.*, the 1989 *Exxon Valdez* oil spill in Alaska. Similarly, monitoring to establish use of "hotspots," ranges, and means of population abundances of shorebirds can be useful when evaluating the effects of shoreline developments or intertidal aquacultural operations (Kelly *et al.* 1996).

Some waterbirds have direct economic values; waterfowl for example are important recreationally and economically to sport hunters and to local and state economies. Even larger economic and aesthetic benefits are provided by these waterbirds as they attract huge numbers of birdwatchers, "eco-tourists" and wildlife artists each year to Cape Cod. Spring and fall migration period "birding festivals" have grown into significant economic enterprises at many coastal sites along the Atlantic shores.

## Linkages to Other Monitoring Protocols

The information derived from this waterbird monitoring program should be useful in integrating the results from the monitoring of fishes, shorelines, and water quality in the estuaries and freshwater ponds within CACO. Most of the waterbirds depend heavily upon abundant forage fishes in shallow waters in the bays, inlets, and along the coastline of the Outer Cape. Fish abundance and composition, in turn, are influenced by water quality. For nesting species such as Piping Plovers, and terns, including Least, Roseate, Common, and Arctic (*S. paradisaea*) it is important to monitor shoreline changes, overwash creation, and inlet dynamics; these physical processes can have marked effects on the attractiveness of beaches as nesting substrates for these specialized species. With data on storm frequency and magnitude, models predicting changes in shoreline width, elevation, slope, aspect, and grain size distribution could prove to be very useful in predicting the relative habitat quality of beaches for many nesting shorebirds.

## Organization

We have divided the protocol into four sections: (a) Piping Plovers, (b) marsh birds (*i.e.*, bitterns, rails, and associated freshwater species such as Pied-billed Grebes (*Podilymbus podiceps*), American Coots (*Fulica americana*), and Common Moorhens (*Gallinula chloropus*), (c) colonial waterbirds (gulls, terns, wading birds), and (d) migratory and wintering shorebirds, waterfowl, and other waterbirds. These four divisions reflect the biological differences of the species of waterbirds being considered, differences in the conservation and management concerns by the National Park Service and other agencies among these different species, and the history of involvement in bird management at CACO. While it could be argued that these four sections could be integrated into one more comprehensive report, we feel that there are enough differences in the timing of activities, the personnel involved, and field methods used to warrant separate sections.

In Part I, we present the background and justification for the questions and approaches at a somewhat general level, while in Part II, we focus on the specifics and details that are recommended for CACO in particular. For discussion of some of the general principles to consider when developing a waterbird monitoring scheme, the reader is referred to Steinkamp (2002). Concepts such as spatial and temporal heterogeneity, and detection probabilities, aspects that are fundamental to a statistically sound monitoring scheme, are discussed in a number of applications to field monitoring of a variety of waterbird species in North and Central America.

## MONITORING QUESTIONS AND SAMPLING METHODS BY SPECIES GROUPS

## PIPING PLOVERS

### Monitoring Questions

Because the Atlantic Coast population of Piping Plovers is listed as "Threatened" by the U.S. Fish and Wildlife Service (hereafter, FWS), a significant legacy of research and management on this species exists. Besides the NPS and the FWS, other significant partners involved with plover monitoring are the USGS Biological Resources Discipline, the Atlantic coastal flyway state agencies, The Nature Conservancy, and other private and non-governmental organizations. The population monitoring protocols in each state and region are coordinated by the Atlantic Coast Population Piping Plover Recovery Plan (FWS 1996). The Plan has steered several general monitoring questions to be addressed within this protocol: (1) What is the Piping Plover breeding population size each year from the scale of the park or refuge to region, state, multistate region, and Atlantic Coast flyway? (2) Is there a detectable trend in breeding pairs at region or state levels over a 10- or 25-year period? What is the power to detect a 25% change over these periods? (3) What is the annual fecundity (*i.e.*, number of fledged young per pair)? (Note: the Plan (FWS 1996) goal in the "New England recovery unit" is a 5-year average productivity of 1.5 fledged young per pair), (4) What are the causes of mortality of eggs, young, and adults? (5) Are human activities, including wildlife management, affecting plover fecundity?

Within federal land management units, management and monitoring of nesting activities (nest timing, fecundity, mortality, and renesting) are occurring simultaneously, hence this protocol fits nicely into an Adaptive Resource Management framework (Walters 1986). Management procedures can be adapted, the results evaluated, and appropriate changes to management implemented to see if the change results in the desired effect. Examples include modifying exclosure design, or changing the timing of sections of beach closure to test their effects on nest success.

Some important research questions that have been raised include: (1) What predators are responsible for most of the egg and chick losses, and how consistent are they among years? (2) Is there regional variation in the percentages of successful nests across years? That is, are their apparent "source" or "sink" areas relative to recruitment? (3) Are there a few key micro-or macrohabitat features that are highly correlated with either nest presence or nest success? (4) Does observer training significantly affect the estimates of numbers of nesting pairs, or the numbers of fledged young? (5) How good is the assumption that all nesting pairs in each management unit are found each year by observers? (*i.e.* is detectability 100% at all locations?)

## Sampling Methods

For Piping Plovers, because the entire park, refuge, or island population is included, no "sampling" per se occurs; there is an explicit effort to include *every* nesting pair of plovers within the boundary of the geographic unit (and throughout each state). This however requires testing using independent observers who accurately map each nest and compare results using a double-observer method (Nichols *et al.* 2000). With this method, two observers conduct the survey together but one is designated as a Primary, the other a Secondary, observer. The Secondary observes which birds/pairs are recorded by the Primary and then separately records any additional birds. After a specified period of time (perhaps an hour of surveying), the roles are reversed. This results in obtaining detection probabilities and assesses individual observer skill. Such an attempt needs to be made at least every 2-3 years.

## Site Selection

All potential beach-dune habitat is canvassed by vehicle and/or on foot (always preferable for increasing detection probability) from early April each year until all young have fledged in August. Care should be taken to not only visit previously-used areas, but also to visit all potential habitats.

## Sampling Unit

The basic unit is a breeding pair within a specified section of beach. All Atlantic Coast surveys of this species must report the total population size each year defined as the number of breeding pairs. The number of fledged young per breeding pair, or annual fecundity, is also reported. From 6-10 habitat variables may be recorded, with the nest being the sampling unit of interest.

## Spatial Sampling

All nests are assumed to be found during intensive plover surveys, thus no "sampling" occurs for this species. This assumption has not been tested in most areas, but given the intense level of effort and manpower, the assumption may seem reasonable. Nonetheless, as indicated above, we recommend that a double-observer approach be attempted on occasion to determine if the probability of detection is truly 1.0 for a given park or refuge.

## Temporal Sampling

Several types of frequent annual monitoring are required by the Region 5 FWS Recovery Plan (FWS 1996). For estimating the number of breeding pairs on CACO, two methods are employed as suggested in Blodget and Melvin (1996). These are detailed below in Section "*Specific Data Collected for Each Sample*".

For estimates of annual fecundity, and for consistency among the many plover surveys along the Atlantic Coast, there is a requirement that both hatching and fledging success be estimated. This demands that each nesting pair be monitored daily from a distance (using binoculars) until hatching and that young be followed until they are at least 25 days old, or can fly at least 20 m. In addition, once a week, nests should be approached closely enough to count eggs. Brood counts should be made every 1-3 days until fledging. Measures of habitat parameters at each nest are to be made once during the season at the time when each nest exclosure is erected.

<u>Specific Data Collected for Each Sample</u>

*Breeding Population Size*

Breeding population sizes are to be reported in 2 ways, following Blodget and Melvin (1996) and the FWS Region 5 protocols: (1) total counts from surveys conducted during a 9-day window in late May and/or early June and (2) the "maximum number of pairs during the season", which includes counts of birds seen for a minimum of two weeks (during sustained courtship) in areas where no nests were found as well as pairs known to lay eggs and produce young. The first count is used, in combination with counts from other areas, to estimate regional breeding pair totals and may be less variable than the second. Occasionally plover pairs will breed unsuccessfully on one beach, than move to another beach (on or off CACO) to renest. Consequently, the second count gives a more accurate measure of the total number of breeding pairs using a given beach over a season, but because of the potential for double counting, may be a more imprecise measure of breeding population size. Without having birds individually marked (prohibited by the FWS), it is not currently possible to use mark-recapture methods to determine whether in fact the *entire* population has been accounted for.

Breeding pair surveys will begin the first week of April and will continue through mid-July within CACO and throughout coastal Massachusetts (Blodget and Melvin 1996). Surveys will be conducted a minimum of twice per week; even more frequently on beaches where nests are present. Surveys are accomplished by walking the entire range of beaches where nesting is possible. Vehicles may be used to access beach survey sites, but will not be used as survey platforms. Surveys are best conducted between about 0600 and 1000 when light conditions are best, human traffic is reduced, and chances are greater to determine causes of nest loss. Plovers are easier to detect when surveys are conducted at or near high tide when they are concentrated in a narrow band of the upper beach. Surveys should not be conducted when winds are >20 mph, during fog, or in heavy rain. Details of field methods are provided in Part II that follows for CACO.

The two counts of plovers, *i.e.*, the 9-day count and the total-season count, are to be compiled by beach management unit, state, regional, and the Atlantic Coast to evaluate the status of each management unit at different scales. Unlike many monitoring programs, Piping Plover monitoring allows for comparisons to be made among populations at five spatial scales.

The field forms for recording nest information (Appendix 1a) and habitat data (Appendix 1b) have been used for several years and are in accord with the Blodget and Melvin (1996) protocols for Massachusetts.

*Annual Fecundity*

For inter-regional comparisons, fecundity estimates are made separately for hatching and fledging success. Also, whenever possible, all causes of nest loss or mortality of young are to be identified. All pairs are monitored daily after nests are confirmed, and nests are marked with reference to natural objects (or artificial markers). Fledging age is 25 days or an observed flight of at least 20 m.

Details of how to locate and monitor the fate of nests, eggs, and chicks are to be found in Part II. An example of a completed field form with chick fates is included in Appendix 1c.

*Habitat Measures*

Up to 10 structural or spatial assessments or measurements should be recorded during the first two weeks of incubation at a given nest. When possible, measurements should be made during the last two weeks of incubation or first two weeks after hatching. These measurements should be made annually at a sample of > 30 nests (Burger 1987).

Habitat type: Each nest will be assigned to one of the followng 6 classes (Fig. 2): 1=berm, 2=foredune, 3=washover/blowout, 4=interdune, 5=bayside beach or marsh, or 6=sandspit (Note: #5 and #6 are not shown in Fig. 2).

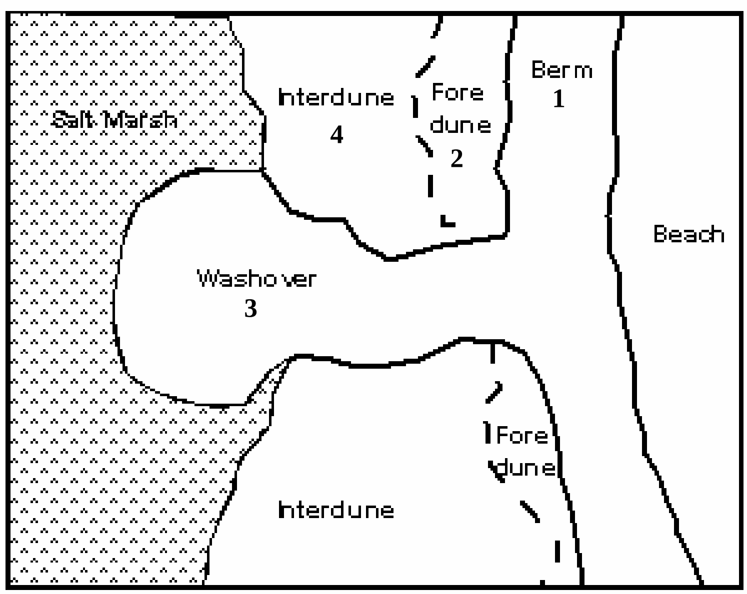


Figure 2. Barrier beach habitat types, Cape Cod National Seashore.

The following habitat measurements at nest sites are recommended (see Fig. 3 also) and are detailed in Part II, Piping Plovers:

- Beach width
- Nearest vegetation
- Distance to nearest pedestrian access (human disturbance)
- Degree of wrack on site
- Width of intertidal zone
- Distances to nearest: pool, bayside water body, overwash fan, inlet
- Nearest neighbor distance (nearest PIPL nest)

Other variables of concern are contaminant levels. Although contaminants have not been cited as causing reproductive impairment in Piping Plovers in New England, few opportunities have been available to examine effects of agricultural or other chemicals. Because biologists can easily collect a large sample of nonviable eggs of plovers each year, a sample of 10 nonviable eggs from 10 different nests should be collected every 3-5 years, wrapped in aluminum foil, and frozen. A contract for analyses of PCBs, PAHs, and organochlorine on the samples should be prearranged in coordination with biologists in the U.S. Fish and Wildlife Service.

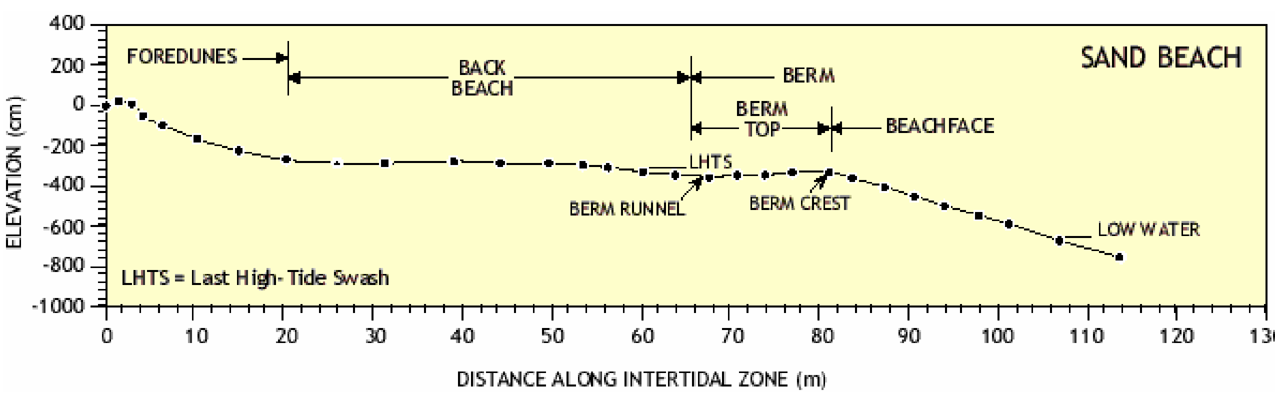


Figure 3. Back beach measurement taken at Piping Plover nests.

## MARSH BIRDS

Monitoring Questions

The primary monitoring questions for this group are: (1) What is the distribution and relative abundance of these secretive rails, bitterns, and other marsh species within the land unit of concern? (2) Is the suite of species of marsh birds using wetland habitats changing over time during breeding, fall migration, or winter? (3) What is the relative abundance of each marsh-dependent species during breeding, fall, and winter? (4) Are the methods adequate to detect a 25% population change over a 20-year period with a Type I error rate of 0.10 or less (alpha <0.10) with at least 80% power for any marsh- bird species? (based on recommendations of current Partners in Flight Monitoring Plan) (5) Do local changes in wetland habitat, surrounding land use, or recreational/management activities influence species composition or relative abundances of marsh birds?

Some research questions that should be addressed: (1) Is mean winter temperatures increasing in the region and, if so, does that increase the probability of some species of marsh birds overwintering in freshwater wetlands?; (2) Does human recreation and disturbance have a negative effect on the probability of site use by breeding marsh-bird species? (3) How does salt marsh restoration influence marsh bird habitat?

## Site Selection

Because this group of cryptic birds is usually rare, we recommend an initial survey that includes as many wetlands as possible, excluding perhaps only the smallest (ca. < 2 ha with little emergent marsh vegetation) wetlands. If extensive salt marsh is included in the survey area, a stratified random selection process may be appropriate, where areas with greater creek length receive more intensive sampling. In freshwater marshes, the sampling pool should include all larger (*e.g.*, > 4 ha) ponds if logistics allow. For those between 2-4 ha, a random sample should be selected.

## Sampling Unit

For this group, the sampling unit is a survey point with a 50 m radius as part of a point count using call broadcast surveys. The response variable of interest is the detection of species *x* at point *i* within a 50 m radius. For small ponds (2-3 ha), only one point is used, but for larger marshes, points are to be spaced at 200 m intervals around the perimeter of the marsh. Along tidal creeks and rivers, one transect bisects the stream and points are established at 200 m intervals as far upstream as high tide levels allow. In extensive salt marsh areas, a series of transects are established with points set at 200 m intervals, and initial points selected at random along the edges of channels. Parallel transects should be placed no closer together than 200 m. For habitat measurements, the point also serves as the center of the sampling unit, with a 50 m radius circle circumscribing the point. It should be noted that the 200 m distance recommended here is half that recommended (400 m) for the national marsh bird protocol; however if parks or refuges desire more thorough coverage, the 200 m distance is advised (Conway, unpubl.).

Using call-broadcast point counts has advantages, but like other survey methods, also requires assumptions. The major problem with monitoring this group of birds is the low detection probability, in large part due to their crypsis and low vocalization rates (Gibbs and Melvin 1993, Conway 1995). Call broadcast typically increases detection probability, but for some species, detection remains very low even with call broadcasts (Conway *et al.* 1993, Legare *et al.* 1999, Conway and Gibbs 2001). Unless birds are also radiomarked, estimating true detection probability is difficult. Therefore, assumptions have to be made that detection probability does not change over time, with variation in population density, or with any habitat changes that may occur due to succession. The double-observer method (Nichols *et al.* 2000) was used earlier at Cape Cod, however, there were no instances where an individual observer failed to detect a species identified by the paired observer, therefore the method was abandoned in later surveys (Erwin *et al.* 2002). This should not suggest however that future surveys in different areas should disregard this method; one must always keep in mind the critical need to estimate detection probability rather than relying on untested indices of abundances (Nichols 1992).

One new approach, the Sequential Method (Farnsworth *et al.* 2002.), is recommended for adaptation to marsh birds. Here, the entire 14 minute call broadcast period is divided into 14 one-minute subsegments. The advantage is that a removal model is adapted, and model selection criteria can then be applied, to estimate species detection probabilities. This slightly modifies the protocol used during the field testing in 1999-2000 when the initial 5 min silent period was not subdivided. This approach will also allow modifications to the protocol in the future.

### Spatial Sampling

For these cryptic species, one sample point was felt to be adequate at small wetlands where the call broadcast could be heard by all birds within the wetland (radius of ca. 100 m broadcast). At larger, isolated wetlands, two or more points were established at least 200 m apart, depending upon the size of the wetland. At riverine sites, or in larger wetlands (*e.g.* salt marsh), a transect-point count approach was used. For rivers, a single transect bisecting the watercourse was used, with points every 200 m. This was expected to result in independent points since the broadcast radius was estimated to be ca. 100 m at 90 dB. In larger marshes, a combination of random and uniform spatial sampling was used: the beginning of the transect was randomly selected along a marsh shoreline with the direction randomly selected. Once the first point was established, however, points were established at fixed 200 m intervals thereafter. Transect lines were not permitted to lie within 200 m of adjacent transects to insure independence of points.

### Temporal Sampling

Surveys are to be conducted three times during the breeding season, spaced about 14-20 days apart between 10 May and 30 June in the northeast. At lower latitudes, *e.g.* from Maryland south, surveys could begin 1 May. If resources are limited, surveys may be conducted every 3-5 years rather than annually. During fall migration, three surveys should be conducted, again at intervals of about 14-20 days, between 15 September and 6 November. Annual surveys are probably not required, but perhaps every 3-4 years. During winter, we recommend two surveys, one between 10-17 December, and another between 10-17 January. These probably are lowest priority, and should be limited to perhaps every 3-5 years. A caveat to consider is that population trend estimates are time-sensitive, so that conducting surveys on a 3-5 year rotation will result in a concurrent increase in the number of years required to detect changes compared to annual surveys. In our field test however within CACO, the very small numbers we encountered during our marsh bird surveys precluded us from determining meaningful trends (Erwin *et al.* 2002).

Specific Data Collected for each Sample

Fixed survey points will be chosen and marked with inconspicuous markers in the field. Locations of all survey points will also be plotted on maps of each wetland using a GPS receiver. The distance between adjacent survey points is 200 m. Survey points in permanent ponds should be located either on the upland-emergent interface or on the open water-emergent interface, whichever will allow easier access and travel between survey points. Some ponds may be more effectively surveyed by boat (with survey points on the open water-emergent interface) and others more effectively surveyed on foot (with survey points on the upland-emergent interface). Survey points within freshwater marshes associated with rivers should be located along mid-river channels where possible. Each survey point receives a unique identification number. The number of survey points per pond will be correlated with pond size; only one survey point is needed on ponds 2-3 ha in total area.

Timing of Surveys

All surveys begin 30 minutes before sunrise and must be completed by 1000 h. For the tidal river marshes (to facilitate access), the surveys should be conducted on a rising or high tide, a minimum of 3 h after low tide. Conducting surveys on low wind days (< ca. 20 kph) is more critical than maintaining precise spacing (*e.g.* 2 weeks) of surveys. Following Erwin *et al.* (2002), we recommend that personnel:

- Conduct 3 surveys during the breeding season; these should be evenly spaced between 10 May (or 1 May in southern areas) and 30 June. Maintain > 2 weeks between subsequent surveys. Three surveys are needed to confirm seasonal presence/absence of marsh birds in a wetland with 90% certainty (Gibbs and Melvin 1993, Conway and Gibbs 2001).
- Conduct 3 surveys during the fall migration; these should be evenly spaced between 15 September and 15 November. Maintain > 2 weeks between subsequent surveys.
- Conduct 2 surveys during winter; the first survey between 10-17 December and the second survey between 10-17 January.

Observers should expect to survey 10-20 survey points each morning, depending on travel times between survey points.

Survey Methods

Standardized survey methods for marsh birds have recently been developed to aid agencies developing marsh bird monitoring programs (Gibbs 1995, Ribic *et al.* 1999, Conway and Gibbs 2001) and were followed during the field testing at CACO (Erwin *et al.* 2002). Because many marsh birds are secretive, seldom observed, and vocalize infrequently, we suggest use of call broadcast to elicit responses during vocal surveys (Gibbs and Melvin 1993). All observers should be experienced or trained with tapes and with other experienced observers for at least a week prior to beginning surveys. At each survey point, observers will record all species heard vocalizing (both primary and "other" species) during both a 5-minute passive period prior to broadcasting calls, and during a period in which pre-recorded vocalizations are broadcast into the marsh. The broadcast sequence includes calls of the primary marsh bird species and is broadcast using a portable CD player connected to an amplified speaker. The CDs are available from Dr. Courtney Conway, USGS Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson AZ. The CDs contain an initial 5-min silent period (passive), followed by 30 sec of recorded calls of each species consisting of a series of approximately 6 sec of calling followed by 6 sec of silence. A 30-sec silent period should be included between each pair of species calls. For example:

5 minutes of silence
30 seconds of calls of first primary species configured similar to this:
    3 Least Bittern *coo-coo* calls
    6 seconds of silence
    3 Least Bittern *coo-coo* calls
    6 seconds of silence
    4 series of Least Bittern *kak* calls
30 seconds of silence
30 seconds of calls of second primary species configured similar to this:
    2 Sora *whinny* calls
    6 seconds of silence
    3 Sora *per-weep* calls
    6 seconds of silence
    4 Sora *kee* calls
30 seconds of silence
30 seconds of calls of third primary species …. Repeat for N species…

A verbal "stop" at the end of the survey interval should be included so that the observers know when to stop the CD.

The chronological order of calls on the broadcast sequence will always be consistent and start with the least intrusive species first. For example, for a New England marsh, the sequence of taped calls during breeding season surveys should be: Least Bittern, Sora, Virginia Rail, King Rail, Clapper Rail, American Bittern, Common Moorhen, American Coot, and Pied-billed Grebe. During migration and winter, both Black and Yellow rails should be added as the first and second primary species in the chronological order, therefore different broadcast sequences are used. The calls used in the broadcast sequence will include the primary advertising call of each species (*e.g.*, '*whinny*' for Sora, '*grunt*' for Virginia Rail, '*clatter*' for King and Clapper Rail, '*kickee-doo*' for Black Rail, '*click-click-click-click-click*' for Yellow Rail, '*coo-coo-coo*' for Least Bittern, '*pump-er-luck*' for American Bittern), and other calls associated with reproduction. Including all the common calls associated with reproduction of each species on the broadcast sequence will increase detection probability during different times of the breeding season and can help observers learn the less-common calls of each target species.

Further details about conducting the 14 minute survey, calibrating the CD player for appropriate sound output and completing all the lines on the field data form (Appendices 2a, 2b, and 2c) are given under Marsh Birds in Part II.

Habitat Measurements

Changes in water level, dredging, wetland restoration efforts and other management activities can lead to dramatic changes in marsh vegetation. Patterns of distribution and local population trends of marsh birds can often be best explained by local changes in wetland habitat. Consequently, quantifying the proportion of major habitat types into the following 11 types is recommended: cattail (*Typha spp*.), aquatic bed vegetation (*e.g.* water lily, pickerelweed), sedges/rushes, common reed (*Phragmites australis*), cordgrass (*Spartina alterniflora*), *Salicornia spp.*, other grasses, open water, mudflat, shrub, and upland. For consistency with other NPS protocols (Roman *et al.* 2001), we suggest using the Braun-Blanquet cover scale: <1-5%, 6-25%, 26-50%, 51-75%, 76-100%. Each observer should independently estimate coverage for each survey point each year to help identify the cause of observed changes in marsh bird populations. Habitat should be quantified at 2 scales: observers should visually estimate the proportion of each major habitat type within a 50 m radius circle around each survey point, dividing each circle into four quadrats and roughly mapping each habitat type, with its estimated proportion. Alternatively, and more accurately, the dominant cover types could be paced using a GPS unit, and a map produced for each point. The habitat measurements should be taken during the first two weeks of July each year. A laser range finder is invaluable for measuring distances from points. Observers may need to reconcile differences in their estimates before recording the final figure. Data are recorded on field forms (Appendix 2c).

## COLONIAL WATERBIRDS

Monitoring Questions

The monitoring questions associated with this group, which includes gulls, terns, Black Skimmers (*Rynchops niger*), Double-crested Cormorants (*Phalacrocorax phalacrocorax*), and wading bird species, include: (1) Are the methods adequate to detect a breeding population change of 25% or more over a 20-year period with a Type I error rate of 0.10 or less (alpha <0.10), with power of 0.80? (2) Do the populations change relative to the regional (*e.g.*, state) populations? (3) Where are colonies located and how are changes (if any) in colony locations related to (a) habitat changes or (b) management activities? (4) How do annual fecundity and/ or other bioindicators (*e.g.* contaminant load) of selected species change through time? (5) Does habitat change or management activity affect annual fecundity? (4) Is local recruitment sufficient to sustain the local breeding colonies, *i.e.* is the local unit of interest a source or sink for the regional population?

