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U.S. Shorebird Conservation Plan

A Comprehensive Monitoring Program for North American Shorebirds

A Technical Report of the Research and Monitoring Working Group
of the U.S. Shorebird Conservation Plan

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A Comprehensive Monitoring Program for North American Shorebirds

I. Introduction

Anthropogenic changes to the biosphere, including widespread degradation and losses of habitats and ecosystems, are causing rapid and profound changes to bird and other wildlife populations throughout the world. Such changes have led to increasing risks and rates of extinction. As a consequence, information on how bird populations are changing is becoming increasingly important to wildlife conservationists and managers. Early detection of population change is crucial for setting wildlife planning and management priorities. For example, information on population size, population vulnerability, and population change has been central to international conservation strategies such as the Ramsar Convention, the Western Hemisphere (Bonn) Convention, and the Western Hemisphere Shorebird Reserve Network. Measuring population size or change is also crucial for evaluating the effectiveness of population management programs implemented by wildlife agencies both locally and regionally.

Although the concept of determining population size is simple, practical difficulties can be enormous and costly to overcome. In the United States, $4 billion will be spent in year 2000 to census the human population, possibly one of the most easily counted of all vertebrates. By contrast, the portion of the FY 2000 budget of the U.S. Department of the Interior allotted for tracking populations of all migratory birds (> 600 species) is less than $5 million (.0125% of the human census figure). This falls far short of the amount required to provide adequate, science-based information about bird populations and population change to wildlife managers

The gap between current ability and need is especially noteworthy for shorebirds. There are 72 species, subspecies, or distinct populations of shorebirds in North America. Even though most of these have received less conservation attention than such groups as waterfowl, colonial waterbirds, or songbirds, recent independent evaluation of data collected for other purposes in the eastern United States and Canada during the 1970s and early 1980s showed that16 of 26 species surveyed are apparently declining, some at rates exceeding 5% per year (Howe et al., 1989). Except for one increasing species, populations of the other 9 species were statistically unchanged over the time period analyzed. In most cases causes of shorebird population declines are poorly known. For some species, the declines may be part of natural population cycles. For others the changes may reflect deterioration of conditions on the nesting grounds, at migration stopover locations, in wintering zones, or combinations of these. Determining which of these scenarios is correct and what management actions, if any, are warranted will be possible only after implementing a comprehensive monitoring plan such as that described here.

II. Goals and Objectives

During 1999, a group of scientific authorities on shorebirds reviewed the current status of shorebirds in the United States and evaluated the capacity of existing programs for monitoring shorebird populations. They concluded that a new, comprehensive, national monitoring program for shorebirds needs to be developed and that it should incorporate the following elements:

Goals

I. Monitor Long-term, Species-specific Population Trends

II. Derive More Precise Estimates of Species-specific Population Size

III. Monitor Regional Patterns of Habitat Use and Population Response to Habitat Management

IV. Ensure that Shorebird Population Information is Effectively Integrated into the National Bird Conservation Planning Dialogue and Implementation Process

Objectives

1. Design, test, and implement a suite of long-term, statistically sound surveys for tracking patterns of population change in all shorebird species at the national/continental scale.

2. Promote an ongoing research program for evaluating and improving estimation and monitoring protocols and interpreting results.

3. Design a long-term program, stratified by NABCI (North American Bird Conservation Initiative) Bird Conservation Region, for monitoring regional patterns of habitat use as a tool for assessing habitat quality, shifts in distribution patterns and identifying regional research and management needs.

4. Designate a national center for (a) maintaining web-accessible, shorebird population databases; (b) conducting regular analyses of population change; and (c) delivering relevant summary information to wildlife policy-makers and managers.

5. Establish a practical mechanism for assuring that wildlife managers (especially in the context of NABCI joint ventures) are adequately informed on how to design and carry out shorebird monitoring programs as a means of evaluating the effectiveness of habitat management programs.

6. Improve international coordination, with the intent of harmonizing monitoring approaches with those under development in other countries that share shorebird populations.

This chapter outlines a consensus approach to achieving these goals and objectives. It includes a brief history of shorebird monitoring programs in North America; an overview of statistical and methodological considerations relevant to survey design and implementation; an evaluation of how biological attributes of shorebirds at different seasons affect our ability to monitor; a compendium of prescriptions for single- and multi-species monitoring protocols needed to attain the best estimates of population change in all North American shorebird species; a list of priority research initiatives; and a proposed general approach to implementation.

III. Important Considerations for Survey Design and Methodology

Design of population sampling framework and choice of counting method are fundamental considerations that require careful thought before any monitoring program is implemented. The correct choices require an understanding of (1) the spatial and temporal dynamics of the population of interest, (2) the advantages and limitations of different counting techniques in different field situations, and (3) statistical issues (e.g., bias and precision) relevant to one's ability to make inferences about population size or trend from data collected in the survey.

As a group, shorebirds present some challenging impediments to survey design and implementation. Over 70 species of shorebirds have been recorded in North America. Each species or distinctive population has its own breeding and wintering distribution, and each has its own migration strategy for connecting breeding and wintering locations. Accessibility (to the human observer) of breeding and wintering areas varies widely among species. Some species breed only in the high Arctic and winter in southern South America, while others are residents within the lower 48 states. Some species are long-distance migrants, while others are either short-distance migrants or non-migratory. Some migrate on broad fronts, using any of a large number of migration stopover locations, while others migrate on narrow fronts, using just one or a small number of possibly critical migration staging areas. Some species exhibit fairly consistent spatial and temporal patterns of migration from year-to-year, while others (especially those that exploit ephemeral habitats) do not. Some species move extensively among locations and habitats during any given day, while others tend to be more sedentary.

All these factors affect the ability of the surveyor to count or sample shorebird populations in a statistically valid manner and need to be thoroughly considered before designing a survey protocol. In this section we review some of the design, biological, and methodological issues that have special relevance to shorebird population surveys

Statistical Design

This section presents a general discussion of the relationship between survey design and accuracy of results, focusing on two critical aspects of accuracy: precision and bias. We explain what each means, why the distinction between them is important, and how they affect the reliability of survey results. The general goal in survey design is to maximize precision and minimize bias.

<u>Definitions</u>

Precision refers to the effect of errors caused by chance factors such as when surveys are made, in what areas, and by whom, or to annual effects caused, for example, by weather or habitat change. Standard errors and confidence intervals are common measures of precision. Precision is improved by increasing sample size and/or the efficiency of the sampling plan. Standard errors – and thus precision - can usually be estimated from the data collected during surveys.

Bias refers to the effect of errors caused by consistent tendencies to over- or under-estimate the quantity of interest. Three sources of bias, of particular importance in shorebird surveys, are errors caused by low or variable detection rates, exclusion of important shorebird areas from the survey program, and certain long-term shifts in shorebird distribution patterns. With larger sample sizes, no clear relationship between bias and sample size can be expected.

One of the reasons for distinguishing these two sources of error is that standard statistical methods make the assumption that there is no bias. Thus, bias causes error that in general is not acknowledged in statistical analyses and may seriously compromise their validity. It is therefore critical that an upper limit be placed on the effect of bias, and this must often be done using specialized studies. Much attention is given in the rest of this report to detecting and removing possible sources of bias. Factors likely to cause bias in estimates of long-term trends, population size, and use of important shorebird areas are discussed below.

Estimating population trends

Trends in population size are generally estimated by calculating a single summary statistic for each year (possibly for each of several areas) and determining whether the points tend to increase or decrease when plotted against years during which the data were collected. For non-breeding surveys, the annual summary statistic is usually the peak count or the mean count per survey. For breeding surveys, the summary statistic is usually the mean number of birds recorded per unit of effort (e.g., birds per route) or per unit of area (e.g., birds/ha). Numerous methods for calculating the trend have been developed including route regression, estimating equations, and LOWESS regression.

Precision of trend estimates is affected by sample size variables such as the number of years, number of sites surveyed per year, and number of surveys/site during each year. Precision is also affected by variation in bird numbers within and between years and by which analytic methods are used to select the survey areas and analyze the resulting data. For example, procedures that utilize habitat information in sample selection or analysis may be much more precise than those that do not.

Bias in estimating population trends is caused *solely* by a trend in the detection ratio, defined as the ratio of the summary statistic to the actual population size. For example, suppose that, on average, observers detect half the birds on plots during the first few years of the survey but this ratio increases to 75% by the end of the period because observers gradually become better at finding birds. This change would generate an apparent 50% increase in population size even if the population was actually stable. On the other hand, variation within or between years in detection rates, habitat, weather, and numbers of birds present (except as caused by long-term trends) do not cause bias in the trend estimate, though they certainly may reduce precision.

For breeding surveys, the most serious sources of bias are probably excluding some portions of the breeding range from the sampled population and long-term changes in observer ability. Excluding some portion of the breeding range only causes bias in the trend estimate if the overall trend on the excluded areas differs from the trend in the sampled portion of the range. Long-term changes in the fraction of birds detected might occur due to progressive changes in habitat, extraneous noise, or other factors.

For non-breeding surveys, the most serious sources of bias are probably long-term trends in the fraction of the breeding population that enters the study area during the study period and changes in the average amount of time birds stay in the study area. Long-term changes in either of these parameters is likely to cause a trend in survey results independent of any change in population size. These changes might collectively be referred to as the "movements hypothesis" to explain change in survey results. *Unless the movements hypothesis can be excluded as a cause of observed changes, one cannot infer from a survey that population size has changed.* Much attention is given to this difficult problem in the rest of this report.

Estimating population size

Shorebird population size may be estimated in several ways. The simplest approach conceptually is to count birds, and this is feasible for several shorebirds either on the breeding ground or when they are concentrated in one or a few places on the staging or wintering grounds. Another approach is to delineate an area – usually the breeding grounds – that contains all the birds, develop an efficient plan for counting a sample of them, and then extrapolate from the sampled area to the entire breeding range. This approach is also feasible for several shorebirds, especially those breeding in the United States. A third approach is to count birds at migration sites and then estimate the proportion of the population that stops at the site and the average amount of time that birds remain there. Total population size can then be estimated from the average number of birds present at the site during the study period. Sites that are relatively small and that a large fraction of the birds pass through are particularly well suited to this method. Other approaches, especially ones involving mark-recapture methods, might be feasible but have not been widely used to estimate population size in shorebirds.

The factors affecting precision and bias in estimators of population size vary to some extent depending on which of the methods above is being used. Estimates based on complete counts are usually extremely accurate unless a substantial fraction of the birds are outside the sampled area at the time of the surveys.

Precision of estimates based on plot sampling depends on number of plots, plot size, plot-to-plot variation in number of birds present and year-to-year variation in average birds/plot. Precision of estimates based on length-of-stay methods depends on the number of birds for which stopover duration was determined, the variability in their residence times, and how well the average number of birds present at the study site is known.

Bias in estimating population size results from a tendency to under- or over-count birds when an assumption of complete counts is made, or from other problems related to extrapolation of the sample results to the population. For example, if birds are counted at stop-over sites and residence times are estimated, a consistent tendency to over- or under-estimate residence times would cause bias in the overall estimate. Exclusion of some sites due to inaccessibility is another source of possible bias, though bias occurs only to the extent that the average density on the excluded sites differs from the average density among sites that might enter the sample.

Estimating trends in shorebird use of stop-over areas

Shorebird use at stop-over areas is usually monitored by periodic surveys of the areas. The results may be summarized as mean number of birds present/survey, peak number recorded, or by a more complex summary statistic such as mean of the top three counts. Multiplying the mean number present times the number of days in the survey period yields an estimate of the number of "shorebird use-days", where one use day is defined as a shorebird present in the area for any part of one day. This definition is similar to the one used in calculating user-days expended by recreationists. We assume below that the objective is to estimate trends in use rather than to estimate the actual amount of use.

Precision in estimating trends in shorebird use is affected by day-to-day variation in numbers present and the fraction of birds that are detected and by the number of surveys. If surveys only cover part of the area used by birds, the survey also affects precision.

Bias in estimating trends in shorebird use results mainly from a change in what fraction of the birds present are detected or from long term changes in what fraction of the birds using the area at all do so during the survey period.

<u>Summary</u>

Distinguishing between precision, which measures the effect of random factors, and bias, which measures the effect of consistent tendencies to over- or under-estimate the quantity of interest, is important because either error may be substantial but standard statistical analyses do not reveal the magnitude of bias. Special efforts must be made in developing shorebird surveys to reduce bias and place upper limits on the magnitude of any remaining bias. In this report, we emphasize three sources of bias: bias caused by long-term changes in detection rates, bias caused by differences between the sampled population and the population of interest, and bias caused by long-term trends in shorebird movements.

Variability in Biological Attributes through the Annual Cycle

This section examines behavioral and population-level attributes that tend to characterize shorebird populations during the nesting season, during migration, and on wintering grounds, and the implications of these attributes for monitoring. Characteristics likely to have positive implications for survey design are listed first in each category, followed by characteristics (in brackets) likely to hamper survey design or feasibility.

<u>Breeding Grounds</u>

- In many species, individual birds may show stronger year-to-year fidelity (philopatry) to breeding sites than they do to wintering sites or migration stopovers (notable exceptions being phalaropes and species preferring ephemeral habitats). Thus, the analyst might have higher confidence that measures of change in breeding populations over a period of years are more representative of true population change than measures of population change at other seasons.

- Populations tend to be stable for longer during the breeding season than at other seasons, because activity is constrained by nest site and brood attentiveness.

- The majority of shorebirds nest in remote arctic and sub-arctic sites where access is difficult and expensive. Because of the remoteness, breeding distribution patterns of some species are poorly delineated.

- Detectability of birds is affected by type of mating system and stage of the nesting season. Some species are most obvious when males are setting up territories and performing flight displays. In polygynous or polyandrous species, the non-incubating sex often leaves nesting areas before the mate. Even in species where both parents incubate, one parent typically leaves the brood one to two weeks earlier than its mate.

- Variation in predation rates can affect persistence of breeders in the survey area, leading to underestimation of actual population. Predation rates on shorebird nests are often inversely correlated with abundance of microtine rodents, whose populations characteristically show substantial annual fluctuations and/or cycles.

- Particularly in larger species with delayed maturation, significant portions of species' populations (including future breeders) may not be present on the breeding grounds.
- In general, the positive factors associated with breeding grounds surveys far outweigh the negative factors for species that breed at middle latitudes and exhibit strong philopatric tendencies.

<u>Wintering Grounds</u>

- In many species, birds are highly concentrated, sometimes allowing access to significant portions of a regional population.

- The primary winter ranges of some species are coastal regions of North America where access is relatively easy.

- The sedentary nature of many wintering populations minimizes counting problems.

- Both adult and juvenile segments of the population can be counted.

- The advantage of accessibility to large winter flocks may be countered by the difficulty of counting birds in large flocks accurately.

- Many species winter in South American locations where logistic and cost considerations may limit accessibility.

- Depending on the sampling method chosen, species with extensive or poorly known ranges or low site fidelity may be difficult to sample effectively.

- Patchy food availability can cause significant and sudden shifts in site use both within and between years. This is especially problematic for migrants in ephemeral, interior habitats.

- The relative importance of positive and negative factors for surveying wintering populations will vary widely by species and locality.

<u>Migration</u>

- For many species, breeding in remote parts of the sub-Arctic or Arctic and wintering to the south of North America, migration periods may be the only time of the year at which the birds are relatively accessible for counting.

- Most important stopover sites in North America are well known.

- The migration period affords an opportunity to recruit volunteer assistance from the thousands of amateur birders in North America who enjoy being in the field during the migration seasons. Many of the most important traditional migration stopovers are located near major human population centers, from which volunteers can be recruited.

- The advantage of accessibility to large winter flocks may be countered by the difficulty of counting birds in large flocks accurately.

- Turnover rates at stopovers are variable and largely unknown.

- Although data are limited, year-to-year fidelity to migration stopovers may be lower than at other seasons.

- Patchy food availability can cause significant and sudden shifts in site use both within and between years. This is especially problematic for migrants in ephemeral, interior habitats.

- In general, the positive factors associated with surveys of migrating populations for the purpose of assessing population change are substantially outweighed by the negative factors.

Bird Counting Methodology

Not only sampling frame, but also choice of method for counting birds at sampling locations can dramatically affect the accuracy of survey results. The reliability of different counting methods, including the effect of differences among observers, has not been adequately investigated and is an important research need identified elsewhere in this Plan. Method of choice will vary widely as a function of sampling design and logistical considerations. Here we present just a few examples of different counting methods and some of the problems associated with each.

<u>Aerial Counting</u>

Disadvantages include poor precision of estimates (ground-truthing is important for improving precision), poor species discrimination, poor visibility of cryptically colored-species, and escape response to aircraft. Information from strategically timed aerial surveys needs to be supplemented by information from other sources for verification. For example, popular perception suggests that a substantial fraction of Red Knots concentrate at Delaware Bay during the northward migration (and clearly this is true in some years). However, there is little information to indicate how consistent this may be from year to year. The available information (e.g. from color band ratios and from aerial surveys) is not in agreement, hinting that usage patterns may vary substantially from year to year. Aerial surveys in remote roadless areas, however, can be much more cost-effective and less complicated logistically than ground-based assessments. (Boat-based surveys in certain instances may permit easier and perhaps more consistent detection of birds than aerial surveys).

<u>Ground-based Counting</u>

Although much smaller segments of local populations can normally be accessed by ground-based counting, this deficiency is compensated to some degree by the opportunity for accurate counting and identifying species clearly. Nonetheless, counting individuals in flocks numbering in the thousands can be extremely difficult and requires experience and training. Ability to make such counts successfully will also vary with topography, sun aspect, and other factors. Birds accessible to the counter can also vary with tidal flux, disturbance by predators, and local movements in response to food availability. These kinds of problems are accentuated in time-constrained sampling designs. All of these factors need to be considered and controlled for to the extent possible in ground-based surveys.

An important factor at migration stopovers is turnover rate (length-of-stay). Numbers of birds passing through stopover sites during migration cannot be accurately assessed without estimates of turnover rates. Capture and marking followed by re-sighting efforts are necessary to determine turnover rates. However, the technique itself can affect length-of-stay and introduce very significant bias into estimates of total population.

IV. History of Shorebird Monitoring in North America

There are several active or recently active bird population surveys in North America that include counts of shorebirds. Some, like the Breeding Bird Survey (BBS) and Christmas Bird Count (CBC), are continent-wide, volunteer-driven, multi-species efforts. The BBS, the only multi-species survey statistically designed to document population change, emphasizes upland habitats. As a result, most species of shorebirds are poorly sampled by the BBS. The CBC covers all habitats but suffers from a lack of statistical design and methodological rigor. At least one ongoing single-species survey, the woodcock singing ground survey, is modeled after the BBS but professionally staffed.

A few existing or recently expired, multi-species surveys target shorebirds specifically: the Maritimes Shorebird Survey (MSS) in eastern Canada, the International Shorebird Survey (ISS) emphasizing the eastern and central United States, and the Pacific Flyway Project (PFP) in the western United States. Because these surveys were not specifically designed to assess long-term population change, their statistical power to detect population change is relatively limited. Nonetheless these surveys have been the most prominent and valuable shorebird surveys in North America and have provided the best clues to population status of the majority of species occurring in the United States.

The ISS and MSS: Migration Surveys Employing Spatio-temporal Sampling

The MSS and ISS, both conducted since 1974, enlist volunteer amateur bird enthusiasts to survey shorebirds during migration. The volunteers select conveniently accessible shorebird stopover sites and conduct species-specific counts of shorebirds at regular intervals following established protocols. The ISS began as a summer/fall survey of southbound migrants and expanded to include a smaller number of spring surveys. The MSS has remained a survey of southbound migrants. Methodologies are very similar, with MSS counts prescribed once every 2 weeks and ISS counts prescribed once every ten days during the migration periods. Cooperators at coastal locations are asked to standardize the times of their counts with respect to tide cycle. Simple categorical information about water levels, disturbance, habitats, land management and ownership also is requested for each site. Both of these surveys provide invaluable information on phenology of migration, habitat preferences, and critical stopover sites. Although neither survey provides regional estimates of total shorebird populations, population trends (proportional change over time) can be calculated for each site and the trends then averaged to derive crude, composite indices to trends for the entire region surveyed.

The designs of the ISS and MSS have two distinct economic advantages: sampling when shorebird populations are sympatric with the largest number of capable surveyors; and making use of competent, volunteer birders willing to donate their time and absorb ancillary expenses. Efficiency is achieved by application of a common methodology to all species that occur in the areas sampled. There are also significant weaknesses in the ISS/MSS approach from a population monitoring perspective: difficulty in enforcing methodological rigor (because volunteers are limited by personal considerations); inconsistent coverage of sites across years; failure to survey important but poorly accessible sites; and variable levels of competency among observers in estimating numbers.

The PFP: Snapshot Estimates of Total Migrating or Wintering Populations

The PFP, conducted between 1988 and 1993, had a fundamentally different goal and design. The goal was to survey all wetlands within a predefined region at approximately the same time (e.g., one weekend or one week) during specific periods such as the peak spring or fall migration, and also in winter. Such "snapshot" or "window" surveys are designed to obtain a single, instantaneous estimate of the total shorebird population in the surveyed region each year. Snapshot surveys may be the best technique for regions where suitable habitat is limited and its distribution variable from year to year. The Central Valley of California, Great Basin of western North America, and prairies of the upper Midwest are good examples of habitats exhibiting these characteristics.

Unlike the ISS and MSS, surveys of this type eliminate the risk of missing significant segments of the population, because observers (theoretically) visit all sites where the birds are believed to be in any given year. Because actual populations are measured, relative abundance of species can also be determined better than in a spatio-temporal sampling scheme. However, significant, logistical obstacles offset these advantages. Administrative burden and cost of organizing the large group of observers necessary to conduct virtually simultaneous counts of birds over a broad geographic area can be prohibitive. Even when economically feasible, predicting where all potential sites containing significant numbers of non-breeding shorebirds will be in a given year is rarely realistic. Furthermore, some sites are typically inaccessible by traditional ground-based methods and have to be surveyed by aerial or other methods that have different levels of precision and accuracy (see above). Finally, because counts are conducted simultaneously, comparisons of populations among years are potentially confounded by variation in migration phenology from year to year.

Strategic Surveys of Major Concentration Sites

Although there have been no long-term surveys of specific critical migration stopovers for very large populations in North

America, for some species this may prove to be the most desirable method of monitoring. Substantial proportions of some shorebird species concentrate at strategic sites during non-breeding seasons. Well-timed and well-executed aerial surveys or combinations of systematic, low-level aerial surveys and boat and ground surveys, have met with some success. A good example is aerial surveys of Delaware Bay shores during spring migration (Clark et al, 1993). Also, work by Bishop and Warnock (1998) has documented that as much as 80% of the Pacific Flyway population of Western Sandpipers stop at the Copper River Delta in a given year. Bishop noted that four key variables of migration can be used to estimate the total abundance of a species passing through an area. They include: 1) daily abundance determined from aerial surveys 2-3 days, combined with point counts that provide % composition, 2) total days of spring migration from aerial and point counts every, 3) average length of stay, and 4) sighting probability. Strategic, low-altitude aerial surveys offer the advantage of reducing a census period to a short time (e.g. a particular tidal stage) over a broad area. Disadvantages of aerial surveys have been noted above.

Single-Species Monitoring Programs

There are few single-species surveys currently in place designed to monitor shorebird populations. The majority of single species surveys have focused on federally listed species (Hawaiian Black-necked Stilt, Piping Plover, Snowy Plover), game birds (American Woodcock), or other species of concern (Bristle-thighed Curlew), with surveys generally being done during the breeding period. Census methodologies for these surveys have varied. Piping Plover populations are counted in their entirety by visiting and searching all known breeding areas, and specific populations of Snowy Plovers are counted using the same methods. American Woodcocks are monitored using a modified BBS survey methodology by driving routes at dusk and listening for displaying males. One non-breeding shorebird monitoring effort has been an 18-year survey of migrating Wilson's Phalaropes staging at Mono Lake, CA, in the fall.

Recent Progress Toward Improving Shorebird Monitoring Capability

To help identify more sensitive options for tracking shorebird population change, a group of shorebird biologists and statisticians met in Quebec City, Canada in 1992. The principal recommendation from this meeting was to initiate a monitoring program that would combine the best features of spatio-temporal and snapshot surveys. The goal was to have an annual, continentally orchestrated, simultaneous count at major shorebird stopovers throughout the U.S. and Canada, supplemented by repeated counts at selected sites for the purpose of calibrating annual differences in migration phenology. This proposal was not universally accepted, because of the focus on the migration period and the problems associated with analysis of migrating populations (see below).