For a more in-depth treatment of designing monitoring programs for a large suite of breeding colonial waterbirds, we refer the reader to the manual being finalized by M. Steinkamp

(Steinkamp 2002) at the USGS Patuxent Wildlife Research Center, entitled "Breeding season population census techniques for seabirds and colonial waterbirds throughout North America" (in the Manager's Toolkit section on the web site for the North American Waterbird Conservation Plan: http://www.waterbirdconservation.org/plan/toolbox.html). Another good general reference on census techniques is Bibby *et al.* (1992).

Site Selection

Colonial waterbirds, by definition, are concentrated into a usually small number of sites known as colonies, therefore at the local level (*e.g.*, Park or Refuge), attempts are made to include *all* nesting colony sites in any monitoring effort. To insure that all active sites are found during each survey, an initial aerial reconnaissance is recommended, followed up with boat or foot surveys. Copies of topographic maps are best used in aircraft, while GPS locations should then be taken on the ground. In general, a colony is operationally defined as a cluster of > 2 nests of a given species, separated by about 200 m from the next nearest cluster (Erwin 1979). For locating important roost sites, we also recommend an aerial approach, or use of a boat or 4WD vehicle if aircraft are not available or affordable. Documenting and monitoring important feeding sites is more problematic given the unpredictability of many such sites over time for many species. Nonetheless, depending on the size of the area and the number of potential sites to include, and the question asked, it may be feasible to monitor either all or a random sample of such sites using vehicles or by setting up a fixed array of observation towers for scanning large areas (Erwin *et al.* 1994).

Sampling Unit

The sampling unit is the area comprising the colony (or roost) site. The variables of interest are the estimates of nesting pairs by species, and some estimate of fecundity. For estimating annual fecundity, the sampling unit is usually the nesting pair, or, if enclosures are used, a subset of nests. For nesting habitat measures, the sampling unit may be the individual nest or the entire colony site where several aspects of habitat and disturbance are measured. In sampling feeding habitats, categories may vary from generic typing such as ocean, inlet, bay, creek, panne, pond, to designated areas (by hectare) within each type, to specific locations (*e.g.* Pond A, B, or Creek 1,2…n) used. For monitoring contaminants, the sampling unit is often an egg, a feather (metals), or an individual bird, often pre-fledged young that can be easily captured (tissue analysis).

Caution must be exercised when conducting statistical analyses using eggs, young, or even groups of adjacent nests in colonies. For example, the results from more than one egg or chick in a brood may be non-independent. Similarly, nests in close proximity may be those of genetically related adults, or at least those of similar age or experience, thus may not represent a random sample of the colony. For contaminants studies, usually only one egg is used to sample a given nest.

## Spatial Sampling

In most studies of colonial species, it is assumed that all colony (or roost) sites are located, however this needs to be addressed, usually by having independent surveyors conducting the surveys each year (*e.g.* using the Double-observer method such as outlined above in the section on Piping Plovers). Errors may occur when observers only revisit sites used previously. Independent surveys will determine whether colony site detection is 100%. Where many colonies exist, and if population trend is the most important question, selecting the largest colonies may suffice (Erwin *et al.* 1984). For questions concerning feeding habitats, the sample chosen will depend upon the scale of interest for monitoring. In conjunction with other monitoring programs, it may be most efficient to couple monitoring of selected species of waterbirds (a species of heron or shorebird) with water quality or fish or invertebrate monitoring to build stronger causal relationships.

For estimates of annual fecundity in gulls or terns, random sampling is desired, using wire or plastic enclosures to monitor the success of nests and survival of young. Without enclosures, the chicks may disperse widely in response to investigator disturbances, resulting in underestimates of fecundity. Because of logistic constraints, truly random selection of nests is seldom possible; instead clusters of nests are identified and enclosed at locations scattered within the interior and on the periphery of the colony (Nisbet and Drury 1972, Erwin and Smith 1985). This is done to sample potentially different age or experience cohorts within the colony, which may be demographically heterogeneous (Hunt and Hunt 1976). At large, traditional colonies, it is recommended that permanent plots or transects be established and marked so that repeated visits can be made to sample the nests. A minimum of 30 nests (or alternatively 10% of the colony) is usually recommended for estimates of success. For wading birds or cormorants and pelicans in bushes and trees, nests can be randomly selected in different parts of the colony, but monitoring chick survival is more difficult because of chick mobility and habitat; usually investigators follow nest success until young are about two weeks of age (Erwin *et al.* 1996). As above, in traditional colonies, we recommend establishing transect lines (3-5 m wide if vegetation is dense, perhaps 10 m or more in open habitats) at random intervals along the perimeter of the colony (Steinkamp 2002).

## Temporal Sampling

To estimate breeding numbers of colonial waterbirds, we recommend annual colony visits at least once during the peak of incubation (except Least Terns, see below). In many cases, depending on the Park or Refuge and its resources, certain species that are higher priority (*e.g.* terns, Black Skimmers, Double-crested Cormorants) may be surveyed annually whereas others (gulls) may only be surveyed on the order of every 4-5 years.

We recommend a one-survey visit every year in mid- to late incubation (in most of the Atlantic region, early May for gulls, late May for wading birds, 5-20 June for terns, pelicans, cormorants) to estimate the number of breeding pairs in a colony. For Least Terns, which are notorious for non-synchrony, we recommend a 5-20 June survey followed by two others, one between 20-30

June, and one in early July. In the event of a major storm during these periods, surveys may be rescheduled 2-3 weeks later.

At least every 3-4 years, we recommend monitoring fecundity of selected species. Depending upon the regional species concerns, this could include one to several species. For example, in parts of the mid- and north Atlantic regions, concerns for fecundity of Common and Gull-billed Terns and Black Skimmers have been raised (see Parnell *et al.* 1995). Because of the rarity and federal protection of the Roseate Tern, we do not recommend routine studies of this species without special research permits.

Setting up enclosures for young (Nisbet and Drury 1972, Erwin and Smith 1985) is usually necessary for the ground nesters, unless one uses observations from blinds or distant observation platforms (*e.g.* Tims 1999 for gulls). This entails visits at least every 5-7 days after hatching commences to locate and count the numbers of live and dead chicks until fledging occurs (operational definition is > 20 days generally for most colonial waterbirds). Similarly, for wading birds and pelicaniforms, 2 visits per week at marked nests are necessary to record the survival of nests and young. For wading birds, nest "success" is usually truncated at about two weeks of age because of the mobility of chicks at that point (Custer and Peterson 1991, Erwin *et al.* 1996).

American Oystercatchers (*Haematopus palliates*) have recently attracted the attention of biologists because of concerns over widespread population declines along the Atlantic Coast (Davis *et al.* 2001). As a result, surveys of all beaches should begin along the Atlantic coast in early April and should mirror the methods (including method for assessing detection probabilities) followed for Piping Plovers. Locations of oystercatchers that are courting for more than a week should be recorded using GPS receivers. Nesting locations require more intense searching by ground observers, at least twice per week, however, since oystercatchers often share the barrier beaches with plovers, there should be little time added by coupling these two surveys.

## Specific Data Collected for Each Sample

### *Breeding Population Estimation*

Least Terns - Details of collecting field data are given in Part II, with specific reference to Cape Cod National Seashore. Field data forms should be completed for each colony site visit. A standard colonial waterbird field data form has been developed (Appendices 3a and 3b). Because Least Terns are notoriously unsynchronized in their nesting, numbers of nests should be estimated a minimum of three times (see above). The best estimate of the number of nesting pairs in a colony is the maximum number of nests estimated among the three (or more) survey periods.

Gulls and Common Terns - Conducting nest estimates for this group is detailed in Part II. Emphasis is placed on obtaining some measure of survey accuracy by assessing probabilities of nest detection using the Lincoln-Petersen Index (*e.g.* see Smith 1966, Morrison *et al.* 2001), a simple yet robust field method that is easily applied under many conditions. Samples of several transects are established where nests are first marked on one pass through the area or along a transect, then recounted on the reverse pass, keeping separate tallies of nests found on the second count that are marked versus unmarked. At the completion of the survey, the total number of nests in the colony is estimated by converting the total count by applying the Lincoln correction as outlined as follows:

The equation in its simplest form is:

$$N = (M * C) / R$$

Where $N$ = the total estimate of the number of nests in the colony; $M$ = the total number of nests observed and marked during the first pass through the survey area; $C$ = the total number of nests observed on the second pass through the survey area: and $R$ = the number of nests counted on the second pass that were already marked on the first pass.

As an example, if our Lincoln marking on two transects showed that we observed and marked 107 nests during the first survey (M), then counted a total of 102 on the second pass (C) of which 97 nests were already marked (R), our N, the estimated total number of nests, is 113. Thus, our first count of 107 was a 5.3% underestimate of the total. We then apply this 5.3 % correction to the remaining counts for the colony for an overall corrected total estimate.

If annual total nest counts are not feasible, a good alternative at large traditional colonies is to establish fixed permanent, randomly selected transects. A minimum of a 20% area sample should be aimed for, marking each transect at fixed intervals of ca. 50-100 m with wooden or PVC markers, coupled with GPS locations. Use of narrow and short (60 cm) PVC or wood markers is recommended to discourage use of these as raptor roosts. Counts of nests within all transects can then be performed as above, using the mark-recapture method for 2-3 transects. The 20 % (or other) sample is then extrapolated for an estimate of the total colony size.

Wading birds - Herons, egrets and ibises are best estimated by making noise (hand clapping) while approaching shrubs (*Myrica* bushes) and trees since they are easily disturbed and take flight often 100 m before observers reach the nesting area. Nesting must be confirmed by entering the dense shrubbery and looking for large stick nests. Sometimes birds appear to be in colonies but are only using the site as a day roost. The number of herons flushed from the site should be approximately equal to the number of nests (Erwin 1979); however this is not always reliable, therefore ground counts of nests must be used. A total nest count in large colonies during nesting is not advised because of the potential for disturbance and nest damage. Wading birds also usually nest in extremely dense often inaccessible patches of vegetation. We suggest establishing transects (3-5 m wide in dense vegetation, wider in more open terrain) at random throughout the colony by first establishing a line parallel with the longest axis of the colony, and marking random points (3-4 m wide "points") to obtain at least a 20% estimate (Portnoy 1977), although 40% is sometimes recommended (Steinkamp 2002). For example, to achieve 20% in a colony of 100 m length, five 4 m wide transects need to be chosen at random, with points spaced > 4m apart to prevent overlap. We suggest using colored plastic tape to mark boundaries of transects. One observer should conduct rapid nest counts at a given transect during incubation. From 2-4 observers are recommended to minimize the time spent walking through the colonies.

At least for 2-3 transects, one observer should mark nests (or shrubs or trees with nests) on the first pass, and a second observer should then repeat the count, recording numbers of nests marked and those unmarked, so a Lincoln-Petersen Index can be generated. If no nests are missed by the first observer, the process does not need repeating at every colony.

Because of confusion in discriminating eggs among several species, we suggest allocating the numbers of nests counted for the medium-sized herons and egrets based on the proportion of birds flushed at the colony. A less-disruptive method for nest counting is to count after the young have fledged. This will result in somewhat of an underestimate as nests may deteriorate over time, as species steal material or storms damage nests. If post-season nest counts are performed, the nests need to be apportioned among species in the same way as indicated above.

For American Oystercatchers, the number of pairs should be recorded during the beach surveys for Piping Plovers. The data should be recorded on the Piping Plover forms or on those provided by the appropriate state wildlife coordinator.

*Annual Fecundity*

Least Tern - Estimating the annual fecundity of species that nest in open terrain such as beach is somewhat easier than for species that nest in vegetation. Nest surveys should be done using a spotting scope with 15X or more, if possible from a vehicle. Weekly (or more often) nest checks provide a useful index. The final check should be conducted when the oldest chicks in the colony are 21-24 days (fledging about 24-27 d). On each survey, observers should also count from the vehicle the number of adults and chicks in attendance for the entire colony (while not precise, young-to-adult ratios provide an index of annual fecundity). To evaluate detection differences between observers, independent counts of adults and young should be conducted by the observers.

Without individually-marked young followed daily, precise estimates of survival will not be possible; instead the above method will only provide an index of annual fecundity. The value of the index can only be determined by conducting both types of studies simultaneously (a potential Master's thesis project).

Gulls and Medium-Sized Terns - Precise estimates of annual fecundity for grass-nesting species such as Herring Gulls and Common Terns are difficult to obtain without a lot of effort and disturbance to the colony (Nisbet and Drury 1972, Erwin and Smith 1985). For threatened or endangered species, *e.g.* Roseate Terns, special permits are required and rigorous review of standard procedures is required by the FWS Recovery Teams before the field work is allowed to proceed.

For the species not considered at risk, the methods vary widely. Often, for gulls and Common Terns and Black Skimmers, when young are large, they may run long distances from their nests upon disturbance; this exposes them to higher levels of predation (both intra- and interspecific). Three approaches are suggested, the first two require enclosures, the third, observation blinds.

(1) For the first Enclosure method, observers should estimate annual fecundity using 4-6 randomly-located enclosed plots in different parts of the colony marked with wooden stakes ca. 60 cm long to demark corners of ca. 5 x 5 m quadrats (if nest density is fewer than 5-7 nests per plot, the plot may have to be larger). Poultry wire fencing (2.5 cm mesh, > 40 cm high) should then be buried in the soil around the periphery of each plot. If possible, a sample of at least 10% of the colony is desired, with 20% being ideal, based on the estimated nest count made earlier. Often however large numbers are not feasible to monitor, but in general a sample of >20 nests is considered minimal. Each quadrat should be labeled and total number of nests should be counted in each plot during early (5-10) June. Plots should be set up within a few days after the nest count is done.

After hatching begins (often the end of June), two visits are to be made. One is to be conducted about two weeks after hatching when numbers of chicks are counted in each quadrat. If the nests are visible from outside the colony, a scope should be used to count young from a distance to reduce disturbance. If vegetation is dense, observers will need to enter the quadrat to do the count. It is best for two people to do this. A second count should be made the same way about 8-10 days later (most terns and gulls fledge at about 23 - 28 d). The total number of young surviving in each quadrat divided by the number of nests in each will provide an estimate of "colony success." Variance among quadrats will be used to adjust the number of sample plots needed to accurately estimate the number of young fledged per colony in future years (see sample size requirements under the USGS Patuxent Wildlife Research Center's website: http://www.mp1-pwrc.usgs.gov/powcase/). After most of the young have fledged in the colony, at least one more late-season count should be made of the ratio of adults to young around the perimeter of the colony, preferably from a boat. This final count should be timed about 10 d after the last visit to count numbers of chicks.

As with Least Tern estimates, these estimates of annual fecundity will also not be as precise as if each nest were monitored, chicks marked, and followed every 1-3 days (see Eyler *et al.* 1999). Instead, nest group (= plot), or "composite fecundity," estimates are obtained which represent an average number of fledglings per nest for the sample plot, or quadrat. This is still far superior to the frequent qualitative manner that is reported by Park and Refuge biologists (*e.g.* "poor", "average", or "good" success). As in other cases, the trade-off is accuracy versus time and colony disturbance.

(2) A second Enclosure method modifies that in (1) above by relying on visits every 1-2 days, banding each young, and monitoring its survival using the Mayfield Method (see Erwin and Custer 1982). The advantage of this method is accuracy, in that the individual nest is the sampling unit, however it is very time and labor intensive, and a smaller number of nests will typically be monitored this way. In southern regions, with intense summer heat, the time spent in the colony may be a significant source of mortality of eggs and young.

(3) Alternatively, nests and young can be marked using spray paint (or colored leg bands on young) and the number of live chicks monitored from a distance (from a blind) with no need to set up enclosures (Tims 1999). This method may require more time over the course of the entire season, depending on how many nests need to be sampled and how they are spaced. If many nests can be observed from one elevated blind, much time will be saved. In some habitats, nest

vegetation may need to be clipped to allow observation during mid and late season. It is somewhat less disturbing than the enclosure method, however in any case, the young still have to be captured and marked after hatching.

The following ancillary information should also be recorded when conducting nest counts, especially for beach-nesting species: (1) number of dead young found and condition of dead young, (2) nesting substrate of the majority of nests, e .g. sand, shell, grass, (3) distance from colony or nest perimeter to designated ORV trail (Least Terns and American Oystercatchers), and (4) comments on presence of any disturbance, tracks, scat, owl pellets, or other signs of predators.

*Habitat Parameters*

Least Terns - Because of the influences of beach management on Least Terns and Piping Plovers, additional habitat measures are needed to monitor the terns (Appendices 3a and 3b). At a minimum, management activities such as ORV use and fencing need to be recorded (presence/absence) at each colony site. Comments should be recorded on the form on each visit if disturbances such as beached boats, ORV tracks or presence, or pedestrians, pets, *etc.* are noted. In addition, three measures of beach width should be made at each colony after terns have fledged (late July to early August); one at the colony center and the other two at the ends of the colony. Beach width is the distance from the berm crest to the toe of the foredune and is measured using a 100 m tape. While the measuring tape is laid out for the 3 points, observers also record the total length that is intercepted by beach vegetation and record vegetated area as a percentage of total length of the beach width transect (< 5% is considered unvegetated).

*Contaminant Assessment*

Given the emphasis of the BEST (Biomonitoring and Evaluation of Status and Trends) program within the USGS on NPS and FWS coastal lands (Rattner *et al.* 2000), some monitoring effort should be undertaken to evaluate contaminants in waterbirds on a regular basis. Before engaging in this however, the regional FWS contaminant specialist or state biologist should be contacted to ascertain their interest. If it is determined that the Park or Refuge should be included in a sampling regime, a cooperative arrangement should be developed. We would recommend that, at 3-year intervals during colony surveys, dead or dying young waterbirds should be collected until a sample of 10 young per colony is achieved. At the same time, one primary feather (primary # 6-8) should be collected from a random sample of 10 healthy young that are > 2 weeks old. Feathers can be analyzed for heavy metal levels and may also provide useful nutritional information through stable isotope analysis (Hobson and Clark 1992, Knoff *et al.* 2001). At a minimum this should be done with Common Terns and Black-crowned Night-Herons since they represent different feeding guilds (bays and oceans versus emergent marsh and brackish wetlands, respectively). Both species seem to be declining in parts of the northeast; these declines have been attributed at least in part to contamination of its food supplies (Boyd 2000, K. Parsons, pers. comm.).

## MIGRATING AND WINTERING WATERBIRDS

### Monitoring Questions

The monitoring questions for this group include: (1) Are there identifiable "hotspots" that are used consistently by either feeding or roosting congregations of shorebird and/or waterfowl species at the scale of the embayment? (2) Are these hotspots (if found) consistent among years? (3) At the small (local) scale, are there certain habitat types that are particularly important for American Black Ducks (*Anas rubripes*), Red Knots (*Calidris canutus)*, Dunlin (*Calidris alpina*) or other shorebirds of concern? (4) Is there any change in species composition occurring over decadal time periods? (5) Are methods adequate to allow meaningful comparisons of local (park or refuge) population trends (*e.g.* detect a 25% change over 20-year periods) with those occurring within the region for shorebirds (International Shorebird Survey, or ISS, data) or for waterfowl (state Mid-Winter Inventory data)? (6) How much annual and species variation is present in mortality data from Beached Bird Surveys?

### Site Selection

This group of birds requires considering several aspects of spatial uses: feeding birds, roosting birds, and beached (dead) birds. Stratification of the study area into potential feeding areas by each foraging guild (beach species, open mudflat species and marsh interior feeders) is necessary. Each unit must decide what the scale of question is: the entire unit (park or refuge), only managed areas (*e.g.*, impoundments), or random selection. Since few areas have adequately sampled for roosting birds, initial surveys should include broad surveys of the entire unit of interest. After several such surveys, later stratification would be advised.

For surveying beached birds, we recommend randomly selecting beach segments of manageable lengths (0.5 to 3.0 km) to be monitored in all directions from which extensive water bodies (ocean, bay, lake) may produce pelagic species of waterbirds.

### Sampling Unit

To identify roosting habitats and to estimate population sizes of roosts, the sampling unit is the site (bar, beach segment, island, spit, or dune). To identify feeding habitat and to estimate numbers of foraging birds, the sampling unit is the designated portion of an embayment, usually an intertidal region, or a segment of an estuary along a beach that has been either defined by natural landmarks (points of land) or arbitrarily determined with GPS locations. To estimate densities of beached birds, the sampling unit is a randomly-selected beach segment ca. 0.5-3 km in length established with GPS points.

The designation of sampling units for feeding waterbirds is difficult because of the mobility of the birds, the vagaries of the water regime (*e.g.* shifting location of edge of tidal water), and the lack of visual landmarks in most areas. Sampling units must be large enough that they will include large, mobile flocks. By using beach and intertidal reaches along continuous corridors, with ranges from upland edge out to ca. 200 m, observers can effectively include all (or most) effective foraging habitat for shorebirds. All tidal stages across the intertidal range should be included within this 200 m zone. For relatively small embayments, fixed points can be used for observation sites and the entire area can be included rather than a sample area. The selection of beach reaches for inclusion in the beached bird monitoring section was based on access for 4WD vehicles.

Using aircraft to sample larger landscapes for shorebirds and waterfowl, requires larger sampling units than those used for ground surveys since the aircraft averages ca. 150-180 kph flight speed. The efficacy of this method needs to be determined on an area by area basis. Where FWS pilots may be readily available, we strongly advise using small fixed-wing aircraft for large-area surveys; however, if private contract aircraft must be used, the logistical and administrative constraints (getting approval through the Office of Aircraft Safety, getting personnel trained) involved may prove prohibitive.

## Spatial Sampling

Setting up foraging survey areas requires that all potentially good feeding sites, not simply those currently used, be surveyed from the ground. The limitation for using random selection is due to access by 4WD vehicles. Because aircraft use may not be practical in some areas, potentially important sites (water more than 200 m offshore) for waterfowl may not be sampled. Thus, some bias exists in the ability to adequately survey wintering waterfowl. We suggest that areas first be included that are accessible by ground methods and, of those, random selection criteria be applied. Based on previous information, biologists should stratify the selection, with known concentration areas receiving heavier weighting than those with little use by birds.

Because certain areas may be of particular interest such as restoration sites, or those subject to human disturbance, more intense surveying should be conducted at these sites as personnel time allows (see *Temporal Sampling* below). Thus a two-tier sampling regime may be appropriate, where most sites are visited only once during a 2-3 week period, whereas others are sampled multiple times per week on occasion.

## Temporal Sampling

To document roosting site use by waterbirds, ground and boat surveys are to be conducted at high tide for spring migrants from 1 May to 15 June and fall migrants from 15 July to 31 October (or to 1 December south of New England), with a minimum of three surveys, preferably five, roughly evenly spaced during the period.

For feeding waterbirds, the same areas are to be surveyed, but surveys are to be performed during low (MLW +/- 2 h) tide. In accordance with the ISS protocol, surveys are to be conducted every ca. 10 days from 1 May to 15 June and from 1 July to 1 December (ending earlier in New England). At the larger scales over many kilometers of habitat, obtaining one estimate of numbers during at least five feeding surveys at each site during each of the spring and fall time periods is sufficient. However, more intensive surveys may need to be focused in areas where either current or potential human activities or disturbances occur, *e.g.* aquaculture sites, boating or fishing recreation, *etc.* Because of the rapid turnover of individuals at feeding sites (often less than 3 days) during shorebird migration, obtaining a "snapshot" of abundance may be misleading. Thus, where certain locations are conducive to obtaining complete fixed location estimates, we recommend a series of 20-min counts be made during a 1 – 1.5 hr period and the maximum count used for analysis. These surveys do not need to be conducted annually, but should be performed at least every three years. We recommend that Manomet Conservation Center personnel be contacted to determine whether any sites being monitored might be included as part of the ISS framework; both the ISS and the Park or Refuge unit would benefit if these local units increased the network of sites being intensively monitored.

A caveat should be mentioned that, even when weekly counts are made throughout the entire spring or fall migration period at a given location, the variation may be so great that the likelihood of detecting long-term trends, even with a moderate degree of power and acceptance of a high (>30%) degree of error, may be low (see Appendices 5a and 5b for our example of a power analysis on some Cape Cod shorebird data).

## Specific Data Collected for each Sample

### *Identifying Roosting Habitats*

High tide roosts are seldom well documented for waterbirds. We tested aircraft methods for large-scale surveying of waterbirds on Cape Cod in late summer-fall 2000 and winter 2001 and concluded that using small fixed-wing aircraft on a regular periodic basis was not logistically pragmatic. The regulations required of federal biologists for aircraft operations over federal lands, the difficulty in coordinating pilot and biologists' schedules, and inclement weather on the outer Cape all conspired to reduce our capability to survey when necessary.

In other coastal areas where small aircraft can be efficiently utilized (or where federal law enforcement pilots commonly survey), we recommend use of small, high-wing aircraft to be flown at low altitude (100 - 200 m). Low-level flying (below the 500 ft, or 154 m, ceiling) requires filing for a Special Use permit with the Office of Aircraft Safety (OAS) and biologists need to recognize that obtaining OAS approval of private aircraft and pilots is an elaborate and time-consuming process; not many vendors are interested unless there are prospects for long-term contracting. We highly recommend using federal pilots within DOI whenever possible.

If small aircraft use is feasible, the aircraft should fly the entire beach shorelines, bays and marshes, and adjacent open sandy uplands (sand bars near inlets) and important (> 200 birds) congregations should be visually located and recorded using GIS receivers. From 3 to 5 surveys should be flown under stable weather conditions (low winds, no precipitation) during the spring migration period of 1 May to 15 June and fall migration, 1 July - 31 October, for shorebird surveys in the northeast (dates adjusted 1-2 weeks depending upon coastal latitudes). In areas south of New England, the fall season can be extended to 1 December, in conformance with the protocol of the ISS (Howe *et al.* 1989). Estimates of waterfowl should be included on the flights after mid September. Copies of topographic maps of each bay or water body should be used to circle and identify by number the roost concentrations. A portable tape recorder should be used to record estimates of numbers for species or groups for each numbered location. Data are to be transferred to field forms as soon as possible afterwards (Appendix 4). Where species identification is problematic, guilds can be used, such as "small peeps" (for small calidrine sandpipers such as Semipalmated Sandpiper [*Calidris pusilla*], or Least Sandpiper [*C. minutilla*]) or "large peeps" (*e.g.* dowitcher spp., whimbrels [*Numenius phaeopus*]) whereas others are usually distinct, such as American Oystercatchers, or Willets (*Catoptrophorus semipalmatus*). One precaution should be noted however; for trend analysis, interpretation of the trends may be difficult using "group" data, *e.g.*, "peeps", instead of individual species. An exception may be "dowitchers" that primarily represent Short-billed (*Limnodromus griseus*) with only a few Long-billed (*L. scolopaceus*) Dowitchers, at least in the eastern U.S. (Howe *et al.* 1989).

Five replicate aircraft surveys are considered a minimum for developing an index of consistency of site use. A major assumption here is that as species composition changes through the migration season, the preference for roosting habitat will not shift accordingly. This can be examined using the surveys conducted on the ground.

If aerial surveys are not practical or affordable, ground surveys, combining boat, truck or ORV use must be required. We recommend that complete area surveys be performed at least twice to include all inlets, sand bars and spits, high open areas near feeding flats, and elevated areas on marsh islands be visited. These should be performed at or near high tide late in the day (within 3 h of sunset) to increase the probability that birds are attending roosts. Because of the longer time "window," we suggest that roost site surveys be performed during the fall shorebird migration period, from late July to late September or October.

Counts of birds and locations using GPS receivers will be recorded on field data forms (Appendix 4) and topographic maps. Natural landmarks will be used for boundaries. A map of each roost area (bay, river, beach area) is useful to accompany the field form, with each roost location numbered to correspond to the data form entry. Because location and approximate size of roosting flocks are most important, emphasis should be on site location and obtaining an overall estimate of numbers, rather than trying to obtain a precise species estimate. When sleeping, species are difficult to identity in many cases. Limiting observations at each site to only one brief survey period will often lead to underestimates of the numerical importance of sites (Hadden 2001); however more information is gained by visiting more sites over a larger landscape, even if sacrificing some accuracy at any given site.

### *Identifying Feeding Habitats*

At intervals of about 3 years, observations will be made of waterbird feeding concentrations during fall migration, using methods similar to those outlined above for roosting. At coastal sites where it is feasible to conduct aerial surveys using small aircraft, surveys should be conducted during low tide periods of stable weather to document shorebirds and waterfowl numbers and feeding areas used over large areas (*i.e.* generally much larger than the average park or refuge). In concordance with the ISS methods (Howe *et al.* 1989), surveys of the estuaries/wetlands identified above should be conducted at low levels (< 100 m) every 10 days between 1 May and 15 June in spring, and between 1 July and 1 December in fall. In alternate years, surveys for waterfowl should include the period 1 September to 1 December and 1 January to 1 March. Because of the difficulty in surveying large numbers of many species over large areas, the focus will be on identifying major concentration areas (those with > 200 birds combined). For the aerial surveys, use of tape recorders will be combined with copies of topographic sheets cross referencing numbered map locations and observers will record the number of each species observed. Data will be later transferred to field forms identified earlier.

At the smaller scales where particular management-related activities are occurring and more data required, more intensive waterbird feeding concentrations should be recorded during ebb (2 h before low) and low (chart low +/- 1 h) tides during the same spring and fall periods as indicated above. To estimate error, we suggest that at least 25% of the surveys employ two observers to estimate numbers independently. Binoculars of 10X power and a scope of 20-40X power should be used. Observation periods of ca. 1.5 - 2 h will be needed to complete three counts by the two individuals at a given location. We suggest three counts because an earlier evaluation of conducting multiple counts at fixed sites indicated that spending more time at each site resulted in higher numbers being recorded for 2-3 count periods (Hadden 2001). In fact, in 1999 at 7 locations, in only 7 of 41 cases were first counts also maximum counts for that day's survey. Similarly, in 2000 at three sites, only 3 of 21 cases revealed that first counts were also maxima for the day (Hadden 2001). Thus, confining one's survey period to one instantaneous estimate will generally underestimate the numbers using that site.

At larger scales with multiple sites to be surveyed using ground methods, data on shorebird feeding flocks should be collected as one moves along ground routes selected in a stratified random method. Segments should be designated that are short enough to be surveyed from only one location where possible. Lateral boundaries are the high tide line and the water-mud margin at low tide. Natural boundaries should be used to demark survey transect limits. In large, open areas without such natural marks, wooden stakes spaced at ca. 400 m should be used and GPS locations determined. Maps of each study area should be used for each survey and locations of such flocks recorded. At each survey segment, the observer(s) should stop at a fixed point and scan the segment area over a ca. 10-min period using a spotting scope. Data should be recorded on the same forms as for the fixed surveys (Appendix 4); the locations will need to be referenced to numbered or lettered beach segments that can be georeferenced. This method will allow us to track the stability of feeding "hotspots" through time and will be useful in making future management decisions.

### *Habitat Measures*

Feeding habitat use will be recorded as either open water or intertidal mudflat. Roosting habitats will simply be characterized as (1) sand spit, ridge, or beach; (2) open water; (3) high marsh; (4) mudflat. Areas of roost habitats should be roughly determined using portable range finders with one observer using a range rod to sight upon. If such areas are discrete (*e.g.* a small marsh island), the area can be estimated simply from the Unit's GIS coverage or from topographic maps.

## BEACHED BIRD SURVEYS

The demands of the other protocols at Cape Cod did not allow time and effort to test a protocol for Beached Bird Surveys. However, where there are a sufficient quantity of competent bird watchers, we recommend that a network of such surveys be established especially under the following conditions: (1) large expanses of easily accessible beaches are found along both oceanfront and bayfront, (2) the probabilities of marine bird and mammal mortalities may be significant due to nearby shipping activities and fishing, (3) large animal concentrations occur at certain locations (*e.g.*, Cape Cod in fall migration and winter for waterbirds).

Sampling certain areas of beach for dead or dying birds has been used in a number of regions to document ambient mortality or mortalities associated with oil spills (*e.g.* Kuyken 1978, Ainley *et al.* 1980, Van Pelt and Piatt 1995, Ford *et al.* 1996, Hass and Parrish 2000). Even though it is not feasible to launch an intensive year-round beached bird survey, late winter and spring surveys should be included in this monitoring effort. This period coincides with period of late winter stress and early migration of waterfowl, and would include spring migration of all species. Beach segments ranging from 2 - 4 km each should be randomly selected; beach segments may need to be stratified according to major human activities (*e.g.* offshore fishing), orientation (bay versus ocean exposure), and ease of access by 4WD vehicle or foot. These will be marked on survey maps using a combination of natural landmarks (mouth of creek, river) and GPS locations (no stakes or other markers will be expected to remain given the level of human activity).

Surveys should be conducted from early March to mid June with each beach transect surveyed at about 10-day intervals. If a catastrophic event occurs however, such as an oil spill or hurricane, an additional 1-2 surveys within a week after the event should be planned regardless of time of year. Surveys should be conducted during morning hours (0700 to 1200 h) to minimize the removal of carcasses by humans or other animals, and at high tide (+/- 2 h) periods. Wind direction during the period 24 h prior to the survey should be recorded on the data form (Appendix 6). Identification of any impaired, or moribund species in the surf zone (<100 m) or on the beach should be recorded, as should parts of carcasses (*e.g.* wings) if possible. Signs of oiling of any carcasses or live birds should be noted especially. Field guides for beached birds are available for some regions (see Ainley *et al.* 1980, Hass and Parrish 2000). Observers should place any carcass found in the upper dune area to prevent previously counted carcasses from being recounted. In the case of marine mammals, contact needs to be established with local museums, or with the Smithsonian Institution, to determine whether measurements or samples from specimens may be needed or whether transport is required. Federal and state permits are generally needed to collect either marine mammals or migratory birds or their parts.

When surveys are conducted infrequently (such as the 10-day intervals recommended), it is important to estimate the rate at which freshly-deposited specimens persist in the drift zone. To estimate this, we suggest frequent visits to selected transects that have little or no disturbance. Carcasses can be marked with aluminum tags and transects revisited >4 times over about a 2-3 week period to determine "survival rates" of carcasses. It would be even more useful to place freshly sacrificed (or road-killed) specimens of different species (*e.g.* gulls, seaducks, shorebirds) at the high tide line to increase sample sizes. Daily survival rates can be calculated using the Mayfield method, as outlined in: http://www.mbr-pwrc.usgs.gov:80/software/Mayfield.html (see Bart and Robson 1982). This experiment should be conducted at least once per year at selected transects because scavenging rates may vary through time. It may be discontinued if, after several years, the survival rates for a 10-day period (the survey interval) are close to 1.0.

## DATA MANAGEMENT

### Raw Data Collection

Field data to be collected is specified in the above Sampling Methods section for each of the major waterbird groups. The minimum data requirement for each field data sheet is the date, the reference location (usually a code number), a point or specific area, and observer name or initials. Examples of data sheets for use in the field are included as Appendices: for Piping Plovers (Appendices 1a, 1b, and 1c), for marsh birds (Breeding, Appendix 2a; Migration and Wintering, Appendix 2b; Habitat, Appendix 2c), for colonial waterbirds (Appendices 3a and 3b), and for migrating shorebirds and waterfowl (Appendix 4). In general, detection probabilities need to be determined for each bird survey conducted. Because of the large amount of data included in these different data collection efforts, we strongly urge that all individuals engaged in data collection be trained in advance of the actual data collection period. Regardless of how clear a field form appears to be, questions always arise about how to record certain types of data. In addition, where counts of birds are recorded, we strongly urge that two observers keep independent records. Variation due to observer differences has been shown to be a major source of error (Sauer *et al.* 1994). Later, after data entry, the two sets can be statistically compared (t-tests, Mann-Whitney *U* tests) to see if they are statistically different. If not, a simple mean of all observations can then be used. If they do differ, and in general when two or more observers will be contributing data, each observer needs to calibrate his/her "count" data with the actual numbers. This can be done using computer software programs (*e.g.* WILDCOUNT) or other methods such as using slides or photographs with known numbers of objects or birds. Each observer should then "calibrate" his/her count periodically (*e.g.* monthly) and then apply these correction factors to the raw counts. Some prefer to enter both the raw and corrected counts into spreadsheets while others use only the corrected.

### Data Entry

Because the National Park Service (as well as other agencies) has determined that Microsoft Access will be the official database management software in the monitoring programs, we recommend it as the primary management tool. Conversion of Excel spreadsheets to Access is not difficult and the structure of the tables is quite similar.

Because the Piping Plover is a Federally Threatened species, the FWS and state agencies have developed their own system of data collection and management, with the State taking responsibility for data coordination and management. The data reporting requirements are outlined in the Region 5 Piping Plover recovery plan (FWS 1996). The spreadsheet that has been used for the past several years at CACO, as a participant in the Massachusetts plover survey, is shown in Appendix 1c. The State also maintains data for tern surveys on Cape Cod and throughout the coastal zone, and their forms are compatible with that data collection effort.

For the majority of the bird data sets, the data are entered directly from field forms into Microsoft Access, a relational database. Examples are listed in Appendices 7a to 7g. Advantages of Access include efficiency, because many fields of data (location, physical parameters) need not be reentered on each successive survey, and flexibility in presentation. A series of tables is listed in the database, and an example of part of a shorebird table is illustrated in Appendix 7a. How the tables are linked to each other by location or survey codes is shown in Appendix 7b, with links among foraging and roosting surveys. For marsh bird surveys, an example of an Access table for breeding, migrating, and wintering birds is shown in Appendix 7c (the length of these records requires several tables). Examples of shorebird and waterbird roosting surveys are shown in Appendices 7d and 7e. For shorebird/waterbird feeding surveys, examples are shown in Appendix 7f and 7g.

## Metadata

The metadata are best structured as five separate components; the overall "Waterbird Database" (within the larger Long Term Monitoring Protocol Database) then is comprised of a: (1) Piping Plover database (Appendix 1c) that contains breeding season data required by the State of Massachusetts and FWS Recovery Plan; (2) Marsh bird database that includes breeding, migrating, and wintering marsh bird data; (3) Colonial waterbird database that includes breeding season data on gulls, terns, and wading bird colonies; (4) Migrating (fall) and wintering shorebirds and waterfowl database, and (5) a Beached Bird database. Details of the data content and full descriptions are given in the above Sampling Methods section for each group.

Quality assurance and quality control are best maintained by having the field data reviewed and entered into the database on the same day it is collected. Two individuals should first review the data to reduce error propagation. Generally it is best to have the person collecting the data also doing the data entry, followed by having a second person compare the computer printout with the original field sheets. This second step can be done at a later date to reduce fatigue on field days.

## Data Storage

Data from each of the 5 components should be given separate code names (*e.g.* see Appendix 7a and 7b). Field data sheets should be stored in a safe, low-fire-risk location. Upon entry into a PC's electronic Access database, an extra copy of the database should be generated on CDs or zip disks which then should be maintained in a separate building. If a computer network is available at the site, the files can be more easily transferred electronically to other PC sites, rather than having to physically transfer media between locations.

Because of the increasing emphasis on data sharing and partnerships, we recommend that the data collected at national parks and seashores and wildlife refuges be maintained and stored not only in the agency's data archives, but that a cooperative agreement be developed with the USGS Patuxent Wildlife Research Center. Patuxent includes as one of its missions to promote a national bird monitoring database.

## DATA ANALYSIS TECHNIQUES

Statistics

The statistical tests that are recommended will vary by species/groups:

*Piping Plover*

The major needs for Piping Plover monitoring are to determine the number of active nesting pairs and nests in each management unit (Cape Cod includes several with CACO being one), the number of eggs laid, annual hatching success, and number of fledglings produced, or annual fecundity. Because individuals are not marked, elaborate demographic models cannot be used; basically summary statistics are all that are needed. The Recovery Plan (FWS 1996) requires that an index be generated to estimate the number of breeding pairs (the 9-day window) as well as a "maximum estimate". Numbers and percentages of hatchlings and fledglings are simply summed over the entire unit and presented as a composite annual fecundity. Within a given Park or Refuge, statistical comparisons could be conducted over time among the units or districts, to allow for management activities to be evaluated. Simple t-tests or one-way ANOVA can be used (with log transformed data) to compare annual fecundity between or among units. Non-parametric regressions such as Spearman's Rank test could also be used by Unit or for the entire Park or Refuge to examine annual trends in numbers of nests, hatching success, or annual fecundity.

*Marsh Birds*

If two observers conduct counts simultaneously, differences between the observers allows detection probability to be assessed (Nichols *et al.* 2000). However, with marsh birds, the larger problem is the low probability of calling for most species (Conway and Gibbs 2001), not failure to detect species once they vocalize. So few individuals of any one species of marsh bird are detected in many Parks or Refuges that simple presence/absence data may be more appropriate (Erwin *et al.* 2002). With three replicate visits to each point, we can estimate probability of detecting presence (MacKenzie *et al.* 2002). With larger numbers of marsh birds in Maine, low call-responses suggested that detecting changes of 25% would still require 2-3 visits to a minimum of 40 routes annually (Gibbs and Melvin 1993).

### *Colonial Waterbirds*

Summarizing Least Tern nest numbers and annual fecundity mirrors the Piping Plover protocol, where an index of adult and nest numbers is generated during a time "window" (5-20 June). Using non-parametric regression, such as Spearman's Rank test, to assess long-term changes in adult breeding populations or overall annual fecundity for a given Park or Refuge is possibly helpful from a management perspective, but analyses should also include the larger regional and state scales. Given the mobility of this species, local-scale analyses may not reflect larger regional patterns.

For analysis of trends of waterbird species, where there are a number of colonies monitored over a number of years, a new hierarchical approach that uses Bayesian methods (Sauer and Link 2002) may prove to be superior to the traditional weighted regression model approach (*e.g.* see Erwin *et al.* 1984).

### *Migrating and Wintering Waterbirds*

Conducting statistical analyses on migratory and wintering waterbirds can be complicated by the highly variable nature of the avian resource. During shorebird migration, surveys at the same location can result in estimates that vary by several hundred percent over a 1-h period (Hadden 2001). We used t tests and Mann-Whitney *U* tests to compare shorebird numbers between two locations, and then conducted power analyses to see if a two-year change could be detected. Power analysis has become an accepted approach to assist field biologists and managers in making decisions about intensity of sampling required to detect specified levels of change with a given Type I error rate for a specified power (usually 0.8 or higher) (see: www.mp1-pwrc.gov/powcase/powcase.html, or Gibbs 1995). We suggest testing count data for normality first, using Anderson-Darling normality tests, and then applying a transformation if necessary. We suggest power analysis using software Nquery Advisor 4.0 (Elashoff 2000) (J. Hatfield, PWRC). We suggest that trend analyses for either shorebirds or wintering waterfowl will prove to be very difficult if one expects to detect changes of < 50% between years, given the degree of variation. Given the mobility of shorebirds and large variations at a given place over short periods, we suggest that individual refuges or parks become part of the larger ISS network wherever possible. Analyses then will be conducted at multiple scales and will have more meaning than will the results from a single location.

Another statistical application however can be used to determine the degree of site fidelity, a useful management tool. If one wants to test whether certain roosting or feeding areas are used more consistently than others, a Markov process model can be used (Erwin *et al.* 1998). Sites can be classified by habitat type and/or by average size of aggregation (*e.g.* small, medium, large) and probability of occupancy can be assessed relative to these parameters (for further information, contact J.D. Nichols, USGS-PWRC to discuss which of a family of models might be appropriate). In many cases, simply knowing which sites are most consistently used (and often containing largest concentrations of birds) may be more valuable than attempting population trends.

Data Interpretation

Examples of data interpretation are expressed in the Appendices for each section. No Piping Plover data interpretation has been presented as only summaries of nesting data had been collected during the protocol development period (S. Hadden, pers. comm.). For other groups, the data are presented and interpreted (Appendix 2 for marsh birds, Appendix 3 for waterbirds, and for migrating shorebirds and waterfowl, Appendix 4).

## EQUIPMENT NEEDED

Major equipment items include: a 4WD large vehicle and if possible an ATV for access to beach segments where larger vehicles are not permitted or where access is difficult at certain tides. Also, a small powerboat for access to wetland areas and/or a canoe for tidal river access are essential. Minor field equipment needed includes: binoculars (8-10 X) and a spotting scope (at least 20X) with tripod, handheld GPS units, laser range finder, tape recorder or portable CD player, CDs/tapes, with recorded marsh bird calls, 50-100 m measuring tapes, wire flagging, PVC pipes for markers (30, 60, and 150 cm lengths), topographic maps, spray paint or water soluble markers, poultry wire (rolls 30 cm high for tern nesting enclosures), field notebooks and waterproof data forms.

## PERSONNEL

Our experience suggests that at least one FTE is needed, preferably at the GS-9 or higher level, to act as the coordinator and field team leader for a given Park or Refuge project. For Piping Plover monitoring alone, additional seasonal employees are usually needed from March until August, in addition to Park or Refuge staff. These individuals need to monitor on a daily basis, whereas permanent personnel usually are required to devote effort to several projects. For the other three groups of birds, we recommend from 1-2 seasonal employees, and at least one intern or volunteer during the May - August period. This assumes that not all elements of the protocol will be required every year. At least two weeks will be needed for naïve personnel to become trained in learning bird identification by sight and sound, to become familiar with the logistics and to learn local Park or Refuge lands and waters, and to become familiar with the protocols, data entry, *etc.* The coordinator will be required to take Department of Interior boat safety training if powerboats will be used. If aircraft is used for survey work, a contractor is recommended rather than a federal employee.

# PART TWO
# WATERBIRD MONIROTING PROTOCOL

## PIPING PLOVER PROTOCOL

### Monitoring Questions

Details involving plover monitoring have been negotiated through partnerships under the Atlantic Coast Population Piping Plover Recovery Plan (FWS 1996). As partners, CACO has agreed to coordinate their protocol, data management and submission with Plan personnel led by the MDFW. The Plan has steered the monitoring questions to be addressed within this protocol: (1) What is the Piping Plover breeding population size within CACO with respect to the landscape (Cape Cod), state, region, and Atlantic Coast flyway? (2) Is there a detectable trend in breeding pairs on CACO or on Cape Cod over a 10- or 25-year period? (3) Do breeding locations change annually and how much site turnover occurs within CACO? (4) What are the habitat features associated with successful reproduction, or with the greatest densities of breeding birds? (5) Do management actions such as off-road vehicle (ORV) beach closures, or opening certain beach access points, influence where plovers breed each year? (6) What is the annual fecundity (*i.e.*, number of fledged young per pair)? (Note: the Plan (FWS 1996) goal in the "New England recovery unit" is a 5-year average productivity of 1.5 fledged young per pair), (7) What are the causes of mortality of eggs, young, and adults? (8) Are human activities, including CACO management such as fencing, affecting plover fecundity?

Priorities for CACO should rank obtaining the estimates and trends of total breeding population size and annual fecundity within the Seashore as High Priority (*i.e.* questions 1, 2, 6, 7). Moderate Priority (MP) should be assigned issues related to how management activities may affect plover nesting (questions 5, 8). Lower Priority (LP) should be assigned those questions associated with landscape or habitat aspects (questions 3,4). While all are important issues, limited resources requires prioritization.

### Sampling and Field Methods

#### *Site Selection*

The north side of Nauset Inlet (Coast Guard Beach) on the Outer Cape north to Provincetown, and around south to include all of Great Island and Jeremy Point (Fig. 1) is the area of concern to CACO personnel. All potential beach-dune habitat is canvassed by vehicle and/or on foot from early April each year until all young have fledged in August.

### *Sampling*

The basic unit is a section of beach while habitat measurements are based on the nest as the unit. All Atlantic Coast surveys of this species must report the total population size (=breeding pairs) and number of fledged young per breeding pair (annual fecundity) each year. Given the intense ground and vehicle coverage on CACO each year, an assumption (though untested) is that the population is *not a sample but in fact is the entire population within CACO.*

To determine the number of breeding pairs on CACO, two count methods are employed, one during a 9-day peak period and the other over the entire season (see *Field Data Collection – Population Monitoring* section below). For estimates of annual fecundity, there is a requirement that both hatching and fledging success be estimated. This demands that each nesting pair be monitored daily from a distance (using binoculars) until hatching and that young be followed until they are at least 25 days old, or can fly at least 20 m. In addition, once a week, nests should be approached closely enough to count eggs. When eggs are lost or abandoned, every effort should be made to determine the cause. This is usually done by observing tracks in the sand or other evidence left at the site (i.e., location of extreme high tides, blood, feathers, carcass). Daily monitoring of nests increases the likelihood of determining causes of nest loss. Brood counts should be made every 1-3 days until fledging. Measures of habitat parameters at all nests are to be made once during the season at the time when each nest exclosure is erected. Habitat measures for young should be recorded each time a brood member is located, at least by habitat type if not precise GPS location. Thus, nest habitat is sampled only once, but habitats used by brood members from that nest may be repeatedly sampled (thus, the locations are probably spatially autocorrelated).

### *Field Data Collection – Population Monitoring*

Breeding population sizes are to be reported in two ways (Blodget and Melvin1996): (1) total counts from surveys conducted during a 9-day window beginning the last Saturday in May and ending on the first Sunday in June and (2) the "maximum number of pairs during the season", which includes counts of birds seen for a minimum of two weeks (during sustained courtship) in areas where no nests were found as well as pairs known to lay eggs and produce young.

Breeding pair surveys will begin the first week of April and will continue through mid-July within CACO and throughout coastal Massachusetts (Blodget and Melvin 1996). Surveys will be conducted a minimum of twice per week. Surveys are accomplished by walking the entire range of beaches where nesting is possible. Vehicles may be used to access beach survey sites, but will not be used as survey platforms. Surveys are best conducted between 0500 and 1000 h when winds are calmer, light conditions are good, and fewer people are present. However, it may be necessary to survey at other times of the day as well as work demands. Plovers are easier to detect when surveys are conducted at or near high tide when they are concentrated in a narrow band of the upper beach. Surveys should not be conducted when winds are >20 mph, during fog, or in heavy rain.

Piping Plovers typically lay an egg every other day in April until the clutch is complete (usually 4 eggs, occasionally 3 or less, especially for re-nests). Plovers usually do not begin full time incubation until the last egg is laid, and may only infrequently visit the nest until the clutch is complete. As a result, finding nests before clutches have been completed (about a 7-day period) is usually harder than finding nests after full-time incubation is underway.

Surveys are conducted by walking at a moderate pace along the beach between the wrack line and foredune. Occasionally the observer stops, listens, and uses binoculars to scan the beach in front. Wide beaches or sand spits are searched in a zigzag pattern in order to cover all available habitat and increase chances of detecting birds. Some birds will sit tight on nests or will not vocalize unless the observer approaches within 50 m. Any areas of potential nesting habitat behind foredunes should also be checked. Listening closely is important since the plover's soft "peep" or "peep-lo" call notes are often the first indication that they are present. Plovers frequently utter these call notes when their territories are entered. Adults that give a "broken-wing" distraction display almost always have a nest nearby that is well along in incubation. When a plover acts like it could have a nest, the observer should back away, sit or crouch on the sand and watch the bird with binoculars. Often within a few minutes the bird will return to the nest, alternately running and stopping until it reaches the nest scrape and settles carefully back onto the eggs. If the bird remains agitated, the observer should move further back. When the incubating bird returns to the nest, the monitor should pick out a landmark that is within 1-2 feet of the nest, and note direction and approximate distance from the landmark to the nest. The landmark may be a distinctive shell, rock, clump of vegetation, or piece of driftwood, but it needs to be large enough that observers can later distinguish it with the unaided eye. Once a landmark has been located, the observer should walk directly toward it. A few meters before the nest area, the observer should stop and look around carefully for the nest. If the nest is not visible within a short time, the observer may need to back off, let the bird resume incubation, and then try again. With some experience, observers can locate the nest by following tracks and "reading" the sand. If the nest is not found on the second try, move on and try later or the next day. Birds should not be kept off nests for longer than 10 minutes, if temperatures are less than 60° F or more than 80° F, or when potential predators such as crows or gulls are nearby. If the bird stops to feed or preen, or begins scraping or "false brooding", this usually means there is no nest or the female has an incomplete clutch. Other nests that are difficult to find are those of exceptionally wary pairs that leave their eggs before you get close and then are reluctant to return, and those that are placed in moderately-dense vegetation.

The upper beach, foredunes, and overwash and "blow-out" areas between and behind foredunes should be the focus of survey efforts, but intertidal areas should also be scanned with binoculars or spotting scope in order to detect feeding birds. These may include unpaired adults, non-incubating members of nesting pairs, adults with broods, or adults whose nests have been recently lost.

Site tenacity (birds present in the same general area at each visit) and breeding behavior (territorial and courtship displays, nest scraping, or copulation) are good indications of resident pairs. On relatively narrow beaches with contiguous pairs in residence, careful observation will help determine territorial boundaries and therefore the number of pairs present. Birds will often run ahead of the surveyor, then turn back (running or flying) when they reach the limits of their territory or are confronted by another pair. Nests are possible anytime after 19 April and chicks may be present after 20 May. Location (latitude and longitude, or UTM coordinates) of all pairs will be recorded with GPS receivers. Survey start and stop times will be noted on the data sheets to allow quantification of survey effort (person-hours or person-days of survey effort).

The field forms for recording nest information (Appendix 1a) and habitat data (Appendix 1b) have been used at CACO for the past several years and are consistent with Blodget and Melvin (1996) for the Massachusetts protocols. Appendix 1c provides an illustration of data collected in 2000.

*Annual Fecundity Estimates*

Annual fecundity estimates are made by separating estimates for hatching and fledging success. Also, whenever possible, all causes of nest loss or mortality of young are to be identified (High Priority). All pairs are monitored daily until nests are confirmed, and nests are marked with reference to natural objects (no stakes or artificial markers are placed). The criterion used for fledging age is minimum 25 days or an observed flight of at least 20 m.