V. Proposed Monitoring Program

Shorebirds are monitored at present primarily by the International Shorebird Survey (ISS) with additional information on a few species being provided by the Breeding Bird Survey and specialized surveys. At the first few meetings of the Monitoring Committee, the first three goals described earlier in this report were established, and those in attendance expressed the view that the existing surveys do not provide the information needed to achieve these goals. Special attention was given to the goal of monitoring trends in population size. A detailed power analysis, particularly of the ISS data, was recommended to investigate how well the current programs are achieving this goal. The analysis showed that precision for many of the trend estimates is acceptable (Appendix 1). Although there are no empirical data, several sources of bias in trend estimation are possible.

The Monitoring Committee has developed a series of recommendations for monitoring species not covered adequately by current surveys. A list of 72 taxa that require separate management was developed for this effort. It includes all currently recognized subspecies and a few distinct populations (Appendix 2). The suggestions for how best to survey each taxon represent the collective judgment of numerous shorebird experts and provide much useful information about how to improve shorebird monitoring in North America. The Monitoring Committee recognizes, however, that detailed assessments will need to be carried out before the best mix of surveys can be identified. A five-year assessment program is thus proposed to investigate these issues. Included in this assessment is a thorough evaluation of the potential of the Breeding Bird Survey and Christmas Bird Count to monitor populations of additional shorebird species.

To determine how well the comprehensive program would accomplish the goals of the monitoring plan, a judgment was made for each taxon of how well the current and proposed protocols would meet each of the first three major goals of the program (Table 1). We classified a taxon as "well monitored" if the surveys provided medium or high ability to meet all goals 1-3. At present, only two species (snowy plover, piping plover) meet the "well monitored" threshold. Implementation of the comprehensive program will raise the number of well-monitored taxa to 63 (88%). Summaries of these analyses are presented in Tables 1 and 2. The detailed descriptions of each protocol are provided in Appendix 3.

Table 1. Summary of how well the proposed set of monitoring protocols would meet the program goals 1-3 for each of the 72 shorebird taxa.

Ability of the proposed program to achieve the goals	Goal		
	Estimate population trend (% of taxa)	Estimate population size (% of taxa)	Monitor shorebird numbers at major non-breeding areas (% of taxa)
None	0%	0%	2%
Little	7%	0%	6%
Medium	78%	83%	70%
High	22%	17%	22%

Taken together, the existing and proposed surveys will provide a comprehensive monitoring and assessment program with three major elements:

1. Surveys of temperate breeding species on their breeding grounds during the breeding season to estimate population size and monitor trends in population size (protocols 1, 2, 4, 5, 7, 10, 15, 24, perhaps combined into a few multi-species programs)

2. Surveys of major staging, migration, and wintering areas to monitor use at these sites and provide estimates of change in population size; will involve an expanded ISS (protocol 27) that covers the entire United States and all habitats (e.g., rocky shores, prairie potholes) and that will be supplemented as necessary by species-specific protocols (3, 6-9, 11, 12, 14-23, 25, 26).

3. An initial survey of northern-breeding species on their breeding grounds to estimate population size, followed by periodic follow-up surveys to assess disturbing trends suggested by staging-migration-wintering surveys.

The rationale underlying this scenario is that breeding populations can best be studied during the breeding season, on the breeding grounds. At this time, populations are stable rather than mobile, surveys are relatively straightforward because the birds are dispersed, and extrapolation from sampled plots to the entire population can be made using standard methods from classical sampling theory. This approach works well in temperate latitudes and northern areas where access is feasible. In more remote, high latitudes areas gaining access is difficult and costly. In such areas, a reasonable approach may be to conduct an initial survey on the breeding grounds to obtain estimates of population size and then to rely on opportunistic data collection from this area and on systematic surveys on staging, migrating, and wintering birds at lower latitudes, where access is reasonably easy, to provide indications of population declines. When such warning signs appear, or at intervals of, say, every 20 years, the breeding ground survey can be repeated to get updated population sizes and thus estimates of change in population size. This approach avoids the high cost of annual surveys in remote northern areas but also avoids complete reliance on trend estimates from the non-breeding grounds where several difficult sources of bias are possible (Appendix 1). The staging-migration-wintering surveys would also permit monitoring use at major stop-over sites. Thus in combination these three types of surveys will provide comprehensive information on shorebird populations in North America.

Specifically, this proposed program will yield reliable estimates of population size, trend in population size, and use of major staging, migration, and wintering sites for all or most of the 72 shorebird taxa that warrant separate consideration from managers.

Table 2. Ability of the proposed surveys to achieve the monitoring goals (0 = no data collected, 1 = little ability, 2 = moderate ability, 3 = high ability). Protocols that will cover each taxon are shown at the right. Numbers correspond to protocol numbers (Appendix 3). Bold numbers indicate protocols that are designed specifically for the taxon indicated at the left side of the table.

Species (common name)	Species (scientific name)	Estimate Population Size	Monitor Population Trend	Monitor Stopover Populations[a]	Protocols (Appendix III)
Black-bellied Plover	*Pluvialis s. squatarola*	2	2	2	16,30
	P. s. cynosurae	2	2	3	19,27,30
Pacific Golden Plover	*Pluvialis fulva*	2	2	1	**3**,13,16,30
American Golden Plover	*Pluvialis dominica*	2	2	2	13,27,30
Snowy Plover	*Charadrius alexandrinus nivosus*	3	3	3	**1,** 2, 22
	C. a. nivosus	3	3	2	**1**
	C. a. tenuirostris	3	3	2	**1**, 2
Wilson's Plover	*Charadrius wilsonia*	3	3	2	2,**4**
Semipalmated Plover	*Charadrius semipalmatus*	2	2	2	27
Piping Plover	*Charadrius m. melodus*	3	3	3	**2**,10
	C. m. circumcinctus Great Lakes	3	3	3	**2**
	C. m. circumcinctus Great Plains	3	3	3	**2**
Killdeer	*Charadrius vociferus*	2	2	3	27,28
Mountain Plover	*Charadrius montanus*	3	3	2	**5**
American Oystercatcher	*Haematopus p. palliatus*	2	2	3	**6**,10,27
Black Oystercatcher	*Haematopus bachmani*	2	3	3	**7**
Black-necked Stilt	*Himantopus mexicanus*	2	2	2	**8**,9,27,28
	H. m. knudseni	2	2	2	**8**
American Avocet	*Recurvirostra americana*	2	2	2	8,**9**,25,27,28
Lesser Yellowlegs	*Tringa flavipes*	2	2	2	27
Greater Yellowlegs	*Tringa melanoleuca*	2	2	2	27
Solitary Sandpiper	*Tringa s. solitara*	2	2	NA	27
	T. s. cinnamomea	2	2	2	27

Willet	*Catoptrophorus s. semipalmatus*	3	3	2	**10**,19,27, 28
	C. s. inornatus	2	2	2	**11**,27,28
Spotted Sandpiper	*Actitis macularia*	2	2	NA	27,28
Upland Sandpiper	*Bartramia longicauda*	2	2	2	27,28
Wandering Tattler	*Heteroscelus incanus*	2	2	NA	**12**
Bristle-thighed Curlew	*Numenius tahitiensis*	3	3	0	**13**,30
Whimbrel	*Numenius phaeopus hudsonicus*	2	2	2	**14**,19,27, 30
	N. p. rufiventris	2	2	2	13,27,30
Long-billed Curlew	*Numenius americanus*	2	2	2	11,**15**,28
Bar-tailed Godwit	*Limosa limosa baueri*	2	2	2	13,**16**,30
Hudsonian Godwit	*Limosa haemastica* (Alaska)	2	2	2	**17**,27
	Limosa haemastica (Canada)	2	2	2	**17**,27
Marbled Godwit	*Limosa f. fedoa* (Great Plains)	1	2	2	6, 9,**11**,28
	L. f. fedoa (Canada)	1	2	2	27
	L. f. beringiae	2	2	2	**11**,16,27
Black Turnstone	*Arenaria melanocephala*	2	2	2	**18**,20,27
Ruddy Turnstone	*Arenaria i. interpres*	2	2	2	30
	A. i. interpres	2	2	NA	30
	A. i. morinella	2	2	2	**19**,27
Surfbird	*Aphriza virgata*	2	2	2	**20**,27
Rock Sandpiper	*Calidris ptilocnemis tschuktschorum*	1	2	2	16,**21**,27
	C. p. ptilocnemis	2	2	2	**21**,30
	C. p. cousei	1	2	1	**21**,30
Purple Sandpiper	*Calidris m. maritima*	2	2	NA	30
	C. m. belcheri	2	2	1	27,29,30
Red Knot	*Calidris canutus rufa*	2	2	2	17,**19**,27, 30
	C. c. islandica	2	2	NA	30
	C. c. roselarri	1	2	2	6,27
Sanderling	*Calidris alba*	2	2	3	**19**,**22**,27, 30
Semipalmated Sandpiper	*Calidris pusilla*	2	2	3	18,19,27, 30
Western	*Calidris mauri*	2	2	3	**23**,27,30

Sandpiper					
Least Sandpiper	*Calidris minutilla*	2	2	2	11,27,30
White-rumped Sandpiper	*Calidris fuscicollis*	2	2	2	17,27,30
Baird's Sandpiper	*Calidris bairdii*	2	2	2	27,30
Pectoral Sandpiper	*Calidris melanotos*	2	2	2	27,30
Dunlin	*Calidris alpina pacifica*	2	2	3	**11**,16,18, 23,27,30
	C. a. arcticola	2	2	NA	30
	C. a. hudsonia	2	2	2	6,27,29,30
Stilt Sandpiper	*Calidris himantopus*	2	2	2	27,30
Buff-breasted Sandpiper.	*Tryngites subruficollis*	2	2	2	27,30
Short-billed Dowitcher	*Limnodromus g. griseus*	2	2	2	6,27,30
	L. g. hendersoni	2	2	2	27,30
	L. g. caurinus	2	2	2	11,23,27, 30
Long-billed Dowitcher	*Limnodromus scolopaceus*	2	2	3	11,27,30
Common Snipe	*Gallinago gallinago*	2	2	3	28,30
American Woodcock	*Scolopax minor*	3	3	NA	**24**
Wilson's Phalarope	*Phalaropus tricolor*	2	2	2	8,9,**25**,27,28
Red-necked Phalarope	*Phalaropus lobatus*	2	2	2	8,9,18,**26**,27,30
Red Phalarope	*Phalaropus fulicaria*	2	2	1	**26**,30

[a] In the United States and Canada (NA = not applicable).

VI. Research Needs Related to Monitoring

The development of a long-term monitoring plan for shorebirds has been somewhat hampered by the lack of systematic research into the factors that affect our ability to monitor these birds. Here, we identify key areas where research would enhance the effective monitoring of a wide range of shorebird species. In addition, there are a number of specific problems that relate to individual species. These are identified in the monitoring protocols for each species (Appendix 3).

Missing information

- Delineate species ranges. Although the outer limits of species ranges are well known for most shorebirds, the fine-scale details of ranges are often poorly known. Refining our knowledge of range boundaries and incorporating this information into a Geographic Information System would greatly enhance the design of monitoring sampling schemes.

- Identify distinct populations. Many shorebird species have disjunct populations which may warrant separate consideration in future conservation planning. Unfortunately, current knowledge of within-species variation is limited in scope. Identifying distinct populations that differ in terms of genetics, distribution, or migratory pathway and delineating their boundaries would allow more effective shorebird conservation.

- Conduct a thorough analysis of existing data to estimate trends. Several data sets exist, most notably from the ISS, which could be used to obtain better estimates of current and recent trends in shorebird population size. These data sets should be subjected to a comprehensive and rigorous analysis to insure that we have the best possible information on regional and population-wide trends in abundance.

- Determine lengths of stay (turnover rates). Logistically, many shorebird species can be monitored most easily during migration. Unfortunately, migration studies may be particularly prone to biases because apparent population sizes can be greatly influenced by the length of time individuals spend at particular sites. A comprehensive understanding of the factors influencing turnover rates is needed to fully evaluate the potential for monitoring during migration. Turnover studies also could provide an index of habitat quality at migration sites. In a similar vein, the effect of turnover on monitoring projects at wintering sites is a concern that could be addressed through studies of site fidelity.

- Estimate changes in the fraction of a population entering the study area during the study period. Many protocols assume that there is no long-term trend in the fraction of the population being monitored that is in the study area during the study period. Determining ways in which this assumption can be efficiently tested would increase confidence in the results of the monitoring protocols.

- Assess counting errors and their effects. Counting shorebirds is a complex process, because they often occur in very large flocks and are constantly on the move. Consequently, counting errors are inevitable. Three classes of error exist: miscounts of flocks that have been detected, failure to detect entire flocks, and duplicate-counting of flocks that have been previously counted. Very little is known about the magnitude of these errors or about their influence on trend detection and population estimates. Field studies to estimate errors in different situations combined with computer modeling to determine the effects of these errors on trend detection would facilitate the interpretation of monitoring results.

- Monitor survival and reproduction. Population trends are determined by birth and death rates. If studies can be designed to detect changes in these variables they could be used to predict and explain trends; detecting small but significant changes however may be very difficult. The collection of data on these demographic variables sometimes can be obtained in conjunction with studies aimed at monitoring population trends and size. Exploring the potential for studies to incorporate estimates of productivity and survival may provide supplemental information that enhances the effectiveness of the monitoring plan and provides early direction for attempts to rectify population declines.

Identification of key shorebird sites

- Develop monitoring sampling frames. The ability of many monitoring protocols to adequately detect population changes depends on how well the sites sampled represent the entire suite of sites where a species occurs. In order to ensure that a representative sample of sites is surveyed it is necessary to develop a complete inventory of all sites where shorebirds occur.
- Improve effectiveness of WHSRN site criteria. Effective shorebird monitoring and conservation requires the identification of key shorebird sites. The Western Hemisphere Shorebird Reserve Network provides an effective mechanism for identifying discrete sites where shorebirds concentrate. Many important areas, however, may not be recognized by the current scheme because they support species that do not concentrate at clearly defined sites or that use ephemeral habitats which shift from year to year. Studies that evaluate the relative importance of different geographic areas, perhaps identified on a grid, by comparing density, productivity, etc. would facilitate the development of appropriate criteria for identifying these sites.

Evaluating Existing Methods

- Estimate precision and bias of different surveys. In general, monitoring schemes that maximize precision while minimizing bias should be preferred over alternatives (see Section III). Detailed analyses of the precision of migration surveys have been conducted, but similar studies for breeding and wintering surveys have not. There are also few estimates of the biases associated with each survey type. Additional statistical analyses to fill these gaps would allow different survey types to be compared directly, facilitating the development of effective broad-brush surveys and, perhaps, reducing the need for some single-species protocols.

- Evaluate the Breeding Bird Survey and Christmas Bird Counts. A thorough analysis of the potential of either of these surveys, in present or expanded/modified form, to yield useful population trend information for shorebirds species -- in addition to those for which these surveys are presently the survey of choice (Appendix 3) -- should be undertaken. This is especially needed for the BBS, for species such as western willets, marbled godwits, and long-billed curlews, which nest in interior locations at temperate latitudes.

- Model migration dynamics. Determining how effectively different sampling schemes can characterize population trends is difficult to do using data from field studies because independent estimates of the true population trends are rarely known. Computer models that simulate shorebird movement patterns and human monitoring protocols provide an alternative option for comparing methods because the true population trend can be determined exactly. Exploring this approach may improve our ability to assess the relative merits of different monitoring schemes.

Development of new methods

- Use habitat data to determine sampling schemes. The increasing availability of detailed habitat information through remote sensing and other techniques provides potential opportunities to more effectively design sampling schemes. This approach may be particularly useful in regions where the location of suitable habitat is constantly changing. Exploring the potential of these techniques could not only reduce biases and increase the viability of less expensive alternatives but also facilitate quantitative assessment of the relationship between habitat change and population change.

- Estimate population size. Much work needs to be done to refine population estimates, especially for taxonomic units below the species level. The development of new and improved techniques for determining population size is thus needed. One option may be to integrate field surveys with remote sensing studies to develop and validate methods for estimating abundance in areas that cannot be surveyed directly. Improved population size estimates would help with prioritizing shorebird conservation actions.

- Develop new technology. In recent years, the introduction of new technological options has opened up several new avenues for improving monitoring techniques. For example, new genetic methods have improved our ability to identify discrete shorebird populations; satellite telemetry holds promise for improving our knowledge of migratory pathways, staging sites, and species ranges; and, remote sensing methods may help in many ways (see above). Future developments in these and other areas of technology should be scrutinized for their potential to enhance shorebird monitoring efforts.

VII. Implementation Strategy

Development and Implementation of Surveys

Appendix 3 of this Plan identifies 32 different potential surveys at various geographic scales that, collectively, would constitute the most effective and comprehensive national shorebird monitoring program as envisioned by national shorebird experts. Although a few of these proposed surveys are fully designed, most are now only conceptual in nature and need much statistical and methodological development. Once developed and peer-reviewed, the goal is for a qualified agency or organization to implement each survey and commit to its long-term operation and management.

The conceptual framework for proceeding with development and implementation of monitoring protocols is envisioned as follows:

1. A solicitation of competitive proposals to address either development alone, or both development and implementation (2-stage proposal), of one or more of the monitoring protocols prescribed in the Plan. Proposals will also be accepted to conduct more generic research on issues such as population estimation, statistical design, methodological biases, simulation modeling, etc., that bear on all surveys or certain categories of surveys. Applicants from both government and non-government sectors will be eligible.

2. Independent, scientific/statistical peer-review of final survey designs produced by grant recipients.

3. In the case of approved protocols from "2-stage" awardees, a follow-on award to implement the survey, or a request to the contractor for additional information to support their qualifications for managing the monitoring program(s).

4. In cases of "development only" proposals from the first round, a second round of competitive solicitations of proposals for operation and management of surveys using the approved protocols.

5. Ongoing support for research efforts designed to improve the effectiveness of survey design and field methods, including incorporation of new technology for incorporating habitat monitoring into survey design and analysis.

Data Management and Delivery

Centralization of databases from broad geographic population monitoring programs is key to minimizing data management costs, ensuring the structural compatibility of related databases, and maximizing accessibility to users. The USGS Patuxent Wildlife Research Center (Patuxent) is developing a national bird population data center well suited to housing the databases that will accumulate from the monitoring programs proposed here. The national Breeding Bird Survey (BBS) database, regional colonial waterbird databases, and the Partners-in-Flight point count databases are examples of the kinds of population data that are already or will soon be housed at Patuxent.

Software will also be developed by Patuxent to enable remote data entry through the Internet. All databases will be web-available for inspection, downloading, and conducting certain on-line analyses by scientists, managers, and the general public. These features have been implemented for the BBS. They have proven to greatly reduce data processing and management costs. Patuxent will also conduct the population trend analyses and related products most in demand by wildlife managers and make them available on a public web site. Analytical results important for conservation policy and management decisions will be transmitted to the Shorebird Monitoring Working Group (see below) and to appropriate management agencies and organizations.

Shorebird Monitoring Working Group

A Shorebird Monitoring Working Group (Group) comprised of experts in shorebird biology or survey technology or both will be established under the National Shorebird Management Plan. The responsibility of the Group will be to continually take stock of shorebird population status and periodically reassess conservation priorities and the comprehensiveness and performance of monitoring programs implemented by this Plan. The Group will also serve as a source of expertise for providing or arranging provision of technical assistance in shorebird monitoring to wildlife managers.

Interface with NABCI and Local/Regional Bird Management Programs

In most cases, land management policies and actions are the means of achieving conservation goals for shorebirds and other species. Monitoring is a fundamental tool for assessing whether recommended policies and management programs are being effective. Therefore, in addition to bringing important information on long-term population change to the attention of managers and policy-makers, it is crucial that shorebird-monitoring experts make their collective knowledge of survey design and field methodology available to local and regional wildlife managers as assessment tools. Integrated bird conservation at the level of the NABCI bird conservation region (including highly coordinated joint venture activities) will be the primary driving force in North American bird conservation in the future. NABCI will provide the logical framework for implementing shorebird conservation, including its monitoring components.

The Group will provide a representative to the U.S. NABCI Monitoring Subcommittee (Subcommittee). This Subcommittee will be the most effective conduit for assuring that shorebird monitoring needs are included prominently in the national bird conservation dialogue fostered by NABCI. It will also serve as a forum for coordination of monitoring efforts among various taxon interest groups and coordination of shorebird monitoring efforts between the U.S., Canada, and Mexico. The Subcommittee will also be an important source of information for the Group. The Subcommittee can inform the Group of developing joint ventures and other local and regional bird conservation developments in need of shorebird monitoring guidance. Members of the Group will initiate contact with managers in the field to discuss these monitoring needs and take steps to assure that monitoring programs are properly designed and implemented.

VIII. Literature Cited

(Note: Citations include those referenced in the proposed monitoring protocols, Appendix III)

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Appendix One: A Quantitative Analysis of Shorebird Monitoring Programs

September 1999

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Summary

A large data set describing shorebird distribution and abundance in the United States was analyzed to investigate how best to monitor shorebirds. Optimal timing for the monitoring period was investigated for each of 25 regions that together covered the coterminous United States. A two-month period was defined for each region. Most of the periods were in late summer and early fall. Analytic methods were developed to estimate trends and their standard errors and to carry out power analyses. Estimates of trend in the mean number of birds recorded per survey, during the proposed survey intervals, were prepared for 37 shorebird species. Standard errors were obtained for each estimate. Bias was investigated by study of the data set and comparison of trend estimates from it with estimates from the Breeding Bird Survey. Major conclusions and recommendations were:

1. Precision of estimated trends based on the current data set is adequate for many purposes and can probably be improved. Standard errors of the estimated annual rate of change in mean number recorded per survey for the 37 species were largely in the 0.01-0.03 range. With improvements in sampling and analytic methods, they can be brought below 0.02 for most species, an acceptable level of precision.

2. Estimates based on the current data set are subject to large biases which make them unreliable despite their adequate precision. A comparison of the trend estimates obtained in this study and estimates from the Breeding Bird Survey showed wide disagreement, and in four cases the estimates obtained in this study were clearly unrealistic. Changes in which sites are surveyed each year appear to be the most serious source of bias but other major sources cannot be ruled out.

3. The potential bias can probably be reduced to acceptable levels. The most important tasks are developing a comprehensive list of shorebird concentration sites to serve as a sampling frame for the monitoring program and insuring that most sites are surveyed in most years. Other tasks include preparing and up-dating site descriptions, and implementing a training program for observers.

4. A well-designed monitoring program during the non-breeding period is feasible and would be useful in many ways. Such a program would reveal large-scale changes in where shorebirds spend the migration and wintering periods, help identify habitat declines at the monitored sites and provide information on movement patterns. Pilot studies for such a program could begin in 2000.

5. A program of surveys on the breeding grounds should be evaluated to augment results from the non-breeding period. Despite the utility of surveys during the non-breeding period, they probably cannot ever provide reliable estimates of change in size of the breeding population. Full confidence in the estimates would require that changes in movement behavior be excluded as the cause of the trend in numbers recorded per survey. Some indication of whether such changes occurred might be obtained through banding studies, but it is difficult to see how the movements hypothesis could ever be fully excluded.

6. The five conclusions above should be reviewed by the FWS and the Research and Monitoring Working Group for the US Shorebird Conservation Plan. The conclusions above lead to several additional tasks, most notably preparing a comprehensive list of shorebird concentration sites and evaluating the feasibility of surveys on the breeding grounds. Current funding is sufficient to carry out the needed analyses but it is important that whatever course is followed for the rest of the project be supported by the sponsor and by shorebird specialists.

Introduction

This Report, prepared under a contract from the USFWS, contains recommendations for monitoring shorebird populations in North America north of Mexico. The goal of the monitoring program is assumed to be estimating temporal trend in size of the breeding populations of as many species as possible. The recommendations are based on analyses of a large data set kindly provided to me by Drs. Brian Harrington of Manomet and Susan Skagen of the USGS in Colorado.

I assume that concentration sites are surveyed up to several times and used to estimate the mean number of birds present at the site during the study period. The estimates are then combined to yield an estimate of the average number of birds present during the study period throughout the study area and this estimate is used as an index to population size on the breeding grounds. I also examine the desirability of using peak counts instead of means.

The general issue of how reliable we might expect such an index to be can be divided into three topics that I regard as roughly equal in importance:

1. Precision of sample means/survey
2. Bias in sample means/survey as an index to the true means/survey
3. Reliability of the true means/survey as an index to size of the breeding population

These topics are used as the major headings in this report.