To effectively monitor nests, daily visits are necessary to assess status (active or failed). The nest should be approached only close enough to determine if an adult is still incubating. Usually this can be done without disturbing the pair or causing them to leave the nest. Once a week, the nest should be approached closely enough to count the eggs; occasionally some but not all of the eggs in a clutch disappear for various (often unknown) reasons. Whenever possible, count eggs from a distance with binoculars or spotting scope. When clutches are completed, wire predator exclosures are erected using 5 cm X 10 cm mesh wire around the nest with 1 cm soft plastic bird netting over the top (full specifications available from MDFW). It is most efficient to have three persons when erecting exclosures. May and June are the periods when most predator exclosures are installed.

Chronology for each nest should be recorded so monitors can anticipate the time when nests are due to hatch. The average incubation period in plovers is 27-28 days; the longest known incubation period with successful hatching is 39 days, although hatching after 32 days of incubation is very unusual. Adults with newly-hatched chicks will usually react much more vocally and with more agitation to observer presence than adults that have lost or abandoned eggs. Adult plovers may move chicks hundreds of meters from nests within 1-2 days after hatching. Daily nest checks are particularly important close to hatching dates in order to determine whether the nest hatched successfully and how many eggs have hatched.

Fate of clutches should be classified as: (a) hatched (1 or more eggs); (b) abandoned; (c) destroyed, or (d) unknown. Hatching is confirmed by the presence of chicks at or near the nest. The number of eggs that did not hatch should be recorded. Nests that are abandoned or destroyed should be carefully investigated and the suspected cause(s) of failure recorded with as much detail as possible. A significant number of Piping Plover nests are abandoned each year. Nests both with and without predator enclosures may be abandoned, although abandonment tends to be more frequent with the former. Causes of nest abandonment are difficult to determine. Clues that abandonment may have occurred are: (1) lack of an adult incubating the eggs, (2) lack of aggressive or agitated adults reacting to your presence near the nest, and (3) eggs that are beginning to be covered by blowing sand suggesting prolonged absence of incubating birds. Adults that have abandoned nests will often re-nest nearby but may seem inattentive and show little reaction to observer presence for several days.

Storms during high tide cycles frequently result in overwash that destroys nests, particularly on oceanside beaches. Eggs affected by overwash are either scattered or covered by sand. Avian and mammalian predators also destroy many nests. Tracks in the sand, bits of hair, feathers, scat, dead birds, or egg shells near empty or partial nests are all indications that predation may have occurred. Detailed notes should be made when predation is suspected.

To monitor the survival of chicks, an accurate estimate of chicks in each brood needs to be conducted every 1 to 3 days, until they are at least 25 days old. For purposes of monitoring chick survival, chicks are assumed to have fledged at 25 days of age or when observed in continuous flight for at least a distance of 20 m, whichever occurs first.

Changes in adult behavior may indicate chick presence. Although agitated, adults with chicks nearby may move toward observers and show no sign of returning to a nest after the observer retreats. In this case, the beach should be quickly scanned with binoculars for chicks that may be running away farther down the beach or escaping into vegetation on a nearby dune. Chicks are especially difficult to see when in dunes or moderately-dense vegetation. Obtaining accurate counts of chicks often entails observing from a distance for a long enough period that the chicks feel safe enough to emerge from cover and move onto the beach or intertidal area where they can be more easily counted.

Exact causes of chick mortality are usually difficult to determine. Field activities should be timed to determine as accurately as possible the date of chick deaths or disappearances by scheduling visits on mornings following heavy rainstorms and strong winds or cold temperatures, and after especially busy weekends. Experience has shown that these periods coincide with high chick mortality.

### *Field Data Collection – Habitat Measures*

<u>Nest Measures</u> - Up to 10 structural or spatial assessments or measurements will be recorded during the first two weeks of incubation at a random sample of 20 nests. When possible, measurements should be made at the same time exclosures are erected around plover nests. Each nest will be assigned to one of the following 6 classes (Fig. 2 in Part I): 1=berm, 2=foredune, 3=washover/blowout, 4=interdune, 5=bayside beach or marsh, or 6=sandspit.

<u>Back beach</u> - Beach width will be measured using measured paces (calibrated to 1-m unit). One field worker will count and then measure paces from the crest of the beach berm to the toe of the foredune, using the nest center as the center point for the transect and record this distance in m.

Nearest Vegetation - The field worker will count and measure paces from the edge of the nest to the edge of the nearest patch of vegetation $\geq$ 10 m in diameter, and record this distance in m.

Human disturbance - Distance of the nest to the nearest major pedestrian access point (>50 car parking area) will be measured by recording nest location (with a GPS receiver) and comparing the latitude/longitude of the nest and the human access point to the beach (normally the end of a wooden walkway or stairs leading from a parking lot). To facilitate this calculation, the position of all beach access points will be collected in advance and stored in the GPS units as named waypoints. Posted ORV access points (normally marked with wooden signs and/or symbolic fencing) will be referenced to determine whether the nest occurs within a public ORV corridor.

Wrack - The field worker will record the number of times that his/her foot lands partially or wholly on wrack while pacing from the base of the foredune to the beach berm. The index of wrack abundance will be an expression of frequency of occurrence (paces) and proportion of "hits" along the length of a transect bisecting the nest from the foredune to the beach berm.

Other variables - Width of the intertidal zone (Fig. 3 in Part I); nearest neighbor (distance to nearest plover nest); and distance to the nearest ephemeral pool, bayside water body, overwash fan, and inlet will be determined using GIS and spatial analyst tools. Nest locations will be plotted on digital orthophotos and landcover maps. This data will be generated at the end of the field season by the Inventory & Monitoring program GIS/data manager.

Other variables of concern are contaminant levels. Although contaminants have not been cited as causing reproductive impairment in Piping Plovers in New England, few opportunities have been available to examine effects of agricultural or other chemicals. Because biologists can easily collect a large sample of nonviable eggs of plovers each year, a sample of 10 eggs from 10 different nests within CACO should be collected every 3 years, wrapped in aluminum foil, and frozen. A contract for analyses of PCBs, PAHs, and organochlorine on the samples should be prearranged in coordination with biologists in the U.S. Fish and Wildlife Service and the State of Massachusetts.

Habitats of Brood Members – As chicks are located after they disperse from the nest vicinity, their locations should be recorded both by habitat type, assigning one of the 6 coarse habitat measures used above, and a GPS location approximated whenever possible. These measures will be valuable in indicating which particular areas of the Seashore are used on a regular predictable basis, which are occasionally used, and which are never used.

Equipment List

- Two 4WD vehicles for two teams of investigators, one for the Northern district (Truro and Provincetown) the other for the Southern district (Wellfleet and Eastham).
- At least 4 spotting scopes (15-60 X) with tripods
- Six 8-10 X binoculars
- At least 4 handheld GPS units
- 2 laser range finders

- 3-4 portable tape recorders
- exclosure wire and supports
- PVC piping (1.5 cm wide)
- wire flagging
- 100 m measuring tapes for habitat measures

Personnel

The number of personnel required varies during the season with the largest requirement during April through June. At least two supervisory (GS 7) biologists (permanent) and four seasonal technicians are necessary during a 3-4 month period on a 55-60 h/ 7 days per week basis. During construction of nest exclosures, an additional volunteer or SCA manpower is required for each team. For data entry, analysis, and report preparation, one supervisory biologist requires approximately 15 days or 120 hours.

Thus, the estimate for the field and report preparation is ca. 4560 man-hours, requiring at least two permanent GS-7 biologists (or Subject to Furlough), four seasonal technicians from April to July (4 mo. each), and volunteer and SCA assistance. The minimum then, is ca. 3 FTEs for the plover project.

Facility List

A number of potential laboratories are available for contaminant analysis of eggs. One contact is Dr. John Moore, Patuxent Analytical Control Facility, Laurel-Bowie Road, Laurel MD 20708.

## MARSH BIRDS PROTOCOL

Monitoring Questions

The original monitoring questions for this group were: (1) What is the distribution and relative abundance of these secretive rails, bitterns, and other marsh species within CACO? (2) Is the suite of species of marsh birds using CACO wetland habitats changing over time during breeding, fall migration, or winter? (3) What is the relative abundance of each marsh-dependent species on CACO during breeding, fall, and winter? (4) Are the methods adequate to detect a 25% population change over a 20-year period with a Type I error rate of 0.10 or less ($\partial$ <0.10) with at least 80% power for any marsh bird species? (based on recommendations of current Partners in Flight Monitoring Plan) (5) Do changes in habitat, surrounding land use, or recreational/management activities on CACO wetlands influence species composition or relative abundances of marsh birds?

Given the limited success in detecting marsh birds in the small wetlands on CACO, we suggest limiting the monitoring to the larger freshwater sites from Truro and Provincetown, including the restoration sites at Hatches Harbor and Herring River during the breeding season. Thus only question # 1 above receives Moderate Priority. This can be limited to monitoring only every 3-5 years, hence it becomes a status type of survey, and not one that can be used to detect population trends. Habitat measurements would be Low Priority (question # 5) and the questions dealing with trend (questions 2 and 4) and abundances at other seasons should not be addressed at CACO, given previous experience.

## Sampling and Field Methods

### *Site Selection*

Because of the large number of freshwater and brackish marshes, we recommend that personnel only survey wetlands > 2.0 ha. Freshwater (*e.g.* kettle ponds), marshes with < 0.5 ha of emergent marsh are to be excluded. The riverine marshes associated with Herring and Pamet Rivers are to be included.

### *Sampling*

For this group, the sampling unit is a point with a 50 m radius within a point count survey route. The response variable of interest is the detection of species *x* at each point. For small ponds (<3 ha), only one point is used, but for larger marshes, points are to be spaced at 200-m intervals around the perimeter of the marsh. Along tidal creeks and rivers, one transect bisects the stream and points are established at 200 m intervals as far upstream as high tide levels allow. For habitat measurements, the point also serves as the center of the sampling unit, with a 50 m radius circle circumscribing the point.

Spatially, one sample point was felt to be adequate at small wetlands where the call broadcast could be heard by all birds within the wetland (radius of ca. 100 m broadcast). At larger isolated wetlands, two or more points were established at least 200 m apart, depending upon the size of the wetland. At riverine sites, or in larger wetlands (*e.g.* salt marsh), a transect-point count approach was used. For rivers, a single transect up the middle of the watercourse was used, with points every 200 m. This was expected to result in independent points since the broadcast radius was estimated to be ca. 100 m at 90 dB. In larger marshes, a combination of random and uniform spatial sampling was used: the beginning of the transect was randomly selected along a marsh shoreline with the direction randomly selected. Once the first point was established, however, points were established at fixed 200-m intervals thereafter. Transect lines were not permitted to lie within 200 m of adjacent transects to insure independence of points.

The survey points were established using GPS and the data are contained on the Marsh Bird CD (copy maintained by Dr. R. Cook at CACO). In addition, all points that yielded positive results are shown in tables (chapter I) in the report by Hadden (2001).

Surveys are to be conducted three times during the breeding season, spaced about 14-20 days between 10 May and 30 June. If resources are limited, surveys may be conducted every 3-5 years rather than annually. A caveat to consider is that population trend estimates are time-sensitive, so that conducting surveys on a 3-5 year rotation will result in concurrent increase in the number of years required to detect a trend. However, with the very small numbers of individuals encountered during our marsh bird surveys (Hadden 2001, Erwin *et al.* 2002) determining trends is probably not feasible.

*Field Data Collection - Survey Methods*

Visits or assessments of all freshwater emergent marshes/ponds are to be made within CACO for wetlands > 2.0 ha in total area. These areas include the large marshes associated with Pilgrim Lake, Pamet River, and Herring River, as well as marshes along the periphery of permanent ponds. Kettle ponds will be included only if the amount of associated marsh area exceeds ca. 0.5 ha. All freshwater emergent marshes will be surveyed during the breeding season only, as our experience showed limited results at other seasons.

Fixed survey points will be chosen and marked with inconspicuous markers in the field. Locations of all survey points will also be plotted on maps of each wetland using a GPS receiver. The distance between adjacent survey points is 200 m. Survey points in permanent ponds should be located either on the upland-emergent interface or on the open water-emergent interface, whichever will allow easier access and travel between survey points. Some ponds may be more effectively surveyed by boat (with survey points on the open water-emergent interface) and others more effectively surveyed on foot (with survey points on the upland-emergent interface). Survey points within freshwater marshes associated with rivers (Pilgrim Lake, Pamet River, Herring River, Fig. 1) should be located along mid-river channels where possible. Each survey point receives a unique identification number. The number of survey points per pond will be correlated with pond size; only one survey point is needed on ponds 2-3 ha in total area.

All surveys begin 30 minutes before sunrise and must be completed by 1000 h. For the tidal river marshes, the surveys should be conducted on a rising or high tide, a minimum of 3 h after low tide. With the frequency of high winds on the Cape, conducting surveys on low wind days (< 20 kph) is more critical than maintaining precise spacing (*e.g.* 2 weeks) of surveys. Following Erwin *et al.* (2002), we recommend that personnel conduct 3 surveys during the breeding season; these should be evenly spaced between 10 May and 30 June. Maintain > 2 weeks between subsequent surveys. Three surveys are needed to confirm seasonal presence/absence of marsh birds in a wetland with 90% certainty (Gibbs and Melvin 1993, Conway and Gibbs 2001).

Observers should expect to survey 10-20 survey points each morning, depending on travel times between survey points. Approximate number of survey points within major wetlands is 12 at Hatches Harbor, 7-9 at Pilgrim Lake, 10 at Pamet River, and <10 at Herring River. Much of the upper reaches of Herring River is not emergent marsh.

Standardized survey methods for marsh birds have recently been developed to aid agencies developing marsh bird monitoring programs (Ribic *et al.* 1999, Conway and Gibbs 2001) and are to be generally followed at CACO (Erwin *et al.* 2002). Because many marsh birds are secretive, seldom observed, and vocalize infrequently, we will use call broadcasts to elicit responses during vocal surveys (Gibbs and Melvin 1993). At each survey point, observers will record all species heard vocalizing (both primary and "other" species) during both a 5-minute passive period prior to broadcasting calls, and during a period in which pre-recorded vocalizations are broadcast into the marsh. The broadcast sequence includes calls of the primary marsh bird species and is broadcast using a portable CD player or cassette recorder connected to an amplified speaker. CDs can be obtained from Dr. Courtney Conway, USGS Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson AZ (cconway@ag.arizona.edu).

The CD contains an initial 5-min silent period (passive), followed by 30 sec of recorded calls of each species consisting of a series of approximately 6 sec of calling followed by 6 sec of silence. A 30-sec silent period should be included between each pair of species calls. For example:

5 minutes of silence
30 seconds of calls of first primary species configured similar to this:

3 Least Bittern *coo-coo* calls
    6 seconds of silence
    3 Least Bittern *coo-coo* calls
    6 seconds of silence
    4 series of Least Bittern *kak* calls
30 seconds of silence
30 seconds of calls of second primary species configured similar to this:
    2 Sora *whinny* calls
    6 seconds of silence
    3 Sora *per-weep* calls
    6 seconds of silence
    4 Sora *kee* calls
30 seconds of silence
30 seconds of calls of third primary species …. Repeat for N species…

Include a verbal "stop" at end of the survey interval so that observers know when to stop the CD or tape.

The chronological order of calls on the broadcast sequence will always be consistent and start with the least intrusive species first. On Cape Cod, the sequence of calls will be: Least Bittern, Sora, Virginia Rail, King Rail, Clapper Rail, American Bittern, Common Moorhen, American Coot, and Pied-billed Grebe. The calls used in the broadcast sequence will include the primary advertising call of each species (*e.g.*, '*whinny*' for Sora, '*grunt*' for Virginia Rail, '*clatter*' for Clapper Rail and King Rail, '*kickee-doo*' for Black Rail, '*click-click-click-click-click*' for Yellow Rail, '*coo-coo-coo*' for Least Bittern, '*pump-er-lunk*' for American Bittern), and other calls associated with reproduction. Including all the common calls associated with reproduction of each species on the broadcast sequence will increase detection probability during different times of the breeding season and can help observers learn the less-common calls of each target species. Each individual bird heard vocalizing (both primary and secondary species) during the 14-minute survey period will be entered on a separate line on the field data form (Appendices 2a and 2b). Observers should record when each individual vocalizes: during any of the 1 min sebsegments during both the passive and call-broadcast periods. It is important to record all the periods during which an individual bird vocalizes so that we can determine whether call broadcasts are effective at eliciting additional responses for each of the primary species. These data will help us determine whether or not to use call-broadcast of all primary species during surveys in future years. Hence, observers must make a decision as to whether each vocalization heard at a survey point is a new individual for that point or is an individual that vocalized previously during that 14 min survey. Observers should receive prior training in the field so that they can also estimate whether each response is within or beyond 50 m of the survey point. Recording those individuals detected within 50 m of each survey point will provide density indices for each species in each habitat type. Density indices by habitat type are useful because they allow managers to extrapolate survey data to estimate total numbers of each marsh bird species at CACO.

The CD player (or cassette recorder) should be placed upright slightly elevated (0.5- 1 m) above the ground (or on the bow of the boat), and sound pressure optimally will be 90 dB at 1 m in front of the speaker. Use a sound-level meter to adjust volume of the CD/cassette player at the beginning of each day. Observers should stand 2 m to one side of the speaker while listening for vocal responses. Surveys should only be conducted when wind speed is <20 km/hr, and not during periods of sustained rain or fog.

*Field Data Collection - Habitat Measures*

Changes in water level, dredging, wetland restoration efforts and other management activities can lead to dramatic changes in marsh vegetation. Because of ongoing wetland restoration activities at Hatches Harbor and Herring River, we think it important to collect both population and habitat information there and use the other sites as reference marshes. Patterns of distribution and local population trends of marsh birds can often be best explained by local changes in wetland habitat. Consequently, quantifying the proportion of major habitat types by Braun-Blanquet percent intervals (see Appendix 2c) into the following 11 types is recommended: cattail (*Typha spp.)*, aquatic bed vegetation (*e.g.* water lily, pickerelweed), sedges/rushes, common reed (*Phragmites australis*)*,* cordgrass (*Spartina alterniflora*)*, Salicornia spp.*, other grasses, open water, mudflat, shrub, and upland. Each observer should independently estimate coverage for each survey point each year to help identify the cause of observed changes in marsh bird populations. Habitat should be quantified at 2 scales: observers should visually estimate the proportion of each major habitat type within a 50 m radius circle around each survey point, dividing each circle into four quadrats and roughly mapping each habitat type, with its estimated proportion. The habitat measurements should be taken during the first two weeks of July each year. A laser range finder is invaluable for measuring distances from points. Observers may need to reconcile differences in their estimates before recording the final figure. At the larger scale, aerial photographs should be used to determine the amount of each major habitat type on all of CACO at 3-5 year intervals. This activity should be coordinated with the ongoing CACO restoration projects at Herring River and Hatches Harbor with all imagery georeferenced and entered into a GIS system.

Equipment List

- 1-2 vehicles (one 4WD preferably)
- 2 portable CD or tape recorders and 2 copies of marsh bird CDs/tapes (extra copies probably needed to account for loss or wear).
- 2 pairs 8-10 X binoculars
- 2 spotting scopes and tripods
- Knee high and hip boots
- PVC markers for point locations
- 2 handheld GPS units
- laser range finder
- 100 m measuring tapes
- field notebooks ("Write in the Rain")

Personnel

Because the marsh bird surveys are to be conducted only periodically, the manpower demands are much lower than for the Piping Plover monitoring efforts. However, since the seasons of the two groups overlap additional hiring will be required. It is recommended that a seasonal biologist and technician (GS 5 or 7s) be hired full time for a four month period to prepare for field work, conduct the monitoring, and enter data and write reports.

## COLONIAL WATERBIRDS PROTOCOL

Monitoring Questions

The monitoring questions associated with this group are as follows: (1) Are the methods adequate to detect, for Common and Least Terns, a breeding population change of 25% or more over a 20-year period with a Type I error rate of 0.10 or less ($\partial <0.10$), with power of 0.80 within CACO? (2) Do the CACO populations of waterbirds, especially Common and Least Terns and American Oystercatchers, change relative to the regional (*e.g.*, Cape) populations? (3) Where are colonies of waterbirds located and how are changes (if any) in colony locations or population numbers related to (a) habitat changes or (b) management activities within the Seashore? (4) How do annual fecundity and/ or other bioindicators (*e.g.* contaminant load) of selected species (Least and Common terns) change through time? (5) Does habitat change or management activity affect annual fecundity? (6) Is local recruitment sufficient to sustain the local breeding colonies, *i.e.* is CACO or the outer Cape a source or sink for the regional population?

Highest Priority should go toward determining the annual breeding population estimates of selected nesting waterbirds, especially tern species, *i.e.* Common, Least, and Arctic, as well as American Oystercatchers, using CACO and determine how that local population reflects the regional one (Question #2). Of moderate priority (MP) are issues relating to management or habitat effects on colony location and/or size (Question #3), whereas all other questions should be relegated to lower priority (LP) (*i.e.* Questions 1, 4-6).

## Sampling and Field Methods

### *Site Selection*

Colony sites for colonial waterbirds are generally traditional on Cape Cod (except the Least Tern, which may occupy many different sites both within and between seasons). The traditional tern colony on New Island and former colony sites at Long Point are to be surveyed during the breeding season; in addition, the New Island site should be surveyed in fall and winter as a potential roost site. The beach surveys that are conducted for Piping Plovers should also include surveying for Least Terns. This includes the beaches from Coast Guard Beach-Nauset north to Race Point, Provincetown, and then south along Hatches Harbor down to Jeremy Point.

### *Sampling*

The sampling unit is the area of the site occupied by a colony. Personnel should estimate the number of breeding pairs in each colony. For estimating annual fecundity, the sampling unit is usually the nesting pair, or, if enclosures are used, a subset of nests. For habitat measures for Least Terns, the sampling unit is the colony site where several aspects of habitat and disturbance are measured. For monitoring contaminants, the sampling unit is often an egg or an individual bird, often pre-fledged young that can be easily captured (tissue analysis).

For all tern colonies within CACO, all colony sites are assumed to be located (conducted simultaneously with the high-intensity plover surveys). Similarly, all colonies of gulls or herons will also be surveyed. If resources allow estimating annual fecundity in Common, Roseate, or Arctic Terns, random sampling is desired, using wire or plastic enclosures to monitor the success of nests and survival of young. Without enclosures, the chicks may disperse widely in response to investigator disturbances, resulting in underestimates of fecundity. Because of logistic constraints, truly random selection of nests is seldom possible; instead clusters of nests are identified and enclosed at locations scattered within the interior and on the periphery of the colony (Nisbet and Drury 1972, Erwin and Smith 1985). This is done to sample potentially different age or experience cohorts within the colony, which may be demographically heterogeneous (Hunt and Hunt 1976).

Species differences among colonial waterbirds demand different sampling approaches. For Least Terns, frequent colony site monitoring can be accomplished during ground surveys of Piping Plovers because they occupy similar sandy beach habitats. A colony is generally defined as a group of >2 nests in a cluster separated by at least 200 m from the next nearest group (Erwin 1979). Estimates of nesting pairs should be made once between 5-20 June (the “A” period according to MDFW), with later counts reported until the end of June or early July if storms result in major renesting. For estimates of productivity for Least Terns, colony checks should begin around the end of June, with second and third checks about every week thereafter. A final check should be conducted when the oldest chicks are about 21-24 days old (fledging at about 24-27 days) to obtain a best estimate of average annual fecundity for the colony. Because of the cryptic nature of the species and the mobility of chicks, remote monitoring with a scope from a vehicle is the most practical method. Chicks are less disturbed, more mobile and therefore more visible when viewed remotely from a vehicle.

For gulls, other terns (Common, Roseate, Arctic) and Black Skimmers, a one-survey visit is made every year in mid- to late incubation (early May for gulls, 5-20 June for terns) to estimate the number of breeding pairs in a colony. As resources allow, we recommend monitoring fecundity of these species. Setting up enclosures for young (Nisbet and Drury 1972, Erwin and Smith 1985) is usually necessary. This entails visits at least every week after hatching commences to find and count the numbers of live and dead chicks until fledging occurs (> 22 days generally).

For other species, different methods are required. For wading birds, usually one visit is made in mid- to late incubation, which in New England is usually late May. The American Oystercatcher (*Haematopus palliates*) has recently attracted the attention of biologists because of concerns over widespread population declines along the Atlantic Coast (Davis *et al.* 2001). As a result, surveys of all beaches within CACO should begin in Massachusetts in early April and should mirror the methods followed for plovers. Locations of oystercatchers that are courting for more than a week should be recorded using GPS receivers. This should be an annual effort.

To put the CACO breeding estimates in perspective, CACO biologists should continue partnerships with other state and NGO biologists in sharing breeding information on an annual basis. For each species, totals for CACO should be compared with both Cape Cod region totals and State totals to determine the relative value of CACO lands within a metapopulation context.

*Field Methods - Breeding Populations*

Least Terns - Because Least Terns nest on open beaches similar to Piping Plovers, they will be surveyed intensively. All beaches are surveyed during the season preferably on foot, covering all beaches where nesting is possible (see Piping Plover protocol above). The center of each tern colony should be recorded using a GPS receiver for site locator information. In addition, colony perimeter documentation should also be recorded (especially in colonies with widely dispersed nests) to facilitate decision making related to management of disturbances. Assign each tern colony a local name (*e.g.* Nauset Inlet) to assist relocating the site. Use the same name consistently over time (if possible, use the traditional one) to preclude errors when conducting population trends through time. Nesting begins as early as late May in some years and may extend into July. The number of incubating birds (= number of nests) should be recorded during several surveys in each colony during the period 5-20 June (the "A count" in Blodget and Melvin 1996), then again after June 20 (the "B count") if a major change due to a storm occurs. Birds may renest until early July. Counts are best made by two independent observers. Keep these counts confidential so that individual observers can be "calibrated" and we can assess how much observer changes (a common Park and Refuge situation) affect population trend estimation (Sauer *et al.* 1994). A spotting scope or at least 8X binoculars should be used. A ground check is made to confirm the stage of egg laying (2-3 eggs is a full clutch). Entrance into the colony should be minimized especially during May and early June when birds are establishing nest sites and beginning egg laying. For most colonies, estimates can be made from vehicles at the periphery of the colony. On islands (*e.g.* New Island), however, ground counts of nests should be made using the method outlined below for Common Terns, using mark-recapture methods. Avoid very warm days or rainy periods when flushing birds. Field data forms should be completed for each colony site visit. A standard colonial waterbird field data form has been developed (Appendices 3a and 3b). Because Least Terns are notoriously unsynchronized in their nesting, numbers of nests should be estimated a minimum of three times (see above). If storms cause large-scale losses, renesting will occur; another survey should be made 2-3 weeks later. The best estimate of the number of nesting pairs in a colony is the maximum number of nests estimated among the three (or more) survey periods.

Gulls and Common Terns - At Common Tern colonies, observers should conduct annual ground counts to estimate the number of nests; for gulls, estimates do not need to be conducted more often than every 3-5 years. Timing of nesting is variable, depending upon year and species, therefore some annual adjustment of survey timing may be necessary. In general for gulls, mid- to late May will mark the period when most egg laying is completed, while for terns it is usually mid-June in New England. A nest count is conducted with a minimum of three observers. If colonies exceed ca. 1000 pairs, a sample of 20-40% is recommended. After establishing a line along the long axis of the colony perimeter, a series of perpendicular transects is covered. The team walks in tandem through the colony during mid-to late incubation if possible (ca. 5-10 May for gulls, 5-20 June for terns) counting and marking (dot of spray paint or water soluble marker on the nest edge) on 1-2 transects, or passes. Afterwards, they repeat the transects in reverse, with observers changing path positions, recording separately the number counted the second time that are marked versus unmarked (Lincoln-Petersen Index, see Smith 1966, Morrison *et al.* 2001). This allows one to estimate detection probabilities associated with the transect survey, *i.e.* the efficiency of the count (assuming a sample of at least 50 nests). After two transects of marking and recounting, the team can simply continue the count without further marking until the colony count is complete. Care should be taken however for the crew to stay abreast of each other to insure that they are not double counting nests as they walk. Observers should ensure that the entire colony area has been surveyed. In gull colonies, training may be required to discriminate species, *e.g.* Herring and Great Black-backed Gull (*Larus argentatus* and *L. marinus*) nests. Inexperienced observers can carry a small wooden frame with a 53 mm width for an egg-width reference (Herring Gulls are smaller, Great Black-backed Gulls larger; K.M. Brown, pers.comm.). At the completion of the survey, the total number of nests in the colony is estimated by converting the total count by applying the Lincoln correction as outlined as follows:

The equation in its simplest form is:

$$N = (M * C) / R$$

Where $N$ = the total estimate of the number of nests in the colony; $M$ = the total number of nests observed and marked during the first pass through the survey area; $C$ = the total number of nests observed on the second pass through the survey area: and $R$ = the number of nests counted on the second pass that were already marked on the first pass.

Other Species - For Black-crowned Night Herons (BCNH) or other wading birds, potential colony sites (Wood End) should be checked on foot and by consulting with local bird clubs (and Massachusetts Audubon Society [MAS] employees). As above, observers will obtain an estimate of flying adults in mid- to late May. BCNH are best estimated by making noise (hand clapping) while approaching low shrubs (*Myrica spp*. bushes) since they are easily disturbed and take flight often 100 m before observers reach the nesting area. Nesting must be confirmed by entering the dense shrubbery and looking for a large stick nest with 3-5 pale blue-green eggs 53 X 37 mm in size. The number of herons flushed from the site should be approximately equal to the number of nests (Erwin 1979), however, this may vary among sites. Thus, 1-2 observers should enter the colony during the incubation period if possible to mark nests and conduct the mark-recapture method described in the section above.

For American Oystercatchers, the number of pairs should be recorded annually during the beach surveys for Piping Plovers. Location of each pair should be recorded using a GPS receiver. Because of the current concern for population declines along the Atlantic coast (Davis *et al.* 2001) observers should confirm each nesting attempt by a pair. This may require extended visits using scopes mounted from a vehicle because oystercatchers leave the nest at considerable distances upon approach. The data should be recorded on the same forms as for the colonial nesting birds (Appendices 3a and 3b). In addition, historically a small number of Roseate and Arctic (*Sterna paradisaea*) terns, and Black Skimmers *(Rynchops niger*) have nested on Cape Cod; these should be noted on forms whenever visits are made to colonies, even if adults are seen but no nests found. If a major storm causes colony disruption at the normal survey time, a second attempt should be made at least two weeks after the storm ends to allow for females to renest.

*Field Methods - Estimating Annual Fecundity*

Least Tern - For those years when time demands from plover monitoring are not all-consuming, an opportunity exists to estimate fecundity of this species. With Least Terns, eggs typically hatch after a 3-week incubation period; after this, observers should estimate the number of chicks at least three times in each colony. The first survey for chicks should be made 10-14 d after hatching begins, normally around the end of June. Second and third checks should be made in subsequent weeks (5-8 d apart). Nest surveys should be done using a spotting scope with 15X or more, if possible from a vehicle. The final check should be conducted when the oldest chicks in the colony are 21-24 days (fledging about 24-27 d). On each survey, observers should also count from the vehicle the number of adults and chicks in attendance for the entire colony (while not precise, young-to-adult ratios provide an index of annual fecundity). If dead chicks are spotted, they should be examined for evidence of predation (*e.g.* missing head usually means owl predation). This information also is recorded on the colony data forms. To evaluate detection differences between observers, independent counts of adults and young should be conducted by the observers.

Without individually-marked young followed daily, precise estimates of survival will not be possible; instead the above method will only provide an index of annual fecundity. The value of the index can only be determined by conducting both types of studies simultaneously. This should be done in at least one colony each year.

Common Tern - Precise estimates of annual fecundity for grass-nesting species such as Common Terns are difficult to obtain without a lot of effort and disturbance to the colony (Nisbet and Drury 1972, Erwin and Smith 1985). We suggest that only when an outside contract is possible should efforts to obtain fecundity estimates be supported.

When young are large, they may run long distances from their nests upon disturbance; this exposes them to higher levels of predation (both intra- and interspecific). Therefore, observers should estimate annual fecundity using 4-6 randomly-located enclosed plots in different parts of the colony marked with wooden stakes ca. 60 cm long to demark corners of ca. 5 x 5 m quadrats (if nest density is fewer than 7 nests per plot, the plot may have to be larger). Poultry wire fencing (2.5 cm mesh, > 40 cm high) should then be buried in the soil around the periphery of each plot. If possible, a sample of at least 10% of the colony is desired, with 20% being ideal, based on the estimated nest count made earlier. Each quadrat should be labeled and total number of nests should be counted in each plot during early (5-10) June. Plots should be set up within a few days after the nest count is done.

After hatching begins (often the end of June), two visits are to be made. One is to be conducted about two weeks after hatching when numbers of chicks are counted in each quadrat. If the nests are visible from outside the colony, a scope should be used to count young from a distance to reduce disturbance. If vegetation is dense, observers will need to enter the quadrat to do the count. It is best for two people to do this. A second count should be made the same way about 8-10 days later (Common Terns fledge at about 24-26 d). The total number of young surviving in each quadrat divided by the number of nests in each will provide an estimate of "colony success." Variance among quadrats will be used to adjust the number of sample plots needed to accurately estimate the number of young fledged per colony in future years. After most of the young have fledged in the colony, at least one more late-season count should be made of the ratio of adults to young around the perimeter of the colony, preferably from a boat. This final count should be timed about 10 d after the last visit to count numbers of chicks.

As with Least Tern estimates, these estimates of annual fecundity will also not be as precise as if each nest were monitored, chicks marked, and followed every 1-3 days (see Eyler *et al.* 1999). Instead, nest group (= plot), or "composite fecundity," estimates are obtained which represent an average number of fledglings per nest for the sample plot, or quadrat. This is still far superior to the frequent qualitative manner that is reported by Park and Refuge biologists (*e.g.* "poor", "average", or "good" success). As in other cases, the trade-off is accuracy versus time and colony disturbance.

Ancillary data - The following information should also be recorded when conducting the tern nest counts: (1) number of dead young found and condition of dead young (only those within study plots for Common Terns), (2) nesting substrate of the majority of nests, *e.g.* sand, shell, grass, (3) distance from colony perimeter to designated ORV trail (Least Terns), and (4) comments on presence of any disturbance, tracks, scat, owl pellets, or other signs of predators.

*Field Methods - Habitat Measures*

Least Terns - Because of the influences of beach management on Least Terns and Piping Plovers, additional habitat measures are needed to monitor the terns. At a minimum, management activities such as ORV use and fencing need to be recorded (presence/absence) at each colony site. For ORV activity, comments should be recorded on the form on each visit. In addition, three measures of beach width should be made at each colony after terns have fledged (late July to early August); one at the colony center and the other two at the ends of the colony. Beach width is the distance from the berm crest to the toe of the foredune and is measured using a 100 m tape. While the measuring tape is laid out for the 3 points, observers also record the total length that is intercepted by beach vegetation and record vegetated area as a percentage of total length of the beach width transect (< 5% is considered unvegetated).

Contaminants - Given the emphasis of the BEST (Biomonitoring and Evaluation of Status and Trends) program within the USGS on NPS and FWS coastal lands (Rattner *et al.* 2000), some monitoring effort should be undertaken to evaluate contaminants in waterbirds on a regular basis. At 3-year intervals, during colony surveys, dead or dying young waterbirds should be collected until a sample of 10 young per colony is achieved. At the same time, one primary feather (primary # 6-8) should be collected from a random sample of 10 healthy young that are > 2 weeks old. Feathers can be analyzed for heavy metal levels and may also provide useful nutritional information through stable isotope analysis (Hobson and Clark 1992, Knoff *et al.* 2001). At a minimum this should be done with Common Terns and Black-crowned Night Herons. Night herons may be declining in the northeast; these declines have been attributed in part to contamination of its food supplies (Boyd 2000).

Equipment List

- Access to a 4WD vehicle
- At least 2 spotting scopes with tripods
- Two pairs of 8-10 X binoculars
- 1-2 handheld GPS units
- One 100 m tape
- laser range finder
- wire forestry flags
- PVC or wooden stakes
- poultry wire
- 2 mallets
- compass
- waterproof notebooks
- permanent markers.

Personnel

At least two people are required to conduct the waterbird surveys, however, the Least Tern surveys can also be conducted at the same time as the plover monitoring. Surveys of Common, Arctic, and Roseate terns require only one day, preferably with 3 people. The gull and heron surveys require only one day and should be performed with at least 3 people. Additional volunteers would be helpful. Conducting fecundity research should require a contract.

## MIGRATING AND WINTERING WATERBIRDS PROTOCOL

Monitoring Questions

The original monitoring questions for this group included: (1) Are there identifiable "hotspots" that are used consistently by either feeding or roosting congregations of shorebird and/or waterfowl species at the scale of the embayment? (2) Are these hotspots (if found) consistent among years? (3) At the small (local) scale, are there certain habitat types that are particularly important for American Black Ducks (*Anas rubripes*), Red Knots (*Calidris canutus)*, Dunlin (*Calidris alpina*) or other shorebirds of concern? (4) Is there any change in species composition occurring over decadal time periods in CACO? (5) Are methods adequate to allow meaningful comparisons of CACO population trends (*e.g.* over 10- or 20-year periods) at selected sites with those occurring within the Cape region for shorebirds (International Shorebird Survey data) or for waterfowl (Mid-Winter Inventory data)? (6) How much annual and species variation is present in mortality data from Beached Bird Surveys?

While all of the above questions are of interest, the time required to obtain adequate estimates of a highly variable resource such as shorebirds would probably preclude any rigorous monitoring of shorebirds during migration. Instead of CACO developing its own monitoring scheme, a more effective strategy might be to provide support for volunteers under the International Shorebird Survey, and to the state when conducting waterfowl surveys in mid-winter. Having volunteers collect migration data on shorebirds at Nauset Marsh and in Wellfleet Bay (in combination with MAS) would probably provide an adequate sample for the northern region of CACO. Concerning a Beach Bird Survey (question # 6), again, partnership with MAS in developing a new survey may be feasible in the future.

Considering the concerns of CACO relative to the growing aquaculture industry, we do suggest that Question # 1 receive High Priority, but at a localized scale. At least at sites in Nauset Marsh and Wellfleet Bay, fairly intensive monitoring of sites proximal to and remote from (reference sites) active and potential aquaculture beds should be conducted. Considering the unlikelihood that resources will permit addressing the other questions, we will not provide details below.

## Sampling and Field Methods

### *Site Selection*

For intensive surveying by CACO personnel, mudflat areas within Nauset Marsh and Wellfleet Bay should be selected that encompass most of the intertidal zone. These areas are the principal shorebird areas within the Seashore and have either active aquaculture activities and/or recreational pressures. Sites should be located using GPS units and also marked with PVC or other marker if there are not adequate natural boundaries or reference markers. The focus should be on feeding habitats rather than on roosting. At other sites within the Seashore, such as Pleasant Bay, CACO is encouraged to coordinate with ISS personnel to add additional sites to their network.

### *Sampling*

To identify feeding habitat and to estimate numbers of foraging birds, the sampling unit is the designated portion of an embayment, usually an intertidal region. The designation of sampling units for feeding waterbirds is difficult because of the mobility of the birds, the vagaries of the water regime (*e.g.* location of edge of tidal water), and the lack of visual landmarks in most areas. Sampling units must be large enough that they will include large, mobile flocks. By using beach and intertidal reaches along continuous corridors, with ranges from upland edge out to ca. 200 m, observers can effectively include all (or most) effective foraging habitat for shorebirds. All tidal stages across the intertidal range should be included within this 200 m zone. For relatively small embayments, fixed points can be used for observation sites and the entire area can be included rather than a sample area.

Setting up foraging survey areas requires that all potentially good feeding sites, not simply those currently used, be surveyed from the ground. The limitation for using random selection is due to access by 4WD vehicles.

The intensity of sampling may vary, depending upon personnel availability. The ISS calls for sampling every 10 days, however, where there is particular interest in monitoring change relative to a management activity, perhaps 1-2 surveys per week will be needed. Given the variation in shorebird counts, even this frequency may not be sufficient for detecting trends (Appendices 5a and 5b).

### *Field Sampling Methods - Ground Surveys for Feeding Birds*

At the smaller scale, at Nauset Marsh and Wellfleet Bay, data on shorebird and waterfowl feeding concentrations will be recorded during ebb (2 h before low) and low (chart low +/- 1 h) tides during the fall migration period, with emphasis on the 1 July to 30 September period, since relatively small numbers remain in late fall and winter. Intensive surveys should be conducted about every 5 days (to preclude autocorrelation, and to allow synchrony with the less-frequent (10-day) ISS surveys) if possible. Time of day is less important for feeding migratory shorebirds than for most other groups of birds. The order in which plots are surveyed should change each visit (as random as possible).

To be consistent with earlier surveys in Nauset Marsh, tidal flat areas should be monitored from the observation points used by Brown (1994). In Wellfleet Bay, locations should be selected based in part on previous studies of shorebirds by K. Tuxbury at MAS. Binoculars of 10X power and a scope of 20-40X power should be used. Observation periods of 1-1.5 h will be needed to complete one count by two independent observers at a given location and for transit between the observation points. We recommend three separate counts conducted over approximate 20 min sampling periods, using a scan sample. Later, for analysis, the maximum count for that day is generally used. It is essential that all mudflat areas be surveyed during the approximate 3-hr low tide period within a marsh complex; otherwise more than one low tide period (or 1 day) would be necessary to complete the survey resulting in high variation between days. Thus, only two observation locations are logistically feasible within a marsh complex.

Maps of each study area should be used for each survey and locations of such flocks recorded. Data should be recorded on field survey forms (Appendix 4); the locations will need to be referenced to numbered or lettered plots, or segments, that can be georeferenced. This method will allow us to track the stability of feeding "hotspots" through time and will be useful in making management decisions concerning petitions for local siting of facilities (*e.g.* aquaculture). The data may also reveal a distance threshold for disturbance.

Equipment List

- Access to a 4WD vehicle
- At least 2 spotting scopes with tripods
- 2 sets of 8-10X binoculars
- 1-2 handheld GPS units
- 1 laser range finder
- PVC for marking locations
- maps of bays
- waterproof notebooks
- One 100-m tape.

Personnel

At least two people should be employed to conduct the observations during surveys, and independent data kept to estimate error. Training may be required using videotapes or local bird experts. At least one of these persons could be the same individual involved in plover monitoring, which generally slows during late July. With two bays, two days would be required to complete one survey at low tide.

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# APPENDICES

Appendix 1a. Piping plover nest observation form.

Location_________________ Nest Name______________ Habitat_________

Date Nest: found______________ complete______________

No. Eggs When: found_______ complete_______ exclosed_______

Date Exclosed__________ Time to Exclose__________ Time to Return_____

No. People Installing______ Type of Excl__________ Mesh: ¼" ¾"

Estim.Hatch Date__________ Hatch Date________ Estim. Fail Date____
Fail Date__________

No. Eggs: Hatched______ Unhatched______ No. Days to Hatch_______

No. Chicks Fledged______ No. Days to Fledge_______

Date Nest Failed__________ Cause of failure_______________________________
_________________________________________________________________________

Did this Pair Renest y n No. of Renest__________

---

***Chick Observations***

| Age (d) | No. Chx Obs. | Age (d) | No. Chx Obs. | Age (d) | No. Chx Obs. |
|---|---|---|---|---|---|
| 1 | | 11 | | 21 | |
| 2 | | 12 | | 22 | |
| 3 | | 13 | | 23 | |
| 4 | | 14 | | 24 | |
| 5 | | 15 | | 25 | |
| 6 | | 16 | | 26 | |
| 7 | | 17 | | 27 | |
| 8 | | 18 | | 28 | |
| 9 | | 19 | | 29 | |
| 10 | | 20 | | 30 | |

Appendix 1b. Field data form for piping plover habitat information.

| | Location | | | | Distance (m) to: | | |
|---|---|---|---|---|---|---|---|
| Nest No. | UTM North. | UTM East. | Date | Habitat* | Back Beach** | Nearest Veg.*** | Wrack Index**** |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

* Habitat type: Berm, foredune, dune/interdune, or washover/blowout.
** Distance measured from crest of the beach berm to the toe of the foredune, using the nest center as the center point for the transect.
*** Distance measured from edge of the nest to the edge of the nearest patch of vegetation > 10 m in size.
**** Index determined by recording the number of times observer's foot lands on wrack while pacing from the base of the foredune to the beach berm. Nest center serves as the center point of the transect. Index expressed in per cent as the frequency of total paces which have wrack occurrence.

Appendix 1c. Example spreadsheet of piping plover nesting data.

**Piping Plover Nest Information -- 2000**

FINAL

| | Nest | | Date | | No. Eggs | | | No. | No. Chx. | | Date | Cause of | Exclosure | | No. Days to | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Beach** | **Name** | **Habitat** | **Found** | **Complete** | **Complete** | **Hatched** | **Unhatched** | **Chicks** | **Fledged** | **HD** | **Failed** | **Failure** | **Time to Install** | **Time to Return** | **Hatch** | **Fledge** |
| WE/LP | WE 11 | Fd | 13-Jun-00 | 15-Jun-00 | 4 | 3 | 1 | 0 | 2 | 10-Jul | | | | | | |
| | WE 7 | Fd | 03-Jun-00 | 06-Jun-00 | 4 | 3 | 1 | 0 | 2 | 2-Jul | | | | | | |
| | WE 10 | Br | 13-Jun-00 | 15-Jun-00 | 4 | 2 | 2 | 0 | 1 | 9-Jul | | | | | | |
| | WE 9 | Br | 13-Jun-00 | NLT 6/13 | 3 | 3 | 0 | 0 | 0 | 8-Jul | | | | | | |
| | WE 2 | Br | 12-May-00 | 15-May-00 | 4 | 4 | 0 | 0 | 4 | 12-Jun | N/A | N/A | 15:00 | 2:00 | | |
| RPN | RPN 6 | Cb | 18-Jun-00 | NLT 6/18 | 4 | 0 | 4 | 0 | 0 | N/A | 22-Jun-00 | Skunk | | | | |
| | RPN 7 | Cb | 18-Jun-00 | N/A | 3 | 0 | 3 | 0 | 0 | N/A | 22-Jun-00 | Skunk | | | | |
| | RPN 5 | Fd | 16-Jun-00 | 19-Jun | 4 | 4 | 0 | 0 | 0 | 16-Jul | | | | | | |
| | RPN 1 | Fd | 22-May-00 | NLT 5/22 | 4 | 4 | 0 | 0 | 1 | 10-Jun | N/A | N/A | | | | |
| RPS | RPS 28 | Fd | 29-Jun-00 | NLT 6/29 | 4 | 4 | 0 | 0 | 2 | 17-Jul | | | | | | |
| | RPS 29 | Fd | 02-Jul-00 | NLT 7/2 | 4 | 4 | 0 | 0 | 3 | 15-Jul | | | | | | |
| | RPS 26 | Br | 22-Jun-00 | NLT 6/22 | 4 | 4 | 0 | 0 | 0 | 16-Jul | | | | | | |
| | RPS 24 | Br | 25-Jun-00 | NLT 6/25 | 3 | 3 | 0 | 0 | 3 | 15-Jul | | | | | | |
| | RPS 21 | Br | 18-Jun-00 | 19-Jun | 2 | 2 | 0 | 0 | 1 | 17-Jul | | | | | | |
| | RPS 30 | Fd | 02-Jul-00 | NLT 7/2 | 4 | 4 | 0 | 0 | 0 | 15-Jul | | | | | | |
| | RPS 25 | Fd | 25-Jun-00 | NLT 6/25 | 3 | 3 | 0 | 0 | 1 | 15-Jul | | | | | | |
| | RPS 22 | Br | 19-Jun-00 | 23-Jun-00 | 3 | 3 | 0 | 0 | 3 | 15-Jul | | | | | | |
| | RPS 23 | Br | 24-Jun-00 | N/A | 3 | 0 | 3 | 0 | 0 | DNH | 27-Jun-00 | Gull | | | | |
| | RPS 5 | Fd | 13-May-00 | 15-May-00 | 2 | 2 | 0 | 0 | 2 | 17-Jun | | | | | | |
| | RPS 20 | Br | 17-Jun-00 | 21-Jun | 4 | 4 | 0 | 0 | 0 | 14-Jul | | | | | | |
| | RPS 27 | Br | 29-Jun-00 | NLT 6/29 | 3 | 0 | 4 | 0 | 0 | DNH | 17-Jul | terr. W/#20 | | | | |
| HH | HHS 4 | Br | 16-Jun-00 | 19-Jun | 5 | 4 | 1 | 0 | 3 | 15-Jul | | | | | | |
| | HHS 3 | Br | 16-Jun-00 | 19-Jun | 4 | 4 | 0 | 0 | 3 | 13-Jul | | | | | | |
| BB | BB 1 | Fd | | | 4 | 4 | 0 | 0 | 3 | 25-May | N/A | N/A | | | | |
| | BB 9 | Br | 24-Jun-00 | 26-Jun-00 | 3 | 2 | 1 | 0 | 0 | | | | | | | |
| | BB 8 | Br | 24-Jun-00 | NLT 6/24 | 4 | 4 | 0 | 0 | 0 | 14-Jul | | | | | | |
| | BB 10 | Br | 25-Jun-00 | 26-Jun-00 | 4 | 0 | 4 | 0 | 0 | DNH | 21-Jul | Over | | | | |

# Appendix 1c. *continued*

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BB 6 | Du | 18-Jun-00 | N/A | 1 | 0 | 1 | 0 | 0 | DNH | 18-Jun | Aband |
| | BB 7 | Br | 24-Jun-00 | NLT 6/24 | 4 | 4 | 0 | 0 | 3 | 11-Jul | | |
| WE/LP | WE 8 | Fd | 03-Jun-00 | N/A | 2 | 0 | 0 | | | | | |
| | WE 6 | Br | 28-May-00 | | 2 | 0 | 0 | | | | | |
| | WE 4 | Br | 12-May-00 | 14-May-00 | 4 | 0 | 0 | | | | | |
| | WE 5 | Br | 16-May-00 | N/A | 1 | 0 | 0 | | | | | |
| | WE 1 | Br | 12-May-00 | 14-May-00 | 4 | 0 | 0 | | | | | |
| | WE 3 | Br | 12-May-00 | N/A | 2 | 0 | 0 | | | | | |
| RPN | RPN 4 | Fd | 04-Jun-00 | NLT 6/4 | 4 | 0 | 0 | | | | | |
| | RPN 3 | Fd | 28-May-00 | 31-May-00 | 4 | 0 | 0 | | | | | |
| | RPN 2 | Fd | 22-May-00 | 28-May-00 | 4 | 0 | 0 | | | | | |
| RPS | RPS 3 | Br | 13-May-00 | N/A | 3 | 0 | 0 | | | | | |
| | RPS 13 | Br | 28-May-00 | N/A | 4 | 0 | 0 | | | | | |
| | RPS 4 | Br | 13-May-00 | 14-May-00 | 4 | 0 | 0 | | | | | |
| | RPS 12 | Br | 24-May-00 | NLT 5/24 | 4 | 0 | 0 | | | | | |
| | RPS 10 | Br | 18-May-00 | 24-May-00 | 4 | 0 | 0 | | | | | |
| | RPS 11 | Fd | 20-May-00 | NLT 5/20 | 4 | 0 | 0 | | | | | |
| | RPS 9 | Br | 17-May-00 | 25-May-00 | 4 | 0 | 0 | | | | | |
| | RPS 2 | Br | 05-May-00 | N/A | 1 | 0 | 0 | | | | | |
| | RPS 1 | Fd | 29-Apr-00 | N/A | 3 | 0 | 0 | | | | | |
| | RPS 16 | Br | 05-Jun-00 | N/A | 2 | 0 | 0 | | | | | |
| | RPS 8 | Br | 15-May-00 | NLT 5/15 | 3 | 0 | 0 | | | | | |
| | RPS 7 | Fd | 15-May-00 | NLT 5/15 | 4 | 0 | 0 | | | | | |
| | RPS 14 | Br | 29-May-00 | N/A | 3 | 0 | 0 | | | | | |
| | RPS 17 | Br | 05-Jun-00 | NLT 6/5 | 4 | 0 | 0 | | | | | |
| | RPS 6 | Fd | 13-May-00 | 19-May-00 | 3 | 0 | 0 | | | | | |
| | RPS 15 | Fd | 30-May-00 | N/A | 3 | 0 | 0 | | | | | |
| HH | HHS 2 | Br | 27-May-00 | NLT 5/27 | 4 | 0 | 0 | | | | | |
| | HHS 1 | Br | 15-May-00 | 17-May-00 | 4 | 0 | 0 | | | | | |
| BB | BB 3 | 31-May | | | 4 | 0 | 0 | | | | | |
| | BB 2 | Fd | 28-Apr-00 | N/A | 3 | 0 | 0 | | | | | |

# Appendix 1c. *continued*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | BB 5 | Br | 03-Jun-00 | NLT 6/3 | 4 | 0 | 0 |
| | BB 4 | Du | 03-Jun-00 | NLT 6/3 | 4 | 0 | 0 |
| | | | | | 205 | 78 | 25 |

| Site | Pairs | Nests | Broods | Chicks | Fledged (Pairs) | Productivity |
|---|---|---|---|---|---|---|
| WE/LP | 5 | 0 | 0 | 0 | 9 (5) | 1.80 |
| RPN | 5 | 0 | 0 | 0 | 1 (5) | 0.20 |
| RPS | 14 | 0 | 0 | 0 | 15 (14) | 1.07 |
| HH | 2 | 0 | 0 | 0 | 6 (2) | 3.00 |
| BB | 5 | 0 | 0 | 0 | 6 (5) | 1.20 |
| Total | 31 | 0 | 0 | 0 | 37 (31) | 1.19 |

Appendix 2a. Example of a marsh bird call-broadcast survey form for use in the breeding season.