Data Used in the Analysis

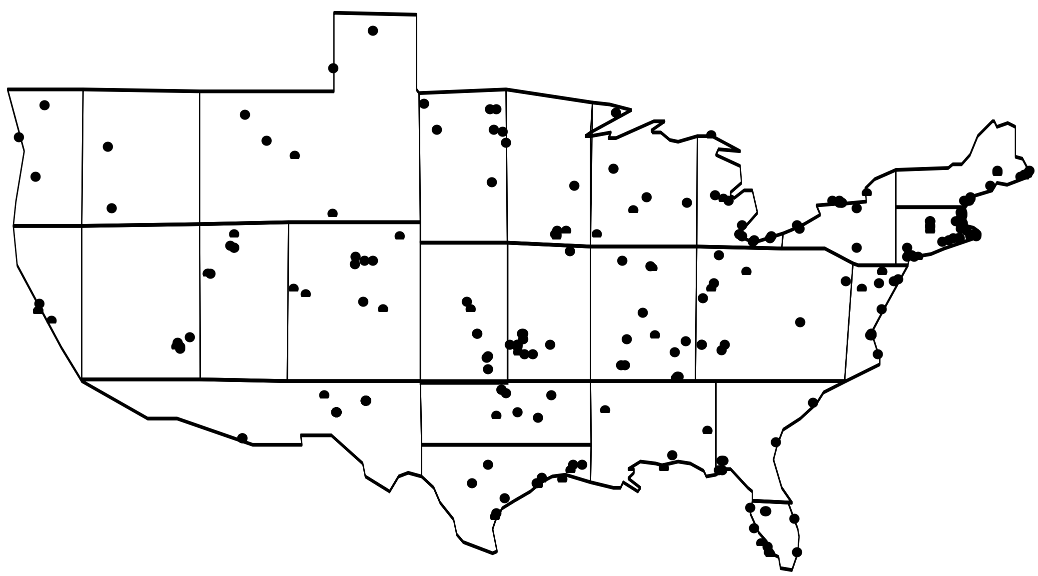


Figure 1. Stratum borders and sites used to define the monitoring periods.

Each record in the data set provided by Drs. Harrington and Skagen (referred to below as the ISS-Skagen data set) includes the number of each shorebird species recorded during one survey of a site. I removed duplicate records and records from outside the coterminous United States and Canada. This left 70,266 records collected mainly during 1975-98 throughout the United States.

I assumed that surveys would be carried out in a fairly brief period, for example 1 to 2 months, and that the period should be approximately the same throughout the study area but (like the Breeding Bird Survey) could be adjusted to account for latitudinal differences.

To explore when the surveys should be conducted I identified sites and years in which at least 20 surveys were carried out during January-June or July-December (or in both periods). This provided a sample of 22,019 records from 269 sites, well-distributed across the study area (Fig. 1). I sub-divided the study area into 25 regions based on the locations of the sites (I would have liked to use the regions delineated by the Research and Monitoring group but their regions were too large and their sub-regions were too small for this analysis).

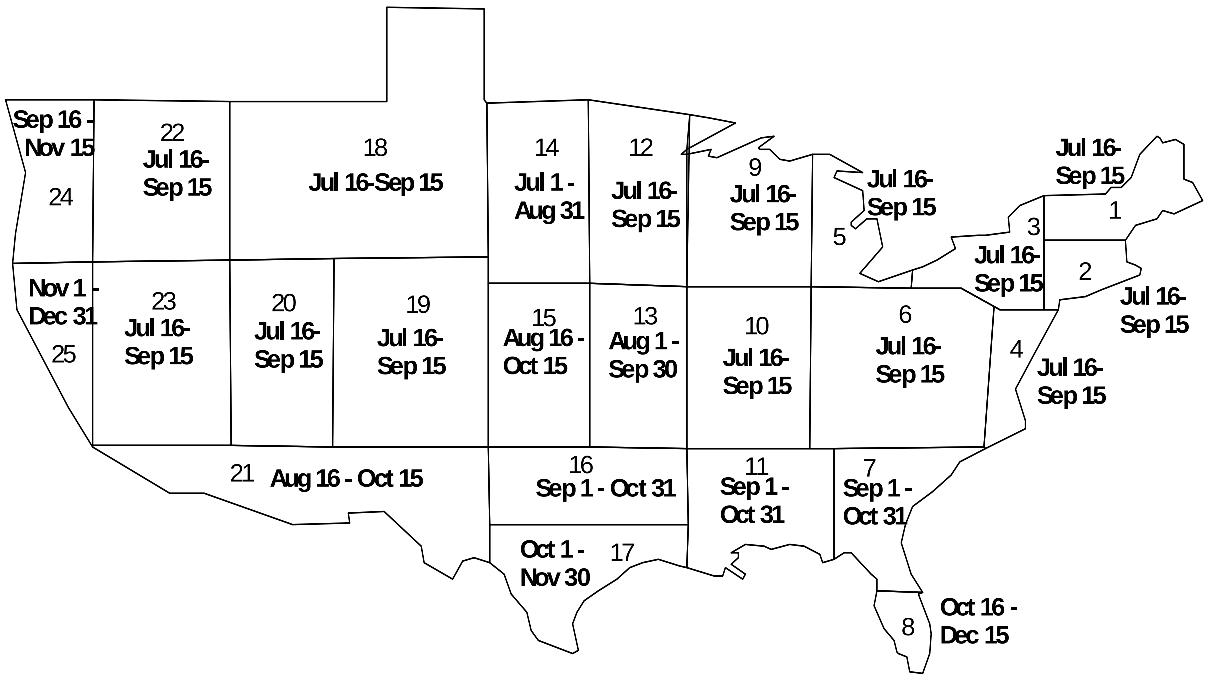


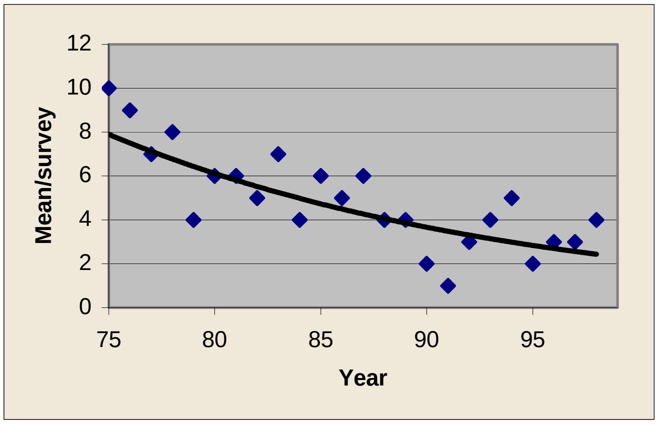
Figure 2. Survey periods used in each stratum (stratum numbers are also shown).

I then calculated the mean number of shorebirds per survey during each month in each region (weighting means per site and years within sites equally). For each species, I identified the two-month period (starting on the month or half-month) in each region during which the maximum number of individuals/survey was recorded. I then combined results across species, identifying the two-month period which captured the most species-specific intervals. Finally, I examined how variable the results were between regions. In all but three regions, the best period was late summer or fall and I therefore selected late summer or the fall as the monitoring period. In most regions this was July 15 to September 15 but it was somewhat later in the southern and western parts of the United States (Fig. 2). Although I carried out this analysis so that I could prepare the rest of the report, it seems possible that the results will be of value in other contexts. The tables for each species are contained in Appendix 1. Appendix 2 provides figures for each species, each figure containing 12 maps of the study area, one for each month, with mean number recorded per survey.

Estimation Method

Suppose that several sites are surveyed one or more times during each of several years and we compute the average number of birds recorded per survey. Methods for making these estimates are discussed below; for now I focus on how to estimate the long-term trend given several years of such estimates $\bar{y}_j$, $j = 1,...,L$ where L = the number of years.

Figure 3. Fitting an exponential curve to annual means/curve.



One approach for estimating the trend is to fit a first-order, exponential curve to the annual estimates as shown below. The usual method for doing this (least squares estimation) is to find values, b_o and b_1, such that the curve

$$\hat{Y}_j = e^{b_o + b_1 X_j}$$

minimizes the sum of the squared deviations,

$$\sum_j^L (\bar{y}_j - \hat{Y}_j)^2,$$

between the observed values, $\bar{y}_j$, and the predicted values, $\hat{Y}_j$. The formulas for the coefficients are

$$b_1 = \frac{cov(X_j, \ln \bar{y}_j)}{Var(X_j)}$$

$$b_o = \left(\frac{1}{L} \sum_j^L \ln \bar{y}_j \right) - b_1 \bar{X}$$

where the X_j are the years (e.g., in my analysis X_1 = 1975).

The estimated trend, using the approach above, is exp(b_1). The trend is the annual rate of change in population size. For example, a value of 1.03 means an increase of 3% per year, and 0.98 means a decline of 2% per year.

This approach is slightly different from the "route regression" methods used to analyze Breeding Bird Survey data, but it gives similar results and is used here because it seems to provide a better foundation for carrying out power calculations.

Precision of Sample Means Per Survey

This section provides estimates of the standard errors (SE) of trends in the mean number of shorebirds recorded/survey. The objective was to determine whether the program is providing information of sufficient precision to be useful. If the standard error of the trend estimate is 0.02 then the 95% confidence interval is about 0.04 so an estimated trend of 0.96 (i.e., a 4% decline per year) would be just significant. To put this decline in perspective, if a population declined at 4%/year it would decline by 56% in 20 years. Thus an estimate that the population had declined by 56% in 20 years would be just significant (at the 5% level) if the standard error was 0.02. This seems like a minimum level of precision.

Table 1. Declines that would be just significant with various standard errors.

Standard error (SE)	Maximum significant annual decline	Decline during 20 years
0.005	0.99	18%
0.01	0.98	33%
0.02	0.96	56%
0.025	0.95	64%

A few other values for just significant declines are given in Table 1. If the standard error was >0.025 then even a 64% decline in a 20-year data set would not be significant. If the standard error was less than 0.01, then quite small declines would be significant.

Such a high level of precision is nice, of course, but it is questionable whether conservation action would (or should) be taken due to population declines of less than 30-40%. If achieving this high level of precision requires scarce resources then it might be

argued that they should be used for other needs. Thus, a reasonable goal for precision in the shorebird monitoring program seems to be that standard errors of the trend for a 20-year data set should be in the 0.01 to 0.02 range.

The methods described above (see *Estimation Method*) were used to estimate trends from a subset of the ISS-Skagen data set. I restricted the analysis to (1) sites that were visited 3^+ times in 3^+ years and at which the mean number of individuals per survey was $\geq$ 1.0 (except for Wilson's plover for which I used 0.1) and (2) years in which 5^+ such sites were surveyed. This subset of the data included 11,680 records at 209 sites. Trend estimates and their standard errors were obtained for 37 species (Table 2). Estimated standard errors varied from 0.0 to 0.047; 16 of them were $\leq$0.02 (Appendix 3 describes the methods; Appendix 4 provides the annual means/survey for each species). The existing program is thus achieving reasonably good precision even when a fairly small subset of the data is analyzed.

Eleven species were not recorded frequently enough for inclusion in the current analysis, and I investigated the feasibility of including them in the future (Table 3). Two species (mountain plover, purple sandpiper) can probably be included though purple sandpiper would require a special survey outside the proposed monitoring periods. Four species (black oystercatcher, black turnstone, surfbird, rock sandpiper) could probably be included if surveys of rocky coastlines in the western United States and Canada are feasible. Three species (Pacific golden-plover, bar-tailed godwit, red phalarope) probably cannot be included though it is possible that useful information on them might be obtained in California (during the proposed survey period). If the study area was extended to Hawaii, Guam, and perhaps elsewhere in the south Pacific then these species might be included. The final species, American woodcock, is probably not worth including because it would take a special effort and is covered by the BBS and other programs.

Table 2. Shorebird trend estimates based on a subset[a] of the ISS-Skagen data set.

Species	Sites	Mn birds/ survey	No. of records	Estimated trend	SE	Potential SE[b]
Black-bellied Plover	100	76	362,464	0.978	0.019	0.008
Lesser Golden-Plover	12	5	3,735	0.988	0.016	0.018
Snowy Plover	22	22	18,928	1.163	0.013	0.013
Wilson's Plover	15	3	1,728	0.986	0.025	0.017
Semipalmated Plover	130	59	453,134	1.006	0.026	0.007
Piping Plover	32	7	11,166	1.005	0.025	0.009
Killdeer	133	34	276,842	0.999	0.000	0.009
American Oystercatcher	19	15	17,427	1.034	0.028	0.011
Black-necked Stilt	24	496	553,804	1.688	0.033	0.018
American Avocet	44	474	1,007,639	1.152	0.042	0.013
Lesser Yellowlegs	109	18	106,477	1.022	0.029	0.007
Greater Yellowlegs	13	10	8,898	1.060	0.012	0.018
Solitary Sandpiper	28	5	10,032	0.945	0.018	0.009
Willet	56	20	46,920	0.940	0.028	0.009
Spotted Sandpiper	83	4	24,128	0.983	0.010	0.005
Upland Sandpiper	7	2	1,265	1.061	0.002	0.019
Whimbrel	15	14	13,649	0.995	0.025	0.014
Long-billed Curlew	9	2	750	1.207	0.011	0.016
Hudsonian Godwit	10	77	57,329	1.073	0.014	0.018
Marbled Godwit	30	233	262,622	1.375	0.028	0.015
Ruddy Turnstone	76	18	73,059	0.984	0.015	0.007
Red Knot	41	124	272,118	0.939	0.016	0.010
Sanderling	110	146	882,397	1.023	0.000	0.009
Semipalmated Sandpiper	147	263	2,339,622	0.965	0.022	0.008
Western Sandpiper	88	142	582,303	0.981	0.047	0.013
Least Sandpiper	169	94	904,083	0.976	0.037	0.011
White-rumped Sandpiper	22	5	8,499	1.069	0.022	0.012
Baird's Sandpiper	41	45	108,179	0.924	0.037	0.014
Pectoral Sandpiper	86	64	381,861	1.008	0.024	0.012
Dunlin	43	97	160,633	1.021	0.033	0.013
Stilt Sandpiper	71	106	434,545	0.916	0.035	0.014
Buff-breasted Sandpiper	18	4	4,329	0.941	0.015	0.015
Short-billed Dowitcher	88	79	412,933	0.980	0.015	0.010
Long-billed Dowitcher	48	247	654,520	0.972	0.040	0.016
Common Snipe	27	6	7,337	1.026	0.013	0.013
Wilson's Phalarope	37	444	772,646	1.287	0.025	0.016
Red-necked Phalarope	28	74	111,938	1.284	0.021	0.018

[a] Analysis for each species used (1) sites surveyed 3^+ times in 3^+ years and in which the mean number of birds/survey was ≥ 1.0 (except for WIPL it was 0.1), and (2) years in which 5^+ such sites were surveyed.

[b] Estimated SE if all sites were surveyed every year and the number of surveys/year was equal to the average number in the actual data set.

Table 3. Feasibility of including the species recorded too rarely for inclusion in the current analysis.

Species	Description	Conclusion
Mountain Plover	Recorded frequently during the survey period in CO, KS, and TX but at sites only surveyed in 1-2 years (which therefore don't enter this analysis)	Precision probably would be adequate if sites were surveyed each year
Purple Sandpiper	Recorded frequently outside the survey period in the northeastern US	Would require a special winter survey but precision would probably then be adequate.
Black Oystercatcher Black Turnstone Surfbird Rock Sandpiper	Breed in remote northern areas; winter along rocky coast of the US and Canada (and south of there) during the proposed survey period.	Precision might be adequate if these areas were surveyed though the feasibility of counting in this habitat is uncertain.
Pacific Golden-Plover Bar-tailed Godwit Red Phalarope	Breed in northern areas; then move largely outside the US and Canada during non-breeding seasons; small numbers occur in winter along the coast of California	Conceivable that surveys in winter in California might yield adequate precision
American Woodcock	Rarely recorded and adequately covered	Special survey for this species

At present, I am unsure of how representative the sites I used are of shorebird sites in general. The periods I used might also not be the best ones. For both these reasons, the precision in an operational program might differ from the estimates I obtained. I cannot think of any reason, however, that the precision in an operational program would be consistently higher or lower than the levels I achieved. It thus seems reasonable to conclude that a non-breeding survey of the sort I analyzed would achieve adequate precision for nearly all of the shorebirds.

Peak Counts vs. Mean Counts

There has been some interest among shorebird biologists in using peak counts as an index rather than mean counts. When peak counts in each site-year are substituted for means, there is little change in standard errors. The average standard error using peak counts was about 1% larger than the average using means. The likelihood of bias when using peak counts is discussed in the next section.

Opportunities for Increasing Precision

Several opportunities exist for increasing precision, perhaps at little cost. For example, few sites were surveyed throughout the study period (1975-1998). As discussed in the next section, retaining sites would substantially reduce the potential bias in the estimates, so it may be of interest to determine how precision would be affected if sites were retained. This analysis can be carried out using the equations in Appendix 3. I estimated the precision that would be obtained if all of the sites included in the analysis for each species were each retained throughout the study period. In this analysis I assumed that the number of visits per site-year was equal to the average number actually made in the data set. The results (right hand column in Table 2) were that precision was substantially increased. All of the standard errors were ≤ 0.02 and 13 were ≤ 0.01.

Improvements in the analytic methods can probably also be made and will further reduce the standard errors. I used simple means as the estimates of the true mean number present per survey at a site but polynomial regression might yield more precise estimates, especially in cases where the numbers build up and decline in a fairly smooth manner. I experimented with this approach and found that standard errors were reduced by up to 50% (results varied widely among species). An even better approach would be to model the arrival and departure of shorebirds during the monitoring period using weather, habitat, and perhaps other factors. This approach could substantially increase precision, especially in cases where numbers present fluctuate widely, but in ways that can be predicted from external variables. Such a modeling effort would also help us understand shorebird movements which would be useful in its own right.

Estimated precision may also be increased in the future by adjusting the equations used to estimate the standard error of the trend to account for the fraction of the sites surveyed. This adjustment, known as the finite population correction (fpc) in sampling theory, is used whenever a substantial proportion (e.g., >0.1) of the statistical population – sites in our case – is included in the sample. At present, no comprehensive list of sites exists so I made the simplifying assumption that the sampled fraction is negligible. If a list of sites is produced, however, then the fpc may turn out to be appreciable at least for some species.

In conclusion, precision of the estimated means/survey was adequate for nearly all of the 48 species considered in this analysis or would be if most sites were surveyed in most years and a few other modifications in the program were made. The current program produces estimates with adequate precision for many analyses. For example, estimates that means/survey had declined by 50% during a 20-year period would be statistically significant at the 5% level for most species, and smaller declines would be significant for some species. Precision can probably be improved substantially in which case regional estimates might also be feasible

Bias of Sample Means/Survey as an Estimate of True Means/Survey

High precision does not guarantee high accuracy. One must also consider sources of error that are not included in estimates of precision. This section is restricted to the question "How well do means/survey in the sample track the true mean number of birds present in the study area during the study period?" How well the true mean number present in the study area tracks the size of the breeding populations is discussed in the next section.

If a constant fraction of the birds present was recorded each year, then the sample mean would provide an excellent estimate of the trend in true means present. Thus, "bias" in this case, refers to bias in the trend estimate, not simply to over- or under-counting. Some of the most important sources of bias in the ISS-Skagen data set are (1) non-representative sites being included; (2) changes in which sites are surveyed during the study; (3) change in average proportion of birds present that are detected (due to change in observer ability, habitat, or other factors).

Among these factors, I have little ability to evaluate numbers 1 and 3 at present. The second factor, changes in sites being surveyed, however, clearly caused serious problems for the present analysis. To take a particularly extreme example, the mean number of black-necked stilts per survey increased from about 0.01 during most of the survey period to more than 1200 in 1995 after which it declined drastically (Fig. 4). This increase was caused by 5 sites in Utah which were only surveyed during 1991-96 and from which large numbers of black-necked stilts were reported. One site had particularly large numbers. In 1995 and 1996 more than 99% of the reported black-necked stilts came from this site.

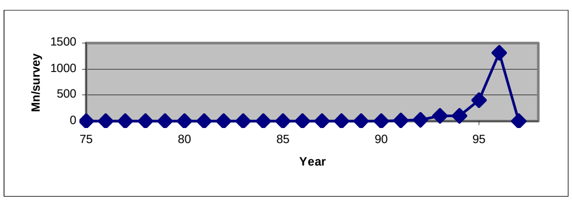


Figure 4. Trend in mean number of black-necked stilts recorded per survey.

This is an extreme example, of course, but major changes occurred throughout the program in which sites were surveyed. For example, in the analyses of precision above, the average number of years per site during the 29-year study period was 6.0 and these years tended to be approximately sequential. Thus sites with large numbers of birds (of a given species) tended to have large effects on the overall trend if they were surveyed early or late in the period. Clearly most species were not affected by site changes as much as black-necked stilts were because their population trends were close to 1.0 (Table 2). The problem, however, as exemplified by the black-necked stilts data, is that when trends were significantly different from 1.0, it was difficult to determine whether this resulted from a true decline in mean numbers present or from a tendency to add poorer sites and lose good ones in later years of the study.

As noted above, many sources of bias may be affecting the current trend estimates. One way of assessing their combined effect is to compare them to estimates derived from the Breeding Bird Survey

(BBS). Eleven species were recorded frequently enough in both programs for the comparison (Table 4). The shorebird program indicated unrealistic increases for black-necked stilts, long-billed curlews, marbled godwits and Wilson's phalaropes. For each of these species, the lower bound on the increase (e.g., 80-fold for Wilson's phalaropes) was far above plausible levels indicating that bias, rather than sampling error, caused the problem. The estimates for American avocets and upland sandpipers showed similar, though smaller, bias. The other species showed more similar trends to those indicated by the BBS. The estimates from the BBS and ISS-Skagen data sets for killdeer were quite close (declines of 2% and 8%) as were the estimates for spotted sandpipers (declines of 13% and 29%). The estimates for common snipes were a bit farther apart (4% decrease vs. 67% increase) as were the estimates for willets (declines of 10% and 71%). The estimates for lesser yellowlegs were still farther apart (71% decline vs. 55% increase). As usual with bias, it is difficult to know exactly what conclusion should be drawn from these examples, especially because the BBS estimates also have biases. Everyone would probably agree, however, that the potential bias is quite large and should not be ignored. My own feeling is that estimates of precision and the statistical methods that they support (e.g., tests, confidence intervals) are probably not warranted with the current data set because of the danger that conclusions would be mis-leading due to bias.

Table 4. Estimated change in population size using BBS data and the ISS-Skagen data set.

Species	Data set	Estimated 20-yr change (and 95% CI)
KILL	BBS ISS-Sk.	0.92 (0.87-0.98) 0.98 (0.96-1.02)
BNST	BBS ISS-Sk	1.88 (0.53-6.14) 35,273 (15,886-75,961)
AMAV	BBS ISS-Sk.	1.10 (0.71-1.67) 16.9 (3.7-69.2)
LEYE	BBS ISS-Sk.	0.29 (0.15-0.56) 1.55 (0.48-4.66)
WILL	BBS ISS-Sk.	0.90 (0.74-1.10) 0.29 (0.08-0.92)
SPSA	BBS ISS-Sk.	0.87 (0.67-1.13) 0.71 (0.47-1.06)
UPSA	BBS ISS-Sk.	1.29 (1.08-1.55) 3.27 (3.03-3.52)
LBCU	BBS ISS-SK.	0.75 (0.49-1.17) 43.1 (29.8-61.8)
MAGO	BBS ISS-Sk.	1.06 (0.79-1.46) 583 (254-1,297)
COSN	BBS ISS-Sk	0.96 (0.82-1.10) 1.67 (1.01-2.76)
WIPH	BBS ISS-Sk.	0.72 (0.52-1.00) 155 (80-295)

Reducing the Potential for Bias

Two major sources of bias may be distinguished in the current program: selection bias and measurement bias. Selection bias refers to the possibility that trends at the surveyed sites, as a group, differ from the overall trend. This is especially likely when sites enter and leave the program frequently, but it would be a problem even if this were not the case. The only effective way to remedy this problem is by defining the set of sites that will comprise the population to be surveyed. "Site" in this context could be a relatively small location like a Refuge, all of which would be surveyed at once, or it could be a region like the Prairie Potholes which might be stratified (e.g., using sections) and then sampled rather than censused. Once such a description exists, it can be used to insure that the sample remains representative of the population. There is no need that the surveyed sites be a simple random sample from the population. For example, a large number of sites might be chosen beforehand for their intrinsic interest. These would be assigned to one group all of which would be surveyed. A sample (perhaps a stratified sample) of the remaining sites could then be selected. Under this plan, in each year an estimate of the overall mean number of birds (of each species) present during the study period would be made. Accordingly, no problem would be caused by increasing or decreasing the number of sites surveyed as long as it was done under a designed protocol. Perhaps the single most important task in developing an improved shorebird monitoring program is creating a comprehensive list of shorebird sites that can serve as the foundation for designing the sample selection process.

Measurement bias, refers to a temporal trend in the proportion of the birds present that are detected during the survey. Changes in the proportion might occur as a result of changes in observer skill or interest, changes in habitat, or perhaps changes in other factors (e.g., disturbance frequency). A first step in remedying this problem is to prepare, for each site in the population, a description of which areas should be surveyed and how the surveys should be conducted. An assessment should also be made of the probability that the visibility conditions will remain approximately the same over long periods of time. Consideration should be given to excluding sites where this is unlikely to be true. In addition, a training and/or evaluation program is needed for participants in the program.

Peak Counts vs. Mean Counts

If peak counts are used as the index, then a discussion of bias requires that we specify what parameter we are using peak counts to estimate. One possibility is the trend in true peak numbers present where “true peak” might, for example, be defined as the average of the peak numbers occurring at each site anytime during the study period. Although this is a reasonable parameter, the relation of peak count in the sample to true peak at a site obviously depends on sample size since the peak count would tend to increase with sample size. This means that the number of visits per site would have to be standardized or that the relationship between sample size, sample peak, and true peak would have to be specified. Standardizing number of visits seems difficult and counter productive and modeling the relationship between sample size and peak numbers seems difficult and arbitrary. Thus, this approach does not seem useful.

Another parameter that we might use peak counts to estimate is trend in mean number present. Bias is then the difference between trend in the mean of the peak counts in the samples and trend in actual mean numbers present. The comments made above about bias with means all apply to bias with peak counts. Thus, rapid replacement of sites causes the potential for serious bias as would changes in habitat or observer skill or interest. I see little basis for choosing one metric over the other on the basis of bias, though investigators more familiar with the field conditions certainly might.

In conclusion, trend estimates made using standard methods from the current data set are subject to bias of such magnitude that the estimates are of little value. Instead, the data must be “corrected”, a process that may well be useful but is subjective and will be carried out differently by different analysts. Steps that might substantially reduce the potential bias include:

1. Construction of a list of sites that would constitute the statistical population.
2. Restricting surveys or at least analyses to agreed upon survey times for each region such as the ones used in this report.
3. Preparing guidelines for surveying each site that standardize the surveys.
4. Monitoring conditions at each site both to assist with when surveys were conducted and to record changes in detectability.
5. Developing a training program for surveyors.

Reliability of True Means/Survey as an Index to Size of the Breeding Population

The relationship between the sample mean/survey for a given species and size of the breeding population is affected by many factors. They can be subdivided into three categories: what proportion of the birds enter the study area during the study period, how long they remain in the study area, and what fraction of them are recorded on surveys. Under this scheme, we may write (without making any assumptions),

$$\bar{y}_j = B_j\left(\frac{F_j G_j P_j}{N}\right)$$

where

$\bar{y}_j$ = the mean number of individuals (of a given species) recorded/survey in year j,
B_j = the number of birds in the breeding population at a specified time of year, for example the end of the breeding season,
F_j = the fraction of the B_j birds that enter the study area during the study period in year j,
G_j = the average proportion of the study period in year j during which the $B_j F_j$ birds are present in the study area,
P_j = the detection rate of birds during the surveys (more specifically, the ratio of $\bar{y}_j$ to the actual mean number of birds present in the study area during the study period),
N = the number of sites in the study area (assumed constant between years).

B_j is the quantity we hope to monitor using $\bar{y}_j$. As can be seen from the expression, any temporal trend in F_j, G_j, or P_j will cause a temporal trend in $\bar{y}_j$ which will mis-lead us about the trend (if any) in B_j. The previous two sections have dealt with random and systematic influences on the P_j and have presented evidence that these sources of error can probably be reduced to acceptable levels by changes in survey design. Movements, however, present a much more serious challenge. It is difficult to imagine how one could be sure that a trend in mean counts was not caused by a change in movements. Global climates will continue to change and to affect broad-scale movements of animals in unpredictable ways. Habitat changes anywhere within the range of a species might cause changes in its distribution and abundance in the study area during the study period without there being any change in the species' population size. Changes in predator populations or the level of human disturbance might also cause a change in mean abundance during the surveys. The importance of these problems is worth emphasizing: ***surveys during the non-breeding period will only yield a useful index to population size if trends in movements can be excluded as the cause of observed changes in the index.***

In theory, trends in movements might be measured by including, as part of the monitoring program, an effort to mark and track or resight shorebirds. Detecting small, long-term trends in the fraction of birds entering the study area during the study period or the average time they remain there, however, would be difficult and expensive if it is even possible. I could investigate the parameters of a program that would provide the needed information, but I doubt that such a program would be practical. The section below, *Breeding Ground Surveys*, presents an alternative approach that I believe may be more feasible.

Peak Counts vs. Mean Counts

If peak counts, rather than mean counts, are used as the index, then the issue becomes not only how changes in F_j or G_j would affect the index, but also how changes in internal movements within the study area during the study period might affect the index. Thus, even if no trends occur in F_j and G_j changes might occur in how concentrated birds are within the study area during the study period, and these might cause bias in the index. I am inclined to recommend use of mean counts rather than peak counts, in part because I have never heard of a survey using peak counts. The issue is complex, however, and I could work more on it if the FWS or specialists working on the shorebird monitoring program wish.

Breeding Grounds Surveys

Given the present, and probably future, difficulties of using surveys during the non-breeding period to make inferences about trend in population size, it seems worthwhile to examine the feasibility of conducting a long-term program on the breeding grounds. For most species, this means surveys in the arctic, or at least in remote northern areas, and this alone might seem to preclude such surveys. I believe, however, that a relatively modest sample might provide estimates of substantial precision, and that such estimates, along with information gained during the non-breeding period might yield far more reliable estimates of trend in population size than could be gained from the non-breeding period alone. In this section, I describe the analytic tools for predicting accuracy of the estimates given samples of different sizes. I propose carrying out an analysis using existing data during the next few months to further evaluate the feasibility of breeding ground surveys.

If surveys are made on a series of plots, covered at least once each year, and if the study area is large relative to the surveyed area (as would be true for a breeding ground survey), then the standard error of the estimated trend may be written as

$$SE(e^b) = \sqrt{\frac{C_1}{n}\left[\frac{C_2}{m} + C_3\right]}$$

where n is the number of sites surveyed, m is the number of visits per site per year, C_1 is a constant that depends only on the number of (sequential) years of data from which the trend is estimated, C_2 is a measure of variability within sites, and C_3 is a measure of variability in the true means/site. Appendix 3 contains the derivation of the *SE*. The formula for the *SE* applies if all n sites are visited the same number (m) of times each year. A value of m>1 implies that a study period is defined (e.g., the first 3 weeks of incubation) and that a *random sample* (including a systematic sample) of m times is selected for surveys at each site. This implies leaving the site and then returning to it. This would be appropriate at the few sites with biologists in residence during the breeding period, but if a special trip has to be made to reach the site, then it is almost surely worthwhile to visit a new site rather than re-visiting an old site (*i.e.*, increasing n reduces both C_2 and C_3 whereas increasing m only reduces C_2). I therefore assume that m=1 which also means that we need only estimate the sum of $C_2 + C_3$, not each term separately, to make an estimate of precision. Assuming that m=1 leaves open the possibility that surveyors might spend a few days in a given location and survey each plot twice; the mean of the results would be used as the estimate.

The power analysis, assuming m=1, requires that advance estimates be made of C_2+C_3. Given such an estimate, and since C_1 is a known constant, we can calculate the *SE* that would be obtained with different numbers of sites (n) or the number of sites that would be needed to achieve a given *SE* such as 0.02. To estimate C_2+C_3 we need the means/survey from several widely scattered sites in each of several years. The data do not all need to come from the same years, but there must be at least some overlap in years and the more the better. It is essential that the sites used in estimating C_2+C_3 show roughly the same site-to-site variation as would be true in the sampled population. It is therefore important that the sites be as widely distributed as possible or substantial under estimates of C_2+C_3 (and over-estimates of precision) might occur.

I have begun collecting the needed data for this analysis and plan (pending FWS approval) to complete this analysis during the next 3-6 months.

Discussion and Conclusions

As noted in the Introduction, to be confident in a program for monitoring shorebird population size by using surveys during the non-breeding period we need to believe that:

1. The trend estimate is precise enough to be useful (i.e., *SE* < 0.02).
2. The trend has low bias when used to estimate trend in the true means present during the study period.
3. The trend in true means/survey provides a reliable index to change in size of the breeding population.

Regarding the first two points, this investigation reveals that the current program is achieving satisfactory precision, and that many opportunities exist to increase precision, perhaps substantially. Bias of the estimates, however, is high and essentially precludes the statistical analyses routinely carried out on standardized surveys such as the BBS or waterfowl counts. Analysts intimately familiar with the species, habitats, and data collection methods certainly could extract useful information about trends, but the process of doing so would necessarily be subjective, and different analysts might well reach widely different conclusions. To reduce the bias to acceptable levels, a comprehensive list of shorebird concentration sites is needed, sites to be surveyed should be selected under some kind of random sampling plan, and most sites to be included in the program need to be surveyed in most years. Preparation of site descriptions including guidelines for how to survey the sites, and development of a training program for surveyors will also help reduce bias. At present, it appears likely that bias could be reduced to an acceptable level if these steps are carried out. Furthermore, recording birds during a relatively brief period (e.g., two months) appears to be sufficient for monitoring purposes, though recording abundance year-round as done at present would certainly provide additional information of use.

At a recent meeting at Patuxent, shorebird experts developing the monitoring component of the Shorebird Conservation Plan discussed the possible need for several new, species-specific surveys. In contrast, the analyses reported here suggest that for most species a single survey might achieve adequate accuracy. One way to pursue this issue would be to compare the precision likely to be achieved by the species-specific surveys with precision of the survey described here (Table 2). Managers could then decide whether the increase in precision that would result from the species-specific survey was worth the added cost.

It seems likely that the sort of program evaluated in this report would provide much useful information about shorebird populations. Some indication of change in population size would certainly be provided (but see next paragraph). Perhaps more importantly, valuable information would be obtained on use of specific sites. If conditions deteriorated, the monitoring program would reveal the problem so it could be studied and hopefully remedied. The sites to be surveyed could be rotated between years (under a designed plan) so information could be obtained on a wide variety of sites. The influence of weather or other factors on shorebird movements could be investigated. Surveyors could be asked to search for marked birds if more intensive studies were being made. Large-scale changes in where birds spend their migration and wintering periods would be revealed and might lead to valuable insights about changes at the regional or global level. I suspect shorebird biologists could identify many other uses for such a monitoring program.

Even with the modifications to increase precision and reduce bias, and despite the many uses such a program would have, it probably cannot be relied on as an index to population size on the breeding ground. The reason is simply that observed changes in means/survey during the non-breeding period could be the result of changes in movement behavior rather than change in population size. Thus, a program to monitor movements would also have to be implemented. The feasibility, however, of monitoring movements for large numbers of species on a continuing basis is questionable and I find it hard to imagine a program that would clearly rule out change in movements as an explanation for change in means/survey.

In contrast, I believe it might be feasible to survey shorebirds on their breeding grounds. Several species, of course, are already being monitored by the Breeding Bird Survey, but for most species new surveys in the far north would be needed. This may turn out to be impractical due to costs, but we need a careful evaluation of this issue before reaching any conclusion.

In summary, the major conclusions and recommendations are:

1. A commitment should be made to improve and continue the current program of conducting surveys on the non-breeding grounds.

2. The program should be improved by (a) developing a comprehensive list of shorebird concentration sites and using it as the sampling frame for the program, (b) preparing descriptions of each site and how it should be surveyed, and (c) undertaking a pilot study to test the new procedures.

3. A detailed evaluation is needed of whether surveys on the breeding grounds are feasible. Investigators familiar with shorebirds in northern North America should be encouraged to participate in the evaluation by contributing data and helping to decide how many sites might be surveyed and what the costs would be. The needed analytic methods are contained in this report so the analysis can be completed quickly once the data have been collected and agreement has been reached on how many sites might be included in the program.

Appendix Two: Shorebird Conservation Units: Subspecies and Distinct Population Segments

Nils Warnock and Chuck Hunter

Conservationists have grappled with the question of what the minimum group of animals within a species is (termed hereafter as the conservation unit) that is worth identifying, dedicating resources towards, and conserving. It has been recognized that for a variety of species, conservation efforts only at the species level overlook fundamental attributes of groups of organisms nested within species, and this potentially may lead to a loss of genetic diversity and local ecological functions (Meffe and Carroll 1994). The Endangered Species Act of 1973 and its amendments recognizes and protects three biological taxa (species, subspecies, and distinct populations segments), with distinct population segments as the "lowest" functional group. This recognition of the population as the minimum unit of conservation along with the ambiguous nature of the word distinct has generated tremendous exchange within the scientific community as to what constitutes a distinct population segment (Ryder 1986, Waples 1991, Gerber and DeMaster 1999). As an attempt to define what a distinct populations segment is, Ryder (1986) coined the term Evolutionarily Significant Units in recognition of the need to combine natural history and phenotypic information with genotypic information. However, exactly how to identify Evolutionarily Significant Units also remains ambiguous (Moritz 1994, Waples 1995, Pennock and Dimmick 1997).

Initial development stages of the US Shorebird Conservation Plan defaulted to the species as the conservation unit, mainly due to the already difficult logistics of dealing with 49 species of shorebirds recognized as breeding regularly enough in North America to justify developing monitoring programs for. However, just as the United States was split into 12(?) shorebird planning regions partly in recognition of oftentimes uniqueness of roles different regions play for different species of shorebirds, it has been recognized that the minimum conservation unit for shorebirds in North America needs to be one that acknowledges ecological and evolutional distinctions of this group of birds below the species level. With this in mind, shorebirds with distinct breeding populations in North America were identified, mainly from peer-reviewed, published sources (Table 1). For the purpose of the US Shorebird Conservation Plan, species were broken down into populations that largely fit the definition of a subspecies under the modified Biological Species Concept (O'Brien and Mayr 1991):

> "Members of a subspecies share a unique geographic range or habitat, a group of phylogentically concordant phenotypic characters, and a unique natural history relative to other subdivisions of the species."

Subspecies were identified using one or all of the following three criteria:

1. Phenotypic/Biogeographic Criteria
    a) Recognized by AOU (1957) as subspecies
    b) Not recognized by AOU (1957), but breeding populations shown to be geographically isolated/disjunct and/or phenotypically distinct within North America.
2. Genetic Differentiation Criteria - populations within North America shown to have distinct genetic differentiation within species.
3. Conservation/Political Criteria - federally listed population and subspecies.

While the terms phenotypically and genotypically distinct are reserved for populations where either phenotypic or genotypic variables were statistically tested and found to be significantly different, determining whether breeding populations are geographically isolated/disjunct has been more ambiguous. This criteria was used only when populations were known to have significant breeding populations (over a few hundred breeding individuals) that are hundreds to thousands of kilometers apart. For this reason, smaller populations of shorebirds of such species as Upland Sandpipers or Greater Yellowlegs breeding in Oregon and Washington are not listed under the subspecies/population table, even though these small populations are of ecological value to different regions.

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Table 1. Shorebird species in North America including Hawaii with distinct population segments or recognized subspecies. Central Flyway defined as Mississippi and Central Flyways combined (Lincoln 1952). Criteria for listing the population/subspecies: 1. Phenotypic/Biogeographic Criteria, a) Recognized by AOU (1957) as subspecies, 1 b) Not recognized by AOU (1957), but breeding populations shown to be geographically isolated/disjunct and/or phenotypically distinct within North America, 2. Genetic Differentiation Criteria - populations within North America shown to have distinct genetic differentiation within species, 3. Conservation/Political Criteria - federally listed population and subspecies.

Species	**Breeding Area**	**Wintering Area**	**Flyway(s) Used**	**Criteria**	**Source**
American Oystercatcher					
Haematopus palliatus palliatus	Atlantic and Gulf coasts	Atlantic and Gulf coasts	Central, Atlantic	1a,b	AOU 1957
H. p. frazari	Formerly Channel Islands south into Baja	Formerly Channel Islands south into Baja, Mexico	Pacific	1a,b	AOU 1957
Black-bellied Plover					
Pluvialis squatarola squatarola	Alaska	Pacific coast and south	Pacific	1b	Paulson 1995, Engelmoer and Roselaar 1998
P. s. cynosurae	N. Canada	Atlantic and Gulf coasts and south	Central, Atlantic	1b	Paulson 1995, Engelmoer and Roselaar 1998
Snowy Plover					
Charadrius alexandrinus nivosus	Pacific coastal (Washington to Baja)	California to Baja	Pacific	1a, 3	Page et al. 1995, G. Page pers. comm.
C. a. nivosus	All other interior breeding birds and Atlantic coast birds	Southern USA and Mexico and Caribbean	Pacific, Central, and Atlantic?	1a, 3	Page et al. 1995, G. Page pers. comm
C. a. tenuirostris	Gulf coast east of LA and Mexico	Caribbean, Cuba, Bahamas	Central, Atlantic	1a, 3	Page et al. 1995, G. Page pers. comm

Species	Breeding Area	Wintering Area	Flyway(s) Used	Criteria	Source
Piping Plover					
Charadrius melodus melodus	Atlantic coast	Atlantic and Gulf coasts, West Indies	Central?, Atlantic	1a, 3	Haig 1992, Plissner and Haig 1997
C. m. circumcinctus	Great Lakes	Atlantic and Gulf coasts?	Central, Atlantic?	1a, 3	Haig 1992, Plissner and Haig 1997
C. m. circumcinctus	Great Plains	Atlantic and Gulf coasts?	Central, Atlantic?	1a, 3	Haig 1992, Plissner and Haig 1997
Black-necked Stilt					
Himantopus mexicanus mexicanus	Continental USA	Coastal and interior sites along Pacific, Atlantic and Gulf coasts	Pacific, Central, Atlantic	1a,b	Robinson et al. *in press*
H. m. knudseni	Hawaii	Hawaii	resident	1a,b, 3	Robinson et al. *in press*
Willet					
Catoptrophorus semipalmatus semipalmatus	Atlantic and Gulf coasts	Central and northern South America	Atlantic	1a,b	Howe 1982
C. s. inornatus	Northern Prairies and Great Basin	Pacific coast into Mexico, Gulf coast and perhaps Atlantic coast	Pacific, Central and Atlantic?	1a,b	AOU 1957
Solitary Sandpiper					
Tringa solitara solitara	British Columbia to e. Canada	Atlantic and Gulf coasts	Central, Atlantic	1a	AOU 1957, Moskoff 1995
T. s. cinnamomea	Alaska to	Mexico to South	Pacific	1a	AOU 1957,

Species	Breeding Area	Wintering Area	Flyway(s) Used	Criteria	Source
	Mackenzie Delta	America			Moskoff 1995
Long-billed Curlew					
Numenius americanus americanus	Southern Great Plains from nw. Nevada into south central Texas	Pacific, Gulf and Atlantic coasts, Mexico	Pacific, Central, Atlantic	1a	AOU 1957
N. a. parvus	Northern Great Plains to Dakotas and n. Great Basin to ne. California	Pacific and w. Gulf states, Mexico	Pacific, Central	1a	AOU 1957
Whimbrel					
Numenius phaeopus hudsonicus	South and west coast of Hudson Bay	Atlantic and Gulf coasts?	Central, Atlantic	1a,b, 2	Zink et al. 1995, Engelmoer and Roselaar 1998
N. p. rufiventris	Alaska west to Melville Hills in NW Terr.	Pacific coast of USA south?	Pacific?	1a,b, 2	Engelmoer and Roselaar 1998
Marbled Godwit					
Limosa fedoa fedoa	Great Plains	West coast into Mexico, Gulf coast	Pacific, Central	1b	Gratto- Trevor *In press*
L. f. fedoa	Hudson Bay	se. U.S. coasts?	Atlantic?	1b	Gratto- Trevor *In press*
L. f. beringiae	Alaska	Washington, Oregon and central California coasts?	Pacific	1b	Gibson and Kessel 1989, Gratto- Trevor *In press*
Hudsonian Godwit					
Limosa haemastica	Western and southern Alaska/ Mackenzie Delta	?	Pacific, Central?	1b, 2	Haig et al. 1997
Limosa haemastica	Hudson Bay	?	Central?,	1b, 2	Haig et al. 1997

Species	Breeding Area	Wintering Area	Flyway(s) Used	Criteria	Source
			Atlantic		
Ruddy Turnstone					
Arenaria interpres interpres	Alaska	Pacific islands and locally from California into Mexico	Pacific	1a,b	Cramp and Simmons 1983, Engelmoer and Roselaar 1998
A. i. interpres	High arctic Canada	Western Europe	Atlantic	1a,b	Cramp and Simmons 1983, Summers et al. 1989
A. i. morinella	Low arctic Canada	Atlantic and Gulf coasts	Central?, Atlantic	1a,b	Cramp and Simmons 1983, Engelmoer and Roselaar 1998
Rock Sandpiper					
Calidris ptilocnemis tschuktschorum	Mainland Alaska, St. Lawrence and Nunivak islands	SE Alaska into BC-WA		1a,b	Gibson and Kessel 1997, Gill pers. comm.
C. p. ptilocnemis	Pribilofs, St. Matthew and Hall islands	Cook Inlet, AK		1a,b	Gibson and Kessel 1997, Gill pers. comm.
C. p. cousei	Attu Island, Aleutians	Aleutians and Alaska Peninsula		1a,b	Gibson and Kessel 1997, Gill pers. comm.
Purple Sandpiper					
Calidris maritima maritima	N. Canada, except east coast Hudson Bay	Europe	Atlantic	1b	Engelmoer and Roselaar 1998
C. m. belcheri	east coast Hudson Bay	E. Canada and ne. USA	Atlantic	1b	Engelmoer and Roselaar 1998
Red Knot					

Species	Breeding Area	Wintering Area	Flyway(s) Used	Criteria	Source
Calidris canutus rufa	Low arctic Canada	Southern South America	Atlantic	1a,b	Morrison and Harrington 1992
C. c. islandica	High arctic Canada	Western Europe		1a,b	Davidson and Wilson 1992
C. c. roselarri	Alaska and Wrangel Island	California south to Atlantic and Gulf coasts	Pacific, Central?, Atlantic?	1a,b	Tomkovich 1992, Piersma and Davidson 1992
Dunlin					
Calidris alpina pacifica	Western Alaska	Pacific coast to Mexico	Pacific	1a,b, 2	Warnock and Gill 1996, Wenink et al. 1996,
C. a. arcticola	Northern Alaska	Asia	Pacific?	1b	Warnock and Gill 1996, Gill pers. comm.
C. a. hudsonia	Central Canada	Atlantic and Gulf coasts	Central, Atlantic	1b, 2	Warnock and Gill 1996, Wenink et al. 1996,
Short-billed Dowitcher					
Limnodromus griseus griseus	Hudson Bay east to Ungava Bay	Central and South America	Central?, Atlantic	1a,b	Cramp and Simmons 1983
L. g. hendersoni	Canada, west of Hudson Bay	Atlantic and Gulf coasts, perhaps to n. South America	Central, Atlantic	1a,b	Cramp and Simmons 1983, Jaramillo et al. 1991
L. g. caurinus	Southern Alaska	Pacific coast North America	Pacific	1a,b	Cramp and Simmons 1983, Jaramillo et al. 1991

[1]Information provided by Guy Morrison and Bob Gill.
[2]Estimate for North American birds, not including Greenland.

[3]Estimate probably includes a number of the subspecies *C. c. rogersi*. Another 10-20,000 birds winter along Gulf and Atlantic coasts and these birds are suspected to be *C. c. roselarri*, but could also be an unidentified population of *C. c. rufa* (Brian Harrington pers. comm.).

Other species where distinct populations have different conservation concerns:
Semipalmated Plover - genetic data, see Haig et al. (1997)
Semipalmated Sandpipers - east and west breeders, different migration routes? Genetic data, see Haig et al. (1997)
Red Phalarope – east and west coast migrants, different breeding grounds?
Red-necked Phalarope – east and west coast migrants, different breeding grounds? Genetic data, see Haig et al. (1997)
Pectoral Sandpiper - Genetic data, see Haig et al. (1997)
Upland Sandpiper - small populations in Washington and Oregon
Stilt Sandpiper – a small population of a few hundred birds winters at the Salton Sea
Common Snipe
American Woodcock
Others

Appendix Three: Monitoring Protocols

This appendix summarizes suggestions for monitoring species not adequately covered at present. The material was prepared using more extensive suggestions provided by species specialists. The original material is archived at Manomet and is available from them (contact Brian Harrington).