Date: Temperature:
Marsh/Quad: Wind speed:
Observer: Cloud Cover:
Survey#: Precipitation:
Tape used:

*put an '1' in appropriate column if bird was heard, 's' if bird was seen but not heard, '1s' if bird was seen and heard

| Survey station # | start time | Species | Responded During: | | | | | | | | | | | | | repeat ? | distance | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **pass 1st** | **pass 2nd** | **pass 3rd** | **pass 4th** | **pass 5th** | LEBI | SORA | VIRA | KIRA | AMBI | COMO | AMCO | PBGR | | | |
| | | | | | | | | | | | | | | | | | | |
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Appendix 2b. Example of a marsh bird call broadcast survey form for use in nonbreeding season (note additional species).

Date:
Marsh/Quad:
Observer:
Survey#:

Temperature:
Wind speed:
Cloud Cover:
Precipitation:
Tape used:

*put an ‘1’ in appropriate column if bird was heard, ‘s’ if bird was seen but not heard, ‘1s’ if bird was seen and heard

| Survey station # | start time | Species | Responded During: | | | | | | | | | | | | | | | repeat ? | distance | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **pass 1st** | **pass 2nd** | **pass 3rd** | **pass 4th** | **pass 5th** | BL RA | LE BI | YE RA | SO RA | VIR A | KI RA | AM BI | CO MO | AM CO | PB GR | | | |
| | | | | | | | | | | | | | | | | | | | | |
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Appendix 2c. Marsh bird habitat field form.

| | | | PERCENT** AREA WITHIN: | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site Code | Pt. | Date | CAT | OEV | SD/RSH | REED | Spartina | Sali-cornia | GRASS | H2O | MUD | SHRB | UPLD |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
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* Habitat codes: CAT=cattail; OEV= other emergent vegetation; SD/RSH=sedge or rush; REED=*Phragmites*; *Spartina; Salicornia*; GRASS=other types of grasses; H2O=open water; MUD=mudflat; SHRB=shrubs; UPLD=upland vegetation.

** Percent figures in units of <1-5%, 6-25%, 26-50%, 51-75%, 76-100% (Braun-Blanquet cover scale)

Appendix 3a. Example of a colonial waterbird nesting field form - Page 1.

## COLONIAL WATERBIRD INVENTORY

USGS, Biological Resources Division

**GENERAL INSTRUCTIONS:** We appreciate any information you can provide us concerning nesting bird colonies. Please send a report even if you cannot provide all the requested information. If you know the colony has been previously censused and you know the official colony name or ID number, then some of the requested information can be omitted. If you visit a colony more than once during a year, you may staple the forms together and omit duplicated information on subsequent forms.

**VISIT AND LOCATION INSTRUCTIONS**
NAME: If you don't know an official name, use a nearby landmark (town, lake, river, etc.) Please provide a colony map / sketch that includes the landmark used for the name. COLONY/SUBCOLONY: Treat nesting groups that are separated by > 200m as separate colonies. TIME: Use military time, e.g. 1:00 PM = 1300, 9:00 AM = 0900. COLONY ID: If using a previous code, give the published source (atlas, etc.)

### COLONY VISIT INFORMATION

Date (mm/dd/yy) ________________

Time started (military) ____________

Length of visit ____. ____ hours

Observer names:

Phone:

Colony visit # ___of ____ for this year.

### COLONY LOCATION INFORMATION

Colony name (local):

Latitude ___° ___' ___" Longitude ___° ___' ___"

UTM Coordinates: ____________E ______________N

Nearest Town: ______________________________

Nearest Waterbody ___________________________

County: ___________________________________

State/Province/Territory _______________________

Colony ID numbers (and source):

### COLONY SITE INFORMATION

General habitat: (Circle One) peninsula(0) barrier island(1) saltwater non-barrier island(2) freshwater island(3) shoreline/lake, pond,impoundment(4) shoreline/ocean, estuary(5) riparian / river, stream(6) other(7)________________

Specific habitat: (Circle One) salt marsh(0) fresh marsh(1) mangrove(2) shrub swamp(3) forested swamp(4) bog(5) spoil/fill area(6) sand bar(7) salt flat or beach(8) gravel beach(9) dune(10) rocks(11) bank (12) cliff (13) grass/sedge (14) deciduous forest(15) evergreen forest(16) mixed forest(17) rooftop(18) parking lot(19) pier/jetty/dock/breakwater(20) other(21)______________

Nest Substrate: (Circle One) evergreen trees(0) deciduous trees(1) mixed trees(2) dead trees(3) shrub(4) grass/sedge/rush/herb(5) dead herbaceous/wrack(6) salt flat(7) soil(8) sand(9) gravel(10) cobble(11) rocks/crevices(12) rocks/cliff(13) burrow(14) man-made structure(15) (explain ________________) other(16)____________________________

LEAST TERN / PIPING PLOVER HABITAT
Beach Width: 1 ____; Center ____; 3 ____
% Vegetation Cover along Transect: 1 ____; Center ____; 3 ____
Fencing/posting around colony? Y N
Off road vehicle tracks (>50m)? Y N

### COLONY DISTURBANCE

| | Mammal | Dogs | Vandals | Vehicles | Pedestrians |
|---|---|---|---|---|---|
| Y | ☐ | ☐ | ☐ | ☐ | ☐ |
| N | ☐ | ☐ | ☐ | ☐ | ☐ |

(Note: check only if currently seen / witnessed; if dog tracks are seen, record as mammal tracks; 'pedestrians' refers to recreationists, photographers, etc.

### COLONY MANAGEMENT

Landowner: ___________________________
Owner's Address:

Management (Circle Yes, No, or Unknown)
Posted? Y N U
Fenced? Y N U
Fence Type (circle one):
string, electric, snow, other__________

Appendix 3b. Example of a colonial waterbird nesting field form - Page 2.

**INSTRUCTIONS FOR REPRODUCTIVE INFORMATION**: Please list each species on a separate line. Choose codes for each column from the lists below. For nesting stage, check the appropriate code. If you band birds, please specify adult (A) and young (Y) numbers. Extra information should be put in REMARKS section. Thank you!

CODES

**COUNTED FROM**: 1-airplane, 2-helicopter, 3-boat, 4-motorized land vehicle, 5-foot (periphery of colony), 6-foot (within colony), 7-other (describe in REMARKS section). **SURVEY TECHNIQUE**: 1-total adult count, 2-total nest count, 3-photography, 4-partial adult count, 5-partial nest count, 6-quadrat sample, 7-transect sample, 8-visual estimate, 9-other (describe in REMARKS section). **PERCENT OF POPULATION SURVEYED**: e.g. 10, 20, or 100% sampled. **NESTING STAGE**: 1-prenesting, 2-egg-laying, 3-incubation, 4-hatching, 5-downy young, 6-feathered young, 7-fledged young, 8-renesting, 9-post nesting. **TOTAL PAIR ESTIMATE**: if correction factor is used, please indicate in REMARKS section.

**REPRODUCTIVE INFORMATION**

| Species | Counted From | Survey Technique | % Population Surveyed | Adult Estimate | Nest Estimate | Nesting Stage | Total Pair Estimate | No. Banded (A,Y) |
|---|---|---|---|---|---|---|---|---|
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QUALITY OF INVENTORY (circle one)

Low (rough estimate)
Fair (sample count extrapolated)
Good (good sampling method)
Excellent (total nest count)

**STUDY PLOTS**

| Species | Nest / Plot # | Contents of nests (see note below) | Adults |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
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| | | | |

Note: Table is designed for recording individual nest data or multiple nests within a plot. For each species, indicate numbers of nests with given combinations of eggs / young, using codes E=egg, Y=young, and DY=dead young. For example, if 8 snowy egret nests were found, 4 having 1 egg and 1 young, 2 having 0 eggs and 2 young, 1 having 2 eggs and 1 young, and 1 having 3 dead young, denote as follows: 4 – 1E, 1Y; 2 – 0E 2Y; 1 – 2E, 1Y; 1 – 0E, 3DY. "Adults" - estimate total number of adults attending the young that are counted/estimated.

**REMARKS:** Attach additional sheets if necessary.

**COLONY MAP/SKETCH:** (Please show colony in relation to landmarks or Latitude/Longitude; attach additional sheets if necessary).

NOTE: In the section under remarks should be documentation of the sampling regime used and an assessment of detection probability. For example, if a mark-recapture method is used for nest estimation, a listing of the values in a Lincoln-Petersen equation should be included.

Appendix 4. Example of shorebird/waterfowl roosting/feeding field form.

Location________________ Date (mo/da/yr)__________ Observer(s) (initials)_______

Temp. (F deg)________ Tide (L, E, F, H )__________ Wind (1=<10 mph, 2=>10) _____

| Time (mil.) | Plot/pond# | Water level (near.10%) | Species (4 letters) | Count | Habitat | Behavior |
|---|---|---|---|---|---|---|
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**Location codes: (NAMA=** Nauset Marsh, etc….)
**Species codes**: Use first two letters of the two names (LESA=Least Sandpiper)
**Habitat codes**: Pond, tidal =TP; Pond, nontidal=NP; Pond, created=CP; Panne= PA; Tidal creek or ditch =TC; Spartina: Tall= TS; Medium= MS, Short= SS; Wrack=WR; Aerial (feeding)=AE
**Tide codes:** L = low, E = ebb, F = flood, H = high
**Behavior codes**: Roosting=R; Feeding=F; Locomotion=L; Maintenance (preen)=M; Social=S

Appendix 5a. Power analysis of shorebird counts made at Cape Cod National Seashore, 1999-2000: Trend assessment, variation, and power.

Conducted by: Diann Prosser, Jeff Hatfield, and Michael Erwin
USGS Patuxent Wildlife Research Center, Laurel MD

To assist in our evaluation of how feasible it might be to determine population trends of selected species or guilds of migratory birds within CACO, we selected a few datasets where replicate counts were done uniformly in both 1999 and 2000. Nauset Bay (NB) and Salt Pond Bay (SPB) were the only sites with consistent spatial and temporal boundaries between the two sampling years, thus data from these sites were chosen to examine trends and power analysis.

The count data were obtained by estimating numbers, by species, of shorebirds at low tide during 5 survey periods from July to September in 1999 and 2000. At one fixed point per bay location, observers estimated numbers using 20-40X scopes and made three counts at ca. 15 min intervals over a 1-h period. For our analyses, we used the maximum count for each species or group on each survey date.

Analysis Methods

The shorebird data were grouped for analysis into datasets based on common taxonomic groups: total count (all shorebirds observed), species richness, number of black-bellied plovers *(Pluvialis squatarola)*, greater yellowlegs *(Tringa melanoleuca)*, dowitchers *(Limnodromus,* combined short- and long-billed), and sandpipers *(Calidris,* combining primarily least, semipalmated, and western). Separate analyses were conducted for NB and SPB. Exploratory statistics and Anderson-Darling normality tests were run for each dataset. Natural log transformations were performed on non-normal datasets; if normalization was achieved, 2-sample *t* tests were used to compare data between years. Otherwise, nonparametric Mann-Whitney *U* tests were run. Analyses were performed using Minitab 12.22 (1998) and SAS 6.12 (1996).

Power analyses over varying combinations of ranges of years and sampling frequencies were performed for each dataset using the correlation coefficient from a regression of 1999 and 2000 data. Power was tested for regression analysis of a given dataset over 5 sampling scenarios: 20, 15, 10, 7, and 5 years of data. Twenty, 10, and 7 years represent annual counts, counts taken every second, or every third year over a 20 year period, respectively; 15 years for surveys taken every other year for 30 years; and 5 years for surveys taken every other year for 10 years. Power estimates are conservative being based on 2 years of actual data, with little change in overall numbers between years (1999 and 2000). Parameters of the power analysis test were as follows: $\alpha$=0.10, 2-tailed test, sample size of 20, 15, 10, 7 or 5, and a correlation coefficient derived from regressions of each dataset for 1999 versus 2000 data. Power analyses were conducted using the software nQuery Advisor 4.0 (Elashoff 2000).

Results

The shorebird data were highly variable within and between years (Appendix 5b,Table 1). In none of the 10 cases did we detect a significant change in numbers between 1999 and 2000. Examining the standard deviations relative to the means however indicates the difficulty in demonstrating significant differences. Of all 10 datasets, only for dowitchers (undo) at Nauset Bay (NB) was there reasonable power shown; 0.62 for annual surveys over 20 years, or 0.51 for bi-annual surveys over 30 years (Appendix 5b,Table 1). There seemed to be a major decline in power when one reduced from annual surveys to every- other- year surveys (compare the n=20 to n=10 columns in Appendix 5b,Table 1). Based on this admittedly small sample of two sites in two years, shorebird migration counts, even when "smoothed" by taking only daily maxima among multiple counts, may be notoriously variable to produce reliable trend estimates even over 20 year periods or longer. Perhaps by combining simultaneous local counts into larger scale regional counts (*e.g.* the Outer Cape as a unit), would variances diminish to allow reasonable trend estimation for species or groups of interest.

References

Elashoff, J.D. 2000. nQuery Advisor Version 4.0 Users Guide. Statistical Solutions Ltd., Cork, Ireland.

Minitab Inc. 1998. Minitab Release 12.22 for Windows. State College, Pennsylvania, USA 16801.

SAS Institute, Inc. 1996. SAS Version 6.12. SAS Campus Drive, Cary, North Carolina, USA 27513.

# Appendix 5b. Results of shorebird power analysis from Cape Cod, 1999-2000.

**Table 1. Power analysis and descriptive statistics of shorebird fall migration counts, 1999 and 2000 at Nauset Bay and Salt Pond Bay, Cape Cod National Seashore, Massachusetts.**

| | | | | | | | | | | Power [e] (n=number of years of data[f]) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dataset[a]** | **Mean 1999** | **SD** | **Mean 2000** | **SD** | **Test Statistic[b]** | **df** | **P-value[b]** | **Transformation[c]** | **Correlation Coefficient[d]** | **n=20** | **n=15** | **n=10** | **n=7** | **n=5** |
| NB, total count | 525 | 503 | 821 | 460 | -0.97 | 7 | 0.36 | none | 0.324 | 0.43 | 0.35 | 0.26 | 0.20 | 0.16 |
| NB, spp richness | 10 | | 10 | | W=29[g] | | 0.83[g] | none | -0.032 | < 0.10 | < 0.10 | < 0.10 | < 0.10 | < 0.10 |
| NB, bbpl | 110 | 140 | 79 | 93 | 0.15 | 7 | 0.88 | log | -0.055 | < 0.10 | < 0.10 | < 0.10 | < 0.10 | < 0.10 |
| NB, grye | 21 | 19 | 23 | 31 | 0.07 | 7 | 0.94 | log | -0.032 | < 0.10 | < 0.10 | < 0.10 | < 0.10 | < 0.10 |
| NB, undo | 22 | 28 | 62 | 63 | -1.3 | 7 | 0.25 | none | 0.417 | 0.62 | 0.51 | 0.37 | 0.28 | 0.20 |
| NB, unsp | 268 | 282 | 384 | 383 | -0.55 | 7 | 0.60 | none | 0.190 | 0.21 | 0.18 | 0.15 | 0.13 | 0.11 |
| SPB, total count | 1535 | 1681 | 1712 | 942 | -0.73 | 7 | 0.49 | log | 0.249 | 0.29 | 0.24 | 0.19 | 0.15 | 0.13 |
| SPB, spp richness | 8.6 | 1.5 | 9.6 | 1.5 | -1.04 | 7 | 0.33 | none | 0.346 | 0.47 | 0.38 | 0.28 | 0.21 | 0.17 |
| SPB, bbpl | 68 | 60 | 94 | 62 | -0.68 | 7 | 0.52 | none | 0.235 | 0.27 | 0.23 | 0.18 | 0.15 | 0.13 |
| SPB, grye | 22 | 11 | 22 | 17 | -0.02 | 6 | 0.98 | none | 0.000 | | | | | |
| SPB, undo | 175 | 282 | 252 | 392 | -0.05 | 7 | 0.96 | log | 0.000 | | | | | |
| SPB, unsp | 605 | 922 | 759 | 532 | -1.05 | 7 | 0.33 | log | 0.348 | 0.48 | 0.39 | 0.28 | 0.22 | 0.17 |

[a] NB=Nauset Bay, SPB=Salt Pond Bay, bbpl=black-bellied plover, grye=greater yellowlegs, undo=dowitchers, unsp=unidentified sandpipers.

[b] Two sample T test, unless otherwise noted.

[c] log=natural log transformation

[d] Correlation Coefficient obtained from regressions using 1999 and 2000 data (needed for Power Analysis)

[e] Power analyses using nQuery (Elashoff 2000); parameters: $\alpha$=0.10, 2-tailed test, correlation coefficient (see [d]), sample size n=20,15, 10, 7, 5 years

[f] Sample sizes: n=20 for 20 years of annual survey data; n=15 for 30 years, sampled every other year; n=10 for 20 years, sampled every other year or 30 years sampled every third year; n=7 for 21 years, sampled every third year; n=5 for 10 years, sampled every other year.

[g] Natural Log transformation did not normalize the data. Ran a Mann-Whitney Test.

Appendix 6. Example of a beached bird survey field form.

Date (MO/DA/YR): Observer(s):

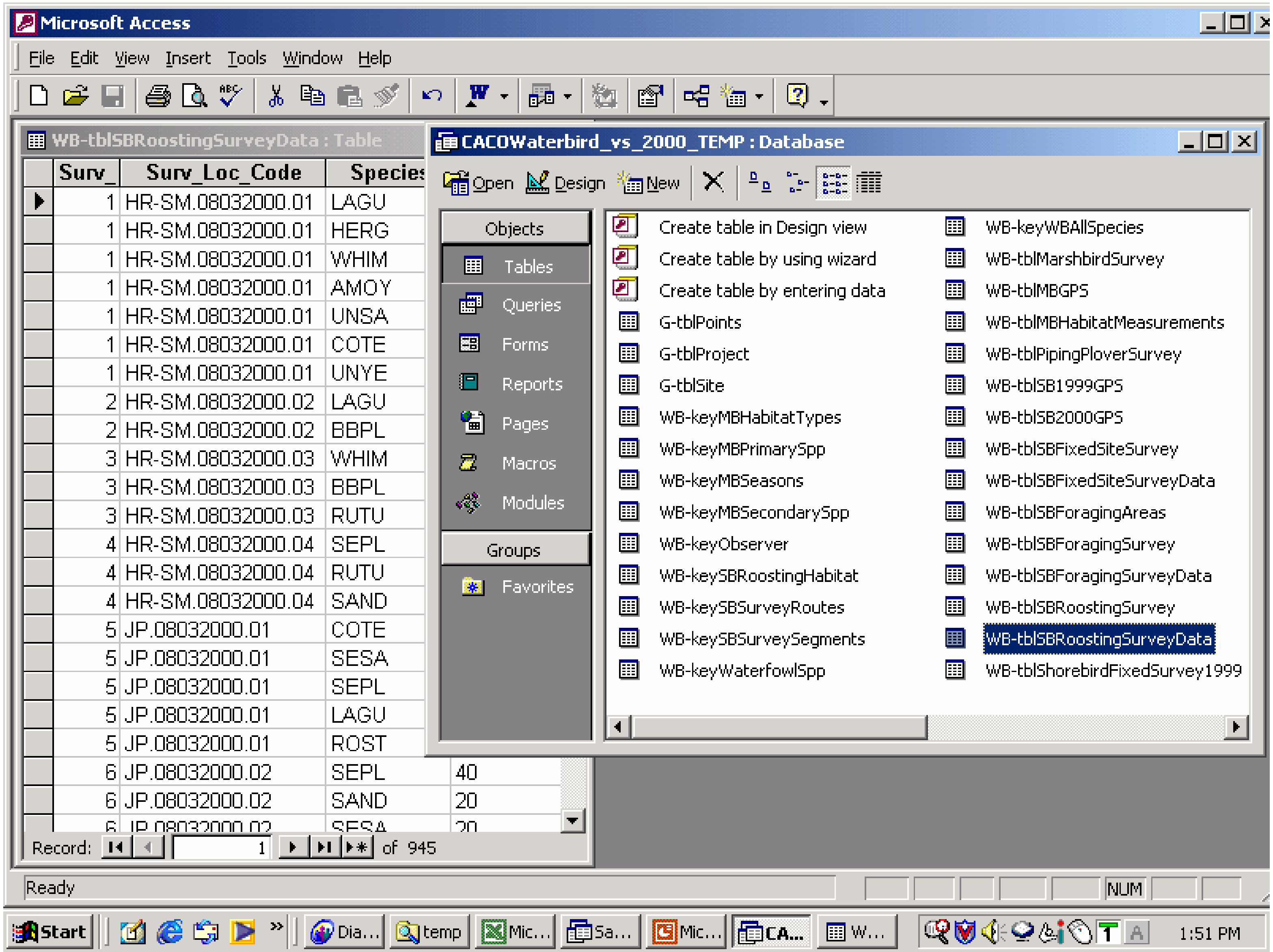
Time (Military): Tide Level (L,M, H):

Wind Direction*: Wind Speed**

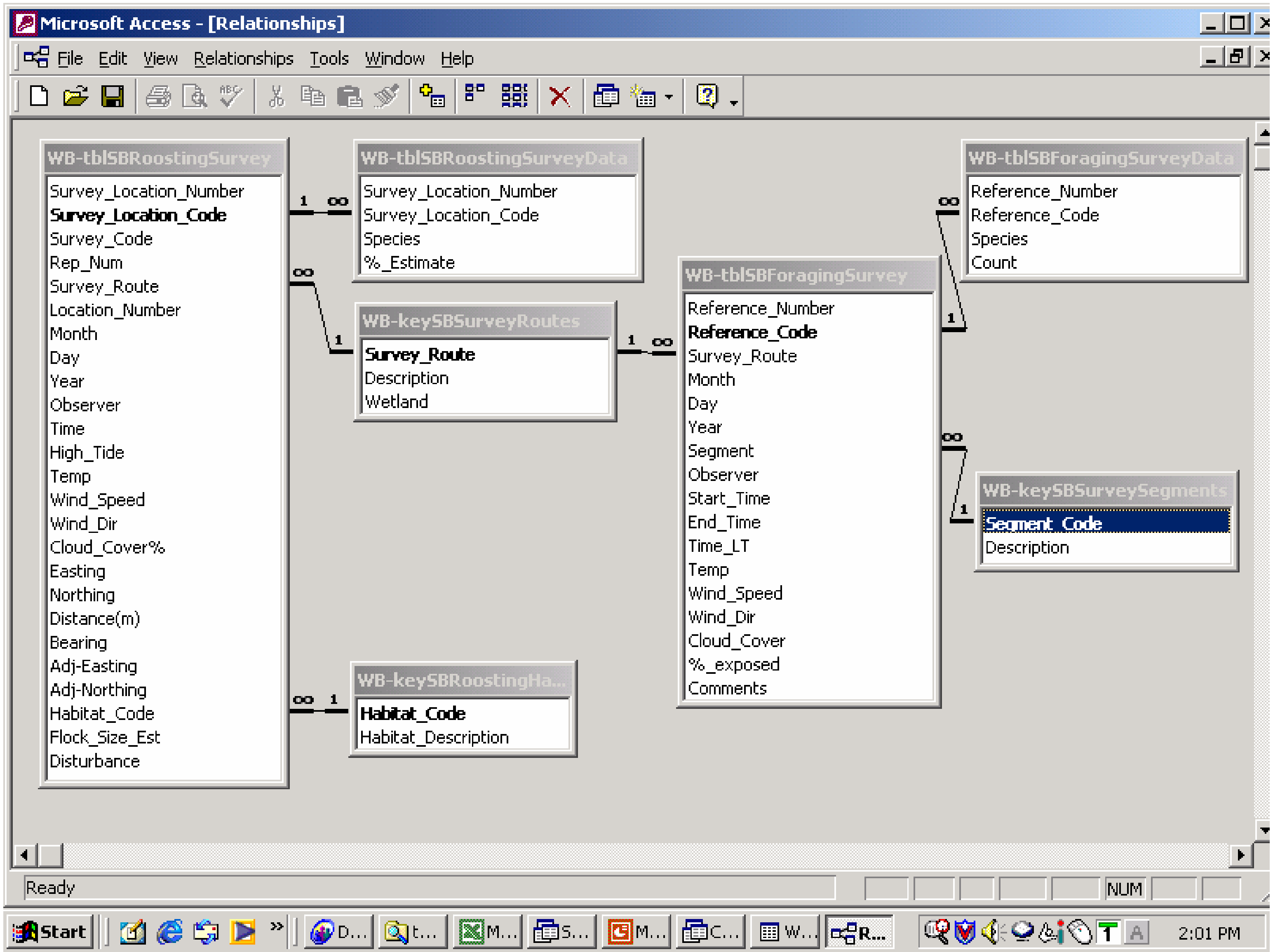
| TRANSECT NUMBER | SPECIES (4 LTR) | CONDITION*** | SIGNS**** |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

*Wind Direction: Give one of the 8 cardinal directions of predominant wind direction over past 24 hours
** Wind Speed: Give speed in ranges of 0-10, 10-20, 20-30, or > 30 knots (1 knot = 1.1 mph)
*** Condition: DF (dead-fresh), DD (dead-decayed), M (moribund, dying), P (partial – *i.e.* only a part of the carcass found, *e.g.* wing, leg, head)
****Signs: Oiled (O), Predated (P) (blood evidence), Scavenged (S)
[NOTE: Forms should be accompanied by a map of the beaches, and all transects should have a GPS point for start and end points]

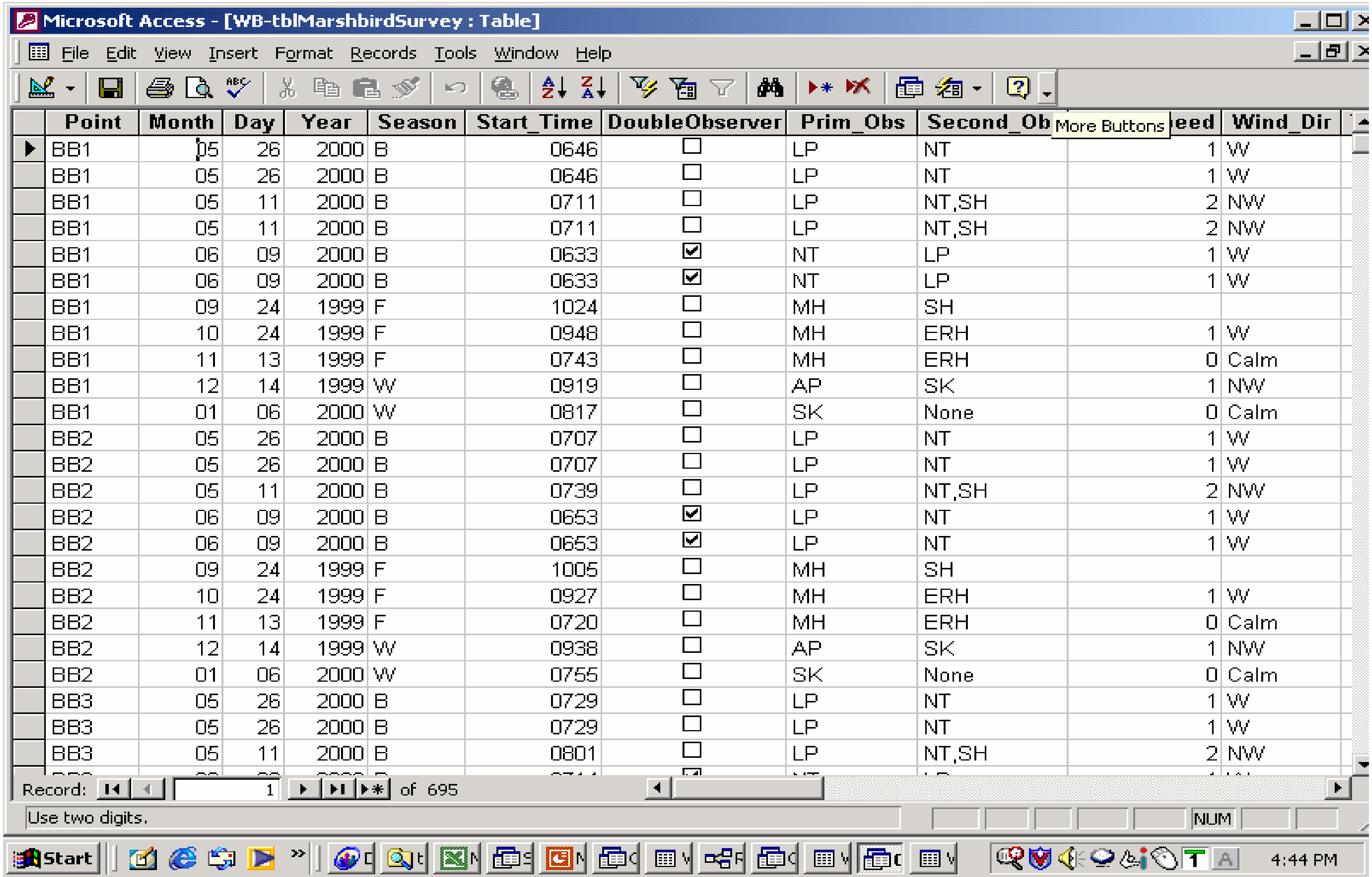
Appendix 7a. Example of the Access tables, and part of one example, in the Waterbird Access Database.