PROTOCOLS FOR ONE OR A FEW SPECIES

1. **Snowy Plover**
2. **Piping Plover**
3. **Pacific Golden-Plover**
4. **Wilson's Plover**
5. **Mountain Plover**
6. **American Oystercatcher**
7. **Black Oystercatcher**
8. **Black-necked Stilt**
9. **American Avocet**
10. **Willet**
11. **Willet, Marbled Godwit, and Dunlin**
12. **Wandering Tattler**
13. **Bristle-thighed Curlew**
14. **Whimbrel**
15. **Long-billed Curlew**
16. **Bar-tailed Godwit**
17. **Hudsonian Godwit**
18. **Black Turnstone**
19. **Ruddy Turnstone, Red Knot, Sanderling**
20. **Surfbird**
21. **Rock Sandpiper**
22. **Sanderling**
23. **Western Sandpiper**
24. **Woodcock**
25. **Wilson's Phalarope**
26. **Red and Red-necked Phalaropes**

MULTIPLE SPECIES PROTOCOLS

27. **The International Shorebird Survey**
28. **The North American Breeding Bird Survey**
29. **National Audubon Society Christmas Bird Counts**
30. **Arctic Breeding Grounds Surveys**

PROTOCOLS FOR ONE OR A FEW SPECIES

1. Snowy Plover (Charadrius alexandrinus)

Species

C. *a. nivosus* (Pacific coast), C. *a. nivosus* (Interior and Atlantic Coast), C. *a. tenuirostris* (Gulf coast and Mexico)

Goals

Estimate population size
Monitor trend in population size

Background

Snowy Plovers nest on beaches, lagoons, and salt-evaporation ponds on the Pacific and Gulf coasts and in widely scattered locations across the western United States. They winter primarily along coasts, largely south of the United States. They are relatively easy to detect during the nesting season but are much more cryptic at other times of year. Most nesting sites west of the Rocky Mountains have been identified (Page et al. 1991), and most nesting sites east of the Rocky Mountains could be identified from existing scientific literature, unpublished reports and *American Birds*. Breeding surveys thus appear to be the most cost-effective method for monitoring Snowy Plovers.

Protocol

The goal will be to survey all known breeding sites of Snowy Plovers once annually between 1 May and 30 June, and preferably between 24 May and 6 June. When feasible, all potential habitat at each breeding site will be surveyed. Areas associated with estuaries should be surveyed during high tide to reduce the chance that plovers will be foraging far from the shore.

One person can cover narrow beaches < 50 m wide. For wider beaches, extra observers spaced 50m apart are advisable. Observers should walk down the beach together with the person(s) closest to the dunes about 25 m ahead of the person next to the water stopping every 50 m to scan at least 100 m ahead. Walking and scanning should be synchronized among members of the survey party. The observer nearest the water should be the survey recorder. Salt pond levees, lagoon margins and lake shores can be surveyed similarly to beaches. Salt pond playas should be surveyed from vantage points along the edges. At dry lakes, springs and seeps should be observed using a spotting scope for at least 15 minute. The maximum number of plovers seen during the 15-min observation period should be recorded along with age and sex of all birds seen.
Tracking birds in flight is important. Those landing behind the surveyor should be counted while those landing ahead of the observer should not be counted unless the number of flying birds is greater than the number subsequently encountered on the ground.

The methods described above will work for most areas. They need to be refined, however, for Great Salt Lake because of its size and the large number of birds there. The current method (Paton and Edwards1992) relies on extrapolating total numbers from counts of marked and unmarked birds and may produce biased estimates.

Assumptions

1. *For population size estimation*: Either few birds are missed or a formal sampling plan is followed in sample selection and is used to estimate total population size.

2. *For trend estimation*: The proportion of the U. S. breeding population detected on surveys is similar from year to year.

Primary Development Tasks

1. Locate nesting areas east of the Rocky Mountains.

2. Prepare large-scale maps showing areas to be searched during surveys and prepare guidelines for the surveys such as when to search in relation to tides.

3. Develop an improved protocol for Great Salt Lake.

Costs

Development: $15K/year for 1 year
Operational: $80K/year mainly for salaries and travel costs.

(From information provided by Gary Page)

2. Piping Plover (*Charadrius melodus*)

Species

Focal: *C. m. melodus* (Atlantic coast), *C. m. circumcinctus* (Great Lakes), *C. m. circumcinctus* (Great Plains)

Secondary**:** Snowy Plover (*Charadrius alexandrinus nivosus*, Interior and Atlantic Coast; *C. a. tenuirostris*, Gulf Coast and Mexico); Wilson's Plover *(Charadrius wilsonia)*

Goals (focal species)

Estimate population size
Monitor trend in population size

Background

The Piping Plover breeds on open beaches, alkali flats, and sand flats along the Atlantic coast, portions of the Great Lakes, and the northern Great Plains. It listed under the Endangered Species Act. As part of the recovery plans, the species is to be censused in winter and during the breeding season every five years until recovery has been attained. After that, censusing will continue once every five years for an additional 15 years to insure recovery is maintained. To date, there have been two international Piping Plover censuses (1991, 1996) with the third to be carried out in 2001. The species is relatively simple to census as they are easily recognized and most local areas are undergoing some sort of study.

Protocol

The census is carried out through the cooperation of the five Piping Plover recovery teams in the U.S. and Canada and coordinated through the International Coordinator (S. Haig). Each team designates a state or provincial coordinator who is responsible for sending results to the International Coordinator. Over 1,000 biologists have participated in both censuses to date. Details are summarized in Haig and Plissner (1993) and Plissner and Haig (in review).

The approach is to carry out a winter census prior to a breeding census in order to get an idea of survivorship from winter to breeding. Both breeding and winter censuses are conducted during roughly the same dates from census to census. In both censuses, the general method is to walk along a beach or sandflat and count adult Piping Plovers. The winter census is conducted from roughly January 15-21. Counts completed during the 2-3 weeks prior to or following the census "window" are also accepted. The winter census is conducted along the southeast Atlantic and Gulf coasts of the U.S.; Puerto Rico; coastal Tamaulipas, Mexico; Cuba; and the Bahamas. Requests for reports of sightings are also sent to key individuals in Jamaica, Bermuda, the Dominican Republic, the U.S. Virgin Islands, and the Mexican states of Yucatan, Sonora, and Sinaloa. These areas encompass virtually the entire known wintering range (Haig and Oring 1985, Haig 1992). A request for winter sightings is also published in the Ornithological Newsletter and Bird Watcher's Digest, and regionally in the broadsheet of the Gosse Bird Club (Jamaica), and the newsletter of the Bahamas National Trust Ornithology Group.

The breeding census covers known and potential breeding areas along the Atlantic Coast from Newfoundland to North Carolina, shorelines of the western Great Lakes, Minnesota and Ontario's Lake-of-the-Woods, and suitable wetlands and rivers of the northern U.S. Great Plains and Canadian Prairie.

Observers are provided with census guidelines and data forms and are asked to avoid conducting censuses during extreme weather conditions and to minimize potential disturbance of birds. Censusers are asked to count numbers of adult Piping Plovers observed in a designated area and are discouraged from searching for nests and young during the breeding portion of the census. To identify pair status, observations of unpaired birds are delineated into those seen with nests or young and those observed without nests or young present. Results are combined to provide an estimate of "breeding pairs," as defined by the Atlantic Coast Recovery Plan. Censusers are also encouraged to designate areas surveyed on maps to facilitate comparisons with past and future censuses. Additional information is requested on census time, weather and tidal conditions, general habitat characteristics, extent of area censused, identification of banded individuals, and observations of injured birds.

A species-wide data base is maintained by the International Coordinator and is made available to interested parties.

Assumptions

Few birds are missed on the counts.

(From information provided by Susan Haig, USGS Forest and Rangeland Ecosystem Sciences Center, Corvallis, Oregon)

3. Pacific Golden-Plovers (*Pluvialis fulva*)

Goals

Monitor trend in population size
Monitor numbers using major wintering areas

Background

Pacific Golden-Plovers nest in western Alaska and winter in Hawaii and widely across the southern Pacific basin. Few attempts have been made to survey their populations, though a number of counts have been made in Hawaii. The major estimates of numbers wintering in the Hawaiian Islands are as follows: approximately 15,000 plovers island-wide on Oahu (Giffin and Medeiros 1968); about 74,000 wintering on the main islands in the southeastern part of the archipelago (Schwartz and Schwartz 1949); approximately 1,900 wintering on Oahu golf courses (Johnson and Johnson 1993); periodic counts on Oahu of populations varying from 100-400 birds at Bellows Air Force Station, Hickam Air Force Base, and the National Memorial Cemetery of the Pacific (Johnson, Johnson, and Bruner, unpubl.); and information from several studies on densities in various habitats (Johnson and Connors 1996). Even fewer systematic efforts have been made to count this species on Guam but a few area support dozens to a few hundred birds, and they could be counted there easily (G. Wiles, pers. comm.).

Plovers have adapted amazingly well to the dramatic impacts of human settlement on these islands. Among these is the replacement of forest and shrubland with extensive plover-friendly environments such as parks, golf courses, residential and other urban lawns, airport and military base grasslands. These areas have become extremely important wintering grounds hosting large numbers of golden-plovers. It is likely that the overall population of plovers in Hawaii has increased substantially over the past century. Except for wintering birds, Pacific Golden-Plovers are difficult to census. Traditional migratory stopovers with build-ups in specific places are not characteristic of this plover (Johnson and Connors 1996). Thus, useful information is likely to emerge primarily from surveys on the wintering grounds where birds are relatively easy to count. Future modification of habitats on survey sites might threaten the continuity of data collection. This could be minimized by selecting wintering sites where significant change is least likely to occur such as cemeteries, protected wetlands, and golf courses. On the other hand, if habitat elsewhere changes in amount or quantity these changes could lead to a change in density in the surveyed areas even if overall population size does not change. The best approach, if it is feasible, may be to conduct annual surveys at carefully selected sites in both Hawaii and Guam and periodic surveys, using a designed sampling plan, throughout the wintering range to detect changes in the proportion of the population present in the study area during the study period. The large scale survey could permit estimation of total population size and yield occasional information on the number of birds using other wintering sites.

A large-scale effort to survey populations in Hawaii would require substantial funding and many workers. A more realistic approach is to identify 2-3 major wintering sites where plover numbers can be determined accurately on each of the main islands (Hawaii, Maui, Molokai, Oahu, and Kauai) and on Guam and possibly the Marianas. Sites on Oahu and on Guam are already known. Locating good sites on the other Hawaiian Islands will involve evaluation of various sites in the field along with advice and assistance from state and federal biologists.

Protocol

A few days on each island will be needed to find, map, and describe the sites, and to count plovers at each location. A given site might consist of more than one habitat (e.g. a military base with wetlands, residential lawns, and airfield grasslands). Depending on the site or parts thereof, on-foot and/or by-vehicle census routes will be established. On Oahu, roadside routes have often been used (Johnson et al. 1981, Johnson and Johnson 1983, Johnson et al. 1999). Where possible, using a vehicle as a mobile blind is the preferred technique.

Major Assumptions

1. For monitoring trend in population size: Periodic surveys provide accurate estimates of changes in the proportion of the wintering population in the sampled area during the study period.

2. For monitoring numbers using major wintering sites: Major wintering sites in Hawaii and Guam are identified; there is no substantial temporal trend in detection rates at these sites.

Primary Development Tasks

1. Identify the sites to be surveyed on Hawaii, Maui, Molokai, Kauai, and Guam.

2. Complete detailed design of the field methods including maps of each site to be surveyed and guidelines for conducting the surveys.

3. Develop the plan for periodic samples of sites throughout the wintering range (prepare a map of the sites, assess numbers present and accessibility, decide on visitation schedule, carry out power analyses).

Costs

Development: $30K/year for 3 years
Operational: $20K/year mainly for travel.

(From information provided by Oscar W. Johnson and Patricia M. Johnson, Montana State University, Montana and Gary Wiles, Guam Division of Aquatic and Wildlife Resources, Guam)

4. Wilson's Plover (*Charadrius wilsonia*)

Goals

Estimate population size
Monitor trend in population size

Background

Wilson's Plovers breed on beaches, tidal flats, and barrier islands along the Gulf and Southern Atlantic Coasts. Within their range, they are uncommon, distributed locally, and are relatively visible. At other times of year their distribution is more variable and harder to predict. The breeding season thus appears to be the best time to study this species.

Protocol

The survey will be conducted in either April (pre-breeding period) or June/July (post-breeding period). The design will be a stratified random sample. Delineation of the sampling area is straightforward because this is an obligate coastal species. Suitable habitat will need to be identified in the nine states that comprise most of the species' breeding range (Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas). Within multiple strata (probably states, but perhaps larger areas such as pairs or groups of states), sampling locations will be selected randomly from all suitable habitats.

At each sampling location, a line transect with multiple (probably 5-20), evenly spaced points will be arranged. Routes most likely will be covered on foot, so the distance between points will be minimized as needed. Depending on visibility and habitat structure, the interpoint distance will be in the range of 200 to 400 meters. At each point, the observer will record all Wilson's Plovers (and possibly secondary species) during a specified time period (~5 minutes) and will use a rangefinder to record the distance to each bird. Sightings of all Wilson's Plovers, including broods, will be recorded, but only adults will be used for trend analyses.

Program DISTANCE (Buckland et al. 1993) will be used to estimate densities of Wilson's Plovers along the survey routes. Trend analyses of these estimates will be used to monitor changes in the population of breeding adults.

Major Assumptions

1. *For estimating population size*: Distribution maps used as the sampling frame include all or nearly all breeding pairs; the survey methods provides essentially unbiased estimates of the number of birds in sample plots.

2. *For monitoring trend in population size:* The same assumptions except that if biases are present they remain constant through time.

Primary Development Tasks

1. Prepare maps showing all suitable breeding habitat

2. Complete detailed design of the sample selection and field methods including a test to estimate detection rates and evaluate assumptions of the DISTANCE method.

3. Conduct a power analysis.

Costs

Development: $30K/year for 2 years
Operational: $20K/year mainly for technician salaries and field costs.

(From information provided by Stephen J. Dinsmore, Colorado State University, Fort Collins, Colorado)

5. Mountain Plover (*Charadrius montanus*)

Goals

Estimate population size
Monitor trend in population size

Background

Mountain Plovers are a declining shorebird of the western Great Plains (Knopf 1996), recently proposed for listing under the U. S. Endangered Species Act. They are relatively easy to survey on their breeding grounds.

Protocol

Surveys will be conducted annually throughout the species breeding range during June and July. The design will be stratified random sampling. Sampling intensity will be higher in Montana, Wyoming, and Colorado, since these states comprise the species' primary breeding range, and lower in peripheral areas including Utah, Nebraska, Kansas, Oklahoma, and New Mexico. The breeding range is highly fragmented (Knopf 1996), so it will be important to prepare detailed maps of likely breeding areas to serve as the sampling frame.

A modified Breeding Bird Survey (BBS) route is likely to be the best survey method though several modifications will be made, including: 1) fewer stops on the route (perhaps 20), 2) some sampling away from the roadside, perhaps by moving a short distance (~100 m) off the road at every other stop, and 3) measuring the actual distance to each sighting with a rangefinder. A route with 20 stops every 0.5 mile covers 9.5 miles. Sampling will occur between 15 June and 15 July, starting in southern areas and working northward. As a rough guideline, sampling south of the 41st parallel would occur from 15-30 June and sampling north of there from 1-15 July. In June and July, plovers are in the post-breeding period and are very visible and easy to detect (F. L. Knopf, pers. comm.). All plover sightings will be recorded, but only adults will be used for the analyses.

Program DISTANCE (Buckland et al. 1993) will be used to estimate population size. Trend analyses of these estimates will be used to monitor changes in population size.

Major Assumptions

1. For estimating population size: The entire breeding range of Mountain Plovers is known; the samples are selected following a rigorous sampling plan; estimates of number present within plots have negligible bias; bias due to restricting counts to roadsides, and areas near to roadsides, is negligible.

2. For estimating trend in population size. The surveys include a constant fraction of the population; no substantial temporal trend occurs in the detection ratio.

Primary Development Tasks

1. Prepare maps showing all suitable breeding habitat

2. Complete detailed design of the sample selection and field methods including a test to estimate detection rates and evaluate assumptions of the DISTANCE method.

3. Assess the potential for bias due to restricting counts to the vicinity of roads.

4. Conduct a power analysis.

Costs

Development: $20K/year for 2 years
Operational: $13K/year, mainly for salaries and travel for technicians.

(From information provided by Stephen J. Dinsmore, Colorado State University, Colorado)

6. American Oystercatcher (*Haematopus palliatus*)

Secondary Species

Marbled Godwit (*Limosa fedoa fedoa,* Great Plains); Short-billed Dowitcher (*Limnodromus griseus griseus,* Eastern Canada); Red Knot (*Calidris canutus rufa*, low arctic Canada), Dunlin (*Calidris alpina hudsonia*, Central Canada)

Goals (focal species)

Monitor trend in population size
Monitor numbers using major wintering areas

Background

American Oystercatchers breed solely in marine habitats. In the United States they occur along the Atlantic Coast from Cape Cod south and on the Gulf Coast from Florida to Mexico. Birds from the New England and mid-Atlantic areas congregate in winter along the coast, especially in Virginia and the Carolinas, and this appears to be the best time to survey them. Birds nesting farther south and along the Gulf Coast may well be sedentary but this is uncertain, and it is not clear how best to survey these populations.

Protocol

Six shoreline surveys will be made each year between 15 December and 1 March for at least six years and periodically (perhaps every fifth year) thereafter. Surveys will be in two sections, the first from Ocean City, Maryland, to Virginia Beach, Virginia (Christmas Bird Counts indicate high and growing numbers wintering on the southern Delmarva Peninsula), and the second from Cape Fear, North Carolina to Savannah, Georgia (Christmas Bird Counts indicate high numbers wintering in the Winyah and Bulls Bay region of South Carolina). Each survey will require approximately 17 hours of flying time, and will occur during tides when American Oystercatchers are roosting. Four hours will be needed for arrangements, weather interruptions, and data management for each hour of air time. Aerial survey data will be recorded simultaneously by two observers (one on either side of aircraft) into voice-recognition computers and two tape recorders (one as a back-up). Positions will be recorded by GPS.

Ground surveys will be made to estimate detection rates at two locations in the north section and two locations in the south section during each survey.

Numbers will be summarized using conspicuously demarcated sections of beach (recognizable from the aircraft) in the north section, and using oyster rakes along inland waterways in the south section.

Surveys will also be made in selected locations from Florida to Texas but these surveys have not been designed yet and it is uncertain whether ground or aerial surveys will be preferable as well as whether the surveys should be during the breeding or wintering periods.

Major Assumptions

1. For trend estimation: The proportion of the population wintering within the survey area has negligible temporal trend; aerial counts provide the best means of counting this species during the study period within the study area.

2. For monitoring major wintering areas: The study area contains the major wintering areas.

Primary Development Tasks

1. Develop a method for evaluating the assumption of little or no long-term trend in what fraction of the total population is present in the surveyed area at the time the surveys are conducted.

2. Estimate precision of the counts and make final decisions on sample size and sampling frequency, including the allocation of effort between air and ground counts.

3. Design the surveys to be made along the Gulf Coast.

Costs

Development: $50/year for 3 years
Operational: $40K/year, mainly for aircraft and field technician salaries.

(From information provided by Brian Harrington, Manomet Center for Conservation Sciences, Manomet, Massachusetts.)

7. Black Oystercatcher (*Haematopus bachmani*)

Goals

Estimate population size
Monitor trend in population size

Background

Black Oystercatchers inhabit rocky shorelines of the Pacific Ocean from the Aleutian Islands to California and northern Mexico. Over most of their range they are residents, undertaking only short movements into flocks in winter. Some birds in Alaska move southward during winter. Geographic differences in movements suggest that region-specific surveys may be most useful for this species. The best approach may be a combination of background level monitoring to track overall population change (e.g. seabird colony counts, aerial surveys) and local pair surveys in areas where a change in population size is suspected.

Protocols

1. *Breeding season survey*. Boat-based cruises of shorelines between 5 May and 15 June will be used to detect oystercatcher pairs. This method may be most appropriate for localized populations on offshore islands in the southern part of their range (e.g. Farallon Islands, CA; Destruction Island, WA; and Cleland Island, BC). To help develop and evaluate the surveys an atlas of known nesting areas should be generated from existing information and surveys along the coasts of British Columbia and Alaska also should be conducted.

2. *Seabird colony surveys*. Intensifying the collection of data on oystercatchers during seabird colony surveys could be a viable survey option (some colonies are surveyed yearly), although timing could be an issue. Although the optimal time for Black Oystercatcher surveys is 5 May to 15 June, information would be valuable from seabird colony surveys if these were temporally standardized. Seabird researchers will be contacted to assess potential for gathering information on oystercatchers at seabird colonies.

3. *Winter flock counts*. Aerial surveys will be conducted between 1 December and 28 February at known winter flock locations. This method is probably the most cost-effective for enumerating oystercatcher populations in the northern part of their range. Winter flock counts could complement pair surveys at selected locations. Areas of oystercatcher concentrations need to be identified in British Columbia and Southeast Alaska. Important locations are known on Kodiak Island and in Prince William Sound, Alaska (10% of the population may occur in these two areas during the winter).

Major Assumptions

For estimating population size: Most or all breeding areas are known and are either censused or sampled using a rigorous sampling plan; detection rates are close to 1.0 on surveys.

For monitoring trend in population size: The same fraction of the population winters in the survey area during the survey period; no substantial temporal trend occurs in detection rates.

Primary Development Tasks

1. Delineate wintering areas and develop a practical sampling frame for winter surveys.

2. Estimate detection rates and assess the potential for long-term trends in the detection rate.

3. If the sampling frame excludes major portions of the wintering population, then develop ways to assess the assumption that no long-term trend occurs in the fraction of birds are present during the study period.

4. Carry out power analyses to determine sample size requirements.

Estimated cost

Development: $40K/yer for 2 years
Operational: $15K/year, mainly for air support

(From information provided by Brad Andres, USFWS, Anchorage, Alaska)

8. Black-necked Stilt (*Himantopus mexicanus*)

Species

Focal: *H. m. mexicanus*, continental United States, and *H.m. knudseni*, Hawaii

Secondary: Wilson's Phalarope (*Phalaropus tricolor*) and American Avocet (*Recurvirostra americana*)

Goals (focal species)

Estimate population size
Monitor trend in population size

Background

Nesting populations of Black-necked Stilts in the U.S. occur primarily in the Western Great Plains, Great Basin and Intermountain west. Smaller numbers breed on the Gulf Coastal Plain, and prairie habitats of the U.S., southern Canada, and Hawaii (Hayman et al., 1986). Major concentrations occur at pre-migration and migration staging areas, especially in the Great Basin, Salton Sea, and the California Central Valley (Oring & Reed 1997; Neel & Henry 1997; Shuford et al 1994). Major wintering zones include southern California and the eastern shore of the Sea of Cortez, especially the Mexican states of Sinaloa and Nayarit (Robinson & Oring 1996; Harrington 1992; Morrison 1992). A few birds are recorded on the Breeding Bird Survey but not enough to provide adequate estimates of trend in population size.

Concentrations of Black-necked Stilt occur and could be monitored during key stages of migration and/or wintering periods. However, available evidence suggests that patterns of occurrence and dispersion may vary considerably from year to year (probably depending upon rainfall) making it difficult to design a sensitive monitoring program outside of the nesting season. A program of monitoring the species during the breeding period is therefore recommended. The program needs to cover a large area, however, because the species' breeding range may shift substantially at this time of year in response to rainfall. Because Black-necked Stilt typically nest in habitats common in wetlands managed for wildlife, the monitoring objective focuses on wildlife areas during the nesting season. Wilson's Phalarope and American Avocets also nest in these areas and better information is needed on them. They will therefore also be recorded on the surveys.

Protocol

Willing state and federal wetland managers within the breeding range of the Black-necked Stilt will be asked to participate in the survey during the incubation period. A correspondence survey will be used to identify potential cooperators, sites, habitat conditions, and rough levels of site-use by Stilt. From this list, sites will be selected for future coverage, following a stratified design based upon the correspondence survey.

This survey may provide an excellent opportunity to collect basic habitat information, especially including vegetation and water-depth conditions, which can then be used to help explain changes observed during the surveys. This possibility should be explored during design of the surveys.

Major Assumptions

1. For estimating population size: Areas that the participating managers can survey cover most or all of the breeding range and either all such areas are accessible or those that are accessible provide a representative basis for extrapolation to the entire breeding range.

2. For monitoring trend in population size: Same assumptions as above, or that the fraction of birds that are accessible and included in the sampling plan shows no substantial temporal trend.

Primary Development Tasks

1. Prepare a map of the breeding habitats to serve as a sampling frame for the survey.

2. Determine whether substantial areas will not be accessible and, if so, assess the potential for this fact to cause substantial bias in estimates of trend and population size.

3. Recruit collaborators.

4. Carry out a power analysis.

Costs

Development: $15K/year for 3 years
Operational: $10K/year mainly for salaries

(*From information provided by Brian Harrington, Manomet Center for Conservation Sciences, Manomet, Massachusetts*)

9. American Avocet (*Recurvirostra americana*)

Secondary Species

Black-necked Stilt (*Himantopus mexicanus mexicanus*, mainland), Marbled Godwit (*Limosa fedoa fedoa*, Great Plains), Wilson's Phalarope (*Phalaropus tricolor*), Red-necked Phalarope (*Phalaropus lobatus*).

Goals (focal species)

Monitor trend in population size
Monitor numbers using major staging areas

Background

American Avocets breed semicolonially in shallow alkaline wetlands in the western United States and southern Canada. They winter mainly in Mexico and in the Central Valley; small numbers winter on the Gulf and Atlantic coasts. They are recorded in small to moderate numbers on the Breeding Bird Survey. Each year, 60-70% of the world's American Avocets molt and stage at Great Salt Lake, UT, and large numbers occur at other western Great Basin sites (Reed et al. 1997; Warnock et al. 1998). These congregations appear to offer the most reliable and cost-effective opportunity for surveying the species.

Protocol

Aerial surveys of Great Salt Lake, NV will be conducted three times per year – approximately 1, 15 and 31 August. Previous shorebird surveys in the Great Basin indicate that these dates include dates of peak shorebird use (Warnock et al. 1998). If resources allow flying alternate sites (Lake Abert and Summer Lake, OR; Lahontan Valley, NV; Mono Lake, CA), these flights will be conducted at the same time as the Great Salt Lake flights. Flights will be by fixed wing aircraft at approximately 25 m height and 160 km/h (Warnock et al. 1998). Auxiliary ground surveys employing point counts at 500 m intervals along key shoreline areas could be used to (a) determine the accuracy of aerial counts, and (b) determine relative abundance of the two phalarope species.

Long term trends in the proportion of the breeding population that enters the study area during the study period – or the average time they remain there – could lead to biased estimates of the trend in population size. Additional surveys elsewhere in the Great Basin would reduce this risk and should be investigated. Radiotagging individuals would allow determination of length of stay of staging birds. In addition, depending upon where radios were attached, determination of the originating breeding grounds or the ultimate wintering sites of Great Salt Lake birds might be possible. Ground surveys would elaborate accuracy of aerial counts and allow determination of the relative abundance of the two common phalarope species.

Major Assumptions

For trend estimation: No substantial, long-term trend occurs in the proportion of birds that enter the study area during the study period or the average time they remain there; no substantial, long-term trend occurs in detection rates during the survey.

For monitoring major staging areas: Major staging areas are included in the survey; no substantial, long-term trend occurs in detection rates on surveys.

Primary Development Tasks

1. Develop methods to measure long-term trends in the proportion of the population that enters the study area during the study period.

2. Develop methods to measure long-term trends in the average length of stay by birds in the study area during the study period.

3. Investigate whether to include other staging areas in the survey.

4. Study the magnitude and causes of variation in detection rates on the aerial surveys.

Costs

Development: $20K/year for three years
Operational: $22K/year mainly for aircraft support

(From information provided by Lewis W. Oring, University of Nevada, Reno, Nevada)

10. Willet (*Catoptrophorus semipalmatus*)

Species

Focal: Willet (*C. s. semipalmatus,* eastern United States))

Secondary: American Oystercatcher (*Haematopus palliatus palliatus*, Atlantic and Gulf coasts), Piping Plover (*Charadrius melodus melodus*, Atlantic coast)

Goals (focal species)

Estimate population size
Monitor trend in population size

Background

Eastern Willets nest in a narrow coastal band of salt marshes along the Atlantic and Gulf coasts. This subspecies is not monitored effectively by the International Shorebird Survey (Howe et al. 1989) or by the Breeding Bird Survey. Eastern Willets appear not to occur in large flocks at traditional staging areas in North America. In summer, this may be because most fly nonstop from the vicinity of the breeding area to wintering areas in northern South America. Even if southbound migrants could be counted with some precision, there is significant mixing with western Willets in late summer and autumn. Given enough resources, aerial surveys of the northern and northeastern coasts of South America might be an effective technique for monitoring eastern Willets, but this is impractical at present. Thus, surveys on the breeding ground appear to be the best way of monitoring this subspecies. A survey based on counts of nests might work in certain local situations but would be too difficult and labor-intensive to implement on a broad scale. Vocal behavior alone is influenced by too many variables to provide a reliable index to population size. A well-designed survey based on visual detections of adult birds is apt to be most effective.

It is likely that a continental survey for secretive marsh birds (rails, etc.) will be implemented in the next five to ten years. State agencies likely will provide personnel for such surveys. Given the extensive sympatry of Willets and Clapper Rails, the possibility of incorporating Willet surveys into a survey for Clapper Rails deserves consideration.

Protocol

The survey should (1) be conducted during the peak (3-4-week window) of the parental care period, after most nesting has ceased (variable with latitude); (2) be conducted within 2-3 hours of low tide (when standard feeding and bathing areas are certain to be accessible); (3) be based on visual detections of all Willets in the survey area during the survey period; (4) have high consistency and repeatability within and between years and across observers; and (5) employ mainly volunteers (if Willets are the only species involved, the required skill-level would be minimal and the pool of candidates much larger than for a BBS-type survey).

The actual sampling design should be consistent with the above criteria. Given the time constraints, a suggested initial approach at each location is a series of ten, 5-minute counts at predetermined, non-overlapping points of suitable habitat along a route. Both intertidal and high-marsh sites should be included. A variable circular or semi-circular plot might be effective. Each route should be surveyed more than once per season (at least during the design phase), so that within-point variance can be estimated. A power analysis is needed to determine the required number of routes. Routes should be distributed widely throughout the range of the species, as logistically feasible. Field testing of the methods is essential. Ideally, a comparison should be made between the counting effectiveness of a survey as described here and a survey focused on the peak of the incubation period.

Major Assumptions

1. *For estimating population size:* All or nearly all of the breeding population is within the sampled population; survey stations are randomly distributed or, if this is not practical, are representative of the possible locations; detection rates increase to 100% or nearly 100% for birds close to the observer.

2. *For trend estimation*: Assumptions above hold or, if this is not true, failures of the assumptions do not cause any substantial, long-term in the detection ratio.

Primary Development Tasks

1. Prepare a map showing all breeding habitat.

2. Test the field methods, especially the required assumptions about survey locations and detection rates.

3. Prepare large-scale maps showing areas to be searched during surveys and prepare guidelines for the surveys such as when to search in relation to tides.

4. Conduct a power analysis to determine sample size requirements.

Costs

Development: $15K/year for 1 year
Operational: $10K/year mainly to coordinate volunteers

(From information supplied by Marshall Howe, USGS Patuxent Wildlife Research Center, Laurel, Maryland)

11. Willet (*Catoptrophorus semipalmatus*), Marbled Godwit (*Limosa fedoa*), Dunlin (*Calidris alpina*)

Species

Focal: Willet (*C. s. inornatus*, Interior), Marbled Godwit (*L. f. fedoa*, Hudson's Bay and *L. f. beringiae*, Alaska), Dunlin (*C. a. pacifica*, Western Alaska)

Secondary: Long-billed Curlew (*Numenius americanus*), Least Sandpiper (*Calidris minutilla*), Short-billed dowitcher (*Limnodromus griseus caurinus*, Southern Alaska), Long-billed dowitcher (*Limndromus scolopaceus*)

Goals (focal species)

Monitor trend in population size
Monitor numbers using major wintering areas

Background

Interior Willets and Hudson's Bay Marbled Godwits breed in the central part of North America and are recorded in moderate numbers on the BBS but the reliability of trends for these species from BBS data is uncertain at present. Both taxa are recorded at major concentration sites in moderate to large numbers in the Great Basin. Western Alaska Dunlin and Alaska Marbled Godwit populations breed in northern regions that are not covered by existing surveys. All three taxa winter in substantial numbers along the Pacific coast from southern British Columbia well south into Mexico. These areas are currently not well covered by the ISS or any other protocol. Better information is thus definitely needed on use of major wintering sites, and this protocol addresses that goal. Better information will probably be needed on trends in population size for all three taxa. This protocol will also attempt to meet this goal, though uncertainty exists at present about how well this will be possible.

Protocol

1) Marbled Godwits and Willets – Two aerial surveys will be conducted in December and January covering San Francisco Bay and Humboldt Bay. These surveys will probably record more than 65% of the Marbled Godwits and Willets wintering on the west coast of the United States (Page et al. *in press*). Flights will be conducted at low tide (between 0-3 ft.) and the entire tide line within each bay will be flown. Ground counts of subsets of San Francisco Bay and Humboldt Bay will be conducted to estimate the ratios of Marbled Godwits to Long-billed Curlews.

Data for Marbled Godwits and Willets from these surveys can be compared to trend data for Marbled Godwits and Willets calculated from Christmas Bird Count data (just using Pacific regions) and BBS surveys (excluding eastern states).

2) Dunlin – Two aerial surveys will be conducted in December and January covering San Francisco Bay, Willapa Bay, Grays Harbor, and Puget Sound. These surveys will probably record more than 75% (60% without Puget Sound) of Western Alaska Dunlin wintering on the west coast of the United States (Page et al. in press). Flights will be conducted at low tide (between 0-3 ft.) and the entire tide line within each bay will be flown. All small shorebirds will be counted. Ground counts of subsets of San Francisco Bay

will be conducted to estimate the proportion of small shorebirds that are Dunlin. North of California, numbers of small sandpipers (other than Dunlin) are low enough in the winter that ground counts may not be necessary. Christmas Bird Count data and other existing information might be used in Washington to get ratios of Dunlin to other small shorebirds.

Data for Dunlin from these surveys can be compared to trend data for Dunlin calculated from Christmas Bird Count data sets (just using regions where *C. a. pacifica* occur) and Dunlin numbers at the Copper River Delta in the spring (Western Sandpiper protocol). Additional winter counts in the Central Valley of California and the Willamette Valley of Oregon would aid in interpreting winter count data for Dunlin, since coastal Dunlin do move to interior locations during winter months (Warnock et al. 1995). Periodic surveys along the coast of Mexico would also help evaluate the possibility of long-term distributional shifts that might decrease reliability of trend estimates obtained from the surveys.

Major Assumptions

1. For trend estimation: Few birds from other populations of the focal species over-winter in the study area during the study period, or if this is not true, no substantial, long term trend in their numbers occurs; no substantial, long-term trend occurs in the proportion of the focal population birds that enter the study area during the study period or the average time they remain there.

2. For monitoring major wintering areas: Major wintering sites are included in the surveys; no substantial, long-term trend occurs in detection rates, as corrected by ground counts.

Primary Development Tasks

1. Carry out detailed design of surveys, investigate the allocation of effort between aerial and ground surveys, and conduct a power analysis to estimate precision likely to be achieved.

2. Develop methods for testing the assumption that the proportion of focal birds in the study area during the study period remains approximately stable.

Costs

Development: $40K/year for 3 years
Operational: $30K/year mainly for salaries and travel
(From information provided by Nils Warnock and Gary Page, Point Reyes Bird Observatory, Stinson Beach, California)

12. Wandering Tattler (*Heteroscelus incanus*)

Secondary Species

Surfbird (*Aphriza virgata*), Black Turnstone (*Calidris ptilocnemis*).

Goals (focal species)

Monitor trend in population size

Background

The Wandering Tattler is probably the most solitary and dispersed of North American shorebirds and is known to "concentrate" only on Middleton Island in the north Gulf of Alaska where on a single occasion 350 birds have been recorded in autumn. The species breeds in extreme E. Siberia, throughout southern Alaska, southern Yukon, and northern British Columbia in fluvial and remnant glacial habitats from sea level to high montane regions. During the nonbreeding period birds occur mainly along rocky coasts from California to Ecuador and over rocky coasts and reefs (sometimes adjacent beaches and freshwater impoundments) throughout south-central Oceania and eastern Australia. Given the species' dispersed nature, choosing a place and time to monitor the population is problematic, but a first attempt should occur on the nonbreeding grounds. Factors favoring such an effort include: 1) the species' high degree of site fidelity to areas used during the nonbreeding period, 2) the greater pool of potential observers available throughout the nonbreeding range, and 3) use of in-place logistic support needed to accomplish the effort.

Protocol

Coordinated mid-season censuses will be conducted of representative portions of the three principal nonbreeding regions: Pacific coast of North and South America, Oceania, and eastern Australia. The protocol entails a two-tiered approach based primarily on logistic constraints. In regions where logistic support is reasonably economical and generally available, such as eastern Australia, along the Pacific coast of North America, and over portions of the Hawaiian Archipelago, a series of sites will be identified and censused once or twice during the nonbreeding period each year. Throughout Oceania, probably the principal nonbreeding area for the species, logistics are costly and less predictable. Census efforts in this region will thus largely depend on opportunistic transportation such as military, government, or private vessels or aircraft to access potential sites. The opportunistic nature of such logistics could introduce bias into the census results. Nevertheless, independent samples from all major nonbreeding regions would be useful for cross-validation of results.

Census areas in all nonbreeding regions will be stratified according to habitat type in proportion to amount available. Actual censuses will be conducted around a fixed seasonal period and during fixed conditions, including stage of tide, wave height, and wind speed and direction. Censuses will entail walking transects along shorelines and/or boat transects adjacent to the shore; the latter will be used primarily where foot access to the shoreline is difficult.

Data collection will be coordinated with a several state, national, and international agencies, including: in the US the USGS, USFWS (Regions 1 and 7); the Hawaii Division of Forestry and Wildlife; Government of Australia and therein the state governments of Queensland and New South Wales; Government of

New Zealand and France; and numerous independent island nations throughout Oceania. Data can be analyzed promptly with relatively straightforward methods.

Access to many island groups in Oceania could be facilitated through scheduled vessels such as those used by the US Coast Guard to tend buoys and lights and those associated with commercial trade in copra and mariculture products, ecotourism, US and foreign military operations, ongoing multi-national natural resource investigations, and private tourism through such organizations as the Oceanic Society. The Hawaii Audubon Society and the Hawaii Division of Forestry and Wildlife annually host a mid-winter, archipelago-wide, census of waterbirds. The design of this effort could be modified to facilitate a tattler census as could ongoing shorebird surveys in Australia conducted by the Queensland Wader Study Group.

Major Assumptions

The study area includes all of the wintering area or, if this is not true, that no substantial, long-term trend occurs in the proportion of birds present in the study area during the study period; survey locations are selected under a well-designed sampling plan, or, if this is not true, that no substantial, long-term trend occurs in the proportion of the wintering birds that are at sites which cannot enter the sample; birds are sedentary during the study period, or, if this is not true, that distributional shifts occur that cause substantial, long-term trends in the detection ratio.

Primary Development Tasks

1. Develop the infrastructure, including participants, information on transportation options, and initial estimates of Tattler abundance across the wintering area, needed to carry out the surveys.

2. Develop the sampling frame and sampling plan and assess the potential for bias identified above under Major Assumptions.

3. Conduct a power analysis to help make decisions about allocation of effort and estimate precision likely to result from the study.

Cost

Development: $50K/year for 3 years
Operational: $20K/year mainly for travel and salaries of seasonal employees

(From information provided by Robert E. Gill, Jr., USGS Alaska Biological Science Center, Anchorage, Alaska)

13. Bristle-thighed Curlew (*Numenius tahitiensis*)

Secondary Species

American Golden-Plover (Pluvialis dominica), Pacific Golden-Plover (Pluvialis fulva), Whimbrel (Numenius phaeopus rufiventris, Alaska and Northwest Canada), Bar-tailed Godwit (Limosa lapponica).

Goals (focal species)

Estimate population size
Monitor trend in population size

Background

Bristle-thighed Curlews nest only in western Alaska in two disjunct regions of montane tundra. After breeding, the entire population is thought to stage on the outer Yukon-Kuskokwim River Delta before migrating to non-breeding areas in southcentral Oceania. Because of the highly dispersed nature of birds during the non-breeding season, population assessment is best carried out on the breeding grounds. This protocol entails periodic replication of established point count routes in the two core breeding areas. Bristle-thighed Curlews do not breed until three years of age; thus, this survey protocol does not monitor a significant portion of the population.

Protocol

A series of point counts will be replicated on the breeding grounds in a stratified-random design every five years during the courtship and early nesting periods, which generally occur during the last 10 days of May. The survey protocol was designed and implemented in the late 1980s. The first replication of the protocol occurred on the southern range in spring 1999; that over the northern range is proposed for spring 2000.

In the initial study, potential breeding areas in western Alaska were stratified by township based on characteristics of slope, elevation, and landcover. A random sample of townships was surveyed within each stratum. Within each township, from one to four linear transects were plotted across gradients of topography and landcover classes so that a systematic sample of each township could be obtained. The starting point of each transect was chosen randomly, and census points were located 500 m apart along transects until a total of 25-30 points had been sampled within each township. Transects were separated by at least one drainage system to minimize duplicate counts of individuals.

At each census point, a single observer recorded the number and behavior of each curlew detected as well as the number of other shorebirds present and all potential curlew predators seen or heard during a 10-min period within a circular plot of unlimited radius. All curlews were found to occur within two small breeding areas. Additional presence-absence surveys of surrounding townships were conducted to delineate the boundaries of these breeding areas and the size of the breeding strata. The mean number of curlews detected per survey point per township and associated standard error were estimated using formulas for a stratified-random design with a finite population correction factor (Scheaffer et al. 1986).

In both the northern and southern core breeding areas, intensive study areas in different townships were established. On each of these, the actual density of breeding pairs was determined for 1-4 years. Transects across these townships were surveyed during the same years to estimate the ratio between the average number of curlews detected per point and actual breeding densities, along with the bootstrapped variance of the ratio. The total number of breeding pairs in the population and associated standard error were estimated using statistical formulas for a double-sampling design (Cochran 1977).

For each of the two core nesting areas, all data can be collected over a 7-10 day period by three, two-person crews using a helicopter as the principal means of deployment. Data entry and manipulation will require another 1-2 weeks. The Bristle-thighed Curlew monitoring protocol is coordinated jointly by the USGS, Alaska Biological Science Center (ABSC) and the USFWS, Yukon Delta National Wildlife Refuge. Data are archived at the ABSC, Anchorage.

Occasional reports continue to surface of curlews seen during the breeding season north of the Seward Peninsula. These may be birds from a small breeding population in this region or failed-nesting birds that have dispersed from Seward Peninsula breeding sites. Previous efforts to verify the breeding status of the species north of the Seward Peninsula (Gill et al. 1996) were inconclusive and, because of logistical constraints, did not include coverage of areas identified as potential primary habitat. A survey using the methodology described herein should be initiated in the western Baird and DeLong mountains north of Kotzebue to determine whether or not a third breeding area exists there.

Juvenile and subadult age classes can be distinguished on the basis of plumage characteristics and progression of molt (Marks 1993). The proportion of the total population that consists of breeders and subadult birds could be determined by capturing samples of birds from a series of sites on the wintering grounds. Monitoring changes in the age structure of the population through time would allow more sophisticated demographic modeling and population viability analysis.

Major Assumptions

For population size estimation: All or nearly all of the breeding population is within the sampled population; counts on surveyed plots are unbiased.

For trend estimation: The study area contains all of the breeding population, or, if this is not true, no substantial, long-term trend occurs in the proportion of the population within the study area; no substantial, long-term trend occurs in the detection ratio.

Costs

Operational: $ 60K/year, mainly for travel and logistics

(From information provided by Robert E. Gill, Jr., and Colleen M. Handel, USGS Biological Research Center, Anchorage, Alaska, and Brian J. McCaffery, USFWS, Bethel, Alaska)

14. Whimbrel (*Numenius phaeopus*)

Species

N. p. hudsonicus, Hudson's Bay

Goals

Estimate population size
Monitor trend in population size

Background

Whimbrels in North America have a disjunct breeding distribution with one group in the Northwestern Canadian and Alaskan Arctic and another in the Hudson Bay Lowlands (HBL). During northward migration through the U.S., largest numbers of Whimbrel appear in southeastern states (Georgia to Virginia), Pacific states (California, especially the Central Valley), and on the Texas coast. Very few are seen in middle-interior regions of the continent. Relationships of Whimbrels using eastern (or western) migration areas to Whimbrels breeding in the HBL and western Arctic parts of North America are unproven but should become clear with work described here.

Recently, Winn and co-workers found a nocturnal roost on the Georgia coast during spring that was used by between 4,000 and 5,000 Whimbrels. Although the population size of Whimbrel is unknown, the minimum estimated size is 50,000 birds (Morrison et al., in prep); no distinction is made between the two breeding groups in this estimate. Although data are lacking, the magnitude of Whimbrel counts from the Pacific Flyway are on the same order as counts from the Atlantic, making it seem unlikely that the population sizes of the two populations are dramatically different.

Determining the HBL population size will be achieved through a mark:resighting program. The marking will be based in Georgia. Resightings made in Georgia will define the proportion of the total that is staging there in spring, and how this fraction may vary between years. Resightings obtained elsewhere at other seasons (Massachusetts in fall, Panama, Surinam, Brazil and Chile during winter) will provide data for determining overall population size.

Protocol

In year 1 a capture and color-banding program will be used to affix radios and then to track daily habits of Whimbrels using the Georgia coast during spring. This will provide information on activity budgets as well as turnover rates. It will also help identify areas away from the nocturnal roost sites where attempts to catch and color-mark Whimbrels can be made. Daily flight-line counts will be used to estimate numbers of Whimbrel using a strategic nocturnal roost site from day to day and week to week. A banding and color-marking ("color banding") program will be started in year 1 and continued in year 2. Resightings will be made in Georgia during spring to establish the fraction of the HBL population which stages there. Sightings and band ratios obtained elsewhere (Eastern Canada, Maine and Massachusetts) during fall, and South America (Panama, Surinam, Brazil, Chile) during boreal winter) will be used to estimate population size.

Nocturnal aerial imagery also will be used to provide information on the spatial area of flocks using roost sites. Nocturnal ground-based imagery (cameras mounted on poles) will provide information on nocturnal flock densities. *Density x area* of the flocks should produce good estimates of numbers and provide an independent estimate from the flight-line studies and the local (GA) mark:resighting study.

Independent searches for color-banded Whimbrels will be made during south migration in New England and Mid-Atlantic States, and in wintering areas of Central and South America. Counts to track numbers of adults checked as well as numbers of color-marked individuals found will be maintained, and will form a basis for estimating the adult population size.

During the first three years, the population size of HBL Whimbrels will be determined along with estimates of what fraction and how consistent a fraction of the population stages in Georgia during spring. Assuming this fraction is sufficiently consistent, continued annual counting of the Georgia spring staging site will be used to track population trends for the population.

Assumptions

For population size estimation: Assumptions of the capture-recapture method are met; adult Whimbrel using New England migration stopover sites during southward migration are from the same population as uses the Georgia coast during spring.

For trend estimation: No substantial, long-term trend occurs in the proportion of the HBL birds present at the nocturnal roost site during the survey; roost flight-line counts and/or aerial imagery provide reasonably precise and unbiased estimates of the number of birds using the Georgia roost.

Primary Development Tasks

1. Insure that the needed mark-recapture methods are available.

2. Carry out the final design work including allocation of effort between the methods and sample size estimation.

Costs

Development: $100K/year for 3 years
Operational: $ 17K/year mainly for salaries and travel
(From information provided by Brian Harrington, Manomet Center for Conservation Sciences, Manomet, Massachusetts and Brad Winn, Georgia Department of Natural Resources, Brunswick, Georgia)

15. Long-billed Curlew (*Numenius americana*)

Goals

Estimate population size
Monitor trend in population size

Background

Long-billed curlews breed in areas that are accessible to people. The species is vocal and easily surveyed early in spring. Surveys at any other time of year would be more difficult to carry out and the results would be difficult to interpret. For these reasons, a breeding season survey is recommended.

Protocol

The design will be a stratified random sample across the species' known breeding range. Surveys will be laid out in two types of areas -- focal areas where curlews are known to breed, and at randomly selected sites where suitable habitat is thought to exist. Maps of potentially suitable nesting habitat in the U.S. should be available from statewide Gap Analysis projects and/or the Environmental Protection Agency's EMAP program.

A modified BBS approach will be used. Surveys will be conducted during the 2-3 weeks between arrival of the males and the beginning of laying. Males engage in conspicuous aerial displays during this period (Redmond et al. 1981). At lower elevations and latitudes (e.g. north Texas and southwest Idaho), this period begins in late March, whereas at higher elevations and latitudes (e.g. Montana's Centennial Valley), it begins in early May. The following modifications to the BBS design are proposed: 1) 20-30 stops per route, 2) periodic sampling away from roadside (up to 100 m every other stop), and 3) measuring the distance to each curlew sighting with a rangefinder. These sightings will be the basis of density estimates (Buckland et al. 1993) that in turn can by used to monitor change in the numbers of breeding Long-billed Curlews over time.