Appendix 7b. Example of the relationships among the Access tables under the shorebird database.

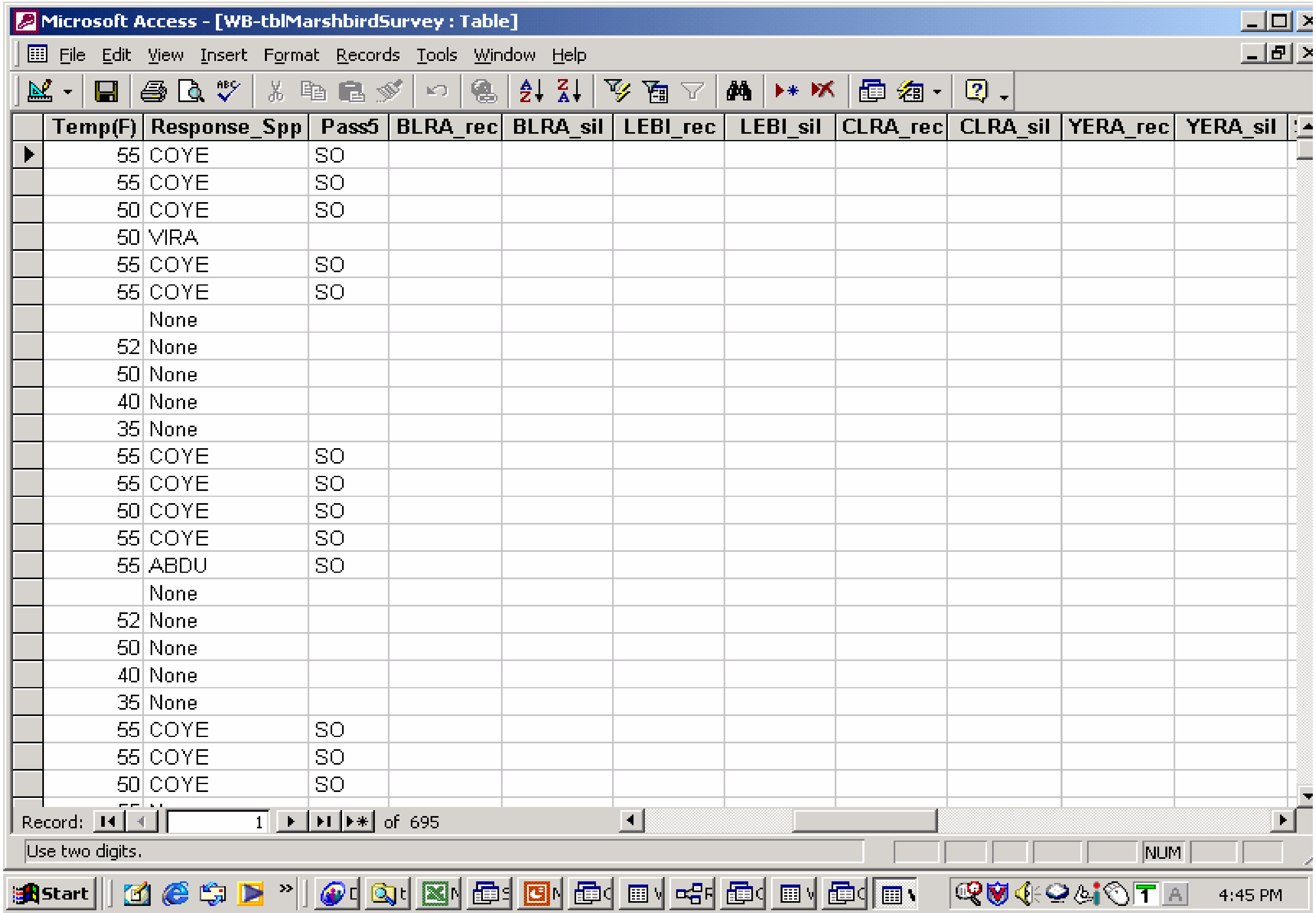


Appendix 7c. Example of a marsh bird data table, showing breeding, migrating, and wintering marsh bird activity (1st of 4 tables).




| Point | Month | Day | Year | Season | Start_Time | DoubleObserver | Prim_Obs | Second_Ob | eed | Wind_Dir |
|---|---|---|---|---|---|---|---|---|---|---|
| BB1 | 05 | 26 | 2000 | B | 0646 | ☐ | LP | NT | 1 | W |
| BB1 | 05 | 26 | 2000 | B | 0646 | ☐ | LP | NT | 1 | W |
| BB1 | 05 | 11 | 2000 | B | 0711 | ☐ | LP | NT,SH | 2 | NW |
| BB1 | 05 | 11 | 2000 | B | 0711 | ☐ | LP | NT,SH | 2 | NW |
| BB1 | 06 | 09 | 2000 | B | 0633 | ☑ | NT | LP | 1 | W |
| BB1 | 06 | 09 | 2000 | B | 0633 | ☑ | NT | LP | 1 | W |
| BB1 | 09 | 24 | 1999 | F | 1024 | ☐ | MH | SH | | |
| BB1 | 10 | 24 | 1999 | F | 0948 | ☐ | MH | ERH | 1 | W |
| BB1 | 11 | 13 | 1999 | F | 0743 | ☐ | MH | ERH | 0 | Calm |
| BB1 | 12 | 14 | 1999 | W | 0919 | ☐ | AP | SK | 1 | NW |
| BB1 | 01 | 06 | 2000 | W | 0817 | ☐ | SK | None | 0 | Calm |
| BB2 | 05 | 26 | 2000 | B | 0707 | ☐ | LP | NT | 1 | W |
| BB2 | 05 | 26 | 2000 | B | 0707 | ☐ | LP | NT | 1 | W |
| BB2 | 05 | 11 | 2000 | B | 0739 | ☐ | LP | NT,SH | 2 | NW |
| BB2 | 06 | 09 | 2000 | B | 0653 | ☑ | LP | NT | 1 | W |
| BB2 | 06 | 09 | 2000 | B | 0653 | ☑ | LP | NT | 1 | W |
| BB2 | 09 | 24 | 1999 | F | 1005 | ☐ | MH | SH | | |
| BB2 | 10 | 24 | 1999 | F | 0927 | ☐ | MH | ERH | 1 | W |
| BB2 | 11 | 13 | 1999 | F | 0720 | ☐ | MH | ERH | 0 | Calm |
| BB2 | 12 | 14 | 1999 | W | 0938 | ☐ | AP | SK | 1 | NW |
| BB2 | 01 | 06 | 2000 | W | 0755 | ☐ | SK | None | 0 | Calm |
| BB3 | 05 | 26 | 2000 | B | 0729 | ☐ | LP | NT | 1 | W |
| BB3 | 05 | 26 | 2000 | B | 0729 | ☐ | LP | NT | 1 | W |
| BB3 | 05 | 11 | 2000 | B | 0801 | ☐ | LP | NT,SH | 2 | NW |

Appendix 7 c. Marsh bird table continued (2nd of 4 tables).



Microsoft Access - [WB-tblMarshbirdSurvey : Table]

| Temp(F) | Response_Spp | Pass5 | BLRA_rec | BLRA_sil | LEBI_rec | LEBI_sil | CLRA_rec | CLRA_sil | YERA_rec | YERA_sil |
|---|---|---|---|---|---|---|---|---|---|---|
| 55 | COYE | SO | | | | | | | | |
| 55 | COYE | SO | | | | | | | | |
| 50 | COYE | SO | | | | | | | | |
| 50 | VIRA | | | | | | | | | |
| 55 | COYE | SO | | | | | | | | |
| 55 | COYE | SO | | | | | | | | |
| | None | | | | | | | | | |
| 52 | None | | | | | | | | | |
| 50 | None | | | | | | | | | |
| 40 | None | | | | | | | | | |
| 35 | None | | | | | | | | | |
| 55 | COYE | SO | | | | | | | | |
| 55 | COYE | SO | | | | | | | | |
| 50 | COYE | SO | | | | | | | | |
| 55 | COYE | SO | | | | | | | | |
| 55 | ABDU | SO | | | | | | | | |
| | None | | | | | | | | | |
| 52 | None | | | | | | | | | |
| 50 | None | | | | | | | | | |
| 40 | None | | | | | | | | | |
| 35 | None | | | | | | | | | |
| 55 | COYE | SO | | | | | | | | |
| 55 | COYE | SO | | | | | | | | |
| 50 | COYE | SO | | | | | | | | |

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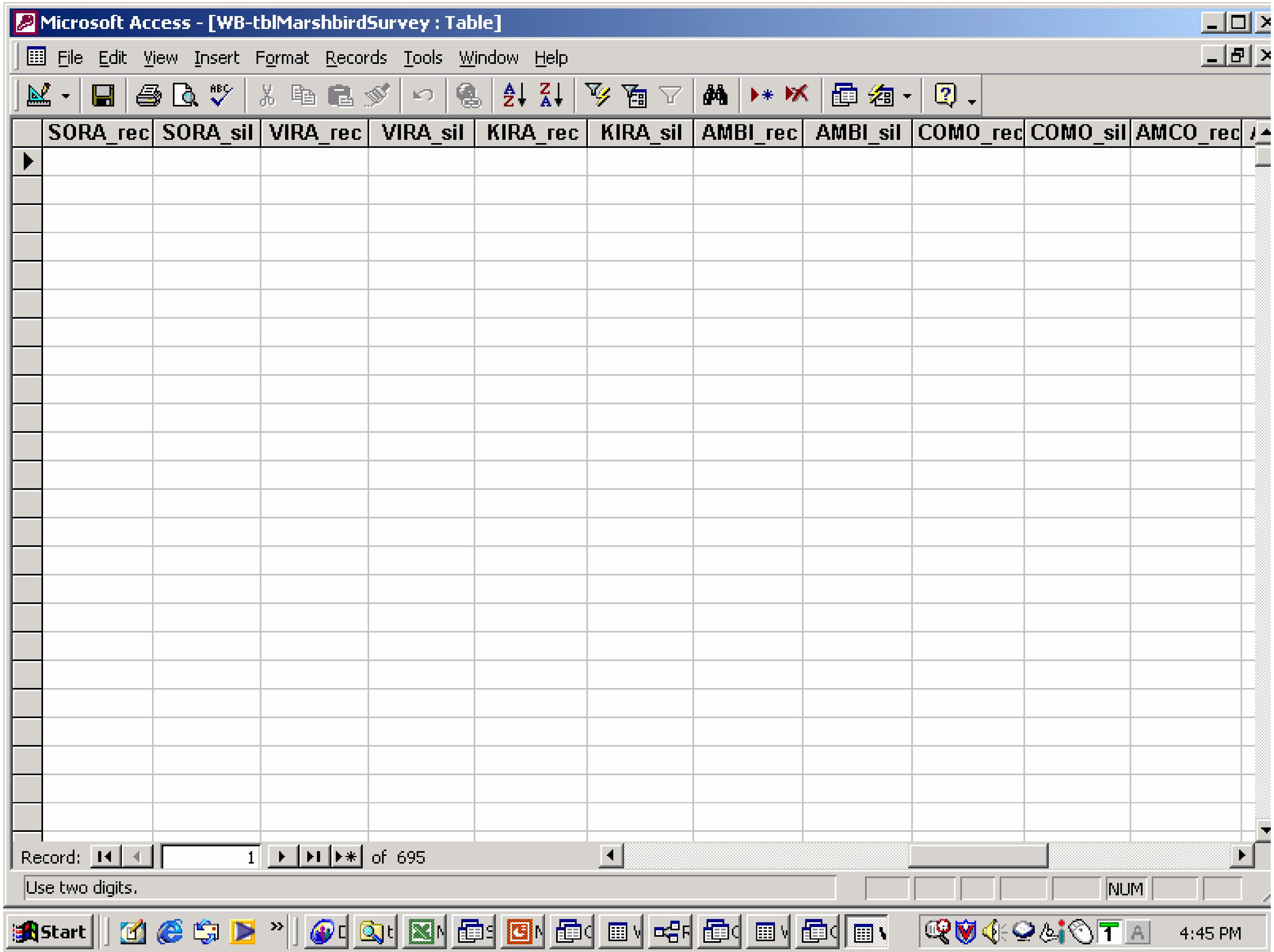
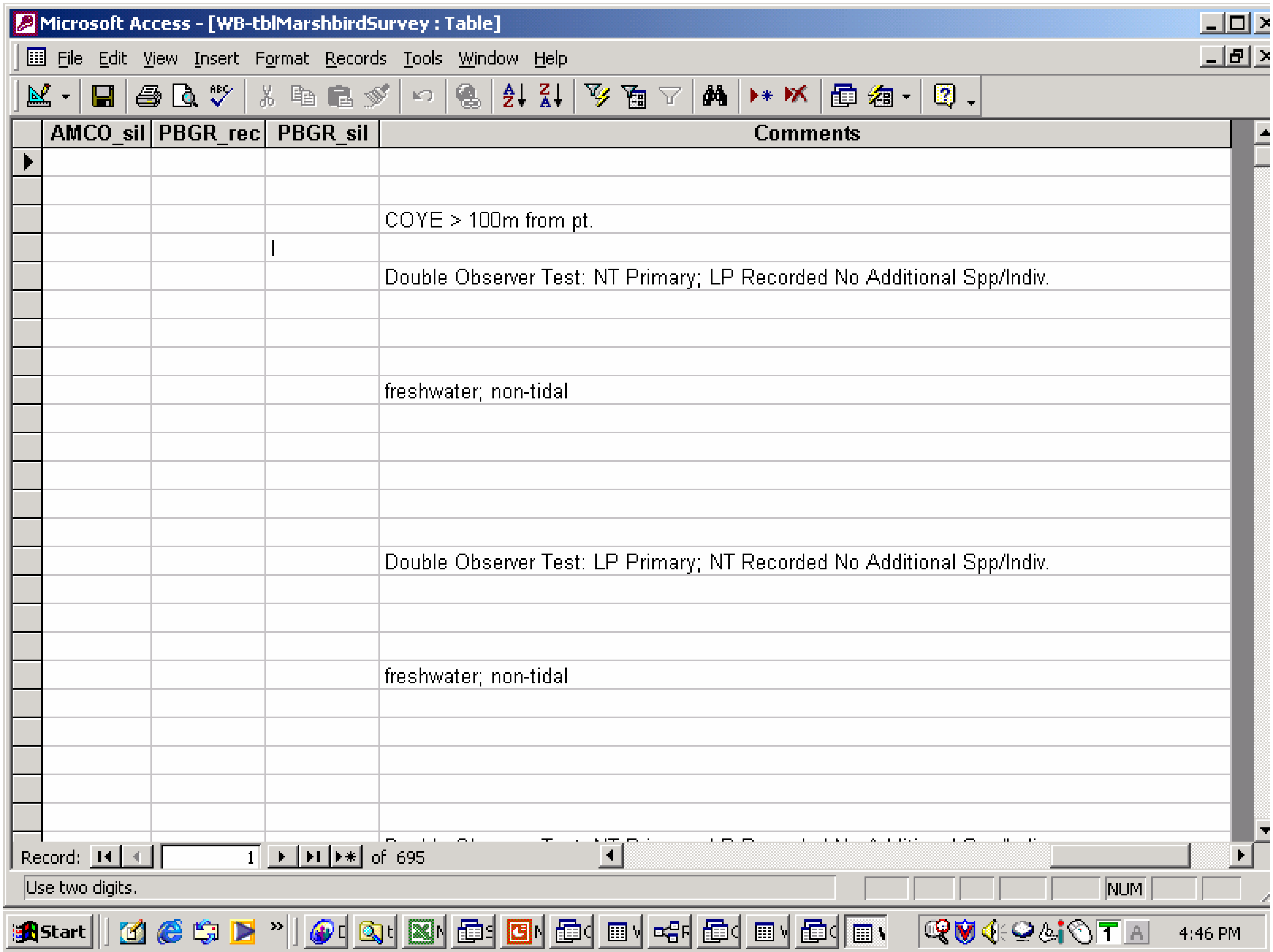
Use two digits.

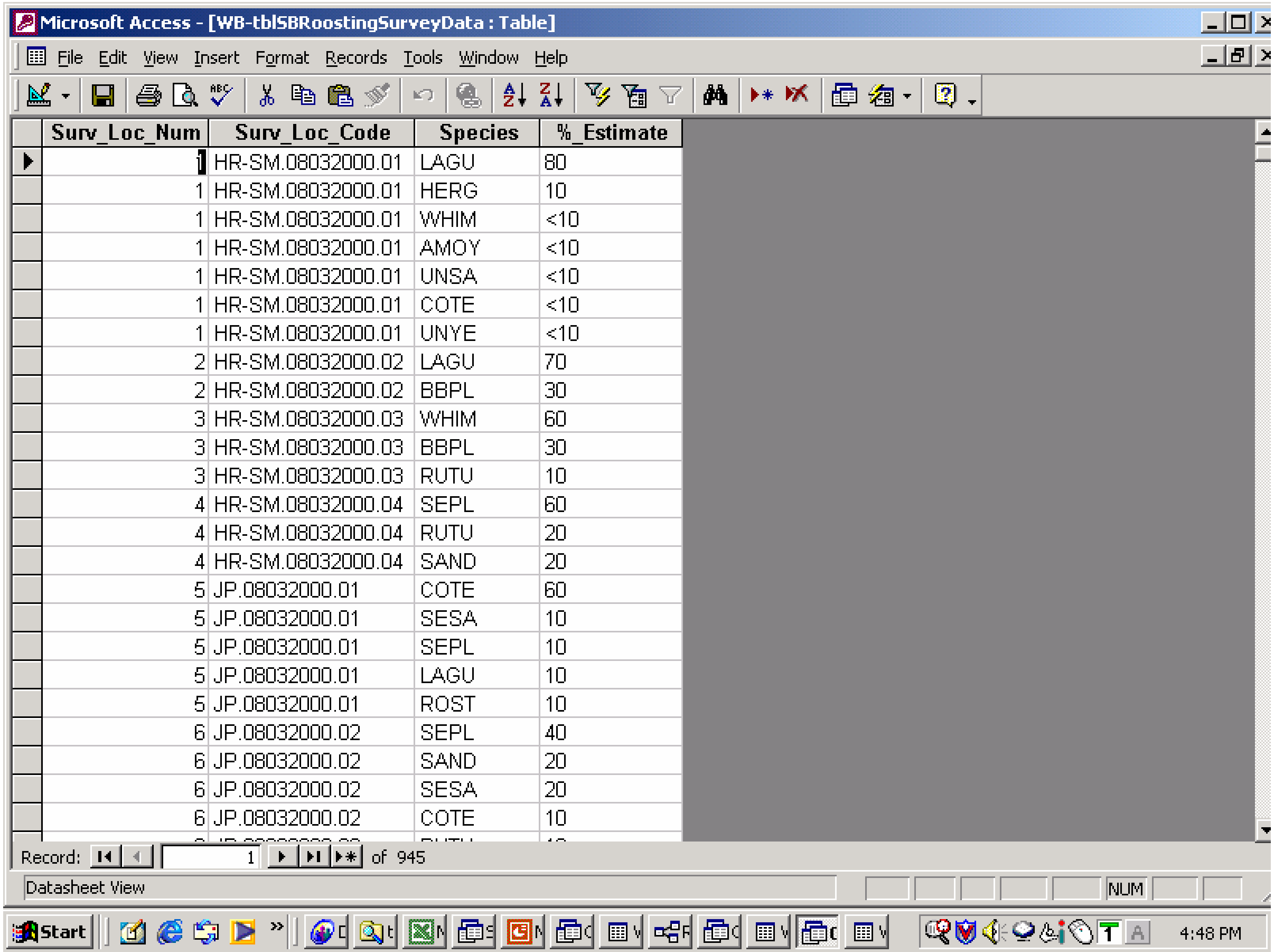
Appendix 7c. Marsh bird data table continued (3rd of 4 tables)



Appendix 7 c. Marsh bird data table continued (4th of 4 tables).

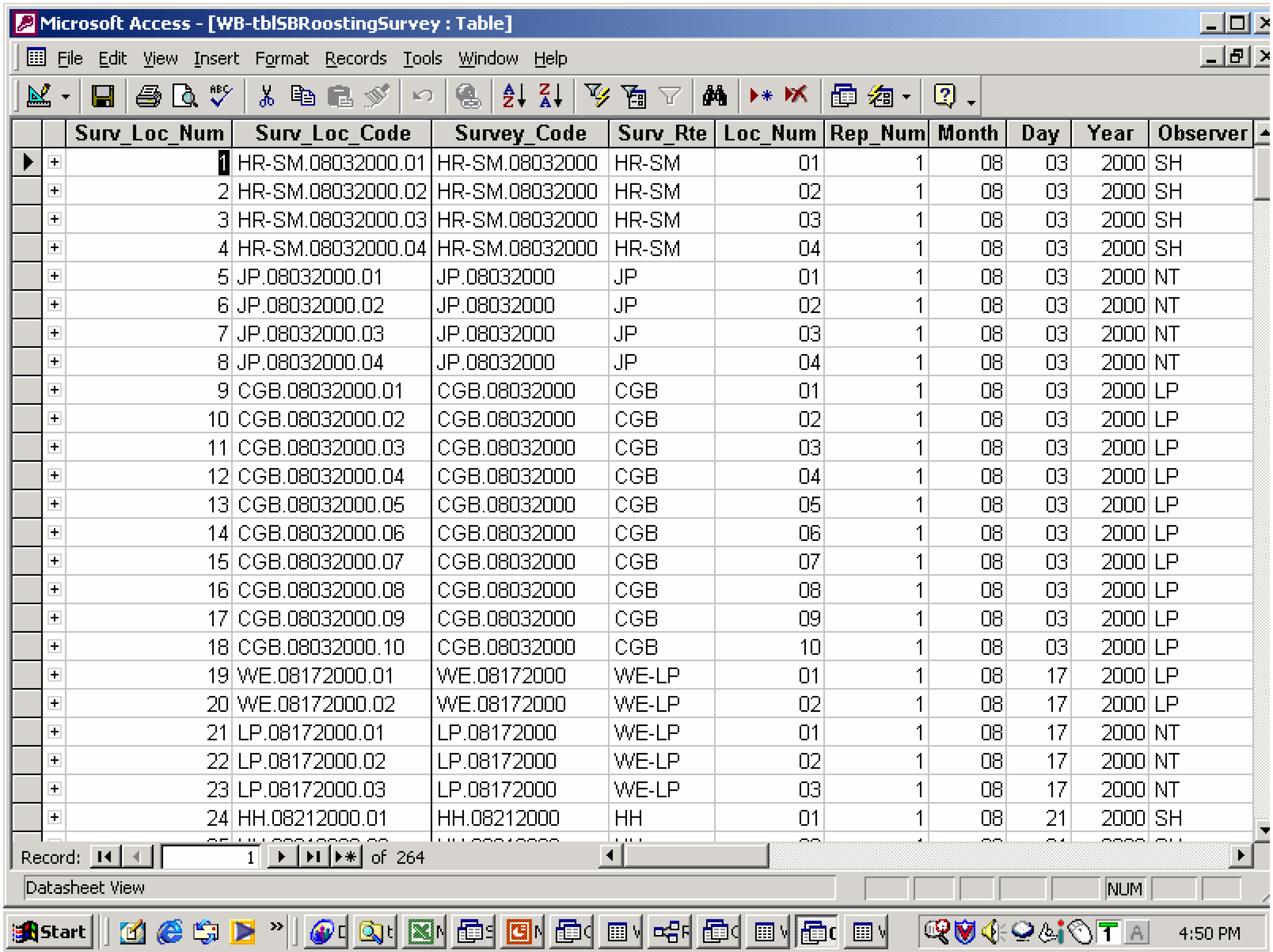


Appendix 7d. Example of a shorebird roosting survey table (linked to following survey table).




| Surv_Loc_Num | Surv_Loc_Code | Species | %_Estimate |
|---|---|---|---|
| 1 | HR-SM.08032000.01 | LAGU | 80 |
| 1 | HR-SM.08032000.01 | HERG | 10 |
| 1 | HR-SM.08032000.01 | WHIM | <10 |
| 1 | HR-SM.08032000.01 | AMOY | <10 |
| 1 | HR-SM.08032000.01 | UNSA | <10 |
| 1 | HR-SM.08032000.01 | COTE | <10 |
| 1 | HR-SM.08032000.01 | UNYE | <10 |
| 2 | HR-SM.08032000.02 | LAGU | 70 |
| 2 | HR-SM.08032000.02 | BBPL | 30 |
| 3 | HR-SM.08032000.03 | WHIM | 60 |
| 3 | HR-SM.08032000.03 | BBPL | 30 |
| 3 | HR-SM.08032000.03 | RUTU | 10 |
| 4 | HR-SM.08032000.04 | SEPL | 60 |
| 4 | HR-SM.08032000.04 | RUTU | 20 |
| 4 | HR-SM.08032000.04 | SAND | 20 |
| 5 | JP.08032000.01 | COTE | 60 |
| 5 | JP.08032000.01 | SESA | 10 |
| 5 | JP.08032000.01 | SEPL | 10 |
| 5 | JP.08032000.01 | LAGU | 10 |
| 5 | JP.08032000.01 | ROST | 10 |
| 6 | JP.08032000.02 | SEPL | 40 |
| 6 | JP.08032000.02 | SAND | 20 |
| 6 | JP.08032000.02 | SESA | 20 |
| 6 | JP.08032000.02 | COTE | 10 |

Appendix 7e. Example of a shorebird roosting survey database (1st of 3 tables).




| Surv_Loc_Num | Surv_Loc_Code | Survey_Code | Surv_Rte | Loc_Num | Rep_Num | Month | Day | Year | Observer |
|---|---|---|---|---|---|---|---|---|---|
| 1 | HR-SM.08032000.01 | HR-SM.08032000 | HR-SM | 01 | 1 | 08 | 03 | 2000 | SH |
| 2 | HR-SM.08032000.02 | HR-SM.08032000 | HR-SM | 02 | 1 | 08 | 03 | 2000 | SH |
| 3 | HR-SM.08032000.03 | HR-SM.08032000 | HR-SM | 03 | 1 | 08 | 03 | 2000 | SH |
| 4 | HR-SM.08032000.04 | HR-SM.08032000 | HR-SM | 04 | 1 | 08 | 03 | 2000 | SH |
| 5 | JP.08032000.01 | JP.08032000 | JP | 01 | 1 | 08 | 03 | 2000 | NT |
| 6 | JP.08032000.02 | JP.08032000 | JP | 02 | 1 | 08 | 03 | 2000 | NT |
| 7 | JP.08032000.03 | JP.08032000 | JP | 03 | 1 | 08 | 03 | 2000 | NT |
| 8 | JP.08032000.04 | JP.08032000 | JP | 04 | 1 | 08 | 03 | 2000 | NT |
| 9 | CGB.08032000.01 | CGB.08032000 | CGB | 01 | 1 | 08 | 03 | 2000 | LP |
| 10 | CGB.08032000.02 | CGB.08032000 | CGB | 02 | 1 | 08 | 03 | 2000 | LP |
| 11 | CGB.08032000.03 | CGB.08032000 | CGB | 03 | 1 | 08 | 03 | 2000 | LP |
| 12 | CGB.08032000.04 | CGB.08032000 | CGB | 04 | 1 | 08 | 03 | 2000 | LP |
| 13 | CGB.08032000.05 | CGB.08032000 | CGB | 05 | 1 | 08 | 03 | 2000 | LP |
| 14 | CGB.08032000.06 | CGB.08032000 | CGB | 06 | 1 | 08 | 03 | 2000 | LP |
| 15 | CGB.08032000.07 | CGB.08032000 | CGB | 07 | 1 | 08 | 03 | 2000 | LP |
| 16 | CGB.08032000.08 | CGB.08032000 | CGB | 08 | 1 | 08 | 03 | 2000 | LP |
| 17 | CGB.08032000.09 | CGB.08032000 | CGB | 09 | 1 | 08 | 03 | 2000 | LP |
| 18 | CGB.08032000.10 | CGB.08032000 | CGB | 10 | 1 | 08 | 03 | 2000 | LP |
| 19 | WE.08172000.01 | WE.08172000 | WE-LP | 01 | 1 | 08 | 17 | 2000 | LP |
| 20 | WE.08172000.02 | WE.08172000 | WE-LP | 02 | 1 | 08 | 17 | 2000 | LP |
| 21 | LP.08172000.01 | LP.08172000 | WE-LP | 01 | 1 | 08 | 17 | 2000 | NT |
| 22 | LP.08172000.02 | LP.08172000 | WE-LP | 02 | 1 | 08 | 17 | 2000 | NT |
| 23 | LP.08172000.03 | LP.08172000 | WE-LP | 03 | 1 | 08 | 17 | 2000 | NT |
| 24 | HH.08212000.01 | HH.08212000 | HH | 01 | 1 | 08 | 21 | 2000 | SH |

Appendix 7e. Shorebird roosting database continued (2nd of 3 tables).