The process of selecting and planning the sampling routes could be standardized and expedited using GIS in the following manner. Assemble seamless layers (Arc/Info grids) of topography, general climate, and land cover for the full extent of the species' presumed breeding range (A.O.U. 1997). These datasets should be available for the western states from the following sources: 1 degree digital elevation models from the USGS, general climate data (1 km^2 resolution) or even lilac bloom dates from the NRCS, and land cover from the USGS, Gap Analysis Program and/or the EPA western EMAP Program. With these grids, one could identify all existing BBS routes that fall within potentially suitable habitat. This list could be cross-referenced with the BBS database to distinguish routes where curlews have never been recorded from those where they are routinely sighted. This information should be supplemented with feedback from biologists and other knowledgeable persons throughout the range to identify other focal areas. Once known and potential areas have been identified and intersected with existing BBS routes, it probably will be necessary to randomly select additional areas for placement of survey transect routes.

Assumptions

For population size estimation: The species' breeding range is known; the sampling design is random; the surveys are not unduly biased by differing conditions related to weather, detectability, observers, etc.

For trend estimation: Same assumptions as above or, if this is not true, that no long term trend occurs in the detection ratio.

Primary Development Tasks

1. Complete detailed design of the sample selection and field methods.

2. Carry out sample size estimation analyses.

Costs

Development: $50K/year for 3 years
Operational: $42K/year mainly for technician salaries and travel.

(From information supplied by Roland L. Redmond, USFWS, Montana Cooperative Wildlife Research Unit, Montana)

16. Bar-tailed Godwit (*Limosa lapponica*)

Seondary Species

Black-bellied Plover (*Pluvialis squatarola squatarola*, Alaska), Pacific Golden-Plover (*Pluvialis fulva*), Marbled Godwit (*Limosa fedoa beringiae*, Alaska), Rock Sandpiper (*Calidris ptilocnemis tschuktschorum*, mainland Alaska), Dunlin (*Calidris alpina pacifica,* Western Alaska).

Goals (focal species)

Estimate population size
Monitor trend in population size
Monitor numbers using major early migration areas

Background

Between three and five subspecies of Bar-tailed Godwit are recognized (del Hoyo et al. 1996, Higgins and Davies 1996, Engelmoer and Roselaar 1998), having a combined population of between 1.2 and 2.2 million individuals (Rose and Scott 1997). The *L. l. baueri* subspecies is thought to breed exclusively in Alaska and number about 100,000 birds (Engelmoer and Roselaar 1998, Gill and McCaffery 1999, Riegen 1999; Sagar et al. 1999, P. Tomkovich in litt.). Each autumn from August to early October, birds stage for several weeks on estuaries of western and southwestern Alaska before migrating to New Zealand, the principal wintering area for the *baueri* population (Gill and McCaffery 1999). Because the entire population is present at these sites for a relatively short period, aerial surveys are an appropriate method for enumerating population size and trend.

Autumn aerial surveys in Alaska would precede by a few weeks similar efforts on the nonbreeding grounds in New Zealand; the latter would afford an independent measure of the accuracy of results obtained in Alaska. It is not known if birds breeding in Asia move to Alaska in autumn. The annual proportion of juveniles within the population is unknown, but can be determined.

Protocol

Low-level aerial surveys will be flown over the coastline of western and southwestern Alaska (Cape Romanzof to Nelson Lagoon) every two years during late August and early September. Surveys will be coordinated around stage of tide and along specific segments of coastline (details appear in Gill and McCaffery, 1999, and Gill and Sarvis, 1999). Survey design should be modified to include:1) survey years that coincide with efforts to assess godwit numbers on principal nonbreeding areas in New Zealand, 2) data collection via Moving Map Display (= real time voice-recognition, georeferenced data entry), and 3) an assessment of the accuracy of flock size estimates via aerial photography or a combination of ground counts and ground photography. Since this protocol involves aerial surveys, trying to enumerate populations of other species (with exception of Marbled Godwits) may decrease the accuracy of counts of Bar-tailed Godwits.

Data collection would be coordinated with USGS, Alaska Biological Science Center, and USFWS, Migratory Bird Management Office, and Yukon Delta, Togiak, Alaska Peninsula/Becharof, and Izembek National Wildlife Refuges.

Assumptions

For population size estimation: For at least a few weeks each autumn, the entire population is present on coastal sites of western and southwestern Alaska; birds from other populations are not coming to Alaska or, if they are, their population size can be determined; detection rates are close to 1.0

For trend estimation: Same assumptions as above or if this is not true that no substantial temporal trend occurs in the proportion of birds that are in the study area at the time of the study period.

For monitoring early migration areas: That the survey area includes the major early migration area.

Primary Development Tasks

1. Verify the assumption that all bar-tailed godwits are present in the study area during the study period, for example by making several repeated counts at short intervals.

2. Determine whether birds from other populations are coming to Alaska and, if so, develop methods for detecting any long-term trend in their numbers.

3. Determine the accuracy of aerial counts.

Costs

Development: $40K/year for 3 years
Operational: $12K/year mainly for aircraft support and aerial surveyors

Prepared by Robert E. Gill, Jr., USGS, Alaska and Brian J. McCaffery, USFWS, Alaska

17. Hudsonian Godwit (*Limosa haemastica*)

Secondary Species

Red Knot (*Calidris canutus rufa*, low arctic Canada), White-rumped Sandpiper (*Calidris fuscicollis*)

Goals (focal species)

Estimate population size
Monitor trend in population size

Background

Hudsonian Godwits breed in northern North America and winter in South America. The majority of the wintering population appears to be well concentrated in two regions in southern south America. On the Atlantic coast, 95% of ~33,000 godwits counted by Morrison and Ross (1989) were found in the Argentinian and Chilean sectors of Tierra del Fuego (with the rest occurring on the coastlines of Argentina and Uruguay); these birds are thought to derive from central Canadian Arctic breeding populations. On the Pacific side, 99% of ~13,000 godwits counted by Morrison and Ross (1989) were found in the Chiloe region of southern Chile; these birds are thought to be come from the western Arctic breeding populations in North America.

Both adults and juveniles are thought to occur together on the wintering grounds. The present methods are based on counting godwits found in coastal sites. The extent to which Hudsonian Godwits may occur in inland habitats (e.g. interior lagoons in Buenos Aires Province in Argentina) is not known.

Protocol

Aerial surveys of two major wintering regions will be conducted during January each year. Low level aerial surveys will be required to obtain full coverage of the major coastal bays and sites in Tierra del Fuego (Argentina and Chile) and in the Chiloe region (Chile). Techniques are described in Morrison and Ross (1989). Periodic counts of inland areas will be made to document any long term temporal trends in the proportion of the populations using these area.

Assumptions

For population size estimation: Few wintering birds will be missed on the aerial surveys

For trend estimation: Same as above or if this is not true then no substantial temporal trend occurs in the proportion of birds that winter in the study area and are detected on surveys

Primary Development Tasks

1. Design surveys to be carried out periodically to estimate the numbers of birds (if any) in inland areas

2. Develop methods to determine which sub-population surveyed birds come from.

Costs

Development: $50K/year for 2 years
Operational: $25K/year mainly for travel including aircraft charter.

(From information provided by Guy Morrison, Canadian Wildlife Service, Quebec, Canada)

18. Black Turnstone (*Arenaria melanocephala*)

Secondary Species

Dunlin (*Calidris alpina pacifica*, western Alaska), Semipalmated Sandpiper (*Calidris pusilla*), Red-necked Phalarope (*Phalaropus lobatus*)

Goals (focal species)

Estimate population size
Monitor trend in population size

Background

Most (85%) of the world's population of Black Turnstones breed on the central Yukon-Kuskokwim Delta, Alaska, and 65% are concentrated along a narrow, 2-km-wide band of coastal meadows (Handel and Gill 1992) where they can be surveyed with relative ease. Black Turnstones are monogamous and highly site-faithful to breeding territories, factors that reduce inter-annual variability in densities of breeding adults (Handel 1982, Handel and Gill in review).

Protocol.

Stratified random sampling will be used to select plots. Surveys will be concentrated on the core breeding area of the central Yukon-Kuskokwim Delta during the last two weeks of incubation, which is generally from about 25 May-10 June. In years with early or late springs, survey dates will be adjusted so that detectability of breeding adults remains relatively constant across years. The extent of coastal lowlands will be delineated from satellite imagery. This area will be stratified by habitat (salt grass meadows or other) and distance from the coast (0-2 km, 2-10 km, > 10 km), because both factors significantly influence nesting density of turnstones (Handel and Gill 1992). East-west transects will be placed randomly across these strata, in allocations proportional to historical nesting density (Handel and Gill 1992). A single observer will walk along each transect and record perpendicular distance to each turnstone detected.

Additional line-transect surveys will be conducted at a selection of known breeding sites outside of the core nesting area, on the northern Seward Peninsula, the Kuskokwim River delta, and Bristol Bay. Coastal lowlands in those areas also will be delineated from satellite imagery and transects will be placed randomly in breeding habitat strata. The same distance-sampling methods will be employed, but sampling efforts will be at lower intensity than in the core breeding area. This effort will allow comparison of population trends in primary and secondary breeding areas.

At 5-year intervals, aerial surveys will be conducted along the coast from Kotzebue Sound to the Alaska Peninsula to document any major shifts in breeding distribution. Flight lines will parallel the coastline 200 m inland from the shore. Two observers will record all turnstones observed within a series of bands from the plane so that densities can be analyzed with distance-sampling techniques. If major shifts are noted, then additional aerial surveys can be flown to document geographic patterns over more extensive inland areas. Ground sampling efforts can also be reallocated if major shifts in geographic distribution occur.

Estimates of the size of the breeding population on the core and secondary breeding areas can be made periodically by surveying line transects placed across intensive study areas on which actual nesting densities have been determined. From these data, correction factors can be calculated and applied to the extensive survey data using double-sampling techniques (Handel and Gill 1992).

Data collection will be coordinated with the USGS, Alaska Biological Science Center; USFWS, Migratory Bird Management Office and Yukon Delta, Togiak, and Selawik NWRs; and NPS, Bering Land Bridge and Cape Krusenstern National Monuments. Data from each survey can be analyzed using program DISTANCE (Buckland et al. 1993) to produce an annual index of breeding density and associated standard error for each habitat stratum and for the core and secondary breeding areas.

Assumptions

For population size estimation: The breeding range of the species is known; ground transects are randomly allocated across predefined strata throughout the range so that inferences can be made about the entire population; assumptions of the distance estimation method are met.

For trend estimation: Same assumptions as above or if they are not met then that no substantial temporal trend occurs in the detection ratio.

Primary Development Tasks

1. Complete detailed design of the sample selection and field methods.

2. Carry out sample size estimation analyses.

Costs
Development: $25K/year for 2 years
Operational: $17K/year mainly for logistics and travel and personnel costs

(From information supplied by Colleen M. Handel and Robert E. Gill, Jr., USGS Biological Research Center, Anchorage, Alaska)

19. Ruddy Turnstone (*Arenaria interpres*), Red Knot (*Calidris canutus*), Sanderling (*Calidris alba*)

Species

Focal: Ruddy Turnstone (*A. i. morinella*, low arctic Canada); Red Knot (*C. c. rufa*, low arctic Canada)

Secondary: Black-bellied Plover (*Pluvialis squatarola cynosurae,* northern Canada); Whimbrel (*Numenius phaeopus hudsonicus,* Hudson Bay); Willet, *Catoptrophorus semipalmatus semipalmatus,* eastern United States), Semipalmated Sandpiper (*Calidris alba*).

Note: Most of the species probably use the Central and Atlantic flyways and are presumably from Canadian arctic and not Alaska where significant numbers of all (except Willets) also breed.

Goals

Monitor trend in population size
Monitor numbers using major migration areas

Background

Ruddy Turnstones and Red Knots breed at low densities in the high arctic where access is expensive and logistically difficult. The focal subspecies migrate through the mid-Atlantic coast to wintering areas of the southern United States and Mexico. They have been widely surveyed during the past 10-15 year in the Delaware Bay area and at other concentration points. This work indicates that a migration survey may provide the best opportunity to study these subspecies.

Protocol

Six shoreline surveys (once each week) will be conducted annually between 10 May and 10 June. Each survey requires two days, including aerial and ground components. The aerial portion commences in New Jersey two hours following a daytime high tide in the vicinity of Avalon, NJ and ends six hours later in the vicinity of Lewes, DE. Six "truthing" sites will be established, including three on the New Jersey side of Delaware Bay and three on the Delaware side of the bay. Ground-truthing will be done ½ hour and again 10 minutes before the counter aircraft passes the truthing sites. Day 2 will include an aerial shoreline survey from Lewes to Fisherman Island NWR at the south end of the Delmarva Peninsula. The return trip will include two hours for flying fixed transects over intertidal habitats (saltmarshes and tidal flats) on the landward side of the barrier islands. Ground-truthing will be done at three locations for return flight surveys.

Aerial survey data will be recorded simultaneously by two observers (one on either side of the aircraft) into voice-recognition computers and two tape recorders (one as a back-up). Positions will be recorded using a GPS unit.
Ground data will be recorded for conspicuously demarcated sections of beach (recognizable from the aircraft). The aircraft observers will record shorebird numbers in these same sections.

Assumptions

For trend estimation: That large fractions of the hemispheric populations of the focal species are staging on the middle Atlantic coast of the U.S. during spring; that no substantial temporal trend occurs in the proportion of the population in the study area during the study period or in the proportion birds that are detected on the surveys.

For monitoring major wintering areas: That the study area includes the most important stop-over areas in the region; that no substantial change occurs in the proportion of birds present that are detected on the survey.

Primary Development Tasks

1. Develop methods for estimating the long-term trend (if any) in what fraction of the breeding populations is present in the study area during the study period.

2. Carry out a power analysis.

Costs

Development: $50K/year for 3 years
Operational: $40K/year mainly for technician salaries and aircraft

(Form information provided by Brian Harrington, Manomet Center for Conservation Sciences, Manomet, Massachusetts and Kathy Clark, New Jersey Department of Environmental Protection, Trenton, New Jersey (and Barry Truitt? address?)

20. Surfbird (*Aphriza virgata*)

Secondary Species

Black Turnstone (*Arenaria melanocephala*)

Goals

Monitor trend in population size

Background

During most of the annual cycle, Surfbirds are extremely dispersed across habitats that are largely inaccessible to humans, including alpine tundra during nesting and high-energy rocky intertidal shores during winter (Senner and McCaffery 1996, Senner 1998). For a 2- to 3-week period in spring, however, the majority of the population concentrates in a few rocky embayments of Prince William Sound, Alaska, where birds build fat reserves needed for egg laying and to sustain them during early nesting (Norton et al. 1990, Martin 1994, Senner and McCaffery 1997, Senner 1998, Bishop and Green 1999, Gill et al. 1999). Recent studies on the breeding grounds have shown extreme annual variation in nesting effort and productivity (Tomkovich et al. 1998, Gill et al. 1999). Trying to account for such variation with ground-based monitoring efforts of the breeding population becomes very problematic. A monitoring effort at spring staging sites in Prince William Sound (PWS), where most of the population is concentrated for a brief period, appears much more practical. Additionally, some historical data exists on Surfbird use of PWS since the late 1980s.

Protocol

Every 5-7 days during the spring staging period (20 April-15 May) a sample of Surfbirds will be captured in four major embayments of northern Montague Island in PWS. All birds will be uniquely color-banded and a subsample will be fitted with radios. Every 3-5 days all embayments will be censused simultaneously using boat or ground-based surveys. Flocks will be systematically searched for color-banded birds to estimate average length of stay throughout the period. Radio-marked birds will be monitored at fixed intervals from both the air and ground and used to derive measures of detectability of color-marked birds, particularly when birds are censused at dense, high tide roosts or when in dispersed feeding aggregations. High-resolution photography (from both air and ground) will be used to determine the accuracy of ocular estimates of flock size.

In order to lessen possible negative effects of capture and marking on length of stay and re-sighting rates, efforts should be made to locate additional areas where birds can be captured and marked in spring prior to their arrival in PWS. In addition, use of high resolution aerial imagery of birds at high tide roost sites and low water feeding areas in PWS should be explored as an alternative to ground- or boat-based censuses to estimate population size.

Data collection will be coordinated with: USGS, Alaska Biological Science Center; USFWS, Migratory Bird Management Office; and USDA, Forest Service. Data will be analyzed using various software packages (e.g. Program MARK) for mark:resighting data.

Large numbers of Black Turnstones have been recorded staging with Surfbirds in these embayments in spring (Norton et al. 1990, Bishop and Green 1999). Populations of both species could be monitored simultaneously using the same techniques at little additional cost. If a consistent and representative proportion of the turnstone population stages in PWS each spring, this effort could provide an independent alternative to the proposed population monitoring on the breeding grounds.

Assumptions

That areas used by Surfbirds are accessible during some or all portions of their stay in PWS; sufficient numbers of birds can be captured and marked so that mark:resighting data can be used to establish population levels; capture and marking methods can be used that do not significantly affect length of stay or resighting probabilities; a consistent and large proportion of the Surfbird population stages in these embayments each spring.

Primary Development Tasks

1. Determine which areas are accessible for the survey and evaluate the assumption that no long-term trend will occur in the proportion of birds that are outside the surveyed area at the time of the surveys.

2. Determine whether capture and marking can be carried out at the survey site or must be conducted elsewhere.

3. Carry out sample size and allocation of effort studies to complete the design.

Costs

Development: $50K/year for 3 years
Operational: $35K/year mainly for personnel and logistic support

(From information provided by Robert E. Gill, Jr., USGS Biological Research Center, Alaska)

21. Rock Sandpiper (*Calidris ptilocnemis*)

Species

C. p. ptilocnemis (Pribilof Islands and St. Matthew/Hall islands), *C. p. couesi* (Aleutian Islands, Alaska Peninsula, Kodiak Island), *C. p. tschuktschorum* (Western Alaska mainland, St. Lawrence and Nunivak islands, and Chukotka)

Goals

Estimate population size
Monitor trend in population size

Background

The Rock Sandpiper has four recognized subspecies. All breed exclusively within Beringia, two only on Bering Sea Islands (Commander and Pribilof islands, and St. Matthew Island) and two along the coast of mainland Alaska and Chukotka (Conover 1944). The only known concentration areas during the nonbreeding season are the distal end of the Alaska Peninsula and in Cook Inlet; most birds instead are spread out along rocky shorelines of the Aleutian Islands and along the coasts of southeastern Alaska and British Columbia. Recent information indicates that at least one of these populations has declined substantially, and concern exists for the Pribilof population and the effect grazing by reindeer is having on habitat quality, especially on St. Paul Island. The goal of this protocol is to assess the size and trend of Rock Sandpiper populations, focusing on those that have breeding ranges restricted mostly to North America. This will entail population-specific methods, mostly ground-based surveys during the breeding season (May), but aerial and ground surveys at autumn staging or wintering sites may be more appropriate for other populations (Gill 1997, Gill and Tibbitts 1999, Tibbitts et al. 1996).

Protocol

C. p. tschuktschorum: Effective monitoring of this population will be difficult. Breeding season transects on St. Lawrence and Nunivak islands would allow monitoring of these insular populations, but current information on breeding season distribution and densities for the mainland Alaska component of the population is insufficient to establish a similar monitoring effort. However, aerial surveys could be used to monitor this population during the postbreeding period (July-October) when birds gather in large flocks and remain for several weeks during molt along the immediate coast of western and southwestern Alaska (Gill and Handel 1981, 1990). This would entail one or two well-timed surveys of the entire coast (see Gill and McCaffery 1999) during the period of peak concentration, usually in September. Aerial photography (Gill and Tibbitts 1999) or ground-based efforts would be used to verify the accuracy of flock size estimates obtained from the air. These would in turn be used to derive correction factors for an overall estimate of population size. Data collection should be coordinated with: USGS, Alaska Biological Science Center; USFWS, Migratory Bird Management Office and Yukon Delta, Togiak, Izembek, Kodiak, and Alaska Maritime NWRs; Regional and Village Native Corporations; and Commander and Sakhalin Island Nature Reserve personnel.

C. p. ptilocnemis: This is probably the smallest of the "Alaska" populations and may number only 20,000 individuals (Gill 1997, Gill and Tibbitts 1999). Upper Cook Inlet appears to be the wintering area for most of the population. Monitoring will entail winter aerial and ground surveys (details in Gill and Tibbitts 1999) of concentrations along the west side of Upper Cook Inlet. Surveys on the breeding grounds, perhaps using landcover classes for strata, would provide a second measure of population size and trend and allow assessment of the impact of reindeer grazing on this insular population. Such an effort on the Pribilof Islands will be relatively inexpensive; that on St. Matthew will need dedicated logistic support.

C. p. couesi: Monitoring what is likely the largest of the populations is problematic, mostly because of its extensive breeding range and unknown aspects of its wintering biology. A goal of quantifying the population size is probably unrealistic until concentration areas throughout the Aleutians are known or until detailed landcover data become available for the archipelago. However, the population could be monitored at several levels. Long-term monitoring is probably best achieved over several core nesting areas (distal end of Alaska Peninsula and larger Aleutian Islands). An extensive series of transects (stratified by land cover) was established in the mid-1990s on the Alaska Peninsula at Izembek NWR where some of the highest nesting densities for the species occur. Similar transects could be established on the more accessible Aleutian Islands (e. g. Unalaska, Adak, Amchitka, Attu).

Assumptions

For population size estimation: For each subspecies, the study area contains all or nearly all of the population; detection rates are close to 1.0 on survey plots.

For trend estimation: No change occurs in the proportion of the population in the study area during the study period or in the detection rates.

Primary Development Tasks

1. Locate primary wintering areas and design the sampling plan for C. p. couesi

2. Conduct aerial surveys to delineate the breeding range for C. p. *tschuktschorum*:

Costs

Development: $90K/year for 3 years
Operational: $50K/year, mainly for salaries and logistic support (estimates assume use of existing DOI vessels or other ships of opportunity to reach insular populations).
(From information provided by Robert E. Gill, Jr., USGS Biological Research Center, Anchorage, Alaska)

22. Sanderling (*Calidris alba*)

Species

<u>Focal</u>: Populations wintering on the west coasts of North and South America.

<u>Secondary</u>**:** Snowy Plover (*Charadrius alexandrinus nivosus*, Pacific coast)

Goals (focal species)

Monitor trend in population size
Monitor numbers using a major wintering area

Background

Sanderlings breed in the high arctic where access is difficult and expensive. They winter on the coasts of North and South America. Access appears to be best during winter in the United States, though periodic surveys will be needed throughout their wintering range.

Protocol

Counts should be made on coastal beaches at very high tides, centered in time around the peak tide to reduce the possibility that birds are foraging elsewhere on sandflats or lagoon shorelines. Short beaches may be monitored by a single observer; longer beaches can be counted by several observers simultaneously walking different stretches. In this case, adjacent observers must walk either toward or away from each other. Two or more observers and beach sections can be coordinated in this manner; each section of beach should be completed within 3 to 3.5 hours spaced around the time of high tide. Flying birds are either added or subtracted from each individual's count depending on whether they pass the observer flying in the direction opposite, or the same as, the observer's walking direction.

Replicate counts should be made on two or more days at each site, over the period from December 1 to February 20. Beaches should be chosen to include those beaches with the highest regional populations and with easy access to census starting points. Suitable beaches include, but are not limited to, in California: central Monterey Bay, Point Reyes, Bodega Bay, outside of Humboldt Bay, Gold Bluff Beach; in Oregon: Coos Bay to Umpqua River, Umpqua River north, Clatsop beach; in Washington: Long Beach, Grayland Beach, Olympic-North Beach.

Assumption:

For trend estimation: That no substantial trend occurs in the proportion of the population that is in the study area during the study period.

For monitoring major wintering areas: That the surveyed areas include the major wintering sites within the survey region.

Primary Development Tasks

1. Complete selection of the survey area and methods within the United States.

2. Design periodic surveys throughout the wintering area.

(From information provided by Peter G. Connors, Bodega Marine Laboratory, University of California, Bodega Bay, California.)

23. Western Sandpiper (*Calidris mauri*)

Secondary Species

Short-billed Dowitcher (*Limnodromus griseus caurinus*, southern Alaska), Dunlin (*Calidris alpina pacifica* western Alaska)

Goals

Estimate population size
Monitor trend in population size
Monitor numbers using a major migration area

Background

In a given year, anywhere from 61-80% of the Western Sandpipers migrating along the Pacific Flyway stop on the Copper River Delta (Iverson et al. 1996, Bishop et al., in review). Surveying the stopover population, then, can provide a good indication of the status of the Pacific Flyway population. In addition, a good foundation has already been established for future monitoring. Three years of data have been collected on length of stay of Western Sandpipers on the Delta (Iverson et al. 1996, Warnock and Bishop 1998), and sandpiper numbers have been monitored for 4 years. Power analysis indicates that 15 years of aerial surveys are needed to detect a 10% decline in Western Sandpiper numbers (Bishop et al., in press).

Senner (1979) suggested all Dunlins of the *pacifica* subspecies stop at the Copper River Delta. If this is the case, the entire population could be monitored at the Copper River Delta. In spring 2001, a study of radiotagged Dunlin and Black-bellied Plover is proposed for the Pacific Flyway that would provide information on length of stay and proportion of birds stopping over on the Copper. If the data indicates that the majority of the Pacific Flyway population of these two species stop over on the Delta, both could potentially be monitored along with the Western Sandpiper.

Protocol

Aerial surveys will be conducted every 2–3 days (8–10 per year, 25 April-15 May) using two fixed-wing aircrafts to simultaneously survey the east and west deltas (east of the Copper River to Controller Bay and west of the Copper River to Orca Inlet, respectively).

Daily point counts (100-m radius, 400–500 m apart) will be conducted using an airboat to access the tideline between Pete Dahl and Alaganik Slough, a total distance of 8–12 km depending on tide height.

Data collection will be coordinated with the Prince William Sound Science Center, USFWS Office of Migratory Bird Management, and USDA Forest Service. Data will be analyzed using methods developed bu Bishop et al. (*in press*).

It will be useful to radiotag Dunlin and Western Sandpiper at San Francisco Bay, California or Grays Harbor, Washington early in migration to determine whether their lengths of stay are different from those birds radiotagged during peak migration. In years with radiotagged birds, radiotelemetry surveys should be conducted daily on the Copper River Delta to determine length of stay.

Assumptions

For population size estimation: Assumptions used in the estimation of numbers are discussed in Bishop et al. (*in press*). They include: (1) All birds present on the Delta are counted during aerial surveys. (2) Species proportions observed during point counts are representative of the entire Delta. (3) Radiotagged birds have a length of stay representative of the species population. (4) Interpolated data is representative of the total bird population and/or species composition on the corresponding day. (5) 10% of Western Sandpipers stop over for <24 hours and are missed on aerial surveys.

For trend estimation: Same assumptions as above or, if this is not true, that no substantial temporal trend occurs in the detection ratio.

Costs

Operational: $40K/year mainly for aircraft and airboats, technician salaries, and radio telemetry supplies and equipment.

(From information provided by Mary Anne Bishop, Prince William Sound Science Center, Cordova, Alaska)

24. Woodcock (The North American Woodcock Singing-ground Survey)

Objective

Estimate population trend

Background

This survey was initiated in 1970 and nearly 30 years of survey data have been collected. Trend estimates are used in establishing hunting regulations for this species. Thus, long-term population trends can be established with a fair degree of confidence. Data are collected throughout the species' range, so that population trends can be established at various geographic scales. The survey is coordinated by the USFWS for establishing hunting regulations for this species. The USFWS will continue to coordinate these activities for the foreseeable future.

Protocol

This survey is based on approximately 1,500 randomly-selected routes that are located on secondary roads across the woodcock's breeding range. These routes are 5.4 km long with 10 stops located at 0.6 km intervals. Two-minute point counts are conducted at each stop and the number of displaying woodcocks is recorded. These surveys begin shortly after sunset and each route is surveyed once during the peak of spring courtship activity, with the timing varying geographically. For more details, see Sauer and Bortner (1990) and Straw et al. (1994).

This survey is coordinated by the Migratory Bird Management Office of the U.S. Fish and Wildlife Service (USFWS). The survey database is managed by USFWS biologists. A route-regression method is used to estimate population trends from these data (Sauer and Bortner 1990). This method is based on linear regression using observers as covariates.

Counts of displaying male woodcocks along survey routes are used to develop annual indices of abundance. Changes in these indices over time are believed to represent temporal changes in the entire population. To be a valid index, counts of singing males must be related to the actual population sizes in some consistent manner. Non-singing males exist in woodcock populations, and variation in the proportions of these non-surveyed birds could reduce the reliability of the survey (Sauer and Bortner 1990). For example, Dwyer et al. (1988) found no correlation between singing male densities and actual population densities at a study site in Maine, while Whitcomb and Burgeois (1974) found a significant correlation at a site in Michigan. Additional studies are needed across the woodcock's range to establish whether or not changes in these indices are consistently related to changes in the entire population.

Assumptions

That no substantial temporal trend occurs in the detection ratio.
(From information provided by Bruce Peterjohn and Marshall Howe, USGS Patuxent Wildlife Research Center, Laurel, Maryland

25. Wilson's Phalarope (*Phalaropus tricolor*)

Secondary Species

American Avocet (*Recurvirostra americana*)

Goals

Monitor trend in population size
Monitor numbers using major staging and migration

Background

Over 90% of the adult population of Wilson's Phalarope evidently molts and stages on one of three hypersaline lakes – Mono Lake, CA, Lake Abert, OR, or Great Salt Lake, UT – before embarking on a nonstop flight to wintering areas in South America (Jehl 1988). Because of the paucity and highly localized nature of suitable staging areas, and the relatively small geographic area involved, Wilson's Phalarope is almost ideal for monitoring. Overlapping migration schedules of males and females insures that most adults will be present at the peak of migration. As a result, it is possible to study trends with relatively little effort. The species has already been monitored for 18 years (depending on site), so that there is a considerable baseline against which to compare additional information. There is no satisfactory way to measure annual production. Juveniles fan out across the continent and do not concentrate at hypersaline lakes.

Protocol

A complete census at three main staging areas each year will be conducted between 28 July and 3 August. Depending on the site, boat, foot, aerial surveys, or a combination will be used. Additional details are provided in Jehl (*in press*).

An additional survey effort to discover how frequently birds use other minor sites (e.g. Stillwater/Carson Sink) when conditions are suitable would be useful. Coordination with refuges and state-owned areas would be encouraged.

Assumptions

No substantial temporal trend occurs in the proportion of the population present in the study area during the study period; all or nearly all birds present during the surveys are detected.

Primary Development Tasks

Determine use at other sites.

Costs

Operational: $15K/year mainly for salaries and travel

(From information provided by Joseph Jehl, Hubbs Sea World Research Institute, San Diego, California

26. Red Phalarope (*Phalaropus fulicaria*), Red-necked Phalarope (*Phalaropus lobatus*)

Species

Populations that use the Atlantic flyway on migration

Goals

Monitor trend in population size

Background

Red and red-necked phalaropes breed across a large area in northern North America where access is difficult and expensive. Birds breeding in the eastern portion of this area are found during migration along the coast occurring in fall at coastal upwelling sites. Traditionally, the Bay of Fundy has supported the largest known concentrations of the two species in North America, and this site offered an excellent opportunity for monitoring studies. Beginning in the mid-1980s they started to disappear from the major fall staging area in the Bay of Fundy. It is not known where these birds have moved to but if the new location can be found it will presumably provide an excellent opportunity for monitoring the species as the Bay of Fundy did in the past.

Protocol

The goal of the protocol proposed here is to gather information that will help design a monitoring plan for Red and Red-necked Phalaropes by focusing efforts on 1) where aerial surveys should be conducted in the future and 2) on how fishermen can become involved and report phalarope sightings to a central coordinator.

Public meetings will be held in fishing communities in a) Deer Island, Campobello Island and Grand Manan Island in Passamaquoddy Bay in southern New Brunswick, b) Tracadie and Shippegan in northern New Brunswick and c) Brier Island and Digby, Yarmouth, Shelburne, Sambro and Guysborough along the eastern shore of Nova Scotia, to inform them of the missing phalarope populations. Feedback will be recorded and, where possible, boat trips with fishermen will be scheduled. Boat trips with fishermen will be undertaken in August and September in areas along the coast of New Brunswick and Nova Scotia where phalaropes are expected to be found. Based on information gathered from the meetings and boat trips proposed above, a phalarope monitoring plan will be prepared that indicates areas where aerial surveys should be undertaken to monitor numbers of phalaropes and to estimate their population sizes.

The coordinator will record all information received at public meetings and summarize it into a report. All sightings of phalaropes made from fishing boats will be recorded and localized using GPS. Locations and numbers of birds seen by boat (latitudes and longitudes and estimated numbers of birds and species, whenever possible) will be entered into a FileMaker Pro database and the data presented as tables and maps using MapInfo.

This approach rests on the following rationale: 1) that a significant proportion of the world's population of Red-necked Phalaropes (between 1 and 2 million birds) and between 10,000 and 50,000 Red Phalaropes, which failed to return to fall staging areas in the mouth of the Bay of Fundy (Passamaquoddy Bay, New Brunswick, for Red-necked Phalaropes and Brier Island, Nova Scotia for Red Phalaropes) since

1986, are staging somewhere in the Gulf of Maine, along the southern and eastern shores of Nova Scotia or in the Gulf of Saint Lawrence in August and September each year, and 2) that interviews and boat trips with fishermen in i) Passamaquoddy Bay, ii) George's Bank, iii) Baccaro and Brown's Bank, iv)Sable Island Bank, v) Banquereau Bank and vi) the Gulf of Saint Lawrence will provide information on their whereabouts. Given the preliminary nature of this initiative, and the degree of uncertainty in locating coastal migration stopover sites that will permit effective monitoring, no assumptions can yet be made about precision and bias.

Assumptions

That the new staging area(s) can be found and will be suitable for monitoring; that no substantial temporal trend occurs in the fraction of the population at the staging areas during the time of the surveys.

Costs

Development: $30K/year for 5 years
Operational: $28K/year mainly for coordinator's salary and travel

(From information provided Peter Hicklin, Canadian Wildlife Service, location?)

MULTISPECIES SURVEYS

27. The International Shorebird Survey

Species

All species found commonly in the lower 48 United States during migration

Goals

Monitor trend in population size
Monitor numbers using major staging, migration, or wintering areas

Background

Most kinds of North American shorebirds live their lives on geographic scales that create vexing challenges to monitor through statistically rigorous sampling designs. A premise underlying the ISS is that a volunteer-based sampling program can operate during non-breeding seasons on the large geographic scale at which most population sampling for shorebirds needs to occur, and that this can be done at sustainable costs.

The ISS is a volunteer-based survey conducted through years (decades) at many locations (hundreds) that can monitor relative abundance between species, geographic shifts of distribution, patterns and changes of migration chronology, and change of population size (trends) (e.g. see Howe et al., 1989; Morrison et al., 1994). ISS surveys have collected counts of shorebirds using Central and Atlantic flyways (east of the 105th Meridian) of the United States. Additional information has been collected west of the 105th Meridian and at Western Hemisphere locations south of the United States. Improvement of trend-monitoring ability should be possible by maintaining focused effort on 'benchmark' locations while continuing less structured promotion of coverage at other sites.

Shorebirds that cross north through many of the interior states and provinces during migration are broadly dispersed on the landscape but are unpredictable in distribution in response to rapidly changing wetland conditions within and between years (Skagen 1997). These attributes greatly complicate efforts to estimate hemispheric population size and trends using survey data. Improvement of coverage in unpredictable landscapes should be possible through coverage at additional locations in those landscapes and through inclusion of route-based (versus site-based) sampling.

The ISS has traditionally focused on regions east of the 105th Meridian. A special effort is needed to increase sampling further west, and to better integrate with and complement work of the Pacific Flyway Project. This should include comparison of information gathered through the Pacific Flyway Project with information collected through ISS protocols as a way of assessing coverage by different sampling protocols.

Protocol

The International Shorebird Survey enlists help from volunteer cooperators who select a locality that they visit and census three times monthly during key migration periods. An accompanying program is focused on developing coverage at a spectrum of National Wildlife Refuges with a goal of having counts maintained for decades. A future goal is to include route-based coverage in landscapes having low numbers of potential volunteers and/or highly unpredictable habitat conditions from year to year.

Cooperators are encouraged to select locations that are convenient for them to visit. The project further encourages coverage at sites (a) where prior ISS coverage has been achieved but was suspended, (b) that are protected from future development, and (c) in federal and state wildlife refuges and management areas.

Spring. Cooperators are asked to make at least one count during each third of April and May, and one during the first ten days of June (i.e. one count between 1 and 10 April, another between 11 and 20, and another between 21 and 30, etc.). More frequent counts are encouraged; less frequent counts are accepted but are not used in many of the analyses.

Some inland areas have unpredictable habitat conditions, and need more intensive protocols. The protocol proposed here for agricultural landscapes, especially western plains and Great Basin region, is comprised of two main efforts to be undertaken in concert. These efforts are 1) regular standardized counts of predetermined 'traditional sites', use of route-based survey, and dedicated survey by professional staff.

With the considerable loss of traditionally used spring migration habitats in many interior states, monitoring of migration also is needed to supply wildlife managers with information needed for management responses to rapidly changing landscape conditions (eg. rainfall).

Fall. Counts are requested for each third of the month from 11 July through 31 October. Counts from other months are welcome as well. More frequent counts are encouraged; less frequent counts are accepted but not used in many of the analyses.

Data management and analysis: Data, submitted seasonally or annually, are keyed, error-checked, and stored in a centralized database to be made accessible by password through the World Wide Web.

Strengths and weaknesses of the ISS are summarized below:

Strengths:
Broad geographic coverage can be practically achieved.
Program can be operated at relatively low cost.
Program is sustainable through decades of operation.
Ongoing public involvement and education
Comparable sampling effort simultaneously applied to all species
Twenty-five years of existing baseline coverage
Easily coordinated with comparable efforts in other countries

Weaknesses:
Weak standardization in sampling protocol (lower power of analysis)
Inconsistency of estimation precision between observers (training might help)
No protocol for selection of census sites (stratified sampling design desirable)

Major Assumptions

For trend estimation: That substantial, long-term changes occur in the proportion of the populations in the study areas at the times of the surveys or in the detection rates.

For monitoring major wintering areas: That the major concentration sites are included in the survey.

Primary Development Tasks

Several improvements to the ISS should be considered:

1. Establish, or if already established, use internet-based communication network to determine where suitable shorebird habitat is likely to occur in the interior region on a weekly basis. Observers/participants may also report shorebird occurrences for verification in survey effort. Identify potential sites for surveys in all parts of each species' known range, using a combination of Skagen et al. (1998) and current information from new sources. Stratify survey effort relative to probability of occurrence based on habitat availability information received from network. Surveys to be conducted by trained observers that are mobile and flexible in their abilities to cover several sites, using a combination of volunteer and paid personnel.

2. Acquire supportive information on migration strategies (e.g. "hop," "jump," "leapfrog"), including lengths-of-stay, body condition, estimated flight ranges, and biogeographical patterns. Determine if southern plains migrants stop again in northern plains or in Canada. Evaluate and choose a technique or combination of techniques from among the following: radio-telemetry, genetic analyses, color-banding/resighting, and/or analysis of chronology and distribution data in Skagen et al. (1998). For example, "hopping" strategies are suggested by chronology and distribution data for Baird's Sandpiper, whereas longer "jumps" are suggested for White-rumped Sandpiper.

3. Work with existing ISS, Pacific Flyway Project, and Maritimes Shorebird Survey data to explore sampling questions and possible methods for increasing trend analysis capabilities.

Costs

Operational: $130K/year mainly for salaries

(From information provided by Brian Harrington, Manomet Center for Conservation Sciences, Manomet, Maine and Susan K. Skagen, USGS Midcontinent Ecological Science Center, Fort Collins, Colorado)

28. The North American Breeding Bird Survey (BBS)

Species

Focal: Killdeer (*Charadrius vociferus*), Common Snipe (*Gallinago gallinago*; southern populations), Upland Sandpiper (*Bartramia longicauda*)

Secondary: American Avocet (*Recurvirostra americana*), Black-necked Stilt (*Himantopus mexicanus*), Marbled Godwit (*Limosa fedoa fedoa*; Great Plains), Long-billed Curlew (*Numenius americanus*), Willet (*Catoptrophorus semipalmatus*), Spotted Sandpiper (*Actitis macularia*), Wilson's Phalarope (*Phalaropus tricolor*).

Goals

Monitor trend in population size

Background

The BBS was initiated in 1966 in eastern North America east of the Mississippi River. Surveys in central North America began in 1967, and by 1968, the BBS was established across the continent. Surveys in Alaska and the northern Canadian territories were initiated in the early 1980s. The goal of the BBS is to monitor the status and trends of North American bird populations at various geographic scales. Counts of birds along survey routes are used to develop annual indices of abundance. Changes in these indices over time are believed to represent temporal changes in the entire population.

Because more than 30 years of data have been collected, long-term population trends can be established with some confidence for species that are well sampled by the survey methodology. Data are collected throughout the species' ranges, so that population trends can be established at various geographic scales. The survey is jointly coordinated by the USGS and the Canadian Wildlife Service, and these agencies will continue to provide all necessary support to coordinate these activities for the foreseeable future.

Analyses of BBS data remain controversial and a number of methods have been employed to produce population trend estimates. Most recent BBS population trend estimates have been produced with a modified route-regression approach, treating observers as covariates (Geissler and Sauer 1990, Link and Sauer 1994), although non-linear models have also been used (James et al. 1996). A multivariate approach recently has been developed which provides a more robust estimation of population trajectories (Link and Sauer 1997).

The focal species (see list above) are regularly detected by point counts and occupy habitats that are commonly found along BBS routes. The secondary species are detected on some BBS routes, but whether these data can be used to provide reliable estimates of population trends is uncertain. Many of these species occupy habitats that are not commonly represented along BBS routes, so the limited data may not be representative of overall population trends. Other species may be poorly detected by point counts, and their relatively low abundances may not provide sufficient data to estimate population trends with necessary precision.

Protocol

The BBS currently has approximately 4,100 active routes scattered across the continental U.S., Canada, and Alaska. Each route is 39.4 km long, with 50 stops placed at 0.8 km intervals. All birds recorded within 0.4 km of each stop are tallied during a three-minute point count. These routes are surveyed once annually during the peak of the breeding season, with most surveys conducted during June, although desert regions and southern states may be surveyed in May. Detailed survey methodology is provided by Robbins et al. (1986) and Peterjohn (1994).

Major Assumptions

That no substantial temporal trend occurs in the detection ratio.

(From information provided by Bruce Peterjohn and Marshall Howe, USGS Patuxent Wildlife Research Center, Laurel, Maryland)

29. National Audubon Society Christmas Bird Counts

Species

Focal: Purple Sandpiper (*Calidris maritima belcheri*,, Hudson Bay; possibly *C. m. maritima*, northern Canada), Dunlin (*Calidris alpina hudsonia*, eastern Canada)

Secondary: All shorebird species whose winter range encompasses portions of the United States and Canada.

Goals

Monitor trend in population size
Monitor numbers using major wintering areas

Background

Christmas Bird Counts (CBC) are conducted throughout the United states and southern Canada. They are the only data set available on the early winter status and distribution of all avian species for the entire continent. These data have been collected on a fairly standard basis since the late 1950s, and the data set extends back to 1900. Hence, estimates of long-term population changes are possible from these data. This program is coordinated by the National Audubon Society, which is expected to continue to support CBCs in the foreseeable future.

However, the CBC is more of a birding event than a scientific exercise, and the lack of defined protocols limits the potential uses of these data to reliably monitor population changes. Some of the more important problems with the use of CBC data include (Butcher 1990): potential identification problems, potential counting biases, biases in habitat coverage, especially for counts where the number of participants has greatly increased over time, the effects of adverse weather conditions on the count day; rain or strong winds may significantly reduce the totals during some years, CBC circles may have moved slightly over time, and effort adjustments may not affect each species equally; analysts need to consider how these adjustments may be influencing their species of interest.

Protocol

All CBCs occur within 15-mile-diameter circles that are chosen at the discretion of the count organizer as long as they do not overlap with other count circles. Count circles are not uniformly distributed across the continent, but tend to be concentrated near urban areas and along coast lines or other features that attract large numbers of birds. The survey period is established by the National Audubon Society, but the local CBC compiler chooses a single date for each year's count. Coverage varies between circles and between 1 and 500+ observers have participated on a single CBC. No specific sampling methods are employed; the participants count all individual birds they see or hear within their territory. Counts from all of the observers are then compiled to produce annual totals for each CBC. See Arbib (1981) and Butcher (1990) for more details on the CBC methodology.

The CBC program is coordinated by the National Audubon Society (NAS), while the database is currently managed by the Cornell Laboratory of Ornithology in association with the NAS. The Cornell Laboratory recently has started to modernize the CBC data processing system, and all data were electronically entered beginning with the 1998-1999 CBC.

The analysis of CBC data remains a controversial topic, and surprisingly little effort has been made to improve the analytical methods since those suggested by Raynor (1975). Adjustment for observer effort is essential in these analyses (Butcher and McCullock 1990), but these adjustments also may introduce some biases into the results. Some other potential biases have been identified, such as those associated with birds that visit feeders (Dunn 1995), but many other potential biases remain unexplored.

Given the methodological shortcomings of the CBC, a number of significant biases may influence the count totals. Whether annual changes in these totals serve as reliable indices of changes in the overall population has never been established. Questions related to the precision of the counts, accuracy of identification, consistency of coverage, and other issues are also associated with the CBC data set. Since the CBC circles are not randomly located, whether these data can be extrapolated to larger geographic areas is uncertain. All of these issues require additional study, especially with regard to the shorebird data, before the ability of the CBC data to reliably monitor bird populations can be ascertained.

Prepared by Bruce Peterjohn and Marshall Howe, USGS Patuxent Wildlife Research Center, Laurel, MD 20708-4038

30. Arctic and boreal breeding grounds surveys

Species

All species breeding in the arctic and boreal zones (approximately 30 species)

Goals

Estimate population size
Monitor trend in population size

Background

This program would be conducted in the far north, in areas where the focal species breed. The reason for evaluating this approach is that the problem of trends in bird movements (see Appendix 1) does not arise because the population of interest (breeding birds) is being surveyed.

It is possible that arctic and boreal areas could be surveyed annually, as envisaged for most other protocols, but a more likely scenario is that the arctic and boreal zone would be surveyed during the first five years of the monitoring program but not again for a few decades unless surveys on the non-breeding grounds indicated that a decline of concern might be occurring. If this happened, then the breeding ground survey could be repeated to provide an independent, and probably more reliable, estimate of the population trends. In the intervening years, data might also be collected opportunistically from the arctic and boreal zone wherever biologists happened to be working. As noted below, the survey protocol involves rapid counts so they would not be too burdensome to biologists doing other work.

The initial wide-ranging survey would provide much useful information in addition to estimates of overall population size for each taxon of interest. Much new distributional information would be obtained, habitat associations would be clarified, limited information on productivity (see below) would be collected, and experience would be gained with the difficult logistic issues of work in the far north. Finally, this effort would provide a better foundation than exists at present for interpreting results gathered opportunistically in subsequent years.

The methods to be used in this protocol have been developed in northern Alaska during the past few years, building on similar work in northern Canada. Estimates of population size across areas several thousand km^2 have been obtained with coefficients of variation in the 7-15% range.

Protocol

During the first 1-2 years, shorebird habitat maps of the arctic and boreal areas will be prepared. The general approach will presumably be to begin with broad habitat zones, based on existing information. Smaller areas will then be selected and detailed habitat maps will be prepared using satellite and/or aerial photos. Areas to be searched on the ground will then be selected from these maps. Survey methods will also be tested and refined during this period and logistic issues will be studied to develop feasible and cost-effective methods for plot selection.

Each year, a new sample of plots will be surveyed a single time during the incubation period using area search methods. A subset of the plots will also be surveyed intensively to estimate detection rates. Results will be used to develop regression-type models that predict shorebird abundance by species, corrected for detection rates, in any plot based on the habitat and landscape traits of the plot. The models will be re-derived each year and used to estimate abundance of each species throughout the arctic and boreal zone. Although the main objective during surveys will be estimating the number of territorial birds, information will also be gathered on pairing and nesting rates, and on nesting success (by recording nests and clutch sizes), and this information will be used to help investigate such issues as habitat quality, the relation between density and habitat quality, and causes of trends in population size.

Although the surveys would be designed especially to detect shorebirds, and this would be the primary objective, information would be recorded on all birds, and selected other species (e.g., foxes). It also seems likely that a limited program to sample habitat (including collection of samples for chemical analysis) could be carried out without compromising the major purpose of the study, and that such data might be useful in understanding ecological trends in the arctic.

Assumptions

For population size estimation: That the survey plots are statistically representative of the breeding range of each species and that counts (corrected for detection rates) provide essentially unbiased estimates of abundance

For trend estimation: Same as above or that *trends* on the sampled plots are similar, on average, to those from plots outside the sampled population.

Primary Development Tasks

1. Estimate sample size requirements by analysis of existing data.
2. Prepare habitat maps.
3. Determine how best to reach sites.
4. Carry out a pilot study to evaluate logistic issues and obtain pilot data.

Costs

Development: $150K/year for 3 years.
Operational: $150K/year, mainly for travel

(*From information provided by Jonathan Bart, Bob Gill, Guy Morrison, Brad Andres and others*.)

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