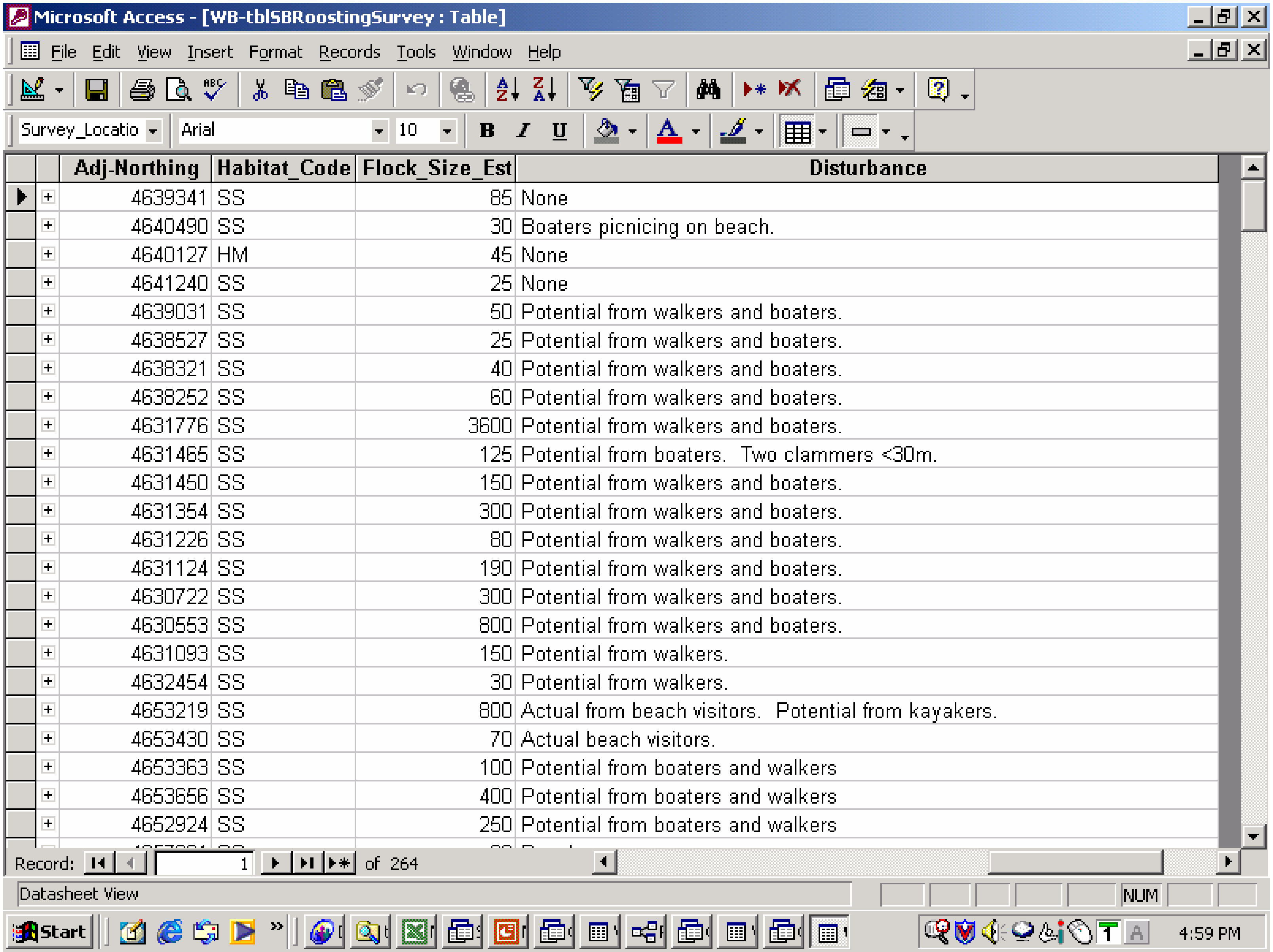
Microsoft Access - [WB-tblSBRoostingSurvey : Table]

| High_Tide | Temp | Wind_Speed | Wind_Dir | Cloud_Cover% | Easting | Northing | Distance(m) | Bearing | Adj-Easting |
|---|---|---|---|---|---|---|---|---|---|
| 1455 | 80 | 2 | SW | 60 | 411323 | 4639341 | 40 | 090 | 411363 |
| 1455 | 80 | 1 | SW | 70 | 411647 | 4640461 | 30 | 017 | 411656 |
| 1455 | 80 | 1 | SW | 90 | 411447 | 4640127 | 0 | 999 | 411447 |
| 1455 | 80 | 2 | SW | 100 | 412246 | 4641226 | 20 | 045 | 412260 |
| 1455 | 75 | 1 | SW | 80 | 411170 | 4639074 | 50 | 150 | 411195 |
| 1455 | 75 | 1 | SW | 100 | 411261 | 4638527 | 0 | 999 | 411261 |
| 1455 | 75 | 1 | SW | 100 | 411265 | 4638321 | 0 | 999 | 411265 |
| 1455 | 75 | 1 | SW | 100 | 411308 | 4638252 | 0 | 999 | 411308 |
| 1648 | 75 | 2 | SW | 100 | 421452 | 4631850 | 75 | 190 | 421439 |
| 1648 | 70 | 2 | SW | 100 | 421420 | 4631504 | 40 | 195 | 421410 |
| 1648 | 70 | 2 | SW | 100 | 421580 | 4631450 | 20 | 090 | 421600 |
| 1648 | 70 | 2 | SW | 100 | 421589 | 4631385 | 40 | 220 | 421563 |
| 1648 | 70 | 2 | SW | 100 | 421632 | 4631226 | 30 | 270 | 421602 |
| 1648 | 70 | 2 | SW | 100 | 421662 | 4631124 | 10 | 090 | 421672 |
| 1648 | 70 | 2 | SW | 100 | 421698 | 4630722 | 60 | 090 | 421758 |
| 1648 | 70 | 2 | SW | 100 | 421676 | 4630553 | 80 | 270 | 421596 |
| 1648 | 70 | 2 | SW | 100 | 421726 | 4631093 | 3 | 270 | 421723 |
| 1648 | 70 | 2 | SW | 100 | 421533 | 4632464 | 10 | 190 | 421531 |
| 1357 | 75 | 2 | NNW | 10 | 400783 | 4653196 | 25 | 020 | 400792 |
| 1357 | 75 | 2 | NNW | 10 | 400548 | 4653417 | 15 | 030 | 400556 |
| 1357 | 80 | 2 | N | 20 | 402315 | 4653336 | 80 | 070 | 402390 |
| 1357 | 80 | 1 | N | 20 | 403104 | 4653726 | 70 | 175 | 403110 |
| 1357 | 80 | 1 | N | 20 | 402452 | 4652939 | 15 | 180 | 402452 |

Record: 1 of 264

Datasheet View

Appendix 7e. Shorebird roosting database continued (3rd of 3 tables).




| Adj-Northing | Habitat_Code | Flock_Size_Est | Disturbance |
|---|---|---|---|
| 4639341 | SS | 85 | None |
| 4640490 | SS | 30 | Boaters picnicing on beach. |
| 4640127 | HM | 45 | None |
| 4641240 | SS | 25 | None |
| 4639031 | SS | 50 | Potential from walkers and boaters. |
| 4638527 | SS | 25 | Potential from walkers and boaters. |
| 4638321 | SS | 40 | Potential from walkers and boaters. |
| 4638252 | SS | 60 | Potential from walkers and boaters. |
| 4631776 | SS | 3600 | Potential from walkers and boaters. |
| 4631465 | SS | 125 | Potential from boaters. Two clammers <30m. |
| 4631450 | SS | 150 | Potential from walkers and boaters. |
| 4631354 | SS | 300 | Potential from walkers and boaters. |
| 4631226 | SS | 80 | Potential from walkers and boaters. |
| 4631124 | SS | 190 | Potential from walkers and boaters. |
| 4630722 | SS | 300 | Potential from walkers and boaters. |
| 4630553 | SS | 800 | Potential from walkers and boaters. |
| 4631093 | SS | 150 | Potential from walkers. |
| 4632454 | SS | 30 | Potential from walkers. |
| 4653219 | SS | 800 | Actual from beach visitors. Potential from kayakers. |
| 4653430 | SS | 70 | Actual beach visitors. |
| 4653363 | SS | 100 | Potential from boaters and walkers |
| 4653656 | SS | 400 | Potential from boaters and walkers |
| 4652924 | SS | 250 | Potential from boaters and walkers |

Appendix 7f. Example of a shorebird foraging survey table-locational data (1st of 2).

Microsoft Access - [WB-tblSBForagingSurvey : Table]

| Reference_Number | Reference_Code | Survey_Route | Month | Day | Year | Segment | Observer | Start_Time |
|---|---|---|---|---|---|---|---|---|
| 1 | WEDO.07202000 | WE-LP | 07 | 20 | 2000 | WEDO | NT | 0815 |
| 2 | WEDI.07202000 | WE-LP | 07 | 20 | 2000 | WEDI | LP | 0815 |
| 3 | LP1.08042000 | WE-LP | 08 | 04 | 2000 | LP1 | NT | 0850 |
| 4 | LP2.08042000 | WE-LP | 08 | 04 | 2000 | LP2 | NT | 0931 |
| 5 | LP3.08042000 | WE-LP | 08 | 04 | 2000 | LP3 | NT | 0908 |
| 6 | LP4.08042000 | WE-LP | 08 | 04 | 2000 | LP4 | NT | 0857 |
| 7 | LP5.08042000 | WE-LP | 08 | 04 | 2000 | LP5 | NT | 0950 |
| 8 | WE1.08042000 | WE-LP | 08 | 04 | 2000 | WE1 | LP | 0840 |
| 9 | WE2.08042000 | WE-LP | 08 | 04 | 2000 | WE2 | LP | 0901 |
| 10 | WE3.08042000 | WE-LP | 08 | 04 | 2000 | WE3 | LP | 0916 |
| 11 | SM.08082000 | HR-SM | 08 | 08 | 2000 | SM | LP | 1142 |
| 12 | SMP2.08082000 | HR-SM | 08 | 08 | 2000 | SMP2 | LP | 1202 |
| 13 | SMP1.08082000 | HR-SM | 08 | 08 | 2000 | SMP1 | LP | 1218 |
| 14 | GBH.08082000 | HR-SM | 08 | 08 | 2000 | GBH | LP | 1251 |
| 15 | MM3.08082000 | HR-SM | 08 | 08 | 2000 | MM3 | LP | 1306 |
| 16 | MM2.08082000 | HR-SM | 08 | 08 | 2000 | MM2 | LP | 1325 |
| 17 | MM1.08082000 | HR-SM | 08 | 08 | 2000 | MM1 | NT | 1155 |
| 18 | GI3.08082000 | HR-SM | 08 | 08 | 2000 | GI3 | NT | 1216 |
| 19 | GIP.08082000 | HR-SM | 08 | 08 | 2000 | GIP | NT | 1226 |
| 20 | GI2.08082000 | HR-SM | 08 | 08 | 2000 | GI2 | NT | 1255 |
| 21 | GI1.08082000 | HR-SM | 08 | 08 | 2000 | GI1 | NT | 1305 |
| 22 | LGUT.08082000 | HR-SM | 08 | 08 | 2000 | LGUT | NT | 1316 |
| 23 | MGUT.08082000 | HR-SM | 08 | 08 | 2000 | MGUT | NT | 1330 |

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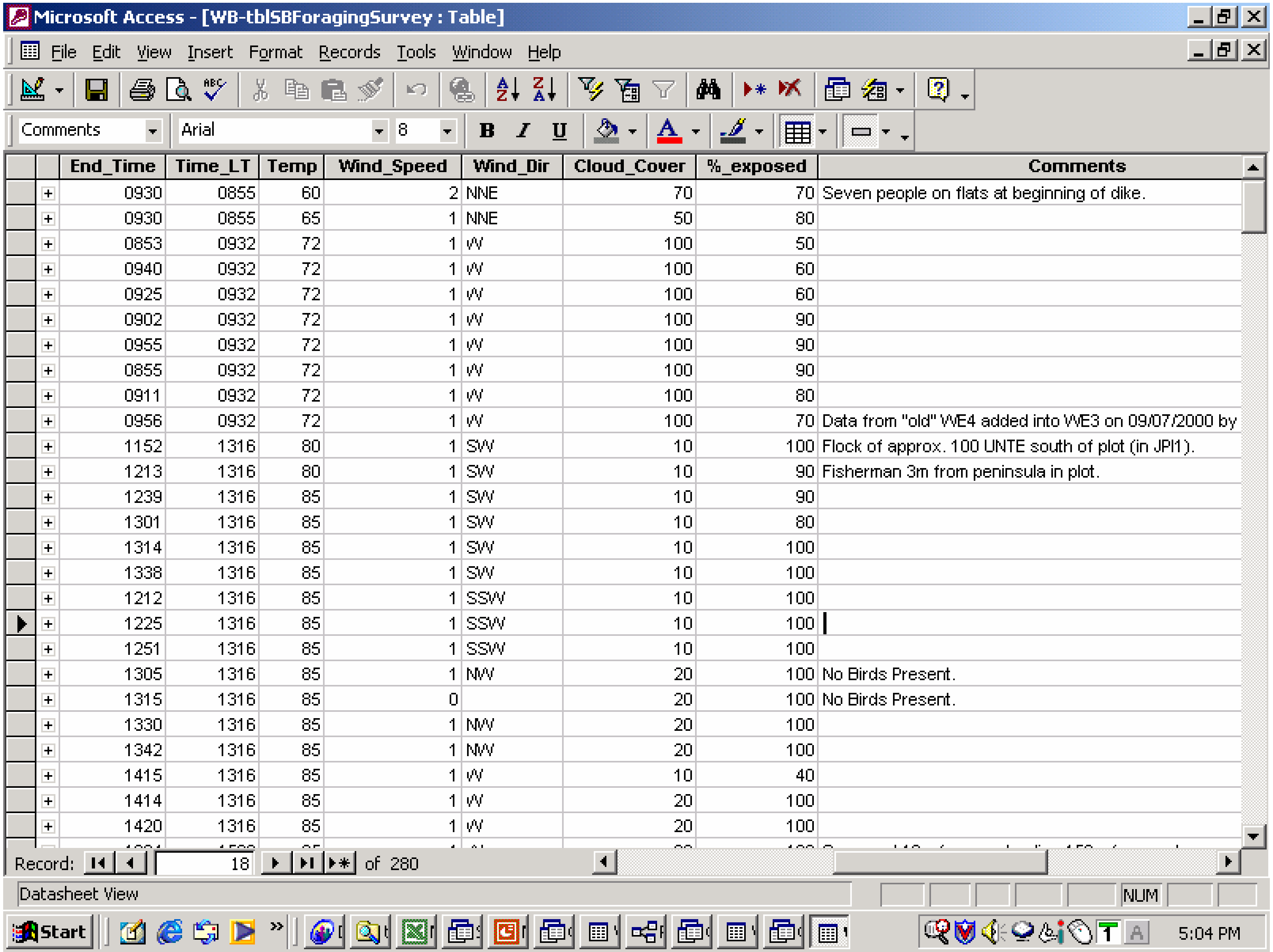
Appendix 7f. Example of a shorebird foraging survey table-locational data continued (2nd of 2).



Microsoft Access - [WB-tblSBForagingSurvey : Table]

| End_Time | Time_LT | Temp | Wind_Speed | Wind_Dir | Cloud_Cover | %_exposed | Comments |
|---|---|---|---|---|---|---|---|
| 0930 | 0855 | 60 | 2 | NNE | 70 | 70 | Seven people on flats at beginning of dike. |
| 0930 | 0855 | 65 | 1 | NNE | 50 | 80 | |
| 0853 | 0932 | 72 | 1 | W | 100 | 50 | |
| 0940 | 0932 | 72 | 1 | W | 100 | 60 | |
| 0925 | 0932 | 72 | 1 | W | 100 | 60 | |
| 0902 | 0932 | 72 | 1 | W | 100 | 90 | |
| 0955 | 0932 | 72 | 1 | W | 100 | 90 | |
| 0855 | 0932 | 72 | 1 | W | 100 | 90 | |
| 0911 | 0932 | 72 | 1 | W | 100 | 80 | |
| 0956 | 0932 | 72 | 1 | W | 100 | 70 | Data from "old" WE4 added into WE3 on 09/07/2000 by |
| 1152 | 1316 | 80 | 1 | SW | 10 | 100 | Flock of approx. 100 UNTE south of plot (in JPI1). |
| 1213 | 1316 | 80 | 1 | SW | 10 | 90 | Fisherman 3m from peninsula in plot. |
| 1239 | 1316 | 85 | 1 | SW | 10 | 90 | |
| 1301 | 1316 | 85 | 1 | SW | 10 | 80 | |
| 1314 | 1316 | 85 | 1 | SW | 10 | 100 | |
| 1338 | 1316 | 85 | 1 | SW | 10 | 100 | |
| 1212 | 1316 | 85 | 1 | SSW | 10 | 100 | |
| 1225 | 1316 | 85 | 1 | SSW | 10 | 100 | |
| 1251 | 1316 | 85 | 1 | SSW | 10 | 100 | |
| 1305 | 1316 | 85 | 1 | NW | 20 | 100 | No Birds Present. |
| 1315 | 1316 | 85 | 0 | | 20 | 100 | No Birds Present. |
| 1330 | 1316 | 85 | 1 | NW | 20 | 100 | |
| 1342 | 1316 | 85 | 1 | NW | 20 | 100 | |
| 1415 | 1316 | 85 | 1 | W | 10 | 40 | |
| 1414 | 1316 | 85 | 1 | W | 20 | 100 | |
| 1420 | 1316 | 85 | 1 | W | 20 | 100 | |

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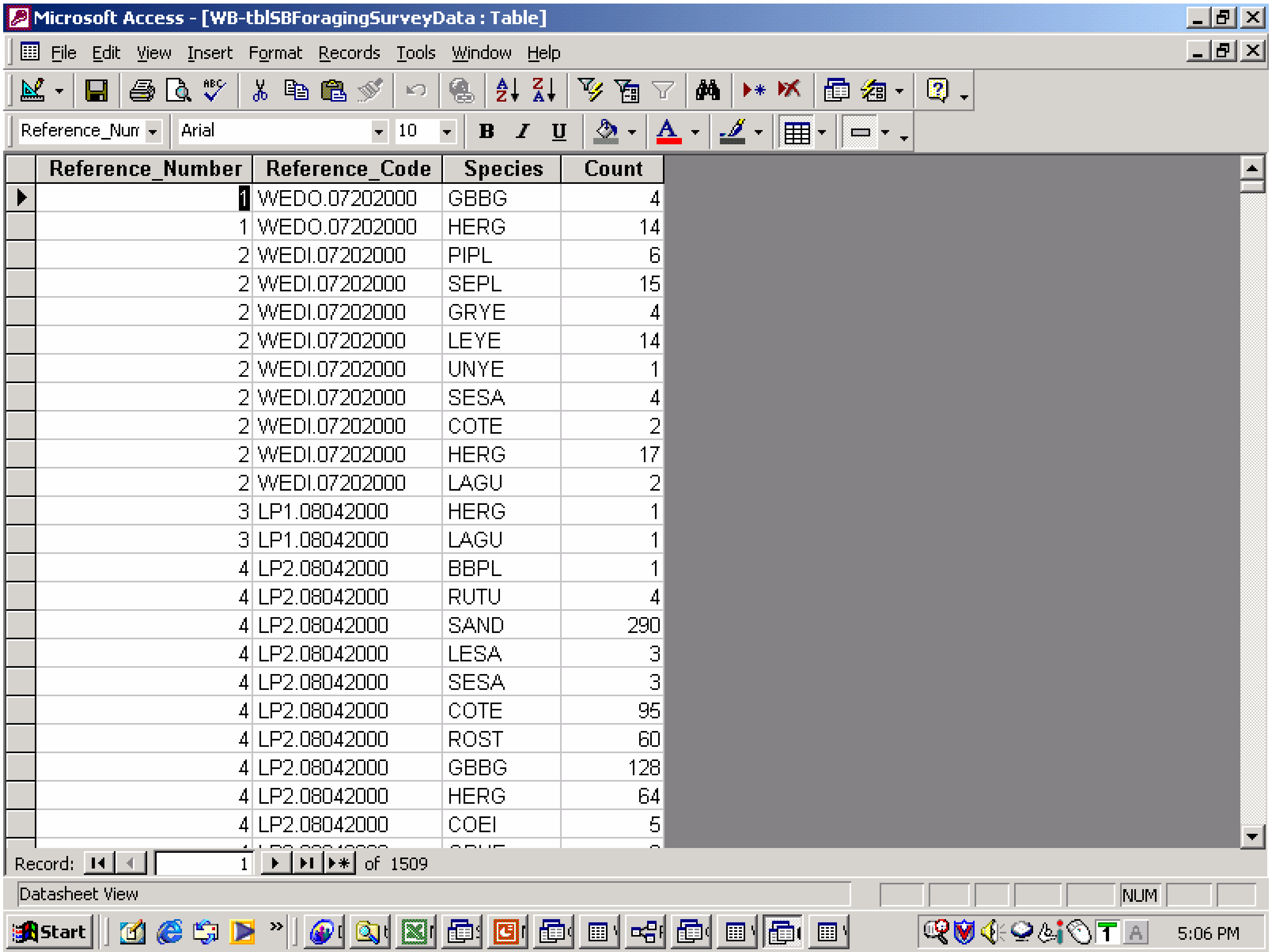
Datasheet View

Appendix 7g. Shorebird foraging survey data table- biological data linked with locational tables (Appendix 7f).



Microsoft Access - [WB-tblSBForagingSurveyData : Table]

| Reference_Number | Reference_Code | Species | Count |
|---|---|---|---|
| 1 | WEDO.07202000 | GBBG | 4 |
| 1 | WEDO.07202000 | HERG | 14 |
| 2 | WEDI.07202000 | PIPL | 6 |
| 2 | WEDI.07202000 | SEPL | 15 |
| 2 | WEDI.07202000 | GRYE | 4 |
| 2 | WEDI.07202000 | LEYE | 14 |
| 2 | WEDI.07202000 | UNYE | 1 |
| 2 | WEDI.07202000 | SESA | 4 |
| 2 | WEDI.07202000 | COTE | 2 |
| 2 | WEDI.07202000 | HERG | 17 |
| 2 | WEDI.07202000 | LAGU | 2 |
| 3 | LP1.08042000 | HERG | 1 |
| 3 | LP1.08042000 | LAGU | 1 |
| 4 | LP2.08042000 | BBPL | 1 |
| 4 | LP2.08042000 | RUTU | 4 |
| 4 | LP2.08042000 | SAND | 290 |
| 4 | LP2.08042000 | LESA | 3 |
| 4 | LP2.08042000 | SESA | 3 |
| 4 | LP2.08042000 | COTE | 95 |
| 4 | LP2.08042000 | ROST | 60 |
| 4 | LP2.08042000 | GBBG | 128 |
| 4 | LP2.08042000 | HERG | 64 |
| 4 | LP2.08042000 | COEI | 5 |

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Datasheet View